

SIEMENS



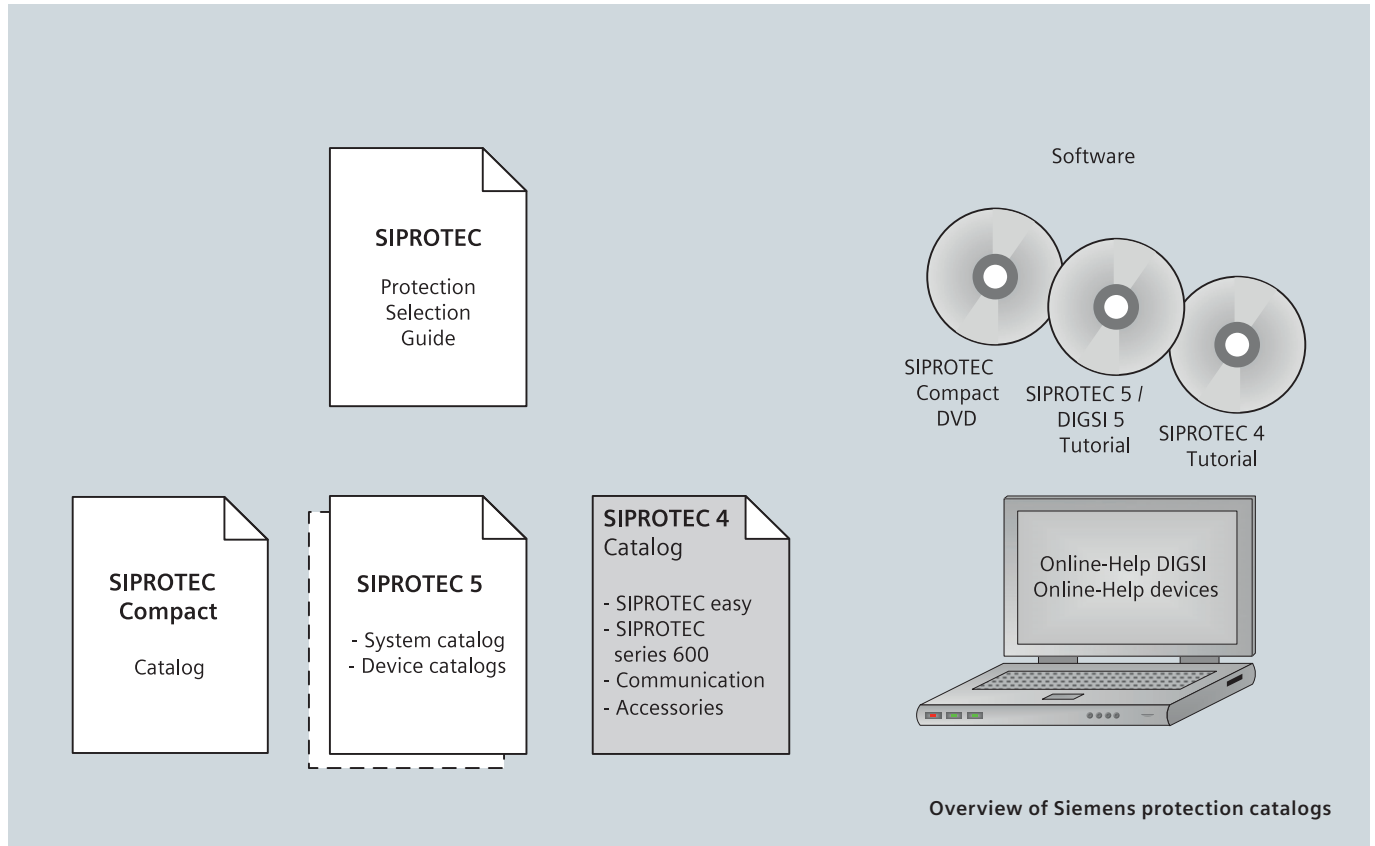
www.siemens.com/protection

SIPROTEC 4, SIPROTEC easy,
SIPROTEC 600 Series, Communication, Accessories

Catalog SIP · Edition No. 7

Answers for infrastructure and cities.

Overview of Siemens Protection Catalogs



SIPROTEC 4, SIPROTEC Series 600, SIPROTEC easy, Communication and Accessories:

This catalog describes the features of the device series SIPROTEC 4, SIPROTEC series 600 and SIPROTEC easy, as well as their devices. In further chapters, the accessories of the complete SIPROTEC family for communication, auxiliary relays and test equipment are described.

Protection Selection Guide:

The selection guide offers an overview of the device series of the Siemens protection devices, and a device selection table.

SIPROTEC Compact catalog:

The SIPROTEC Compact catalog describes the features of the SIPROTEC Compact series and presents the available devices and their application possibilities.

SIPROTEC 5 catalogs:

The system catalog describes the features of the SIPROTEC 5 system. The SIPROTEC 5 device catalogs describe device-specific features such as scope of functions, hardware and application.

SIPROTEC 4, SIPROTEC easy, SIPROTEC 600 Series, Communication, Accessories

Energy Automation

Catalog SIP · Edition No. 7

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The products and systems described in this catalog are manufactured and sold according to a certified management system (acc. to ISO 9001, ISO 14001 and BS OHSAS 18001).

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Product Selection

Product Selection

Function overview SIPROTEC 4, SIPROTEC easy and SIPROTEC 600 Series

1

Device application		Distance protection	Line differential protection												
ANSI	Functions		Abbr.	Type	SIPROTEC 4				SIPROTEC 600 Series		SIPROTEC 4		SIPROTEC easy		
					7SA522	7SA61	7SA63	7SA64	7SD60	7SD610	7SD5	7SJ45	7SJ46		
	Protection functions for 3-pole tripping	3-pole			■	■	■	■	■	■	■	■	■		
	Protection functions for 1-pole tripping	1-pole			●	●	●	●	-	●	●	-	-		
14	Locked rotor protection	$I > + V <$			-	-	-	-	-	-	-	-	-		
21	Distance protection	$Z <$			■	■	■	■	-	-	●	-	-		
24	Overexcitation protection	V/f			-	-	-	-	-	-	-	-	-		
25	Synchrocheck, synchronizing function	Sync			●	●	●	●	-	-	●	-	-		
27	Undervoltage protection	$V <$			●	●	●	●	-	●	●	-	-		
27TN/59TN	Stator ground fault 3 rd harmonics	$V0 <, >_{(3.Harm.)}$			-	-	-	-	-	-	-	-	-		
27/Q	Undervoltage-controlled reactive power protection	$Q > / V <$			-	-	-	-	-	-	-	-	-		
32	Directional power supervision	$P < >, Q < >$			■	■	■	■	-	●	■	-	-		
37	Undercurrent, underpower	$I <, P <$			-	-	-	-	-	-	-	-	-		
38	Temperature supervision	$\Theta >$			-	-	-	-	-	-	-	-	-		
40	Underexcitation protection	$1/X_D$			-	-	-	-	-	-	-	-	-		
46	Unbalanced-load protection	$I2 >$			-	-	-	-	-	-	-	-	-		
46	Negative-sequence system overcurrent protection	$I2 >, I2/I1 >$			-	-	-	-	-	-	-	-	-		
47	Phase-sequence-voltage supervision	LA, LB, LC			■	■	■	■	-	■	■	-	-		
48	Starting-time supervision	I^2_{start}			-	-	-	-	-	-	-	-	-		
49	Thermal overload protection	θ, I^2t			-	■	■	■	-	■	■	-	-		
50/50N	Definite time-overcurrent protection	$I >$			■	■	■	■	●	■	■	■	■		
50Ns	Sensitive ground-current protection	$I_{Ns} >$			●	●	●	●	-	-	●	-	-		
	Intermittent ground fault protection	$lie >$			-	-	-	-	-	-	-	-	-		
50L	Load-jam protection	$I >_L$			-	-	-	-	-	-	-	-	-		
50BF	Circuit-breaker failure protection	CBFP			●	●	●	●	●	●	■	-	-		
51/51N	Inverse time-overcurrent protection	I_p, I_{Np}			■	■	■	■	-	■	■	■	■		
51C	Cold load pickup				-	-	-	-	-	-	-	-	-		
51V	Voltage dependent overcurrent protection	$t=f(I)+V <$			-	-	-	-	-	-	-	-	-		
55	Power factor	$\cos\varphi$			■	■	■	■	-	■	■	-	-		
59	Overvoltage protection	$V >$			●	●	●	●	-	●	●	-	-		
59R, 27R	Rate-of-voltage-change protection	dV/dt			-	-	-	-	-	-	-	-	-		
60FL	Fuse-Failure-Monitor				■	■	■	■	-	●	■	-	-		
64	Sensitive ground-fault protection (machine)				-	-	-	-	-	-	-	-	-		
66	Restart inhibit	I^2t			-	-	-	-	-	-	-	-	-		
67	Directional time-overcurrent protection, phase	$I >, I_p \angle (V, I)$			■	■	■	■	-	●	-	-	-		

■ = basic ● = optional (additional price) - = not available

1) in preparation

2) via CFC

More functions on page 1/4

You will find the whole function overview of the SIPROTEC devices in the Selection Guide at: www.siemens.com/protection or in the catalog: IC1000-K4456-A101-AX-7600

Product Selection

Function overview SIPROTEC 4, SIPROTEC easy and SIPROTEC 600 Series

1

Device application			Distance protection				Line differential protection					
ANSI	Functions	Abbr.	Device family	SIPROTEC 4				SIPROTEC 600 Series			SIPROTEC easy	
				Type	7SA522	7SA61	7SA63	7SA64	7SD60	7SD610	7SD5	7SJ45
67N	Directional time-overcurrent protection for ground-faults	$I_N >, I_{NP} \angle (V, I)$		●	●	●	●	●	●	●	-	-
67Ns	Sensitive ground-fault detection for systems with resonant or isolated neutral	$I_{Ns} >, I_{Nsp} \angle (V, I)$		●	●	●	●	-	-	●	-	-
67Ns	Directional intermittent ground fault protection	IIE dir>		-	-	-	-	-	-	-	-	-
68	Power-swing blocking	$\Delta Z/\Delta t$		●	●	●	●	-	-	●	-	-
74TC	Trip-circuit supervision	TCS		■	■	■	■	-	■	■	-	-
78	Out-of-step protection	$\Delta Z/\Delta t$		●	●	●	●	-	-	●	-	-
79	Automatic reclosing	AR		●	●	●	●	-	●	●	-	-
81	Frequency protection	$f <, f >$		●	●	●	●	-	●	●	-	-
81R	Rate-of-frequency-change protection	df/dt		-	-	-	-	-	-	-	-	-
	Vector-jump protection	$\Delta \varphi_U >$		-	-	-	-	-	-	-	-	-
85	Teleprotection			■	■	■	■	■	■	■	-	-
86	Lockout			■	■	■	■	-	■	■	-	-
87	Differential protection	ΔI		-	-	-	-	■	■	■	-	-
87N	Differential ground-fault protection	ΔI_N		-	-	-	-	■	-	●	-	-
	Broken-wire detection for differential protection			-	-	-	-	-	■	■	-	-
FL	Fault locator	FL		■	■	■	■	-	■	■	-	-
	Further Functions											
	Measured values			■	■	■	■	■	■	■	-	-
	Switching-statistic counters			■	■	■	■	■	■	■	-	-
	Logic editor			■	■	■	■	■	■	■	-	-
	CFC switching sequences for control applications			-	-	-	-	●	■	■	-	-
	Inrush-current detection			■	■	■	■	■	■	■	-	-
	External trip initiation			■	■	■	■	■	■	■	-	-
	High Speed busbar transfer function			-	-	-	-	-	-	-	-	-
	Fault recording of analog and binary signals			■	■	■	■	■	■	■	-	-
	Monitoring and supervision			■	■	■	■	■	■	■	-	-
	Protection interface, serial			●	●	●	●	-	■	■	-	-
	No. Setting groups			4	4	4	4	-	4	4	1	1
	Changeover of setting group			■	■	■	■	-	■	■	-	-

■ = basic ● = optional (additional price) - = not available

- 1) in preparation
- 2) via CFC

You will find the whole function overview of the SIPROTEC devices in the Selection Guide at: www.siemens.com/protection or in the catalog: IC1000-K4456-A101-AX-7600

Product Selection

Function overview SIPROTEC 4, SIPROTEC easy and SIPROTEC 600 Series

1

Device application							Generator and motor protection		Transformer protection			Busbar protection		Bay controller			Breaker management	Synchronizing	High Speed Busbar Transfer	Voltage and frequency protection
SIPROTEC 600 Series		SIPROTEC 4					SIPROTEC 4		SIPROTEC 4			SIPROTEC 600 Series		SIPROTEC 4			SIPROTEC 4	SIPROTEC 4	SIPROTEC 4	SIPROTEC 600 Series
7SJ600	7SJ602	7SJ61	7SJ62	7SJ63	7SJ64	7UM61	7UM62	7UT612	7UT613	7UT63	7SS60	7SS52	6MD61	6MD63	6MD66	7VK61	7VE6	7VU683	7RW60	
-	-	-	●	●	●	■	■	-	-	-	-	-	-	-	-	-	-	-	-	
-	●	-	●	●	●	■	■	-	-	-	-	-	-	-	-	-	-	-	-	
-	-	-	■	-	■	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
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●	●	●	●	●	●	■	■	-	●	●	-	-	-	-	-	■	-	-	■	
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-	●	●	●	●	●	●	●	●	●	●	-	-	-	-	-	-	-	-	-	
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■	■	■	■	■ ²⁾	■	■	■	■	■	■	-	■	-	-	-	■	●	-	●	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
■	■	■	■	■	■	■	■	■	■	■	■	■	-	-	●	■	■	■	■	
■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1	1	4	4	4	4	2	2	4	4	4	1	1	4	4	4	4	4	4	1	
■	■	■	■	■	■	■	■	■	■	■	-	-	■	■	■	■	■	■	-	

Overview/Applications

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Solutions for today's and future power supply systems – for more than 100 years

SIPROTEC has established itself on the energy market for decades as a powerful and complete system family of numerical protection relays and bay controllers from Siemens.

SIPROTEC protection relays from Siemens can be consistently used throughout all applications in medium and high voltage. With SIPROTEC, operators have their systems firmly and safely under control, and have the basis to implement cost-efficient solutions for all duties in modern, intelligent and "smart" grids. Users can combine the units of the different SIPROTEC device series at will for solving manifold duties – because SIPROTEC stands for continuity, openness and future-proof design.

As the innovation driver and trendsetter in the field of protection systems for more than 100 years, Siemens helps system operators to design their grids in an intelligent, ecological, reliable and efficient way, and to operate them economically. As a pioneer, Siemens has decisively influenced the development of numerical protection systems (Fig. 2/2). The first application went into operation in Würzburg, Germany, in 1977. Consistent integration of protection and control functions for all SIPROTEC devices was the innovation step in the 90ies. After release of the communication standard IEC 61850 in the year 2004, Siemens was the first manufacturer worldwide to put a system with this communication standard into operation. In the meantime we have delivered more than 250,000 devices with IEC 61850 included.









Fig. 2/1

How can system operators benefit from this experience?

- Proven and complete applications
- Easy integration into your system
- Highest quality of hardware and software
- Excellent operator friendliness of devices and tools
- Easy data exchange between applications
- Extraordinary consistency between product- and system-engineering
- Reduced complexity by easy operation
- Siemens as a reliable, worldwide operating partner.

SIPROTEC – a synonym for protection devices

Over 100 years of experience in the field of protection devices and substation automation almost says it all. Yet the highest appreciation must be given to some milestones in the history of this great product. The very first family of SIPROTEC products already had a head start in being ahead of its competitors. Find out how the continuous drive for technological improvements and brilliant minds have kept this success story going and going and going.

Several milestones in the history of SIPROTEC have defined not only the technology of this product family but its fundamental character. With more than one million SIPROTEC units in the field, we are clearly the market leader in Digital Protection Technology.

1902	1925	1940	1970	1977	1980s	1985	1998	2004	2006	2008	2010
Schuckart & Co. (1887): DC metering device based on Georg Hummel's principle	First overcurrent relay RA1 and delayed action relay RS1	Introduction of new overcurrent relay RAS	Introduction of analog electronic relays	First digital application in Würzburg, Germany	The digital era for relays begins	Introduction of first numerical relay in combination with control technology SINAUT LSA	Introduction of SIPROTEC 4 family	Siemens installs the world's first substation with IEC 61850-based control in Winznau-sachsen, CH	Siemens awarded the Frost & Sullivan "Technology Leadership Award" for the implementation of IEC 61850	SIPROTEC Compact, the new member of the SIPROTEC family, is introduced	Introduction of the new SIPROTEC 5 family

history

Fig. 2/2 SIPROTEC – Pioneer over generations

Overview

SIPROTEC relay families

2

SIPROTEC easy

SIPROTEC easy are CT power supplied or auxiliary power supplied, numerical overcurrent-time protection relays, which can be used as line and transformer protection (back-up protection) in electrical power supply systems with single-ended supply. They offer definite-time and inverse-time overcurrent protection functions according to IEC and ANSI. The comfortable operation via DIP switch is self-explanatory and simple.

- Two-stage overcurrent-time protection
- Saving the auxiliary power supply by operation via integrated current transformer supply
- Cost-efficient due to the use of instrument transformers with low ratings
- Tripping via pulse output (DC 24 V/0.1 Ws) or tripping relay output
- Simple, self-explanatory parameterization and operation via DIP switch directly at the device
- Easy installation due to compact assembly on DIN rail.

SIPROTEC Compact (series 600)

The devices of the SIPROTEC Compact series (series 600) are compact, numerical protection devices for application in medium-voltage or industrial power supply systems. The corresponding device types are available for the different applications such as overcurrent-time protection, line differential protection, transient ground-fault relay or busbar protection.

- Space-saving due to compact design
- Reliable process connections by means of solid terminal blocks
- Effective fault evaluation by means of integrated fault recording and SIGRA 4
- Communication interface
- Operable and evaluable via DIGSI 4
- Different device types available for directional and non-directional applications.



Fig. 2/3 SIPROTEC easy



Fig. 2/4 SIPROTEC Compact (series 600)

SIPROTEC Compact – Maximum protection-minimum space

Perfect protection, smallest space reliable and flexible protection for energy distribution and industrial systems with minimum space requirements. The devices of the SIPROTEC Compact family offer an extensive variety of functions in a compact and thus space-saving 1/6 x 19" housing. The devices can be used as main protection in medium-voltage applications or as back-up protection in high-voltage systems.

SIPROTEC Compact provides suitable devices for many applications in energy distribution, such as the protection of feeders, lines or motors. Moreover, it also performs tasks such as system decoupling, load shedding, load restoration, as well as voltage and frequency protection.

The SIPROTEC Compact series is based on millions of operational experience with SIPROTEC 4 and a further-developed, compact hardware, in which many customer suggestions were integrated. This offers maximum reliability combined with excellent functionality and flexibility.

- Simple installation by means of pluggable current and voltage terminal blocks
- Thresholds adjustable via software (3 stages guarantee a safe and reliable recording of input signals)
- Easy adjustment of secondary current transformer values (1 A/5 A) to primary transformers via DIGSI 4
- Quick operations at the device by means of 9 freely programmable function keys
- Clear overview with six-line display
- Easy service due to buffer battery replaceable at the front side
- Use of standard cables via USB port at the front
- Integration in the communication network by means of two further communication interfaces
- Integrated switch for low-cost and redundant optical and electrical Ethernet rings
- Ethernet redundancy protocols RSTP, PRP and HSR for highest availability
- Reduction of wiring between devices by means of cross-communication via Ethernet (IEC 61850 GOOSE)
- Time synchronization to the millisecond via Ethernet with SNTP for targeted fault evaluation
- Adjustable to the protection requirements by means of "flexible protection functions"
- Comfortable engineering and evaluation via DIGSI 4.



Fig. 2/5 SIPROTEC Compact



Fig. 2/6 SIPROTEC Compact – rear view



Fig. 2/7 Feeder protection relay 7SC80

Overview

SIPROTEC relay families

2

SIPROTEC 5 – the new benchmark for protection, automation and monitoring

The SIPROTEC 5 series is based on the long field experience of the SIPROTEC device series, and has been especially designed for the new requirements of modern high-voltage systems. For this purpose, SIPROTEC 5 is equipped with extensive functionalities and device types. With the holistic and consistent engineering tool DIGSI 5, a solution has also been provided for the increasingly complex processes, from the design via the engineering phase up to the test and operation phase.

Thanks to the high modularity of hardware and software, the functionality and hardware of the devices can be tailored to the requested application and adjusted to the continuously changing requirements throughout the entire life cycle.

Besides the reliable and selective protection and the complete automation function, SIPROTEC 5 offers an extensive database for operation and monitoring of modern power supply systems. Synchrophasors (PMU), power quality data and extensive operational equipment data are part of the scope of supply.

- Powerful protection functions guarantee the safety of the system operator's equipment and employees
- Individually configurable devices save money on initial investment as well as storage of spare parts, maintenance, expansion and adjustment of your equipment
- Clear and easy-to-use of devices and software thanks to user-friendly design
- Increase of reliability and quality of the engineering process
- High reliability due to consequent implementation of safety and security
- Powerful communication components guarantee safe and effective solutions
- Full compatibility between IEC 61850 Editions 1 and 2
- Integrated switch for low-cost and redundant optical and electrical Ethernet rings
- Ethernet redundancy protocols RSTP, PRP and HSR for highest availability
- Efficient operating concepts by flexible engineering of IEC 61850 Edition 2
- Comprehensive database for monitoring of modern power grids
- Optimal smart automation platform for transmission grids based on integrated synchrophasor measurement units (PMU) and power quality functions.



Fig. 2/8 SIPROTEC 5 – modular hardware



Fig. 2/9 SIPROTEC 5 – rear view



Fig. 2/10 Application in the high-voltage system

SIPROTEC 4 – the proven, reliable and future-proof protection for all applications

SIPROTEC 4 represents a worldwide successful and proven device series with more than 1 million devices in field use.

Due to the homogenous system platform, the unique engineering program DIGSI 4 and the great field experience, the SIPROTEC 4 device family has gained the highest appreciation of users all over the world. Today, SIPROTEC 4 is considered the standard for numerical protection systems in all fields of application.

SIPROTEC 4 provides suitable devices for all applications from power generation and transmission up to distribution and industrial systems.

SIPROTEC 4 is a milestone in protection systems. The SIPROTEC 4 device series implements the integration of protection, control, measuring and automation functions optimally in one device. In many fields of application, all tasks of the secondary systems can be performed with one single device. The open and future-proof concept of SIPROTEC 4 has been ensured for the entire device series with the implementation of IEC 61850.

- Proven protection functions guarantee the safety of the systems operator's equipment and employees
- Comfortable engineering and evaluation via DIGSI 4
- Simple creation of automation solutions by means of the integrated CFC
- Targeted and easy operation of devices and software thanks to user-friendly design
- Powerful communication components guarantee safe and effective solutions
- Maximum experience worldwide in the use of SIPROTEC 4 and in the implementation of IEC 61850 projects
- Future-proof due to exchangeable communication interfaces and integrated CFC.
- Integrated switch for low-cost and redundant optical Ethernet rings
- Ethernet redundancy protocols RSTP, PRP and HSR for highest availability.



Fig. 2/11 SIPROTEC 4



Fig. 2/12 SIPROTEC 4 rear view



Fig. 2/13 SIPROTEC 4 in power plant application

Overview

SIPROTEC relay families

2

To fulfill vital protection redundancy requirements, only those functions that are interdependent and directly associated with each other are integrated into the same unit. For backup protection, one or more additional units should be provided.

All relays can stand fully alone. Thus, the traditional protection principle of separate main and backup protection as well as the external connection to the switchyard remain unchanged.

“One feeder, one relay” concept

Analog protection schemes have been engineered and assembled from individual relays. Interwiring between these relays and scheme testing has been carried out manually in the workshop.

Data sharing now allows for the integration of several protection and protection-related tasks into one single numerical relay. Only a few external devices may be required for completion of the total scheme. This has significantly lowered the costs of engineering, assembly, panel wiring, testing and commissioning. Scheme failure probability has also been lowered.

Engineering has moved from schematic diagrams toward a parameter definition procedure. The powerful user-definable logic of SIPROTEC 4 allows flexible customized design for protection, control and measurement.

Measuring included

For many applications, the accuracy of the protection current transformer is sufficient for operational measuring. The additional measuring current transformer was required to protect the measuring instruments under short-circuit conditions. Due to the low thermal withstand capability of the measuring instruments, they could not be connected to the protection current transformer. Consequently, additional measuring core current transformers and measuring instruments are now only necessary where high accuracy is required, e.g., for revenue metering.

Corrective rather than preventive maintenance

Numerical relays monitor their own hardware and software. Exhaustive self-monitoring and failure diagnostic routines are not restricted to the protection relay itself but are methodically carried through from current transformer circuits to tripping relay coils.

Equipment failures and faults in the current transformer circuits are immediately reported and the protection relay is blocked.

Thus, service personnel are now able to correct the failure upon occurrence, resulting in a significantly upgraded availability of the protection system.

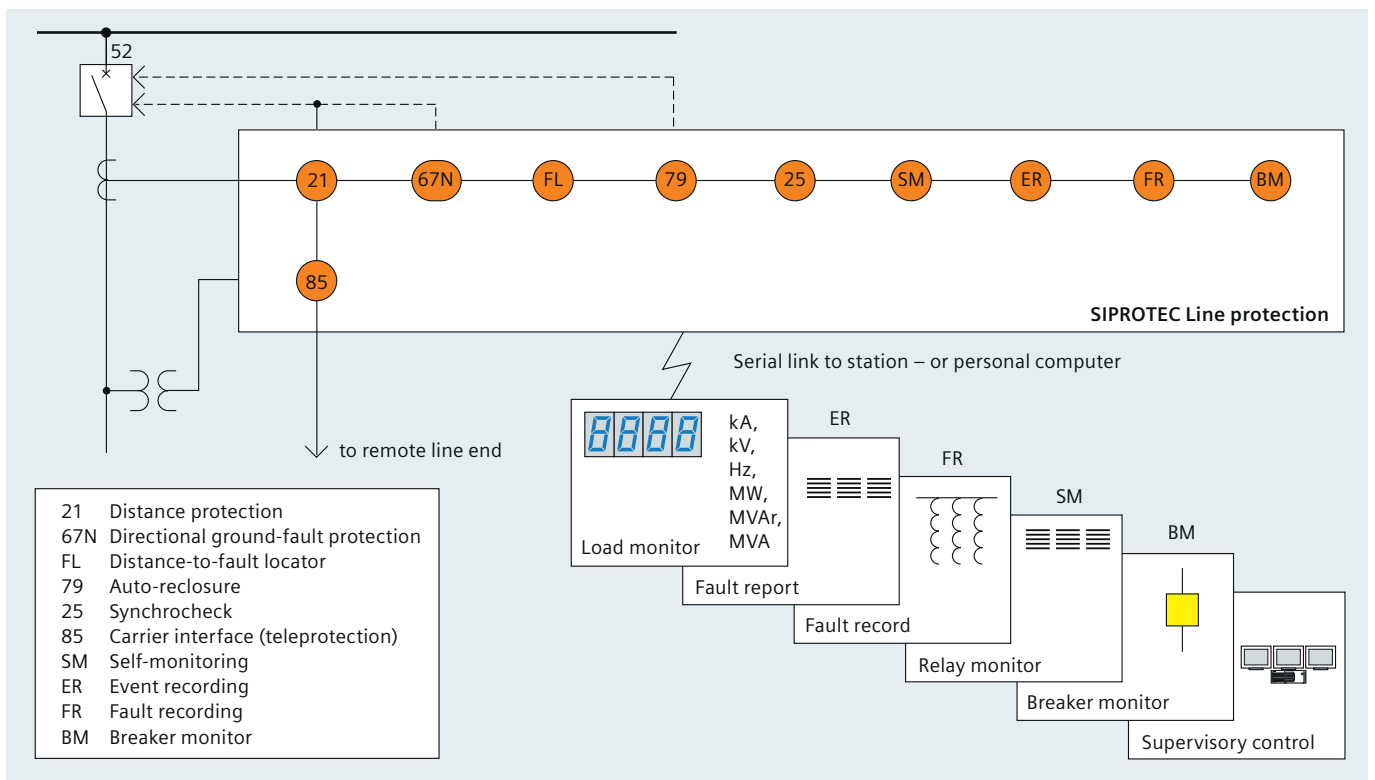


Fig. 2/14 Numerical relays offer increased information availability

Adaptive relaying

Numerical relays now offer reliable, convenient and comprehensive matching to changing conditions. Matching may be initiated either by the relay's own intelligence or from other systems via contacts or serial telegrams. Modern numerical relays contain a number of parameter sets that can be pretested during commissioning of the scheme. One set is normally operative. Transfer to the other sets can be controlled via binary inputs or a serial data link (Fig. 2/15).

There are a number of applications for which multiple setting groups can upgrade the scheme performance, for example:

- For use as a voltage-dependent control of overcurrent-time relay pickup values to overcome alternator fault current decrement to below normal load current when the automatic voltage regulator (AVR) is not in automatic operation
- For maintaining short operation times with lower fault currents, e.g., automatic change of settings if one supply transformer is taken out of service
- For "switch-onto-fault" protection to provide shorter time settings when energizing a circuit after maintenance so that normal settings can be restored automatically after a time delay
- For auto-reclosure programs, that is, instantaneous operation for first trip and delayed operation after unsuccessful reclosure
- For cold load pickup problems where high starting currents may cause relay operation
- For "ring open" or "ring closed" operation.

Implemented functions

SIPROTEC relays are available with a variety of protective functions (please refer to Fig. 2/17). The high processing power of modern numerical units allows further integration of non-protective add-on functions.

The question as to whether separate or combined relays should be used for protection and control cannot be unambiguously answered. In transmission-type substations, separation into independent hardware units is still preferred, whereas a trend toward higher function integration can be observed on the distribution level. Here, the use of combined feeder/line relays for protection, monitoring and control is becoming more common (Fig. 2/16).

Relays with protection functions only and relays with combined protection and control functions are being offered. SIPROTEC 4 relays offer combined protection and control functions. SIPROTEC 4 relays support the "one relay one feeder" principle, and thus contribute to a considerable reduction in space and wiring requirements.

With the well-proven SIPROTEC 4 family, Siemens supports both stand-alone and combined solutions on the basis of a single hardware and software platform. The user can decide within wide limits on the configuration of the control and protection, and the reliability of the protection functions (Fig. 2/17).

The following solutions are available within one relay family:

- Separate control and protection relays
- Feeder protection and remote control of the line circuit-breaker via the serial communication link
- Combined relays for protection, monitoring and control.

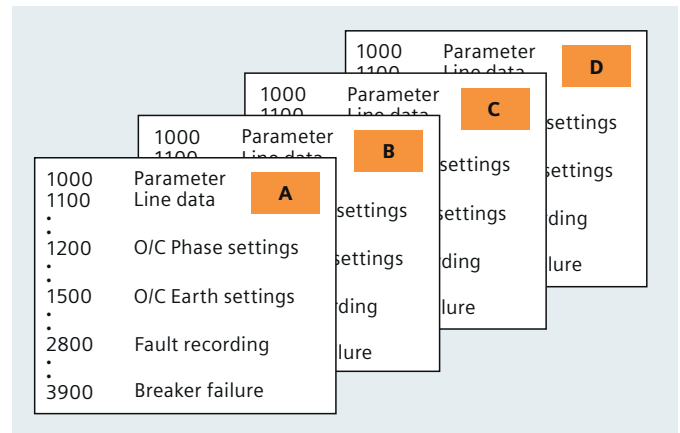


Fig. 2/15 Alternate parameter groups



Fig. 2/16 Left: switchgear with numerical relay (7SJ62) and traditional control; right: switchgear with combined protection and control relay (7SJ64)

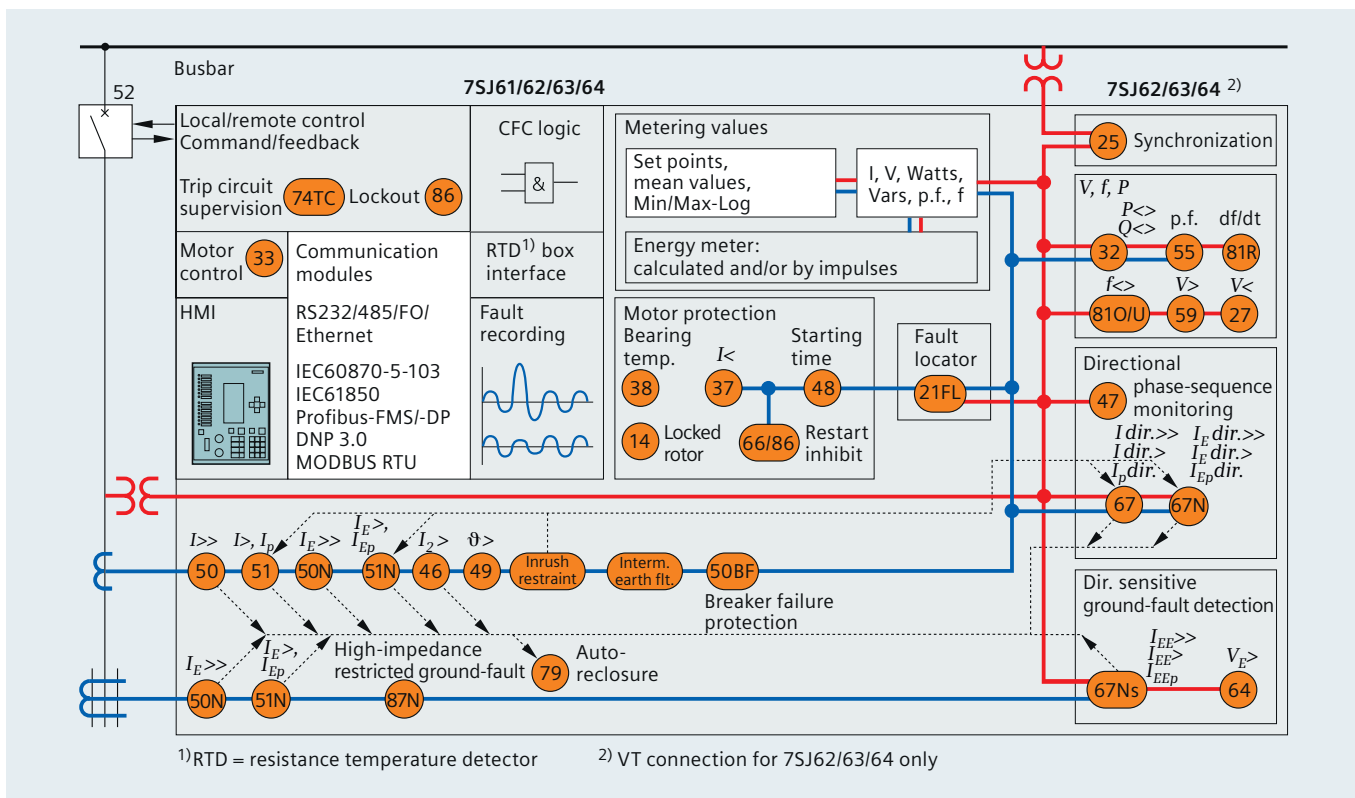


Fig. 2/17 SIPROTEC 4 relays 7SJ61/62/63, 64 implemented functions

Terminals: Standard relay version with screw-type terminals

Current terminals	
Connection	$W_{max} = 12 \text{ mm}$
Ring cable lugs	$d_1 = 5 \text{ mm}$
Wire size	2.7 – 4 mm ² (AWG 13 – 11)
Direct connection	Solid conductor, flexible lead, connector sleeve
Wire size	2.7 – 4 mm ² (AWG 13 – 11)
Voltage terminals	
Connection	$W_{max} = 10 \text{ mm}$
Ring cable lugs	$d_1 = 4 \text{ mm}$
Wire size	1.0 – 2.6 mm ² (AWG 17 – 13)
Direct connection	Solid conductor, flexible lead, connector sleeve
Wire size	0.5 – 2.5 mm ² (AWG 20 – 13)
Some relays are alternatively available with plug-in voltage terminals	
Current terminals	
Screw type (see standard version)	
Voltage terminals	
2-pin or 3-pin connectors	
Wire size	0.5 – 1.0 mm ² 0.75 – 1.5 mm ² 1.0 – 2.5 mm ²

Mechanical Design

SIPROTEC 4 relays are available in 1/3 to 1/4 of 19" wide housings with a standard height of 243 mm. Their size is compatible with that of other relay families. Therefore, compatible exchange is always possible (Fig. 2/18 to Fig. 2/20).

All wires (cables) are connected at the rear side of the relay with or without ring cable lugs. A special relay version with a detached cable-connected operator panel (Fig. 2/21) is also available. It allows, for example, the installation of the relay itself in the low-voltage compartment, and of the operator panel separately in the door of the switchgear.



Fig. 2/18 1/4 of 19" housing



Fig. 2/19 1/2 of 19" housing

Fig. 2/20 1/3 of 19" housing

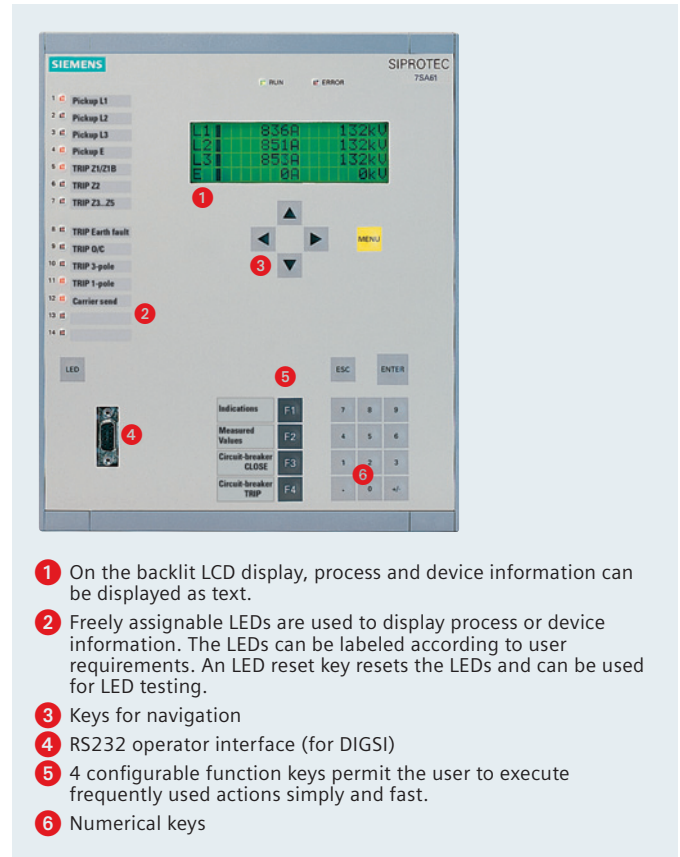


Fig. 2/22 Local operation: All operator actions can be executed and information displayed via an integrated user interface. Two alternatives for this interface are available.

- 1 On the backlit LCD display, process and device information can be displayed as text.
- 2 Freely assignable LEDs are used to display process or device information. The LEDs can be labeled according to user requirements. An LED reset key resets the LEDs and can be used for LED testing.
- 3 Keys for navigation
- 4 RS232 operator interface (for DIGSI)
- 5 4 configurable function keys permit the user to execute frequently used actions simply and fast.
- 6 Numerical keys



Fig. 2/21 SIPROTEC 4 combined protection, control and monitoring relay with detached operator panel

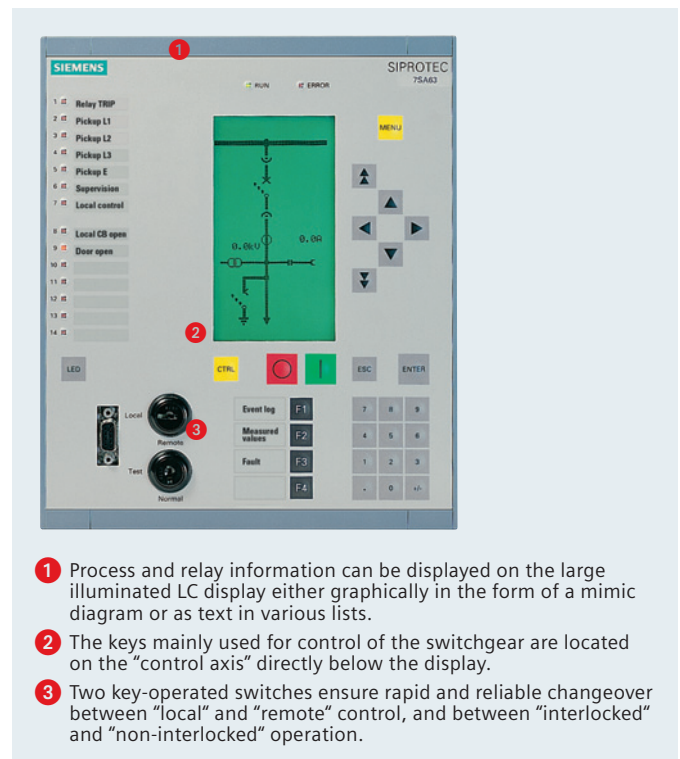


Fig. 2/23 Additional features of the interface with graphic display

- 1 Process and relay information can be displayed on the large illuminated LC display either graphically in the form of a mimic diagram or as text in various lists.
- 2 The keys mainly used for control of the switchgear are located on the "control axis" directly below the display.
- 3 Two key-operated switches ensure rapid and reliable changeover between "local" and "remote" control, and between "interlocked" and "non-interlocked" operation.

Overview

SIPROTEC relay families

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Apart from the relay-specific protection functions, the SIPROTEC 4 units have a multitude of additional functions that

- provide the user with information for the evaluation of faults
- facilitate adaptation to customer-specific application
- facilitate monitoring and control of customer installations.

Operational measured values

The large scope of measured and limit values permits improved power system management as well as simplified commissioning.

The r.m.s. values are calculated from the acquired current and voltage along with the power factor, frequency, active and reactive power. The following functions are available depending on the relay type

- Currents $I_{L1}, I_{L2}, I_{L3}, I_N, I_{EE}$ (67Ns)
- Voltages $V_{L1}, V_{L2}, V_{L3}, V_{L1-L2}, V_{L2-L3}, V_{L3-L1}$
- Symmetrical components $I_1, I_2, 3I_0; V_1, V_2, 3V_0$
- Power Watts, $V_{ars}, V_A/P, Q, S$
- Power factor p.f. ($\cos \varphi$)
- Frequency
- Energy \pm kWh \pm kVarh, forward and reverse power flow
- Mean as well as minimum and maximum current and voltage values
- Operating hours counter
- Mean operating temperature of overload function
- Limit value monitoring
Limit values are monitored using programmable logic in the CFC. Commands can be derived from this limit value indication.
- Zero suppression
In a certain range of very low measured values, the value is set to zero to suppress interference.

Metered values (some types)

For internal metering, the unit can calculate energy metered values from the measured current and voltage values. If an external meter with a metering pulse output is available, some SIPROTEC 4 types can obtain and process metering pulses via an indication input.

The metered values can be displayed and passed on to a control center as an accumulation with reset. A distinction is made between forward, reverse, active and reactive energy.

Operational indications and fault indications with time stamp

The SIPROTEC 4 units provide extensive data for fault analysis as well as control. All indications listed here are stored, even if the power supply is disconnected.

- Fault event log
The last eight network faults are stored in the unit. All fault recordings are time-stamped with a resolution of 1 ms.
- Operational indications
All indications that are not directly associated with a fault (e.g., operating or switching actions) are stored in the status indication buffer. The time resolution is 1 ms (Fig. 2/24, Fig. 2/25).

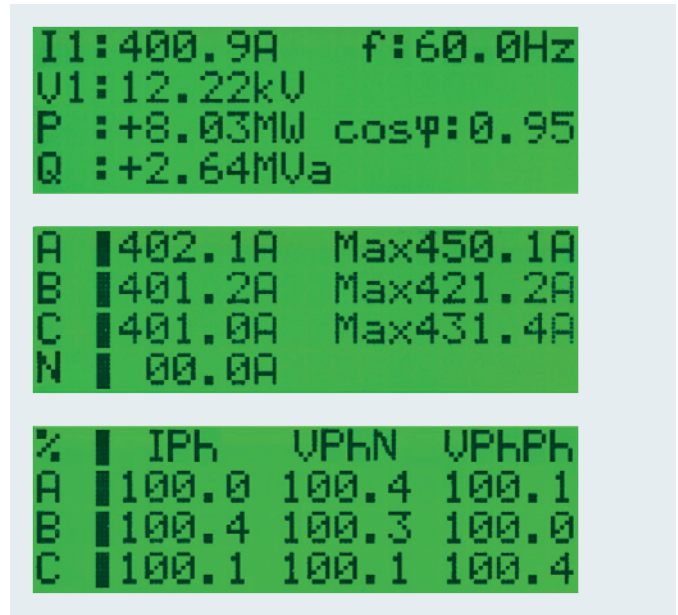


Fig. 2/24 Operational measured values

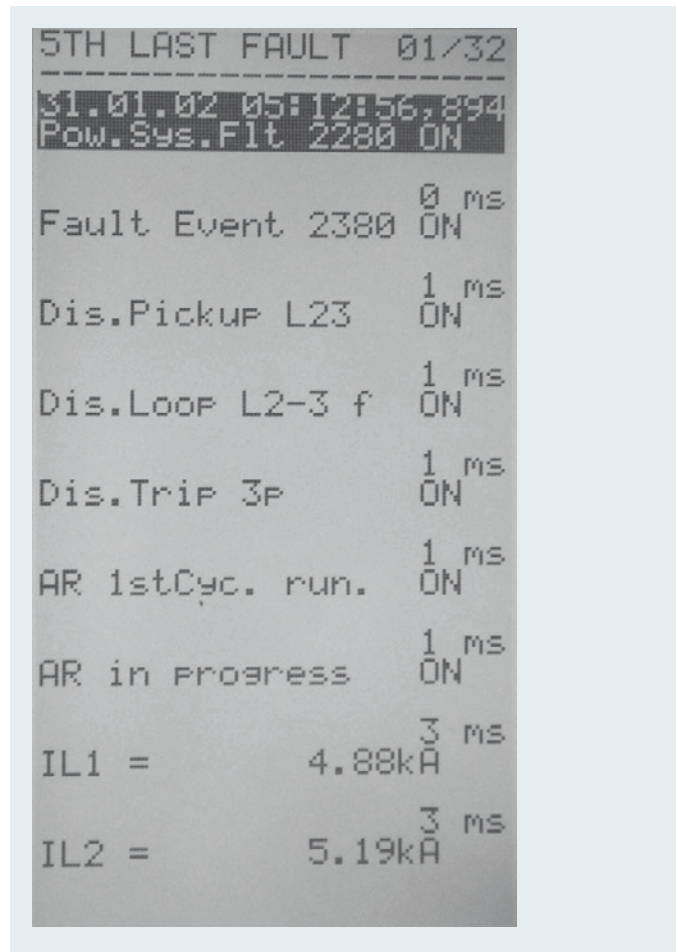


Fig. 2/25 Fault event log on graphical display of the device

Display editor

A display editor is available to design the display on SIPROTEC 4 units with graphic display. The predefined symbol sets can be expanded to suit the user. The drawing of a single-line diagram is extremely simple. Load monitoring values (analog values) and any texts or symbols can be placed on the display where required.

Four predefined setting groups for adapting relay settings

The settings of the relays can be adapted quickly to suit changing network configurations. The relays include four setting groups that can be predefined during commissioning or even changed remotely via a DIGSI 4 modem link. The setting groups can be activated via binary inputs, via DIGSI 4 (local or remote), via the integrated keypad or via the serial substation control interface.

Fault recording up to five or more seconds

The sampled values for phase currents, earth (ground) currents, line and zero-sequence currents are registered in a fault record. The record can be started using a binary input, on pickup or when a trip command occurs. Up to eight fault records may be stored. For test purposes, it is possible to start fault recording via DIGSI 4. If the storage capacity is exceeded, the oldest fault record in each case is overwritten.

For protection functions with long delay times in generator protection, the RMS value recording is available. Storage of relevant calculated variables (V_1 , V_E , I_1 , I_2 , I_{EE} , P , Q , $f-f_n$) takes place at increments of one cycle. The total time is 80 s.

Time synchronization

A battery-backed clock is a standard component and can be synchronized via a synchronization signal (DCF77, IRIG B via satellite receiver), binary input, system interface or SCADA (e.g., SICAM). A date and time is assigned to every indication.

Selectable function keys

Four function keys can be assigned to permit the user to perform frequently recurring actions very quickly and simply.

Typical applications are, for example, to display the list of operating indications or to perform automatic functions such as "switching of circuit-breaker".

Continuous self-monitoring

The hardware and software are continuously monitored. If abnormal conditions are detected, the unit immediately signals. In this way, a great degree of safety, reliability and availability is achieved.

Reliable battery monitoring

The battery provided is used to back up the clock, the switching statistics, the status and fault indications, and the fault recording in the event of a power supply failure. Its function is checked by the processor at regular intervals. If the capacity of the battery is found to be declining, an alarm is generated. Regular replacement is therefore not necessary.

All setting parameters are stored in the Flash EPROM and are not lost if the power supply or battery fails. The SIPROTEC 4 unit remains fully functional.

Commissioning support

Special attention has been paid to commissioning. All binary inputs and output contacts can be displayed and activated directly. This can significantly simplify the wiring check for the user. Test telegrams to a substation control system can be initiated by the user as well.

CFC: Programming logic

With the help of the CFC (Continuous Function Chart) graphic tool, interlocking schemes and switching sequences can be configured simply via drag and drop of logic symbols; no special knowledge of programming is required. Logical elements, such as AND, OR, flip-flops and timer elements are available. The user can also generate user-defined annunciations and logical combinations of internal or external signals.

Communication interfaces

With respect to communication, particular emphasis has been placed on high levels of flexibility, data integrity and utilization of standards commonly used in energy automation. The design of the communication modules permits interchangeability on the one hand, and on the other hand provides openness for future standards.

Local PC interface

The PC interface accessible from the front of the unit permits quick access to all parameters and fault event data. Of particular advantage is the use of the DIGSI 4 operating program during commissioning.

Overview

SIPROTEC relay families

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Retrofitting: Communication modules

It is possible to supply the relays directly with two communication modules for the service and substation control interfaces, or to retrofit the communication modules at a later stage. The modules are mounted on the rear side of the relay. As a standard, the time synchronization interface is always supplied.

The communication modules are available for the entire SIPROTEC 4 relay range. Depending on the relay type, the following protocols are available: IEC 60870-5-103, PROFIBUS DP, MODBUS RTU, DNP 3.0 and Ethernet with IEC 61850. No external protocol converter is required.

With respect to communication, particular emphasis is placed on the requirements in energy automation:

- Every data item is time-stamped at the source, that is, where it originates.
- The communication system automatically handles the transfer of large data blocks (e.g., fault records or parameter data files). The user can apply these features without any additional programming effort.
- For reliable execution of a command, the relevant signal is first acknowledged in the unit involved. When the command has been enabled and executed, a check-back indication is issued. The actual conditions are checked at every command-handling step. Whenever they are not satisfactory, controlled interruption is possible.



Fig. 2/26 Protection relay

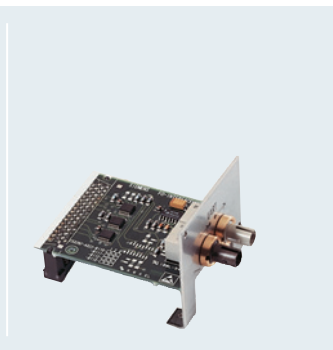


Fig. 2/27 Communication module, optical

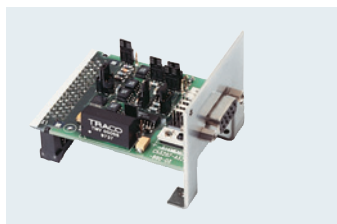


Fig. 2/28 Communication module RS232,RS485

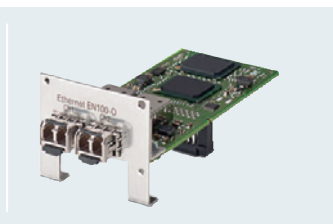
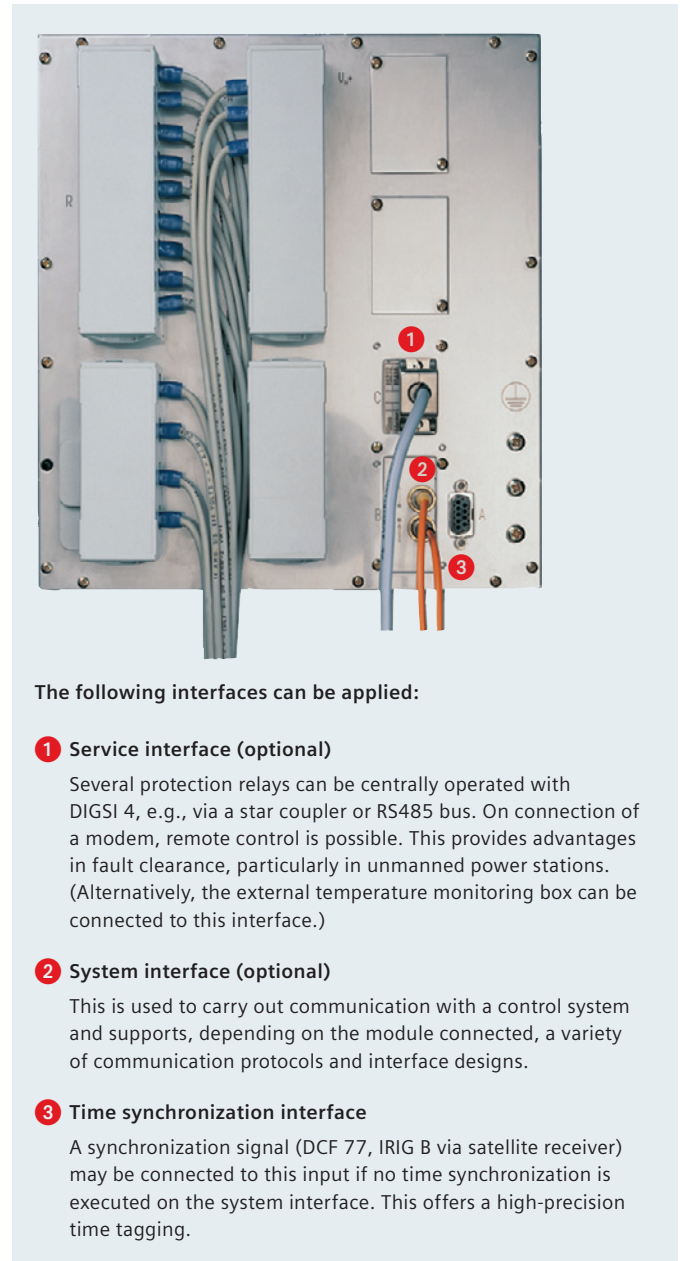


Fig. 2/29 Communication module, optical ring



The following interfaces can be applied:

1 Service interface (optional)

Several protection relays can be centrally operated with DIGSI 4, e.g., via a star coupler or RS485 bus. On connection of a modem, remote control is possible. This provides advantages in fault clearance, particularly in unmanned power stations. (Alternatively, the external temperature monitoring box can be connected to this interface.)

2 System interface (optional)

This is used to carry out communication with a control system and supports, depending on the module connected, a variety of communication protocols and interface designs.

3 Time synchronization interface

A synchronization signal (DCF 77, IRIG B via satellite receiver) may be connected to this input if no time synchronization is executed on the system interface. This offers a high-precision time tagging.

Fig. 2/30 Rear view with wiring, terminal safety cover and serial interfaces

Safe bus architecture

- **Fiber-optic double ring circuit via Ethernet**
The fiber-optic double ring circuit is immune to electro-magnetic interference. Upon failure of a section between two units, the communication system continues to operate without interruption. If a unit were to fail, there is no effect on the communication with the rest of the system (Fig. 2/31).
- **RS485 bus**
With this data transmission via copper wires, electro-magnetic interference is largely eliminated by the use of twisted-pair conductors. Upon failure of a unit, the remaining system continues to operate without any faults (Fig. 2/32).
- **Star structure**
The relays are connected with a fiber-optic cable with a star structure to the control unit. The failure of one relay / connection does not affect the others (Fig. 2/33).

Depending on the relay type, the following protocols are available:

- **IEC 61850 protocol**
Since 2004, the Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens is the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between feeder units so as to set up simple masterless systems for feeder and system interlocking. Access to the units via the Ethernet bus will also be possible with DIGSI.
- **IEC 60870-5-103**
IEC 60870-5-103 is an internationally standardized protocol for efficient communication between the protection relays and a substation control system. Specific extensions that are published by Siemens can be used.
- **PROFIBUS DP**
For connection to a SIMATIC PLC, the PROFIBUS DP protocol is recommended. With the PROFIBUS DP, the protection relay can be directly connected to a SIMATIC S5/S7. The transferred data are fault data, measured values and control commands.

Substation automation system

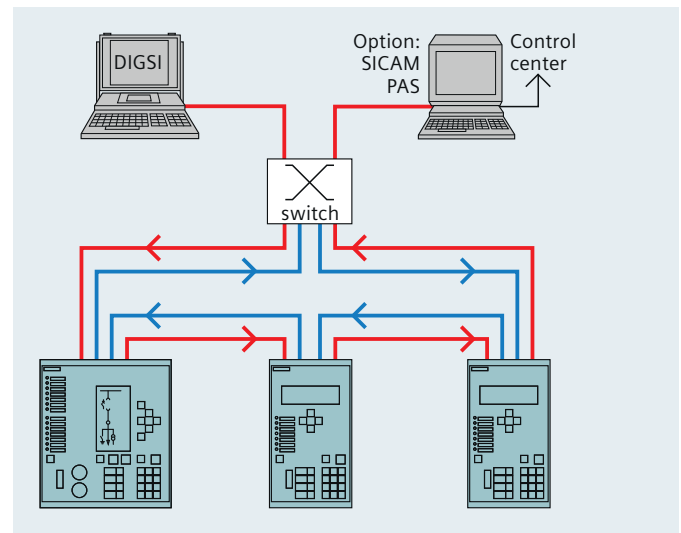


Fig. 2/31 Ring bus structure for station bus with Ethernet and IEC 61850

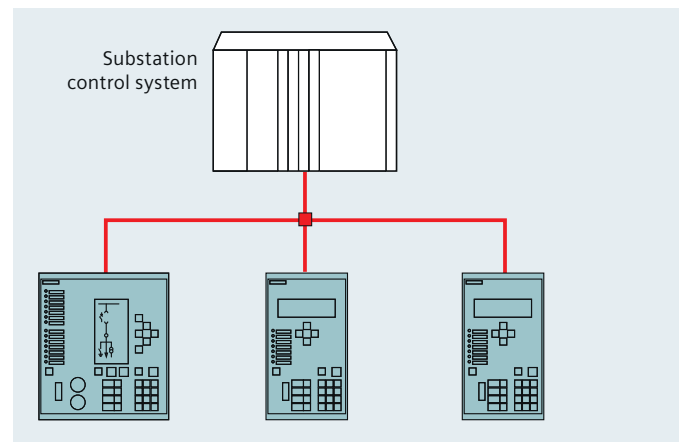


Fig. 2/32 PROFIBUS: Electrical RS485 bus wiring

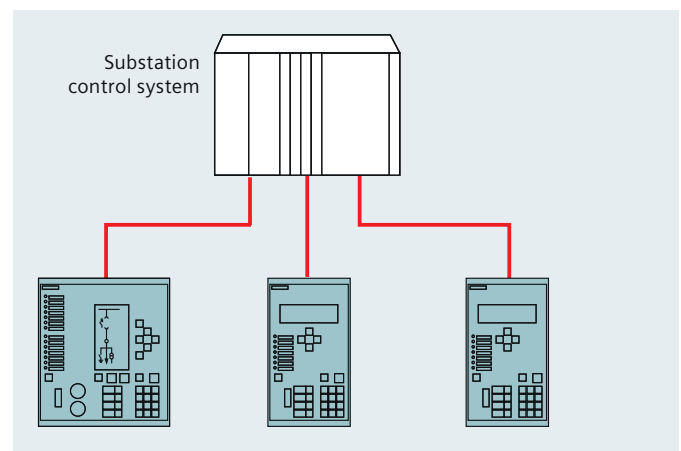


Fig. 2/33 IEC 60870-5-103: Star structure with fiber-optic cables

Overview

SIPROTEC relay families

MODBUS RTU

MODBUS is also a widely utilized communication standard and is used in numerous automation solutions.

DNP 3.0

DNP 3.0 (Distributed Network Protocol, version 3) is a messaging-based communication protocol. The SIPROTEC 4 units are fully Level 1 and Level 2-compliant with DNP 3.0, which is supported by a number of protection unit manufacturers.

Control

In addition to the protection functions, the SIPROTEC 4 units also support all control and monitoring functions required for operating medium-voltage or high-voltage substations. The main application is reliable control of switching and other processes. The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated to the relay via binary inputs.

Therefore, it is possible to detect and indicate both the OPEN and CLOSED positions or a faulty or intermediate breaker position. The switchgear can be controlled via:

- Integrated operator panel
- Binary inputs
- Substation control system
- DIGSI 4.

Automation

With the integrated logic, the user can set specific functions for the automation of the switchgear or substation by means of a graphic interface (CFC). Functions are activated by means of function keys, binary inputs or via the communication interface.

Switching authority

The following hierarchy of switching authority is applicable: LOCAL, DIGSI 4 PC program, REMOTE. The switching authority is determined according to parameters or by DIGSI 4. If the LOCAL mode is selected, only local switching operations are possible. Every switching operation and change of breaker position is stored in the status indication memory with detailed information and time tag.



Fig. 2/34 Protection engineer at work

Command processing

The SIPROTEC 4 protection relays offer all functions required for command processing, including the processing of single and double commands, with or without feedback, and sophisticated monitoring. Control actions using functions, such as runtime monitoring and automatic command termination after output check of the external process, are also provided by the relays. Typical applications are:

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable feeder interlocking
- Operating sequences combining several switching operations, such as control of circuit-breakers, disconnectors (isolators) and grounding switches
- Triggering of switching operations, indications or alarms by logical combination of existing information (Fig. 2/34).

The positions of the circuit-breaker or switching devices are monitored by feedback signals. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication changes as a consequence of a switching operation or due to a spontaneous change of state.

Indication derivation

A further indication (or a command) can be derived from an existing indication. Group indications can also be formed. The volume of information to the system interface can thus be reduced and restricted to the most important signals.

Typical protection schemes

1. Cables and overhead lines

Radial systems

Notes:

- 1) Auto-reclosure (ANSI 79) only with overhead lines.
- 2) Negative sequence overcurrent protection 46 as sensitive backup protection against asymmetrical faults.

General notes:

- The relay at the far end (D) is set with the shortest operating time. Relays further upstream have to be time-graded against the next downstream relay in steps of about 0.3 s.
- Inverse time or definite time can be selected according to the following criteria:
 - Definite time:
 - Source impedance is large compared to the line impedance, that is, there is small current variation between near and far end faults.
 - Inverse time:
 - Longer lines, where the fault current is much less at the far end of the line than at the local end.
 - Strong or extreme inverse-time:
 - Lines where the line impedance is large compared to the source impedance (high difference for close-in and remote faults), or lines where coordination with fuses or reclosers is necessary. Steeper characteristics also provide higher stability on service restoration (cold load pickup and transformer inrush currents).

Ring-main circuit

General notes:

- Operating time of overcurrent relays to be coordinated with downstream fuses of load transformers (preferably with strong inverse-time characteristic with about 0.2 s grading-time delay)
- Thermal overload protection for the cables (option)
- Negative sequence overcurrent protection (46) as sensitive protection against asymmetrical faults (option).

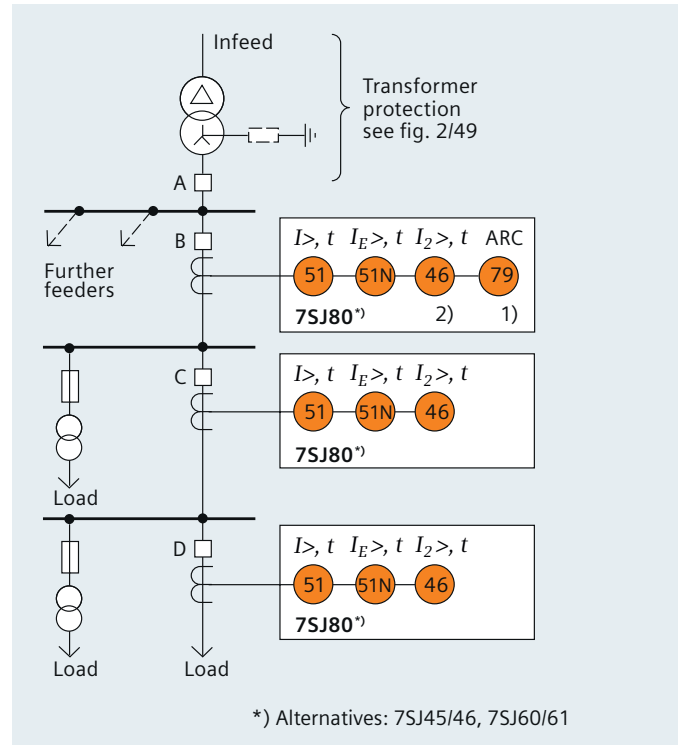


Fig. 2/35 Radial systems

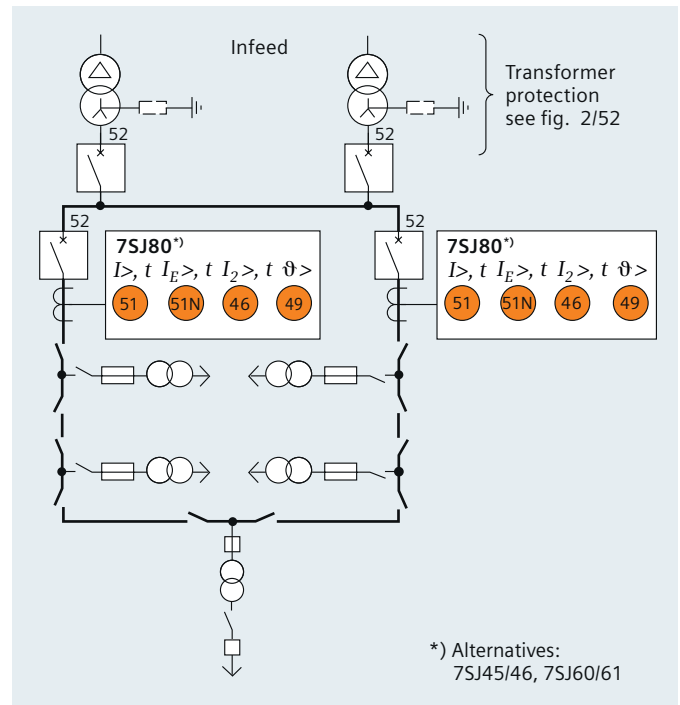


Fig. 2/36 Ring-main circuit

Overview

Typical protection schemes

2

Switch-onto-fault protection

If switched onto a fault, instantaneous tripping can be effected. If the internal control function is used (local, via binary input or via serial interface), the manual closing function is available without any additional wiring. If the control switch is connected to a circuit-breaker bypassing the internal control function, manual detection using a binary input is implemented.

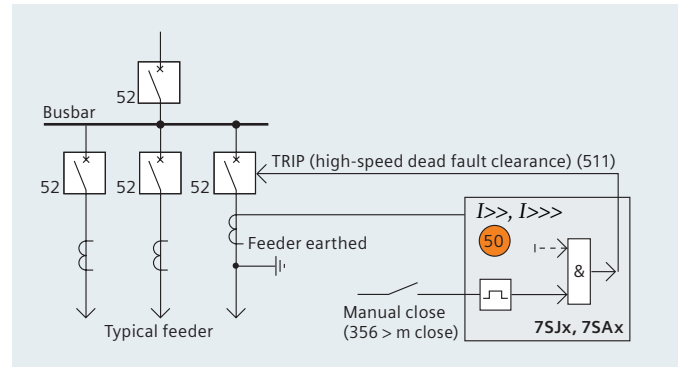


Fig. 2/37 Switch-onto-fault protection

Directional comparison protection (cross-coupling)

Cross-coupling is used for selective protection of sections fed from two sources with instantaneous tripping, that is, without the disadvantage of time coordination. The directional comparison protection is suitable if the distances between the protection stations are not significant and pilot wires are available for signal transmission. In addition to the directional comparison protection, the directional coordinated overcurrent-time protection is used for complete selective backup protection. If operated in a closed-circuit connection, an interruption of the transmission line is detected.

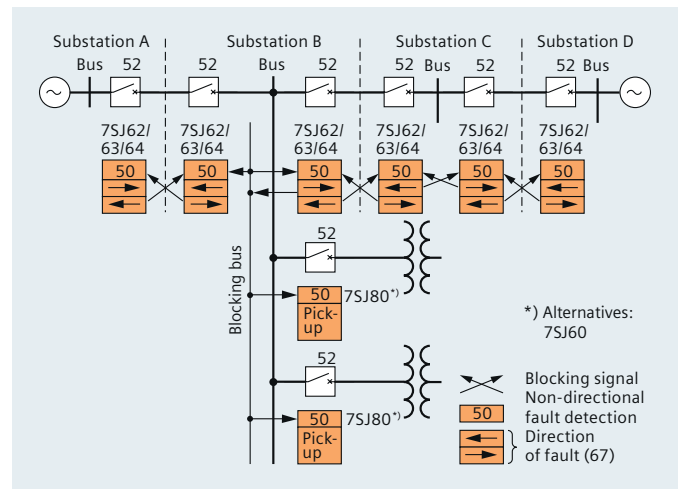


Fig. 2/38 Directional comparison protection

Distribution feeder with reclosers

General notes:

- The feeder relay operating characteristics, delay times and auto-reclosure cycles must be carefully coordinated with downstream reclosers, sectionalizers and fuses. The 50/50N instantaneous zone is normally set to reach out to the first main feeder sectionalizing point. It has to ensure fast clearing of close-in faults and prevent blowing of fuses in this area ("fuse saving"). Fast auto-reclosure is initiated in this case. Further time-delayed tripping and reclosure steps (normally two or three) have to be graded against the recloser.
- The overcurrent relay should automatically switch over to less sensitive characteristics after long breaker interruption times in order to enable overriding of subsequent cold load pickup and transformer inrush currents.

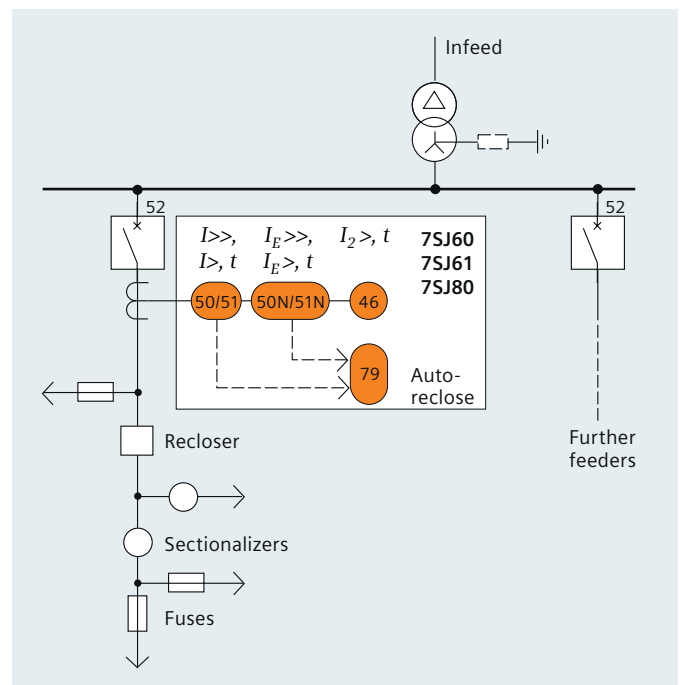


Fig. 2/39 Distribution feeder with reclosers

3-pole multishot auto-reclosure (AR, ANSI 79)

Auto-reclosure (AR) enables 3-phase auto-reclosing of a feeder that has previously been disconnected by overcurrent protection.

SIPROTEC 7SJ61 allows up to nine reclosing shots. The first four dead times can be set individually. Reclosing can be blocked or initiated by a binary input or internally. After the first trip in a reclosing sequence, the high-set instantaneous elements ($I_{>>>}$, $I_{>>}$, $I_{E>>>}$) can be blocked. This is used for fuse-saving applications and other similar transient schemes using simple overcurrent relays instead of fuses. The low-set definite-time ($I_{>}$, $I_{E>}$) and the inverse-time (I_p , I_{Ep}) overcurrent elements remain operative during the entire sequence.

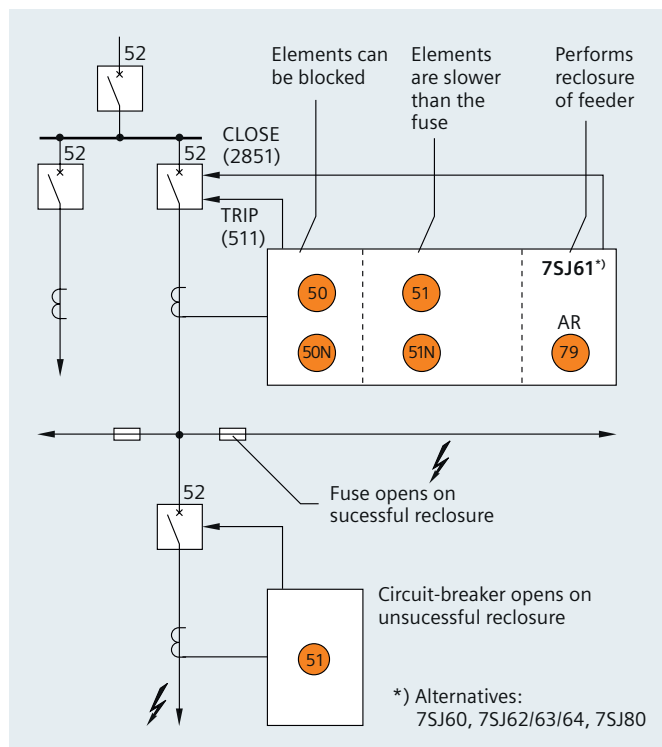


Fig. 2/40 3-pole multishot auto-reclosure (AR, ANSI 79)

Parallel feeder circuit

General notes:

- The preferred application of this circuit is in the reliable supply of important consumers without significant infeed from the load side.
- The 67/67N directional overcurrent protection trips instantaneously for faults on the protected line. This saves one time-grading interval for the overcurrent relays at the infeed.
- The 51/51N overcurrent relay functions must be time-graded against the relays located upstream.

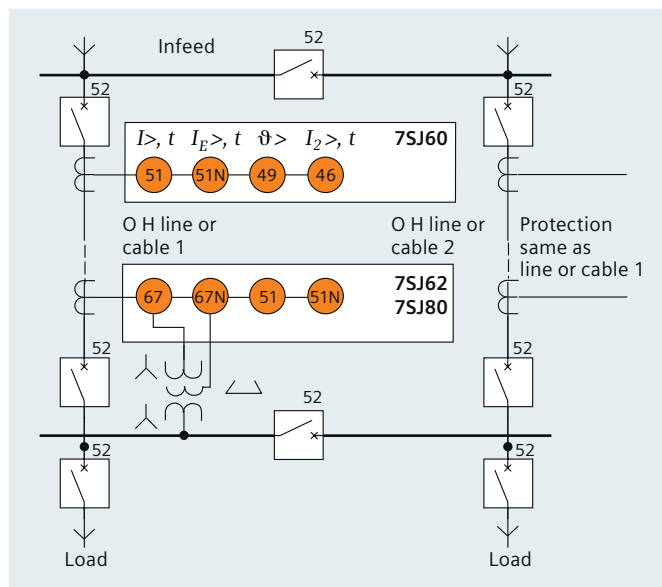


Fig. 2/41 Parallel feeder circuit

Overview

Typical protection schemes

2

Reverse-power monitoring at double infeed

If a busbar is fed from two parallel infeeds and a fault occurs on one of them, only the faulty infeed should be tripped selectively in order to enable supply to the busbar to continue from the remaining supply. Unidirectional devices that can detect a short-circuit current or energy flow from the busbar toward the incoming feeder should be used. Directional overcurrent protection is usually set via the load current. However, it cannot clear weak-current faults. The reverse-power protection can be set much lower than the rated power, thus also detecting the reverse-power flow of weak-current faults with fault currents significantly below the load current.

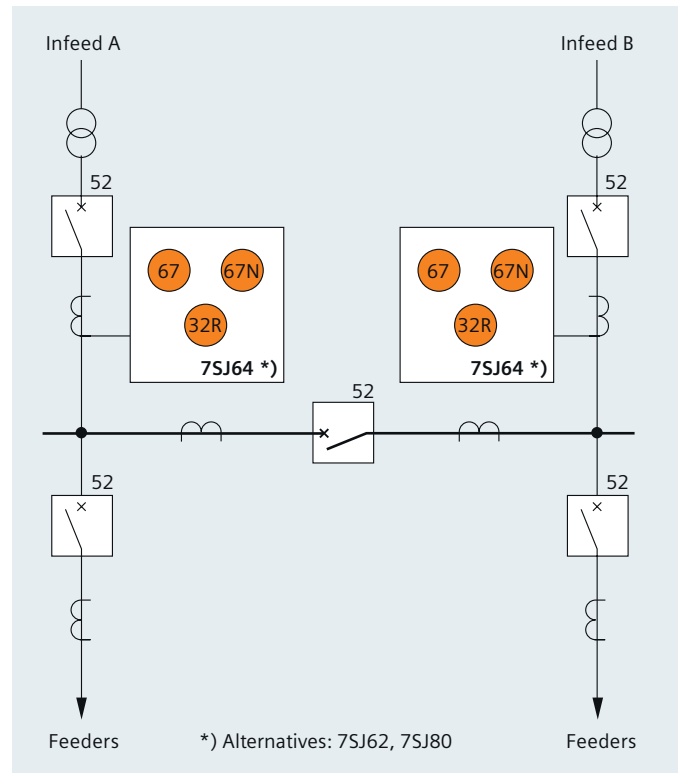


Fig. 2/42 Reverse-power monitoring at double infeed

Synchronization function

Note:

Also available in relays 7SA6, 7SD5, 7SA522, 7VK61.

General notes:

- When two subsystems must be interconnected, the synchronization function monitors whether the subsystems are synchronous and can be connected without risk of losing stability.
- This synchronization function can be applied in conjunction with the auto-reclosure function as well as with the control function CLOSE commands (local / remote).

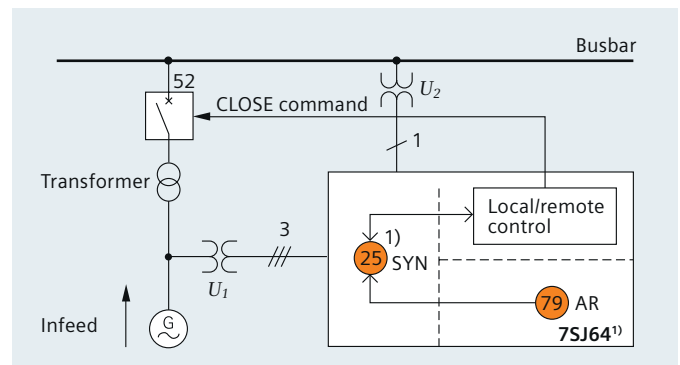


Fig. 2/43 Synchronization function

Cables or short overhead lines with infeed from both ends

Notes:

- 1) Auto-reclosure only with overhead lines
- 2) Differential protection options:
 - Type 7SD5 or 7SD610 with direct fiber-optic connection up to about 100 km or via a 64 kbit/s channel (optical fiber, microwave)
 - Type 7SD52 or 7SD610 with 7XV5662 (CC-CC) with 2 and 3 pilot wires up to about 30 km
 - Type 7SD80 with pilot wire and/or fibre optic protection data interface.

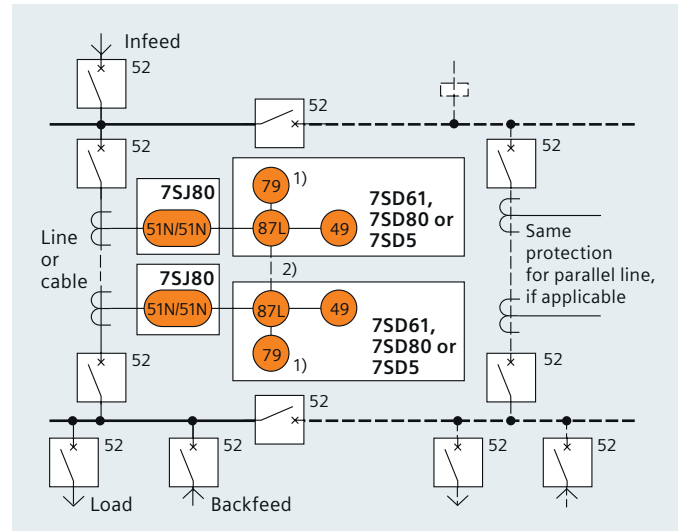


Fig. 2/44 Cables or short overhead lines with infeed from both ends

Overhead lines or longer cables with infeed from both ends

Notes:

- 1) Teleprotection logic (85) for transfer trip or blocking schemes. Signal transmission via pilot wire, power line carrier, digital network or optical fiber (to be provided separately). The teleprotection supplement is only necessary if fast fault clearance on 100 % line length is required, that is, second zone tripping (about 0.3 s delay) cannot be accepted for far end faults. For further application notes on teleprotection schemes, refer to the table on the following page.
- 2) Directional ground-fault protection 67N with inverse-time delay against high-resistance faults
- 3) Single or multishot auto-reclosure (79) only with overhead lines.

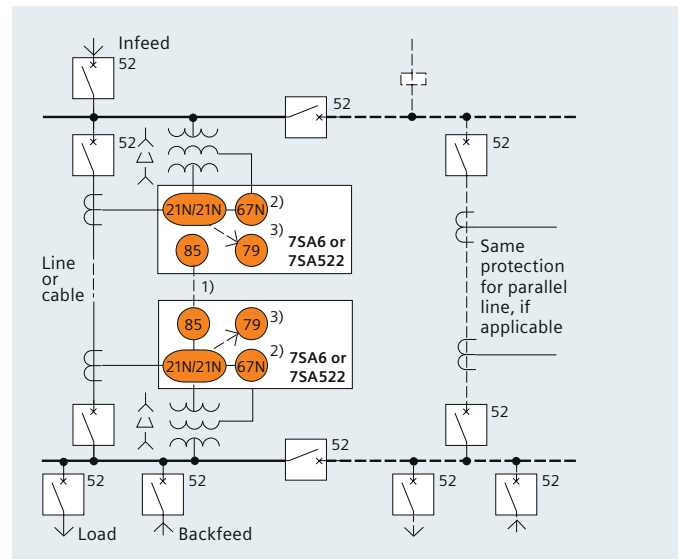


Fig. 2/45 Overhead lines or longer cables with infeed from both ends

Subtransmission line

Note:

Connection to open delta winding if available. Relays 7SA6/522 and 7SJ62 can, however, also be set to calculate the zero-sequence voltage internally.

General notes:

- Distance teleprotection is proposed as main protection and time-graded directional overcurrent as backup protection.
- The 67N function of 7SA6/522 provides additional high-resistance ground-fault protection. It can be used in parallel with the 21/21N function.
- Recommended teleprotection schemes: PUTT on medium and long lines with phase shift carrier or other secure communication channel POTT on short lines. BLOCKING with On/Off carrier (all line lengths).

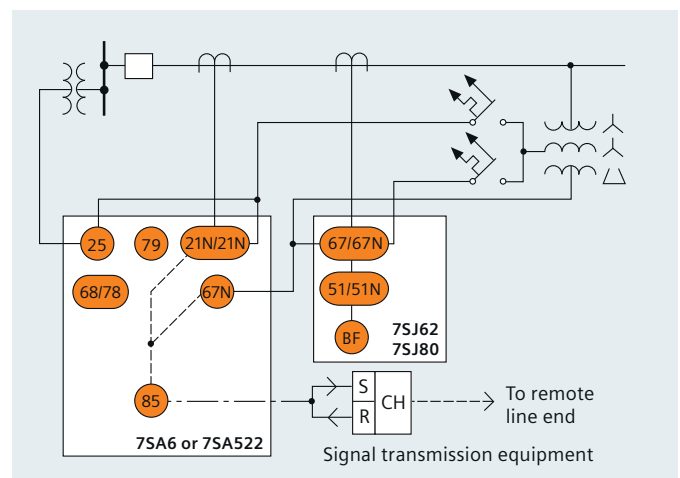


Fig. 2/46 Subtransmission line

Overview

Typical protection schemes

2

		Permissive underreach transfer trip (PUTT)	Permissive overreach transfer trip (POTT)	Blocking	Unblocking
Preferred application	Signal transmission system	<p>Dependable and secure communication channel:</p> <ul style="list-style-type: none"> Power line carrier with frequency shift modulation. HF signal coupled to 2 phases of the protected line, or even better, to a parallel circuit to avoid transmission of the HF signal through the fault location. Microwave radio, especially digital (PCM) Fiber-optic cables 		<p>Reliable communication channel (only required during external faults)</p> <ul style="list-style-type: none"> Power line carrier with amplitude modulation (ON/OFF). The same frequency may be used on all terminals) 	<p>Dedicated channel with continuous signal transfer</p> <ul style="list-style-type: none"> Power line carrier with frequency shift keying. Continuous signal transmission must be permitted.
	Characteristic of line	<p>Best suited for longer lines – where the underreach zone provides sufficient resistance coverage</p>	<ul style="list-style-type: none"> Excellent coverage on short lines in the presence of fault resistance. Suitable for the protection of multi-terminal lines with intermediate infeed 	<p>All line types – preferred practice in the US</p>	<p>Same as POTT</p>
Advantages		<ul style="list-style-type: none"> Simple technique No coordination of zones and times with the opposite end required. The combination of different relay types therefore presents no problems 	<ul style="list-style-type: none"> Can be applied without underreaching zone 1 stage (e.g., overcompensated series uncompensated lines) Can be applied on extremely short lines (impedance less than minimum relay setting) Better for parallel lines as mutual coupling is not critical for the overreach zone Weak infeed terminals are no problem (Echo and Weak Infeed logic is included) 	<p>Same as POTT</p>	<p>Same as POTT but:</p> <ul style="list-style-type: none"> If no signal is received (no block and no uncompensated block) then tripping by the overreach zone is released after 20 ms
Drawbacks		<ul style="list-style-type: none"> Overlapping of the zone 1 reaches must be ensured. On parallel lines, teed feeders and tapped lines, the influence of zero sequence coupling and intermediate infeeds must be carefully considered to make sure a minimum overlapping of the zone 1 reach is always present. Not suitable for weak infeed terminals 	<ul style="list-style-type: none"> Zone reach and signal timing coordination with the remote end is necessary (current reversal) 	<p>Same as POTT</p> <ul style="list-style-type: none"> Slow tripping – all teleprotection trips must be delayed to wait for the eventual blocking signal Continuous channel monitoring is not possible 	<p>Same as POTT</p>

Table 2/1 Application criteria for frequently used teleprotection schemes

Transmission line with reactor (Fig. 2/47)

Notes:

- 1) 51N only applicable with grounded reactor neutral.
- 2) If phase CTs at the low-voltage reactor side are not available, the high-voltage phase CTs and the CT in the neutral can be connected to a restricted ground-fault protection using one 7VH60 high-impedance relay.

General notes:

- Distance relays are proposed as main 1 and main 2 protection. Duplicated 7SA6 is recommended for series-compensated lines.
- Operating time of the distance relays is in the range of 15 to 25 ms depending on the particular fault condition. These tripping times are valid for faults in the underreaching distance zone (80 to 85 % of the line length). Remote end faults must be cleared by the superimposed teleprotection scheme. Its overall operating time depends on the signal transmission time of the channel, typically 15 to 20 ms for frequency shift audio-tone PLC or microwave channels, and lower than 10 ms for ON/OFF PLC or digital PCM signaling via optical fibers.

Teleprotection schemes based on distance relays therefore have operating times on the order of 25 to 30 ms with digital PCM coded communication. With state-of-the-art two-cycle circuit-breakers, fault clearing times well below 100 ms (4 to 5 cycles) can normally be achieved.

- Dissimilar carrier schemes are recommended for main 1 and main 2 protection, for example, PUTT, and POTT or Blocking/Unblocking.
- Both 7SA522 and 7SA6 provide selective 1-pole and / or 3-pole tripping and auto-reclosure. The ground-current directional comparison protection (67N) of the 7SA6 relay uses phase selectors based on symmetrical components. Thus, 1-pole auto-reclosure can also be executed with high-resistance faults. The 67N function of the 7SA522 relay can also be used as time-delayed directional overcurrent backup.
- The 67N functions are provided as high-impedance fault protection. 67N is often used with an additional channel as a separate carrier scheme. Use of a common channel with distance protection is only possible if the mode is compatible (e.g., POTT with directional comparison). The 67N may be blocked when function 21/21N picks up. Alternatively, it can be used as time-delayed backup protection.

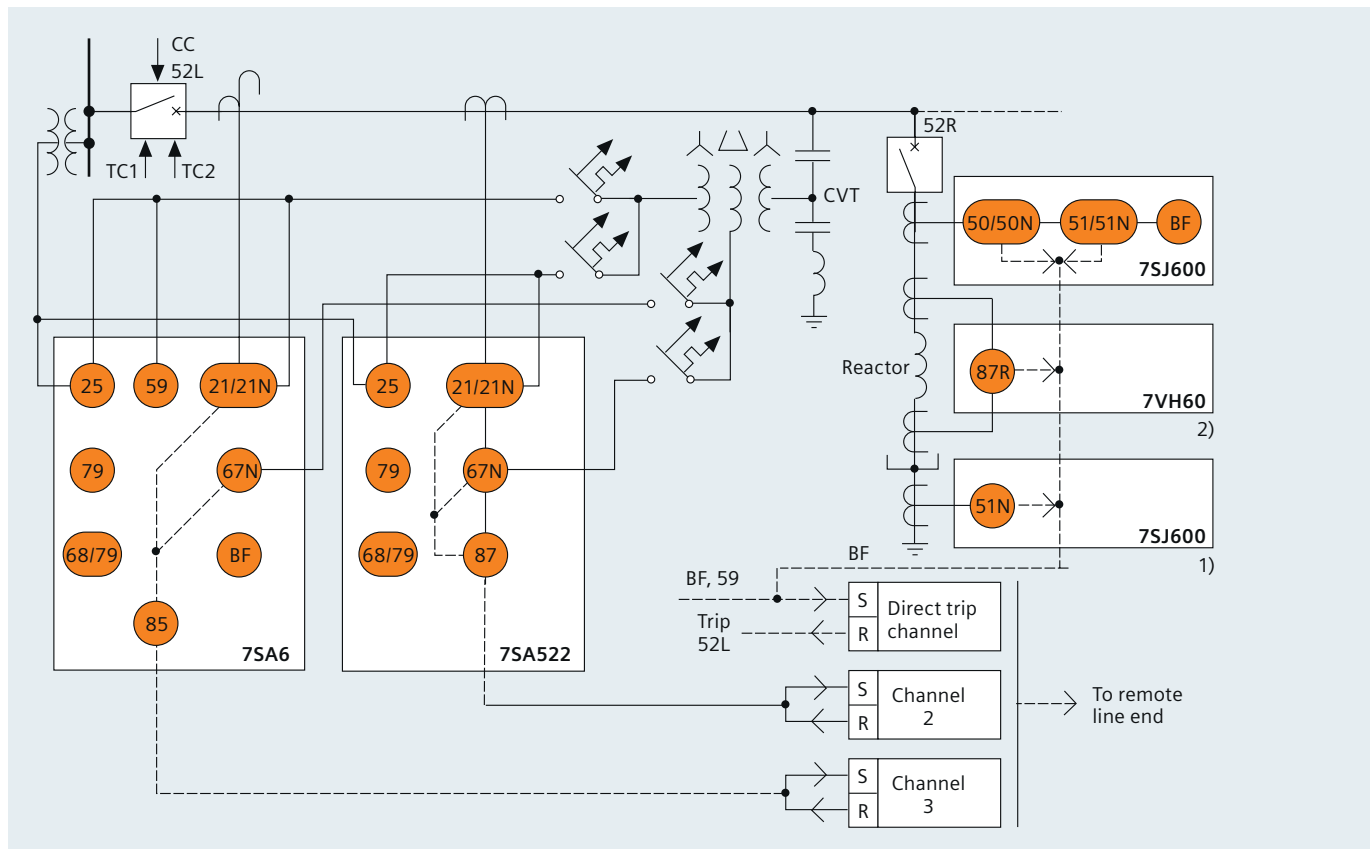


Fig. 2/47 Transmission line with reactor

Overview

Typical protection schemes

2

Transmission line or cable (with wide-band communication)

General notes:

- Digital PCM-coded communication (with $n \times 64$ kbit/s channels) between line ends is becoming more and more frequently available, either directly by optical or microwave point-to-point links, or via a general-purpose digital communication network.

In both cases, the relay-type current differential protection 7SD52/61 can be applied. It provides absolute phase and zone selectivity by phase-segregated measurement, and is not affected by power swing or parallel line zero-sequence coupling effects. It is, furthermore, a current-only protection that does not need a VT connection. For this reason, the adverse effects of CVT transients are not applicable.

This makes it particularly suitable for double and multi-circuit lines where complex fault situations can occur.

The 7SD5/61 can be applied to lines up to about 120 km in direct relay-to-relay connections via dedicated optical fiber cores (see also application "Cables or short overhead lines with infeed from both ends", page 2/21), and also to much longer distances of up to about 120 km by using separate PCM devices for optical fiber or microwave transmission.

The 7SD5/61 then uses only a small part (64 to 512 kbit/s) of the total transmission capacity (on the order of Mbits/s).

- The 7SD52/61 protection relays can be combined with the distance relay 7SA52 or 7SA6 to form a redundant protection system with dissimilar measuring principles complementing each other (Fig. 2/48). This provides the highest degree of availability. Also, separate signal transmission ways should be used for main 1 and main 2 line protection, e.g., optical fiber or microwave, and power line carrier (PLC). The current comparison protection has a typical operating time of 15 ms for faults on 100 % line length, including signaling time.

General notes for Fig. 2/49:

- SIPROTEC 7SD5 offers fully redundant differential and distance relays accommodated in one single bay control unit, and provides both high-speed operation of relays and excellent fault coverage, even under complicated conditions. Precise distance-to-fault location avoids time-consuming line patrolling, and reduces the downtime of the line to a minimum.
- The high-speed distance relay operates fully independently from the differential relay. Backup zones provide remote backup for upstream and downstream lines and other power system components

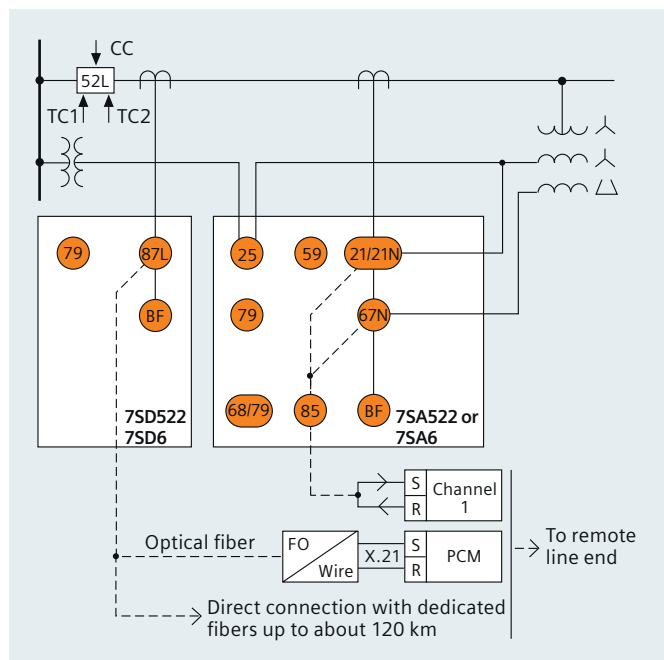


Fig. 2/48 Redundant transmission line protection

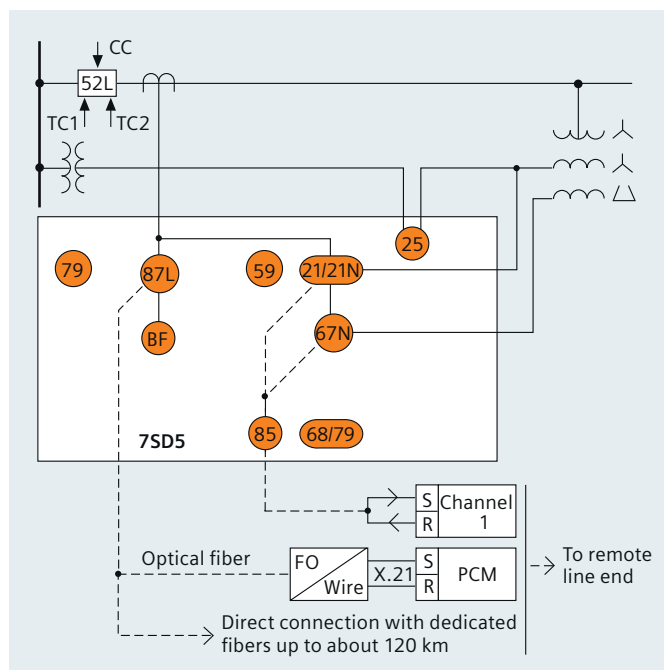


Fig. 2/49 Transmission line protection with redundant algorithm in one device

Transmission line, one-breaker-and-a-half terminal

Notes:

- 1) When the line is switched off and the line line disconnector (isolator) is open, high through-fault currents in the diameter may cause maloperation of the distance relay due to unequal CT errors (saturation). Normal practice is therefore to block the distance protection (21/21N) and the directional ground-fault protection (67N) under this condition via an auxiliary contact of the line line disconnector (isolator). A standby overcurrent function (50/51N, 51/51N) is released instead to protect the remaining stub between the breakers ("stub" protection).
- 2) Overvoltage protection only with 7SA6/52.

General notes:

- The protection functions of one diameter of a breaker-and-a-half arrangement are shown.
- The currents of two CTs have each to be summed up to get the relevant line currents as input for main 1 and 2 line protection.
- The location of the CTs on both sides of the circuit-breakers is typical for substations with dead-tank circuit-breakers. Live-tank circuit-breakers may have CTs only on one side to reduce cost. A fault between circuit-breakers and CT (end fault) may then still be fed from one side even when the circuit-breaker has opened. Consequently, final fault clearing by cascaded tripping has to be accepted in this case.
- The 7VK61 relay provides the necessary end fault protection function and trips the circuit-breakers of the remaining infeeding circuits.

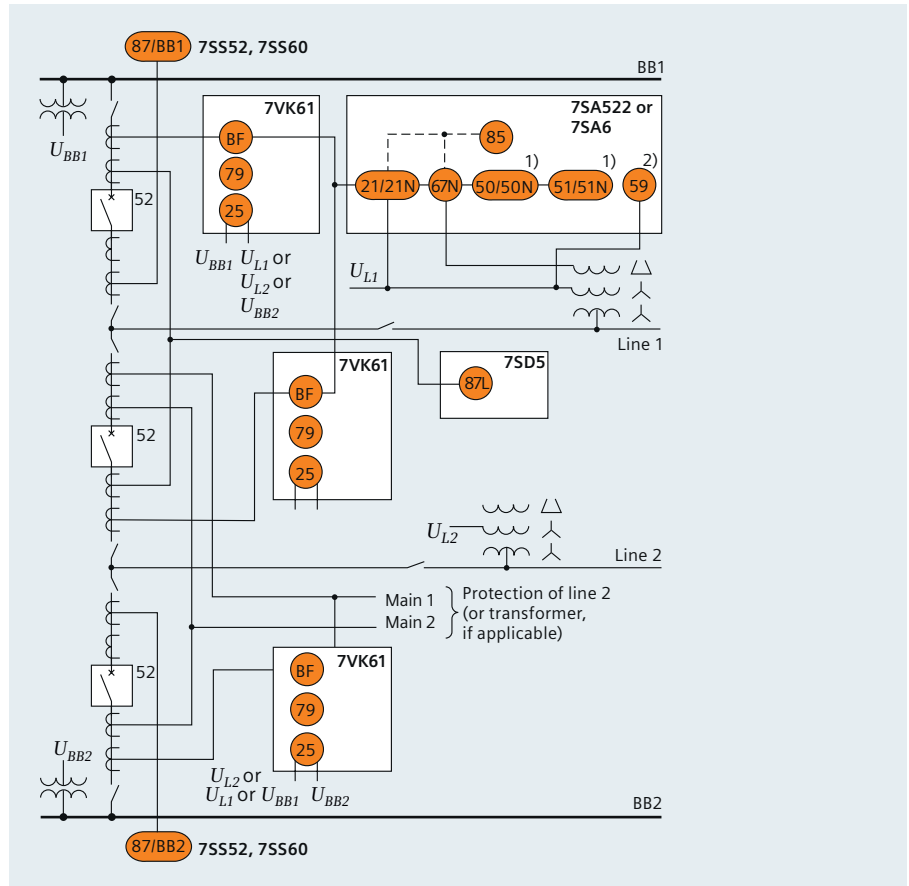


Fig. 2/50 Transmission line, one-breaker-and-a-half terminal, using 3 breaker management relays 7VK61

Overview

Typical protection schemes

2

General notes for Fig. 2/50 and 2/51:

- For the selection of the main 1 and main 2 line protection schemes, the comments of application examples "Transmission with reactor", page 2/23 and "Transmission line or cable", page 2/24 apply.
- Auto-reclosure (79) and synchrocheck function (25) are each assigned directly to the circuit-breakers and controlled by main 1 and 2 line protection in parallel. In the event of a line fault, both adjacent circuit-breakers have to be tripped by the line protection. The sequence of auto-reclosure of both circuit-breakers or, alternatively, the auto-reclosure of only one circuit-breaker and the manual closure of the other circuit-breaker, may be made selectable by a control switch.
- A coordinated scheme of control circuits is necessary to ensure selective tripping interlocking and reclosing of the two circuit-breakers of one line (or transformer feeder).
- The voltages for synchrocheck have to be selected according to the circuit-breaker and disconnector (isolator) position by a voltage replica circuit.

General notes for Fig. 2/51:

- In this optimized application, the 7VK61 is only used for the center breaker. In the line feeders, functions 25, 79 and BF are also performed by transmission line protection 7SA522 or 7SA6.

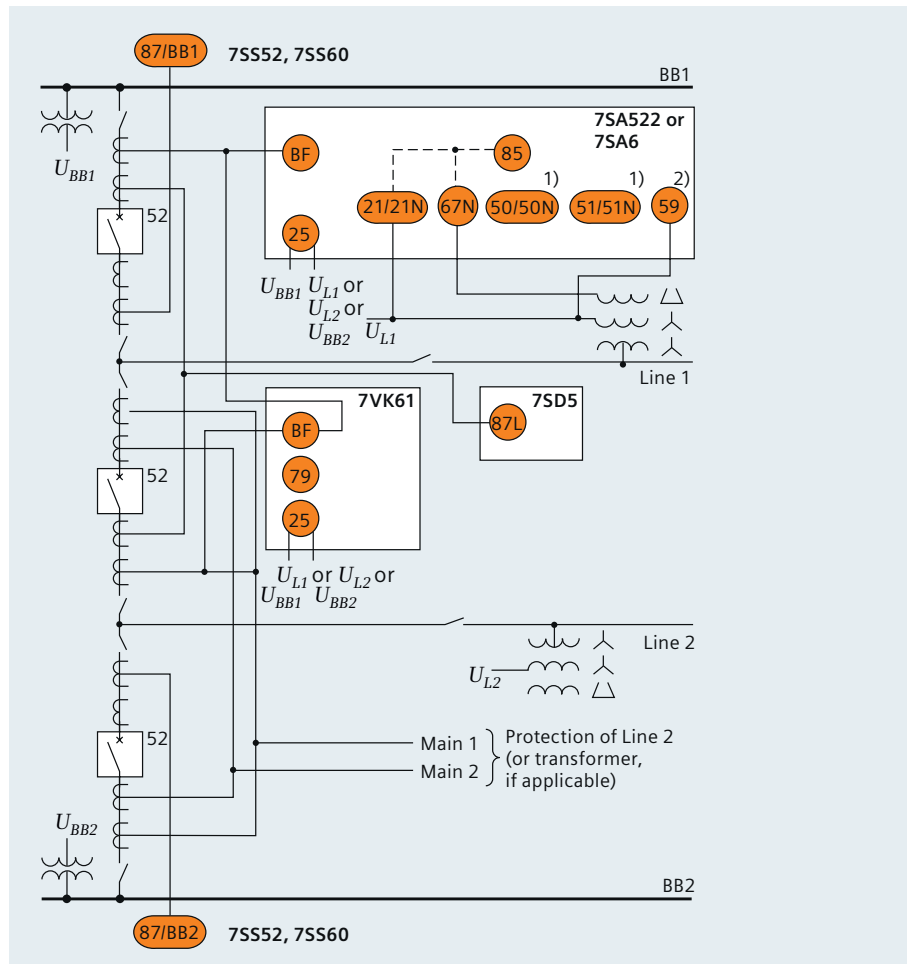


Fig. 2/51 Transmission line, breaker-and-a-half terminal, using 1 breaker management relay 7VK61

2. Transformers

Small transformer infeed

General notes:

- Ground faults on the secondary side are detected by current relay 51N. However, it has to be time-graded against downstream feeder protection relays.
- The restricted ground-fault relay 87N can optionally be applied to achieve fast clearance of ground faults in the transformer secondary winding. Relay 7VH60 is of the high-impedance type and requires class \times CTs with equal transformation ratios.
- Primary circuit-breaker and relay may be replaced by fuses.

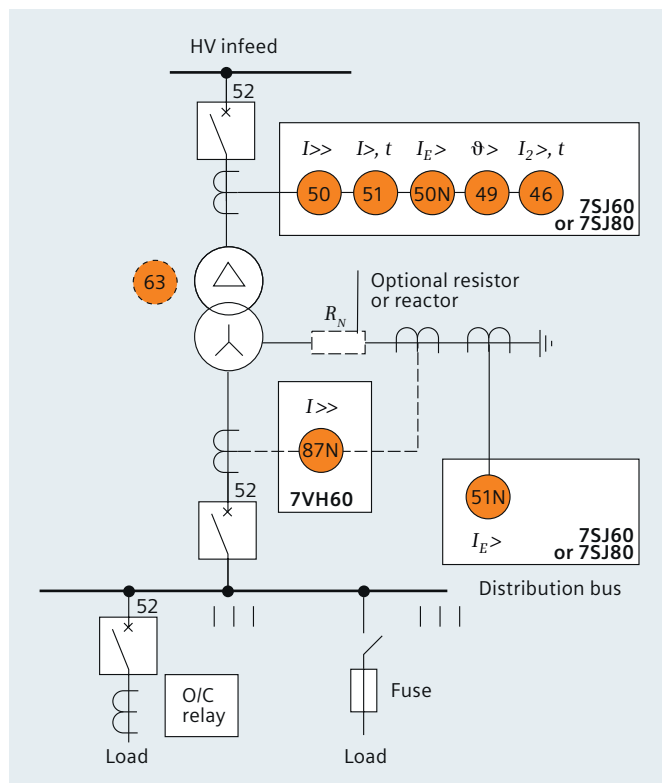


Fig. 2/52 Small transformer infeed

Large or important transformer infeed

General note:

- Relay 7UT612 provides numerical ratio and vector group adaptation. Matching transformers as used with traditional relays are therefore no longer applicable.

Notes:

- 1) If an independent high-impedance-type ground-fault function is required, the 7VH60 ground-fault relay can be used instead of the 87N inside the 7UT612. However, class \times CT cores would also be necessary in this case (see small transformer protection).
- 2) 51 and 51N may be provided in a separate 7SJ60 if required.

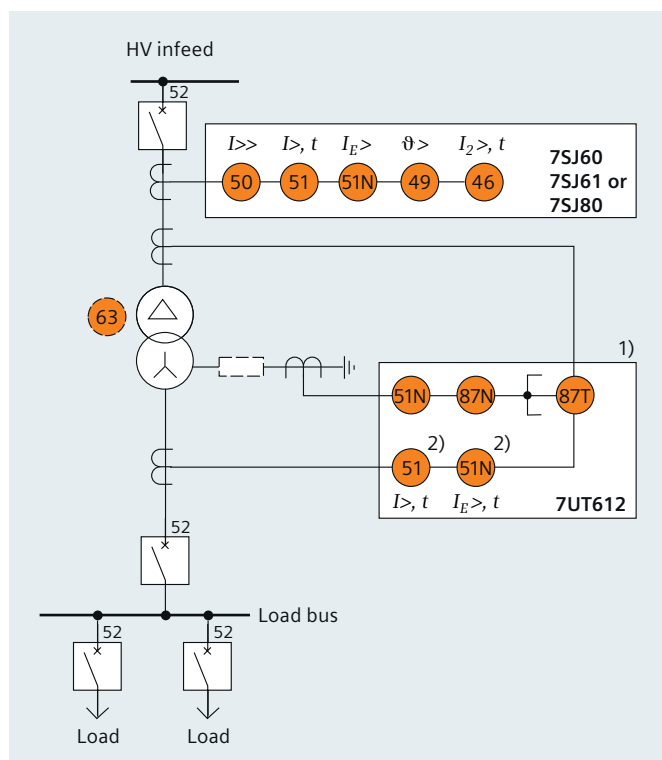


Fig. 2/53 Large or important transformer infeed

Overview

Typical protection schemes

2

Dual infeed with single transformer

General notes:

- Line CTs are to be connected to separate stabilizing inputs of the differential relay 87T in order to ensure stability in the event of line through-fault currents.
- Relay 7UT613 provides numerical ratio and vector group adaptation. Matching transformers, as used with traditional relays, are therefore no longer applicable.

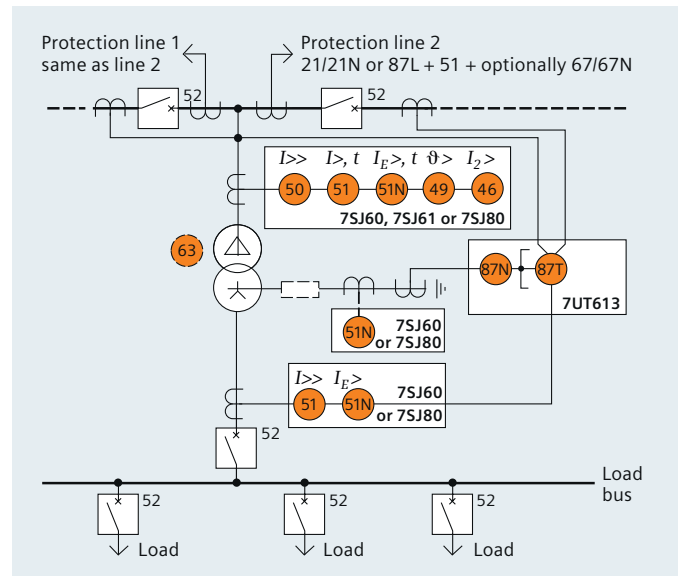


Fig. 2/54 Dual infeed with single transformer

Parallel incoming transformer feeders

Note:

The directional functions 67 and 67N do not apply for cases where the transformers are equipped with the transformer differential relays 87T.

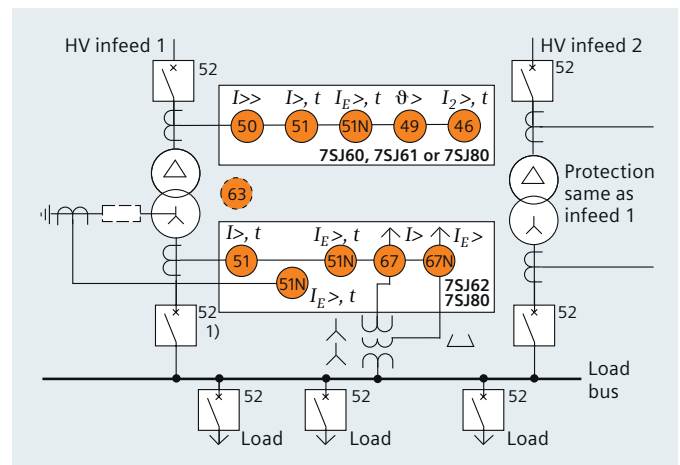


Fig. 2/55 Parallel incoming transformer feeders

Parallel incoming transformer feeders with bus tie

General notes:

- Overcurrent relay 51, 51N each connected as a partial differential scheme. This provides simple and fast busbar protection and saves one time-grading step.

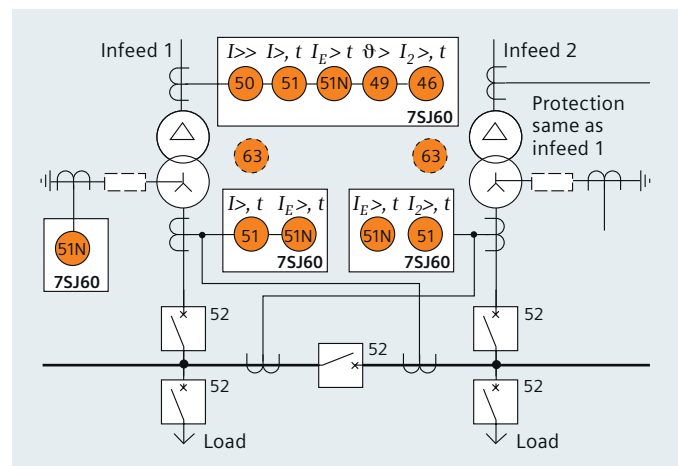


Fig. 2/56 Parallel incoming transformer feeders with bus tie

Three-winding transformer

Notes:

1) The zero-sequence current must be blocked before entering the differential relay with a delta winding in the CT connection on the transformer side with grounded starpoint. This is to avoid false operation during external ground faults (numerical relays provide this function by calculation). About 30 % sensitivity, however, is then lost in the event of internal faults. Optionally, the zero-sequence current can be regained by introducing the winding neutral current in the differential relay (87T). Relay type 7UT613 provides two current inputs for this purpose. By using this feature, the ground-fault sensitivity can be upgraded again to its original value. Restricted ground-fault protection (87T) is optional. It provides backup protection for ground faults and increased ground-fault sensitivity (about 10 % I_N , compared to about 20 to 30 % I_N of the transformer differential relay). Separate class \times CT-cores with equal transmission ratio are also required for this protection.

2) High impedance and overcurrent in one 7SJ61.

General notes:

- In this example, the transformer feeds two different distribution systems with cogeneration. Restraining differential relay inputs are therefore provided at each transformer side.
- If both distribution systems only consume load and no through-feed is possible from one MV system to the other, parallel connection of the CTs of the two MV transformer windings is admissible, which allows the use of a two-winding differential relay (7UT612)

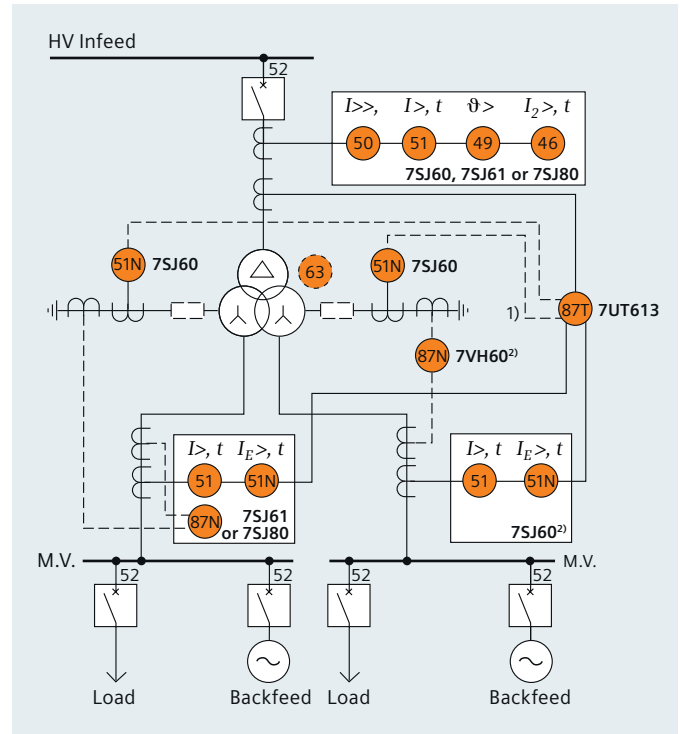


Fig. 2/57 Three-winding transformer

Autotransformer

Notes:

- 1) 87N high-impedance protection requires special class \times current transformer cores with equal transformation ratios.
- 2) The 7SJ60 relay can alternatively be connected in series with the 7UT613 relay to save this CT core.

General note:

- Two different protection schemes are provided: 87T is chosen as the low-impedance three-winding version (7UT613). 87N is a 1-phase high-impedance relay (7VH60) connected as restricted ground-fault protection. (In this example, it is assumed that the phase ends of the transformer winding are not accessible on the neutral side, that is, there exists a CT only in the neutral grounding connection.)

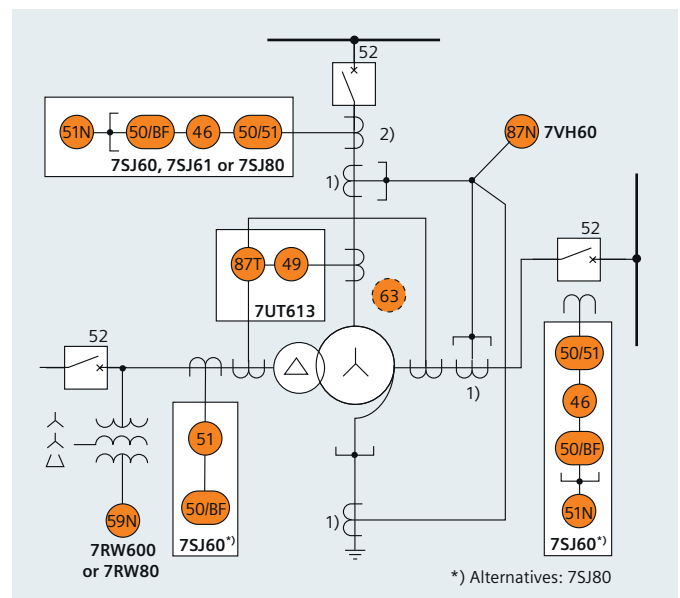


Fig. 2/58 Autotransformer

Overview

Typical protection schemes

2

Large autotransformer bank

General notes:

- The transformer bank is connected in a breaker-and-a-half arrangement. Duplicated differential protection is proposed:
- **Main 1:** Low-impedance differential protection 87TL (7UT613) connected to the transformer bushing CTs.
- **Main 2:** High-impedance differential overall protection 87TL (7VH60). Separate class \times cores and equal CT ratios are required for this type of protection.
- Backup protection is provided by distance protection relay (7SA52 and 7SA6), each “looking” with an instantaneous first zone about 80 % into the transformer and with a time-delayed zone beyond the transformer.
- The tertiary winding is assumed to feed a small station supply system with isolated neutral.

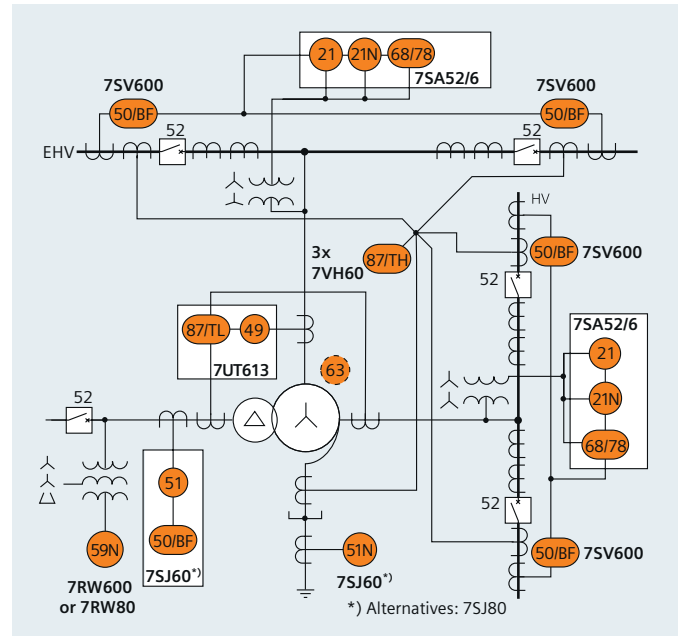


Fig. 2/59 Large autotransformer bank

3. Motors

Small and medium-sized motors < about 1 MW

a) With effective or low-resistance grounded infeed ($I_E \geq I_{N \text{ Motor}}$)

General note:

- Applicable to low-voltage motors and high-voltage motors with low-resistance grounded infeed ($I_E \geq I_{N \text{ Motor}}$)

b) With high-resistance grounded infeed ($I_E \leq I_{N \text{ Motor}}$)

Notes:

- 1) Core-balance CT.
- 2) Sensitive directional ground-fault protection (67N) only applicable with infeed from isolated or Petersen coil grounded system (for dimensioning of the sensitive directional ground-fault protection, see also application circuit page 2/33 and Fig. 2/68)
- 3) The 7SJ602 relay can be applied for isolated and compensated systems.

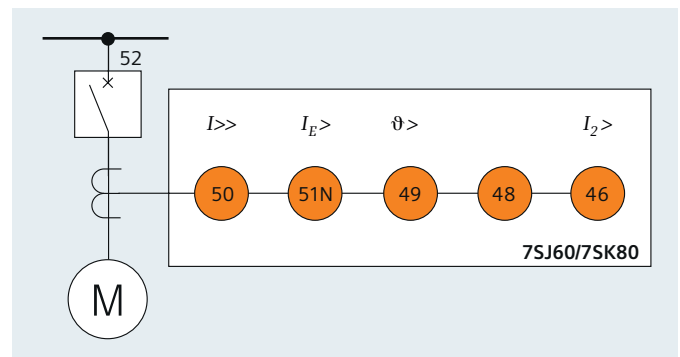


Fig. 2/60 Motor protection with effective or low-resistance grounded infeed

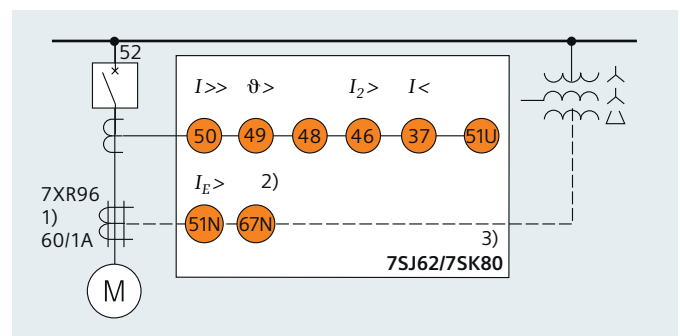


Fig. 2/61 Motor protection with high-resistance grounded infeed

Large HV motors > about 1 MW

Notes:

- 1) Core-balance CT.
- 2) Sensitive directional ground-fault protection (67N) only applicable with infeed from isolated or Petersen coil grounded system.
- 3) This function is only needed for motors where the startup time is longer than the safe stall time t_E . According to IEC 60079-7, the t_E time is the time needed to heat up AC windings, when carrying the starting current $I_{A,}$ from the temperature reached in rated service and at maximum ambient air temperature to the limiting temperature. A separate speed switch is used to supervise actual starting of the motor. The motor circuit-breaker is tripped if the motor does not reach speed in the preset time. The speed switch is part of the motor supply itself.
- 4) Pt100, Ni100, Ni120
- 5) 49T only available with external temperature detector device (RTD-box 7XV5662)

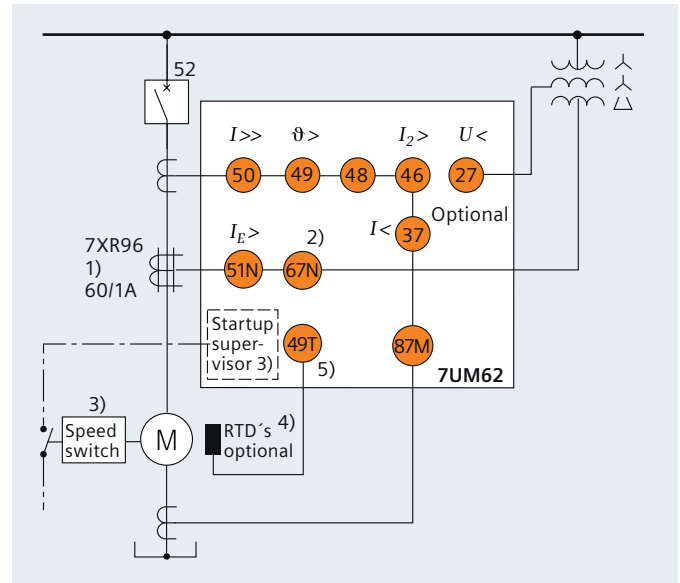


Fig. 2/62 Protection of large HV motors > about 1 MW

Cold load pickup

By means of a binary input that can be wired from a manual close contact, it is possible to switch the overcurrent pickup settings to less sensitive settings for a programmable amount of time. After the set time has expired, the pickup settings automatically return to their original setting. This can compensate for initial inrush when energizing a circuit without compromising the sensitivity of the overcurrent elements during steady-state conditions.

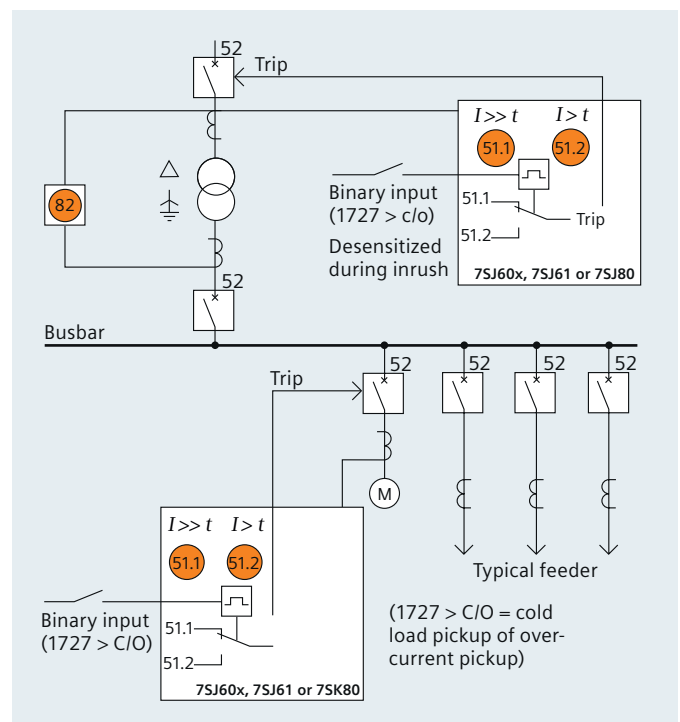


Fig. 2/63 Cold load pickup

Overview

Typical protection schemes

4. Generators

Generators < 500 kW (Fig. 2/64 and Fig.2/65)

Note:

If a core-balance CT is provided for sensitive ground-fault protection, relay 7SJ602 with separate ground-current input can be used.

Generators, typically 1 – 3 MW

(Fig. 2/66)

Note:

Two VTs in V connection are also sufficient.

Generators > 1 – 3 MW

(Fig. 2/67)

Notes:

- 1) Functions 81 and 59 are required only where prime mover can assume excess speed and the voltage regulator may permit rise of output voltage above upper limit.
- 2) Differential relaying options:
 - Low-impedance differential protection 87.
 - Restricted ground-fault protection with low-resistance grounded neutral (Fig. 2/66).

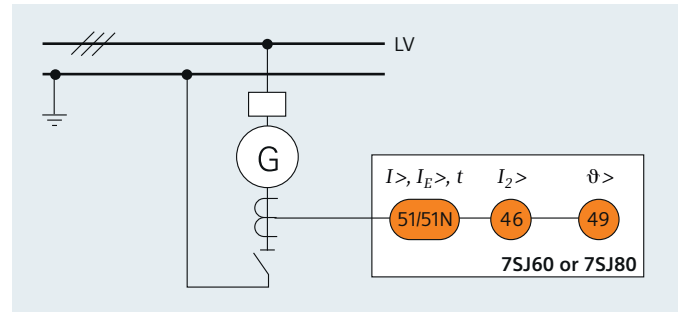


Fig. 2/64 Generator with solidly grounded neutral

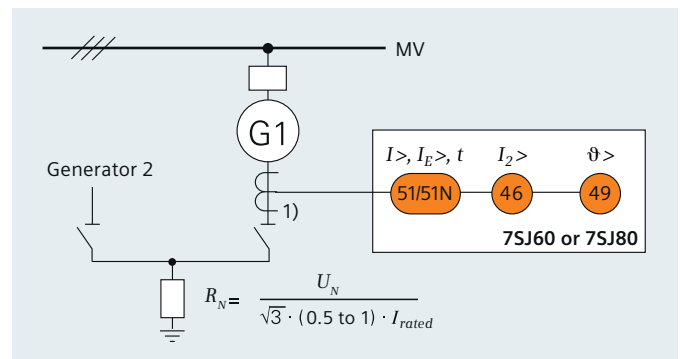


Fig. 2/65 Generator with resistance-grounded neutral

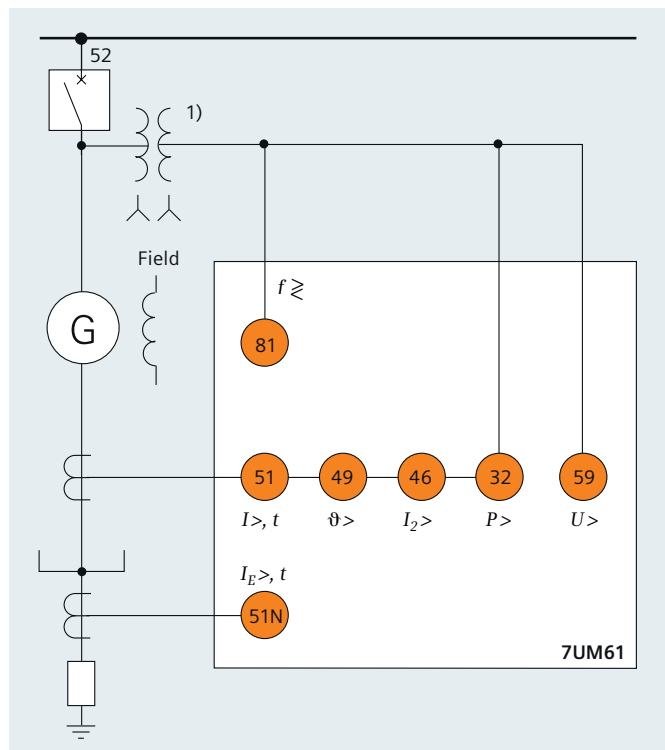


Fig. 2/66 Protection for generators 1 – 3 MW

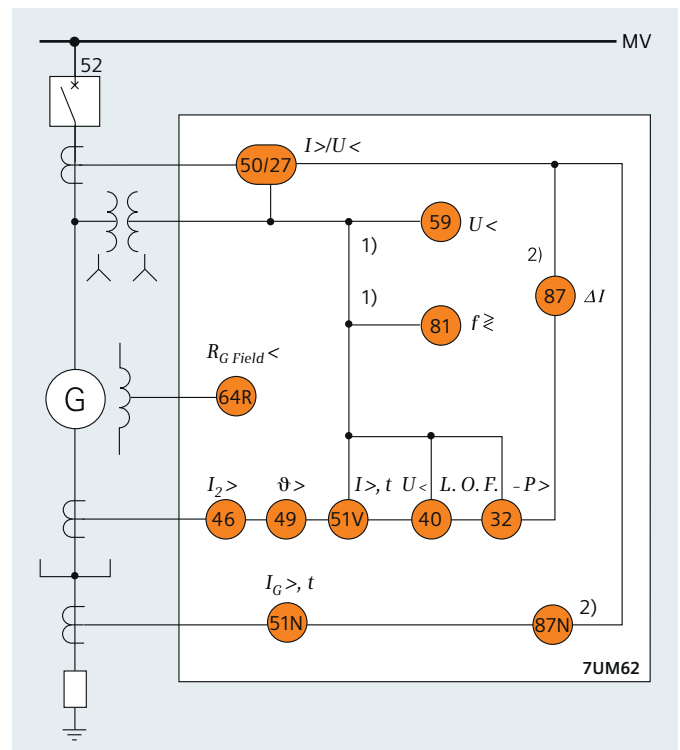


Fig. 2/67 Protection for generators > 1 – 3 MW

Generators > 5–10 MW feeding into a system with isolated neutral

(Fig. 2/68)

General notes:

- The setting range of the directional ground-fault protection (67N) in the 7UM6 relay is 2–1,000 mA. Depending on the current transformer accuracy, a certain minimum setting is required to avoid false operation on load or transient currents.
- In practice, efforts are generally made to protect about 90 % of the machine winding, measured from the machine terminals. The full ground current for a terminal fault must then be ten times the setting value, which corresponds to the fault current of a fault at 10 % distance from the machine neutral.

Relay ground-current input connected to:	Minimum relay setting:	Comments:
Core-balance CT 60 / 1 A: 1 single CT 2 parallel CTs 3 parallel CTs 4 parallel CTs	2 mA 5 mA 8 mA 12 mA	
Three-phase CTs in residual (Holmgreen) connection	1 A CT: 50 mA 5 A CT: 200 mA	In general not suitable for sensitive ground-fault protection
Three-phase CTs in residual (Holmgreen) connection with special factory calibration to minimum residual false currents (≤ 2 mA)	2–3 ‰ of secondary rated CT current $I_{n\text{SEC}}$ 10–15 mA with 5 A CTs	1 A CTs are not recommended in this case

For the most sensitive setting of 2 mA, we therefore need 20 mA secondary ground current, corresponding to $(60/1) \times 20 \text{ mA} = 1.2 \text{ A}$ primary.

If sufficient capacitive ground current is not available, an grounding transformer with resistive zero-sequence load can be installed as ground-current source at the station busbar. The smallest standard grounding transformer TGAG 3541 has a 20 s short-time rating of input connected to: $S_G = 27 \text{ kVA}$

In a 5 kV system, it would deliver:

$$I_{G\ 20\text{s}} = \frac{\sqrt{3} \cdot S_G}{U_N} = \frac{\sqrt{3} \cdot 27,000 \text{ VA}}{5,000 \text{ V}} = 9.4 \text{ A}$$

corresponding to a relay input current of $9.4 \text{ A} \times 1/60 \text{ A} = 156 \text{ mA}$. This would provide a 90 % protection range with a setting of about 15 mA, allowing the use of 4 parallel connected core-balance CTs. The resistance at the 500 V open-delta winding of the grounding transformer would then have to be designed for

$$R_B = U_{\text{SEC}}^2 / S_G = 500^2 / 27,000 \text{ VA} = 9.26 \ \Omega \ (27 \text{ kW}, 20 \text{ s})$$

For a 5 MVA machine and 600/5 A CTs with special calibration for minimum residual false current, we would get a secondary current of $I_{G\ \text{SEC}} = 9.4 \text{ A} / (600/5) = 78 \text{ mA}$.

With a relay setting of 12 mA, the protection range would in this case be $100 \left(1 - \frac{12}{78}\right) = 85 \%$.

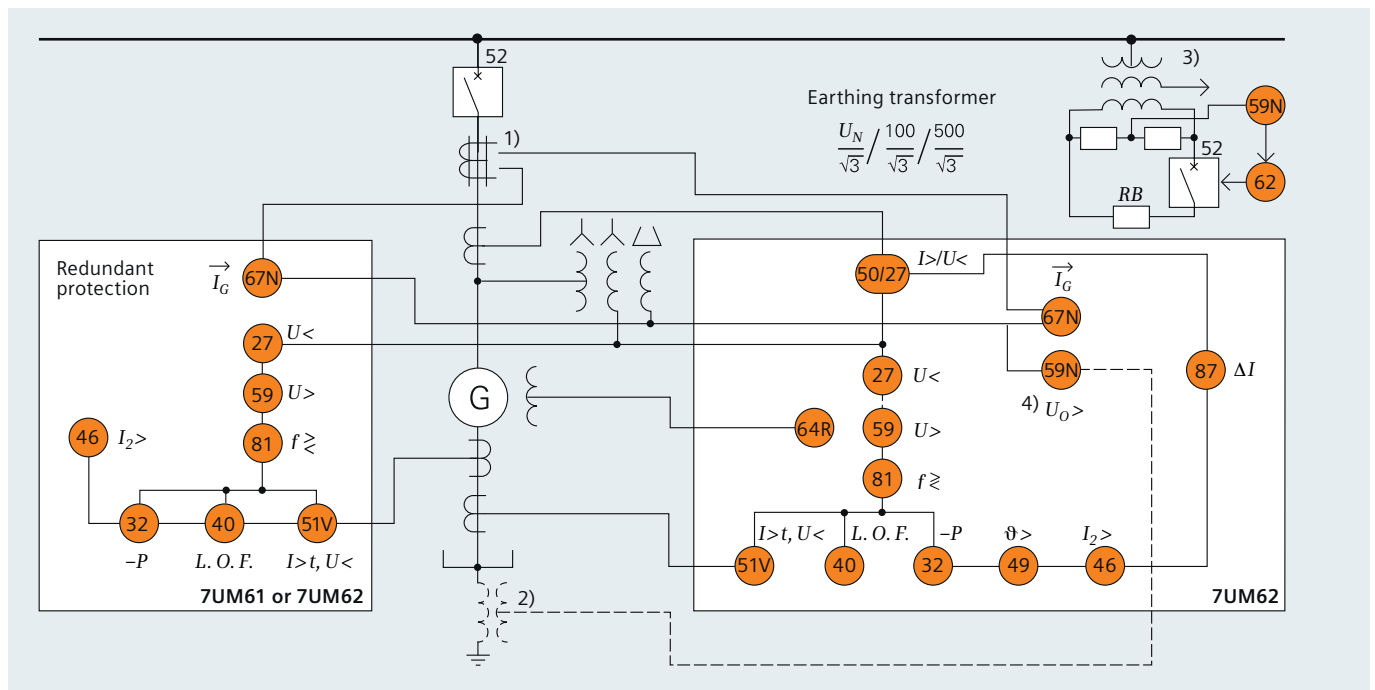


Fig. 2/68 Protection for generators > 5–10 MW

Overview

Typical protection schemes

2

Notes (Fig. 2/68):

- 1) The standard core-balance CT 7XR96 has a transformation ratio of 60/1 A.
- 2) Instead of an open-delta winding at the terminal VT, a 1-phase VT at the machine neutral could be used as zero-sequence polarizing voltage.
- 3) The grounding transformer is designed for a short-time rating of 20 s. To prevent overloading, the load resistor is automatically switched off by a time-delayed zero-sequence voltage relay (59N + 62) and a contactor (52).
- 4) During the startup time of the generator with the open circuit-breaker, the grounding source is not available. To ensure ground-fault protection during this time interval, an auxiliary contact of the circuit-breaker can be used to change over the directional ground-fault relay function (67N) to a zero-sequence voltage detection function via binary input.

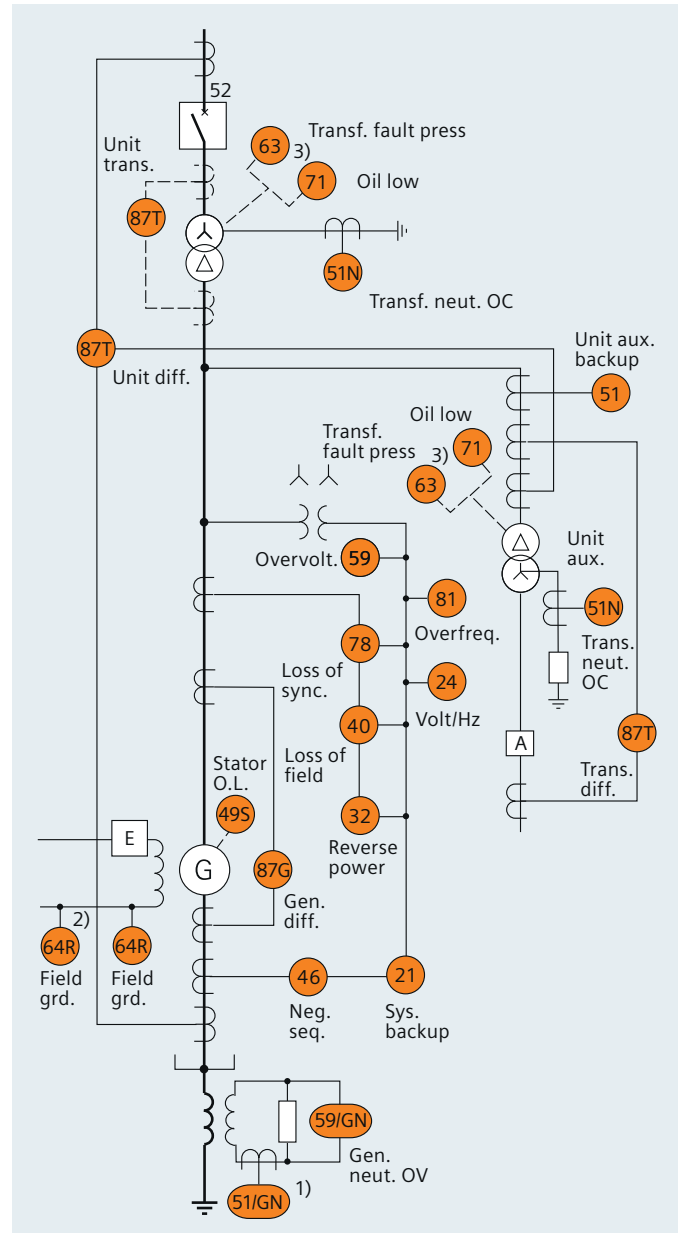


Fig. 2/69 Protections for generators > 50 MW

Generators > 50 – 100 MW in generator transformer unit connection

(Fig. 2/69)

Notes:

- 1) 100 % stator ground-fault protection based on 20 Hz voltage injection
- 2) Sensitive rotor ground-fault protection based on 1– 3 Hz voltage injection
- 3) Non-electrical signals can be incoupled in the protection via binary inputs (BI)
- 4) Only used functions shown; further integrated functions available in each relay type; for more information, please refer to part 1 of this catalog.

Relay type	Functions ⁴⁾	Number of relays required
7UM62	21, 24, 32, 40, 46, 49, 51GN, 59GN, 59, 64R, 64R, 78, 81, 87G via BI: 71, 63	2
7UM61 or 7UM62	51, 51N optionally, 21, 59, 81 via BI: 71, 63	1
7UT612	87T, 51N	optionally 2
7UT613	87T	1

Fig. 2/70 Assignment for functions to relay type

Synchronization of a generator

Fig. 2/71 shows a typical connection for synchronizing a generator. Paralleling device 7VE6 acquires the line and generator voltage, and calculates the differential voltage, frequency and phase angle. If these values are within a permitted range, a CLOSE command is issued after a specified circuit-breaker make time. If these variables are out of range, the paralleling device automatically sends a command to the voltage and speed controller. For example, if the frequency is outside the range, an actuation command is sent to the speed controller. If the voltage is outside the range, the voltage controller is activated.

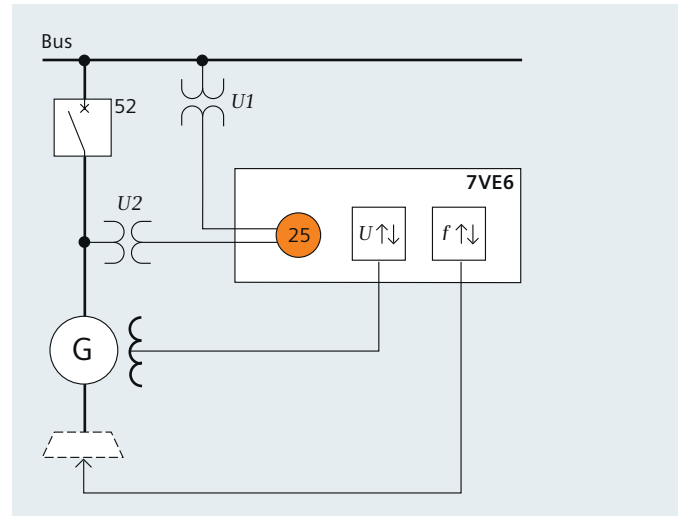


Fig. 2/71 Synchronization of a generator

5. Busbars

Busbar protection by overcurrent relays with reverse interlocking

General note:

- Applicable to distribution busbars without substantial ($< 0.25 \times I_N$) backfeed from the outgoing feeders.

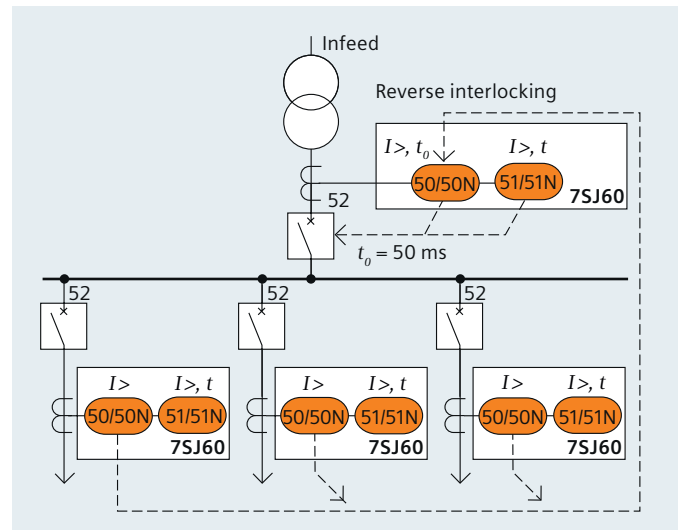


Fig. 2/72 Busbar protection by O/C relays with reverse interlocking

Overview

Typical protection schemes

2

High-impedance busbar protection

General notes:

- Normally used with single busbar, and one-breaker-and-a-half schemes.
- Requires separate class X current transformer cores. All CTs must have the same transformation ratio.

Note:

A varistor is normally applied across the relay input terminals to limit the voltage to a value safely below the insulation voltage of the secondary circuits.

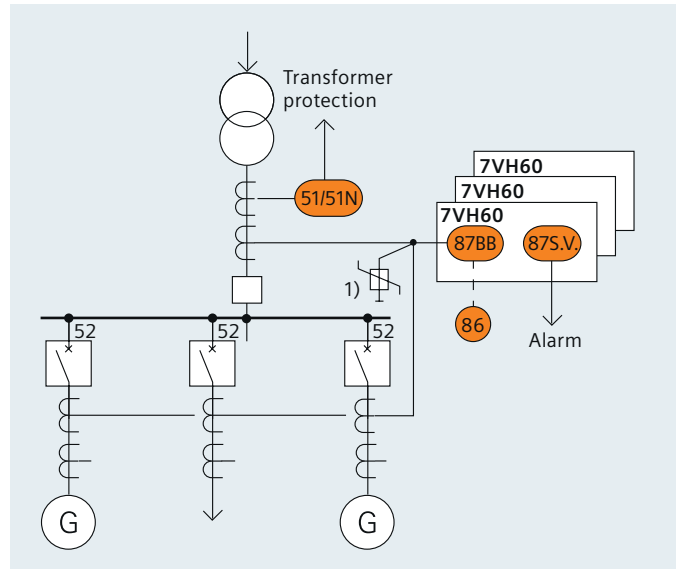


Fig. 2/73 High-impedance busbar protection

Low-impedance busbar protection 7SS60

General notes:

- Normally used with single busbar, one-breaker-and-a-half, and double busbar schemes, different transformation ratios can be adapted by matching transformers.
- Unlimited number of feeders.
- Feeder protection can be connected to the same CT core.

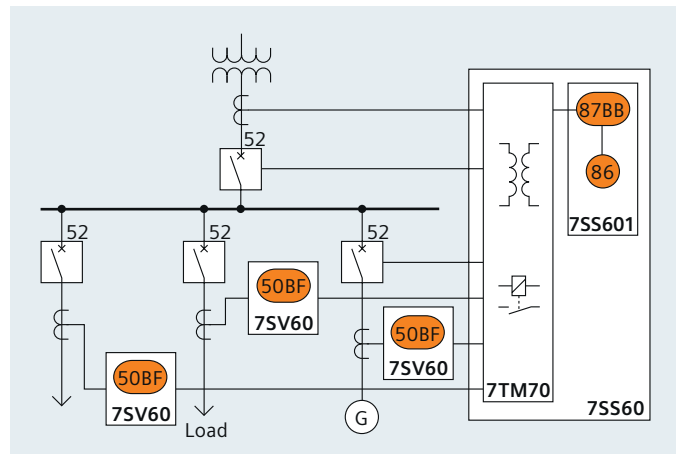


Fig. 2/74 Low-impedance busbar protection 7SS60

Distributed busbar protection 7SS52

General notes:

- Suitable for all types of busbar schemes.
- Preferably used for multiple busbar schemes where a disconnector (isolator) replica is necessary.
- The numerical busbar protection 7SS52 provides additional breaker failure protection.
- Different CT transformation ratios can be adapted numerically.
- The protection system and the disconnector (isolator) replica are continuously self-monitored by the 7SS52.
- Feeder protection can be connected to the same CT core.

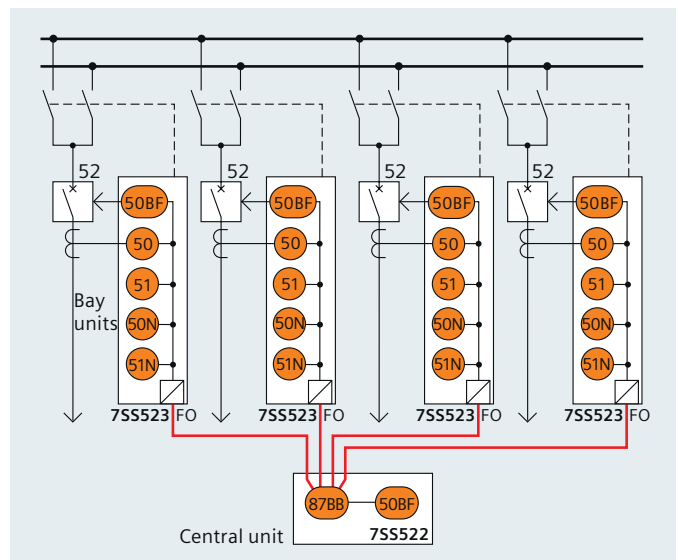


Fig. 2/75 Distributed busbar protection 7SS52

6. Power systems

Load shedding

In unstable power systems (e.g., isolated systems, emergency power supply in hospitals), it may be necessary to isolate selected loads from the power system to prevent overload of the overall system. The overcurrent-time protection functions are effective only in the case of a short-circuit.

Overloading of the generator can be measured as a frequency or voltage drop.

(Protection functions 27 and 81 available in 7RW600, 7SJ6 and 7SJ8.)

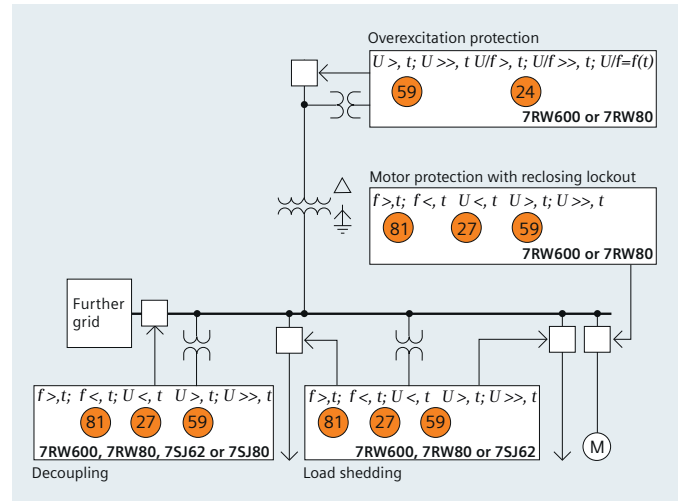


Fig. 2/76 Load shedding

Load shedding with rate-of-frequency-change protection

The rate-of-frequency-change protection calculates, from the measured frequency, the gradient or frequency change df/dt . It is thus possible to detect and record any major active power loss in the power system, to disconnect certain consumers accordingly and to restore the system to stability. Unlike frequency protection, rate-of-frequency-change protection reacts before the frequency threshold is undershot. To ensure effective protection settings, it is recommended to consider requirements throughout the power system as a whole. The rate-of-frequency-change protection function can also be used for the purposes of system decoupling.

Rate-of-frequency-change protection can also be enabled by an underfrequency state.

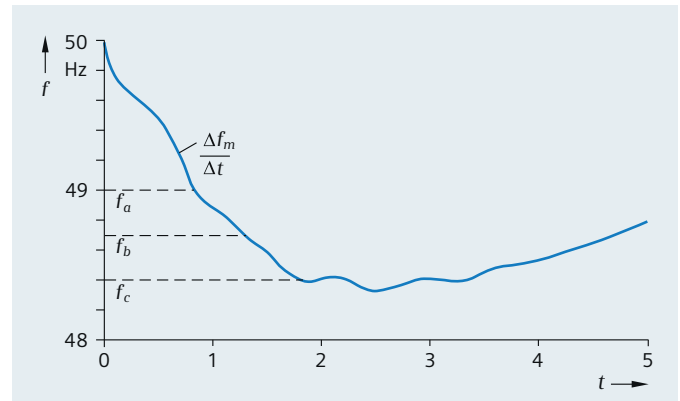


Fig. 2/77 Load shedding with rate-of-frequency-change protection

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for the trip circuit supervision.

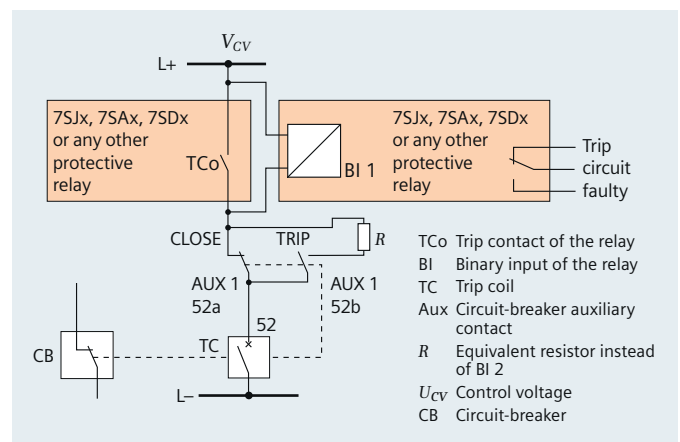


Fig. 2/78 Trip circuit supervision (ANSI 74TC)

Overview

Typical protection schemes

Disconnecting facility with flexible protection function

General note:

The SIPROTEC protection relay 7SJ64 disconnects the switchgear from the utility power system if the generator feeds energy back into the power system (protection function $P_{reverse}$). This functionality is achieved by using flexible protection. Disconnection also takes place in the event of frequency or voltage fluctuations in the utility power system (protection functions $f <$, $f >$, $U <$, $U >$, $I_{dir} >$, $I_{Edir} >$ 81, 27, 59, 67, 67N).

Notes:

- 1) The transformer is protected by differential protection and inverse or definite-time overcurrent protection functions for the phase currents. In the event of a fault, the circuit-breaker CB1 on the utility side is tripped by a remote link. Circuit-breaker CB2 is also tripped.
- 2) Overcurrent-time protection functions protect feeders 1 and 2 against short-circuits and overload caused by the connected loads. Both the phase currents and the zero currents of the feeders can be protected by inverse and definite-time overcurrent stages. The circuit-breakers CB4 and CB5 are tripped in the event of a fault.

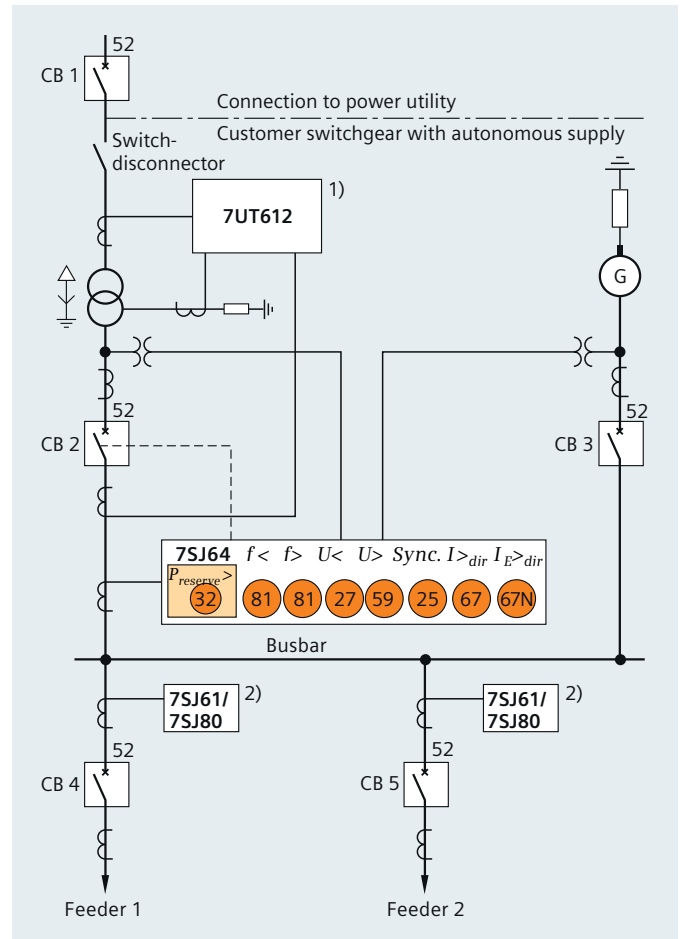


Fig. 2/79 Example of a switchgear with autonomous generator supply

Protection coordination

Typical applications and functions

Relay operating characteristics and their settings must be carefully coordinated in order to achieve selectivity. The aim is basically to switch off only the faulty component and to leave the rest of the power system in service in order to minimize supply interruptions and to ensure stability.

Sensitivity

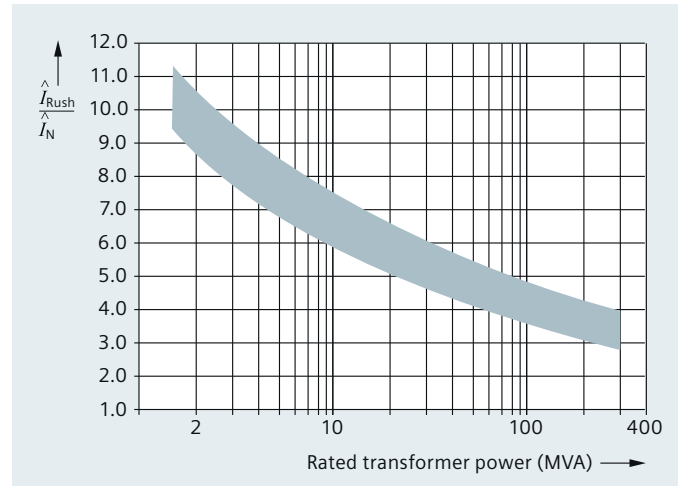
Protection should be as sensitive as possible in order to detect faults at the lowest possible current level. At the same time, however, it should remain stable under all permissible load, overload and through-fault conditions. For more information: <http://www.siemens.com/systemplanning>. The Siemens engineering programs SINICAL and SIGRADE are especially designed for selective protection grading of protection relay systems. They provide short-circuit calculations, international standard characteristics of relays, fuses and circuit-breakers for easy protection grading with respect to motor starting, inrush phenomena, and equipment damage curves.

Phase-fault overcurrent relays

The pickup values of phase overcurrent relays are normally set 30 % above the maximum load current, provided that sufficient short-circuit current is available. This practice is recommended particularly for mechanical relays with reset ratios of 0.8 to 0.85. Numerical relays have high reset ratios near 0.95 and allow, therefore, about a 10 % lower setting. Feeders with high transformer and/or motor load require special consideration.

Transformer feeders

The energizing of transformers causes inrush currents that may last for seconds, depending on their size (Fig. 2/79). Selection of the pickup current and assigned time delay have to be coordinated so that the inrush current decreases below the relay overcurrent reset value before the set operating time has elapsed. The inrush current typically contains only about a 50 % fundamental frequency component. Numerical relays that filter out harmonics and the DC component of the inrush current can therefore be set to be more sensitive. The inrush current peak values of Fig. 2/80 will be reduced to more than one half in this case. Some digital relay types have an inrush detection function that may block the trip of the overcurrent protection resulting from inrush currents.



Time constant of inrush current			
Nominal power (MVA)	0.5 ... 1.0	1.0 ... 10	> 10
Time constant (s)	0.16 ... 0.2	0.2 ... 1.2	1.2 ... 720

Fig. 2/80 Peak value of inrush current

Ground-fault protection relays

Ground-current relays enable a much more sensitive setting, because load currents do not have to be considered (except 4-wire circuits with 1-phase load). In solidly and low-resistance grounded systems, a setting of 10 to 20 % rated load current can generally be applied. High-resistance grounding requires a much more sensitive setting, on the order of some amperes primary. The ground-fault current of motors and generators, for example, should be limited to values below 10 A in order to avoid iron burning. In this case, residual-current relays in the start point connection of CTs cannot be used; in particular, with rated CT primary currents higher than 200 A. The pickup value of the zero-sequence relay would be on the order of the error currents of the CTs. A special core-balance CT is therefore used as the ground-current sensor. The core-balance CT 7XR96 is designed for a ratio of 60/1 A. The detection of 6 A primary would then require a relay pickup setting of 0.1 A secondary. An even more sensitive setting is applied in isolated or Petersen coil grounded systems where very low ground currents occur with 1-phase-to-ground faults. Settings of 20 mA and lower may then be required depending on the minimum ground-fault current. Sensitive directional ground-fault relays (integrated into the relays 7SJ62, 63, 64, 7SJ80, 7SK80, 7SA6) allow settings as low as 5 mA.

Overview

Protection coordination

Motor feeders

The energization of motors causes a starting current of initially 5 to 6 times the rated current (locked rotor current).

A typical time-current curve for an induction motor is shown in Fig. 2/81.

In the first 100 ms, a fast-decaying asymmetrical inrush current also appears. With conventional relays, it was common practice to set the instantaneous overcurrent stage of the short-circuit protection 20 to 30 % above the locked rotor current with a short-time delay of 50 to 100 ms to override the asymmetrical inrush period.

Numerical relays are able to filter out the asymmetrical current component very rapidly so that the setting of an additional time delay is no longer applicable.

The overload protection characteristic should follow the thermal motor characteristic as closely as possible. The adaptation is made by setting the pickup value and the thermal time constant, using the data supplied by the motor manufacturer. Furthermore, the locked-rotor protection timer has to be set according to the characteristic motor value.

Time grading of overcurrent relays (51)

The selectivity of overcurrent protection is based on time grading of the relay operating characteristics. The relay closer to the infeed (upstream relay) is time-delayed against the relay further away from the infeed (downstream relay). The calculation of necessary grading times is shown in Fig. 2/83 by an example for definite-time overcurrent relays.

The overshoot times take into account the fact that the measuring relay continues to operate due to its inertia, even if when the fault current is interrupted. This may be high for mechanical relays (about 0.1 s) and negligible for numerical relays (20 ms).

Inverse-time relays (51)

For the time grading of inverse-time relays, in principle the same rules apply as for the definite-time relays. The time grading is first calculated for the maximum fault level and then checked for lower current levels (Fig. 2/82).

If the same characteristic is used for all relays, or if when the upstream relay has a steeper characteristic (e.g., very much over normal inverse), then selectivity is automatically fulfilled at lower currents.

Differential relay (87)

Transformer differential relays are normally set to pickup values between 20 and 30 % of the rated current. The higher value has to be chosen when the transformer is fitted with a tap changer.

Restricted ground-fault relays and high-resistance motor/generator differential relays are, as a rule, set to about 10 % of the rated current.

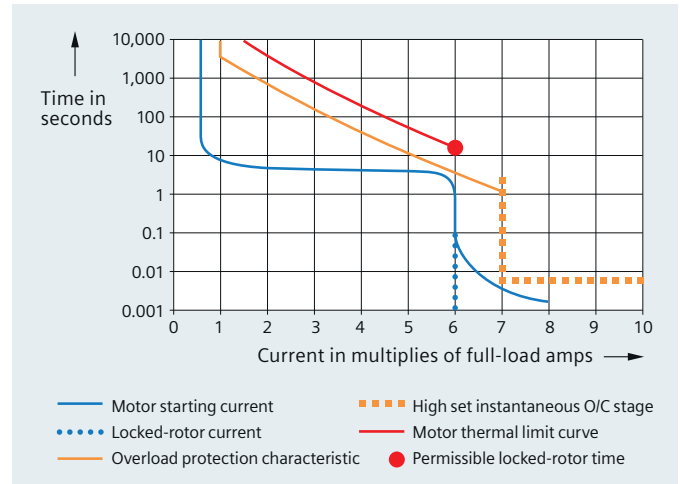


Fig. 2/81 Typical motor current-time characteristics

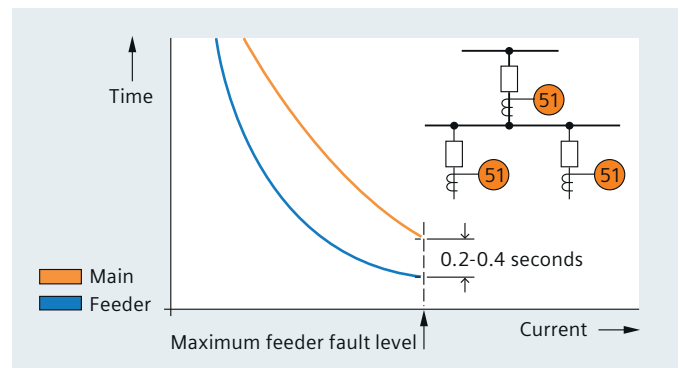


Fig. 2/82 Coordination of inverse-time relays

Instantaneous overcurrent protection (50)

This is typically applied on the final supply load or on any protection relay with sufficient circuit impedance between itself and the next downstream protection relay. The setting at transformers, for example, must be chosen about 20 to 30 % higher than the maximum through-fault current. The relay must remain stable during energization of the transformer.

Calculation example

The feeder configuration of Fig. 2/84 and the associated load and short-circuit currents are given. Numerical overcurrent relays 7SJ60 with normal inverse-time characteristics are applied.

The relay operating times, depending on the current, can be derived from the diagram or calculated with the formula given in Fig. 2/85.

The I_p/I_N settings shown in Fig. 2/84 have been chosen to get pickup values safely above maximum load current.

This current setting should be lowest for the relay farthest downstream. The relays further upstream should each have equal or higher current settings.

The time multiplier settings can now be calculated as follows:

Station C:

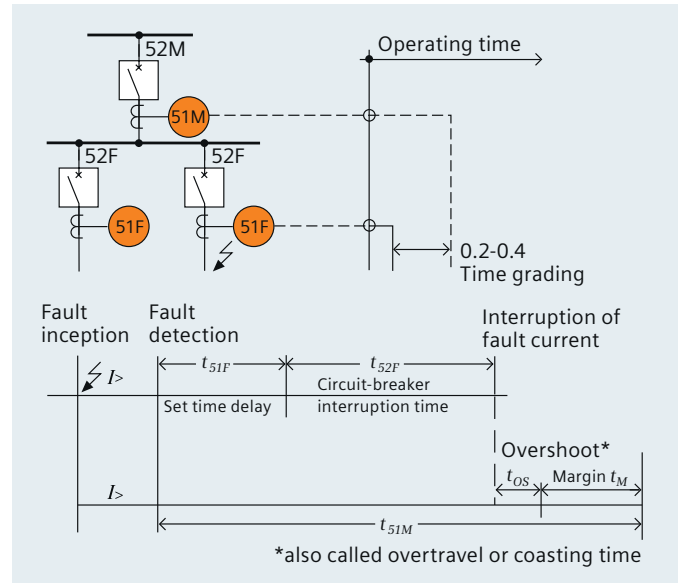
- For coordination with the fuses, we consider the fault in location F1. The short-circuit current $I_{SCC, max}$ related to 13.8 kV is 523 A. This results in 7.47 for I/I_p at the overcurrent relay in location C.
- With this value and $T_p = 0.05$, an operating time of $t_A = 0.17$ s can be derived from Fig. 2/85.
- This setting was selected for the overcurrent relay to get a safe grading time over the fuse on the transformer low-voltage side. Safety margin for the setting values for the relay at station C are therefore:
- Pickup current: $I_p/I_N = 0.7$
- Time multiplier: $T_p = 0.05$.

Station B:

The relay in B has a primary protection function for line B-C and a backup function for the relay in C. The maximum through-fault current of 1.395 A becomes effective for a fault in location F2. For the relay in C, an operating time time of 0.11 s ($I/I_p = 19.93$) is obtained.

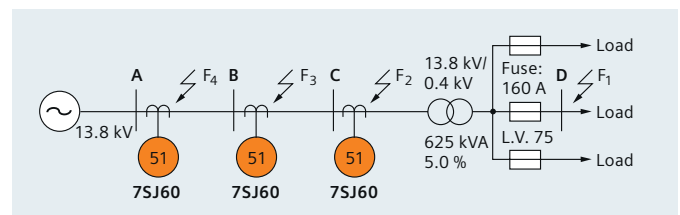
It is assumed that no special requirements for short operating times exist and therefore an average time grading interval of 0.3 s can be chosen. The operating time of the relay in B can then be calculated.

- $t_B = 0.11 + 0.3 = 0.41$ s
- Value of $I_p/I_N = \frac{1,395 \text{ A}}{220 \text{ A}} = 6.34$ (Fig. 2/84)
- With the operating time 0.41 s and $I_p/I_N = 6.34$, $T_p = 0.11$ can be derived from Fig. 2/85.



Time grading	
$t_{TS} = t_{51M} - t_{51F} = t_{52F} + t_{OS} + t_M$	
Example 1	$t_{TG} = 0.10 \text{ s} + 0.15 \text{ s} + 0.15 \text{ s} = 0.40 \text{ s}$
Oil circuit-breaker	$t_{52F} = 0.10 \text{ s}$
Mechanical relays	$t_{OS} = 0.15 \text{ s}$
Safety margin for measuring errors, etc.	$t_M = 0.15 \text{ s}$
Example 2	$t_{TG} = 0.08 + 0.02 + 0.10 = 0.20 \text{ s}$
Vacuum circuit-breaker	$t_{52F} = 0.08 \text{ s}$
Numerical relays	$t_{OS} = 0.02 \text{ s}$
Safety margin	$t_M = 0.10 \text{ s}$

Fig. 2/83 Time grading of overcurrent-time relays



Station	Max. load A	$I_{SCC, max}^*$ A	CT ratio	I_p/I_N^{**}	I_{prim}^{***} A	$I/I_p = \frac{I_{SCC, max}}{I_{prim}}$
A	300	4,500	400/5	1.0	400	11.25
B	170	2,690	200/5	1.1	220	12.23
C	50	1,395	100/5	0.7	70	19.93
D	-	523	-	-	-	-

*) $I_{SCC, max}$ = Maximum short-circuit current
 **) I_p/I_N = Relay current multiplier setting
 ***) I_{prim} = Primary setting current corresponding to I_p/I_N

Fig. 2/84 Time grading of inverse-time relays for a radial feeder

Overview

Protection coordination

2

The setting values for the relay at station B are:

- Pickup current: $I_p/I_N = 1.1$
- Time multiplier $T_p = 0.11$

Given these settings, the operating time of the relay in B for a close fault in F3 can also be checked: The short-circuit current increases to 2,690 A in this case (Fig. 2/84). The corresponding I/I_p value is 12.23.

- With this value and the set value of $T_p = 0.11$, an operating time of 0.3 s is obtained again (Fig. 2/85).

Station A:

- Adding the time grading interval of 0.3 s, the desired operating time is $t_A = 0.3 + 0.3 = 0.6$ s.

Following the same procedure as for the relay in station B, the following values are obtained for the relay in station A:

- Pickup current: $I_p/I_N = 1.0$
- Time multiplier $T_p = 0.17$
- For the close-in fault at location F4, an operating time of 0.48 s is obtained.

The normal way

To prove the selectivity over the whole range of possible short-circuit currents, it is normal practice to draw the set of operating curves in a common diagram with double log scales. These diagrams can be calculated manually and drawn point-by-point or constructed by using templates.

Today, computer programs are also available for this purpose. Fig. 2/86 shows the relay coordination diagram for the selected example, as calculated by the Siemens program SIGRADE (Siemens Grading Program).

Note:

To simplify calculations, only inverse-time characteristics have been used for this example. About 0.1 s shorter operating times could have been reached for high-current faults by additionally applying the instantaneous zones $I_{>>}$ of the 7SJ60 relays.

Coordination of overcurrent relays with fuses and low-voltage trip devices

The procedure is similar to the above-described grading of overcurrent relays. A time interval of between 0.1 and 0.2 s is usually sufficient for a safe time coordination.

Strong and extremely inverse characteristics are often more suitable than normal inverse characteristics in this case. Fig. 2/87 shows typical examples.

Simple distribution substations use a power fuse on the secondary side of the supply transformers (Fig. 2/87a).

In this case, the operating characteristic of the overcurrent relay at the infeed has to be coordinated with the fuse curve.

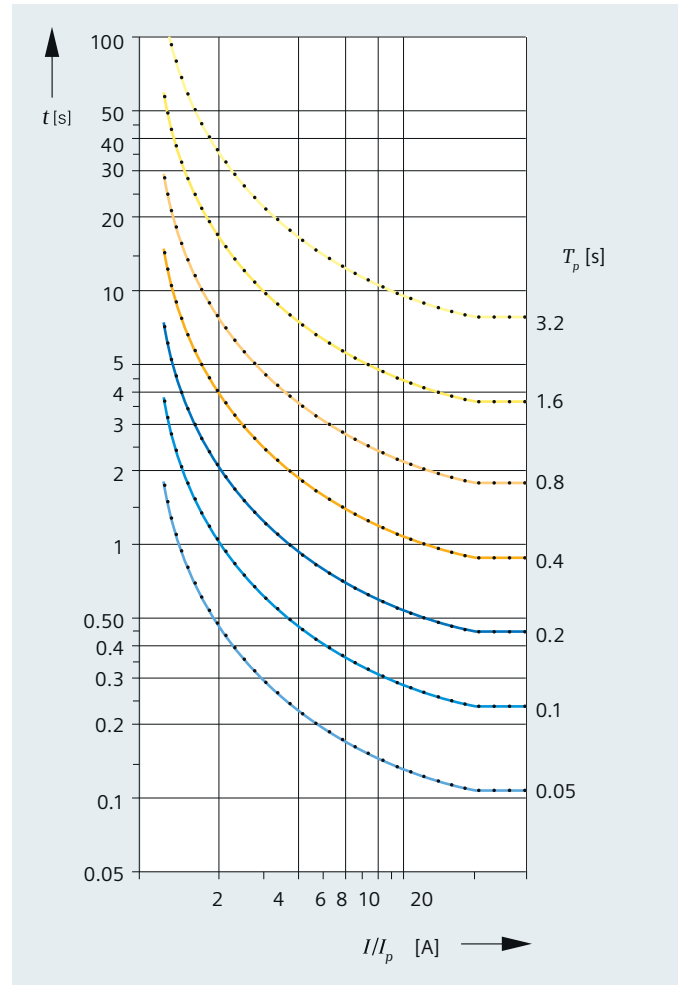


Fig. 2/85 Normal inverse-time characteristic of the 7SJ60 relay

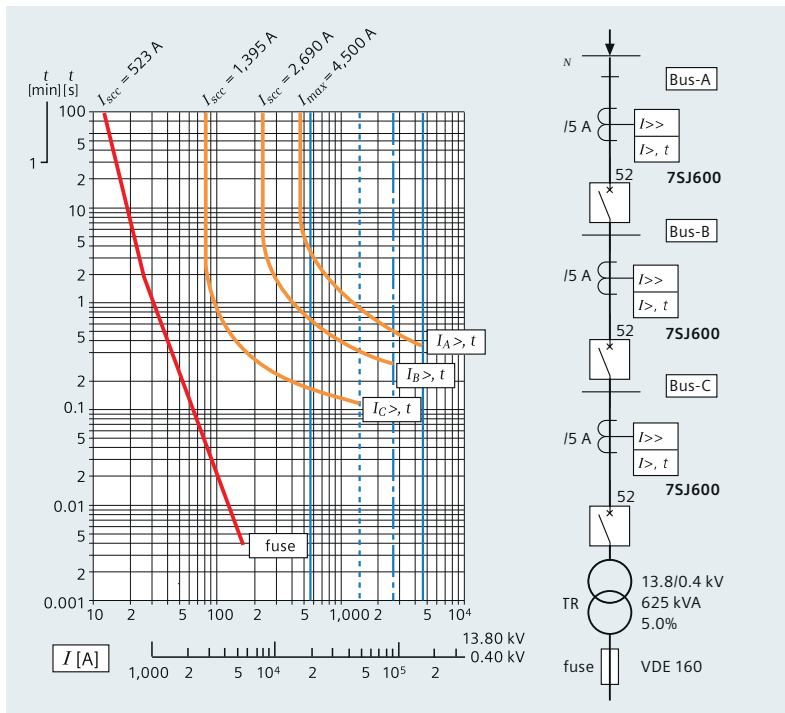
Normal inverse

$$t = \frac{0.14}{(I/I_p)^{0.02} - 1} \cdot T_p(s)$$

Strong inverse characteristics may be used with expulsion-type fuses (fuse cutouts), while extremely inverse versions adapt better to current limiting fuses.

In any case, the final decision should be made by plotting the curves in the log-log coordination diagram.

Electronic trip devices of LV breakers have long-delay, short-delay and instantaneous zones. Numerical overcurrent relays with one inverse-time and two definite-time zones can closely be adapted to this (Fig. 2/87b).



Setting range	
$I_p = 0.10 - 4.00 I_N$ $T_p = 0.05 - 3.2 \text{ s}$ $I_{>>} = 0.1 - 25 I_N$	$I_p = 1.0 I_N$ $T_p = 0.17 \text{ s}$ $I_{>>} = \infty$
$I_p = 0.10 - 4.00 I_N$ $T_p = 0.05 - 3.2 \text{ s}$ $I_{>>} = 0.1 - 25 I_N$	$I_p = 1.0 I_N$ $T_p = 0.11 \text{ s}$ $I_{>>} = \infty$
$I_p = 0.10 - 4.00 I_N$ $T_p = 0.05 - 3.2 \text{ s}$ $I_{>>} = 0.1 - 25 I_N$	$I_p = 0.7 I_N$ $T_p = 0.05 \text{ s}$ $I_{>>} = \infty$
HRC fuse 160 A	

Fig. 2/86 Overcurrent-time grading diagram

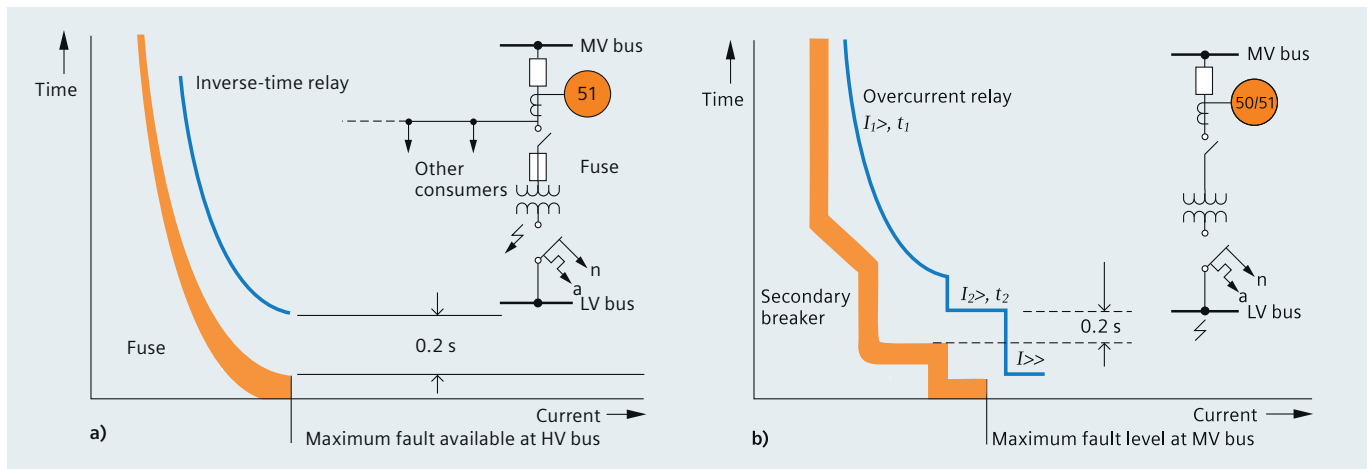


Fig. 2/87 Coordination of an overcurrent relay with an MV fuse and low-voltage breaker trip device

Coordination of distance relays

The distance relay setting must take into account the limited relay accuracy, including transient overreach (5 %, according to IEC 60255-6), the CT error (1 % for class 5P and 3 % for class 10P) and a security margin of about 5 %. Furthermore, the line parameters are often only calculated, not measured. This is a further source of errors. A setting of 80 to 85 % is therefore common practice; 80 % is used for mechanical relays, while 85 % can be used for the more accurate numerical relays.

Where measured line or cable impedances are available, the protected zone setting may be extended to 90 %. The second and third zones have to keep a safety margin of about 15 to 20 % to the corresponding zones of the following lines. The shortest following line always has to be considered (Fig. 2/88).

As a general rule, the second zone should at least reach 20 % over the next station to ensure backup for busbar faults, and the third zone should cover the longest following line as backup for the line protection.

Overview

Protection coordination

2

Grading of zone times

The first zone normally operates undelayed. For the grading of the time delays of the second and third zones, the same rules as for overcurrent relays apply (Fig. 2/83, page 2/41). For the quadrilateral characteristics (relays 7SA6 and 7SA5), only the reactance values (X values) have to be considered for the protected zone setting. The setting of the R values should cover the line resistance and possible arc or fault resistances. The arc resistance can be roughly estimated as follows:

$$R_{ARC} = \frac{2.5 \cdot I_{arc}}{I_{SSC Min}} [\Omega]$$

I_{arc} = Arc length in mm

$I_{SSC Min}$ = Minimum short-circuit current in kA

- Typical settings of the ratio R/X are:
 - Short lines and cables (≤ 10 km): R/X = 2 to 6
 - Medium line lengths < 25 km: R/X = 2
 - Longer lines 25 to 50 km: R/X = 1

Shortest feeder protectable by distance relays

The shortest feeder that can be protected by underreaching distance zones without the need for signaling links depends on the shortest settable relay reactance.

$$X_{Prim Min} = X_{Relay Min} \cdot \frac{VT_{ratio}}{CT_{ratio}}$$

$$I_{min} = \frac{X_{Prim Min}}{X'_{Line}}$$

The shortest setting of the numerical Siemens relays is 0.05 Ω for 1 A relays, corresponding to 0.01 Ω for 5 A relays. This allows distance protection of distribution cables down to the range of some 500 meters.

Breaker failure protection setting

Most numerical relays in this guide provide breaker failure (BF) protection as an integral function. The initiation of the BF protection by the internal protection functions then takes place via software logic. However, the BF protection function may also be initiated externally via binary inputs by an alternate protection. In this case, the operating time of intermediate relays (BFI time) may have to be considered. Finally, the tripping of the infeeding breakers requires auxiliary relays, which add a small time delay (BFI) to the overall fault clearing time. This is particularly the case with one-breaker-and-a-half or ring bus arrangements where a separate breaker failure relay (7SV600 or 7VK61) is used per breaker (Fig. 2/83, Fig. 2/84).

The decisive criterion of BF protection time coordination is the reset time of the current detector (50BF), which must not be exceeded under any condition during normal current interruption. The reset times specified in the Siemens numerical relay manuals are valid for the worst-case condition: interruption of a fully offset short-circuit current and low current pickup setting (0.1 to 0.2 times rated CT current).

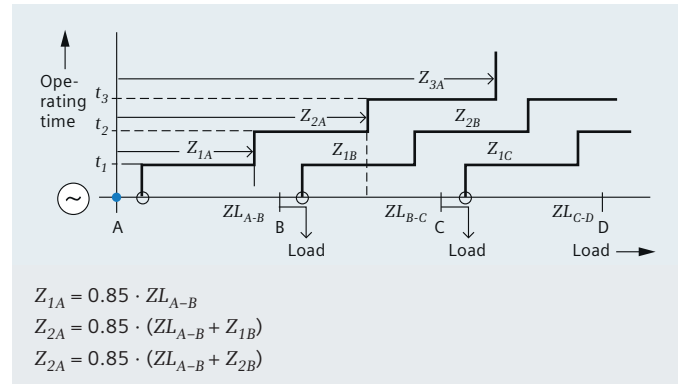


Fig. 2/88 Grading of distance zones

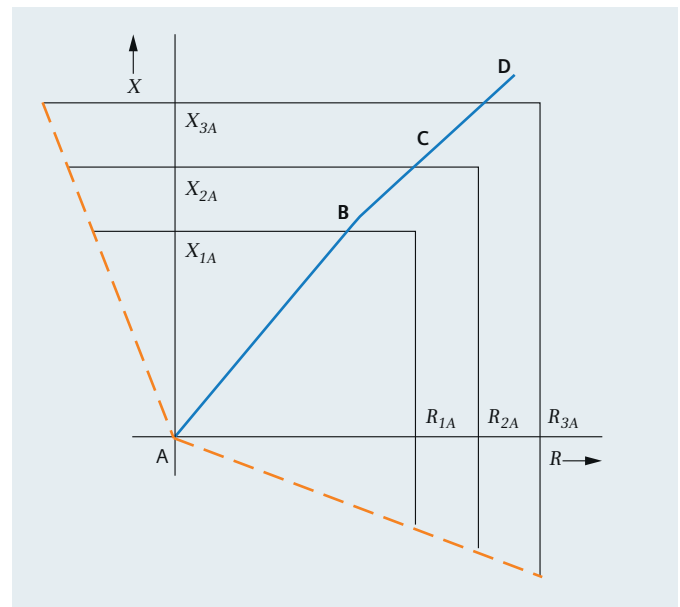


Fig. 2/89 Operating characteristics of Siemens distance relays

The reset time is 1 cycle for EHV relays (7SA6/52, 7VK61) and 1.5 to 2 cycles for distribution type relays (7SJ**).

Fig. 2/91 (next page) shows the time chart for a typical breaker failure protection scheme. The stated times in parentheses apply for transmission system protection and the times in square brackets for distribution system protection.

High-impedance differential protection; verification of design

The following design data must be established: CT data

The prerequisite for high-impedance scheme is that all CTs used for that scheme must have the same ratio. They should also be of low leakage flux design according to Class PX of IEC 60044-1 (former Class X of BS 3938) or TPS of IEC 60044-6, when used for high-impedance busbar protection scheme. When used for restricted ground-fault differential protection of e.g. a transformer winding especially in solidly grounded networks, CTs of Class 5P according to IEC 60044-1 can be used as well. In each case the excitation characteristic and the secondary winding resistance are to be provided by the manufacturer. The knee-point voltage of the CT must be at least twice the relay pickup voltage to ensure operation on internal faults.

The relay

The relay can be either:

- a) dedicated design high-impedance relay, e.g., designed as a sensitive current relay 7VH60 or 7SG12 (DAD-N) with external series resistor R_{stab} . If the series resistor is integrated into the relay, the setting values may be directly applied in volts, as with the relay 7VH60 (6 to 60V or 24 to 240 V); or
- b) digital overcurrent protection relay with sensitive current input, like 7SJ6 or 7SR1 (Argus-C). To the input of the relay a series stabilizing resistor R_{stab} will be then connected as a rule in order to obtain enough stabilization for the high-impedance scheme. Typically, a non-linear resistor V (varistor) will be also connected to protect the relay and wiring against overvoltages.

Sensitivity of the scheme

For the relay to operate in the event of an internal fault, the primary current must reach a minimum value to supply the relay pickup current (I_{set}), the varistor leakage current (I_{var}) and the magnetizing currents of all parallel-connected CTs at the set pickup voltage. A low relay voltage setting and CTs with low magnetizing current therefore increase the protection sensitivity

Stability during external faults

This check is made by assuming an external fault with maximum through-fault current and full saturation of the CT in the faulty feeder. The saturated CT is then substituted with its secondary winding resistance R_{CT} , and the appearing relay voltage V_R corresponds to the voltage drop of the in-feeding currents (through-fault current) across R_{CT} and R_{lead} . The current (voltage) at the relay must, under this condition, stay reliably below the relay pickup value.

In practice, the wiring resistances R_{lead} may not be equal. In this case, the worst condition with the highest relay voltage (corresponding to the highest through-fault current) must be sought by considering all possible external feeder faults.

Setting

The setting is always a trade-off between sensitivity and stability. A higher voltage setting leads not only to enhanced through-fault stability but also to higher CT magnetizing and varistor leakage currents, resulting consequently in a higher primary pickup current.

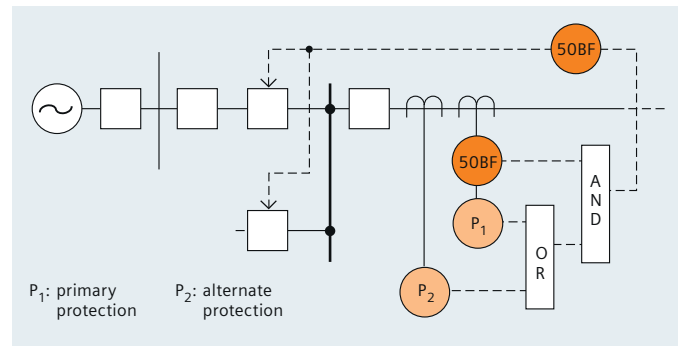


Fig. 2/90 Breaker failure protection, logic circuit

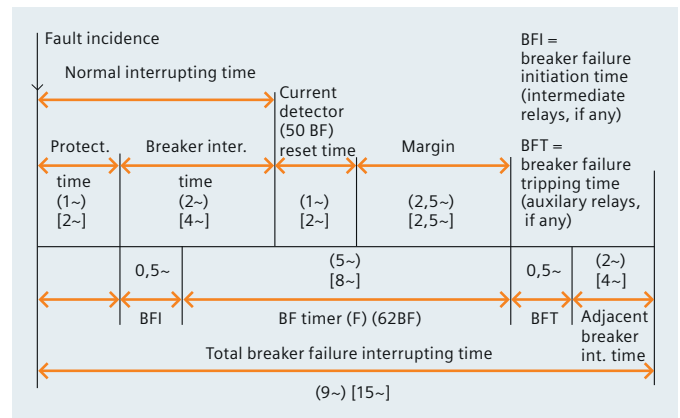


Fig. 2/91 Time coordination of BF time setting

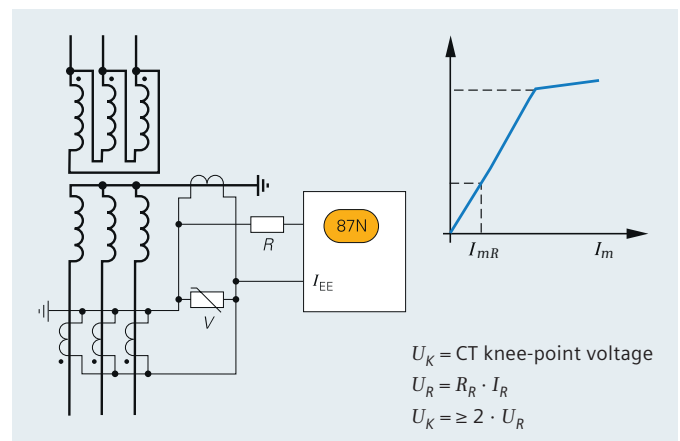


Fig. 2/92 Principle connection diagram for high-impedance restricted ground-fault protection of a winding of the transformer using SIPROTEC digital overcurrent relay (e.g. 7SJ61)

Relay setting U_{rms}	C	β	Varistor type
≤ 125	450	0.25	600 A / S1 / S256
125 – 240	900	0.25	600 A / S1 / S1088

Calculation example:

Restricted ground fault protection for the 400 kV winding of 400 MVA power transformer with $I_{r,400kV} = 577$ A installed in a switchgear with rated withstand short-circuit current of 40 kA.

Given:

$N = 4$ CTs connected in parallel; $I_{pn}/I_{sn} = 800$ A / 1 A – CT ratio;

$U_k = 400$ V – CT Knee-point voltage;

$I_m = 20$ mA – CT magnetizing current at U_k ;

$R_{CT} = 3 \Omega$ – CT internal resistance;

$R_{lead} = 2 \Omega$ – secondary wiring (lead) resistance

Relay: 7SJ612; Time overcurrent 1Phase input used with setting range

$I_{set} = 0.003$ A to 1.5 A in steps of 0.001 A; relay internal burden

$R_{relay} = 50$ m Ω

Stability calculation

$$U_{s,min} = I_{k,max,thr} \frac{I_{sn}}{I_{pn}} (R_{CT} + R_{lead}) = 10,000 \frac{1}{800} (3+2) = 62.6 \text{ V}$$

with $I_{k,max,thr}$ taken as $16 \cdot I_{r,400kV} = 16 \cdot 577 \text{ A} = 9,232 \text{ A}$, rounded up to 10 kA.

The actual stability voltage for the scheme U_s can be taken with enough safety margin as $U_s = 130 \text{ V}$ (remembering that $2U_s < U_k$).

Fault setting calculation

For the desired primary fault sensitivity of 125 A, which is approx. 22 % of the rated current of the protected winding $I_{r,400kV}$ (i.e. $I_{p,des} = 125$ A) the following current setting can be calculated:

$$I_{set} = I_{p,des} \frac{I_{sn}}{I_{pn}} - N \cdot I_m \frac{U_s}{U_k} = 125 \frac{1}{800} - 4 \cdot 0.02 \frac{130}{400} = 0.13 \text{ A}$$

Stabilizing resistor calculation

From the U_s and I_{set} values calculated above the value of the stabilizing resistor R_{stab} can be calculated:

$$R_{stab} = \frac{U_s}{I_{set}} - R_{relay} = \frac{130}{0.13} - 0.05 = \approx 1,000 \Omega$$

where the relay resistance can be neglected.

The stabilizing resistor R_{stab} can be chosen with a necessary minimum continuous power rating $P_{stab,cont}$ of:

$$P_{stab,cont} \geq \frac{U_s^2}{R_{stab}} = \frac{130^2}{1000} = 16.9 \text{ W}$$

Moreover, R_{stab} must have a short time rating large enough to withstand the fault current levels before the fault is cleared. The time duration of 0.5 seconds can be typically considered ($P_{stab,0.5s}$) to take into account longer fault clearance times of back-up protection.

The rms voltage developed across the stabilizing resistor is decisive for the thermal stress of the stabilizing resistor. It is calculated according to formula:

$$U_{rms,relay} = 1.3 \cdot \sqrt[4]{U_{k3} \cdot R_{stab} \cdot I_{k,max,int} \frac{I_{sn}}{I_{pn}}} = 1.3 \cdot \sqrt[4]{400^3 \cdot 1000 \cdot 50} = 1738.7 \text{ V}$$

The resulting short-time rating $P_{stab,0.5s}$, 0.5 s equals to:

$$P_{stab,0.5s} = \frac{U_{rms,relay}^2}{R_{stab}} = \frac{1739^2}{1000} = 3023 \text{ W}$$

Check whether the voltage limitation by a varistor is required

The relay should normally be applied with an external varistor which should be connected across the relay and stabilizing resistor input terminals. The varistor limits the voltage across the terminals under maximum internal fault conditions. The theoretical voltage which may occur at the terminals can be determined according to following equation:

$$U_{k,max,int} = I_{k,max,int} \frac{I_{sn}}{I_{pn}} (R_{relay} + R_{stab}) = 40,000 \frac{1}{800} (0.05+1000) = 50003 \text{ V}$$

with $I_{k,max,int}$ taken as the rated short-circuit current of the switchgear = 40 kA.

The resulting maximum peak voltage across the panel terminals (i.e. tie with relay and Rstab connected in series):

$$\hat{U}_{max,relay} = 2\sqrt{2U_k(U_{k,max,int})} = 2\sqrt{2 \cdot 400(50003 - 400)} = 12600 \text{ V}$$

Since $U_{max,relay} > 1.5$ kV the varistor is necessary.

Exemplarily, a METROSIL of type 600A/S1/Spec.1088 can be used ($\beta = 0.25$, $C = 900$).

This Metrosil leakage current at voltage setting $U_s = 130$ V equals to

$$I_{rms} = 0.52 \left(\frac{U_{set,rms} \cdot \sqrt{2}}{C} \right)^{1/\beta} = 0.91 \text{ mA}$$

and can be neglected by the calculations, since its influence on the proposed fault-setting is negligible.

A higher voltage setting also requires a higher knee-point voltage of the CTs and therefore greater size of the CTs. A sensitivity of 10 to 20 % of I_r (rated current) is typical for restricted ground-fault protection. With busbar protection, a pickup value $\geq I_r$ is normally applied. In networks with neutral grounding via impedance the fault setting shall be revised against the minimum ground fault conditions.

Non-linear resistor (varistor)

Voltage limitation by a varistor is needed if peak voltages near or above the insulation voltage (2 kV ... 3 kV) are expected. A limitation to $U_{rms} = 1,500$ V is then recommended. This can be checked for the maximum internal fault current by applying the formula shown for $U_{max,relay}$. A restricted ground-fault protection may sometimes not require a varistor, but a busbar protection in general does. However, it is considered a good practice to equip with a varistor all high impedance protection installations. The electrical varistor characteristic of a varistor can be expressed as $U = C I^\beta$ where C and β are the varistor constants.

CT requirements for protection relays

Instrument transformers

Instrument transformers must comply with the applicable IEC recommendations IEC 60044 and 60186 (PT), ANSI/IEEE C57.13 or other comparable standards.

Voltage transformers (VT)

Voltage transformers (VT) in single-pole design for all primary voltages have typical single or dual secondary windings of 100, 110 or 115 V/ $\sqrt{3}$ with output ratings between 10 and 50 VA suitable from most application with digital metering and protection equipment, and accuracies of 0.1 % to 6 % to suit the particular application. Primary BIL values are selected to match those of the associated switchgear.

Current transformers

Current transformers (CT) are usually of the single-ratio type with wound or bar-type primaries of adequate thermal rating. Single, double or triple secondary windings of 1 or 5 A are standard. 1 A rating should, however, be preferred, particularly in HV and EHV stations, to reduce the burden of the connected lines. Output power (rated burden in VA), accuracy and saturation characteristics (rated symmetrical short-circuit current limiting

factor) of the cores and secondary windings must meet the requirements of the particular application. The CT classification code of IEC is used in the following:

- Measuring cores**
 These are normally specified 0.2 % or 0.5 % accuracy (class 0.2 or class 0.5), and an rated symmetrical short-circuit current limiting factor FS of 5 or 10.
 The required output power (rated burden) should be higher than the actually connected burden. Typical values are 2.5, 5 or 10 VA. Higher values are normally not necessary when only electronic meters and recorders are connected.
 A typical specification could be: 0.5 FS 10, 5 VA.
- Cores for billing values metering**
 In this case, class 0.25 FS is normally required.
- Protection cores**
 The size of the protection core depends mainly on the maximum short-circuit current and the total burden (internal CT burden, plus burden of connected lines plus relay burden) Furthermore, a transient dimensioning factor has to be considered to cover the influence of the DC component in the short-circuit current.

Glossary of used abbreviations (according to IEC 60044-6, as defined)	
K_{SSC}	= Rated symmetrical short-circuit current factor (example: CT cl. 5P20 → $K_{SSC} = 20$)
K'_{SSC}	= Effective symmetrical short-circuit current factor
K_{td}	= Transient dimensioning factor
$I_{SSC max}$	= Maximum symmetrical short-circuit current
I_{pn}	= CT rated primary current
I_{sn}	= CT rated secondary current
R_{ct}	= Secondary winding d.c. resistance at 75 °C / 167 °F (or other specified temperature)
R_b	= Rated resistive burden
R'_b	= $R_{lead} + R_{relay}$ = connected resistive burden
T_p	= Primary time constant (net time constant)
U_K	= Kneepoint voltage (r.m.s.)
R_{relay}	= Relay burden
R_{lead}	= $\frac{2 \cdot \rho \cdot l}{A}$
with	
l	= Single conductor length from CT to relay in m
ρ	= Specific resistance = 0.0175 Ωmm ² /m (copper wires) at 20 °C / 68 °F (or other specified temperature)
A	= Conductor cross-section in mm ²

In general, an accuracy of 1 % in the range of 1 to 2 times nominal current (class 5 P) is specified. The rated symmetrical short-circuit current factor K_{SSC} should normally be selected so that at least the maximum short-circuit current can be transmitted without saturation (DC component is not considered).

This results, as a rule, in rated symmetrical short-circuit current factors of 10 or 20 depending on the rated burden of the CT in relation to the connected burden. A typical specification for protection cores for distribution feeders is 5P10, 10 VA or 5P20, 5 VA.

The requirements for protective current transformers for transient performance are specified in IEC 60044-6. In many practical cases, iron-core CTs cannot be designed to avoid saturation under all circumstances because of cost and space reasons, particularly with metal-enclosed switchgear.

The Siemens relays are therefore designed to tolerate CT saturation to a large extent. The numerical relays proposed in this guide are particularly stable in this case due to their integrated saturation detection function.

CT dimensioning formulae
$K'_{SSC} = K_{SSC} \cdot \frac{R_{ct} + R_b}{R_{ct} + R'_b}$ (effective)
with $K'_{SSC} \geq K_{td} \cdot \frac{I_{SSC max}}{I_{pn}}$ (required)

The effective symmetrical short-circuit current factor K'_{SSC} can be calculated as shown in the table above.

The rated transient dimensioning factor K_{td} depends on the type of relay and the primary DC time constant. For relays with a required saturation free time from ≤ 0.4 cycle, the primary (DC) time constant T_p has little influence.

CT design according to BS 3938/IEC 60044-1 (2000)
IEC Class P can be approximately transferred into the IEC Class PX (BS Class X) standard definition by following formula:
$U_k = \frac{(R_b + R_{ct}) \cdot I_n \cdot K_{SSC}}{1.3}$
Example: IEC 60044: 600/1, 5P10, 15 VA, $R_{ct} = 4 \Omega$
IEC PX or BS: $U_K = \frac{(15 + 4) \cdot 1 \cdot 10}{1.3} = 146 \text{ V}$ $R_{ct} = 4 \Omega$
For CT design according to ANSI/IEEE C 57.13 please refer to page 2/50

The CT requirements mentioned in Table 2/2 are simplified in order to allow fast CT calculations on the safe side. More accurate dimensioning can be done by more intensive calculation with Siemens's CTDIM (www.siemens.com/ctdim) program. Results of CTDIM are released by the relay manufacturer.

Adaption factor for 7UT6, 7UM62 relays – (limited resolution of measurement)

$$F_{Adap} = \frac{I_{pn}}{I_{nO}} \cdot \frac{I_{Nrelay}}{I_{sn}} = \frac{I_{pn} \cdot \sqrt{3} \cdot U_{nO}}{S_{Nmax}} \cdot \frac{I_{Nrelay}}{I_{sn}} \rightarrow \text{Request: } \frac{1}{8} \leq 8$$

7SD52, 53, 610, when transformer inside protected zone

$$\frac{I_{n-pri-CT_{max}}}{I_{n-pri-CT_{min}}} \cdot \frac{1}{\text{Transformer Ratio}^*} \leq 8$$

* If transformer in protection zone, else 1

$$I_{n-pri-CT-Transf-Site} \leq 2 \cdot I_n - \text{Obj-Transf-Site} \quad \text{AND}$$

$$I_{n-pri-CT-Transf-Site} \geq I_n - \text{Obj-Transf-Site} \quad \text{with}$$

- I_{nO} = Rated current of the protected object
- U_{nO} = Rated voltage of the protected object
- I_{Nrelay} = Rated current of the relay
- S_{Nmax} = Maximun load of the protected object
(for transformers: winding with max. load)

Overview

Protection coordination

2

Relay type	Transient dimensioning factor K_{td}			Min. required sym. short-circuit current factor K'_{ssc}	Min. required knee-point voltage U_k
Overcurrent-time and motor protection 7SJ511, 512, 531 7SJ45, 46, 60 7SJ61, 62, 63, 64 7SJ80, 7SK80	-			$K'_{ssc} \geq \frac{I_{\text{High set point}}}{I_{pn}}$ at least: 20	$U_k \geq \frac{I_{\text{High set point}}}{1.3 \cdot I_{pn}} \cdot (R_{ct} + R'_b) \cdot I_{sn}$ at least: $\frac{20}{1.3} \cdot (R_{ct} + R'_b) \cdot I_{sn}$
Line differential protection (pilot wire) 7SD600	-			$K'_{ssc} \geq \frac{I_{sc \text{ max (ext. fault)}}}{I_{pn}}$ and: $\frac{3}{4} \leq \frac{(K'_{ssc} \cdot I_{pn})_{\text{end1}}}{(K'_{ssc} \cdot I_{pn})_{\text{end2}}} \leq \frac{4}{3}$	$U_k \geq \frac{I_{sc \text{ max (ext. fault)}}}{1.3 \cdot I_{pn}} \cdot (R_{ct} + R'_b) \cdot I_{sn}$ and: $\frac{3}{4} \leq \frac{(U_k / (R_{ct} + R'_b)) \cdot I_{pn} / I_{sn})_{\text{end1}}}{(U_k / (R_{ct} + R'_b)) \cdot I_{pn} / I_{sn})_{\text{end2}}} \leq \frac{4}{3}$
Line differential protection (without distance function) 7SD52x, 53x, 610 (50/60 Hz)	Transformer 1.2	Busbar / Line 1.2	Gen. / Motor 1.2	$K'_{ssc} \geq \frac{I_{sc \text{ max (ext. fault)}}}{I_{pn}}$ $K_{td} \cdot \frac{I_{sc \text{ max (ext. fault)}}}{I_{pn}}$ and (only for 7SS): $\frac{I_{sc \text{ max (ext. fault)}}}{I_{pn}} \leq 100$ (measuring range)	$U_k \geq \frac{I_{sc \text{ max (ext. fault)}}}{1.3 \cdot I_{pn}} \cdot (R_{ct} + R'_b) \cdot I_{sn}$ and (only for 7SS): $\frac{I_{sc \text{ max (ext. fault)}}}{I_{pn}} \leq 100$ (measuring range)
Transformer/generator differential protection 7UT612, 7UT612 V4.0 7UT613, 633, 635, 7UT612 V4.6 7UM62	Transformer 4 3 4	Busbar / Line 4 3 -	Gen. / Motor 5 5 5		
Busbar protection 7SS52, 7SS60	for stabilizing factors $k \geq 0.5$ 0.5				
Distance protection (with distance function) 7SA522, 7SA6, 7SD5xx	primary DC time constant T_p [ms]			$K'_{ssc} \geq$ $K_{td} (a) \cdot \frac{I_{sc \text{ max (close-in fault)}}}{I_{pn}}$ and: $K_{td} (b) \cdot \frac{I_{sc \text{ max (zone 1-end fault)}}}{I_{pn}}$	$U_k \geq$ $K_{td} (a) \cdot \frac{I_{sc \text{ max (close-in fault)}}}{1.3 \cdot I_{pn}} \cdot (R_{ct} + R'_b) \cdot I_{sn}$ and: $K_{td} (b) \cdot \frac{I_{sc \text{ max (zone 1-end fault)}}}{I_{pn}} \cdot (R_{ct} + R'_b) \cdot I_{sn}$
	$K_{td} (a)$	$K_{td} (b)$			
	≤ 30	≤ 50	≤ 100	≤ 200	
	1	2	4	4	
	4	5	5	5	

Table 2/2 CT requirements

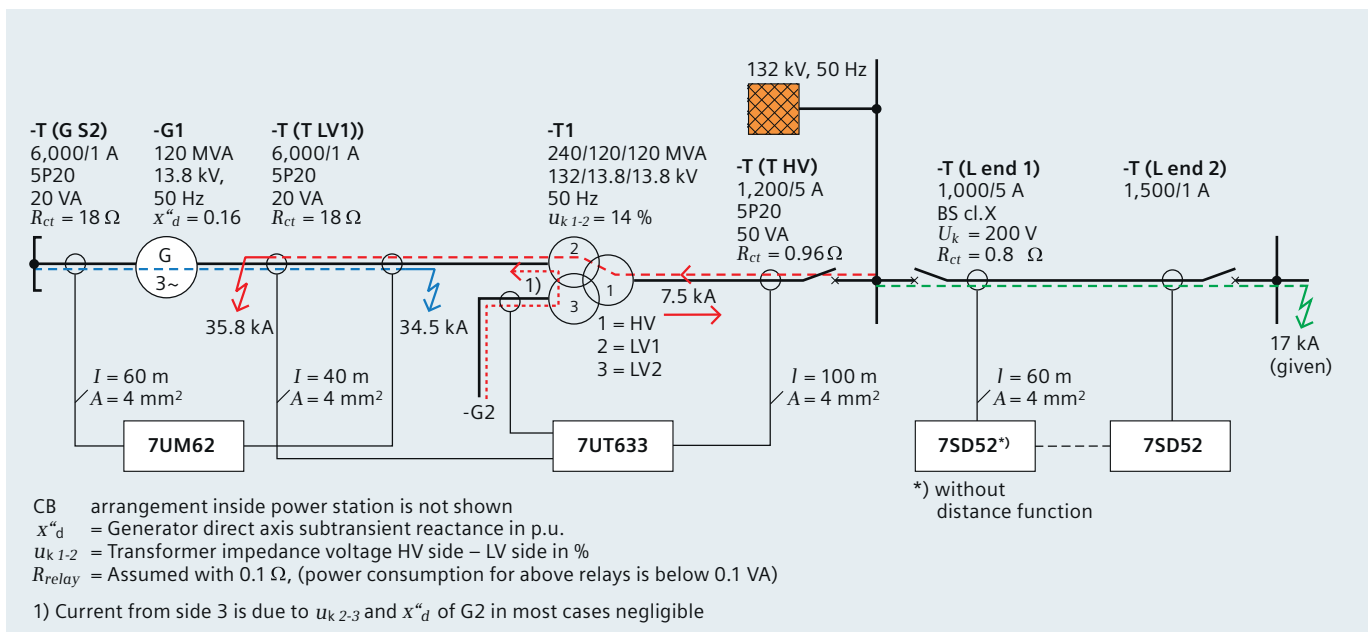


Fig. 2/93 Example 1 – CT verification for 7UM62, 7UT6, 7SD52 (7SD53, 7SD610)

-T (G S2), 7UM62	-T (T LV1), 7UT633	-T (T HV), 7UT633	-T (L end 1), 7SD52
$I_{sc \max (\text{ext. fault})} = \frac{c \cdot S_{NG}}{\sqrt{3} \cdot U_{NG} X''_d}$ $= \frac{1.1 \cdot 120,000 \text{ kVA}}{\sqrt{3} \cdot 13.8 \text{ kV} \cdot 0.16} = 34,516 \text{ A}$	$I_{sc \max (\text{ext. fault})} = \frac{S_{NT}}{\sqrt{3} \cdot U_{NT} u_k''}$ $= \frac{120,000 \text{ kVA}}{\sqrt{3} \cdot 13.8 \text{ kV} \cdot 0.14} = 35,860 \text{ A}$	$I_{sc \max (\text{ext. fault})} = \frac{S_{NT}}{\sqrt{3} \cdot U_{NT} u_k''}$ $= \frac{240,000 \text{ kVA}}{\sqrt{3} \cdot 132 \text{ kV} \cdot 0.14} = 7,498 \text{ A}$	$I_{sc \max (\text{ext. fault})} = 17 \text{ kA (given)}$
$K_{td} = 5 \text{ (from Table 2/2)}$	$K_{td} = 3 \text{ (from Table 2/2)}$	$K_{td} = 3 \text{ (from Table 2/2)}$	$K_{td} = 1.2 \text{ (from Table 2/2)}$
$K'_{ssc} \geq K_{td} \cdot \frac{I_{sc \max (\text{ext. fault})}}{I_{pn}}$ $= 5 \cdot \frac{31,378 \text{ A}}{6,000 \text{ A}} = 28.8$	$K'_{ssc} \geq K_{td} \cdot \frac{I_{sc \max (\text{ext. fault})}}{I_{pn}}$ $= 3 \cdot \frac{35,860 \text{ A}}{6,000 \text{ A}} = 17.9$	$K'_{ssc} \geq K_{td} \cdot \frac{I_{sc \max (\text{ext. fault})}}{I_{pn}}$ $= 3 \cdot \frac{7,498 \text{ A}}{1,200 \text{ A}} = 18.7$	
$R_b = \frac{S_n}{I_{sn}^2} = \frac{20 \text{ VA}}{1 \text{ A}^2} = 20 \Omega$	$R_b = \frac{S_n}{I_{sn}^2} = \frac{20 \text{ VA}}{1 \text{ A}^2} = 20 \Omega$	$R_b = \frac{S_n}{I_{sn}^2} = \frac{50 \text{ VA}}{(5 \text{ A})^2} = 2 \Omega$	
$R'_b = R_{lead} + R_{relay}$ $R_b = \frac{2 \cdot p \cdot l}{A} + 0.1 \Omega$ $= \frac{2 \cdot 0.0175 \frac{\Omega \text{ mm}^2}{\text{m}} \cdot 60 \text{ m}}{4 \text{ mm}^2}$ $+ 0.1 \Omega$ $= 0.625 \Omega$	$R'_b = R_{lead} + R_{relay}$ $R_b = \frac{2 \cdot p \cdot l}{A} + 0.1 \Omega$ $= \frac{2 \cdot 0.0175 \frac{\Omega \text{ mm}^2}{\text{m}} \cdot 640 \text{ m}}{4 \text{ mm}^2}$ $+ 0.1 \Omega$ $= 0.450 \Omega$	$R'_b = R_{lead} + R_{relay}$ $R_b = \frac{2 \cdot p \cdot l}{A} + 0.1 \Omega$ $= \frac{2 \cdot 0.0175 \frac{\Omega \text{ mm}^2}{\text{m}} \cdot 100 \text{ m}}{4 \text{ mm}^2}$ $+ 0.1 \Omega$ $= 0.975 \Omega$	$R'_b = R_{lead} + R_{relay}$ $R_b = \frac{2 \cdot p \cdot l}{A} + 0.1 \Omega$ $= \frac{2 \cdot 0.0175 \frac{\Omega \text{ mm}^2}{\text{m}} \cdot 60 \text{ m}}{4 \text{ mm}^2}$ $+ 0.1 \Omega$ $= 0.625 \Omega$
$K'_{ssc} = K_{ssc} \cdot \frac{R_{ct} + R_b}{R_{ct} + R'_b}$ $= 20 \cdot \frac{18 \Omega + 20 \Omega}{18 \Omega + 0.625 \Omega} = 40.8$	$K'_{ssc} = K_{ssc} \cdot \frac{R_{ct} + R_b}{R_{ct} + R'_b}$ $= 20 \cdot \frac{18 \Omega + 20 \Omega}{18 \Omega + 0.450 \Omega} = 41.2$	$K'_{ssc} = K_{ssc} \cdot \frac{R_{ct} + R_b}{R_{ct} + R'_b}$ $= 20 \cdot \frac{0.96 \Omega + 2 \Omega}{0.96 \Omega + 0.975 \Omega} = 30.6$	$U_K \geq K_{td} \cdot \frac{I_{sc \max (\text{ext. fault})}}{1.3 \cdot I_{pn}} \cdot (R_{ct} + R'_b) \cdot I_{sn}$ $= 1.2 \cdot \frac{17,000 \text{ A}}{1.3 \cdot 1,000 \text{ A}} \cdot (0.8 \Omega + 0.625 \Omega) \cdot 5 \text{ A}$ $= 111.8 \text{ V}$
$K'_{ssc} \text{ required} = 28.8,$ $K_{ssc} \text{ effective} = 40.8$ $28.8 < 40.8$ <p>→ CT dimensioning is ok</p>	$K'_{ssc} \text{ required} = 17.9,$ $K_{ssc} \text{ effective} = 41.2$ $17.9 < 41.2$ <p>→ CT dimensioning is ok</p>	$K'_{ssc} \text{ required} = 18.7,$ $K_{ssc} \text{ effective} = 30.6$ $18.7 < 30.6$ <p>→ CT dimensioning is ok</p>	$U_K \text{ required} = 111.8 \text{ V},$ $U_K \text{ effective} = 200 \text{ V}$ $111.8 \text{ V} < 200 \text{ V}$ <p>→ CT dimensioning is ok</p>
$F_{Adap} = \frac{I_{pn} \cdot \sqrt{3} \cdot U_{nO}}{S_{Nmax}} \cdot \frac{I_{Nrelay}}{I_{sn}}$ $= \frac{6,000 \text{ A} \cdot \sqrt{3} \cdot 13.8 \text{ kV}}{120,000 \text{ kVA}} \cdot \frac{1 \text{ A}}{1 \text{ A}}$ $= 1.195$ $\frac{1}{8} \leq 1.195 \leq 8 \rightarrow \text{ok!}$	$F_{Adap} = \frac{I_{pn} \cdot \sqrt{3} \cdot U_{nO}}{S_{Nmax}} \cdot \frac{I_{Nrelay}}{I_{sn}}$ $= \frac{6,000 \text{ A} \cdot \sqrt{3} \cdot 13.8 \text{ kV}}{240,000 \text{ kVA}} \cdot \frac{1 \text{ A}}{1 \text{ A}}$ $= 0.598$ $\frac{1}{8} \leq 0.598 \leq 8 \rightarrow \text{ok!}$	$F_{Adap} = \frac{I_{pn} \cdot \sqrt{3} \cdot U_{nO}}{S_{Nmax}} \cdot \frac{I_{Nrelay}}{I_{sn}}$ $= \frac{1,200 \text{ A} \cdot \sqrt{3} \cdot 132 \text{ kV}}{240,000 \text{ kVA}} \cdot \frac{5 \text{ A}}{5 \text{ A}}$ $= 1.143$ $\frac{1}{8} \leq 1.143 \leq 8 \rightarrow \text{ok!}$	$\frac{I_{pn \max}}{I_{pn \min}} \leq 8$ $\frac{1,500 \text{ A}}{1,000 \text{ A}} = 1.5 \leq 8 \rightarrow \text{ok!}$

Table 2/3 Example 1 (continued) – verification of the numerical differential protection

Attention (only for 7UT6 V4.0): When low-impedance REF is used, the request for the REF side (3-phase) is:

$$\frac{1}{4} \leq F_{Adap} \leq 4, \text{ (for the neutral CT: } \frac{1}{8} \leq F_{Adap} \leq 8)$$

Further condition for 7SD52x, 53x, 610 relays (when used as line differential protection without transformer inside protected zone): Maximum ratio between primary currents of CTs at the end of the protected line:

$$\frac{I_{pn \max}}{I_{pn \min}} \leq 8$$

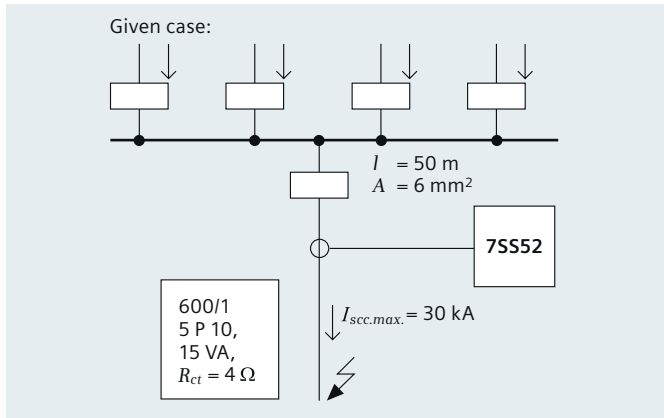


Fig. 2/94 Example 2

$$\frac{I_{scc \max}}{I_{pn}} = \frac{30,000 \text{ A}}{600 \text{ A}} = 50$$

According to Table 2/2, page 2/48 $K_{td} = 1/2$

$$K'_{ssc} \geq \frac{1}{2} \cdot 50 = 25$$

$$R_b = \frac{15 \text{ VA}}{1 \text{ A}^2} = 15 \Omega$$

$$R_{\text{relay}} = 0.1 \Omega$$

$$R_{\text{lead}} = \frac{2 \cdot 0.0175 \cdot 50}{6} = 0.3 \Omega$$

$$R'_b = R_{\text{lead}} + R_{\text{relay}} = 0.3 \Omega + 0.1 \Omega = 0.4 \Omega$$

$$K'_{ssc} = \frac{R_{ct} + R_b}{R_{ct} + R'_b} \cdot K_{ssc} = \frac{4 \Omega + 15 \Omega}{4 \Omega + 0.4 \Omega} \cdot 10 = 43.2$$

Result:

The effective K'_{ssc} is 43.2, the required K'_{ssc} is 25. Therefore the stability criterion is fulfilled.

Relay burden

The CT burdens of the numerical relays of Siemens are below 0.1 VA and can therefore be neglected for a practical estimation. Exceptions are the busbar protection 7SS60 and the pilot-wire relays 7SD600.

Intermediate CTs are normally no longer necessary, because the ratio adaptation for busbar protection 7SS52 and transformer protection is numerically performed in the relay.

Analog static relays in general have burdens below about 1 VA.

Mechanical relays, however, have a much higher burden, up to the order of 10 VA. This has to be considered when older relays are connected to the same CT circuit.

In any case, the relevant relay manuals should always be consulted for the actual burden values.

Burden of the connection leads

The resistance of the current loop from the CT to the relay has to be considered:

$$R_{\text{lead}} = \frac{2 \cdot \rho \cdot l}{A}$$

l = Single conductor length from the CT to the relay in m

Specific resistance:

$$\rho = 0.0175 \frac{\Omega \cdot \text{mm}^2}{\text{m}} \text{ (copper wires) at } 20 \text{ }^\circ\text{C} / 68 \text{ }^\circ\text{F}$$

A = Conductor cross-section in mm^2

CT design according to ANSI/IEEE C 57.13

Class C of this standard defines the CT by its secondary terminal voltage at 20 times rated current, for which the ratio error shall not exceed 10 %. Standard classes are C100, C200, C400 and C800 for 5 A rated secondary current.

This terminal voltage can be approximately calculated from the IEC data as follows:

ANSI CT definition

$$U_{s.t.\max} = 20 \cdot 5 \text{ A} \cdot R_b \cdot \frac{K_{ssc}}{20}$$

with

$$R_b = \frac{P_b}{I_{sn}^2} \text{ and } I_{Nsn} = 5 \text{ A, the result is}$$

$$U_{s.t.\max} = \frac{P_b \cdot K_{ssc}}{5 \text{ A}}$$

Example:

IEC 600/5, 5P20, 25 VA, 60044

ANSI

$$C57.13: U_{s.t.\max} = \frac{(25 \text{ VA} \cdot 20)}{5 \text{ A}} = 100 \text{ V, acc. to class C100}$$

Operating Programs

Page

DIGSI 4 an operating software
for all SIPROTEC protection relays 3/3

SIGRA 4 powerful analysis
of all protection fault records 3/9

3



SIGRA 4
Fault Record Evaluation

Version 4.51 ©2011 Siemens AG

Description

The PC operating program DIGSI 4 is the user interface to the SIPROTEC devices, regardless of their version. It is designed with a modern, intuitive user interface. With DIGSI 4, SIPROTEC devices are configured and evaluated – it is the tailored program for industrial and energy distribution systems.

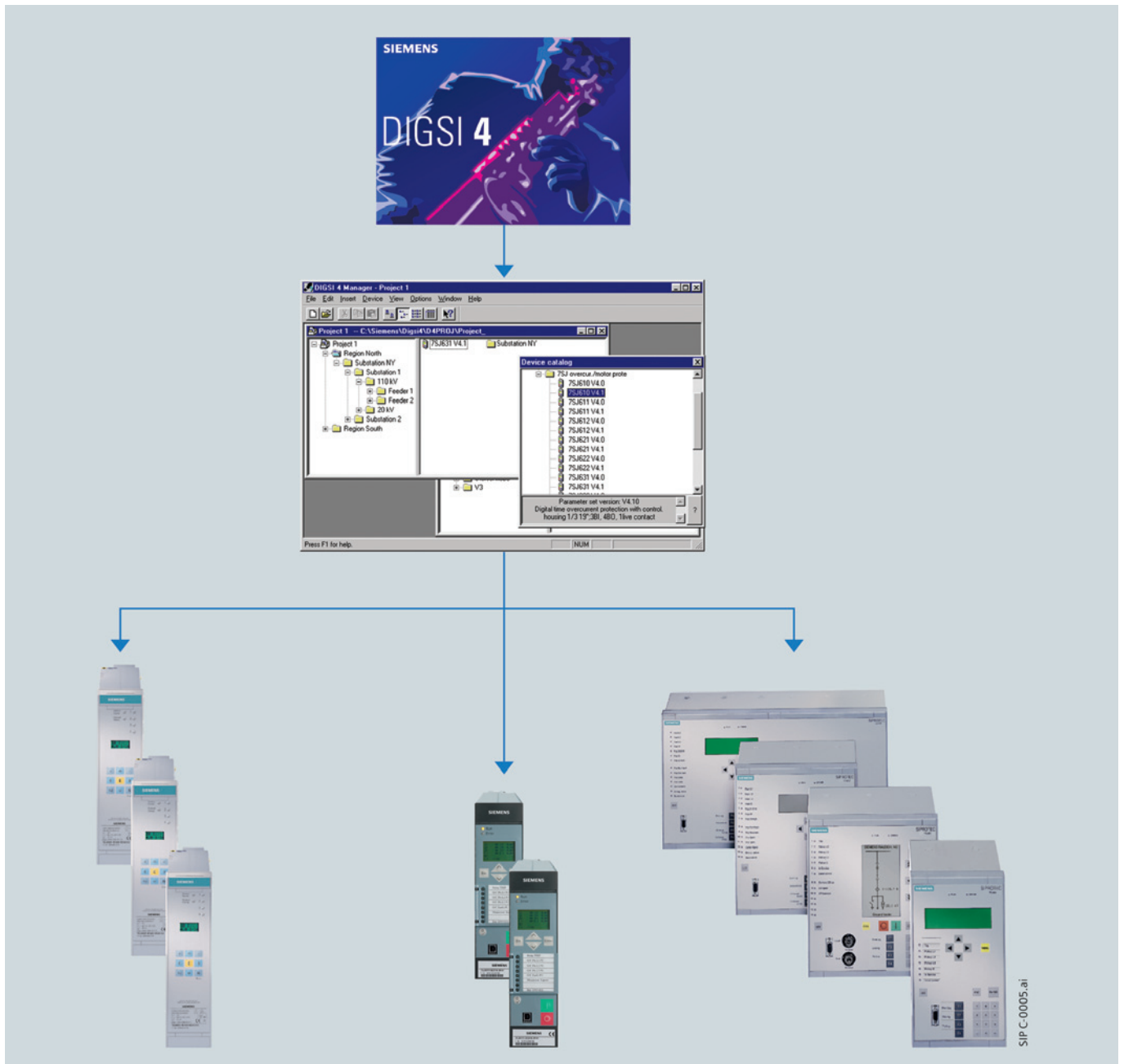


Fig. 3/1 DIGSI 4 operating program

Operating Program/DIGSI 4

Functions

Functions

Simple protection setting

From the numerous protection functions it is possible to easily select only those which are really required (see Fig. 3/2). This increases the clearness of the other menus.

Device setting with primary or secondary values

The settings can be entered and displayed as primary or secondary values. Switching over between primary and secondary values is done with one mouse click in the tool bar (see Fig. 3/2).

Assignment matrix

The DIGSI 4 matrix shows the user the complete configuration of the device at a glance (Fig. 3/3). For example, the assignment of the LEDs, the binary inputs and the output relays are displayed in one image. With one click, the assignment can be changed.

CFC: Projecting the logic instead of programming

With the CFC (continuous function chart), it is possible to link and derive information without software knowledge by simply drawing technical processes, interlocks and operating sequences.

Logical elements such as AND, OR, timers, etc., as well as limit value requests of measured values are available (Fig. 3/4).

Commissioning

Special attention has been paid to commissioning. All binary inputs and outputs can be set and read out in targeted way. Thus, a very simple wiring test is possible. Messages can be sent to the serial interface deliberately for test purposes.

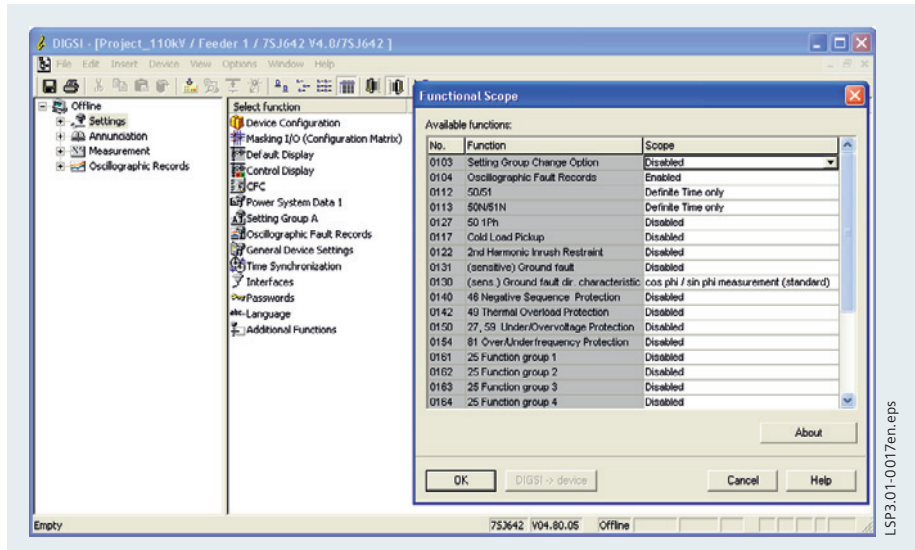


Fig. 3/2 Main menu, selection of protection functions

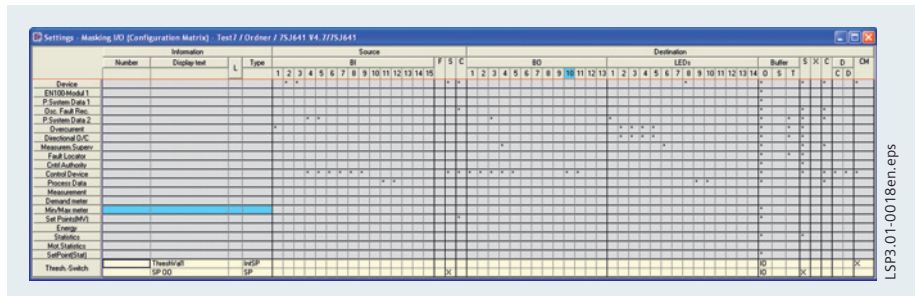


Fig. 3/3 DIGSI 4, assignment matrix

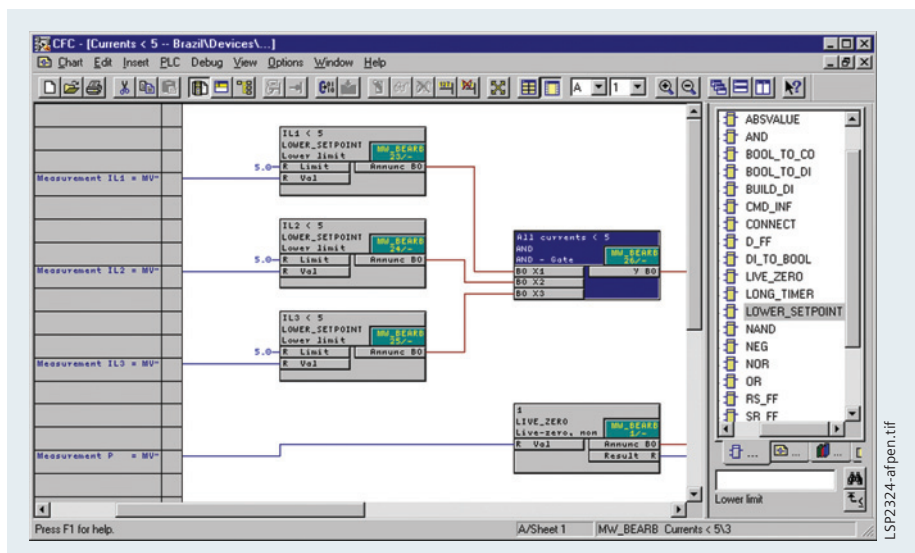


Fig. 3/4 CFC plan

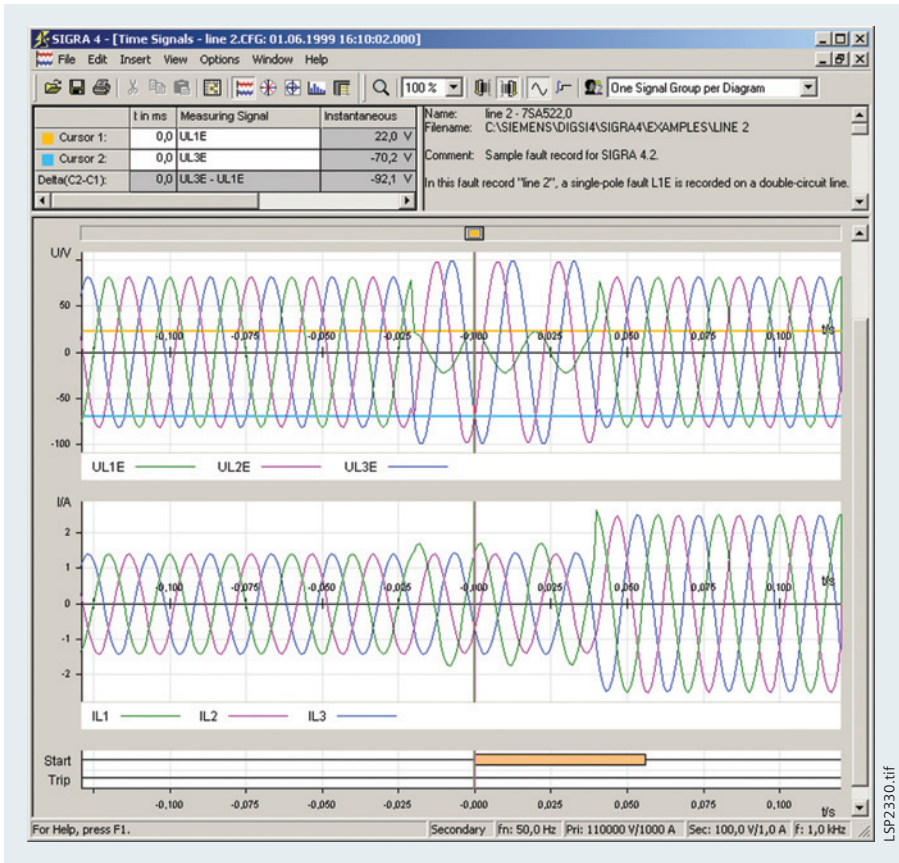


Fig. 3/5 Typical time-signal representation

IEC 61850 system configurator

The IEC 61850 system configurator, which is started out of the system manager, is used to determine the IEC 61850 network structure as well as the extent of data exchange between the participants of an IEC 61850 station. To do this, subnets are added in the "network" working area – if required, available participants are assigned to the subnets, and addressing is defined. The "assignment" working area is used to link data objects between the participants, e.g., the starting message of the V inverse-time overcurrent protection $I>$ -function of feeder 1, which is transferred to the incoming supply in order to prompt the reverse interlocking of the V inverse-time overcurrent protection $I>>$ function there (see Fig. 3/6).

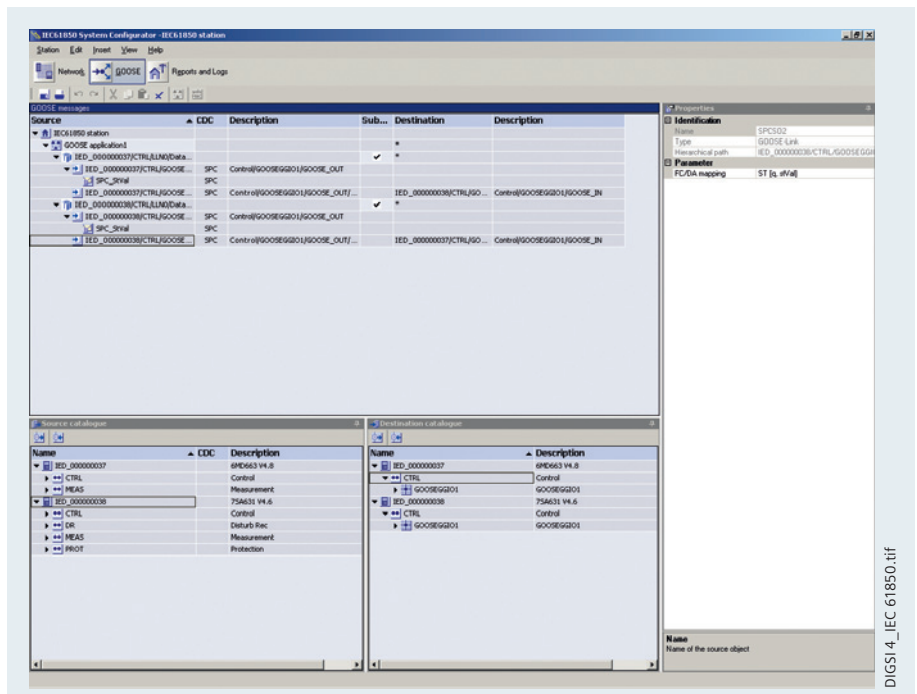


Fig. 3/6 IEC 61850 system configurator

Operating Program/DIGSI 4

Selection and ordering data

3

Variants	Order No.
DIGSI 4 Software for projecting and usage of all Siemens protection devices is running under MS Windows XP Prof. / MS Windows Server 2008 R2, MS Windows 7 Professional and Ultimate/Enterprise. See product information for supported Service packs of operating systems. Incl. device templates, online manual and DIGSI cable for all device types. Start Up manual (paper) Incl. service (upgrade, update, hotline) Operator language: German, English, French, Spanish, Italian, Chinese, Russian, Turkish are included. Delivery on DVD-ROM	
Basic Basic version with license for 10 computers (authorisation by serial number)	7XS5400-0AA00
Professional Basic version and additionally SIGRA (Fault record analysis), CFC Editor (Logic editor), Display Editor (Editor for control displays) and DIGSI 4 Remote (Remote operation) with license for 10 computers (authorisation by serial number)	7XS5402-0AA00
DIGSI 4 Professional + IEC 61850 Professional version and IEC 61850 System Configurator with license for 10 computers (authorisation by serial number)	7XS5403-0AA00
Upgrade from DIGSI 4 Basis to DIGSI 4 Professional	7XS5407-0AA00
Upgrade from DIGSI 4 Basis to DIGSI 4 Professional + IEC61850	7XS5408-0AA00
SIPROTEC 4 Tutorial Multimedia information and training for: SIPROTEC 4, DIGSI 4, SIGRA 4 and IEC 61850 Incl. trial software, manuals and catalogs	E50001-U310-D21-X-7100
DIGSI 4 Trial like DIGSI 4 Professional + IEC 61850, but <u>only</u> valid for 30 days (test version) (no authorisation required)	7XS5401-1AA00

Variants	Order No.
<p>DIGSI 4 Scientific like DIGSI 4 Professional + IEC 61850, only for university-level institutions with license for 10 PCs (authorisation by serial number)</p>	7XS5402-2AA00
<p>DIGSI 4 DVD Update Latest version of DIGSI 4 DVD includes DIGSI 4 and IEC 61850 System Configurator and SIGRA Incl. the latest Service packs. Current content of DIGSI 4 Update DVD can be found at www.siemens.com/siprotec</p>	7XS5490-0AA00
<p>IEC 61850 System Configurator Software for configuration of substations via IEC 61850-communication is running MS Windows XP Prof./ MS Windows Server 2008 R2, MS Windows 7 Professional and Ultimate/Enterprise. See product information for supported Service packs of operating systems Incl. electronic help Incl. service (update, hotline) Operator language: German, English, French, Spanish, Italian, Chinese, Russian, Turkish are included.</p>	
<p>IEC 61850 System Configurator for DIGSI 4 Professional Upgrade from DIGSI 4 Prof. to DIGSI 4 Prof. + IEC 61850 version with license for 10 computers (authorisation by serial number) For ordering the specification of a DIGSI 4 license number is required.</p>	7XS5460-0AA00
<p>IEC 61850 System Configurator for Reyrolle devices with license for 10 PCs. Installation without DIGSI 4 (authorization by serial number) Delivery on DVD-ROM</p>	7XS5461-0AA00
<p>GOOSE Inspector for IEC 61850 Ethernet station bus with license for 1 PC PC-tool for online-monitoring of IEC 61850 GOOSE-telegrams Checking of all GOOSE connections on the station bus and validation with the configured connections in the system configurator (SCD) Contains installation CD with USB-dongle Recommended system requirements: Windows XP, 32 Bit, SP2 or SP3 Duo CPU at least 1.6 GHz; RAM 2 GB Network interface (Ethernet LAN, TCP/IP) Supported languages: English, German</p>	7XS5900-0AA00



Fig. 3/7 Typical time-signal representation

Description

It is of crucial importance after a line fault that the fault is quickly and fully analyzed so that the proper measures can be immediately derived from the evaluation of the cause. As a result, the original line condition can be quickly restored and the downtime reduced to an absolute minimum. It is possible with SIGRA 4 to display records from digital protection units and fault recorders in various views and measure them, as required, depending on the relevant task.

In addition to the usual time-signal display of the measured variables record, it is also designed to display vector diagrams, circle diagrams, bar charts for indicating the harmonics and data tables. From the measured values which have been recorded in the fault records, SIGRA 4 calculates further values, such as: absent quantities in the three-wire system, impedances, outputs, symmetrical components, etc. By means of two measuring cursors, it is possible to evaluate the fault trace simply and conveniently. With SIGRA, however, you can add additional fault records. The signals of another fault record (e.g. from the opposite end of the line) are added to the current signal pattern by means of Drag & Drop. SIGRA 4 offers the possibility to display signals from various fault records in one diagram and fully automatically synchronize these signals to a common time base. In addition to finding out the details of the line fault, the localization of the fault is of special interest.

A precise determination of the fault location will save time that can be used for the on-site inspection of the fault. This aspect is also supported by SIGRA 4 – with its "offline fault localization" feature.

SIGRA 4 can be used for all fault records using the COMTRADE file format.

The functional features and advantages of SIGRA 4 can, however, only be optimally shown on the product itself. For this reason, it is possible to test SIGRA 4 for 30 days with the trial version.

Function overview

- 6 types of diagrams: time signal representation (usual), circle diagram (e.g. for R/X), vector diagram (reading of angles), bar charts (e.g. for visualization of harmonics), table (lists values of several signals at the same instant) and fault locator (shows the location of a fault)
- Calculate additional values such as positive impedances, r.m.s. values, symmetric components, vectors, etc.
- Two measurement cursors, synchronized in each view
- Powerful zoom function
- User-friendly configuration via drag & drop
- Innovative signal configuration in a clearly-structured matrix
- Time-saving user profiles, which can be assigned to individual relay types or series
- Addition of other fault records to the existing fault record
- Synchronization of several fault records to a common time basis
- Easy documentation by copying diagrams to documents of other MS Windows programs
- Offline fault localization

Hardware requirements

- Pentium 4 with 1-GHz processor or similar
- 1 GB of RAM (2 GB recommended)
- Graphic display with a resolution of 1024 x 768 (1280 x 1024 recommended)
- 50 MB free storage space on the hard disk
- DVD-ROM drive
- Keyboard and mouse

Software requirements

- MS Windows XP Professional
- MS Windows Server 2008 R2 used as a Workstation computer
- MS Windows 7 Professional and Enterprise Ultimate

Functions

Different views of a fault record

In addition to the standard time signal representation, SIGRA 4 also supports the display of circle diagrams (e.g. R/X diagrams), vectors, which enable reading of angles, and bar charts (e.g. for visualization of harmonics). To do this, SIGRA uses the values recorded in the fault record to calculate additional values such as positive impedances, r.m.s. values, symmetric components, vectors, etc.

Measurement of a fault record

Two measurement cursors enable fast and convenient measurement of the fault record. The measured values of the cursor positions and their differences are presented in tables. The cursors operate interactively and across all views, whereby all cursor movement is synchronized in each view: In this manner, the cursor line enables simultaneous "intersection" of a fault occurrence in both a time signal characteristic and circle diagram characteristic. And of course a powerful zoom function ensures that you do not lose track of even the tiniest detail. The views of SIGRA 4 can accommodate any number of diagrams and in each diagram any number of signals.

Operational features

The main aim of the developers of SIGRA 4, who were assisted by ergonomic and design experts, was to produce a system that was simple, intuitive and user-friendly:

- The colours of all the lines have been defined so that they are clear and easily distinguishable. However, the colour, as well as the line style, the scale and other surface features, can be adjusted to suit individual requirements.
- Pop-up menus for each situation offer customized functionality – thus eliminating the need to browse through numerous menu levels (total operational efficiency).
- Configuration of the individual diagrams is simple and intuitive: object-oriented, measured variables can be simply dragged and dropped from one diagram to another (also diagrams of different types).

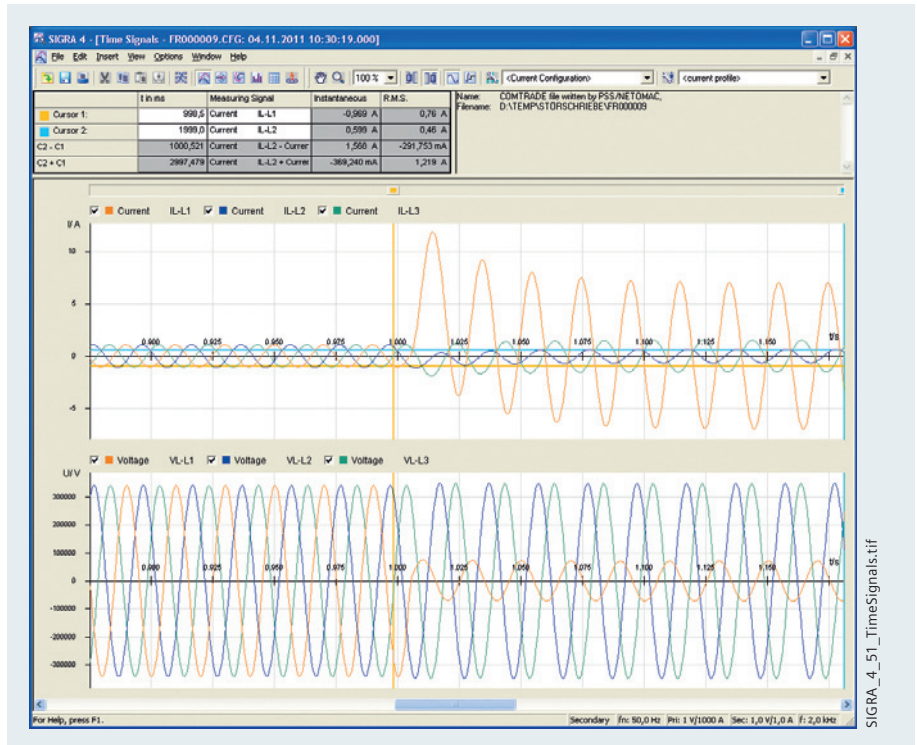


Fig. 3/8 Typical time signal representation

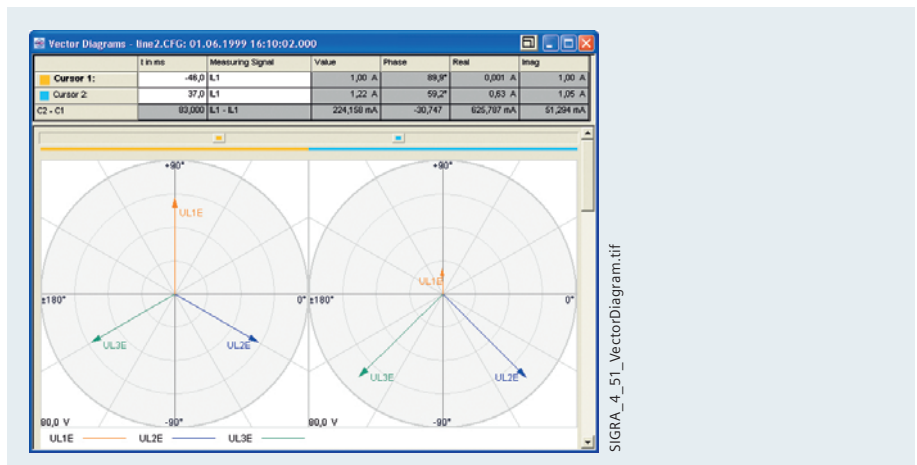


Fig. 3/9 Vector diagrams

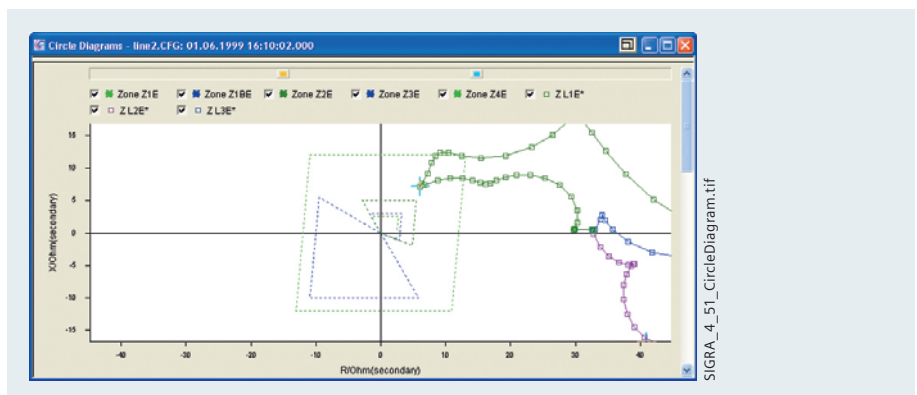


Fig. 3/10 Circle diagram

- “Snap-to-grid” and “snap-to-object” movement of the cursor lines for easy and accurate placement.
- Redundancy: Most user tasks can be achieved via up to five different operational methods, thus ensuring quick and easy familiarization with the analysis software.
- Utilization of the available screen space is automatically optimized by an intelligent function that, like the “synchronous mouse cursors”, has since been patented.

User friendly tools support you in your daily work:

- Storage of user defined views (e.g. zoom, size), in so-called user profiles and to assign them to individual relay types or series. Then simply select from the toolbar and you can display each fault record quickly and easily as required. No need to waste time scrolling, zooming or resizing and moving windows.
- Additional fault records, e.g. from the other end of a line, can be added to existing records.
- A special function allows several fault records to be synchronized on a mutual time basis, thus considerably improving the quality of fault analysis.
- Fault localization with data from one line end the fault record data (current and voltage measurement) values are imported from the numerical protection unit into SIGRA 4. The fault localisator in SIGRA 4 is then started by the user and the result represented in % or in km of the line length, depending on the parameters assigned.
- Fault localization with data from both line ends. The algorithm of the implemented fault location does not need a zero-phase sequence system. Thus, measuring errors due to ground impedance or interference with the zero current of the parallel line are ruled out. Errors with contact resistance on lines with infeed from both ends are also correctly recorded. The above influences are eliminated due to the import of fault record data from both line ends into SIGRA. For this purpose, the imported data are synchronized in SIGRA and the calculation of the fault location is then started. Consequently, fault localization is independent from the zero-phase sequence system and the line infeed conditions and produces precise results to allow as fast an inspection of the fault location as possible.

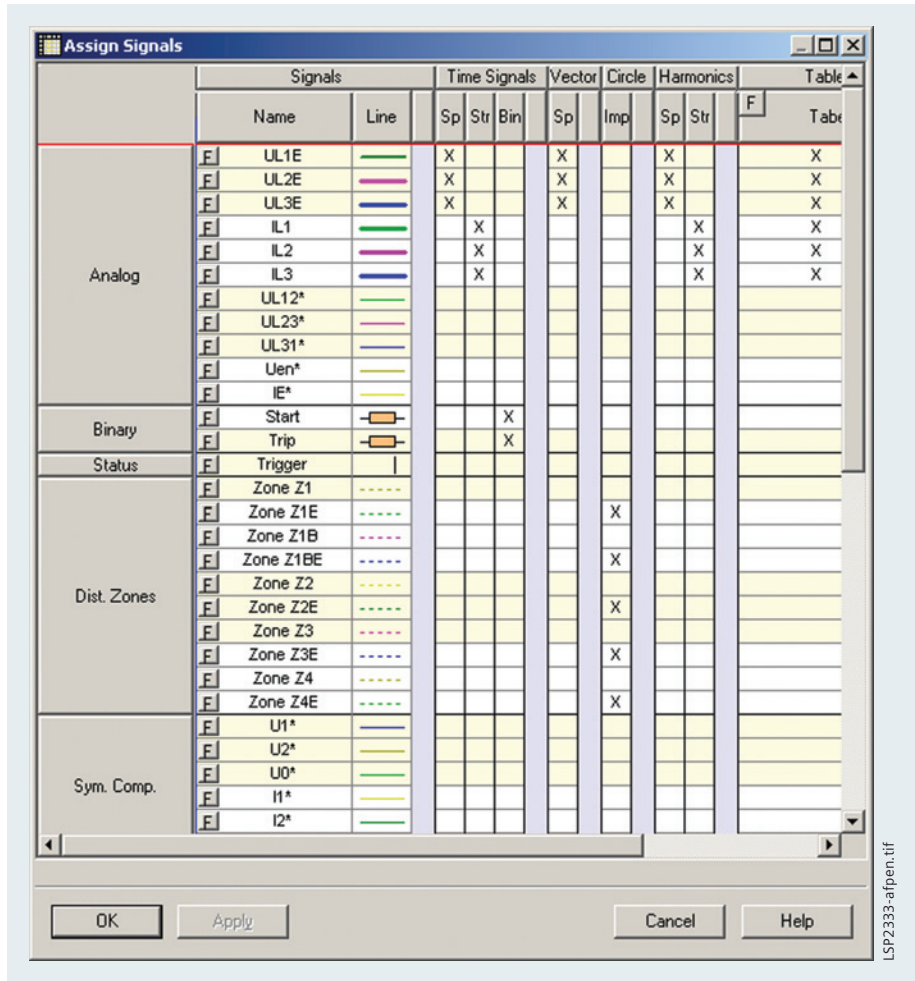


Fig. 3/11 Concise matrix for assigning signals to diagrams

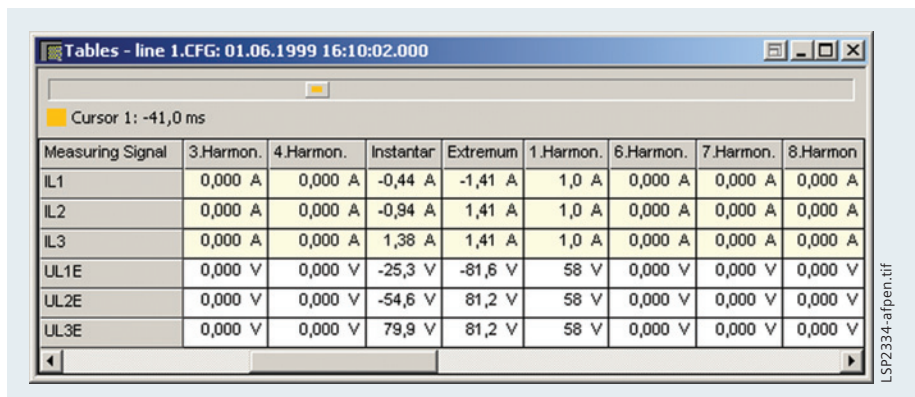


Fig. 3/12 Table with values at a definite time

- So-called marks, which users can insert at various instants as required, enable suitable commentary of the fault record. Each individual diagram can be copied to a document of another MS Windows program via the “clipboard”: documenting fault records really could not be easier.

Scope of delivery

The software product is quick and easy to install from a CD-ROM. It has a comprehensive “help” system. An user-friendly and practical manual offers easy step-by-step instructions on how to use SIGRA.

Operating Program / SIGRA 4

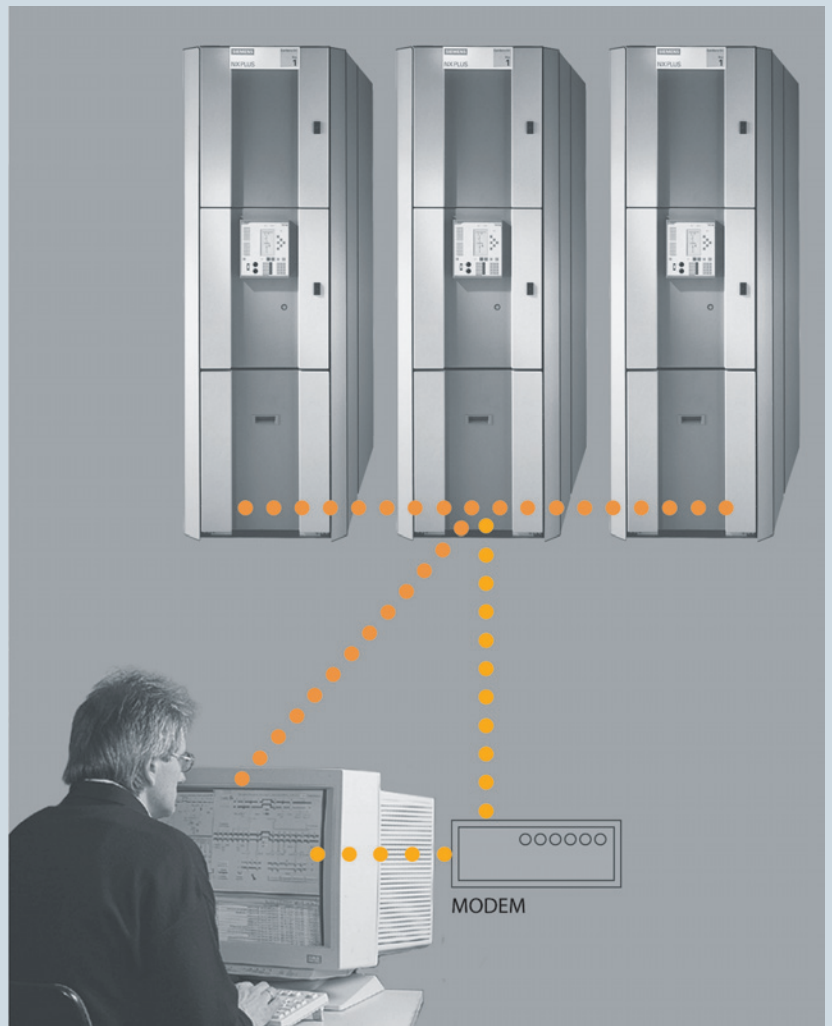
Selection and ordering data

3

Variants	Order No.
SIGRA 4 Software for graphic visualisation, analysis and evaluation of fault and measurement records is running under MS Windows XP Prof./MS Windows Server 2008 R2, MS Windows 7 Professional and Ultimate/Enterprise. See product information for supported Service packs of operating systems. Incl. templates, online manual Incl. service (upgrade, update, hotline) Operator language: German, English, French, Spanish, Italian, Chinese, Russian, Turkish are included. Incl. multimedia tutorial on separate CD. Delivery on DVD-ROM	
SIGRA 4 for DIGSI with license for 10 PCs (authorisation by serial number) For ordering the specification of a DIGSI 4 serial number is required.	7XS5410-0AA00
SIGRA 4 Stand Alone with license for 10 PCs. Installation without DIGSI 4 (authorisation by serial number)	7XS5416-0AA00
SIGRA 4 Scientific Installation without DIGSI 4 only for university-level institutions with license for 10 PCs (authorisation by serial number)	7XS5416-1AA00
SIGRA 4 Trial like SIGRA 4 Stand Alone, but only valid for 30 days (test version) (no authorisation required)	7XS5411-1AA00
Upgrade SIGRA 4 Trial to SIGRA 4 Stand Alone like SIGRA 4 Stand Alone. For customers who want to unlock their trail version. With license for 10 PC	7XS5416-2AA00

Communication

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Integration into the SICAM power automation system	4/9
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Integration into the SICAM PAS power automation system	4/11
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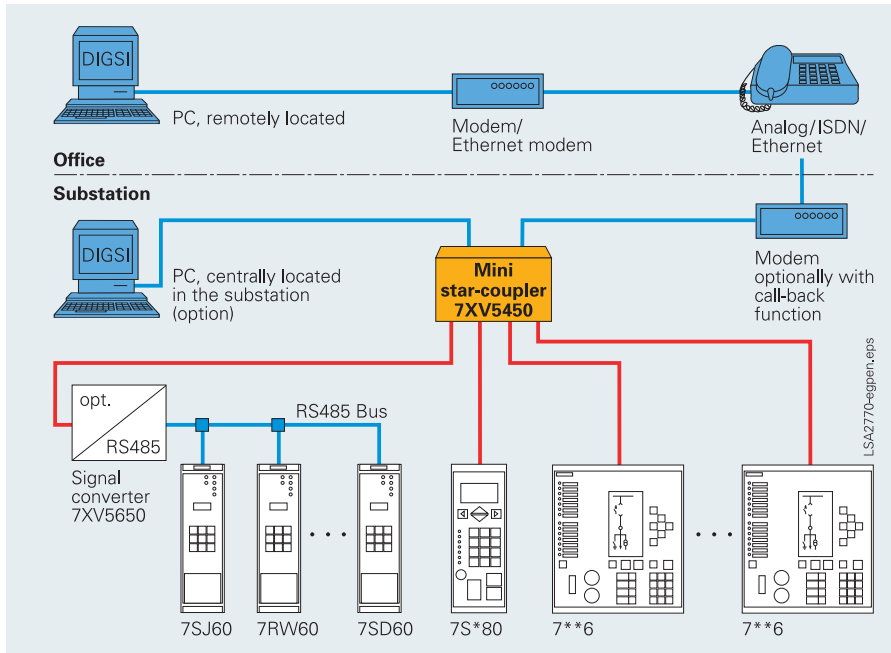


Fig. 4/1 Communication structure

Description

Communication interfaces on protection relays are becoming increasingly important for the efficient and economical operation of substations and networks. The interfaces can be used for:

- Accessing the protection relays from a PC using the DIGSI operating program. Remote access via modem, Ethernet modem is possible with a serial service port at the relay. This allows remote access to all data of the protection relay.
- Integrating the relays into control systems with IEC 60870-5-103 protocol, PROFIBUS-FMS protocol, PROFIBUS-DP protocol, DNP 3.0 protocol, MODBUS protocol, DNP3 TCP, PROFINET and Redundancy protocols for Ethernet (RSTP; PRP and HSR). The standardized IEC 61850 protocol is available since Oct. 2004 and with its SIPROTEC units Siemens has provided this standard as the first manufacturer worldwide.
- Peer-to-peer communication of differential relays and distance relays to exchange real-time protection data via fiber-optic cables, communication network, telephone networks or analog pilot wires.

Function overview

Description

- Remote communication with DIGSI
- Remote communication with SIPROTEC 4 units
- Remote communication with SIPROTEC 3 units and SIPROTEC '600 units

Typical applications

- SIPROTEC 4 units on an RS485 bus
- SIPROTEC 4 units with FO/RS485
- Mixed system SIPROTEC 4,
- SIPROTEC 3 units,
- SIPROTEC '600 units
- Configuration with active star-coupler

Integration into substation control systems

Integration into the SICAM power automation system

Integration into other systems

Description

Description

Remote communication with DIGSI

By using the remote communication functions of DIGSI it is possible to access relays from your office via the telephone network. So you do not have to drive to the substation at all and, if you need to carry out a quick fault analysis, for example, you can transfer the fault data into your office in just a few minutes so that you can use DIGSI to evaluate it.

Another alternative is the ability to access all the units of a substation from a central point within that station. This saves you having to connect your PC individually to all the relays in the station.

In both cases you need a few simple communication units and a PC with DIGSI and a remote communication component installed. The data traffic with DIGSI uses a secure protocol based on the IEC standard similar to IEC 60870-5-103 so that, amongst other things, the relays have unique addresses for accessing purposes.

A high level of data integrity is achieved through the check sum incorporated in the telegram. Any telegrams that might become distorted during transmission are repeated. A comparison of parameters between relay and PC to ensure that they match also improves the integrity. There are other security functions too such as passwords and a substation modem callback function which can also be triggered from events.

Remote communication with SIPROTEC 4 units

SIPROTEC 4 units are well equipped for remote communication. A separate serial service interface for the protection engineer, independent of the system interface, allows the units to be easily integrated into any communication configuration. The front interface then remains free for local operation. Together with a flexibility in the choice of interface, i.e. optical with an ST connector for multi-mode FO cables or electrical for RS232 or RS485 hard-wired connections, it is easy to create the optimum solution for any particular application.

With SIPROTEC 4 units you can also use PROFIBUS-FMS to provide a central link with DIGSI via the control system interface. For this you will need a PC with a special PROFIBUS card that must be connected to the PROFIBUS system. This solution is intended exclusively for SIPROTEC 4 units with PROFIBUS-FMS.

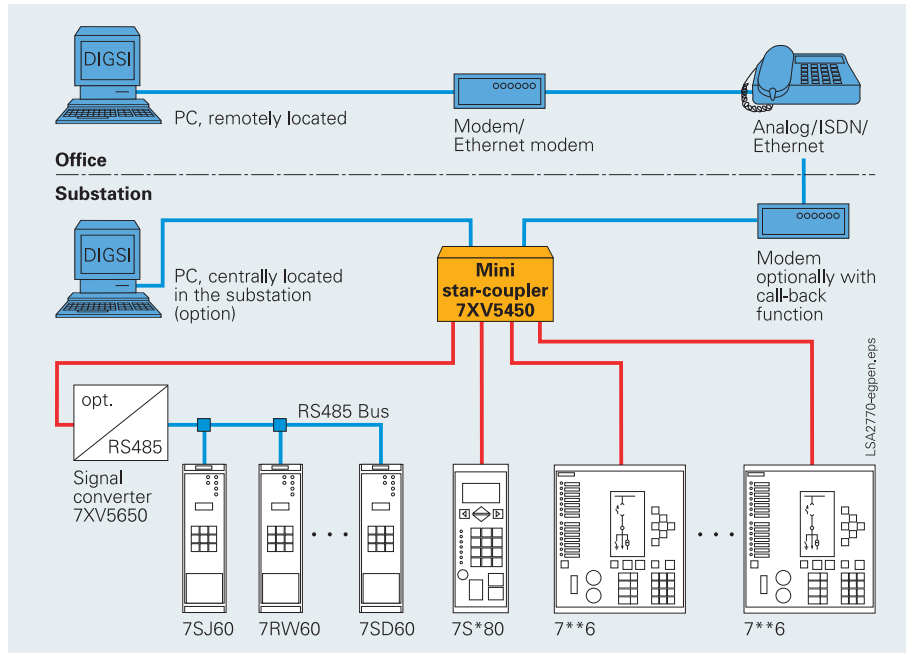


Fig. 4/2 Remote relay communication

Since Oct. 2004, a relay can be accessed remotely with DIGSI via an Ethernet interface in the relay and with the IEC 61850 protocol. This allows access to the relays via an Ethernet network. Some relays include a Web server, so an Internet browser can also be used for remote access via Ethernet.

Remote communication with SIPROTEC 3 and series '600 relays

These relays are ideal for applications involving remote communication. When configuring the actual communication system, however, it is important to take into account the smaller number of relay interfaces compared with SIPROTEC 4 units.

In the case of SIPROTEC 3 units, communication is normally effected via the system interface at the back of the unit. If this interface is already being used for communication with the substation control system, the front interface can be used for the DIGSI communication instead. A suitable connector module is available to convert from electrical to optical interface.

Series '600 relays normally have one RS485 interface which can be used for communication either with the substation control system or with DIGSI.

SIPROTEC series '80 relays offer the same features regarding communication possibilities as SIPROTEC 4 devices.

Typical applications

An extensive range of communication components, such as modems, star couplers, optoelectric converters, prefabricated FO connection cables and electric connection cables (see part 13 of this catalog) allows you to create a variety of different solutions: FO connections immune to interference or cost-effective solutions using the two-wire RS485 electric bus.

The following examples give some indication of what configurations are possible, which items are needed for the purpose and what baud rates are possible.

Example 1: SIPROTEC 4 units on an RS485 bus

Remote communication is effected via a private or public telephone network with both analog or digital telephone lines being possible. An Ethernet network can also be used together with Ethernet modems. The 8N1 data format and an analog baud rate of 57.6/64 kbit/s have become established as the standard for serial modem links. The connection between modem and units is initially optical. An FO/RS485 converter 7XV5650 that can be installed close to the units then converts the signals for the RS485 bus. Up to 31 relays can be connected to the RS485 bus. Particularly in the case of modems, we recommend the use of the types of units listed in part 13.

Example 2: SIPROTEC 4 units with FO/RS485

In the case of larger substations with longer distances we recommend the use of FO connection cables. The following example shows a mixed system of optical and electrical connections. Typically, all relays in a cubicle can be linked together via RS485 and the cubicles themselves can be connected to the star coupler via FO cables (see Fig. 4/4).

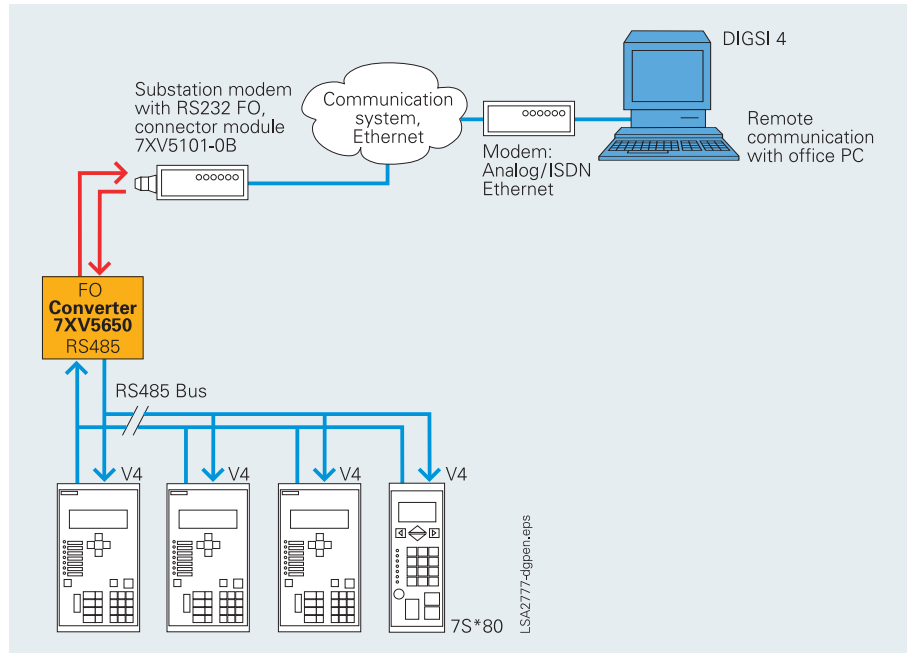


Fig. 4/3 SIPROTEC 4 units on an RS485 bus (Example 1)

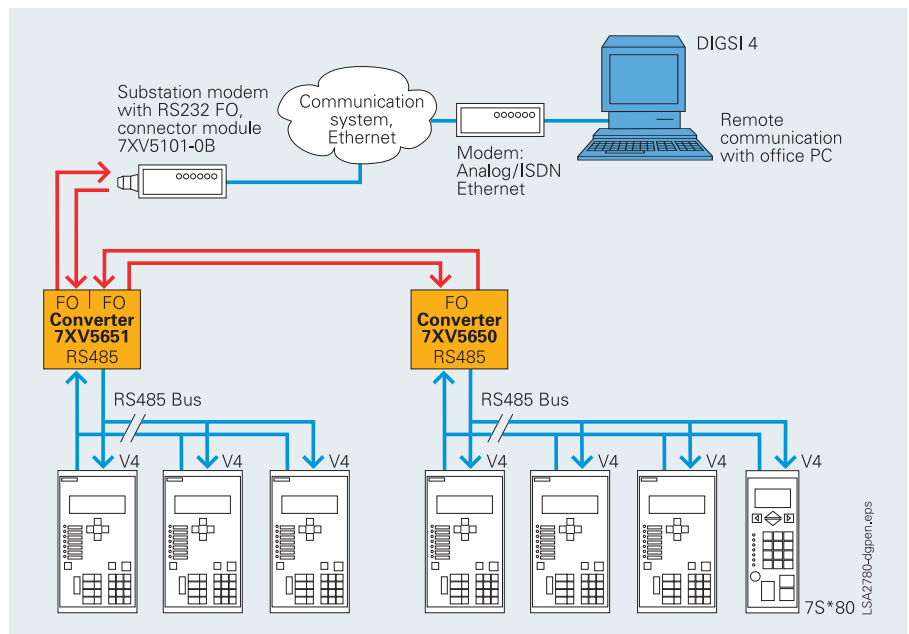


Fig. 4/4 Two groups of SIPROTEC 4 units on an RS485bus (Example 2)

Example 3: Mixed system – SIPROTEC 4, SIPROTEC 3, series '600

Relays from different families can be integrated into a remote communication system, as illustrated in Example 3 (see Fig. 4/5). This example also shows how relays can be integrated by means of FO links and star couplers. With this kind of arrangement the baud rate for all links must be set at 19.2 kbaud because the SIPROTEC 3 units and the series '600 relays cannot support a higher baud rate. In this case we recommend to use the 7XV5550 active mini star-coupler (see Fig. 4/6).

Communication will then generally be at 57.6/64 kbit/s on the modem link. For any units that cannot operate at this baud rate the active star-coupler will convert the rate accordingly.

Example 4: Configuration with active star-coupler

With this configuration it is also possible to integrate relays that can only be connected via the front interface and whose maximum baud rates are less than 19.2 kbaud (see Fig. 4/6).

The following points must be noted with this type of configuration:

- One output of the active mini star-coupler is used to service several SIPROTEC 4 units through further star couplers or RS485 converters. On that output, a mixed system containing SIPROTEC 3 and series '600 relays should be avoided so that 57600 baud operation is possible for SIPROTEC 4 relays.
- Several SIPROTEC 3 units and series '600 relays can also be connected to another output of the active mini star-coupler (via mini star-couplers or RS485 converters). The baud rate for this output must be set less or equal to 19200 baud.
- Relays that are not available with communication functions according to IEC 60870-5-103 protocol (e.g. 7VE51, 7VK51, 7SV51 and older firmware versions of some relays) can also be connected via the active star-coupler as illustrated in Fig. 4/6. In this case one output must be assigned to each relay. The baud rate must be set according to the unit.

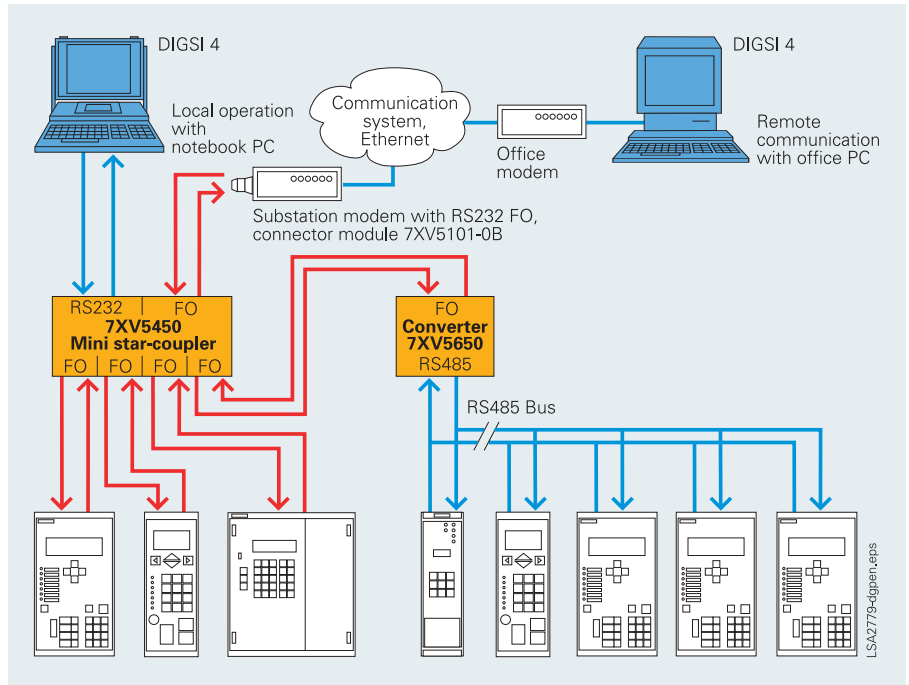


Fig. 4/5 Mixed system, FO/RS485 with units from different families (Example 3)

The solutions for central and/or remote communication with SIPROTEC units have easy upgrade compatibility. Different versions of relays can be integrated into a remote communication concept. This is supported by the substation and device management in the DIGSI software. A substation can be retrofitted with add-on remote communication components provided it has the communication connection available. And changing of the telephone line from, say, analog to digital does not necessitate the replacement of all components. Also, Ethernet networks can be used. The telephone modem is then replaced by an Ethernet modem. The infrastructure in the substation remains unchanged.

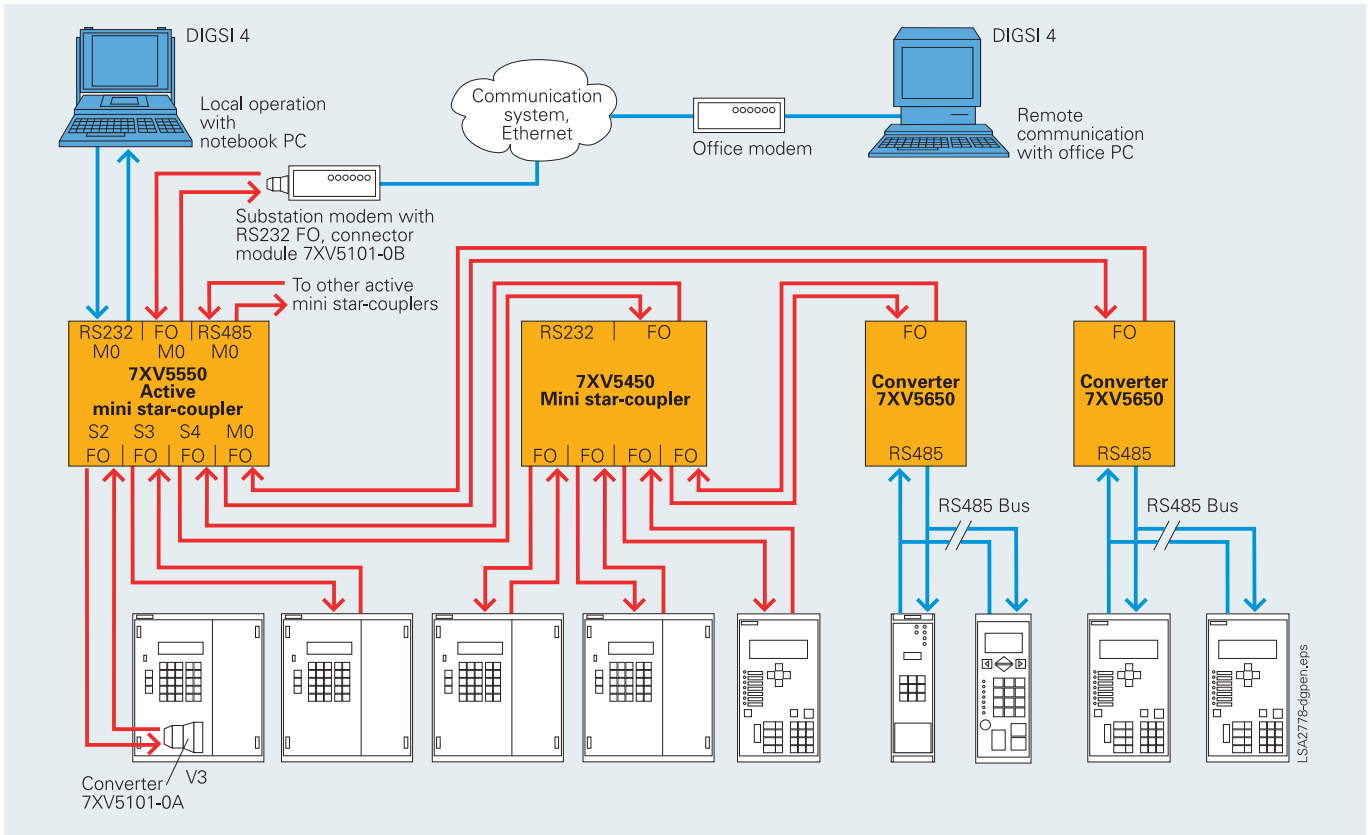


Fig. 4/6 Mixed system with relays from different families, with active star-coupler (Example 4)

Integration into substation control systems

Almost all SIPROTEC units can be integrated into substation control systems via communication interfaces.

The relays can be supplied as part of an integrated Siemens system offering all substation control and protection. In addition, the relays can also be integrated into other control systems via standard protocols. An integrated system offers type-tested functions, consistent configuration and optimally coordinated communication protocols. SICAM PAS and SICAM RTUs are proven systems available from Siemens. These systems, also offer Ethernet communication with IEC 61850.

For situations where you would like to integrate SIPROTEC units into other control systems we can offer open communication interfaces. In addition to the IEC 60870-5-103 protocol that is available in almost all relays we can also offer other communication protocols for SIPROTEC 4 units like PROFIBUS-DP, MODBUS, DNP 3.0, DNP3 TCP, PROFINET and Redundancy protocols for Ethernet (RSTP;PRP and HSR).

An overview which communication protocols are available in the various SIPROTEC relays can be found in the Internet at www.siemens.com/siprotec or in the catalog "Selection Guide for SIPROTEC and Reyrolle" order no. IC1000-K4456-A101-Ax-7600

IEC 61850 protocol

Since Oct. 2004, the Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations, Siemens was the first manufacturer to support the protocol in its devices. By means of this protocol, information can also be exchanged directly between bay units so as to enable the creation of simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus is also possible with DIGSI.

It will also be possible to retrieve operating and fault messages and fault recordings via a browser. This Web monitor will also provide a few items of unit specific information in browser windows.

IEC 60870-5-103 protocol

The IEC 60870-5-103 protocol is an international standard for the transmission of protective data and fault recordings. All messages from the unit (and also control commands) can be transferred via published, Siemens-specific extensions.

PROFIBUS-DP protocol

PROFIBUS-DP is the most widespread protocol in industrial automation. Via PROFIBUS-DP, SIPROTEC units make their information available to a SIMATIC controller or, in the control direction, receive commands from a central SIMATIC. Measured values can also be transferred. The information is assignable to a mapping file with DIGSI.

MODBUS RTU protocol

This uncomplicated, serial protocol is mainly used in industry and by power supply corporations, and is supported by a number of unit vendors. SIPROTEC units behave as MODBUS slaves, making their information available to a master or receiving information from it. Information is assignable to a mapping file with DIGSI.

DNP 3.0 protocol

Power utilities use the serial DNP 3.0 (Distributed Network Protocol) for the station and network control levels. SIPROTEC units function as DNP slaves, supplying their information to a master system or receiving information from it.

DNP3 TCP

The ethernet-based TCP variant of the DNP3 protocol is supported with the electrical and optical ethernet module. Two DNP3 TCP clients are supported. Redundant ring structures can be realized for DNP3 TCP with the help of the integrated switch in the module. For instance, a redundant optical ethernet ring can be constructed. Single-point indications, double-point indications, measured and metered values can be configured with DIGSI 4 and are transmitted to the DNPI client. Switching commands can be executed in the controlling direction. Fault records of the device are stored in the binary Comtrade format and can be retrieved via the DNP 3 file transfer. The time synchronization is performed via the DNPI client or SNTP. The device can also be integrated into a network monitoring system via the SNMP V2 protocol. Parallel to the DNP3 TCP protocol the IEC 61850 protocol (the device works as a server) and the GOOSE messages of the IEC 61850 are available for the intercommunication between devices.

PROFINET

PROFINET is the ethernet-based successor of Profi bus DP and is supported in the variant PROFINET IO. The protocol which is used in industry together with the SIMATIC systems control is realized on the optical and electrical Plus ethernet modules which are delivered since November 2012. All network redundancy procedures which are available for the ethernet modules, such as RSTP, PRP or HSR, are also available for PROFINET. The time synchronization is made via SNTP. The network monitoring is possible via SNMP V2 where special MIB files exist for PROFINET. The LLDP protocol of the device also supports the monitoring of the network topology. Single-point indications, double-point indications, measured and metered values can be transmitted cyclically in the monitoring direction via the protocol and can be selected by the user with DIGSI 4. Important events are also transmitted spontaneously via configurable process alarms. Switching commands can be executed by the system control via the device in the controlling direction. The PROFINET implementation is certified. The device also supports the IEC 61850 protocol as a server on the same ethernet module in addition to the PROFINET protocol. Client server connections are possible for the intercommunication between devices, e.g. for transmitting fault records and GOOSE messages.

Redundancy protocols for Ethernet (RSTP; PRP and HSR)

The redundancy protocols RSTP, PRP and HSR can be loaded and activated easily via software on the existing optical Ethernet modules. PRP and HSR guarantee a redundant, uninterruptible and seamless data transfer in Ethernet networks without extensive parameter settings in the switches.

	Substation control port B							Port C
	IEC 61850	IEC 60870-5-103	PROFIBUS-DP	MODBUS	DNP 3.0	DNP3 TCP ⁴⁾	PROFINET ⁴⁾	DIGSI
Alarms (relay → central unit)	✓ with time stamp	✓ with time stamp	✓ with time stamp	✓ with time stamp	✓ with time stamp	✓ with time stamp	✓ with time stamp	✓ with time stamp
Commands (BC/central unit → relay)	✓	✓	✓	✓	✓	✓	✓	✓
Measured values	✓	✓	✓	✓	✓	✓	✓	✓
Time synchronization	✓	✓	✓	✓	✓	✓	✓	1)
Fault records (sampled values)	✓	✓	Separate port (with DIGSI) ²⁾	Separate port (with DIGSI) ²⁾	Separate port (with DIGSI) ²⁾	✓	Separate port (with DIGSI) ³⁾	
Protection settings	✓ (with DIGSI)	Separate port (with DIGSI) ³⁾	Separate port (with DIGSI) ³⁾	Separate port (with DIGSI) ³⁾	Separate port (with DIGSI) ³⁾	Separate port (with DIGSI) ³⁾	Separate port (with DIGSI) ³⁾	✓
Parameter group switchover	✓	✓	✓	✓	✓	✓	✓	✓
RSTP/PRP/HSR	✓					✓	✓	

- 1) There is no time synchronization via this protocol. For time synchronization purposes it is possible to use a separate time synchronization interface (Port A in SIPROTEC 4 relays).
- 2) The transmission of fault records is not part of the protocol. They can be read out with DIGSI via the service interface Port C or the front operating interface.
- 3) This protocol does not support the transmission of protection settings. Only setting groups can be changed. For this purpose you should use the service interface or the front operating interface together with DIGSI.
- 4) Only 7SJ61/62/64; 7SJ80/7SK80; 7SC80

Integration into the SICAM power automation system

SIPROTEC 4 is tailor-made for use with the SIMATIC-based SICAM power automation system. The SICAM family comprises the following components:

- SICAM RTUs, the modern telecontrol systems with automation and programmable logic functions
- SICAM PAS, the substation automation system based on dedicated hardware

Data management and communication is one of the strong points of the SICAM / SIPROTEC 4 system. Powerful engineering tools make working with SICAM convenient and easy. SIPROTEC 4 units are optimally matched for use in SICAM PAS. With SICAM and SIPROTEC 4 continuity exists at three crucial points:

- Data management
- Software architecture
- Communication

The ability to link SICAM/ SIPROTEC to other substation control, protection and automation components is assured, thanks to open interfaces such as IEC 60870-5-103 protocol and the Ethernet-based IEC 61850 protocol. Other protocols like PROFIBUS-DP, DNP 3.0, MODBUS, RTU, DNP3 TCP, PROFINET and Redundancy protocols for Ethernet (RSTP;PRP and HSR) are also supported.

Communication

Integration into substation automation system

SIPROTEC 4 is tailor-made for use with the SICAM substation automation system. Over the low-cost electrical RS485 bus, the units exchange information with the control system. Units featuring IEC 60870-5-103 interfaces can be connected to SICAM interference free and radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers.

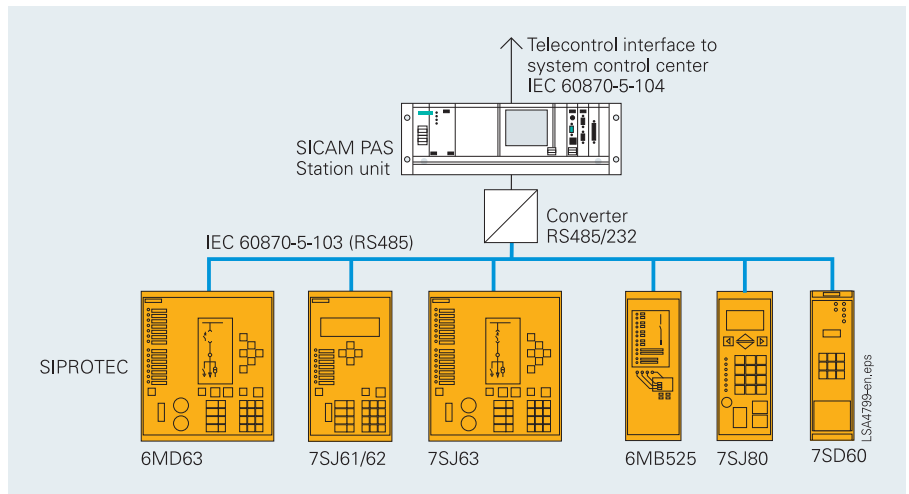


Fig. 4/7 Communication structure with substation automation system

Integration into the SICAM PAS power automation system

SIPROTEC 4 is tailor-made for use with the SICAM power automation system together with IEC 61850 protocol. Via the 100 Mbit/s Ethernet bus, the units are linked electrically or optically to the station PC with PAS. Connection may be simple or redundant. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. Units featuring an IEC 60870-5-103 interface or other serial protocols are connected via the Ethernet station bus to SICAM PAS by means of serial/Ethernet converters (see Fig. 4/8). DIGSI and the Web monitor can also be used over the same station bus.

Together with Ethernet/IEC 61850, an interference-free optical solution is also provided (see Fig. 4/9). The Ethernet interface in the relay includes an Ethernet switch. Thus, the installation of expensive external Ethernet switches can be avoided. The relays are linked in an optical ring structure.

Integrated SNMP (Simple Network Management Protocol) facility allows the supervision of the network from the station controller.

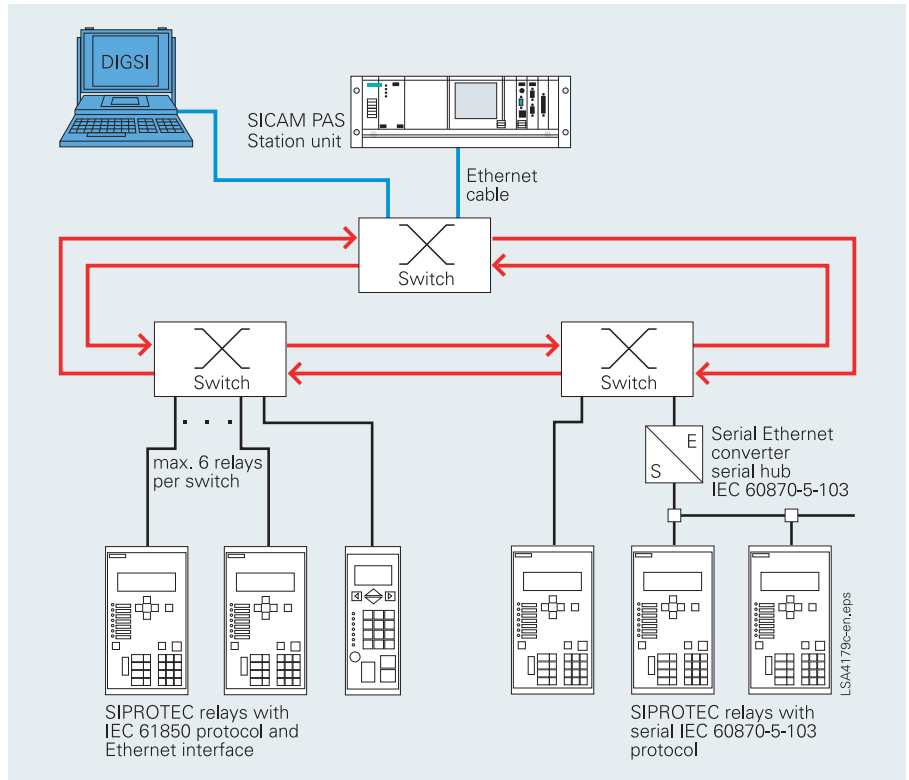


Fig. 4/8 Ethernet-based system with SICAM PAS with electrical Ethernet interface

Integration into a substation automation system of other makes

Thanks to the standardized interfaces, IEC 61850, IEC 60870-5-103, DNP3.0, MODBUS, PROFIBUS-DP, SIPROTEC units can also be integrated into non-Siemens systems or in SIMATIC S5/S7. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

4

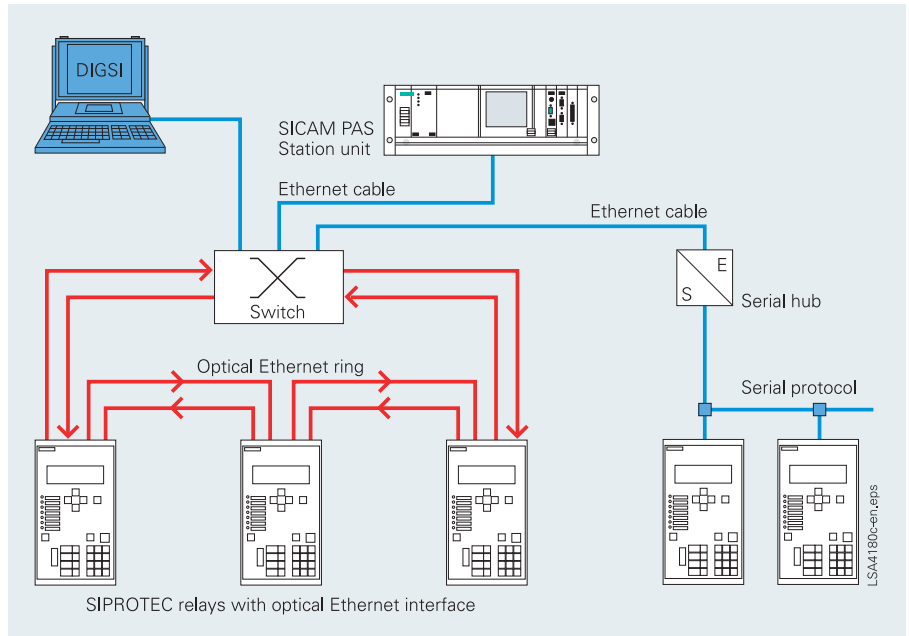


Fig. 4/9 Ethernet-based system with SICAM PAS with optical Ethernet interface

Solution without substation control system

Ethernet-based communication with optical Ethernet interface between SIPROTEC protection relays without substation control offers many advantages:

- Fast remote access via DIGSI 4
- High-speed setting and parameterization with DIGSI 4
- Interlocking between different field devices and exchange of binary signals via GOOSE messages of IEC 61850
- Common time synchronization of all relays from central time synchronization server (eg. SICLOCK)

For automation of new substations (or plants) and modernization of existing substations you get future investment security, without additional investment.

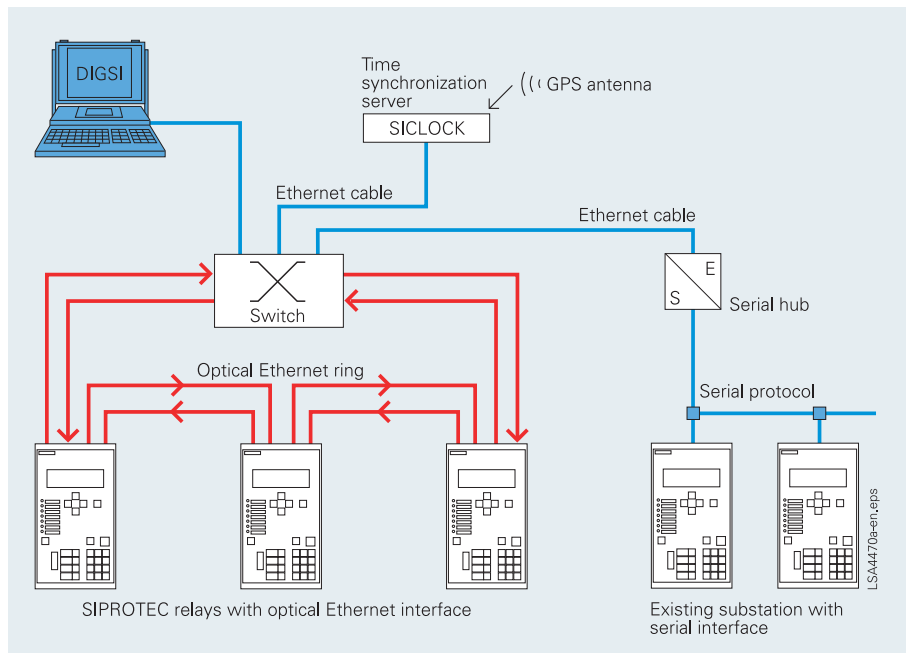


Fig. 4/10 Ethernet-based system with optical Ethernet interface and migration of relays with serial protocol

Overcurrent Protection

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Fig. 5/1 SIPROTEC easy 7SJ45 numerical overcurrent protection relay powered by current transformers (CT)

Description

The SIPROTEC easy 7SJ45 is a numerical overcurrent protection relay which is primarily intended as a radial feeder or transformer protection (backup) in electrical networks. It provides definite-time and inverse-time overcurrent protection according to IEC and ANSI standards. The 7SJ45 relay does not require auxiliary voltage supply. It imports its power supply from the current transformers.

Function overview

- Operation without auxiliary voltage via integrated CT power supply
- Standard current transformers (1 A/5 A)
- Low power consumption: 1.4 VA at I_N (of the relay)
- Easy mounting due to compact housing
- Easy connection via screw-type terminals

Protection functions

- 2-stage overcurrent protection
- Definite-time and inverse-time characteristics (IEC/ANSI)
- High-current stage $I_{>>}$ or calculated ground-current stage $I_{E>}$ or $I_{Ep>}$ selectable
- Trip with pulse output (DC 24 V / 0.1 Ws) or relay output (changeover contact)
- Repetition of trip during circuit-breaker failure (relays with pulse output)
- Combination with electromechanical relays is possible due to the emulation algorithm

Monitoring functions

- Hardware and software are continuously monitored during operation

Front design

- Simple setting via DIP switches (self-explaining)
- Settings can be executed without auxiliary voltage – no PC
- Integrated mechanical trip indication optionally

Additional features

- Optional version available for most adverse environmental conditions (condensation permissible)
- Flush mounting or surface (rail) mounting

Overcurrent Protection / 7SJ45

Application, construction

Application

The SIPROTEC easy 7SJ45 is a numerical overcurrent protection relay which is primarily intended as a radial feeder or transformer protection (backup) in electrical networks. It provides definite-time and inverse-time overcurrent protection according to IEC and ANSI standards. The convenient setting with DIP switches is self-explanatory and simple.

The 7SJ45 relay does not require auxiliary voltage supply. It imports its power supply (1.4 VA at I_N , sum of all phases) from the current transformers.

Impulse output for low-energy trip release or contact output for additional auxiliary transformer are available. An optional integrated trip indication shows that a trip occurred.

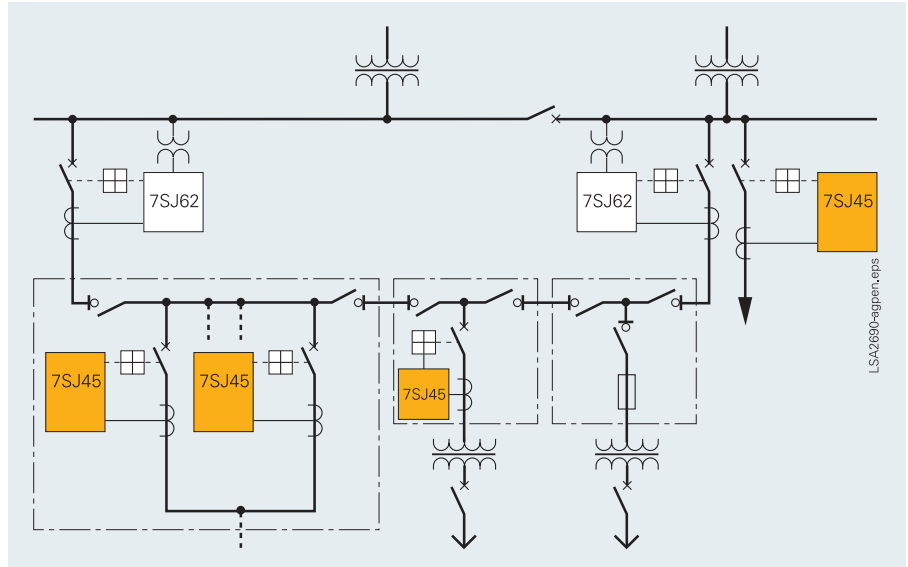


Fig. 5/2 Typical application

ANSI	IEC	Protection functions
50	$I >>$	Instantaneous overcurrent protection
50, 51	$I > t, I_p$	Overcurrent protection (phase)
50N, 51N	$I_E > t, I_{Ep}$	Overcurrent protection (ground)

Construction

Within its compact housing the protection relay contains all required components for:

- Measuring and processing
- Alarm and command output
- Operation and indication (without a PC)
- Optional mechanical trip indication
- Auxiliary supply from current transformers
- Maintenance not necessary

The housing dimensions of the units are such that the 7SJ45 relays can in general be installed into the existing cutouts in cubicles. Alternative constructions are available (surface mounting and flush mounting). The compact housing permits easy mounting, and a version for the most adverse environmental conditions, even with extreme humidity, is also available.



Fig. 5/3 Application in distribution switchgear



Fig. 5/4 Screw-type terminals

Protection functions

The overcurrent function is based on phase-selective measurement of the three phase currents.

The earth (ground) current I_E (Gnd) is calculated from the three line currents I_{L1} (A), I_{L2} (B), and I_{L3} (C).

The relay has always a normal stage for phase currents $I>$ (50/51). For the second stage, the user can choose between a high-current stage for phase currents $I>>$ (50) or a normal stage for calculated ground currents $I_{E>}$ (50N/51N).

The inverse-time overcurrent protection with integrating measurement method (disk emulation) emulates the behaviour of electromechanical relays.

The influence of high-frequency transients and transient DC components is largely suppressed by the implementation of numerical measured-value processing.

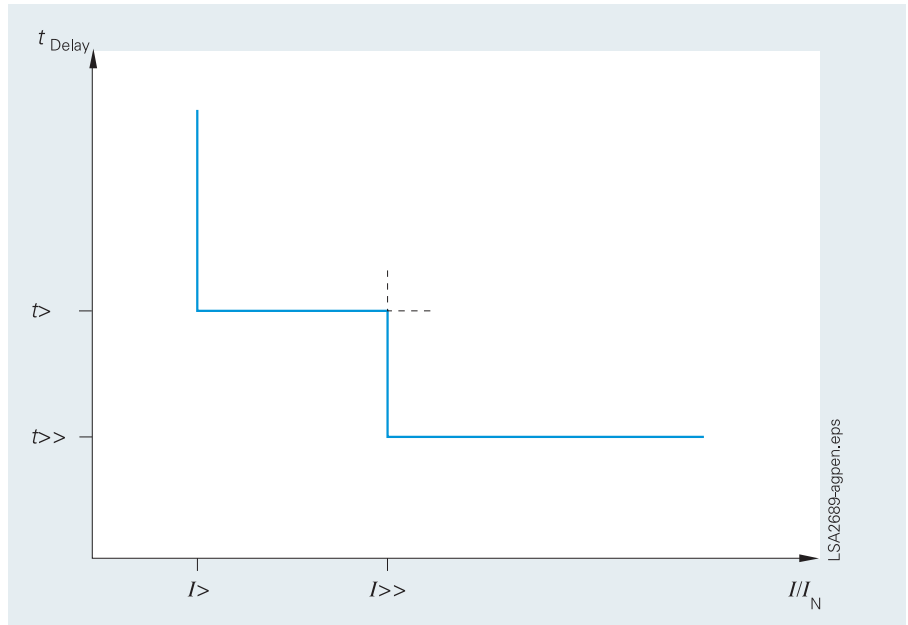


Fig. 5/5 Definite-time overcurrent characteristic

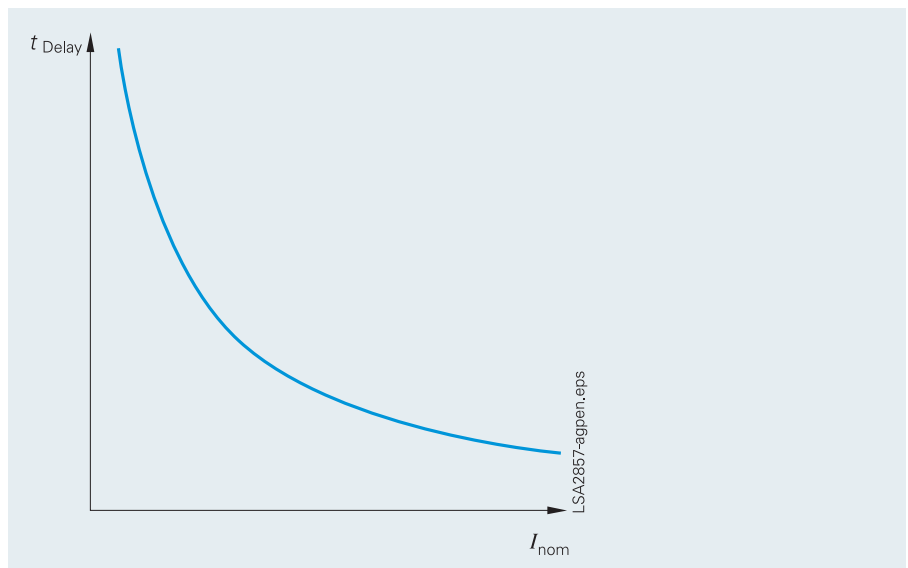


Fig. 5/6 Inverse-time overcurrent characteristic

Available inverse-time characteristics

Characteristics acc. to	ANSI/IEEE	IEC 60255-3
Moderately inverse/normal inverse	•	•
Very inverse	•	•
Extremely inverse	•	•

Overcurrent Protection / 7SJ45

Connection diagrams

Connection diagrams

Pulse output or relay output are optionally available.

Pulse output

These relays require a low-energy trip release (DC 24 V/0.1 Ws) in the circuit-breaker, and are intended for modern switchgear. In case of circuit-breaker failure, a repetition of the tripping signal is initiated.

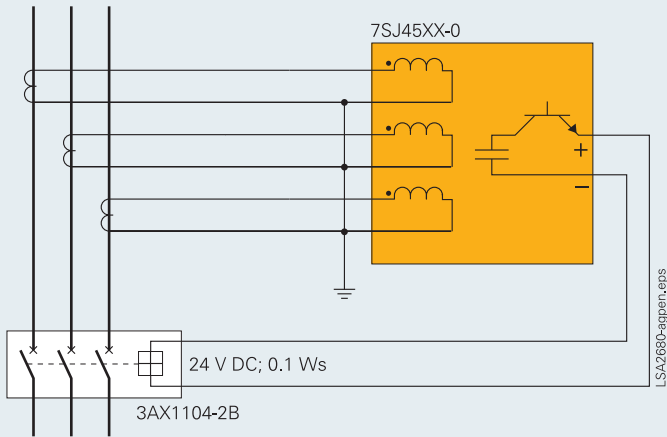


Fig. 5/7 Connection of 3 CTs with pulse output

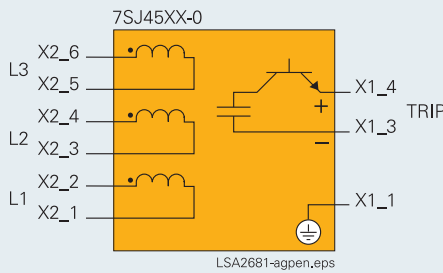


Fig. 5/8 Connection diagram 7SJ45 with impulse output

Relay output

These relays can be applied with all conventional switchgear. A transformer that provides the trip circuit energy, must be connected in the current transformer circuit.

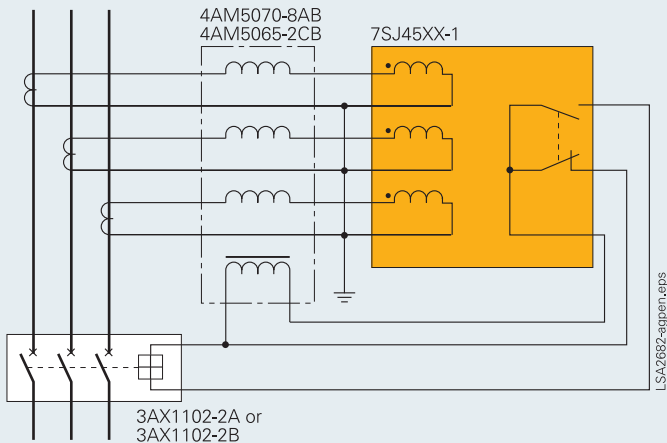


Fig. 5/9 Connection of 3 CTs with trigger transformer and relay output

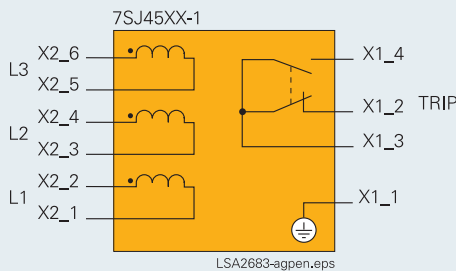


Fig. 5/10 Connection diagram 7SJ45 with relay output

General unit data	
<i>Analog input</i>	
System frequency f_N	50 or 60 Hz (selectable)
<i>Current transformer inputs</i>	
Rated current, normal ground current I_N	1 or 5 A
Power consumption At $I_N = 1 / 5$ A	Approx. 1.4 VA at I_N (relay)
Rating of current transformer circuit Thermal (r.m.s.)	50 · I_N for 1 s 15 · I_N for 10 s 2 · I_N continuous
Dynamic (peak)	100 · I_N for half a cycle
Recommended primary current transformers	10 P 10, 2.5 VA or according to the requirements and required tripping power
<i>Output relays</i>	
<i>Pulse output (7SJ45XX-0*)</i>	
Number	1 pulse output DC 24 V / 0.1 Ws
<i>Relay output (7SJ45XX-1*)</i>	
Number	1 changeover contact
Contact rating	Make 1000 W/VA Break 30 VA 40 W resistive 25 VA at L/R ≤ 50 ms
Rated contact voltage	≤ DC 250 V or ≤ AC 240 V
Permissible current per contact	5 A continuous 30 A for 0.5 s (inrush current)
<i>Unit design</i>	
Housing	Flush mounting DIN 43700/ IEC 61554 Adaptable for rail mounting (recommended for local mounting only)
Dimensions (WxHxD) in mm	78.5 x 147 x 205.8 (incl. transparent cover and terminal blocks)
Weight (mass) approx.	1.5 kg
Degree of protection according to IEC 60529	
Housing	
Front	IP 51
Rear	IP 20
Protection of personnel	IP1X
<i>UL-listing</i>	
Listed under "69CA".	
<i>Electrical tests</i>	
<i>Specifications</i>	
Standards	IEC 60255 (product standards) ANSI C37.90.0/1.1.2; UL508 See also standards for individual tests
<i>Insulation tests</i>	
Standards	IEC 60255-5
Voltage test (routine test)	2.5 kV (r.m.s.), 50 Hz, 1 min
All circuits except for pulse output-ground	
Voltage test (type test) across open command contacts	1.0 kV (r.m.s.), 50 Hz, 1 min
Impulse voltage test (type test) all circuits, class III	5 kV (peak); 1.2/50 μs; 0.5 J; 3 positive and 3 negative impulses in intervals of 1 s

EMC tests for interference immunity; type tests	
Standards	IEC 60255-6, IEC 60255-22, EN 50263 (product standards) EN 50082-2 (generic standard) EN 61000-6-2 IEC 61000-4 (basic standards)
High-frequency test IEC 60255-22-1, class III	2.5 kV (peak); 1 MHz; τ = 15 ms; $R_i = 200 \Omega$; 400 surges/s; duration ≥ 2 s
Electrostatic discharge IEC 60255-22-2, class III EN 61000-4-2, class III	4 kV/6 kV contact discharge; 8 kV air discharge; both polarities; 150 pF; = 330 Ω
Irradiation with radio-frequency field, amplitude-modulated IEC 60255-22-3 and IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 %; 1 kHz; AM
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 % 30 V/m; 1890 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transient interference/bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst duration = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50 \Omega$; duration 1 min
High-energy surge voltage, IEC 61000-4-5 installation, class III Measuring inputs, binary outputs	Impulse: 1.2/50 μs Circuit groups to ground: 2 kV; 42 W, 0.5 μF Across circuit groups: 1 kV; 42 W, 0.5 μF
Line-conducted HF, amplitude-modulated, IEC 60255-22-6 and IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 %; 1 kHz; $R_i = 150 \Omega$
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m continuous; 300 A/m for 5 s; 50 Hz 0.5 mT; 50 Hz
Damped wave IEC 60694, IEC 61000-4-12, class III	2.5 kV (peak, polarity alternating) 100 kHz, 1 MHz, 10 MHz and 50 MHz, $R_i = 200 \Omega$, duration ≥ 2 s
Oscillatory surge withstand capability ANSI/IEEE C37.90.1 Not across open contacts	2.5 to 3 kV (peak); 1 to 1.5 MHz damped wave; 50 shots per s; duration ≥ 2 s; $R_i = 150 \Omega$ to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1 not across open contacts	4 to 5 kV; 10/150 ns; 50 and 120 surges per ≥ 2 s; both polarities; duration ≥ 2 s; $R_i = 80 \Omega$
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz amplitude and pulse-modulated
<i>EMC tests for interference emission; type test</i>	
Standard	EN 50081-* (generic)
Interference field strength IEC CISPR 22	30 to 1000 MHz, class B

Overcurrent Protection / 7SJ45

Technical data

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Mechanical stress tests	
<i>Vibration, shock stress and seismic vibration</i>	
<u>During operation</u>	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 10 to 60 Hz ± 0.075 mm amplitude: 60 to 150 Hz; 1 g acceleration Frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60225-21-2; class I	Semi-sinusoidal 5 g acceleration, duration 11 ms, each 3 shocks in both directions of the 3 axes
Seismic vibration IEC 60255-21-3; class I IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 4.0 mm amplitude (horizontal vector) 1 to 8 Hz: ± 2.0 mm amplitude (vertical vector) 8 to 35 Hz: 1 g acceleration (horizontal vector) 8 to 35 Hz: 0.5 g acceleration (vertical vector) Frequency sweep 1 octave/min 1 cycle in 3 perpendicular axes
<u>During transport (flush mounting)</u>	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 Hz to 8 Hz: ± 7.5 mm amplitude; 8 Hz to 150 Hz: 2 g acceleration frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal 15 g acceleration, duration 11 ms, each 3 shocks in both directions of the 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Semi-sinusoidal 10 g acceleration, duration 16 ms, each 1000 shocks in both directions of the 3 axes

Climatic stress tests	
<i>Temperatures</i>	
Temperatures during service	–20 °C to +70 °C / –4 °F to +158 °F With continuous current $2I_N$: –20 °C to +55 °C / –4 °F to +131 °F
Permissible temperature during storage	–25 °C to +55 °C / –13 °F to +131 °F
Permissible temperature during transport	–25 °C to +85 °C / –13 °F to +185 °F
<i>Humidity</i>	
Permissible humidity class (standard)	Annual mean value ≤ 75 % relative humidity; on 30 days per year up to 95 % relative humidity; condensation not permissible.
Permissible humidity class (condensation proof)	Condensation is permissible according to IEC 60654-1, class III

Functions	
<i>Overcurrent protection</i>	
<i>Definite time (DT O/C ANSI 50/51)</i>	
<u>Setting range / steps</u>	
Current pickup $I_{>>}$ (phases)	2 I_N to 20 I_N or deactivated, step 0.5 I_N
Current pickup $I_{>}$ (phases) 3-phase supply: see note*	0.5 I_N to 6.2 I_N or deactivated, step 0.1 I_N
Current pickup $I_{E>}$ 3-phase supply: see note*	0.5 I_N to 6.2 I_N or deactivated, step 0.1 I_N
Delay times $T_{I>>}$	0 to 1575 ms, step 25 ms
Delay times $T_{I>}$	0 to 6300 ms, step 100 ms
The set time delays are pure delay times.	
<i>Inverse time (IEC or ANSI 51)</i>	
<u>Setting range / steps</u>	
Current pickup I_p (phases) 3-phase supply: see note*	0.5 I_N to 4 I_N or deactivated, step 0.1 I_N
Current pickup $I_{Ep>}$ (ground calculated) 3-phase supply: see note*	0.5 I_N to 4 I_N or deactivated, step 0.1 I_N
Delay times T_{Ip} (IEC)	0.05 to 3.15 s, step 0.05 s
Delay times D (ANSI)	0.5 to 15.00 s, step 0.25 s
<u>Trip times</u>	
Total time delay impulse output	Approx. 32 ms
Total time delay relay output	Approx. 38 ms
Reset ratio	Approx. 0.95 (with definite time) Approx. 0.91 (with inverse time)
<u>Tolerances</u>	
Definite time (DT O/C 50/51) Current pickup $I_{>>}$, $I_{>}$, $I_{E>}$	5 % of the set value or 5 % of I_N (at threshold < I_N)
Delay times T	1 % or 30 ms
Inverse time (IEC or ANSI 51) Pickup thresholds	5 % of the set value or 5 % of I_N (at threshold < I_N)
Time behavior for $2 \leq II_p \leq 20$	5 % or 50 ms
<u>Deviation of the measured values as a result of various interferences</u>	
Frequency in the range of $0.95 < f/f_N < 1.05$	< 2.5 %
Frequency in the range of $0.9 < f/f_N < 1.1$	< 10 %
Harmonics up to 10 % 3 rd and 5 th harmonic	< 1 %
DC components	< 5 %
Temperature in the range of –5 °C to 70 °C / 23 °F to 158 °F	< 0.5 %/10 K
* Note: The device allows minimum setting values of 0.5 I_N (3-phase). With single supply, operation is ensured from 0.8 I_N (7SJ45XX-0*; pulse output) or 1.3 I_N (7SJ45XX-1*; relay output) onwards (printed on the front).	

Overcurrent Protection/7SJ45

Selection and ordering data

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EG. previous 89/336/EEC).

This unit conforms to the international standard IEC 60255.

The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2.



Selection and ordering data

Description	Order No.
SIPROTEC easy 7SJ45 numerical overcurrent protection relay powered by CTs	7SJ450□-□□□00-□AA□
Current transformer I_N	
1 A	1
5 A	5
Trip	
Pulse output (for further details refer to "Accessories")	0
Relay output (for further details refer to "Accessories")	1
Unit design	
For rail mounting	B
For panel flush mounting	E
Region-specific functions	
Region World, 50/60 Hz; standard	A
Region World, 50/60 Hz; condensation-proof	B
IEC / ANSI	
IEC	0
ANSI	1
Indication (flag)	
Without	0
With	1

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Accessories	Order No.
Protection relay with pulse output Low energy trip release	3AX1104-2B
Protection relay with relay output Auxiliary transformers for the trip circuit (30 VA CTs recommended)	
1 A	4AM5065-2CB00-0AN2
5 A	4AM5070-8AB00-0AN2
Current transformer-operated trip release	
0.5 A (rated operating current)	3AX1102-2A
1 A (rated operating current)	3AX1102-2B

Overcurrent Protection / 7SJ45

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Fig. 5/11 SIPROTEC easy 7SJ46 numerical overcurrent protection relay

Description

The SIPROTEC easy 7SJ46 is a numerical overcurrent protection relay which is primarily intended as a radial feeder or transformer protection (backup) in electrical networks. It provides definite-time and inverse-time overcurrent protection according to IEC and ANSI standards. The 7SJ46 relay has an AC and DC auxiliary power supply with a wide range allowing a high degree of flexibility in its application.

Function overview

- Universal application due to integrated wide range AC/DC power supply.
- Standard current transformers (1 A/5 A)
- Easy mounting due to compact housing
- Easy connection via screw-type terminals

Protection functions

- 2-stage overcurrent protection
- Definite-time and inverse-time characteristics (IEC/ANSI)
- High-current stage $I_{>>}$ or calculated ground-current stage $I_{E>}$ or $I_{Ep>}$ selectable
- Two command outputs for “trip” or “pickup”
- Combination with electromechanical relays is possible due to the emulation algorithm

Monitoring functions

- One live contact for monitoring
- Hardware and software are continuously monitored during operation

Front design

- Simple setting via DIP switches (self-explaining)
- Settings can be executed without auxiliary voltage – no PC
- Individual phase pickup indication with stored or not stored LEDs
- Trip indication with separate LED

Additional features

- Optional version available for most adverse environmental conditions (condensation permissible)
- Flush mounting or surface (rail) mounting

Overcurrent Protection / 7SJ45

Application, construction

Application

The SIPROTEC easy 7SJ46 is a numerical overcurrent protection relay which is primarily intended as a radial feeder or transformer protection (backup) in electrical networks.

It provides definite-time and inverse-time overcurrent protection according to IEC and ANSI standards. The convenient setting with DIP switches is self-explanatory and simple.

The 7SJ46 relay has an AC and DC auxiliary power supply with a wide range allowing a high degree of flexibility in its application. Phase-selective indication of protection pickup is indicated with LEDs.

ANSI	IEC	Protection functions
50	$I >>$	Instantaneous overcurrent protection
50, 51	$I > t, I_p$	Overcurrent protection (phase)
50N, 51N	$I_E > t, I_{Ep}$	Overcurrent protection (ground)

Construction

Within its compact housing the protection relay contains all required components for:

- Measuring and processing
- Pickup and command output
- Operation and indication (without a PC)
- Wide range AC/DC power supply
- Maintenance not necessary (no battery)

The housing dimensions of the units are such that the 7SJ46 relays can in general be installed into the existing panel cutouts. Alternative constructions are available (rail mounting and flush mounting). The compact housing permits easy mounting, and a version for the most adverse environmental conditions, even with extreme humidity, is also available.

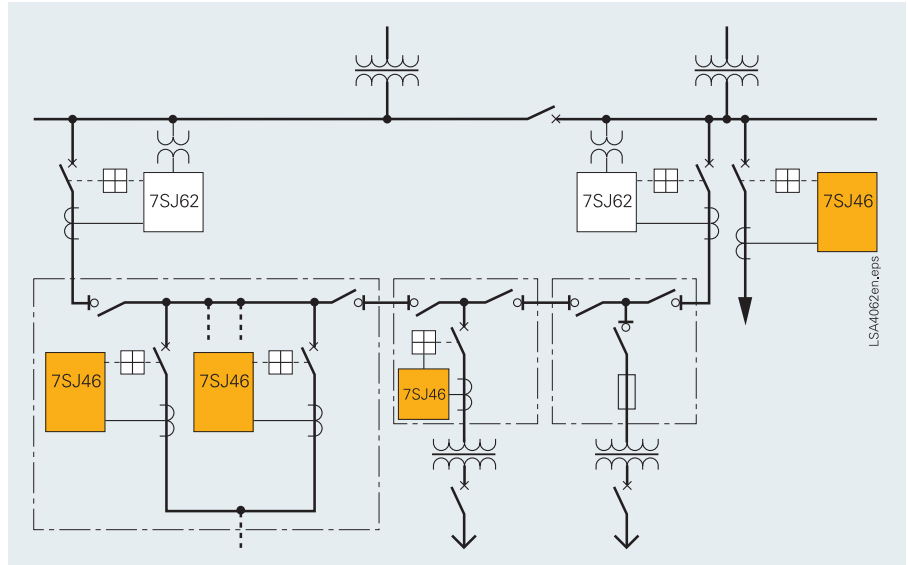


Fig. 5/12 Typical application



Fig. 5/13 Application in distribution switchgear



Fig. 5/14 Screw-type terminals

Protection functions

The overcurrent function is based on phase-selective measurement of the three phase currents.

The earth (ground) current I_E (Gnd) is calculated from the three line currents I_{L1} (A), I_{L2} (B), and I_{L3} (C).

The relay has always a normal stage for phase currents $I>$ (50/51).

For the second stage, the user can choose between a high-current stage for phase currents $I>>$ (50) or a normal stage for calculated ground currents $I_E>$ (50N/51N).

The inverse-time overcurrent protection with integrating measurement method (disk emulation) emulates the behavior of electromechanical relays.

The influence of high frequency transients and transient DC components is largely suppressed by the implementation of numerical measured-value processing.

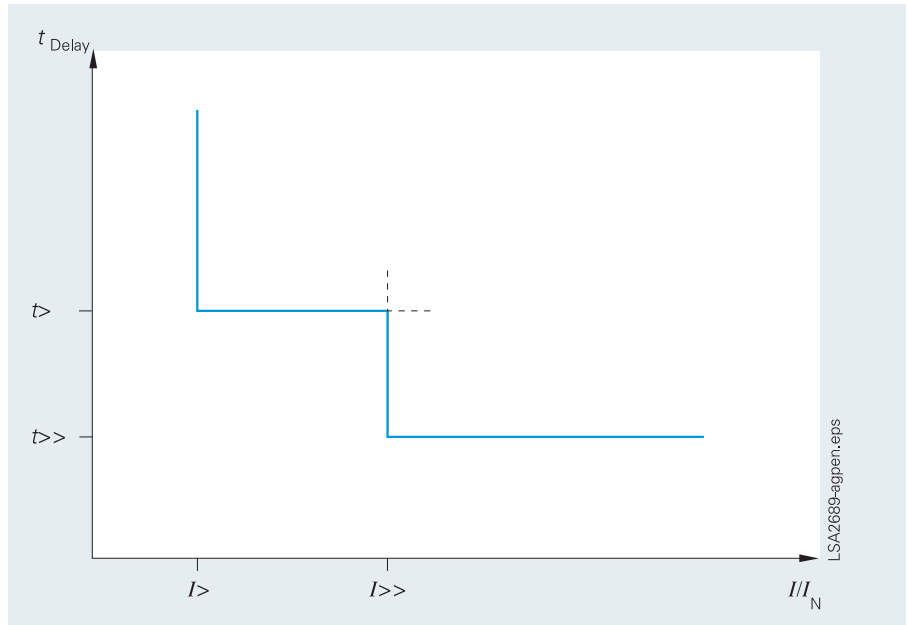


Fig. 5/15 Definite-time overcurrent characteristic

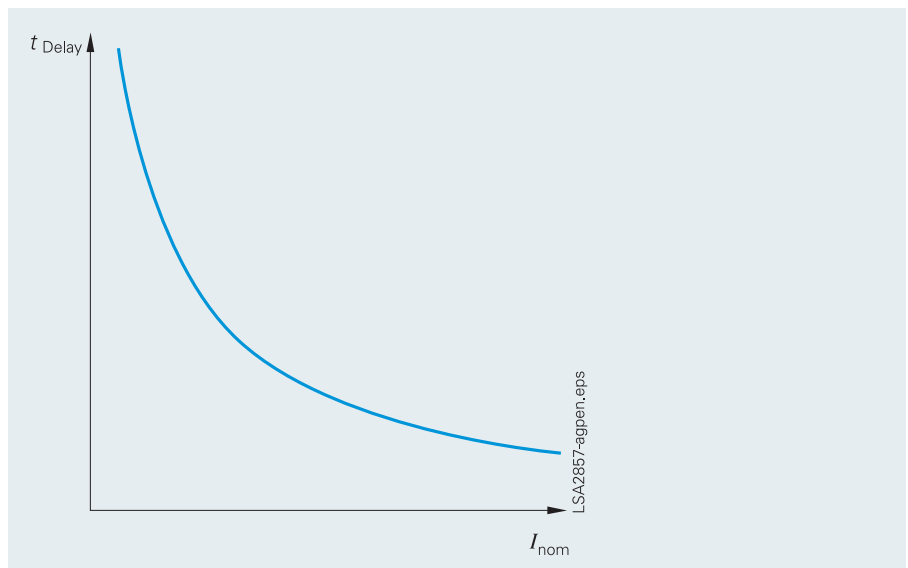


Fig. 5/16 Inverse-time overcurrent characteristic

Available inverse-time characteristics

Characteristics acc. to	ANSI/IEEE	IEC 60255-3
Moderately inverse/normal inverse	•	•
Very inverse	•	•
Extremely inverse	•	•

Overcurrent Protection / 7SJ46

Connection diagrams

Connection diagrams

The 7SJ46 has a trip contact, a contact which is adjustable for trip or pickup, and a live contact for the self-monitoring function.

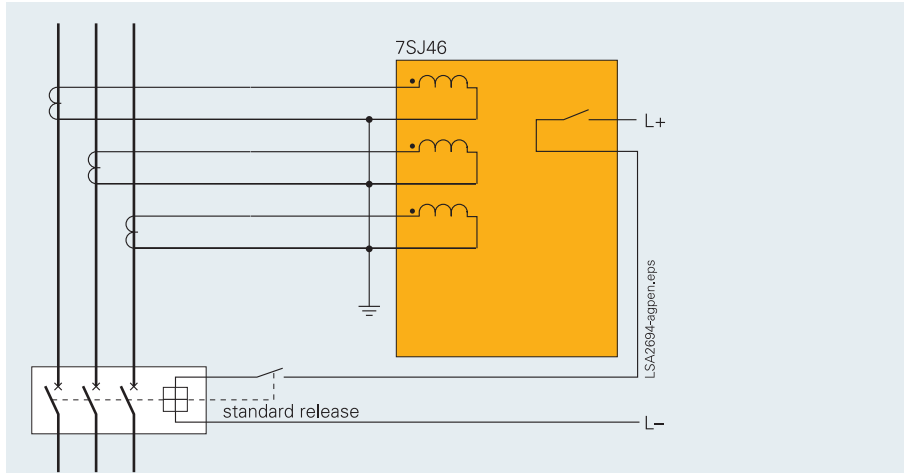


Fig. 5/17 Connection of 3 CTs

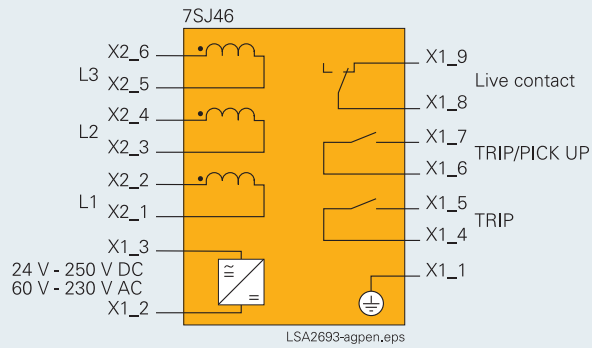


Fig. 5/18 Connection diagram 7SJ46

General unit data	
<i>Analog input</i>	
System frequency f_N	50 or 60 Hz (selectable)
<i>Current transformer inputs</i>	
Rated current, normal ground current I_N	1 or 5 A
Power consumption Per phase at $I_N = 1$ A Per phase at $I_N = 5$ A	Approx. 0.01 VA at I_N Approx. 0.2 VA at I_N (relay)
Rating of current transformer circuit Thermal (r.m.s.) Dynamic (peak)	100 · I_N for 1 s 30 · I_N for 10 s 4 · I_N continuous 250 · I_N for half a cycle
<i>Auxiliary voltage AC/DC powered</i>	
Input voltage range	DC 24 to 250 V (± 20 %) AC 60 to 230 V (-20 %, +15 %)
Power consumption	DC – power supply: Approx. 1.5 W AC – power supply: Approx. 3 VA at 110 V approx. 5.5 VA at 230 V
<i>Output relays</i>	
Number	2 (normally open), 1 live contact
Contact rating	Make 1000 W/VA Break 30 VA 40 W resistive 25 VA at L/R ≤ 50 ms
Rated contact voltage	≤ DC 250 V or ≤ AC 240 V
Permissible current per contact	5 A continuous 30 A for 0.5 s (inrush current)
<i>Unit design</i>	
Housing	Flush mounting DIN 43700/ IEC 61554 Adaptable for rail mounting recommended for local mounting only
Dimensions (WxHxD) in mm	78.5 x 147 x 205.8 (incl. transparent cover and terminal blocks)
Weight (mass) approx.	1 kg
Degree of protection according to IEC 60529	
Housing Front Rear	IP 51 IP 20
Protection of personnel	IP1X
<i>UL-listing</i>	
Listed under "69CA".	
Electrical tests	
<i>Specifications</i>	
Standards	IEC 60255 (product standards) ANSI C37.90.0/1/1.2; UL508 See also standards for individual tests
<i>Insulation tests</i>	
Standards	IEC 60255-5
Voltage test (routine test) all circuits except auxiliary supply	2.5 kV (r.m.s.), 50 Hz, 1 min
Voltage test (routine test) auxiliary supply	3.5 kVDC; 30 s; both polarities
Voltage test (type test) Across open contacts Across open live contact	1.5 kV (r.m.s.), 50 Hz; 1 min 1.0 kV (r.m.s.), 50 Hz; 1 min

Impulse voltage test (type test) all circuits, class III	5 kV (peak); 1.2/50 μs; 0.5 J; 3 positive and 3 negative impulses in intervals of 1 s
<i>EMC tests for interference immunity; type tests</i>	
Standards	IEC 60255-6, IEC 60255-22, EN 50263 (product standards) EN 50082-2 (generic standard) EN 61000-6-2 IEC 61000-4 (basic standards)
High-frequency test IEC 60255-22-1, class III	2.5 kV (peak); 1 MHz; τ = 15 ms; $R_i = 200 \Omega$; 400 surges/s; duration ≥ 2 s
Electrostatic discharge IEC 60255-22-2, class III EN 61000-4-2, class III	4 kV/6 kV contact discharge; 8 kV air discharge; both polarities; 150 pF; = 330 Ω
Irradiation with radio-frequency field, amplitude-modulated IEC 60255-22-3 and IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 %; 1 kHz; AM
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 % 30 V/m; 1810 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transient interference/bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst duration = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50 \Omega$; duration 1 min
High-energy surge voltage, IEC 61000-4-5 installation, class III	Impulse: 1.2/50 μs
Auxiliary voltage	circuit groups to ground: 2 kV; 12 Ω, 9 μF between circuit groups: 1 kV; 2 Ω, 18 μF
Measuring inputs, binary outputs	circuit groups to ground: 2 kV; 42 Ω, 0.5 μF between circuit groups: 1 kV; 42 Ω, 0.5 μF
Line-conducted HF, amplitude-modulated. IEC 60255-22-6 and IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 %; 1 kHz; AM; $R_i = 150 \Omega$
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m continuous; 300 A/m for 5 s; 50 Hz 0.5 mT; 50 Hz
Damped wave IEC 60694, IEC 61000-4-12, class III	2.5 kV (peak, polarity alternating) 100 kHz, 1 MHz, 10 MHz and 50 MHz, $R_i = 200 \Omega$, duration ≥ 2 s
Oscillatory surge withstand capability ANSI/IEEE C37.90.1 not across open contacts	2.5 to 3 kV (peak); 1 to 1.5 MHz damped wave; 50 shots per s; duration ≥ 2 s; $R_i = 150 \Omega$ to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1 not across open contacts	4 kV to 5 kV; 10/150 ns; 50 and 120 surges per s; both polarities; duration ≥ 2 s; $R_i = 80 \Omega$
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m 25 MHz to 1000 MHz amplitude and pulse-modulated
<i>EMC tests for interference emission; type test</i>	
Standard	EN 50081-* (generic)
Conducted interference voltage, auxiliary voltage IEC CISPR 22, EN 55022, DIN EN VDE 0878 Part 22	150 kHz to 30 MHz, class B
Interference field strength IEC CISPR 22	30 MHz to 1000 MHz, class B

Overcurrent Protection / 7SJ46

Technical data

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Mechanical stress test	
<i>Vibration, shock and seismic vibration</i>	
<u>During operation</u>	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz; 1 g acceleration Frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60225-21-2; class I	Semi-sinusoidal 5 g acceleration, duration 11 ms, each 3 shocks in both directions of the 3 axes
Seismic vibration IEC 60255-21-3; class I IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 4.0 mm amplitude (horizontal vector) 1 to 8 Hz: ± 2.0 mm amplitude (vertical vector) 8 to 35 Hz: 1 g acceleration (horizontal vector) 8 to 35 Hz: 0.5 g acceleration (vertical vector) Frequency sweep 1 octave/min 1 cycle in 3 perpendicular axes
<u>During transport (flush mounting)</u>	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 Hz to 8 Hz: ± 7.5 mm amplitude; 8 Hz to 150 Hz: 2 g acceleration frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal 15 g acceleration, duration 11 ms, each 3 shocks in both directions of the 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Semi-sinusoidal 10 g acceleration, duration 16 ms, each 1000 shocks in both directions of the 3 axes

Climatic stress tests	
<i>Temperatures</i>	
Temperatures during service	–20 °C to +70 °C / –4 °F to +158 °F with continuous current 4 I _N : –20 °C to +55 °C / –4 °F to +131 °F
Maximum temperature during storage	–25 °C to +55 °C / –13 °F to +131 °F
Maximum temperature during transport	–25 °C to +85 °C / –13 °F to +185 °F
<i>Humidity</i>	
Permissible humidity class (standard)	Annual mean value ≤ 75 % relative humidity; on 30 days per year up to 95 % relative humidity; condensation not permissible.
Permissible humidity class (condensation proof)	Condensation is permissible according to IEC 60654-1, class III

Function	
<i>Overcurrent protection</i>	
<i>Definite time (DT O/C ANSI 50/51)</i>	
Setting range / steps	
Current pickup I _{>>} (phases)	2 I _N to 20 I _N or deactivated, step 0.5 I _N
Current pickup I _{>} (phases)	0.5 I _N to 6.2 I _N or deactivated, step 0.1 I _N
Current pickup I _{E>} (ground calculated)	0.5 I _N to 6.2 I _N or deactivated, step 0.1 I _N
Delay times T _{I>>}	0 to 1575 ms, step 25 ms
Delay times T _{I>}	0 to 6300 ms, step 100 ms
The set time delays are pure delay times.	
<i>Inverse time (IEC or ANSI 51)</i>	
Current pickup I _p (phases)	0.5 I _N to 4 I _N or deactivated, step 0.1 I _N
Current pickup I _{E p>} (ground calculated)	0.5 I _N to 4 I _N or deactivated, step 0.1 I _N
Delay times T _{Ip} (IEC)	0.05 to 3.15 s, step 0.05 s
Delay times D (ANSI)	0.5 to 15.00 s, step 0.25 s
Trip times	
Switch on to fault, relay output	Approx. 38 ms
Reset ratio	
	Approx. 0.95 (with definite time) Approx. 0.91 (with inverse time)
Tolerances	
Definite time (DT O/C 50/51)	
Current pickup I _{>>} , I _{>} , I _{E>}	5 % of the set value or 5 % of I _N (at threshold < I _N)
Delay times T	1 % or 30 ms
Inverse time (IEC or ANSI 51)	
Pickup thresholds	5 % of I _N (at threshold < I _N)
Time behaviour for 2 ≤ III _p ≤ 20	5 % or 50 ms
<i>Deviation of the measured values as a result of various interferences</i>	
Frequency in the range of 0.95 < f/f _N < 1.05	< 2.5 %
Frequency in the range of 0.9 < f/f _N < 1.1	< 10 %
Harmonics up to 10 % 3 rd and 5 th harmonic	< 1 %
DC components	< 5 %
Auxiliary supply voltage DC in the range of 0.8 ≤ V _{aux} /V _{aux N} ≤ 1.2	< 1 %
Auxiliary supply voltage AC in the range of 0.8 ≤ V _{aux} /V _{aux N} ≤ 1.15	< 1 %
Temperature in the range of –5 °C to 70 °C / 23 °F to 158 °F	< 0.5 %/10 K

CE conformity
This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EG previous 89/336/EEC).
This unit conforms to the international standard IEC 60255.
The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.
This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the eneric standards EN 50081-2 and EN 50082-2.



Overcurrent Protection/7SJ46

Selection and ordering data

Description	Order No.
SIPROTEC easy 7SJ46 numerical overcurrent protection relay	7SJ460□-1□□00-□AA0
Current transformer I_N	
1 A	1
5 A	5
Unit design	
For rail mounting	B
For panel flush mounting	E
Region-specific functions	
Region World, 50/60 Hz; standard	A
Region World, 50/60 Hz; condensation-proof	B
IEC / ANSI	
IEC	0
ANSI	1

Overcurrent Protection / 7SJ46

Overcurrent Protection/7SJ600

SIPROTEC 7SJ600 numerical overcurrent, motor and overload protection relay



Fig. 5/19 SIPROTEC 7SJ600
numerical overcurrent, motor and overload protection relay

Description

The SIPROTEC 7SJ600 is a numerical overcurrent relay which, in addition to its primary use in radial distribution networks and motor protection, can also be employed as backup for feeder, transformer and generator differential protection.

The SIPROTEC 7SJ600 provides definite-time and inverse-time overcurrent protection along with overload and negative-sequence protection for a very comprehensive relay package. In this way, equipment such as motors can be protected against asymmetric and excessive loading. Asymmetric short-circuits with currents that can be smaller than the largest possible load currents or phase interruptions are reliably detected.

Function overview

Feeder protection

- Overcurrent-time protection
- Ground-fault protection
- Overload protection
- Negative-sequence protection
- Cold load pickup
- Auto-reclosure
- Trip circuit supervision

Motor protection

- Starting time supervision
- Locked rotor

Control functions

- Commands for control of a circuit-breaker
- Control via keyboard, DIGSI 4 or SCADA system

Measuring functions

- Operational measured values I

Monitoring functions

- Fault event logging with time stamp (buffered)
- 8 oscillographic fault records
- Continuous self-monitoring

Communication

- Via personal computer and DIGSI 3 or DIGSI 4 (≥ 4.3)
- Via RS232 – RS485 converter
- Via modem
- IEC 60870-5-103 protocol, 2 kV-isolated
- RS485 interface

Hardware

- 3 current transformers
- 3 binary inputs
- 3 output relays
- 1 live status contact

Overcurrent Protection / 7SJ600

Application

Wide range of applications

The SIPROTEC 7SJ600 is a numerical overcurrent relay which, in addition to its primary use in radial distribution networks and motor protection, can also be employed as backup for feeder, transformer and generator differential protection.

The SIPROTEC 7SJ600 provides definite-time and inverse-time overcurrent protection along with overload and negative-sequence protection for a very comprehensive relay package. In this way, equipment such as motors can be protected against asymmetric and excessive loading. Asymmetric short-circuits with currents that can be smaller than the largest possible load currents or phase interruptions are reliably detected.

The integrated control function allows simple control of a circuit-breaker or disconnector (electrically operated/ motorized switch) via the integrated HMI, DIGSI 3 or DIGSI 4 (≥ 4.3) or SCADA (IEC 60870-5-103 protocol).

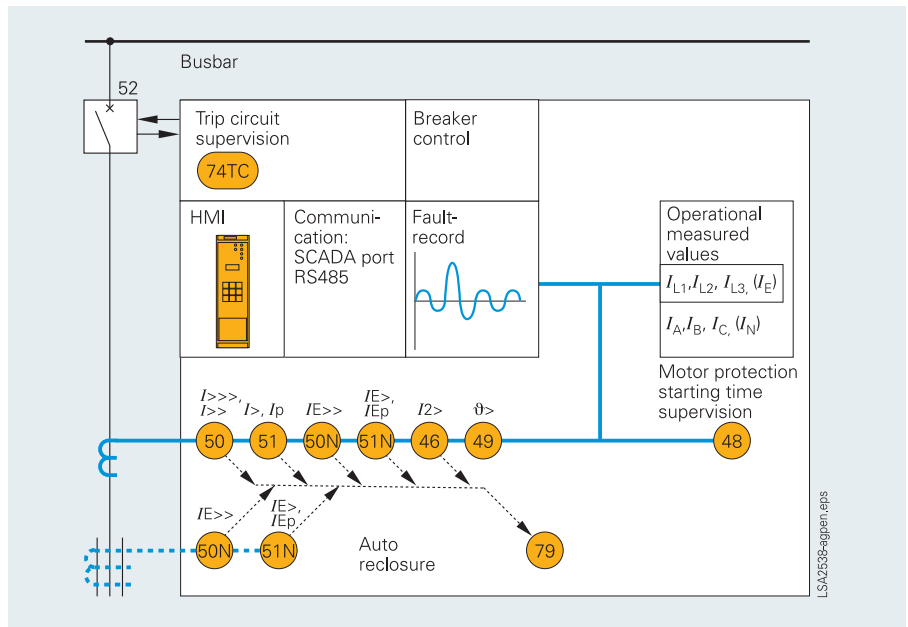


Fig. 5/20 Typical application

ANSI	IEC	Protection functions
50, 50N	$I>$, $I>>$, $I>>>$ $I_E>$, $I_E>>$	Instantaneous overcurrent protection
50, 51N	I_p , I_{Ep}	Inverse overcurrent protection (phase/neutral)
79		Auto-reclosure
46	I_2	Phase-balance current protection (negative-sequence protection)
49	$\theta>$	Thermal overload protection
48		Starting time supervision
74TC		Trip circuit supervision breaker control



Fig. 5/21 SIPROTEC 7SJ600 numerical overcurrent, motor and overload protection relay

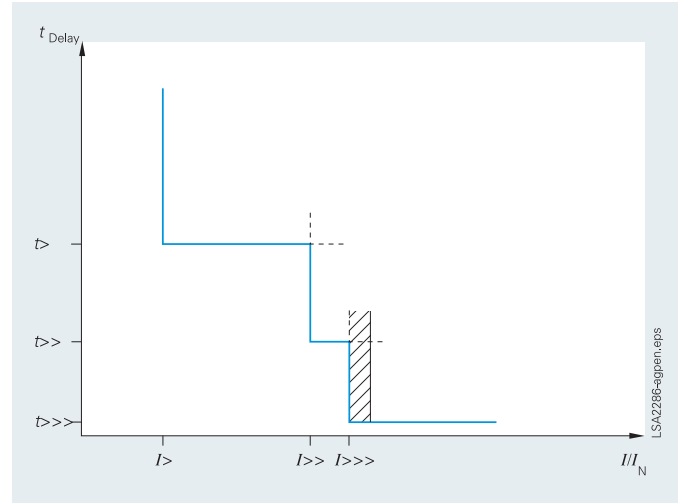


Fig. 5/22 Definite-time overcurrent characteristic

Construction

The relay contains all the components needed for

- Acquisition and evaluation of measured values
- Operation and display
- Output of signals and trip commands
- Input and evaluation of binary signals
- SCADA interface (RS485)
- Power supply.

The rated CT currents applied to the SIPROTEC 7SJ600 can be 1 or 5 A. This is selectable via a jumper inside the relay.

Two different housings are available. The flush-mounting/ cubicle-mounting version has terminals accessible from the rear. The surface-mounting version has terminals accessible from the front.

Protection functions

Definite-time characteristics

The definite-time overcurrent function is based on phase-selective measurement of the three phase currents and/or ground current.

Optionally, the earth (ground) current I_E (Gnd) is calculated or measured from the three line currents $I_{L1}(I_A)$, $I_{L2}(I_B)$ and $I_{L3}(I_C)$.

The definite-time overcurrent protection for the 3 phase currents has a low-set overcurrent element ($I>$), a high-set overcurrent element ($I>>$) and a high-set instantaneous-tripping element ($I>>>$). Intentional trip delays can be parameterized from 0.00 to 60.00 seconds for the low-set and high-set overcurrent elements. The instantaneous zone $I>>>$ trips without any intentional delay. The definite-time overcurrent protection for the earth (ground) current has a low-set overcurrent element ($I_E>$) and a high-set overcurrent element ($I_E>>$). Intentional trip delays can be parameterized from 0.00 to 60.00 seconds.

Inverse-time characteristics

In addition, inverse-time overcurrent protection characteristics (IDMTL) can be activated.

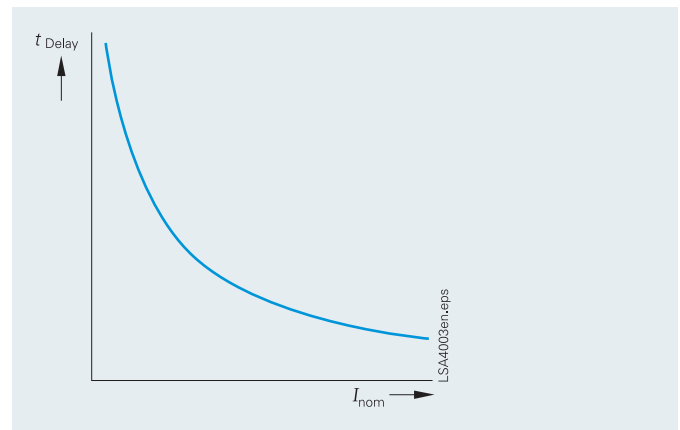


Fig. 5/23 Inverse-time overcurrent characteristic

Available inverse-time characteristics

Characteristics acc. to	ANSI/IEEE	IEC 60255-3
Inverse	•	•
Short inverse	•	
Long inverse	•	•
Moderately inverse	•	
Very inverse	•	•
Extremely inverse	•	•
Definite inverse	•	
$I^2 T$	•	

Overcurrent Protection / 7SJ600

Protection functions

Thermal overload protection (ANSI 49)

The thermal overload protection function provides tripping or alarming based on a thermal model calculated from phase currents.

Thermal overload protection without preload

For thermal overload protection without consideration of the preload current, the following tripping characteristic applies only when

$$I \geq 1.1 \cdot I_L$$

For different thermal time constants T_L , the tripping time t is calculated in accordance with the following equation:

$$t = \frac{35}{\left(\frac{I}{I_L}\right)^2 - 1} \cdot T_L$$

- I = Load current
- I_L = Pickup current
- T_L = Time multiplier

The reset threshold is above $1.03125 \cdot III_N$

Thermal overload protection with preload

The thermal overload protection with consideration of preload current constantly updates the thermal model calculation regardless of the magnitude of the phase currents. The tripping time t is calculated in accordance with the following tripping characteristic (complete memory in accordance with IEC 60255-8).

$$t = \tau \cdot \ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2 - \left(\frac{I_{pre}}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1}$$

- t = Tripping time after beginning of the thermal overload
- τ = $35.5 \cdot T_L$
- I_{pre} = Pre-load current
- T_L = Time multiplier
- I = Load current
- k = k factor (in accordance with IEC 60255-8)
- \ln = Natural logarithm
- I_N = Rated (nominal) current

Negative-sequence protection ($I_{2>>}$, $I_{2>}$ /ANSI 46 Unbalanced-load protection)

The negative-sequence protection (see Fig. 5/24) detects a phase failure or load unbalance due to network asymmetry. Interruptions, short-circuits or crossed connections to the current transformers are detected.

Furthermore, low level single-phase and two-phase short-circuits (such as faults beyond a transformer) as well as phase interruptions can be detected.

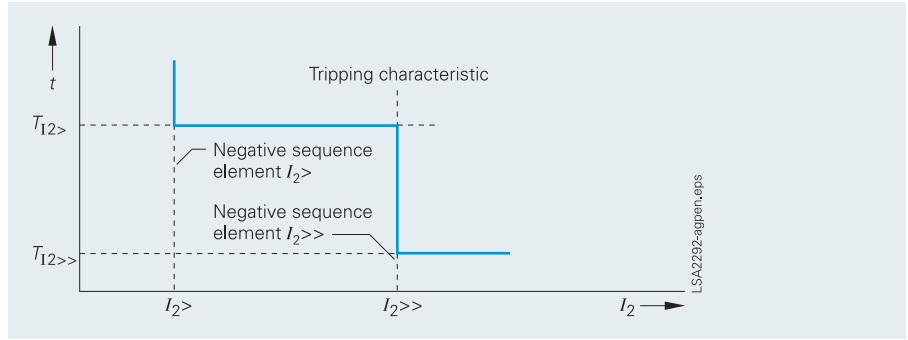


Fig. 5/24 Tripping characteristic of the negative-sequence protection function

This function is especially useful for motors since negative sequence currents cause impermissible overheating of the rotor.

In order to detect the unbalanced load, the ratio of negative phase-sequence current to rated current is evaluated.

- I_{2-} = Negative-sequence current
- T_{I2} = Tripping time

Transformer protection

The high-set element permits current coordination where the overcurrent element functions as a backup for the lower-level protection relays, and the overload function protects the transformer from thermal overload. Low-current single-phase faults on the low voltage side that result in negative phase-sequence current on the high-voltage side can be detected with the negative-sequence protection.

Cold load pickup

By means of a binary input which can be wired from a manual close contact, it is possible to switch the overcurrent pickup settings to less sensitive settings for a programmable duration of time. After the set time has expired, the pickup settings automatically return to their original setting. This can compensate for initial inrush when energizing a circuit without compromising the sensitivity of the overcurrent elements during steady state conditions.

3-pole multishot auto-reclosure (AR, ANSI 79)

Auto-reclosure (AR) enables 3-phase auto-reclosing of a feeder which has previously been disconnected by overcurrent protection.

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for the trip circuit monitoring.

Control

The relay permits circuit-breakers to be opened and closed without command feedback. The circuit-breaker/disconnector may be controlled by DIGSI, or by the integrated HMI, or by the LSA/SCADA equipment connected to the interface.

For further details please refer to part 2 "Overview".

Switch-onto-fault protection

If switched onto a fault, instantaneous tripping can be effected. If the internal control function is used (local or via serial interface), the manual closing function is available without any additional wiring. If the control switch is connected to a circuit-breaker bypassing the internal control function, manual detection using a binary input is implemented.

Busbar protection (Reverse interlocking)

Binary inputs can be used to block any of the six current stages. Parameters are assigned to decide whether the input circuit is to operate in open-circuit or closed-circuit mode. In this case, reverse interlocking provides high-speed busbar protection in radial or ring power systems that are opened at one point. The reverse interlocking principle is used, for example, in medium-voltage power systems and in switchgear for power plants, where a high-voltage system transformer feeds a busbar section with several medium-voltage outgoing feeders.

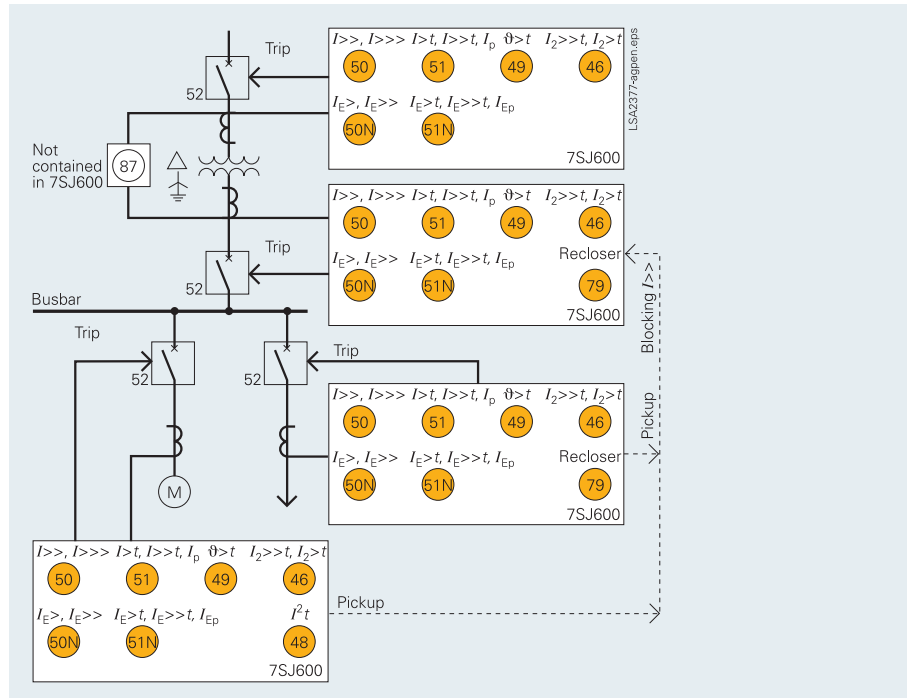


Fig. 5/25 Reverse interlocking

Motor protection

For short-circuit protection, e.g. elements $I_{>>}$ (50) and I_E (50N) are available. The stator is protected against thermal overload by $\vartheta_s >$ (49), the rotor by $I_2 >$ (46), starting time supervision (48).

Motor starting time supervision (ANSI 48)

The start-up monitor protects the motor against excessively long starting. This can occur, for example, if the rotor is blocked, if excessive voltage drops occur when the motor is switched on or if excessive load torques occur. The tripping time depends on the current.

$$t_{TRIP} = \left(\frac{I_{start}}{I_{rms}} \right)^2 \cdot t_{startmax}$$

$$\text{for } I_{rms} > I_{start}, \text{ reset ratio } \frac{I_N}{I_{start}}$$

approx. 0.94

t_{TRIP} = Tripping time

I_{start} = Start-up current of the motor

$t_{startmax}$ = Maximum permissible starting time

I_{rms} = Actual current flowing

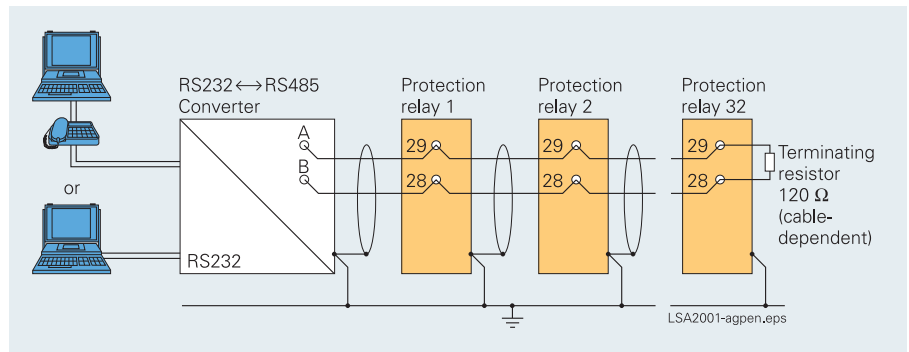


Fig. 5/26 Wiring communication
For convenient wiring of the RS485 bus, use bus cable system 7XV5103 (see part 14 of this catalog).

Features

Serial data transmission

A PC can be connected to ease setup of the relay using the Windows-based program DIGSI which runs under MS-Windows.

It can also be used to evaluate up to 8 oscillographic fault records, 8 fault logs and 1 event log containing up to 30 operational indications. The SIPROTEC 7SJ600 transmits a subset of data via IEC 60870-5-103 protocol:

- General fault detection
- General trip
- Phase current I_{L2}
- User-defined message
- Breaker control
- Oscillographic fault recording

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Connection diagrams

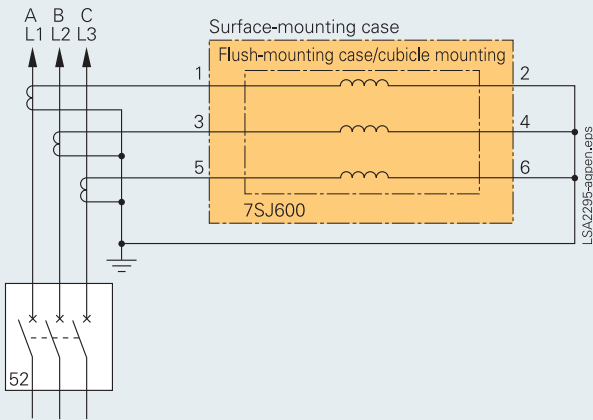


Fig. 5/27 Connection of 3 CTs with measurement of the phase currents

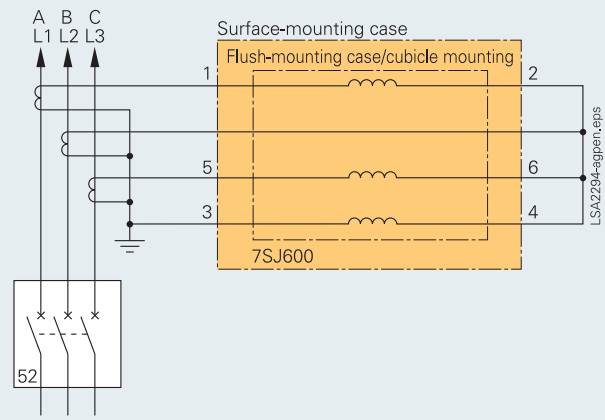


Fig. 5/28 Connection of 3 CTs with measurement of the earth (ground) current

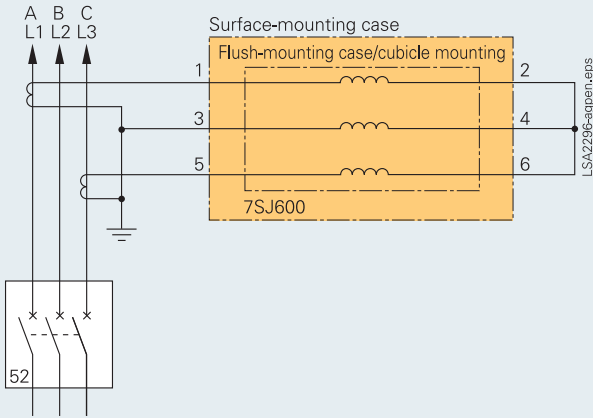


Fig. 5/29 Connection of 2 CTs only for isolated or resonant-earthed (grounded) power systems

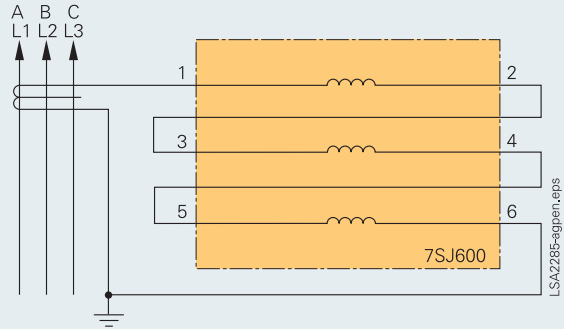


Fig. 5/30 Sensitive ground-fault protection (3-times increased sensitivity)

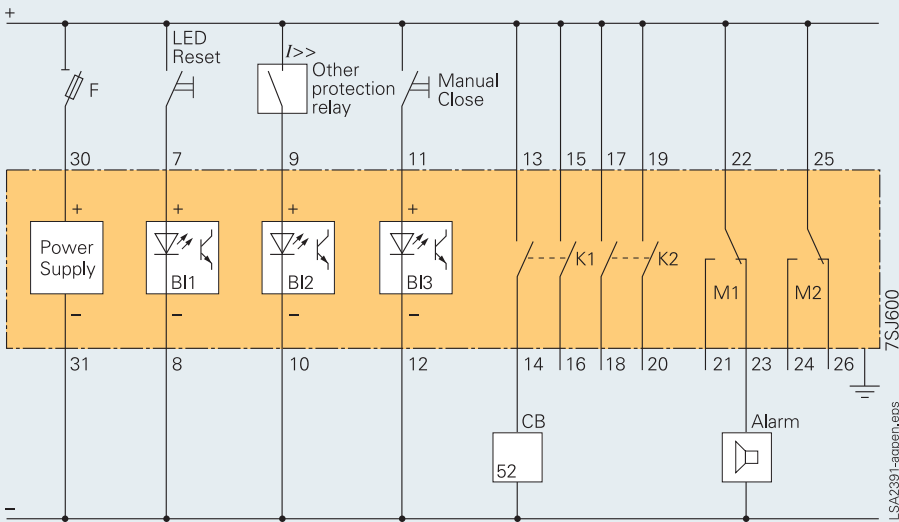


Fig. 5/31 Example of typical wiring

General unit data	
<i>CT circuits</i>	
Rated current I_N	1 or 5 A
Rated frequency f_N	50/60 Hz (selectable)
Overload capability current path Thermal (r.m.s.)	100 x I_N for ≤ 1 s 30 x I_N for ≤ 10 s 4 x I_N continuous 250 x I_N one half cycle
Dynamic (pulse current)	
Power consumption	
Current input at $I_N = 1$ A	< 0.1 VA
at $I_N = 5$ A	< 0.2 VA
<i>Power supply via integrated DC/DC converter</i>	
Rated auxiliary voltage V_{aux} / permissible variations	DC 24, 48 V/± 20 % DC 60, 110/125 V/± 20 % DC 220, 250 V/± 20 % AC 115 V/-20 % +15 % AC 230 V/-20 % +15 %
Superimposed AC voltage, peak-to-peak at rated voltage	≥ 12 %
at limits of admissible voltage	≥ 6 %
Power consumption	
Quiescent	Approx. 2 W
Energized	Approx. 4 W
Bridging time during failure/short-circuit of auxiliary voltage	≤ 50 ms at $V_{aux} \leq$ DC 110 V ≤ 20 ms at $V_{aux} \leq$ DC 24 V
<i>Binary inputs</i>	
Number	3 (marshallable)
Operating voltage	DC 24 to 250 V
Current consumption, independent of operating voltage	Approx. 2.5 mA
Pickup threshold, reconnectable by solder bridges	
Rated aux. voltage	
DC 24/48/60 V V_{pickup}	\geq DC 17 V
$V_{drop-out}$	< DC 8 V
DC 110/125/220/250 V V_{pickup}	\geq DC 74 V
$V_{drop-out}$	< DC 45 V
<i>Signal contacts</i>	
Signal/alarm relays	2 (marshallable)
Contacts per relay	1 CO
Switching capacity	
Make	1000 W / VA
Break	30 W / VA
Switching voltage	250 V
Permissible current	5 A

Heavy-duty (command) contacts	
Trip relays, number	2 (marshallable)
Contacts per relay	2 NO
Switching capacity	
Make	1000 W / VA
Break	30 W / VA
Switching voltage	250 V
Permissible current	
Continuous	5 A
For 0.5 s	30 A
<i>Design</i>	
Housing 7XP20	Refer to part 14 for dimension drawings
Weight	
Flush mounting /cubicle mounting	Approx. 4 kg
Surface mounting	Approx. 4.5 kg
Degree of protection acc. to EN 60529	
Housing	IP51
Terminals	IP21
<i>Serial interface</i>	
<i>Interface, serial; isolated</i>	
Standard	RS485
Test voltage	DC 2.8 kV for 1 min
Connection	Data cable at housing terminals, two data wires, one frame reference, for connection of a personal computer or similar; core pairs with individual and common screening, screen must be earthed (grounded), communication possible via modem
Transmission speed	As delivered 9600 baud min. 1200 baud, max. 19200 baud
<i>Electrical tests</i>	
<i>Specifications</i>	
Standards	IEC 60255-5; ANSI/IEEE C37.90.0
<i>Insulation test</i>	
Standards	IEC 60255-5, ANSI/IEEE C37.90.0
High-voltage test (routine test) Except DC voltage supply input and RS485	2 kV (r.m.s.), 50 Hz
Only DC voltage supply input and RS485	DC 2.8 kV
High-voltage test (type test) Between open contacts of trip relays	1.5 kV (r.m.s.), 50 Hz
Between open contacts of alarm relays	1 kV (r.m.s.), 50 Hz
Impulse voltage test (type test) all circuits, class III	5 kV (peak), 1.2/50 μ s, 0.5 J, 3 positive and 3 negative impulses at intervals of 5 s

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<i>EMC tests for interference immunity; type tests</i>	
Standards	IEC 60255-6; IEC 60255-22 (product standard) EN 50082-2 (generic standard), DIN VDE 0435 Part 303
High-frequency test IEC 60255-22-1, class III	2.5 kV (peak), 1 MHz, $\tau = 15$ ms, 400 surges/s, duration 2 s
Electrostatic discharge IEC 60255-22-2, class III and IEC 61000-4-2, class III	4 kV/6 kV contact discharge, 8 kV air discharge, both polarities, 150 pF, $R_i=330 \Omega$
Irradiation with radio-frequency field	
Non-modulated, IEC 60255-22-3 (report) class III	10 V/m, 27 to 500 MHz
Amplitude modulated, IEC 61000-4-3, class III	10 V/m, 80 to 1000 MHz, 80 % AM, 1 kHz
Pulse modulated, IEC 61000-4-3, class III	10 V/m, 900 MHz, repetition frequency, 200 Hz, duty cycle 50 %
Fast transient interference/bursts IEC 60255-22-4 and IEC 61000-4-4, class III	2 kV, 5/50 ns, 5 kHz, burst length 15 ms, repetition rate 300 ms, both polarities, $R_i = 50 \Omega$, duration 1 min
Conducted disturbances induced by radio-frequency fields, amplitude modulated IEC 601000-4-6, class III	10 V, 150 kHz to 80 MHz, 80 % AM, 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m continuous, 50 Hz 300 A/m for 3 s, 50 Hz 0.5 mT; 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1 (common mode)	2.5 to 3 kV (peak), 1 MHz to 1.5 MHz, decaying oscillation, 50 shots per s, duration 2 s, $R_i = 150 \Omega$ to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1 (common mode)	4 to 5 kV, 10/150 ns, 50 surges per s, both polarities, duration 2 s, $R_i = 80 \Omega$
Radiated electromagnetic inter- ference, ANSI/IEEE C37.90.2	10 to 20 V/m, 25 to 1000 MHz, amplitude and pulse-modulated
High-frequency test Document 17C (SEC) 102	2.5 kV (peak, alternating polarity), 100 kHz, 1 MHz, 10 MHz and 50 MHz, decaying oscillation, $R_i = 50 \text{ W}$
<i>EMC tests for interference emission; type tests</i>	
Standard	EN 50081-* (generic standard)
Conducted interference voltage, aux. voltage CISPR 22, EN 55022, DIN VDE 0878 Part 22, limit value class B	150 kHz to 30 MHz
Interference field strength CISPR 11, EN 55011, DIN VDE 0875 Part 11, limit value class A	30 to 1000 MHz

Mechanical stress tests	
<i>Vibration, shock and seismic vibration</i>	
<u>During operation</u>	
Standards	Acc. to IEC 60255-2-1 and IEC 60068-2
Vibration IEC 60255-21-1, class 1 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.035 mm amplitude, 60 to 150 Hz: 0.5 g acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1	Half-sine, acceleration 5 g, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
Seismic vibration IEC 60255-21-3, class 1, IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 g acceleration (horizontal axis) 8 to 35 Hz: 0.5 g acceleration (vertical axis) Sweep rate 1 octave/min 1 cycle in 3 orthogonal axes
<u>During transport</u>	
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 g acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sine, acceleration 15 g, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Half-sine, acceleration 10 g duration 16 ms, 1000 shocks in each direction of 3 orthogonal axes
Climatic stress tests	
<i>Temperatures</i>	
Recommended temperature during operation	-5 °C to +55 °C / +23 °F to +131 °F > 55 °C decreased display contrast
Permissible temperature during operation during storage during transport (Storage and transport with standard works packaging)	-20 °C to +70 °C / -4 °F to +158 °F -25 °C to +55 °C / -13 °F to +131 °F -25 °C to +70 °C / -13 °F to +158 °F
<i>Humidity</i>	
	Mean value per year ≤ 75 % relative humidity, on 30 days per year 95 % relative humidity, condensation not permissible

Functions	
Definite-time overcurrent protection (ANSI 50, 50N)	
Setting range/steps	
Overcurrent pickup phase I ground $I_{E>}$ phase $I_{>>}$ ground $I_{E>>}$ phase $I_{>>>}$	$III_{IN} = 0.1$ to 25 (steps 0.1), or ∞ $= 0.05$ to 25 (steps 0.01), or ∞ $III_{IN} = 0.1$ to 25 (steps 0.1), or ∞ $= 0.05$ to 25 (steps 0.01), or ∞ $III_{IN} = 0.3$ to 12.5 (steps 0.1), or ∞
Delay times T for $I_{>}$, $I_{E>}$, $I_{>>}$ and $I_{E>>}$	0 s to 60 s (steps 0.01 s)
The set times are pure delay times	
Pickup times $I_{>}$, $I_{>>}$, $I_{E>}$, $I_{E>>}$	
At 2 x setting value, without meas. repetition	Approx. 35 ms
At 2 x setting value, with meas. repetition	Approx. 50 ms
Pickup times for $I_{>>>}$ at 2 x setting value	Approx. 20 ms
Reset times $I_{>}$, $I_{>>}$, $I_{E>}$, $I_{E>>}$	Approx. 35 ms Approx. 65 ms
Reset ratios	Approx. 0.95
Overshot time	Approx. 25 ms
Tolerances	
Pickup values $I_{>}$, $I_{>>}$, $I_{>>>}$, $I_{E>}$, $I_{E>>}$	5 % of setting value
Delay times T	1 % of setting value or 10 ms
Influencing variables	
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	$\leq 1 \%$
Temperature, range: $0^\circ\text{C} \leq \Theta_{amb} \leq 40^\circ\text{C}$	$\leq 0.5 \%$ /10 K
Frequency, range: $0.98 \leq f/f_N \leq 1.02$	$\leq 1.5 \%$
Frequency, range: $0.95 \leq f/f_N \leq 1.05$	$\leq 2.5 \%$
Harmonics	
Up to 10 % of 3 rd harmonic	$\leq 1 \%$
Up to 10 % of 5 th harmonic	$\leq 1 \%$
Inverse-time overcurrent protection (ANSI 51/51N)	
Setting range/steps	
Overcurrent pickup phase I_p ground I_{Ep}	$III_{IN} = 0.1$ to 4 (steps 0.1) $= 0.05$ to 4 (steps 0.01)
Time multiplier for I_p , I_{Ep} T_p	(IEC charac.) 0.05 to 3.2 s (steps 0.01 s) (ANSI charac.) 0.5 to 15 s (steps 0.1 s)
Overcurrent pickup phase $I_{>>>}$ phase $I_{>>>>}$ ground $I_{E>>>}$	$III_{IN} = 0.1$ to 25 (steps 0.1), or ∞ $= 0.3$ to 12.5 (steps 0.1), or ∞ $= 0.05$ to 25 (steps 0.01), or ∞
Delay time T for $I_{>>>}$, $I_{E>>>}$	0 s to 60 s (steps 0.01 s)
Tripping time characteristics acc. to IEC	
Pickup threshold	Approx. $1.1 \times I_p$
Drop-out threshold	Approx. $1.03 \times I_p$
Drop-out time	Approx. 35 ms
Tripping time characteristics acc. to ANSI / IEEE	
Pickup threshold	Approx. $1.06 \times I_p$
Drop-out threshold, alternatively: disk emulation	Approx. $1.03 \times I_p$
Tolerances	
Pickup values	5 %
Delay time for $2 \leq III_p \leq 20$ and $0.5 \leq III_N \leq 24$	5 % of theoretical value $\pm 2 \%$ current tolerance, at least 30 ms
Influencing variables	
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	$\leq 1 \%$
Temperature, range: $-5^\circ\text{C} \leq \Theta_{amb} \leq 40^\circ\text{C}$ $+23^\circ\text{F} \leq \Theta_{amb} \leq 104^\circ\text{F}$	$\leq 0.5 \%$ /10 K
Frequency, range: $0.95 \leq f/f_N \leq 1.05$	$\leq 8 \%$ referred to theoretical time value
Negative-sequence overcurrent protection (ANSI 46)	
Setting range/steps	
Tripping stage	
$I_{2>}$ in steps of 1 %	8 % to 80 % of I_N
$I_{2>>}$ in steps of 1 %	8 % to 80 % of I_N
Time delays $T(I_{2>})$, $T(I_{2>>})$ in steps of 0.01s	0.00 s to 60.00 s
Lower function limit	At least one phase current $\geq 0.1 \times I_N$
Pickup times	At $f_N =$ 50 Hz 60 Hz
Tripping stage $I_{2>}$, tripping stage $I_{2>>}$	Approx. 60 ms 75 ms
But with currents $III_N > 1.5$ (overcurrent case) or negative-sequence current < (set value $+0.1 \times I_N$)	Approx. 200 ms 310 ms
Reset times	At $f_N =$ 50 Hz 60 Hz
Tripping stage $I_{2>}$, tripping stage $I_{2>>}$	Approx. 35 ms 42 ms
Reset ratios	
Tripping stage $I_{2>}$, tripping stage $I_{2>>}$	Approx. 0.95 to $0.01 \times I_N$
Tolerances	
Pickup values $I_{2>}$, $I_{2>>}$ with current $III_N \leq 1.5$ with current $III_N > 1.5$	$\pm 1 \%$ of $I_N \pm 5 \%$ of set value $\pm 5 \%$ of $I_N \pm 5 \%$ of set value
Stage delay times	$\pm 1 \%$ or 10 ms
Influence variables	
Auxiliary DC voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	$\leq 1 \%$
Temperature, range: $-5^\circ\text{C} \leq \Theta_{amb} \leq +40^\circ\text{C}$ $+23^\circ\text{F} \leq \Theta_{amb} \leq +104^\circ\text{F}$	$\leq 0.5 \%$ /10 K
Frequency, range: $0.98 \leq f/f_N \leq 1.02$ range: $0.95 \leq f/f_N \leq 1.05$	$\leq 2 \%$ of I_N $\leq 5 \%$ of I_N
Auto-reclosure (option) (ANSI 79)	
Number of possible shots	1 up to 9
Auto-reclose modes	3-pole
Dead times for 1 st to 3 rd shot for 4 th and any further shot	0.05 s to 1800 s (steps 0.01 s) 0.05 s to 1800 s (steps 0.01 s)
Reclaim time after successful AR	0.05 s to 320 s (steps 0.01 s)
Lock-out time after unsuccessful AR	0.05 s to 320 s (steps 0.01 s)
Reclaim time after manual close	0.50 s to 320 s (steps 0.01 s)
Duration of RECLOSE command	0.01s to 60 s (steps 0.01 s)
Control	
Number of devices	1
Evaluation of breaker control	None

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Thermal overload protection with memory (ANSI 49) (total memory according to IEC 60255-8)	
Setting ranges	
Factor k acc. to IEC 60255-8	0.40 to 2 (steps 0.01)
Thermal time constant τ_{th}	1 to 999.9 min (steps 0.1 min)
Thermal alarm stage $\Theta_{alarm}/\Theta_{trip}$	50 to 99 % referred to trip temperature rise (steps 1 %)
Prolongation factor at motor stand-still k_T	1 to 10 (steps 0.01)
Reset ratios	
Θ/Θ_{trip}	Reset below Θ_{alarm}
Θ/Θ_{alarm}	Approx. 0.99
Tolerances	
Referring to $k \cdot I_N$	$\pm 5\%$ (class 5 % acc. to IEC 60255-8)
Referring to trip time	$\pm 5\% \pm 2\text{ s}$ (class 5 % acc. to IEC 60255-8)
Influence variables referred to $k \cdot I_N$	
Auxiliary DC voltage in the range of $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	$\leq 1\%$
Temperature, range:	
$-5\text{ °C} \leq \Theta_{amb} \leq +40\text{ °C}$	$\leq 0.5\% / 10\text{ K}$
$+23\text{ °F} \leq \Theta_{amb} \leq +104\text{ °F}$	
Frequency, range:	
$0.95 \leq f/f_N \leq 1.05$	$\leq 1\%$
Without pickup value I_L/I_N	0.4 to 4 (steps 0.1)
Memory time multiplier T_L (= t_6 -time)	1 to 120 s (steps 0.1 s)
Reset ratio I/I_L	Approx. 0.94
Tolerances	
Referring to pickup threshold $1.1 \cdot I_L$	$\pm 5\%$
Referring to trip time	$\pm 5\% \pm 2\text{ s}$
Influence variables	
Auxiliary DC voltage in the range of $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	$\leq 1\%$
Temperature, range:	
$-5\text{ °C} \leq \Theta_{amb} \leq +40\text{ °C}$	$\leq 0.5\%/10\text{ K}$
$+23\text{ °F} \leq \Theta_{amb} \leq +104\text{ °F}$	
Frequency, range:	
$0.95 \leq f/f_N \leq 1.05$	$\leq 1\%$
Starting time supervision (motor protection)	
Setting ranges	
Permissible starting current I_{start}/I_N	0.4 to 20 (steps 0.1)
Permissible starting time t_{start}	1 to 360 s (steps 0.1 s)
Tripping characteristic	$t = \left(\frac{I_{start}}{I_{rms}}\right)^2 \cdot t$ for $I_{rms} > I_{start}$
Reset ratio I_{rms}/I_{start}	Approx. 0.94
Tolerances	
Pickup value	5%
Delay time	5 % of setting value or 330 ms

Fault recording	
Measured values	I_{L1}, I_{L2}, I_{L3}
Start signal	Trip, start release, binary input
Fault storage	Max. 8 fault records
Total storage time (fault detection or trip command = 0 ms)	Max. 5 s, incl. 35 power-fail safe selectable pre-trigger and post-fault time
Max. storage period per fault event T_{max}	0.30 to 5.00 s (steps 0.01 s)
Pre-trigger time T_{pre}	0.05 to 0.50 s (steps 0.01s)
Post-fault time T_{post}	0.05 to 0.50 s (steps 0.01 s)
Sampling rate	1 instantaneous value per ms at 50 Hz 1 instantaneous value per 0.83 ms at 60 Hz


Additional functions	
Operational measured values	
Operating currents	I_{L1}, I_{L2}, I_{L3}
Measuring range	0 % to 240 % I_N
Tolerance	3 % of rated value
Thermal overload values	
Calculated temperature rise	Θ/Θ_{trip}
Measuring range	0 % to 300 %
Tolerance	5 % referred to Θ_{trip}
Fault event logging	
Storage of indications of the last 8 faults	
Time assignment	
Resolution for operational indications	1 s
Resolution for fault event indications	1 ms
Max. time deviation	0.01 %
Trip circuit supervision	
With one or two binary inputs	
Circuit-breaker trip test	
With live trip or trip/reclose cycle (version with auto-reclosure)	

CE conformity	
This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EG previous 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 2006/95/EG previous 73/23/EEC).	
This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).	
The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.	
This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".	
	

Overcurrent Protection/7SJ600

Selection and ordering data

Description	Order No.
7SJ600 numerical overcurrent, motor and overload protection relay Binary input voltage 24 to 250 V DC with isolated RS485 port	7SJ600 <input type="checkbox"/> - <input type="checkbox"/> <input type="checkbox"/> A <input type="checkbox"/> 0 - <input type="checkbox"/> D <input type="checkbox"/> <input type="checkbox"/>
Rated current at 50/60 Hz	
1 A ¹⁾	1
5 A ¹⁾	5
Rated auxiliary voltage	
24, 48 V DC	2
60, 110, 125 V DC ²⁾	4
220, 250 V DC, 115 V AC ²⁾	5
230 V AC ³⁾	6
Unit design	
For panel surface mounting, terminals on the side B	B
Terminal connection on top and bottom D	D
For panel flush mounting/cubicle mounting	E
Languages	
English, German, Spanish, French, Russian	0
Auto-reclosure (option)	
Without	0
With	1
Control	
Without	A
With	B
UL-Listing	
Without UL-listing	0
With UL-listing	1

Accessories	Description	Order No.
 <p>Mounting rail</p> <p>LSP2289-a1p.eps</p>	Converter RS232 (V.24) - RS485* With communication cable for the 7SJ600 numerical overcurrent, motor and overload protection relay Length 1 m PC adapter	
	With power supply unit AC 230 V	7XV5700- 0 <input type="checkbox"/> <input type="checkbox"/> 00 ⁴⁾
	With power supply unit AC 110 V	7XV5700- 1 <input type="checkbox"/> <input type="checkbox"/> 00 ⁴⁾
	Converter, full-duplex, fiber-optic cable RS485 with built-in power supply unit Auxiliary voltage 24 to DC 250 V and AC 110/230 V	7XV5650- 0BA00
	Mounting rail for 19" rack	C73165-A63-C200-1
	Manual for 7SJ600	
	German	C53000-G1100-C106-9
	English	C53000-G1176-C106-7
	Spanish	C53000-G1178-C106-1
	French	C53000-G1177-C106-3
Sample order		
7SJ600, 1 A, 60 – 125 V, flush mounting, ARC	7SJ6001-4EA00-1DA0	
Converter V.24 -RS485, AC 230 V	7XV5700-0AA00	
Manual, English	C53000-G1176-C106-7	
or visit www.siemens.com/siprotec		

1) Rated current can be selected by means of jumpers.
 2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.
 3) Only when position 16 is not "1" (with UL-listing).
 4) Possible versions see part 13.
 * RS485 bus system up to 115 kbaud
 RS485 bus cable and adaptor
 7XV5103- AA ; see part 13.

Overcurrent Protection / 7SJ600

Connection diagram

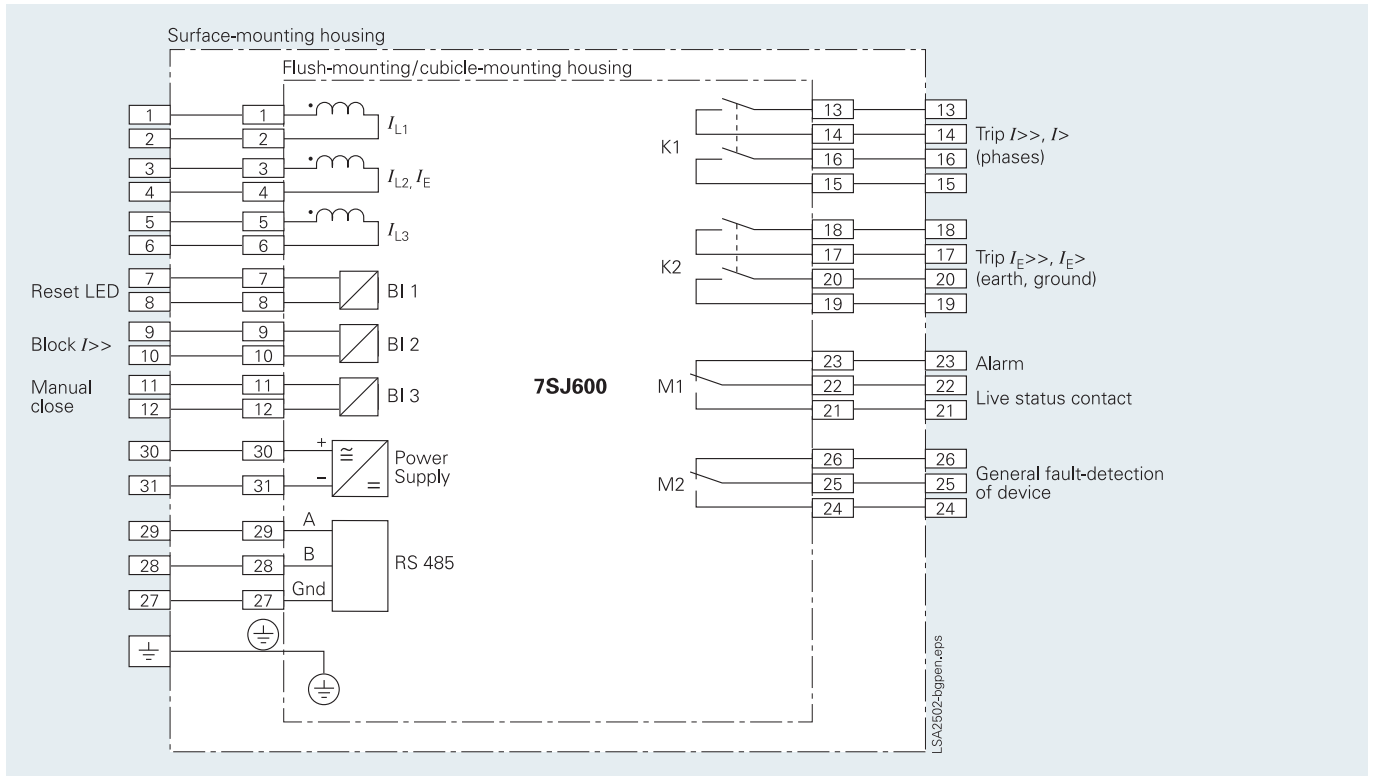


Fig. 5/32 Connection diagram according to IEC standard



Fig. 5/33 SIPROTEC 7SJ602 multifunction protection relay

Description

The SIPROTEC 7SJ602 is a numerical overcurrent relay which, in addition to its primary use in radial distribution networks and motor protection, can also be employed as backup for line, transformer and generator differential protection. The SIPROTEC 7SJ602 provides definite-time and inverse-time overcurrent protection along with overload and unbalanced-load (negative-sequence) protection for a very comprehensive relay package.

For applications with ground-current detection two versions are available: One version with four current transformer inputs for non-directional earth (ground) fault detection and a second version with three current inputs (2 phase, 1 earth/ground) and one voltage input for directional earth (ground) fault detection.

The flexible communication interfaces are open for modern communication architectures with control systems.

Function overview

Feeder protection

- Overcurrent-time protection
- Sensitive ground-fault detection
- Directional sensitive ground-fault detection
- Displacement voltage
- Disk emulation
- Overload protection
- Breaker failure protection
- Negative-sequence protection
- Cold load pickup
- Auto-reclosure
- Trip circuit supervision

Motor protection

- Starting time supervision
- Locked rotor
- Restart inhibit
- Undercurrent monitoring
- Temperature monitoring

Control functions

- Commands for control of a circuit-breaker
- Control via keyboard, DIGSI 4 or SCADA system

Measuring functions

- Operational measured values I , V
- Power measurement P , Q , S , W_p , W_q
- Slavepointer
- Mean values

Monitoring functions

- Fault event logging with time stamp (buffered)
- 8 oscillographic fault records
- Continuous self-monitoring

Communication interfaces

- System interface
 - IEC 60870-5-103 protocol
 - PROFIBUS-DP
 - MODBUS RTU/ASCII
- Front interface for DIGSI 4

Hardware

- 4 current transformers or
- 3 current + 1 voltage transformers
- 3 binary inputs
- 4 output relays
- 1 live status contact

Overcurrent Protection / 7SJ602

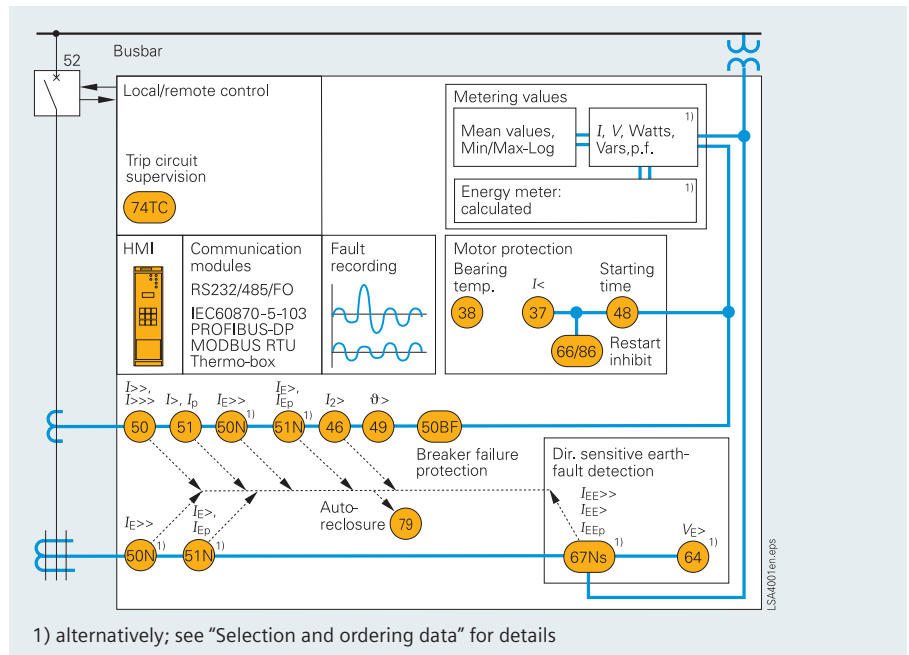
Application

Wide range of applications

The SIPROTEC 7SJ602 is a numerical overcurrent relay which, in addition to its primary use in radial distribution networks and motor protection, can also be employed as backup for feeder, transformer and generator differential protection.

The SIPROTEC 7SJ602 provides definite-time and inverse-time overcurrent protection along with overload and negative sequence protection for a very comprehensive relay package. In this way, equipment such as motors can be protected against asymmetric and excessive loading. Asymmetric short-circuits with currents that can be smaller than the largest possible load currents or phase interruptions are reliably detected.

The integrated control function allows simple control of a circuit-breaker or disconnector (electrically operated/ motorized switch) via the integrated HMI, DIGSI or SCADA.



1) alternatively; see "Selection and ordering data" for details

Fig. 5/34 Function diagram

ANSI	IEC	Protection functions
50, 50N	$I>$, $I>>$, $I>>>$ $I_E>$, $I_E>>$	Definite-time overcurrent protection (phase/neutral)
50, 51N	I_p , I_{Ep}	Inverse-time overcurrent protection (phase/neutral)
67Ns, 50Ns	$I_{EE>}$, $I_{EE>>}$, I_{EEp}	Directional/non-directional sensitive ground-fault detection
64	$I_2>$	Displacement voltage
50BF		Breaker failure protection
79		Auto-reclosure
46	$I_2>$	Phase-balance current protection (negative-sequence protection)
49	$\theta>$	Thermal overload protection
48		Starting time supervision
66/86		Restart inhibit
37	$I<$	Undercurrent monitoring
38		Temperature monitoring via external device, e.g. bearing temperature monitoring
74TC		Trip circuit supervision breaker control

Construction

The relay contains all the components needed for

- Acquisition and evaluation of measured values
- Operation and display
- Output of signals and trip commands
- Input and evaluation of binary signals
- SCADA interface (RS485, RS232, fiber-optic)
- Power supply.

The rated CT currents applied to the SIPROTEC 7SJ602 can be 1 A or 5 A. This is selectable via a jumper inside the relay.

Two different housings are available. The flush-mounting version has terminals accessible from the rear. The surface-mounting version has terminals accessible from the front. Retrofitting of a communication module, or replacement of an existing communication module with a new one are both possible.



Fig. 5/35 Rear view of flush-mounting housing



Fig. 5/36 View from below showing system interface (SCADA) with FO connection (for remote communications)

Protection functions

Definite-time characteristics

The definite-time overcurrent function is based on phase-selective evaluation of the three phase currents and ground current.

The definite-time overcurrent protection for the 3 phase currents has a low-set overcurrent element ($I_{>}$), a high-set overcurrent element ($I_{>>}$) and a high-set instantaneous element ($I_{>>>}$). Intentional trip delays can be set from 0 to 60 seconds for all three overcurrent elements.

The definite-time overcurrent protection for the earth (ground) current has a low-set overcurrent element ($I_{E>}$) and a high-set overcurrent element ($I_{E>>}$). Intentional trip delays can be parameterized from 0 to 60 seconds.

Inverse-time characteristics

In addition, inverse-time overcurrent protection characteristics (IDMTL) can be activated.

Reset characteristics

For easier time coordination with electromechanical relays, reset characteristics according to ANSI C37.112 and IEC 60255-3 / BS 142 standards are applied. When using the reset characteristic (disk emulation), a reset process is initiated after the fault current has disappeared.

This reset process corresponds to the reverse movement of the Ferraris disk of an electromechanical relay (thus: disk emulation).

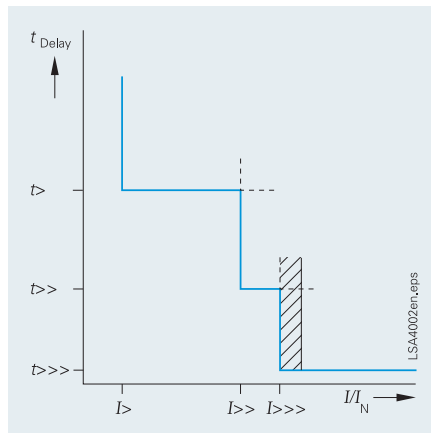


Fig. 5/37 Definite-time overcurrent characteristic

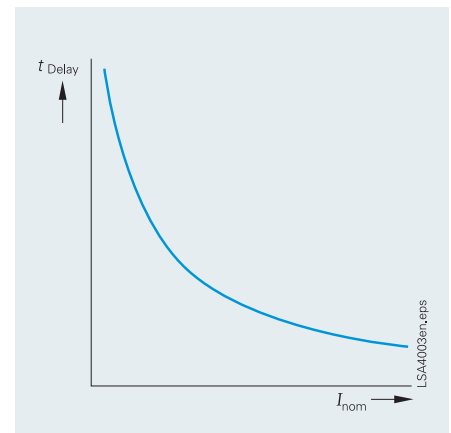


Fig. 5/38 Inverse-time overcurrent characteristic

Available inverse-time characteristics		
Characteristics acc. to	ANSI/IEEE	IEC 60255-3
Inverse	•	•
Short inverse	•	
Long inverse	•	•
Moderately inverse	•	
Very inverse	•	•
Extremely inverse	•	•
Definite inverse	•	
I squared T	•	
R1/RD-type		

Overcurrent Protection / 7SJ602

Protection functions

(Sensitive) directional ground-fault detection (ANSI 64, 67Ns)

The direction of power flow in the zero sequence is calculated from the zero-sequence current I_0 and zero-sequence voltage V_0 . For networks with an isolated neutral, the reactive current component is evaluated; for compensated networks the active current component or residual resistive current is evaluated. For special network conditions, e.g. high-resistance grounded networks with ohmic-capacitive ground-fault current or low-resistance grounded networks with ohmic-inductive current, the tripping characteristics can be rotated approximately ± 45 degrees (cosine/sinus).

Two modes of ground-fault direction detection can be implemented: tripping or in "signalling only mode".

It has the following functions:

- TRIP via the displacement voltage V_E .
- Two instantaneous elements or one instantaneous plus one inverse characteristic.
- Each element can be set in forward, reverse, or non-directional.

(Sensitive) ground-fault detection (ANSI 50Ns, 51Ns/50N, 51N)

For high-resistance grounded networks, a sensitive input transformer is connected to a phase-balance neutral current transformer (also called core-balance CT).

Thermal overload protection (ANSI 49)

The thermal overload protection function provides tripping or alarming based on a thermal model calculated from phase currents.

The ambient temperature or the temperature of the coolant can be detected serially via an external temperature monitoring box (also called thermo-box). If there is no thermo-box it is assumed that the ambient temperatures are constant.

Thermal overload protection without preload:

For thermal overload protection without consideration of the preload current, the following tripping characteristic applies only when

$$I \geq 1.1 \cdot I_L$$

For different thermal time constants T_L , the tripping time t is calculated in accordance with the following equation:

$$t = \frac{35}{\left(\frac{I}{I_L}\right)^2 - 1} \cdot T_L$$

I = Load current

I_L = Pickup current

T_L = Time multiplier

The reset threshold is above $1.03125 \cdot III_N$

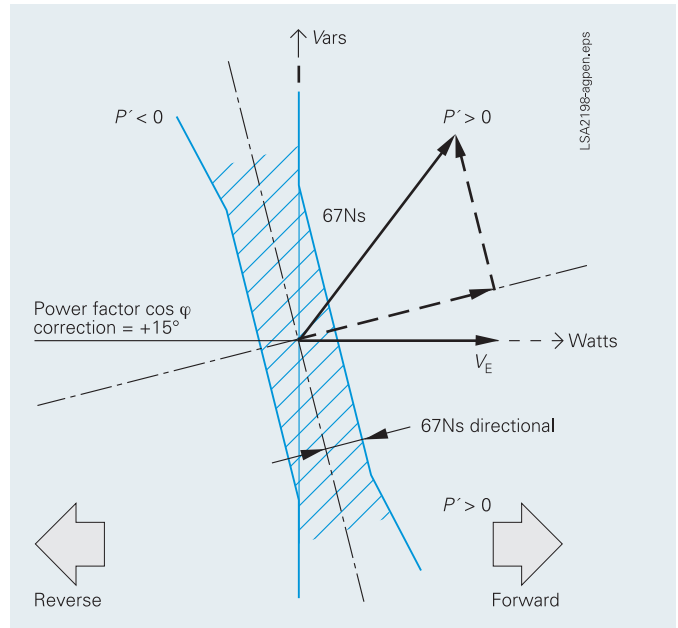


Fig. 5/39 Directional determination using cosine measurements

Thermal overload protection with preload

The thermal overload protection with consideration of preload current constantly updates the thermal model calculation regardless of the magnitude of the phase currents. The tripping time t is calculated in accordance with the following tripping characteristic (complete memory in accordance with IEC 60255-8).

$$t = t \cdot \ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2 - \left(\frac{I_{pre}}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1}$$

t = Tripping time after beginning of the thermal overload

$$t = 35.5 \cdot T_L$$

I_{pre} = Preload current

I = Load current

k = k factor (in accordance with IEC 60255-8)

I_N = Natural logarithm

T_L = Time multiplier

I_N = Rated (nominal) current

Breaker failure protection (ANSI 50BF)

If a faulted portion of the electrical circuit is not disconnected upon issuance of a trip command, another command can be initiated using the breaker failure protection which operates the circuit-breaker, e.g. of an upstream (higher-level) protection relay. Breaker failure is detected if after a trip command, current is still flowing in the faulted circuit. As an option it is possible to make use of the circuit-breaker position indication.

Negative-sequence protection ($I_{2>>}$, $I_{2>}$ /ANSI 46 Unbalanced-load protection)

The negative-sequence protection (see Fig. 5/40) detects a phase failure or load unbalance due to network asymmetry. Interruptions, short-circuits or crossed connections to the current transformers are detected.

Furthermore, low level single-phase and two-phase short-circuits (such as faults beyond a transformer) as well as phase interruptions can be detected.

This function is especially useful for motors since negative-sequence currents cause impermissible overheating of the rotor.

In order to detect the unbalanced load, the ratio of negative phase-sequence current to rated current is evaluated.

I_2 = negative-sequence current

T_{12} = tripping time

Transformer protection

The high-set element permits current coordination where the overcurrent element functions as a backup for the lower-level protection relays, and the overload function protects the transformer from thermal overload. Low-current single-phase faults on the low voltage side that result in negative phase-sequence current on the high-voltage side can be detected with the negative-sequence protection.

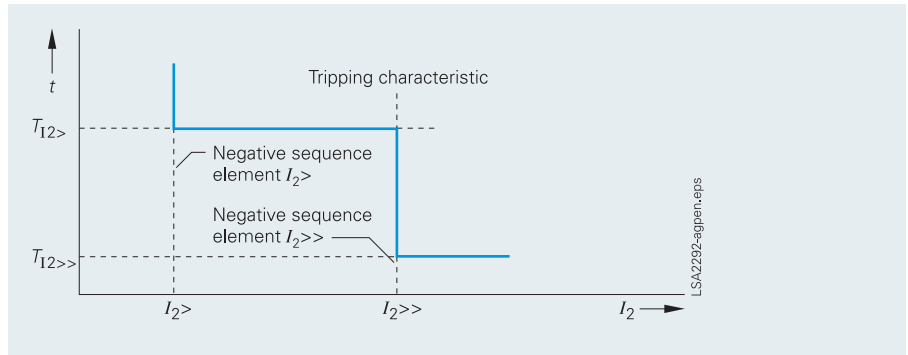


Fig. 5/40 Tripping characteristics of the negative-sequence protection function

Cold load pickup

By means of a binary input which can be wired from a manual close contact, it is possible to switch the overcurrent pickup settings to less sensitive settings for a programmable duration of time. After the set time has expired, the pickup settings automatically return to their original setting. This can compensate for initial inrush when energizing a circuit without compromising the sensitivity of the overcurrent elements during steady state conditions.

3-pole multishot auto-reclosure (AR, ANSI 79)

Auto-reclosure (AR) enables 3-phase auto-reclosing of a feeder which has previously been disconnected by overcurrent protection.

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for trip circuit monitoring.

Control

The relay permits circuit-breakers to be opened and closed without command feedback. The circuit-breaker/disconnector may be controlled by DIGSI, or by the integrated HMI, or by the LSA/SCADA equipment connected to the interface.

Overcurrent Protection / 7SJ602

Protection functions

Switch-onto-fault protection

If switched onto a fault, instantaneous tripping can be effected. If the internal control function is used (local or via serial interface), the manual closing function is available without any additional wiring. If the control switch is connected to a circuit-breaker by-passing the internal control function, manual detection using a binary input is implemented.

Busbar protection (Reverse interlocking)

Binary inputs can be used to block any of the six current stages. Parameters are assigned to decide whether the input circuit is to operate in open-circuit or closed-circuit mode. In this case, reverse interlocking provides highspeed busbar protection in radial or ring power systems that are opened at one point. The reverse interlocking principle is used, for example, in medium-voltage power systems and in switchgear for power plants, where a high-voltage system transformer feeds a busbar section with several medium-voltage outgoing feeders.

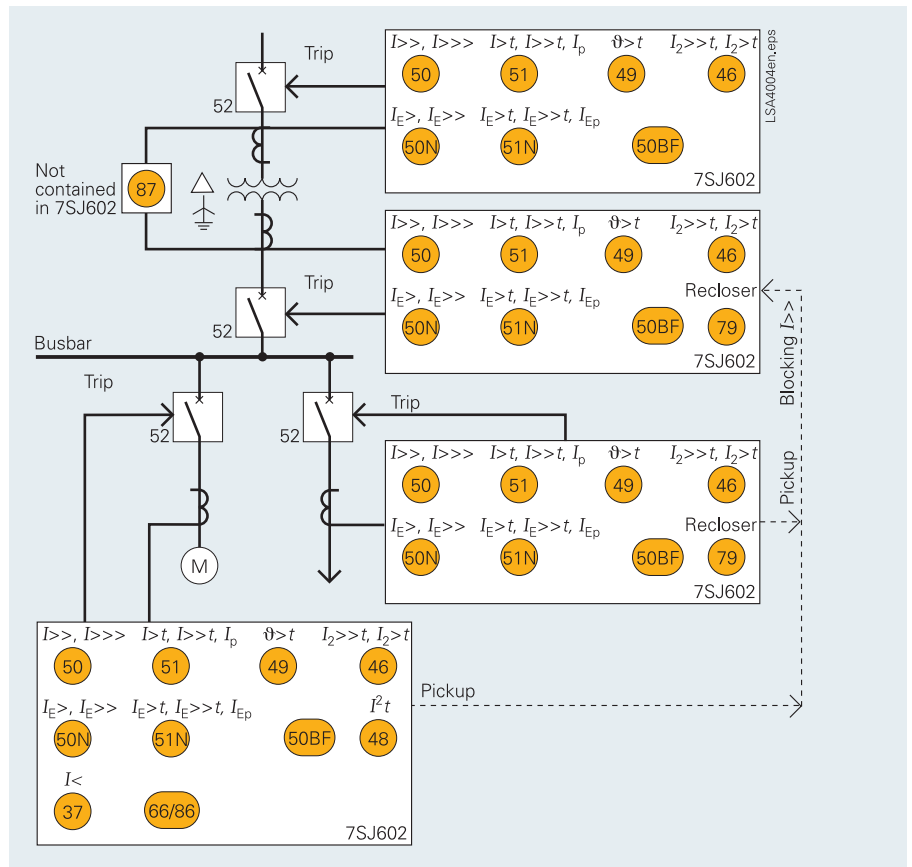


Fig. 5/41 Reserve interlocking

Motor protection

Starting time supervision (ANSI 48)

Starting time supervision protects the motor against long unwanted start-ups that might occur when excessive load occurs, excessive voltage drops occur within the motor or if the rotor is locked. Rotor temperature is calculated from measured stator current. The tripping time is calculated according to the following equation:

$$t_{\text{TRIP}} = \left(\frac{I_{\text{START}}}{I_{\text{rms}}} \right)^2 \cdot t_{\text{start max}}$$

for $I_{\text{rms}} > I_{\text{start}}$, reset ratio $\frac{I_{\text{N}}}{I_{\text{START}}}$ approx. 0.94

t_{TRIP} = tripping time

I_{start} = start-up current of the motor

$t_{\text{start max}}$ = maximum permissible starting time

I_{rms} = actual current flowing

Restart inhibit (ANSI 66/86)

If a motor is started up too many times in succession, the rotor can be subject to thermal overload, especially the upper edges of the bars. The rotor temperature is calculated from the stator current and the temperature characteristic is shown in a schematic diagram. The reclosing lockout only permits startup of the motor if the rotor has sufficient thermal reserves for a complete start-up.

Undercurrent monitoring (ANSI 37)

With this function, a sudden drop in current, which may occur due to a reduced motor load, is detected. This can cause shaft breakage, no-load operation of pumps or fan failure.

Temperature monitoring (ANSI 38)

A temperature monitoring box with a total of 6 measuring sensors can be used for temperature monitoring and detection by the protection relay. The thermal status of motors, generators and transformers can be monitored with this device. Additionally, the temperature of the bearings of rotating machines are monitored for limit value violation. The temperatures are measured with the help of temperature detectors at various locations of the device to be protected. This data is transmitted to the protection relay via a temperature monitoring box (also called thermo-box or RTD-box) (see "Accessories").

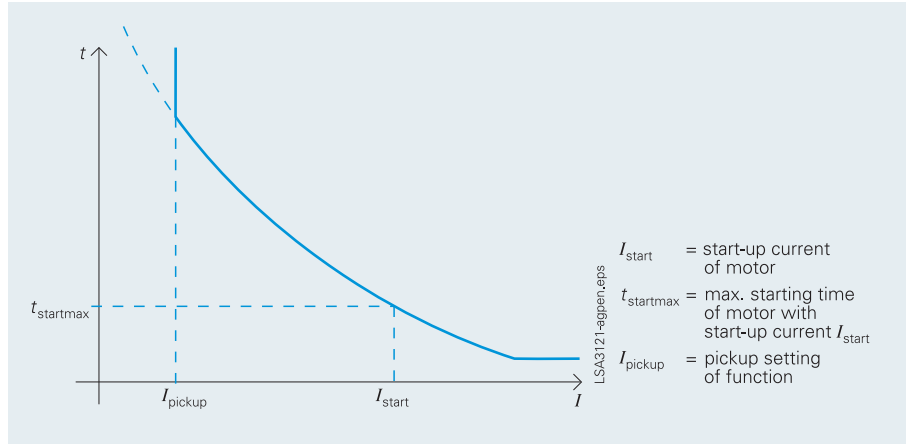


Fig. 5/42 Starting time supervision

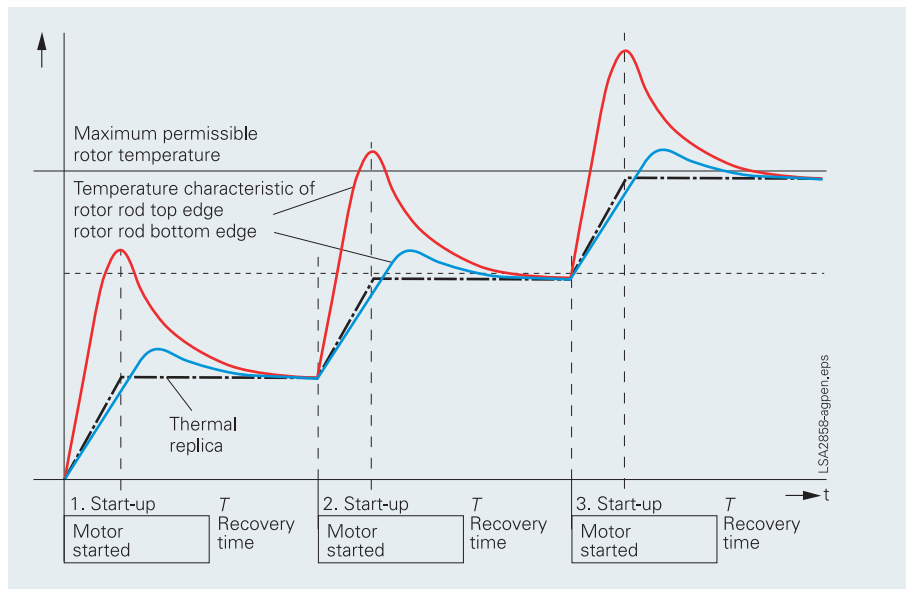


Fig. 5/43 Restart inhibit

Additional functions

Measured values

The r.m.s. values are calculated from the acquired current and voltage along with the power factor, active and reactive power. The following functions are available for measured value processing:

- Currents I_{L1} , I_{L2} , I_{L3} , I_E , I_{EE} (67Ns)
- Voltages V_{L1} , V_E (67Ns if existing)
- Power Watts, Vars, VA/P, Q, S
- Power factor ($\cos \varphi$),
- Energy \pm kWh, \pm kVarh, forward and reverse power flow
- Mean as well as minimum and maximum current, voltage and power values

Overcurrent Protection / 7SJ602

Communication

Communication

With respect to communication, particular emphasis has been placed on high levels of flexibility, data integrity and utilization of standards common in energy automation. The design of the communication modules permits interchangeability.

Local PC interface

The SIPROTEC 7SJ602 is fitted with an RS232 PC front port. A PC can be connected to ease set-up of the relay using the Windows-based program DIGSI which runs under MS-Windows. It can also be used to evaluate up to 8 oscillographic fault records, 8 fault logs and 1 event log containing up to 30 events.

System interface on bottom of the unit

A communication module located on the bottom part of the unit incorporates optional equipment complements and readily permits retrofitting. It guarantees the ability to comply with the requirements of different communication interfaces.

This interface is used to carry out communication with a control or a protection system and supports a variety of communication protocols and interface designs, depending on the module connected.

IEC 60870-5-103 protocol

IEC 60870-5-103 is an internationally standardized protocol for the efficient communication in the protected area. IEC 60870-5-103 is supported by a number of protection device manufacturers and is used worldwide.

PROFIBUS-DP

PROFIBUS-DP is an industry-recognized standard for communications and is supported by a number of PLC and protection device manufacturers.

MODBUS RTU

MODBUS RTU is an industry-recognized standard for communications and is supported by a number of PLC and protection device manufacturers.

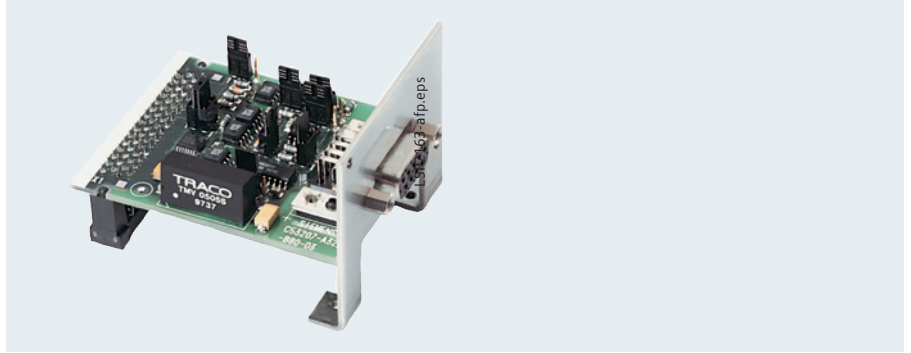


Fig. 5/44 RS232/RS485 electrical communication module

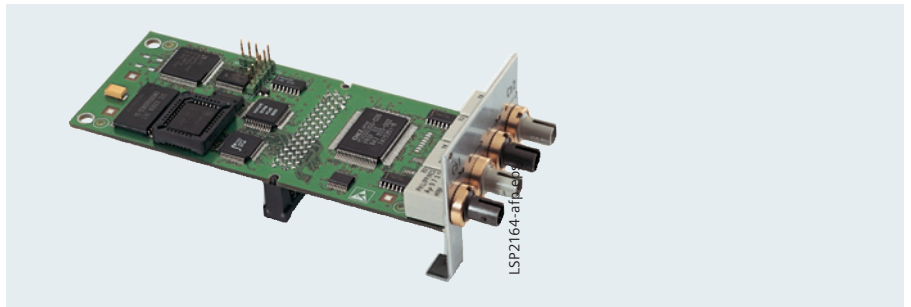


Fig. 5/45 PROFIBUS fiber-optic double ring communication module

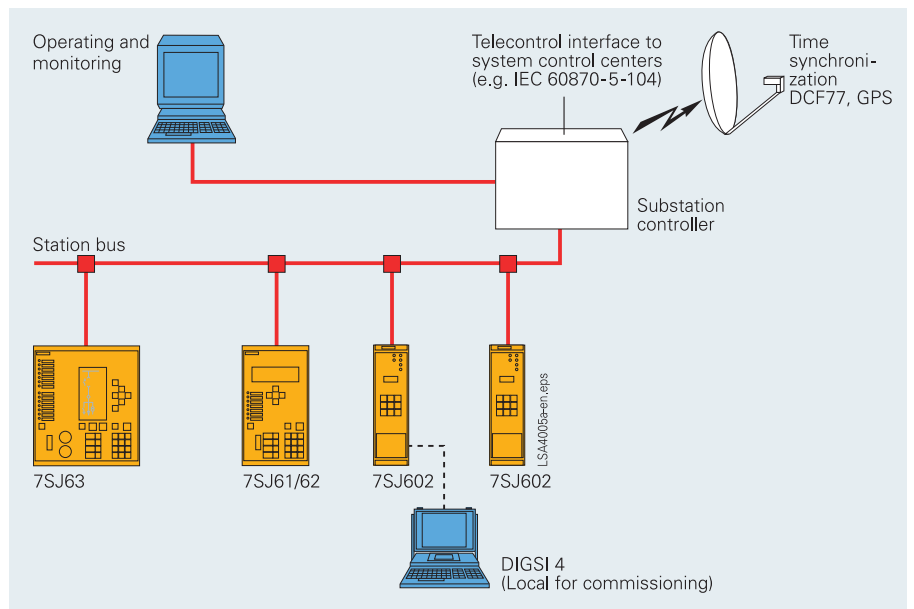


Fig. 5/46 System solution/communication

Typical connections

CT connections

Fig. 5/47 Standard

- Phase current measured
- Ground current measured (e. g. core balance CT)

Fig. 5/48 Standard connection

- Connection of 3 CTs with residual connection for neutral fault

Fig. 5/49 • Isolated networks only

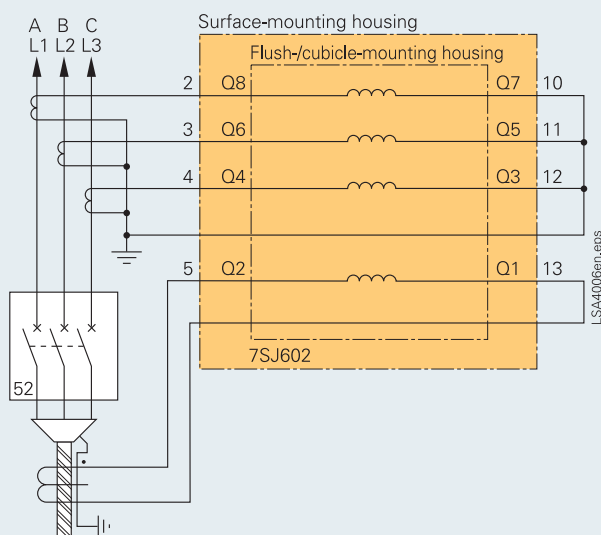


Fig. 5/47 Connection of 4 CTs with measurement of the earth (ground) current

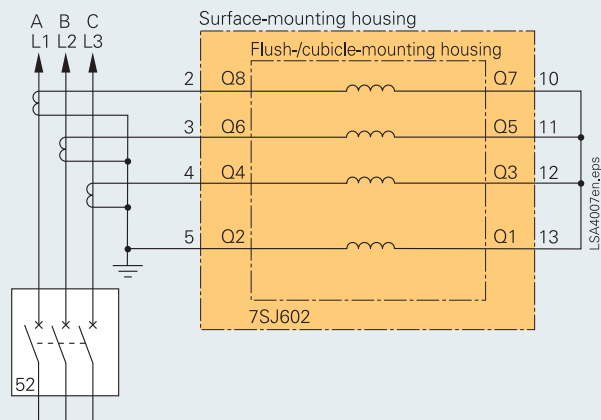


Fig. 5/48 Connection of 3 CTs with residual connection for neutral fault

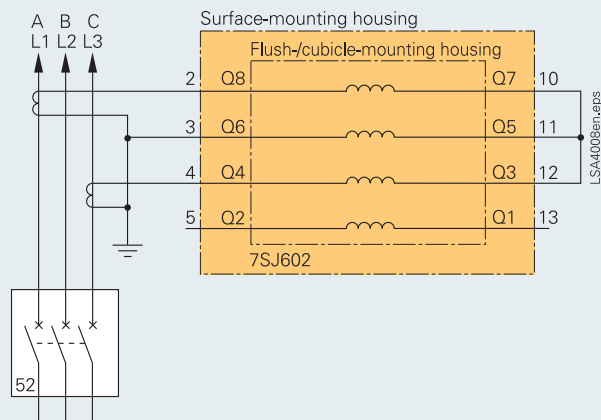


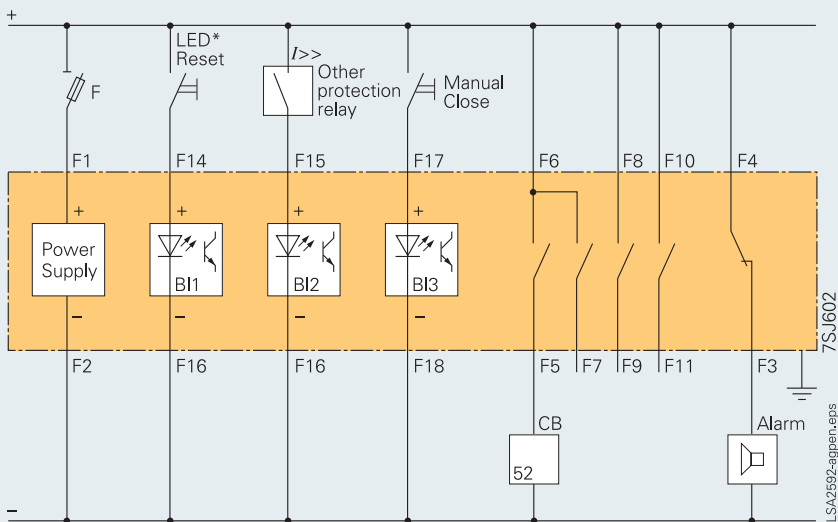
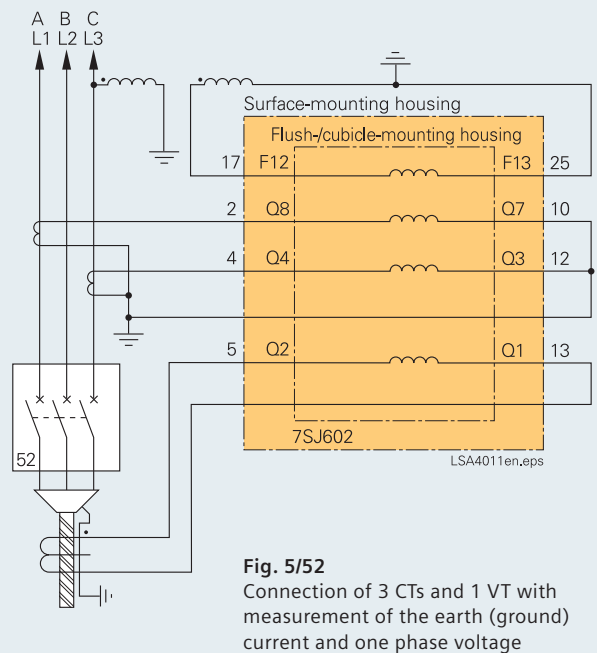
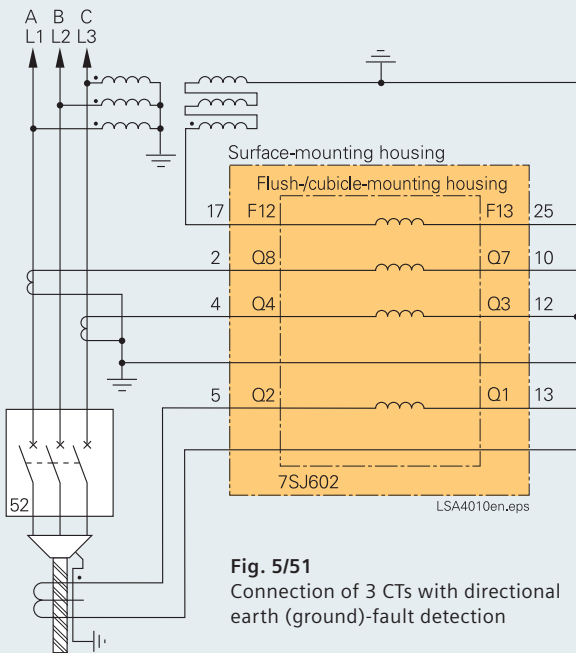
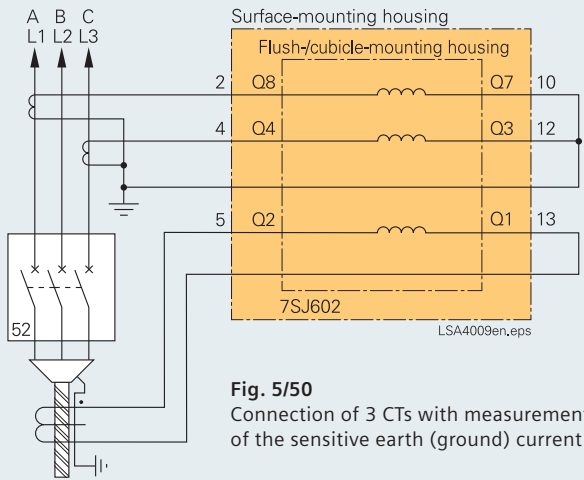
Fig. 5/49 Connection of 2 CTs only for isolated or resonant-earthed (grounded) power systems

Overcurrent Protection / 7SJ602

Typical connections

7SJ6022/7SJ6026

5



General unit data	
<i>CT circuits</i>	
Rated current I_N	1 or 5 A (settable)
Option: sensitive ground-fault CT	$I_{EE} < 1.6$ A or < 8 A (settable)
Rated frequency f_N	50/60 Hz (selectable)
Power consumption	
Current input at $I_N = 1$ A	< 0.1 VA
at $I_N = 5$ A	< 0.3 VA
For sensitive ground-fault detection at 1 A	Approx. 0.05 VA
Overload capability	
Thermal (r.m.s.)	100 x I_N for 1 s 30 x I_N for 10 s 4 x I_N continuous
Dynamic (pulse current)	250 x I_N one half cycle
Overload capability if equipped with sensitive ground-fault current transformer	
Thermal (r.m.s.)	300 A for 1 s 100 A for 10 s 15 A continuous
Dynamic (impulse current)	750 A (half cycle)
<i>Voltage transformer</i>	
Rated voltage V_N	100 to 125 V
Power consumption at $V_N = 100$ V	< 0.3 VA per phase
Overload capability in voltage path (phase-neutral voltage)	
Thermal (r.m.s.)	230 V continuous
<i>Power supply</i>	
Power supply via integrated DC/DC converter	
Rated auxiliary voltage V_{aux} / permissible variations	DC 24/48 V/± 20 % DC 60/110 V/± 20 % DC 110/125/220/250 V/± 20 % AC 115 V/- 20 %, + 15 % AC 230 V/- 20 %, + 15 %
Superimposed AC voltage, peak-to-peak	
At rated voltage	≤ 12 %
At limits of admissible voltage	≤ 6 %
Power consumption	Approx. 3 to 6 W, depending on operational status and selected auxiliary voltage
Bridging time during failure/short-circuit of auxiliary voltage	≥ 50 ms at $V_{aux} \geq AC/DC 110$ V ≥ 20 ms at $V_{aux} \geq DC 24$ V
<i>Binary outputs</i>	
<i>Trip relays</i>	4 (configurable)
Contacts per relay	1 NO/form A (Two contacts changeable to NC/form B, via jumpers)
Switching capacity	
Make	1000 W/VA
Break	30 VA, 40 W resistive 25 VA with L/R ≤ 50 ms
Switching voltage	250 V
Permissible current	
Continuous	5 A
For 0.5 s	30 A
Permissible total current	
For common potential:	
Continuous	5 A
For 0.5 s	30 A

<i>Alarm relays</i>	1
Contacts per relay	1 NO/NC (form A/B)
Switching capacity	
Make	1000 W/VA
Break	30 VA, 40 W resistive 25 VA with L/R ≤ 50 ms
Switching voltage	250 V
Permissible current	5 A continuous
<i>Binary inputs</i>	
Number	3 (configurable)
Operating voltage	DC 24 to 250 V
Current consumption, independent of operating voltage	Approx. 1.8 mA
Pickup threshold, selectable via bridges	
Rated aux. voltage	
DC 24/48/60/110 V	$V_{pickup} \geq DC 19$ V
DC 110/125/220/250 V	$V_{pickup} \geq DC 88$ V
Permissible maximum voltage	DC 300 V
<i>Connection (with screws)</i>	
Current terminals	
Connection ring cable lugs	$W_{max} = 11$ mm, $d_1 = 5$ mm
Wire size	2.0 – 5.3 mm ² (AWG 14-10)
Direct connection	Solid conductor, flexible lead, connector sleeve
Wire size	2.0 – 5.3 mm ² (AWG 14-10)
Voltage terminals	
Connection ring cable lugs	$W_{max} = 10$ mm, $d_1 = 4$ mm
Wire size	0.5 – 3.3 mm ² (AWG 20-12)
Direct connection	Solid conductor, flexible lead, connector sleeve
Wire size	0.5 – 3.3 mm ² (AWG 20-12)
<i>Unit design</i>	
Housing 7XP20	For dimensions please refer to dimension drawings, part 14
Degree of protection acc. to EN 60529	
For the device	
in surface-mounting housing	IP 51
in flush-mounting housing	
front	IP 51
rear	IP 20
For personal safety	IP 2x with closed protection cover
Weight	
Flush mounting/ cubicle mounting	Approx. 4 kg
Surface mounting	Approx. 4.5 kg
<i>Serial interfaces</i>	
<i>Operating interface</i>	
Connection	At front side, non-isolated, RS232, 9-pin subminiature connector
Operation	With DIGSI 4.3 or higher
Transmission speed	As delivered 19200 baud, parity: 8E1 Min. 1200 baud Max. 19200 baud
Distance	15 m

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System interface (bottom of unit)	
<i>IEC60870-5-103 protocol</i>	
Connection	Isolated interface for data transmission
Transmission rate	Min. 1200 baud, max. 19200 baud As delivered 9600 baud
<u>RS232/RS485 acc. to ordered version</u>	
Connection	9-pin subminiature connector on the bottom part of the housing
Test voltage	AC 500 V
RS232 maximum distance	15 m
RS485 maximum distance	1000 m
<u>Fiber-optic</u>	
Connector type	ST connector on the bottom part of the housing
Optical wavelength	$\lambda = 820 \text{ nm}$
Laser class 1 acc. to EN 60825-1/-2	For glass fiber 50/125 μm or 62.5/125 μm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 μm
Bridgeable distance	Max. 1.5 km
No character position	Selectable, setting as supplied „light off“
<i>PROFIBUS-DP</i>	
Isolated interface for data transfer to a control center	
Transmission rate	Up to 1.5 Mbaud
Transmission reliability	Hamming distance $d = 4$
<u>RS485</u>	
Connection	9-pin subminiature connector
Distance	1000 m/3300 ft $\leq 93.75 \text{ kbaud}$; 500 m/1500 ft $\leq 187.5 \text{ kbaud}$; 200 m/600 ft $\leq 1.5 \text{ Mbaud}$
Test voltage	AC 500 V against ground
<u>Fiber optic</u>	
Connection fiber-optic cable	Integrated ST connector for fiber optic connection
Optical wavelength	$\lambda = 820 \text{ nm}$
Laser class 1 acc. to EN 60825-1-2	For glass fiber 50/125 μm or 62.5/125 μm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 μm
Distance	500 kB/s 1.6 km/0.99 miles 1500 kB/s 530 m/0.33 miles
Idle state of interface	Settable, setting as supplied "light off"

System interface (bottom of unit), cont'd	
<i>MODBUS RTU/ASCII</i>	
Isolated interface for data transfer to a control center	
Transmission rate	Up to 19200 baud
Transmission reliability	Hamming distance $d = 4$
<u>RS485</u>	
Connection	9-pin subminiature connector
Distance	Max. 1 km/3300 ft max. 32 units recommended
Test voltage	AC 500 V against ground
<u>Fiber-optic</u>	
Connection fiber-optic cable	Integrated ST connector for fiber optic connection
Optical wavelength	820 nm
Laser class 1 acc. to EN 60825-1-2	For glass fiber 50/125 μm or 62.5/125 μm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 μm
Distance	Max. 1.5 km/0.9 miles
Idle state of interface	"Light off"

Electrical tests	
<i>Specifications</i>	
Standards	IEC 60255-5; ANSI/IEEE C37.90.0
<i>Insulation tests</i>	
High-voltage tests (routine test) all circuits except for auxiliary voltage, binary inputs and communication interfaces	2.5 kV (r.m.s. value), 50 Hz
High-voltage tests (routine test) Auxiliary voltage and binary inputs	DC 3.5 kV
High-voltage tests (routine test) only isolated communication interfaces	500 V (r.m.s. value); 50 Hz
Impulse voltage tests (type test) all circuits, except communication interfaces	5 kV (peak value), 1.2/50 ps, 0.5 J, 3 positive and 3 negative impulses at intervals of 5 s
<i>EMC tests for interference immunity; type tests</i>	
Standards	IEC 60255-6; IEC 60255-22, (product standard) EN 50082-2 (generic standard) DIN 57435 Part 303
High-frequency test IEC 60255-22-1, class III and VDE 0435 Part 303, class III	2.5 kV (peak value); 1 MHz, $\tau = 15 \text{ ms}$; 400 surges per s; test duration 2 s; $R_i = 200 \Omega$
Electrostatic discharge IEC 60255-22-2 class IV EN 61000-4-2, class IV	8 kV contact discharge, 15 kV air gap discharge, both polarities, 150 pF; $R_i = 330 \Omega$
Irradiation with radio-frequency field, non-modulated IEC 60255-22-3 (Report), class III	10 V/m, 27 to 500 MHz
Irradiation with radio-frequency field, amplitude-modulated IEC 61000-4-3, class III	10 V/m, 80 to 1000 MHz, AM 80 %; 1 kHz duration > 10 s
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204, class III	10 V/m, 900 MHz, repetition frequency 200 Hz duty cycle 50 % PM

EMC tests for interference immunity; type tests, (cont'd)	
Fast transients interference/bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50 \Omega$; test duration 1 min
Surge voltage IEC 61000-4-5, class III Auxiliary voltage	Pulse: 1.2/50 μ s From circuit to circuit (common mode): 2 kV, 12 Ω , 9 μ F; Across contacts (diff. mode): 1 kV, 2 W, 18 μ F
Measuring inputs, binary inputs/outputs	From circuit to circuit (common mode): 2 kV, 42 Ω , 0.5 μ F; Across contacts (diff. mode): 1 kV, 42 W, 0.5 μ F
Conducted RF amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; AM 80 %; 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m continuous 300 A/m for 3 s, 50 Hz 0.5 mT, 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak value), 1 to 1.5 MHz damped wave; 50 surges per s; duration 2 s $R_i = 150$ to 200 Ω ;
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV, 10/150 ns, 50 surges per s, both polarities; duration 2 s, $R_i = 80 \Omega$;
Radiated electromagnetic interference ANSI/IEEE Std C37.90.2	35 V/m; 25 to 1000 MHz; amplitude and pulse-modulated
Damped wave IEC 60694/ IEC 61000-4-12	2.5 kV (peak value), polarity alternating 100 kHz, 1 MHz, 10 and 50 MHz, $R_i = 200 \Omega$;

EMC tests interference emission; type tests	
Standard	EN 50081-* (generic specification)
Conducted interferences, only auxiliary voltage IEC/CISPR 22	150 kHz to 30 MHz limit class B
Radio interference field strength IEC/CISPR 22	30 to 1000 MHz limit class B
Harmonic currents on incoming lines of system at AC 230 V IEC 61000-3-2	Unit belongs to class D (applies only to units with > 50 VA power consumption)
Voltage fluctuation and flicker range on incoming lines of system at AC 230 V IEC 61000-3-3	Limit values are adhered to

Mechanical stress tests	
<i>Vibration, shock and seismic vibration</i>	
<u>During operation</u>	
Standards	Acc. to IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class I IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.035 mm amplitude; 60 to 150 Hz: 0.5 g acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I	Half-sine, acceleration 5 g, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
Seismic vibration IEC 60255-21-3, class I IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 g acceleration (horizontal axis) 8 to 35 Hz: 0.5 g acceleration (vertical axis) Sweep rate 1 octave/min 1 cycle in 3 orthogonal axes
<u>During transportation</u>	
Standards	Acc. to IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 g acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I IEC 60068-2-27	Half-sine, acceleration 15 g, duration 11 ms; 3 shocks in each direction of 3 orthogonal axes
Continuous shock IEC 60255-21-2, class I IEC 60068-2-29	Half-sine, acceleration 10 g, duration 16 ms, 1000 shocks in each direction of 3 orthogonal axes

Climatic stress tests	
<i>Temperatures</i>	
Recommended temperature During operation	-5 °C to +55 °C / 23 °F to 131 °F, (> 55 °C decreased display contrast)
Limit temperature During operation During storage During transport (Storage and transport with standard works packaging)	-20 °C to +70 °C / -4 °F to 158 °F -25 °C to +55 °C / -13 °F to 131 °F -25 °C to +70 °C / -13 °F to 158 °F
<i>Humidity</i>	
Permissible humidity stress: It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average: ≤ 75 % relative humidity, on 56 days per year 95 % relative humidity, condensation not permissible!

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Functions		Inverse-time overcurrent protection (ANSI 51/51N)	
<i>Definite-time overcurrent protection (ANSI 50, 50N)</i>		<i>Inverse-time overcurrent protection (ANSI 51/51N)</i>	
Setting ranges/steps		Setting ranges/steps	
Low-set overcurrent element		Low-set overcurrent element	
Phase I>	$III_N = 0.1$ to 25 (steps 0.1); or ∞	Phase I_p	$III_N = 0.1$ to 4 (steps 0.1)
Ground I_E>	$III_N = 0.05$ to 25 (steps 0.01); or ∞	Ground I_{Ep}	$III_N = 0.05$ to 4 (steps 0.01)
High-set overcurrent element		Time multiplier for I_p, I_{Ep} (IEC charac.)	$T_p = 0.05$ to 3.2 s (steps 0.01 s)
Phase I>>	$III_N = 0.1$ to 25 (steps 0.1); or ∞	Time multiplier for I_p, I_{Ep} (ANSI charac.)	$D = 0.5$ to 15 s (steps 0.1 s)
Ground I_E>>	$III_N = 0.05$ to 25 (steps 0.01); or ∞	High-set overcurrent element	
Instantaneous tripping		Phase I>>>	$III_N = 0.1$ to 25 (steps 0.1); or ∞
Phase I>>>	$III_N = 0.3$ to 12.5 (steps 0.1); or ∞	Ground I_E>>>	$III_N = 0.05$ to 25 (steps 0.01); or ∞
Delay times T for I>, I_E>, I>>, I_E>> and I>>>	0 to 60 s (steps 0.01 s)	Instantaneous tripping	
The set times are pure delay times		Phase I>>>>	$III_N = 0.3$ to 12.5 (steps 0.1); or ∞
Pickup times I>, I>>, I_E>, I_E>>		Delay time T_I>>>	0 to 60 s (steps 0.01 s)
At 2 x setting value, without meas. repetition	Approx. 25 ms	Tripping time characteristic acc. to IEC	See page 5/33
At 2 x setting value, with meas. repetition	Approx. 35 ms	Pickup threshold	Approx. $1.1 \times I_p$
Pickup times for I>>> at 2 x setting value	Approx. 15 ms	Reset threshold, alternatively disk emulation	Approx. $1.03 \times I_p$
Reset times I>, I>>, I_E>, I_E>>	Approx. 40 ms	Dropout time	
Reset time I>>>	Approx. 50 ms	50 Hz	Approx. 50 ms
Reset ratios	Approx. 0.95	60 Hz	Approx. 60 ms
Overshot time	Approx. 55 ms	Tolerances	
Tolerances		Pickup values	5 % of setting value or 5 % of rated value
Pickup values I>, I>>, I>>>, I_E>, I_E>>	5 % of setting value or 5 % of rated value	Timing period for $2 \leq III_p \leq 20$ and $0.5 \leq III_p \leq 24$	5 % of theoretical value ± 2 % current tolerance; at least 30 ms
Delay times T	1 % of setting value or 10 ms	Influencing variables	
Influencing variables		Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %	Temperature, range: $-5^\circ\text{C} \leq \Theta_{amb} \leq 40^\circ\text{C}$ / $-23^\circ\text{F} \leq \Theta_{amb} \leq 104^\circ\text{F}$	≤ 0.5 %/10 K
Temperature, range: $-5^\circ\text{C} \leq \Theta_{amb} \leq 40^\circ\text{C}$ / $23^\circ\text{F} \leq \Theta_{amb} \leq 104^\circ\text{F}$	≤ 0.5 %/10 K	Frequency, range: $0.95 \leq f/f_N \leq 1.05$	≤ 8 %, referred to theoretical time value
Frequency, range: $0.98 \leq f/f_N \leq 1.02$ / $0.95 \leq f/f_N \leq 1.05$	≤ 1.5 % / ≤ 2.5 %	Tripping characteristic acc. to ANSI/IEEE	See page 5/33
Harmonics		Pickup threshold	Approx. $1.06 \times I_p$
Up to 10 % of 3 rd harmonic	≤ 1 %	Dropout threshold, alternatively disk emulation	Approx. $1.03 \times I_p$
Up to 10 % of 5 th harmonic	≤ 1 %	Tolerances	
		Pickup threshold	5 % of setting value or 5 % of rated value
		Timing period for $2 \leq III_p \leq 20$ and $0.5 \leq III_p \leq 24$	5 % of theoretical value ± 2 % current tolerance; at least 30 ms
		Influencing variables	
		Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
		Temperature, range: $-5^\circ\text{C} \leq \Theta_{amb} \leq 40^\circ\text{C}$ / $23^\circ\text{F} \leq \Theta_{amb} \leq 104^\circ\text{F}$	≤ 0.5 %/10 K
		Frequency, range: $0.95 \leq f/f_N \leq 1.05$	≤ 8 %, referred to theoretical time value

<i>(Sensitive) ground-fault protection (directional/non-directional)</i>	
Definite-time ground-fault protection (ANSI 50Ns)	
Setting ranges/steps	
Low-set element $I_{EE>}$	$III_{EEN} = 0.003$ to 1.5 (steps 0.001); or ∞ (deactivated)
High-set element $I_{EE>>}$	$III_{EEN} = 0.003$ to 1.5 (steps 0.001); or ∞ (deactivated)
Delay times T for $I_{EE>}$ and $I_{EE>>}$	0 to 60 s (steps 0.01 s)
Pickup times $I_{EE>}, I_{EE>>}$	
At 2 x setting value without meas. repetition	Approx. 35 ms
At 2 x setting value with meas. repetition	Approx. 55 ms
Reset times $I_{EE>}, I_{EE>>}$	
At 50 Hz	Approx. 65 ms
At 60 Hz	Approx. 95 ms
Reset ratios	Approx. 0.95
Overshot time	Approx. 55 ms
Tolerances	
Pickup values $I_{EE>}, I_{EE>>}$	5 % of setting value or 5 % of rated value
Delay times T	1 % of setting value or 10 ms
Influencing variables	
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	$\leq 1 \%$
Temperature, range: $-5 \text{ }^\circ\text{C} \leq \Theta_{amb} \leq 40 \text{ }^\circ\text{C} / 23 \text{ }^\circ\text{F} \leq \Theta_{amb} \leq 104 \text{ }^\circ\text{F}$	$\leq 0.5 \%$ /10 K
Frequency, ranges: $0.98 \leq f/f_N \leq 1.02$	$\leq 1.5 \%$
$0.95 \leq f/f_N \leq 1.05$	$\leq 2.5 \%$
Harmonics	
Up to 10 % of 3 rd harmonic	$\leq 1 \%$
Up to 10 % of 5 rd harmonic	$\leq 1 \%$
Inverse-time ground-fault protection (ANSI 51Ns)	
Setting ranges/steps	
Low-set element I_{EEP}	$III_{EEN} = 0.003$ to 1.4 (steps 0.001)
Time multiplier for I_{EEP} (IEC characteristic)	$T_p = 0.05$ to 3.2 s (steps 0.01 s)
Time multiplier for I_{EEP} (ANSI characteristic)	$D = 0.5$ to 15 s (steps 0.1 s)
High-set element $I_{EE>>}$	$III_{EEN} = 0.003$ to 1.5 (steps 0.001); or ∞ (deactivated)
Delay time T for $I_{EE>>}$	0 to 60 s (steps 0.01 s)
Tripping time characteristic acc. to IEC	See page 5/33
Pickup threshold	Approx. $1.1 \times I_{EEP}$
Reset threshold alternatively disk emulation	Approx. $1.03 \times I_{EEP}$
Dropout time	
50 Hz	Approx. 50 ms
60 Hz	Approx. 60 ms
Tolerances	
Pickup values	5 % of setting value or 5 % of rated value
Timing period for $2 \leq III_{EEP} \leq 20$ and $0.5 \leq III_{EEN} \leq 24$	5 % of theoretical value $\pm 2 \%$ current tolerance; at least 30 ms
Influencing variables	
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	$\leq 1 \%$

Inverse-time ground-fault protection (ANSI 51Ns), cont'd	
Temperature, range: $-5 \text{ }^\circ\text{C} \leq \Theta_{amb} \leq 40 \text{ }^\circ\text{C} / 23 \text{ }^\circ\text{F} \leq \Theta_{amb} \leq 104 \text{ }^\circ\text{F}$	$\leq 0.5 \%$ /10 K
Frequency, range: $0.95 \leq f/f_N \leq 1.05$	$\leq 8 \%$, referred to theoretical time value
Tripping characteristic acc. to ANSI/IEEE	See page 5/33
Pickup threshold	Approx. $1.06 \times I_{EEP}$
Dropout threshold, alternatively disk emulation	Approx. $1.03 \times I_{EEP}$
Tolerances	
Pickup threshold	5 % of setting value or 5 % of rated value
Timing period for $2 \leq III_{EEP} \leq 20$ and $0.5 \leq III_{EEN} \leq 24$	5 % of theoretical value $\pm 2 \%$ current tolerance; at least 30 ms
Influencing variables	
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	$\leq 1 \%$
Temperature, range: $-5 \text{ }^\circ\text{C} \leq \Theta_{amb} \leq 40 \text{ }^\circ\text{C} / 23 \text{ }^\circ\text{F} \leq \Theta_{amb} \leq 104 \text{ }^\circ\text{F}$	$\leq 0.5 \%$ /10 K
Frequency, range: $0.95 \leq f/f_N \leq 1.05$	$\leq 8 \%$, referred to theoretical time value
Direction detection (ANSI 67Ns)	
Direction measurement	I_E, V_E (measured)
Measuring principle	Active/reactive measurement
Measuring enable	
For sensitive input	$III_{EEN} = 0.003$ to 1.2 (in steps of 0.001 III_{EEN})
Reset ratio	Approx. 0.8
Measuring method	$\cos \varphi$ and $\sin \varphi$
Direction vector	-45° to $+45^\circ$ (in steps of 0.1°)
Dropout delay T_{Reset} Delay	1 to 60 s (steps 1 s)
Angle correction for cable converter (for resonant-grounded system)	In 2 operating points F1 and F2
Angle correction F1, F2	0° to 5° (in steps of 0.1°)
Current values I_1, I_2	
For sensitive input	$III_{EEN} = 0.003$ to 1.6 (in steps of 0.001 III_{EEN})
Measuring tolerance acc. to DIN 57435	2 % of the setting value or 1 mA
Angle tolerance	3°
Displacement voltage (ANSI 64)	
Displacement voltage, measured	$V_E > V_N = 0.02$ to 1.3 (steps 0.001)
Measuring time	Approx. 60 ms
Pickup delay time	0.04 to 320 s or ∞ (steps 0.01 s)
Time delay	0.1 to 40000 s or ∞ (steps 0.01 s)
Dropout ratio	0.95 or (pickup value - 0.6 V)
Measuring tolerance	
V_E (measured)	3 % of setting value, or 0.3 V
Operating time tolerances	1 % of setting value, or 10 ms
The set times are pure delay times	

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Thermal overload protection with memory (ANSI 49) with preload	
Setting ranges	
Factor k according to IEC 60255-8	0.40 to 2 (steps 0.01)
Thermal time constant τ_{th}	1 to 999.9 min (steps 0.1 min)
Thermal warning stage $\Theta_{alarm}/\Theta_{trip}$	50 to 99 % referred to trip temperature rise (steps 1 %)
Prolongation factor at motor stand-still k_T	1 to 10 (steps 0.01)
Reset ratios	
Θ/Θ_{trip}	Reset below 0.99 Θ_{alarm}
Θ/Θ_{alarm}	Approx. 0.99
Tolerances	
Referring to $k \cdot I_N$	$\pm 5\%$ (class 5 % acc. to IEC 60255-8)
Referring to trip time	$\pm 5\% \pm 2\text{ s}$ (class 5 % acc. to IEC 60255-8)
Influencing variables	
Auxiliary DC voltage, range $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	$\leq 1\%$
Temperature, range $-5\text{ °C} \leq \Theta_{amb} \leq +40\text{ °C}$ / $23\text{ °F} \leq \Theta_{amb} \leq 104\text{ °F}$	$\leq 0.5\% / 10\text{ K}$
Frequency, range $0.95 \leq f/f_N \leq 1.05$	$\leq 1\%$
Thermal overload protection without memory (ANSI 49) without preload	
Setting ranges	
Pickup value	$I_L/I_N = 0.4$ to 4 (steps 0.1)
Time multiplier t_L (= t_6 -time)	1 to 120 s (steps 0.1 s)
Reset ratio I/I_L	Approx. 0.94
Tolerances	
Referring to pickup threshold $1.1 I_L$	$\pm 5\%$ of setting value or 5 % of rated value
Referring to trip time	$\pm 5\% \pm 2\text{ s}$
Influencing variables	
Auxiliary DC voltage, range $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	$\leq 1\%$
Temperature, range $-5\text{ °C} \leq \Theta_{amb} \leq +40\text{ °C}$ / $23\text{ °F} \leq \Theta_{amb} \leq 104\text{ °F}$	$\leq 0.5\% / 10\text{ K}$
Frequency, range $0.95 \leq f/f_N \leq 1.05$	$\leq 1\%$
Breaker failure protection	
Setting ranges/steps	
Pickup of current element	CB $I>/I_N = 0.04$ to 1.0 (steps 0.01)
Delay time	0.06 to 60 s or ∞ (steps 0.01 s)
Pickup times (with internal start) (via control) (with external start)	is contained in the delay time is contained in the delay time is contained in the delay time
Dropout time	Approx. 25 ms
Tolerances	
Pickup value	2 % of setting value
Delay time	1 % or 20 ms

Negative-sequence protection (ANSI 46)	
Setting ranges/steps	
Tripping stages $I_{2>}$ and $I_{2>>}$	8 to 80 % to I_N (steps 1 %)
Delay times $T(I_{2>})$, $T(I_{2>>})$	0 to 60 s (steps 0.01 s)
Lower function limit	At least one phase current $\geq 0.1 \times I_N$
Pickup times	
Tripping stages $I_{2>}$ and $I_{2>>}$ But with currents $I/I_N > 1.5$ (overcurrent case) or negative-sequence current $<$ (set value $+0.1 \times I_N$)	at $f_N = 50\text{ Hz}$ at $f_N = 60\text{ Hz}$ Approx. 60 ms Approx. 75 ms
Reset times	Approx. 200 ms Approx. 310 ms
Tripping stages $I_{2>}$ and $I_{2>>}$	Approx. 35 ms Approx. 42 ms
Reset ratios	
Tripping stages $I_{2>}$ and $I_{2>>}$	Approx. 0.9 to 0.01 $\times I_N$
Tolerances	
Pickup values $I_{2>}$, $I_{2>>}$	
Current $I/I_N \leq 1.5$	$\pm 1\%$ of $I_N \pm 5\%$ of set value
Current $I/I_N > 1.5$	$\pm 5\%$ of $I_N \pm 5\%$ of set value
Delay times $T(I_{2>})$ and $T(I_{2>>})$	$\pm 1\%$ but min. 10 ms
Influencing variables	
Auxiliary DC voltage, range $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	$\leq 1\%$
Temperature, range $-5\text{ °C} \leq \Theta_{amb} \leq +40\text{ °C}$ / $23\text{ °F} \leq \Theta_{amb} \leq 104\text{ °F}$	$\leq 0.5\% / 10\text{ K}$
Frequency, range $0.98 \leq f/f_N \leq 1.02$ / $0.95 \leq f/f_N \leq 1.05$	$\leq 1\%$ of I_N $\leq 5\%$ of I_N
Auto-reclosure (ANSI 79)	
Number of possible shots	1 to 9, configurable
Auto-reclosure modes	3-pole
Dead times for 1 st and any further shot	0.05 s to 1800 s (steps 0.01 s)
Blocking time after successful AR	0.05 s to 320 s (steps 0.01 s)
Lock-out time after unsuccessful AR	0.05 s to 320 s (steps 0.01 s)
Reclaim time after manual close	0.50 s to 320 s (steps 0.01 s)
Duration of reclose command	0.01 s to 60 s (steps 0.01 s)
Trip circuit supervision (ANSI 74TC)	
Trip circuit supervision	With one or two binary inputs
Circuit-breaker trip test	Trip/reclosure cycle
Control	
Number of devices	1
Evaluation of breaker contact	None

Motor protection	
Setting ranges/steps Rated motor current/ transformer rated current	$I_{motor}/I_N = 0.2$ to 1.2 (in steps of 0.1)
Start-up current of the motor	$I_{start}/I_{motor} = 0.4$ to 20 (in steps of 0.1)
Permissible start-up time $t_{start\ max}$	1 to 360 s (in steps of 0.1 s)
Starting time supervision (ANSI 48)	
Setting ranges/steps Pickup threshold	$I_{pickup}/I_{motor} = 0.4$ to 20 (in steps of 0.1)
Tripping time characteristic	$t_{TRIP} = \left(\frac{I_{start}}{I_{rms}} \right)^2 \cdot t_{start\ max}$ For $I_{rms} > I_{pickup}$ I_{start} = Start-up current of the motor I_{rms} = Current actually flowing I_{pickup} = Pickup threshold, from which the motor start-up is detected $t_{start\ max}$ = Maximum permissible starting time t_{TRIP} = Tripping time
Reset ratio I_{rms}/I_{pickup}	Approx. 0.94
Tolerances Pickup values	5 % of setting value or 5 % rated value
Delay time	5 % or 330 ms
Restart inhibit for motors (ANSI 66/86)	
Setting ranges/steps Rotor temperature compensation time T_{COMP}	0 to 60 min (in steps of 0.1 min)
Minimum restart inhibit time $T_{restart}$	0.2 to 120 min (in steps of 0.1 min)
Maximum permissible number of warm starts n_w	1 to 4 (in steps of 1)
Difference between cold and warm start $n_c - n_w$	1 to 2 (in steps of 1)
Extension factor for cooling simulation of the rotor (running and stop)	1 to 10 (in steps of 0.1)
Restarting limit	$\Theta_{restart} = \Theta_{rot\ max\ perm} \cdot \frac{n_c - 1}{n_c}$ $\Theta_{restart}$ = Temperature limit below which restarting is possible $\Theta_{rot\ max\ perm}$ = Maximum permissible rotor overtemperature (= 100 % in operational measured value $\Theta_{rot}/\Theta_{rot\ trip}$) n_c = Number of permissible start-ups from cold state
Undercurrent monitoring (ANSI 37)	
Threshold	$I_L < I_N = 0.1$ to 4 (in steps of 0.01)
Delay time for $I_L <$	0 to 320 s (in steps of 0.1 s)

Thermo-box (instead of system interface) (ANSI 38)	
Number of temperature sensors	Max. 6
Type of measuring	Pt 100 Ω or Ni 100 Ω or Ni 120 Ω
Installation drawing	"Oil" or "Environment" or "Stator" or "Bearing" or "Other"
Limit values for indications For each measuring detector	
Warning temperature (stage 1)	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)
Alarm temperature (stage 2)	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)


Additional functions	
Operational measured values	
For currents	$I_{L1}, I_{L2}, I_{L3}, I_E$ in A (Amps) primary or in % I_N 10 to 240 % I_N 3 % of measured value
Range Tolerance	
For voltages	V_{L1-E} , in kV primary or in % 10 to 120 % of V_N ≤ 3 % of measured value
Range Tolerance	
For sensitive ground-current detection	$I_{EE}, I_{EEac}, I_{EEreac}$ (r.m.s., active and reactive current) in A (kA) primary, or in % 0 to 160 % I_{EEN} ≤ 3 % of measured value
Range Tolerance	
Power/work	
S Apparent power	in kVA, MVA, GVA
S/VA (apparent power)	For $V/V_N, I/I_N = 50$ to 120 % typically < 6 %
P Active power, P/Watts (active power)	in kW, MW, GW For $ \cos \phi = 0.707$ to 1, typically < 6 %, for $V/V_N, I/I_N = 50$ to 120 %
Q Reactive power, Q/Var (reactive power)	In kvar, Mvar, Gvar For $ \sin \phi = 0.707$ to 1, typically < 6 %, for $V/V_N, I/I_N = 50$ to 120 %
$\cos \phi$, total and phase-selective	-1 to +1
Power factor $\cos \phi$	For $ \cos \phi = 0.707$ to 1, typically < 5 %
Metering	
+ W_p kWh - W_p kWh + W_q kvarh - W_q kvarh	In kWh, MWh, GWh forward In kWh reverse In kvarh inductive In kvarh, Mvarh, Gvarh capacitive
Long-term mean values	
Mean values	15, 30, 60 minutes mean values
$I_{L1\ dmd}$ in A, kA	P_{dmd} in kW
$I_{L2\ dmd}$ in A, kA	Q_{dmd} in kvar
$I_{L3\ dmd}$ in A, kA	S_{dmd} in kVA

Overcurrent Protection / 7SJ602

Technical data

5

Min./max. LOG (memory)	
Measured values	With date and time
Reset automatic	Time of day (settable in minutes) Time range (settable in days; 1 to 365, ∞)
Reset manual	Via binary input Via keyboard Via communication
Min./max. values of primary currents	I_{L1} ; I_{L2} ; I_{L3}
Min./max. values of primary voltages	V_{L1-E}
Min./max. values of power	S Apparent Power P Active power Q Reactive power Power factor $\cos \varphi$
Min./max. values of primary currents mean values	I_{L1dmd} , I_{L2dmd} , I_{L3dmd}
Min./max. values of power mean value	P_{dmd} , Q_{dmd} , S_{dmd}
Fault event log	
Storage	Storage of the last 8 faults
Time assignment	
Resolution for operationa indications	1 s
Resolution for fault event indications	1 ms
Max. time deviation	0.01 %
Fault recording	
Storage	Storage of max. 8 fault events
Total storage time (fault detection or trip command = 0 ms)	Max. 5 s, selectable pre-trigger and post-fault time
Max. storage period per fault event T_{max}	0.30 s to 5 s (steps 0.01 s)
Pre-trigger time T_{pre}	0.05 s to 0.50 s (steps 0.01 s)
Post-fault time T_{post}	0.05 s to 0.50 s (steps 0.01 s)
Sampling rate at 50 Hz	1 instantaneous value per ms
Sampling rate at 60 Hz	1 instantaneous value per 0.83 ms
Backup battery	Lithium battery 3 V/1 Ah, type CR 1/2 AA Self-discharge time > 5 years "Battery fault" battery charge warning

CE conformity
<p>This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EG previous 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 2006/95/EG previous 73/23/EEC).</p> <p>This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).</p> <p>The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.</p> <p>This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".</p>


Description	Order No.	
7SJ602 multifunction overcurrent and motor protection relay	7SJ602 <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	
Measuring inputs (4 x I), default settings		
$I_N = 1A^{1)}$, 15 th position only with A	1	
$I_N = 5A^{1)}$, 15 th position only with A	5	
Measuring inputs (1 x V, 3 x I), default settings		
$I_{ph} = 1A^{1)}$, I_e = sensitive ($I_{EE} = 0.003$ to 1.5 A), 15 th position only with B and J	2	
$I_{ph} = 5A^{1)}$, I_e = sensitive ($I_{EE} = 0.015$ to 7.5 A), 15 th position only with B and J	6	
Auxiliary voltage		
DC 24/48 V, binary input threshold DC 19 V	2	
DC 60/110 V ²⁾ , binary input threshold DC19 V ³⁾	4	
DC 110/125/220/250 V, AC 115/230 V ²⁾ binary input threshold 88 V ³⁾	5	
Unit design		
Surface-mounting housing, terminals on top and bottom	B	
Flush-mounting housing, screw-type terminals	E	
Region-specific default and language settings		
Region World, 50/60 Hz, ANSI/IEC characteristic, languages: English, German, French, Spanish, Russian	B	
System port (on bottom of unit)		
No system port	0	
IEC 60870-5-103, electrical RS232	1	
IEC 60870-5-103, electrical RS485	2	
IEC 60870-5-103, optical 820 nm, ST connector	3	
Temperature monitoring box, electrical RS485 ⁴⁾	8	
PROFIBUS-DP Slave, electrical RS485	9	L O A
PROFIBUS-DP Slave, optical 820 nm, double ring, ST connector	9	L O B
MODBUS, electrical RS485	9	L O D
MODBUS, optical 820 nm, ST connector	9	L O E
Command (without process check back signal)		
Without command	0	
With command	1	
Measuring/fault recording		
Oscillographic fault recording	1	
Oscillographic fault recording, slave pointer, mean values, min./max. values	3	

See next page

1) Rated current can be selected by means of jumpers.
 2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.
 3) The binary input thresholds can be selected in two stages by means of jumpers.
 4) Temperature monitoring box 7XV5662-□AD10, refer to part 13.

Overcurrent Protection / 7SJ602

Selection and ordering data

ANSI No.	Description	Order No.
7SJ602 multifunction overcurrent and motor protection relay		7SJ602□-□□□□□-□□□□
Basic version		
50/51	Overcurrent protection TOC phase $I>$, $I>>$, $I>>>$, I_p , reverse interlocking	
50N/51N	Earth/ground-fault protection TOC ground/earth $I_{E>}$, $I_{E>>}$, I_{Ep}	
49	Thermal overload protection	
74TC	Trip-circuit supervision	
50BF	Circuit-breaker failure protection	
	Cold load pickup	
46	Negative-sequence system overcurrent protection	F A 1)
Basic version + directional earth/ground-fault detection		
50/51	Overcurrent protection TOC phase $I>$, $I>>$, $I>>>$, I_p , reverse interlocking	
67Ns	Directional sensitive earth/ground-fault detection $I_{EE>}$, $I_{EE>>}$, I_{Ep}	
64	Sensitive ground-fault protection	
49	Thermal overload protection	
74TC	Trip-circuit supervision	
50BF	Circuit-breaker failure protection	
	Cold load pickup	
46	Negative-sequence system overcurrent protection	F B 2)
Basic version + sensitive earth/ground-fault detection + measuring		
50/51	Overcurrent protection TOC phase $I>$, $I>>$, $I>>>$, I_p , reverse interlocking	
50Ns/51Ns	Sensitive earth/ground-fault detection $I_{EE>}$, $I_{EE>>}$, I_{Ep}	
49	Thermal overload protection	
74TC	Trip-circuit supervision	
50BF	Circuit-breaker failure protection	
	Cold load pickup	
46	Negative-sequence system overcurrent protection	
	Voltage and power measuring	F J 2)
Basic version + motor protection		
50/51	Overcurrent protection TOC phase $I>$, $I>>$, $I>>>$, I_p , reverse interlocking	
50N/51N	Earth/ground-fault protection TOC ground/earth $I_{E>}$, $I_{E>>}$, I_{Ep}	
49	Thermal overload protection	
74TC	Trip circuit supervision	
50BF	Circuit-breaker failure protection	
	Cold load pickup	
46	Negative-sequence system overcurrent protection	
48	Start-time supervision	
37	Undercurrent/loss of load monitoring	
66/86	Restart inhibit	H A 1)
Basic version + directional ground/earth fault protection + motor protection		
50/51	Overcurrent protection TOC phase $I>$, $I>>$, $I>>>$, I_p , reverse interlocking	
67Ns	Sensitive ground fault detection for systems with resonant or isolated $I_{EE>}$, $I_{EE>>}$, I_{Ep}	
64	Displacement voltage	
49	Thermal overload protection	
74TC	Trip circuit supervision	
50BF	Circuit-breaker failure protection	
	Cold load pickup	
46	Negative-sequence system overcurrent protection	
48	Start-time supervision	
37	Undercurrent/loss of load monitoring	
66/86	Restart inhibit	H B 2)
Basic version + sensitive ground/earth-fault detection + measuring + motor protection		
50/51	Overcurrent protection TOC phase $I>$, $I>>$, $I>>>$, I_p , reverse interlocking	
50Ns/51Ns	Sensitive ground/earth-fault detection $I_{EE>}$, $I_{EE>>}$, I_{Ep}	
49	Thermal overload protection	
74TC	Trip circuit supervision	
50BF	Circuit-breaker failure protection	
	Cold load pickup	
46	Negative-sequence system overcurrent protection	
	Voltage and power measuring	
48	Start-time supervision	
37	Undercurrent/loss of load monitoring	
66/86	Restart inhibit	H J 2)
Auto-reclosure (ARC)		
	Without auto-reclosure ARC	0
79	With auto-reclosure ARC	1

1) Only with position 7 = 1 or 5

2) Only with position 7 = 2 or 6

Overcurrent Protection/7SJ602

Selection and ordering data

Accessories	Description	Order No.
	DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition, device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper) Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
	Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
	SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally). Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows. Incl. templates, electronic manual with license for 10 PCs on CD-ROM. Authorization by serial number.	7XS5410-0AA00
	Temperature monitoring box AC/DC 24 to 60 V	7XV5662-2AD10
	AC/DC 90 to 240 V	7XV5662-5AD10
	Connecting cable (contained in DIGSI 4, but can be ordered additionally) Cable between PC/notebook (9-pin con.) and protection unit (9-pin connector)	7XV5100-4
	Cable between temperature monitoring box and SIPROTEC 4 unit - length 5 m / 16.4 ft - length 25 m / 82 ft - length 50 m / 164 ft	7XV5103-7AA05 7XV5103-7AA25 7XV5103-7AA50
	Manual for 7SJ602 English please visit www.siemens.com/siprotec Spanish please visit www.siemens.com/siprotec	

Accessories	Description	Order No.	Size of package	Supplier
 <p>LSP2093-afp.eps</p> <p>Short-circuit links for current terminals</p>  <p>LSP2289-afp.eps</p> <p>Mounting rail</p>	Terminal safety cover			
	Voltage/current terminal 18-pole	C73334-A1-C31-1	1	Siemens
	Voltage/current terminal 8-pole	C73334-A1-C32-1	1	Siemens
	Short-circuit links			
	For current terminals	C73334-A1-C33-1	1	Siemens
For other terminals	C73334-A1-C34-1	1	Siemens	
	Mounting rail for 19" rack	C73165-A63-D200-1	1	Siemens
	Your local Siemens representative can inform you on local suppliers.			

Overcurrent Protection / 7SJ602

Connection diagram

5

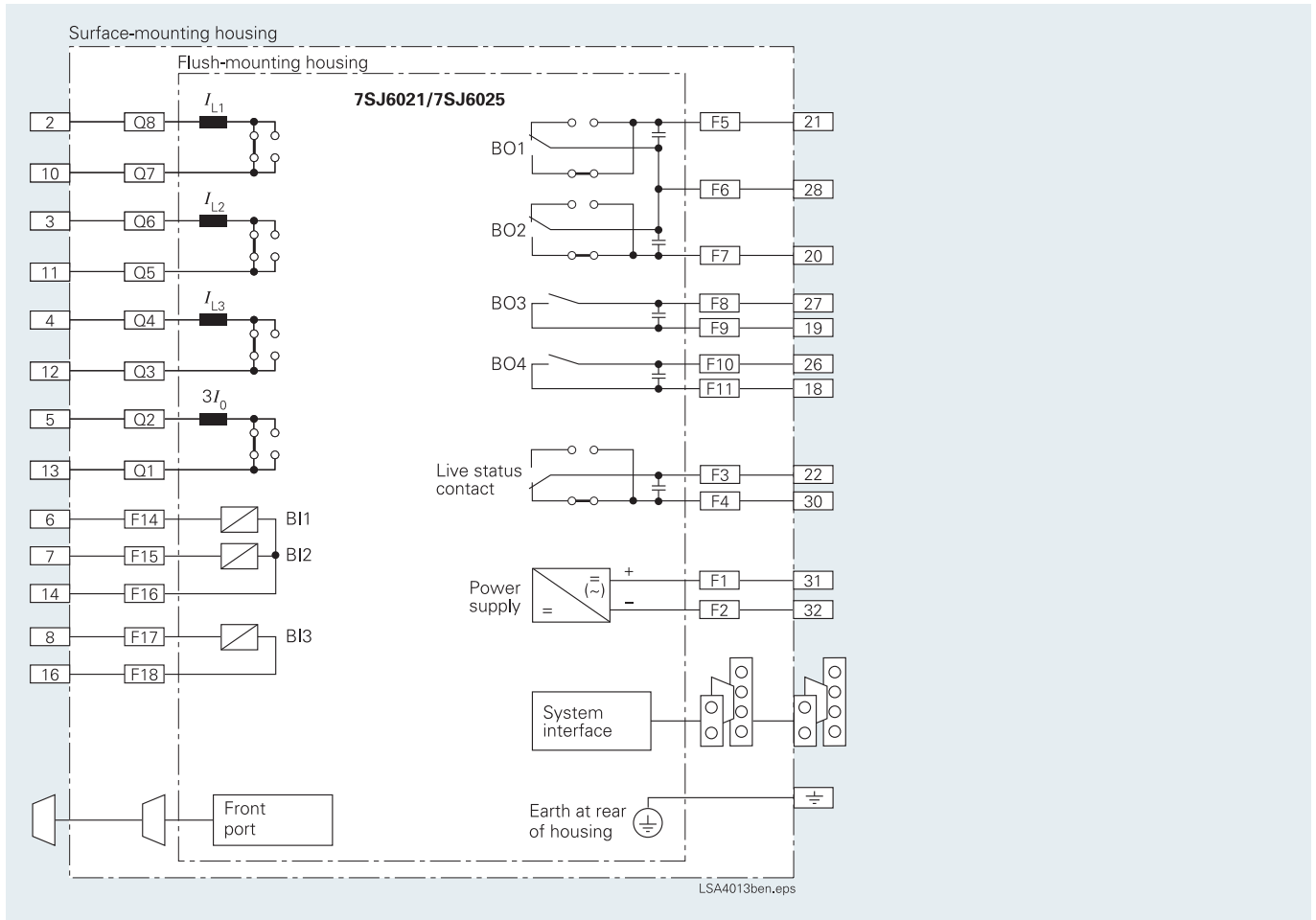


Fig. 5/54 Connection diagram according to IEC standard

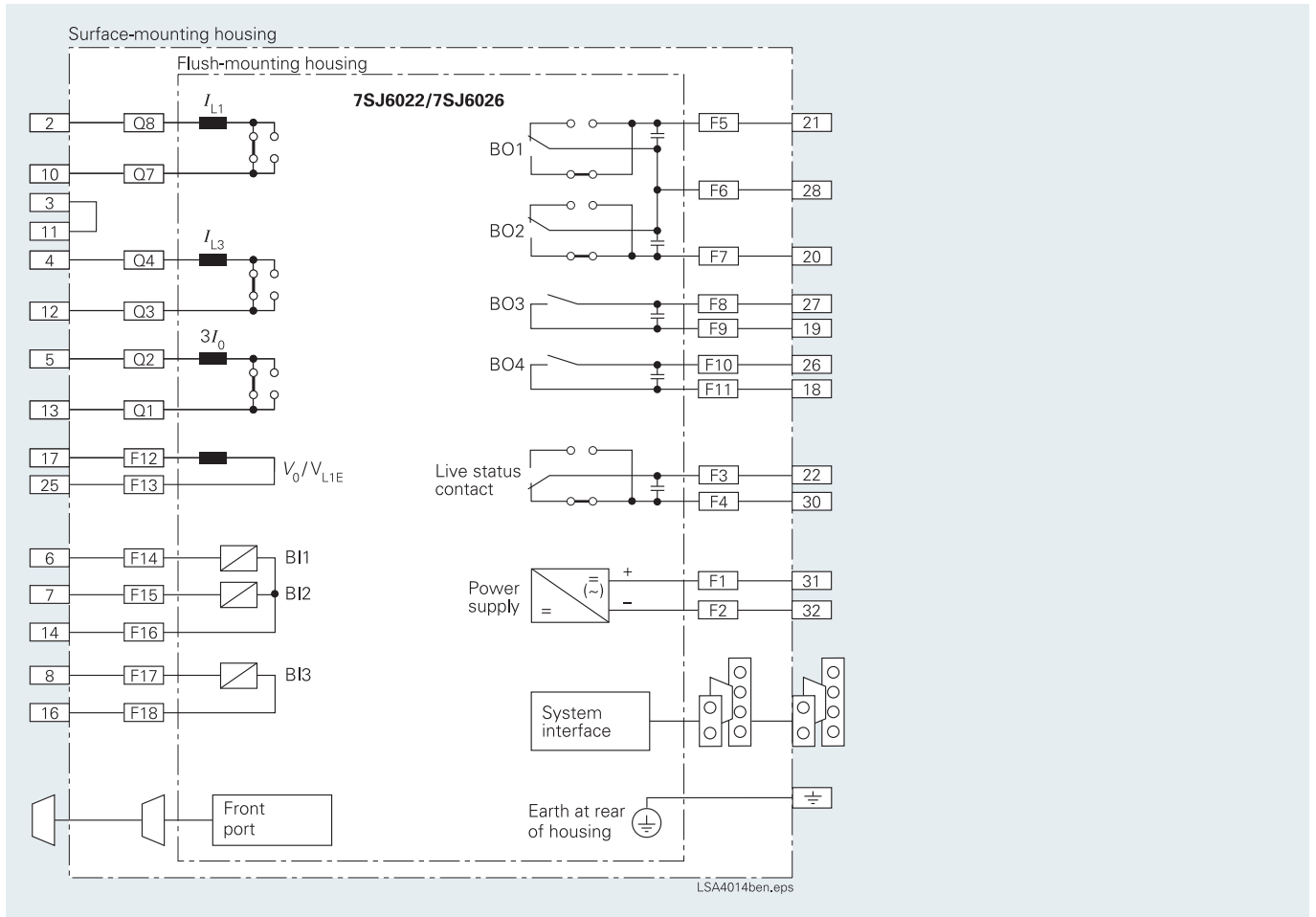


Fig. 5/55 Connection diagram according to IEC standard



Fig. 5/56 SIPROTEC 4 7SJ61 multifunction protection relay with text (left) and graphic display

Description

The SIPROTEC 4 7SJ61 relays can be used for line protection of high and medium voltage networks with earthed (grounded), low-resistance grounded, isolated or compensated neutral point. When protecting motors, the SIPROTEC 4 7SJ61 is suitable for asynchronous machines of all sizes. The relay performs all functions of backup protection supplementary to transformer differential protection.

The relay provides control of the circuit-breaker, further switching devices and automation functions. The integrated programmable logic (CFC) allows the user to implement their own functions, e. g. for the automation of switchgear (interlocking). The user is also allowed to generate user-defined indications.

The flexible communication interfaces are open for modern communication architectures with control systems.

Function overview

Protection functions

- Overcurrent protection (definite-time/inverse-time/user-def.)
- Sensitive ground-fault detection
- Intermittent ground-fault protection
- High-impedance restricted ground fault
- Inrush-current detection
- Motor protection
 - Undercurrent monitoring
 - Starting time supervision
 - Restart inhibit
 - Locked rotor
 - Load jam protection
- Overload protection
- Temperature monitoring

- Breaker failure protection
- Negative-sequence protection
- Auto-reclosure
- Lockout

Control functions/programmable logic

- Commands for control of a circuit-breaker and of isolators
- Position of switching elements is shown on the graphic display
- Control via keyboard, binary inputs, DIGSI 4 or SCADA system
- User-defined logic with CFC (e.g. interlocking)

Monitoring functions

- Operational measured values *I*
- Circuit-breaker wear monitoring
- Slave pointer
- Time metering of operating hours
- Trip circuit supervision
- 8 oscillographic fault records
- Motor statistics

Communication interfaces

- System interface
 - IEC 60870-5-103, IEC 61850
 - PROFIBUS-FMS/-DP
 - DNP 3.0/ DNP3 TCP/MODBUS RTU
- Service interface for DIGSI 4 (modem)
- Front interface for DIGSI 4
- Time synchronization via IRIG B/DCF77

Hardware

- 4 current transformers
- 3/8/11 binary inputs
- 4/8/6 output relays

Overcurrent Protection / 7SJ61

Application

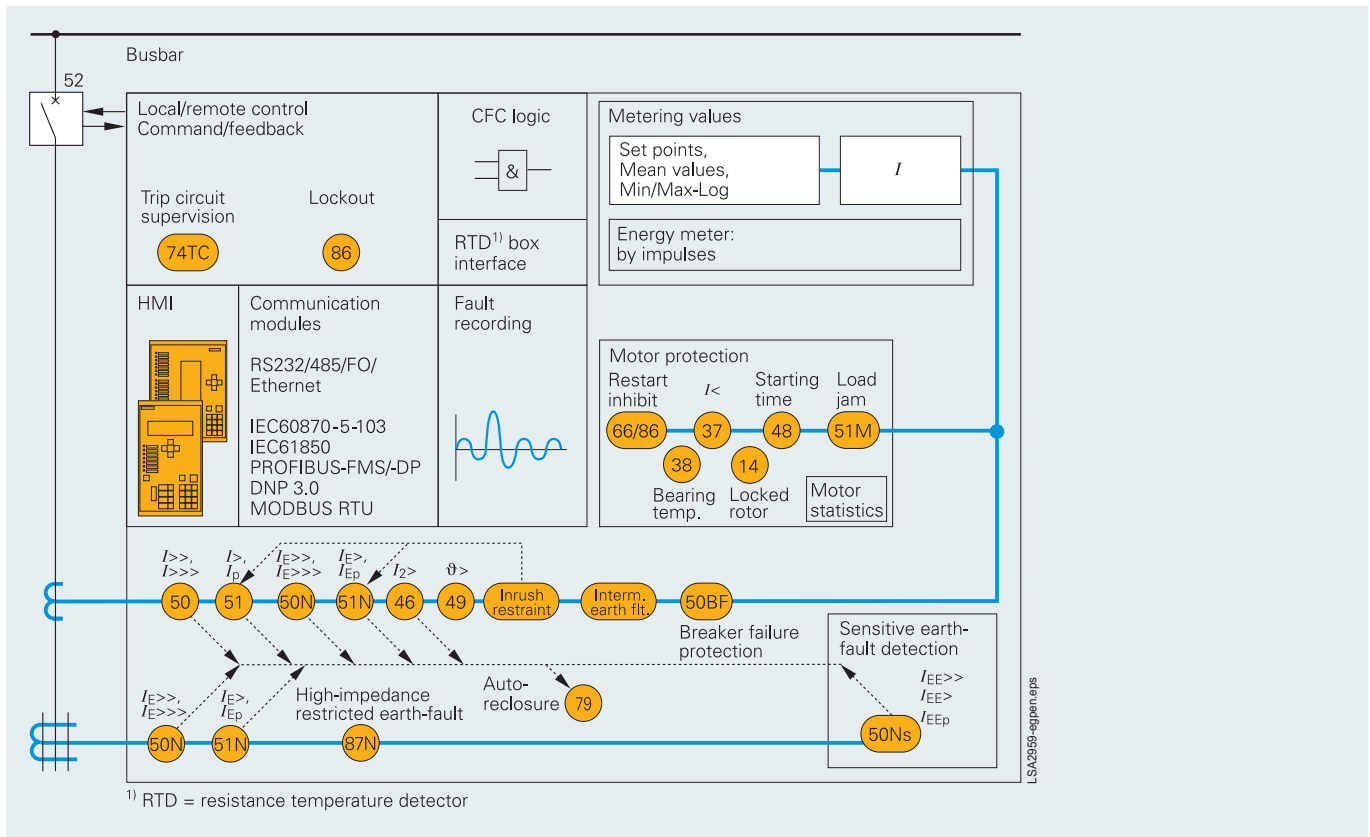


Fig. 5/57 Function diagram

Application

The SIPROTEC 4 7SJ61 unit is a numerical protection relay that also performs control and monitoring functions and therefore supports the user in cost-effective power system management, and ensures reliable supply of electric power to the customers. Local operation has been designed according to ergonomic criteria. A large, easy-to-read display was a major design aim.

Control

The integrated control function permits control of disconnect devices, grounding switches or circuit-breakers via the integrated operator panel, binary inputs, DIGSI 4 or the control and protection system (e.g. SICAM). The present status (or position) of the primary equipment can be displayed, in case of devices with graphic display. A full range of command processing functions is provided.

Programmable logic

The integrated logic characteristics (CFC) allow the user to implement their own functions for automation of switchgear (interlocking) or a substation via a graphic user interface. The user can also generate user-defined indications.

Line protection

The relay is a non-directional overcurrent relay which can be used for line protection of high and medium-voltage networks with earthed (grounded), low-resistance grounded, isolated or compensated neutral point.

Motor protection

When protecting motors, the 7SJ61 relay is suitable for asynchronous machines of all sizes.

Transformer protection

The relay performs all functions of backup protection supplementary to transformer differential protection. The inrush suppression effectively prevents tripping by inrush currents.

The high-impedance restricted ground-fault protection detects short-circuits and insulation faults on the transformer.

Backup protection

The 7SJ61 can be used universally for backup protection.

Flexible protection functions

By configuring a connection between a standard protection logic and any measured or derived quantity, the functional scope of the relays can be easily expanded by up to 20 protection stages or protection functions.

Metering values

Extensive measured values, limit values and metered values permit improved system management.

ANSI	IEC	Protection functions
50, 50N	$I>$, $I>>$, $I>>>$ $I_{E>}$, $I_{E>>}$	Definite-time overcurrent protection (phase/neutral)
50, 51N	I_p , I_{Ep}	Inverse-time overcurrent protection (phase/neutral)
50Ns, 51Ns	$I_{EE>}$, $I_{EE>>}$, I_{EEp}	Sensitive ground-fault protection
–		Cold load pick-up (dynamic setting change)
–	$I_{E>}$	Intermittent ground fault
87N		High-impedance restricted ground-fault protection
50BF		Breaker failure protection
79		Auto-reclosure
46	$I_{2>}$	Phase-balance current protection (negative-sequence protection)
49	$\vartheta>$	Thermal overload protection
48		Starting time supervision
51M		Load jam protection
14		Locked rotor protection
66/86		Restart inhibit
37	$I<$	Undercurrent monitoring
38		Temperature monitoring via external device (RTD-box), e.g. bearing temperature monitoring

Construction

Connection techniques and housing with many advantages

1/3-rack size (text display variants) and 1/2-rack size (graphic display variants) are the available housing widths of the 7SJ61 relays referred to a 19" module frame system. This means that previous models can always be replaced. The height is a uniform 244 mm for flush-mounting housings and 266 mm for surface-mounting housing. All cables can be connected with or without ring lugs.

In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located in a sloped case at the top and bottom of the housing.



Fig. 5/58 Rear view with screw-type, 1/3-rack size

Overcurrent Protection / 7SJ61

Protection functions

Protection functions

Overcurrent protection (ANSI 50, 50N, 51, 51N)

This function is based on the phase-selective measurement of the three phase currents and the ground current (four transformers). Three definite-time overcurrent protection elements (DMT) exist both for the phases and for the ground. The current threshold and the delay time can be set within a wide range. In addition, inverse-time overcurrent protection characteristics (IDMTL) can be activated.

Reset characteristics

For easier time coordination with electromechanical relays, reset characteristics according to ANSI C37.112 and IEC 60255-3 / BS 142 standards are applied.

When using the reset characteristic (disk emulation), a reset process is initiated after the fault current has disappeared. This reset process corresponds to the reverse movement of the Ferraris disk of an electromechanical relay (thus: disk emulation).

User-definable characteristics

Instead of the predefined time characteristics according to ANSI, tripping characteristics can be defined by the user for phase and ground units separately. Up to 20 current/ time value pairs may be programmed. They are set as pairs of numbers or graphically in DIGSI 4.

Inrush restraint

The relay features second harmonic restraint. If the second harmonic is detected during transformer energization, pickup of non-directional normal elements ($I>$, I_p) are blocked.

Cold load pickup/dynamic setting change

For overcurrent protection functions the initiation thresholds and tripping times can be switched via binary inputs or by time control.

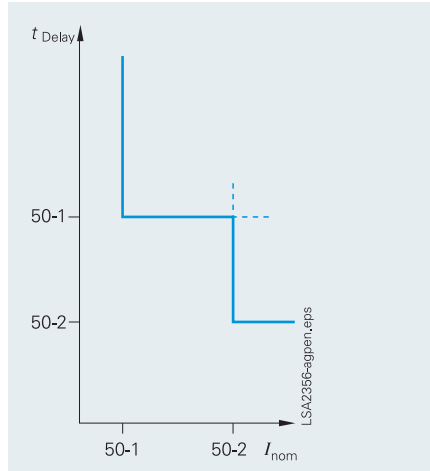


Fig. 5/59 Definite-time overcurrent characteristic

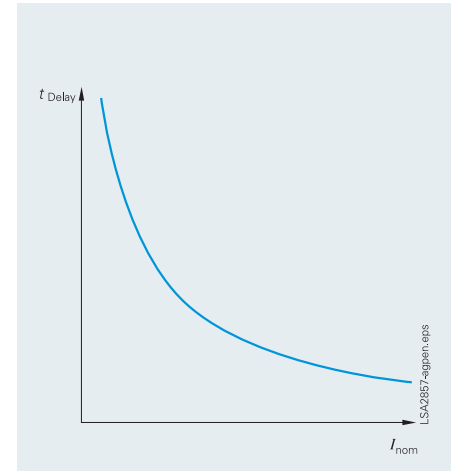


Fig. 5/60 Inverse-time overcurrent characteristic

Available inverse-time characteristics		
Characteristics acc. to	ANSI/IEEE	IEC 60255-3
Inverse	•	•
Short inverse	•	
Long inverse	•	•
Moderately inverse	•	
Very inverse	•	•
Extremely inverse	•	•

Flexible protection functions

The 7SJ61 units enable the user to easily add on up to 20 protective functions. To this end, parameter definitions are used to link a standard protection logic with any chosen characteristic quantity (measured or derived quantity). The standard logic consists of the usual protection elements such as the pickup message, the parameter-definable delay time, the TRIP command, a blocking possibility, etc. The mode of operation for current quantities can be three-phase or single-phase. The quantities can be operated as greater than or less than stages. All stages operate with protection priority. Protection stages/functions attainable on the basis of the available characteristic quantities:

Function	ANSI No.
$I>$, $I_E>$	50, 50N
$3I_0>$, $I_1>$, $I_2>$, $I_2/I_1>$	50N, 46
Binary input	

(Sensitive) ground-fault detection (ANSI 50Ns, 51Ns/50N, 51N)

For high-resistance grounded networks, a sensitive input transformer is connected to a phase-balance neutral current transformer (also called core-balance CT).

The function can also be operated in the insensitive mode as an additional short-circuit protection.

Intermittent ground-fault protection

Intermittent (re-striking) faults occur due to insulation weaknesses in cables or as a result of water penetrating cable joints. Such faults either simply cease at some stage or develop into lasting short-circuits. During intermittent activity, however, star-point resistors in networks that are impedance-grounded may undergo thermal overloading. The normal ground-fault protection cannot reliably detect and interrupt the current pulses, some of which can be very brief.

The selectivity required with intermittent ground faults is achieved by summing the duration of the individual pulses and by triggering when a (settable) summed time is reached. The response threshold I_{IE} evaluates the r.m.s. value, referred to one systems period.

Breaker failure protection (ANSI 50BF)

If a faulted portion of the electrical circuit is not disconnected upon issuance of a trip command, another command can be initiated using the breaker failure protection which operates the circuit-breaker, e.g. of an upstream (higher-level) protection relay. Breaker failure is detected if after a trip command, current is still flowing in the faulted circuit. As an option it is possible to make use of the circuit-breaker position indication.

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

In line protection, the two-element phase-balance current/negative-sequence protection permits detection on the high side of high-resistance phase-to-phase faults and phase-to-ground faults that are on the low side of a transformer (e.g. with the switch group Dy 5). This provides backup protection for high-resistance faults beyond the transformer.

Settable dropout delay times

If the devices are used in parallel with electromechanical relays in networks with intermittent faults, the long dropout times of the electromechanical devices (several hundred milliseconds) can lead to problems in terms of time grading. Clean time grading is only possible if the dropout time is approximately the same. This is why the parameter of dropout times can be defined for certain functions such as overcurrent protection, ground short-circuit and phase-balance current protection.

Auto-reclosure (ANSI 79)

Multiple reclosures can be defined by the user and lockout will occur if a fault is present after the last reclosure. The following functions are possible:

- 3-pole ARC for all types of faults
- Separate settings for phase and ground faults
- Multiple ARC, one rapid auto-reclosure (RAR) and up to nine delayed auto-reclosures (DAR)
- Starting of the ARC depends on the trip command selection (e.g. 46, 50, 51)
- Blocking option of the ARC via binary inputs
- ARC can be initiated externally or via CFC

- The overcurrent elements can either be blocked or operated non-delayed depending on the auto-reclosure cycle
- Dynamic setting change of the overcurrent elements can be activated depending on the ready AR

Thermal overload protection (ANSI 49)

For protecting cables and transformers, an overload protection with an integrated pre-warning element for temperature and current can be applied. The temperature is calculated using a thermal homogeneous-body model (according to IEC 60255-8), which takes account both of the energy entering the equipment and the energy losses. The calculated temperature is constantly adjusted accordingly. Thus, account is taken of the previous load and the load fluctuations.

For thermal protection of motors (especially the stator) a further time constant can be set so that the thermal ratios can be detected correctly while the motor is rotating and when it is stopped. The ambient temperature or the temperature of the coolant can be detected serially via an external temperature monitoring box (resistance-temperature detector box, also called RTD-box). The thermal replica of the overload function is automatically adapted to the ambient conditions. If there is no RTD-box it is assumed that the ambient temperatures are constant.

High-impedance restricted ground-fault protection (ANSI 87N)

The high-impedance measurement principle is an uncomplicated and sensitive method for detecting ground faults, especially on transformers. It can also be applied to motors, generators and reactors when these are operated on an grounded network.

When the high-impedance measurement principle is applied, all current transformers in the protected area are connected in parallel and operated on one common resistor of relatively high R whose voltage is measured (see Fig. 5/61). In the case of 7SJ6 units, the voltage is measured by detecting the current through the (external) resistor R at the sensitive current measurement input I_{EE} . The varistor V serves to limit the voltage in the event of an internal fault. It cuts off the high momentary voltage spikes occurring at transformer saturation. At the same time, this results in smoothing of the voltage without any noteworthy reduction of the average value. If no faults have occurred and in the event of external faults, the system is at equilibrium, and the voltage through the resistor is approximately zero. In the event of internal faults, an imbalance occurs which leads to a voltage and a current flow through the resistor R .

The current transformers must be of the same type and must at least offer a separate core for the high-impedance restricted ground-fault protection. They must in particular have the same transformation ratio and an approximately identical knee-point voltage. They should also demonstrate only minimal measuring errors.

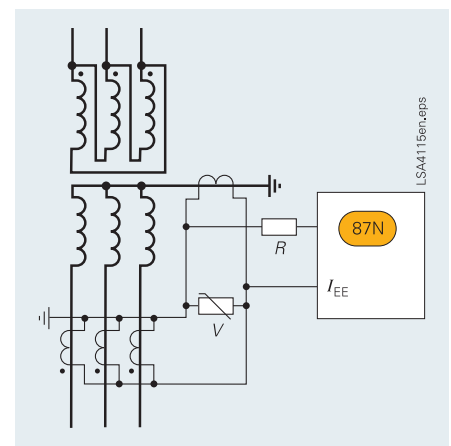


Fig. 5/61 High-impedance restricted ground-fault protection

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Protection functions

■ Motor protection

Starting time supervision (ANSI 48)

Starting time supervision protects the motor against long unwanted start-ups that might occur when excessive load torque occurs, excessive voltage drops occur within the motor or if the rotor is locked. Rotor temperature is calculated from measured stator current. The tripping time is calculated according to the following equation:

for $I > I_{\text{MOTOR START}}$

$$t = \left(\frac{I_A}{I} \right)^2 \cdot T_A$$

I = Actual current flowing

$I_{\text{MOTOR START}}$ = Pickup current to detect a motor start

t = Tripping time

I_A = Rated motor starting current

T_A = Tripping time at rated motor starting current (2 times, for warm and cold motor)

The characteristic (equation) can be adapted optimally to the state of the motor by applying different tripping times T_A in dependence of either cold or warm motor state. For differentiation of the motor state the thermal model of the rotor is applied.

If the trip time is rated according to the above formula, even a prolonged start-up and reduced voltage (and reduced start-up current) will be evaluated correctly. The tripping time is inverse (current dependent).

A binary signal is set by a speed sensor to detect a blocked rotor. An instantaneous tripping is effected.

Temperature monitoring (ANSI 38)

Up to 2 temperature monitoring boxes with a total of 12 measuring sensors can be used for temperature monitoring and detection by the protection relay. The thermal status of motors, generators and transformers can be monitored with this device. Additionally, the temperature of the bearings of rotating machines are monitored for limit value violation. The temperatures are being measured with the help of temperature detectors at various locations of the device to be protected. This data is transmitted to the protection relay via one or two temperature monitoring boxes (see "Accessories", page 5/78).

Load jam protection (ANSI 51M)

Sudden high loads can cause slowing down and blocking of the motor and mechanical damages. The rise of current due to a load jam is being monitored by this function (alarm and tripping). The overload protection function is too slow and therefore not suitable under these circumstances.

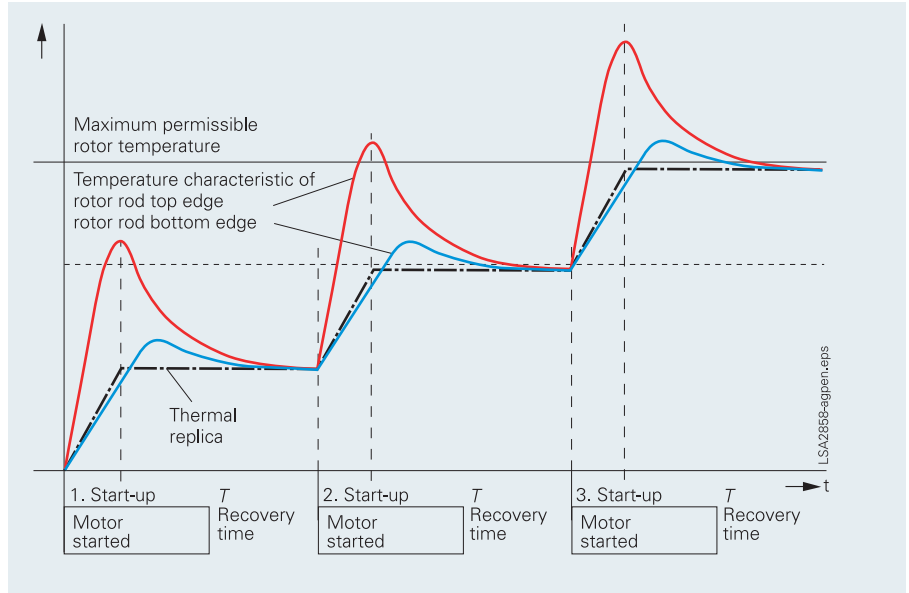


Fig. 5/62

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

The negative-sequence / phase-balance current protection detects a phase failure or load unbalance due to network asymmetry and protects the rotor from impermissible temperature rise.

Restart inhibit (ANSI 66/86)

If a motor is started up too many times in succession, the rotor can be subject to thermal overload, especially the upper edges of the bars. The rotor temperature is calculated from the stator current. The reclosing lockout only permits start-up of the motor if the rotor has sufficient thermal reserves for a complete start-up (see Fig. 5/62).

Emergency start-up

This function disables the reclosing lockout via a binary input by storing the state of the thermal replica as long as the binary input is active. It is also possible to reset the thermal replica to zero.

Undercurrent monitoring (ANSI 37)

With this function, a sudden drop in current, that can occur due to a reduced motor load, is detected. This may be due to shaft breakage, no-load operation of pumps or fan failure.

Motor statistics

Essential information on start-up of the motor (duration, current, voltage) and general information on number of starts, total operating time, total down time, etc. are saved as statistics in the device.

Circuit-breaker wear monitoring

Methods for determining circuit-breaker contact wear or the remaining service life of a circuit-breaker (CB) allow CB maintenance intervals to be aligned to their actual degree of wear. The benefit lies in reduced maintenance costs.

There is no mathematically exact method of calculating the wear or the remaining service life of circuit-breakers that takes into account the arc-chamber's physical conditions when the CB opens.

This is why various methods of determining CB wear have evolved which reflect the different operator philosophies. To do justice to these, the devices offer several methods:

- ΣI
- ΣI^x , with $x = 1 \dots 3$
- Σi^2t

The devices additionally offer a new method for determining the remaining service life:

- Two-point method

The CB manufacturers double-logarithmic switching cycle diagram (see Fig. 5/63) and the breaking current at the time of contact opening serve as the basis for this method. After CB opening, the two-point method calculates the number of still possible switching cycles. To this end, the two points P1 and P2 only have to be set on the device. These are specified in the CB's technical data.

All of these methods are phase-selective and a limit value can be set in order to obtain an alarm if the actual value falls below or exceeds the limit value during determination of the remaining service life.

Commissioning

Commissioning could hardly be easier and is fully supported by DIGSI 4. The status of the binary inputs can be read individually and the state of the binary outputs can be set individually. The operation of switching elements (circuit-breakers, disconnect devices) can be checked using the switching functions of the bay controller. The analog measured values are represented as wide-ranging operational measured values.

To prevent transmission of information to the control center during maintenance, the bay controller communications can be disabled to prevent unnecessary data from being transmitted. During commissioning, all indications with test marking for test purposes can be connected to a control and protection system.

Test operation

During commissioning, all indications can be passed to an automatic control system for test purposes.

■ Control and automatic functions

Control

In addition to the protection functions, the SIPROTEC 4 units also support all control and monitoring functions that are required for operating medium-voltage or high-voltage substations.

The main application is reliable control of switching and other processes.

The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated to the 7SJ61 via binary inputs. Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a fault or intermediate circuit-breaker or auxiliary contact position.

The switchgear or circuit-breaker can be controlled via:

- integrated operator panel
- binary inputs
- substation control and protection system
- DIGSI 4

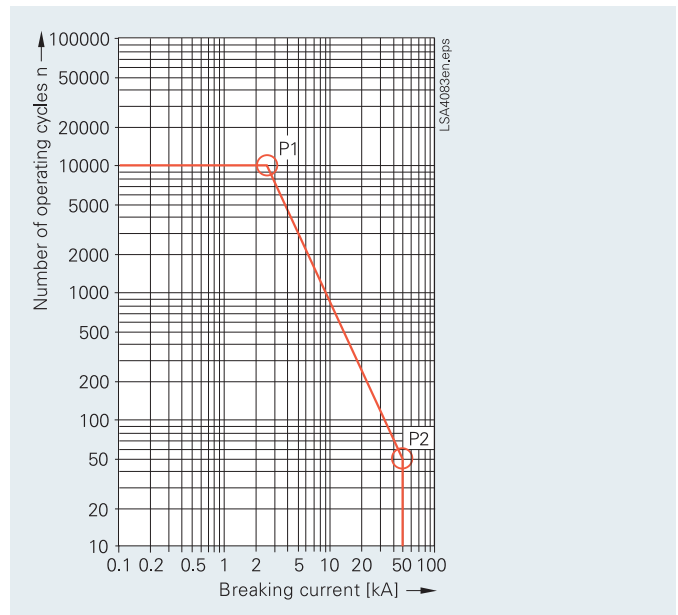


Fig. 5/63 CB switching cycle diagram

Automation / user-defined logic

With integrated logic, the user can set, via a graphic interface (CFC), specific functions for the automation of switchgear or substation. Functions are activated via function keys, binary input or via communication interface.

Switching authority

Switching authority is determined according to parameters and communication.

If a source is set to "LOCAL", only local switching operations are possible. The following sequence of switching authority is laid down: "LOCAL"; DIGSI PC program, "REMOTE".

Command processing

All the functionality of command processing is offered. This includes the processing of single and double commands with or without feedback, sophisticated monitoring of the control hardware and software, checking of the external process, control actions using functions such as runtime monitoring and automatic command termination after output. Here are some typical applications:

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable bay interlocks
- Operating sequences combining several switching operations such as control of circuit-breakers, disconnectors and ground-ing switches
- Triggering of switching operations, indications or alarm by combination with existing information

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Functions

Functions

Assignment of feedback to command

The positions of the circuit-breaker or switching devices and transformer taps are acquired by feedback. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication change is a consequence of switching operation or whether it is a spontaneous change of state.

Chatter disable

Chatter disable feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

Indication filtering and delay

Binary indications can be filtered or delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time. In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

A further indication (or a command) can be derived from an existing indication. Group indications can also be formed. The volume of information to the system interface can thus be reduced and restricted to the most important signals.

Measured values

The r.m.s. values are calculated from the acquired current. The following functions are available for measured value processing:

- Currents I_{L1} , I_{L2} , I_{L3} , I_E , I_{EE} (50Ns)
- Symmetrical components I_1 , I_2 , $3I_0$
- Mean as well as minimum and maximum current values
- Operating hours counter
- Mean operating temperature of overload function
- Limit value monitoring
Limit values are monitored using programmable logic in the CFC. Commands can be derived from this limit value indication.
- Zero suppression
In a certain range of very low measured values, the value is set to zero to suppress interference.



Fig. 5/64 NXAIR panel (air-insulated)

Metered values

If an external meter with a metering pulse output is available, the SIPROTEC 4 unit can obtain and process metering pulses via an indication input.

The metered values can be displayed and passed on to a control center as an accumulation with reset.

Switchgear cubicles for high/medium voltage

All units are designed specifically to meet the requirements of high/medium-voltage applications.

In general, no separate measuring instruments or additional control components are necessary.

Communication

In terms of communication, the units offer substantial flexibility in the context of connection to industrial and power automation standards. Communication can be extended or added on thanks to modules for retrofitting on which the common protocols run. Therefore, also in the future it will be possible to optimally integrate units into the changing communication infrastructure, for example in Ethernet networks (which will also be used increasingly in the power supply sector in the years to come).

Serial front interface

There is a serial RS232 interface on the front of all the units. All of the unit's functions can be set on a PC by means of the DIGSI 4 protection operation program. Commissioning tools and fault analysis are also built into the program and are available through this interface.

Rear-mounted interfaces¹⁾

A number of communication modules suitable for various applications can be fitted in the rear of the flush-mounting housing. In the flush-mounting housing, the modules can be easily replaced by the user.

The interface modules support the following applications:

- Time synchronization interface
All units feature a permanently integrated electrical time synchronization interface. It can be used to feed timing telegrams in IRIG-B or DCF77 format into the units via time synchronization receivers.
- System interface
Communication with a central control system takes place through this interface. Radial or ring type station bus topologies can be configured depending on the chosen interface. Furthermore, the units can exchange data through this interface via Ethernet and IEC 61850 protocol and can also be operated by DIGSI.
- Service interface
The service interface was conceived for remote access to a number of protection units via DIGSI. On all units, it can be an electrical RS232/RS485 or an optical interface. For special applications, a maximum of two temperature monitoring boxes (RTD-box) can be connected to this interface as an alternative.

System interface protocols (retrofittable)

IEC 61850 protocol

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens was the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus is also possible with DIGSI.

IEC 60870-5-103 protocol

The IEC 60870-5-103 protocol is an international standard for the transmission of protective data and fault recordings. All messages

1) For units in panel surface-mounting housings please refer to note on page 5/77.

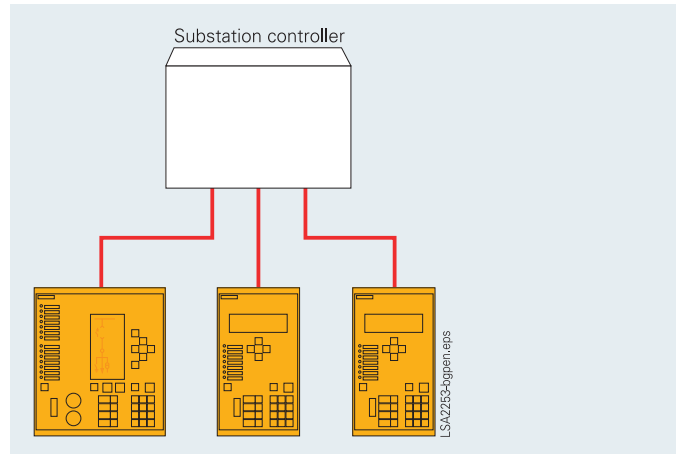


Fig. 5/65 IEC 60870-5-103: Radial fiber-optic connection

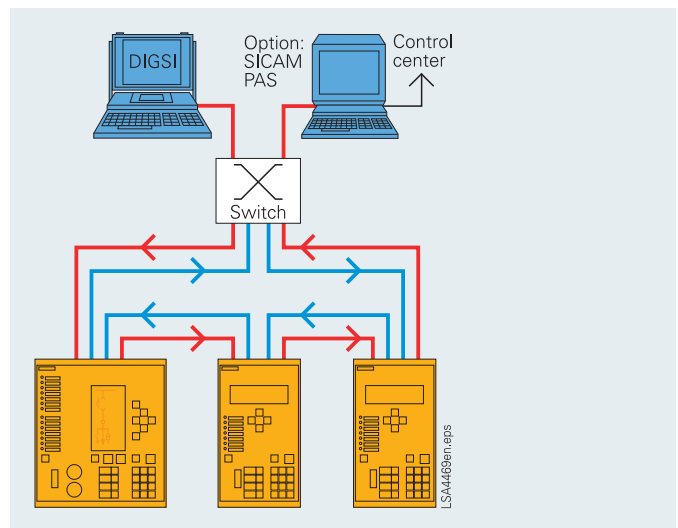


Fig. 5/66 Bus structure for station bus with Ethernet and IEC 61850, fiber-optic ring

from the unit and also control commands can be transferred by means of published, Siemens-specific extensions to the protocol.

Redundant solutions are also possible. Optionally it is possible to read out and alter individual parameters (only possible with the redundant module).

PROFIBUS-DP protocol

PROFIBUS-DP is the most widespread protocol in industrial automation. Via PROFIBUS-DP, SIPROTEC units make their information available to a SIMATIC controller or, in the control direction, receive commands from a central SIMATIC. Measured values can also be transferred.

MODBUS RTU protocol

This uncomplicated, serial protocol is mainly used in industry and by power supply corporations, and is supported by a number of unit manufacturers. SIPROTEC units function as MODBUS slaves, making their information available to a master or receiving information from it.

A time-stamped event list is available.

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Communication

PROFINET

PROFINET is the ethernet-based successor of Profibus DP and is supported in the variant PROFINET IO. The protocol which is used in industry together with the SIMATIC systems control is realized on the optical and electrical Plus ethernet modules which are delivered since November 2012. All network redundancy procedures which are available for the ethernet modules, such as RSTP, PRP or HSR, are also available for PROFINET. The time synchronization is made via SNTP. The network monitoring is possible via SNMP V2 where special MIB files exist for PROFINET. The LLDP protocol of the device also supports the monitoring of the network topology. Single-point indications, double-point indications, measured and metered values can be transmitted cyclically in the monitoring direction via the protocol and can be selected by the user with DIGSI 4. Important events are also transmitted spontaneously via configurable process alarms. Switching commands can be executed by the system control via the device in the controlling direction. The PROFINET implementation is certified. The device also supports the IEC 61850 protocol as a server on the same ethernet module in addition to the PROFINET protocol. Client server connections are possible for the intercommunication between devices, e.g. for transmitting fault records and GOOSE messages.

DNP 3.0

Power utilities use the serial DNP 3.0 (Distributed Network Protocol) for the station and network control levels. SIPROTEC units function as DNP slaves, supplying their information to a master system or receiving information from it.

DNP3 TCP

The ethernet-based TCP variant of the DNP3 protocol is supported with the electrical and optical ethernet module. Two DNP3 TCP clients are supported. Redundant ring structures can be realized for DNP3 TCP with the help of the integrated switch in the module. For instance, a redundant optical ethernet ring can be constructed. Single-point indications, double-point indications, measured and metered values can be configured with DIGSI 4 and are transmitted to the DNP3 TCP client. Switching commands can be executed in the controlling direction. Fault records of the device are stored in the binary Comtrade format and can be retrieved via the DNP3 file transfer. The time synchronization is performed via the DNP3 TCP client or SNTP. The device can also be integrated into a network monitoring system via the SNMP V2 protocol. Parallel to the DNP3 TCP protocol the IEC 61850 protocol (the device works as a server) and the GOOSE messages of the IEC 61850 are available for the intercommunication between devices.

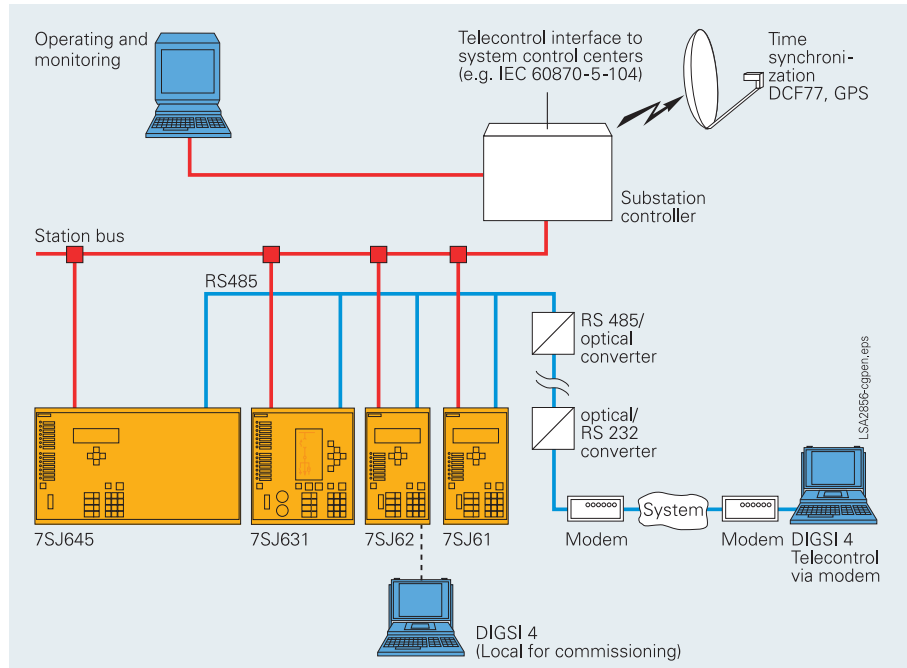


Fig. 5/67 System solution/communication

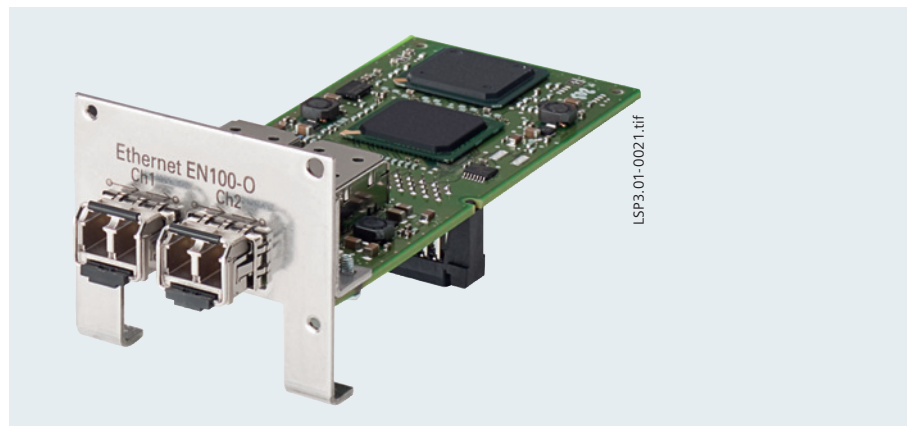


Fig. 5/68 Optical Ethernet communication module for IEC 61850 with integrated Ethernet-switch

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system.

Units featuring IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 5/65).

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 5/66).

Typical connections

■ Connection of current and voltage transformers

Standard connection

For grounded networks, the ground current is obtained from the phase currents by the residual current circuit.

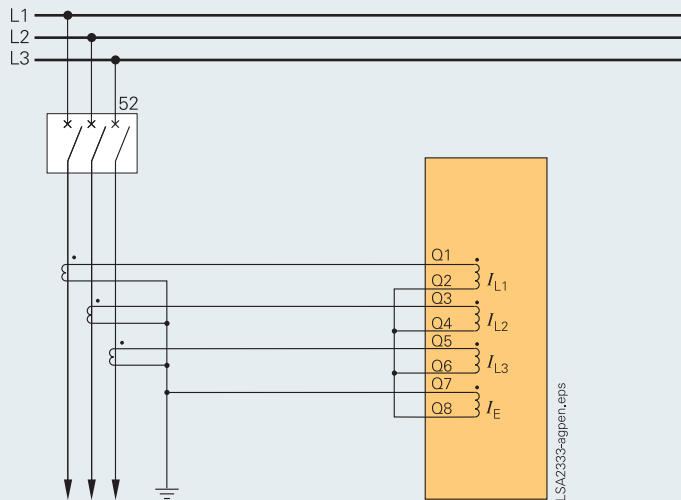


Fig. 5/69 Residual current circuit

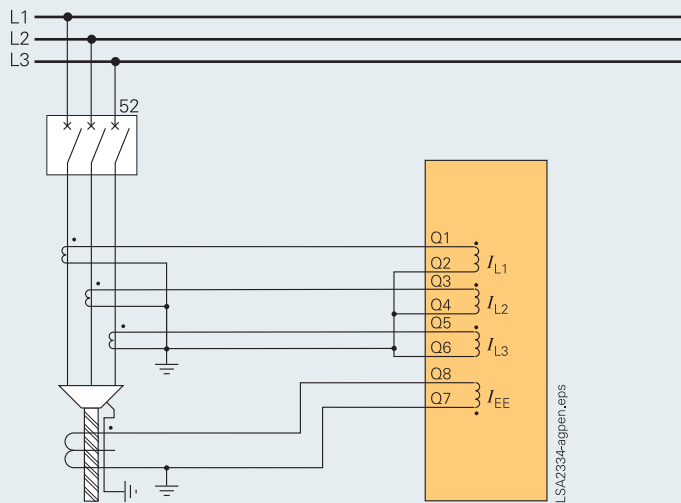


Fig. 5/70 Sensitive ground current detection

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Typical applications

Overview of connection types		
Type of network	Function	Current connection
(Low-resistance) grounded network	Overcurrent protection hase/ground non-directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformer possible
(Low-resistance) grounded networks	Sensitive ground-fault protection	Phase-balance neutral current transformers required
Isolated or compensated networks	Overcurrent protection phases non-directional	Residual circuit, with 3 or 2 phase current transformers possible
Isolated networks	Sensitive ground-fault protection	Phase-balance neutral current transformers required
Compensated networks	Sensitive ground-fault protection	Phase-balance neutral current transformers required

Typical applications

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal occurs whenever the circuit is interrupted.

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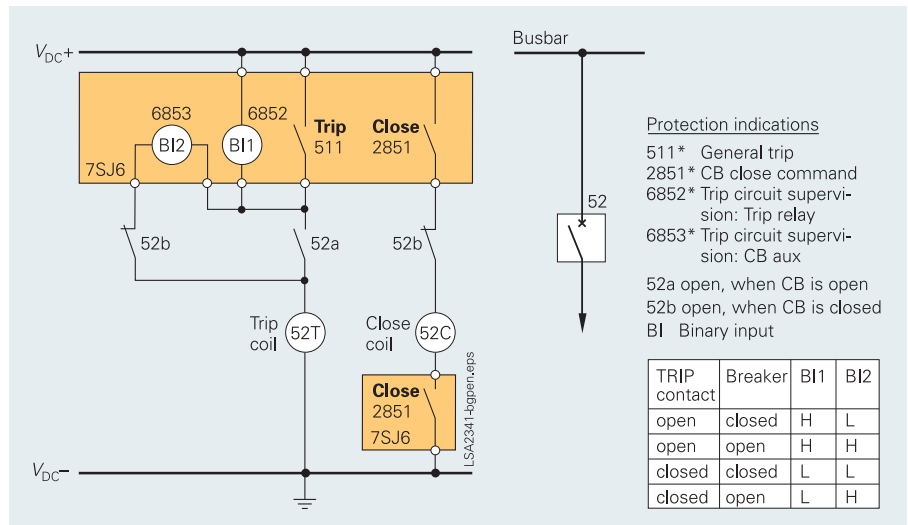


Fig. 5/71 Trip circuit supervision with 2 binary inputs

General unit data	
<i>Measuring circuits</i>	
System frequency	50 / 60 Hz (settable)
<i>Current transformer</i>	
Rated current I_{nom}	1 or 5 A (settable)
Option: sensitive ground-fault CT	$I_{EE} < 1.6 A$
Power consumption at $I_{nom} = 1 A$ at $I_{nom} = 5 A$ for sensitive ground-fault CT at 1 A	Approx. 0.05 VA per phase Approx. 0.3 VA per phase Approx. 0.05 VA
Overload capability Thermal (effective)	500 A for 1 s 150 A for 10 s 20 A continuous
Dynamic (impulse current)	250 x I_{nom} (half cycle)
Overload capability if equipped with sensitive ground-fault CT Thermal (effective)	300 A for 1 s 100 A for 10 s 15 A continuous
Dynamic (impulse current)	750 A (half cycle)
<i>Auxiliary voltage (via integrated converter)</i>	
Rated auxiliary voltage V_{aux}	DC 24/48 V 60/125 V 110/250 V AC 115/230 V
Permissible tolerance	DC 19-58 V 48-150 V 88-330 V AC 92-138 V 184-265 V
Ripple voltage, peak-to-peak	$\leq 12 \%$
Power consumption	
Quiescent	Approx. 3 W
Energized	Approx. 7 W
Backup time during loss/short-circuit of auxiliary voltage	≥ 50 ms at $V \geq DC 110 V$ ≥ 20 ms at $V \geq DC 24 V$ ≥ 200 ms at AC 115 V/230 V
<i>Binary inputs/indication inputs</i>	
Type	7SJ610 7SJ611, 7SJ612, 7SJ613 7SJ614
Number	3 8 11
Voltage range	DC 24–250 V
Pickup threshold	Modifiable by plug-in jumpers
Pickup threshold	DC 19 V 88 V
For rated control voltage	DC 24/48/60/110/125 V 110/220/250 V
Response time/drop-out time	Approx. 3.5 ms
Power consumption energized	1.8 mA (independent of operating voltage)
<i>Binary outputs/command outputs</i>	
Type	7SJ610, 7SJ611, 7SJ613 7SJ612, 7SJ614
Number command/indication relay	4 8 6
Contacts per command/indication relay	1 NO / form A (2 contacts changeable to NC / form B, via jumpers)
Live status contact	1 NO / NC (jumper) / form A / B
Switching capacity	Make 1000 W/VA Break 30 W/VA / 40 $W_{resistive}$ / 25 W at $L/R \leq 50$ ms
Switching voltage	$\leq DC 250 V$
Permissible current	5 A continuous, 30 A for 0.5 s making current, 2000 switching cycles

Electrical tests	
<i>Specification</i>	
Standards	IEC 60255 ANSI C37.90, C37.90.1, C37.90.2, UL508
<i>Insulation tests</i>	
Standards	IEC 60255-5; ANSI/IEEE C37.90.0
Voltage test (100 % test) all circuits except for auxiliary voltage and RS485/RS232 and time synchronization	2.5 kV (r.m.s. value), 50/60 Hz
Auxiliary voltage	DC 3.5 kV
Communication ports and time synchronization	AC 500 V
Impulse voltage test (type test) all circuits, except communication ports and time synchronization, class III	5 kV (peak value); 1.2/50 μs ; 0.5 J 3 positive and 3 negative impulses at intervals of 5 s
<i>EMC tests for interference immunity; type tests</i>	
Standards	IEC 60255-6; IEC 60255-22 (product standard) EN 50082-2 (generic specification) DIN 57435 Part 303
High-frequency test IEC 60255-22-1, class III and VDE 0435 Part 303, class III	2.5 kV (peak value); 1 MHz; $\tau = 15$ ms; 400 surges per s; test duration 2 s
Electrostatic discharge IEC 60255-22-2 class IV and EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air gap discharge; both polarities; 150 pF; $R_i = 330 \Omega$
Irradiation with radio-frequency field, non-modulated IEC 60255-22-3 (Report) class III	10 V/m; 27 to 500 MHz
Irradiation with radio-frequency field, amplitude-modulated IEC 61000-4-3; class III	10 V/m, 80 to 1000 MHz; AM 80 %; 1 kHz
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204; class III	10 V/m, 900 MHz; repetition rate 200 Hz, on duration 50 %
Fast transient interference/burst IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50 \Omega$; test duration 1 min
High-energy surge voltages (Surge) IEC 61000-4-5; class III	
Auxiliary voltage	From circuit to circuit: 2 kV; 12 Ω ; 9 μF across contacts: 1 kV; 2 Ω ; 18 μF
Binary inputs/outputs	From circuit to circuit: 2 kV; 42 Ω ; 0.5 μF across contacts: 1 kV; 42 Ω ; 0.5 μF
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; AM 80 %; 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m; 50 Hz, continuous 300 A/m; 50 Hz, 3 s 0.5 mT, 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak value), 1 to 1.5 MHz damped wave; 50 surges per s; duration 2 s, $R_i = 150$ to 200 Ω

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Technical data

5

EMC tests for interference immunity; type tests (cont'd)	
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per s both polarities; duration 2 s, $R_i = 80 \Omega$
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz; amplitude and pulse-modulated
Damped wave IEC 60694 / IEC 61000-4-12	2.5 kV (peak value, polarity alternating) 100 kHz, 1 MHz, 10 and 50 MHz, $R_i = 200 \Omega$
EMC tests for interference emission; type tests	
Standard	EN 50081-* (generic specification)
Conducted interferences only auxiliary voltage IEC/CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC/CISPR 11	30 to 1000 MHz Limit class B
Units with a detached operator panel must be installed in a metal cubicle to maintain limit class B	

Mechanical stress tests	
Vibration, shock stress and seismic vibration	
During operation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz; ± 0.075 mm amplitude; 60 to 150 Hz; 1 g acceleration frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 5 g, duration 11 ms; 3 shocks in both directions of 3 axes
Seismic vibration IEC 60255-21-3, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 g acceleration (horizontal axis) 8 to 35 Hz: 0.5 g acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 perpendicular axes
During transportation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz; 2 g acceleration, frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, Class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 15 g, duration 11 ms 3 shocks in both directions of 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Semi-sinusoidal Acceleration 10 g, duration 16 ms 1000 shocks in both directions of 3 axes

Climatic stress tests	
Temperatures	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C / -13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	-20 °C to +70 °C / -4 °F to -158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C / +131 °F)	-5 °C to +55 °C / +25 °F to +131 °F
- Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to +131 °F
- Limiting temperature during transport	-25 °C to +70 °C / -13 °F to +158 °F
Humidity	
Permissible humidity It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average 75 % relative humidity; on 56 days a year up to 95 % relative humidity; condensation not permissible!
Unit design	
Housing	7XP20
Dimensions	See dimension drawings, part 14
Weight	
1/3 19", surface-mounting housing	4.5 kg
1/3 19", flush-mounting housing	4.0 kg
1/2 19", surface-mounting housing	7.5 kg
1/2 19", flush-mounting housing	6.5 kg
Degree of protection acc. to EN 60529	
Surface-mounting housing	IP 51
Flush-mounting housing	Front: IP 51, rear: IP 20;
Operator safety	IP 2x with cover
Serial interfaces	
Operating interface (front of unit)	
Connection	Non-isolated, RS232; front panel, 9-pin subminiature connector
Transmission rate	Factory setting 115200 baud, min. 4800 baud, max. 115200 baud
Service/modem interface (rear of unit)	
Isolated interface for data transfer	Port C: DIGSI / modem / RTD-box
Transmission rate	Factory setting 38400 baud, min. 4800 baud, max. 115200 baud
RS232/RS485	
Connection	
For flush-mounting housing / surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location "C"
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	15 m / 49.2 ft
Distance RS485	Max. 1 km / 3300 ft
Test voltage	AC 500 V against ground

<u>System interface (rear of unit)</u>	
<u>IEC 60870-5-103 protocol</u>	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Factory setting 9600 baud, min. 1200 baud, max. 115200 baud
<u>RS232/RS485</u>	
Connection	Mounting location "B"
For flush-mounting housing/ surface-mounting housing with detached operator panel	
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	Max. 15 m / 49 ft
Distance RS485	Max. 1 km / 3300 ft
Test voltage	AC 500 V against ground
<u>Fiber optic</u>	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection Mounting location "B"
For flush-mounting housing/ surface-mounting housing with detached operator panel	
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	Max. 1.5 km / 0.9 miles
<u>IEC 60870-5-103 protocol, redundant</u>	
<u>RS485</u>	
Connection	Mounting location "B"
For flush-mounting housing/ surface-mounting housing with detached operator panel	
For surface-mounting housing with two-tier terminal on the top/bottom part	(not available)
Distance RS485	Max. 1 km / 3300 ft
Test voltage	AC 500 V against ground
<u>Ethernet (EN 100) for DIGSI, IEC 61850, DNP3 TCP, PROFINET</u>	
Isolated interface for data transfer: - to a control center - with DIGSI - between SIPROTEC 4 relays	Port B, 100 Base T acc. to IEEE802.3
Transmission rate	100 Mbit
<u>Ethernet, electrical</u>	
Connection	Two RJ45 connectors mounting location "B"
For flush-mounting housing/ surface-mounting housing with detached operator panel	
Distance	Max. 20 m / 65.6 ft
Test voltage	AC 500 V against ground
<u>Ethernet, optical</u>	
Connection	Integr. LC connector for FO connection Mounting location "B"
For flush-mounting housing/ surface-mounting housing with detached operator panel	
Optical wavelength	1300 nm
Distance	1.5 km / 0.9 miles

<u>PROFIBUS-FMS/DP</u>	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 1.5 Mbaud
<u>RS485</u>	
Connection	9-pin subminiature connector, mounting location "B"
For flush-mounting housing/ surface-mounting housing with detached operator panel	
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance	1000 m / 3300 ft ≤ 93.75 kbaud; 500 m / 1500 ft ≤ 187.5 kbaud; 200 m / 600 ft ≤ 1.5 Mbaud; 100 m / 300 ft ≤ 12 Mbaud
Test voltage	AC 500 V against ground
<u>Fiber optic</u>	
Connection fiber-optic cable	Integr. ST connector for FO connection Mounting location "B"
For flush-mounting housing/ surface-mounting housing with detached operator panel	
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing Important: Please refer to footnotes ¹⁾ and ²⁾ on page 5/99
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	500 kB/s 1.6 km / 0.99 miles 1500 kB/s 530 m / 0.33 miles
<u>MODBUS RTU, ASCII, DNP 3.0</u>	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 19200 baud
<u>RS485</u>	
Connection	9-pin subminiature connector, mounting location "B"
For flush-mounting housing/ surface-mounting housing with detached operator panel	
For surface-mounting housing with two-tier terminal at the top/bottom part	At bottom part of the housing: shielded data cable
Distance	Max. 1 km / 3300 ft max. 32 units recommended
Test voltage	AC 500 V against ground
<u>Fiber optic</u>	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection Mounting location "B"
For flush-mounting housing/ surface-mounting housing with detached operator panel	
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing Important: Please refer to footnotes ¹⁾ and ²⁾ on page 5/77
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	Max. 1.5 km / 0.9 miles

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Time synchronization DCF77 / IRIG-B signal (Format IRIG-B000)	
Connection	9-pin subminiature connector (SUB-D) (terminal with surface-mounting housing)
Voltage levels	5 V, 12 V or 24 V (optional)

Functions	
Definite-time overcurrent protection (ANSI 50, 50N)	
Operating mode phase protection (ANSI 50)	3-phase (standard) or 2-phase (L1 and L3)
Number of elements (stages)	$I>$, $I>>$, $I>>>$ (phases) $I_{E>}$, $I_{E>>}$, $I_{E>>>}$ (ground)
Setting ranges	
Pickup phase elements	0.5 to 175 A or ∞ (in steps of 0.01 A)
Pickup ground elements	0.25 to 175 A or ∞ (in steps of 0.01 A)
Delay times T	0 to 60 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Times	
Pickup times (without inrush restraint, with inrush restraint + 10 ms)	
With twice the setting value	pprox. 30 ms
With five times the setting value	Approx. 20 ms
Dropout times	Approx. 40 ms
Dropout ratio	Approx. 0.95 for $III_{nom} \geq 0.3$
Tolerances	
Pickup	2 % of setting value or 50 mA ¹⁾
Delay times T , T_{DO}	1 % or 10 ms

Inverse-time overcurrent protection (ANSI 51, 51N)	
Operating mode phase protection (ANSI 51)	3-phase (standard) or 2-phase (L1 and L3)
Setting ranges	
Pickup phase element I_p	0.5 to 20 A or ∞ ¹⁾ (in steps of 0.01 A)
Pickup ground element I_{EP}	0.25 to 20 A or ∞ ¹⁾ (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.05 to 15 s or ∞ (in steps of 0.01 s)
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse, long inverse
ANSI	Inverse, short inverse, long inverse, moderately inverse, very inverse, extremely inverse, definite inverse
User-defined characteristic	Defined by a maximum of 20 value pairs of current and time delay
Dropout setting	
Without disk emulation	Approx. $1.05 \cdot$ setting value I_p for $I_p/III_{nom} \geq 0.3$, corresponds to approx. $0.95 \cdot$ pickup threshold
With disk emulation	Approx. $0.90 \cdot$ setting value I_p
Tolerances	
Pickup/dropout thresholds I_p , I_{EP}	2 % of setting value or 50 mA ¹⁾
Pickup time for $2 \leq III_p \leq 20$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms
Dropout ratio for $0.05 \leq III_p \leq 0.9$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms

1) For $I_{nom} = 1$ A, all limits divided by 5.

Inrush blocking	
Influenced functions	Time-overcurrent elements, $I>$, $I_{E>}$, I_p , I_{EP}
Lower function limit phases	At least one phase current (50 Hz and 100 Hz) ≥ 125 mA ¹⁾
Lower function limit ground	Ground current (50 Hz and 100 Hz) ≥ 125 mA ¹⁾
Upper function limit (setting range)	1.5 to 125 A ¹⁾ (in steps of 0.01 A)
Setting range I_{2f} II	10 to 45 % (in steps of 1 %)
Crossblock (I_{L1} , I_{L2} , I_{L3})	ON/OFF

Dynamic setting change	
Controllable function	Pickup, tripping time
Start criteria	Current criteria, CB position via aux. contacts, binary input, auto-reclosure ready
Time control	3 timers
Current criteria	Current threshold (reset on dropping below threshold; monitoring with timer)

(Sensitive) ground-fault detection (ANSI 50 Ns, 51Ns)	
Ground-fault pickup for all types of ground faults	
Definite-time characteristic (ANSI 50Ns)	
Setting ranges	
Pickup threshold $I_{EE>}$, $I_{EE>>}$	
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A ¹⁾ (in steps of 0.01 A)
Delay times T for $I_{EE>}$, $I_{EE>>}$	0 to 320 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Times	
Pickup times	Approx. 50 ms
Dropout ratio	Approx. 0.95
Tolerances	
Pickup threshold $I_{EE>}$, $I_{EE>>}$	2 % of setting value or 1 mA
Delay times	1 % of setting value or 20 ms

Ground-fault pickup for all types of ground faults	
Inverse-time characteristic (ANSI 51Ns)	
User-defined characteristic	
Setting ranges	Defined by a maximum of 20 pairs of current and delay time values
Pickup threshold I_{EEP}	
For sensitive input	0.001 A to 1.4 A (in steps of 0.001 A)
For normal input	0.25 to 20 A ¹⁾ (in steps of 0.01 A)
User defined	
Time multiplier T	0.1 to 4 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	Approx. 50 ms
Pickup threshold	Approx. $1.1 \cdot I_{EEP}$
Dropout ratio	Approx. $1.05 \cdot I_{EEP}$
Tolerances	
Pickup threshold	2 % of setting value or 1 mA
For sensitive input	2 % of setting value or 50 mA ¹⁾
For normal input	7 % of reference value for $2 \leq III_{EEP}$
Dropout times in linear range	$\leq 20 + 2$ % current tolerance, or 70 ms
<u>Logarithmic inverse</u>	Refer to the manual
<u>Logarithmic inverse with knee point</u>	Refer to the manual

High-impedance restricted ground-fault protection (ANSI 87N) / single-phase overcurrent protection	
Setting ranges	
Pickup thresholds $I_{>}$, $I_{>>}$	
For sensitive input	0.003 to 1.5 A or ∞ (in steps of 0.001 A)
For normal input	0.25 to 175 A ¹⁾ or ∞ (in steps of 0.01 A)
Delay times $T_{I>}$, $T_{I>>}$	0 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
Minimum	Approx. 20 ms
Typical	Approx. 30 ms
Dropout times	Approx. 30 ms
Dropout ratio	Approx. 0.95 for $III_{nom} \geq 0.5$
Tolerances	
Pickup thresholds	3 % of setting value or 1 % rated current at $I_{nom} = 1$ or 5 A; 5 % of setting value or 3 % rated current at $I_{nom} = 0.1$ A
Delay times	1 % of setting value or 10 ms
Intermittent ground-fault protection	
Setting ranges	
Pickup threshold	
For I_E $I_{IE>}$	0.25 to 175 A ¹⁾ (in steps of 0.01 A)
For $3I_0$ $I_{IE>}$	0.25 to 175 A ¹⁾ (in steps of 0.01 A)
For I_{EE} $I_{IE>}$	0.005 to 1.5 A (in steps of 0.001 A)
Pickup prolon- gation time T_V	0 to 10 s (in steps of 0.01 s)
Ground-fault accu- mulation time T_{sum}	0 to 100 s (in steps of 0.01 s)
Reset time for accumulation T_{res}	1 to 600 s (in steps of 1 s)
Number of pickups for intermittent ground fault	2 to 10 (in steps of 1)
Times	
Pickup times	
Current = 1.25 · pickup value	Approx. 30 ms
Current $\geq 2 \cdot$ pickup value	Approx. 22 ms
Dropout time	Approx. 22 ms
Tolerances	
Pickup threshold $I_{IE>}$	3 % of setting value, or 50 mA ¹⁾
Times T_V , T_{sum} , T_{res}	1 % of setting value or 10 ms
Thermal overload protection (ANSI 49)	
Setting ranges	
Factor k	0.1 to 4 (in steps of 0.01)
Time constant	1 to 999.9 min (in steps of 0.1 min)
Warning overtemperature $\Theta_{alarm}/\Theta_{trip}$	50 to 100 % with reference to the tripping overtemperature (in steps of 1 %)
Current warning stage I_{alarm}	0.5 to 20 A (in steps of 0.01 A)
Extension factor when stopped k_t factor	1 to 10 with reference to the time constant with the machine running (in steps of 0.1)
Rated overtemperature (for I_{nom})	40 to 200 °C (in steps of 1 °C)

1) For $I_{nom} = 1$ A, all limits divided by 5.

Tripping characteristic For $(I/k \cdot I_{nom}) \leq 8$	$t = \tau_{th} \cdot \ln \frac{(I/k \cdot I_{nom})^2 - (I_{pre}/k \cdot I_{nom})^2}{(I/k \cdot I_{nom})^2 - 1}$ <p> t = Tripping time τ_{th} = Temperature rise time constant I = Load current I_{pre} = Preload current k = Setting factor acc. to VDE 0435 Part 3011 and IEC 60255-8 I_{nom} = Rated (nominal) current of the protection relay </p>
Dropout ratios Θ/Θ_{Trip} Θ/Θ_{Alarm} III_{Alarm}	Drops out with Θ_{Alarm} Approx. 0.99 Approx. 0.97
Tolerances With reference to $k \cdot I_{nom}$ With reference to tripping time	Class 5 acc. to IEC 60255-8 5 % \pm 2 s acc. to IEC 60255-8
Auto-reclosure (ANSI 79)	
Number of reclosures	0 to 9 Shot 1 to 4 individually adjustable
Program for phase fault Start-up by	Time-overcurrent elements, negative sequence, binary input
Program for ground fault Start-up by	Time-overcurrent elements, sensitive ground-fault protection, binary input
Blocking of ARC	Pickup of protection functions, three-phase fault detected by a protective element, binary input, last TRIP command after the reclosing cycle is complete (unsuccessful reclosing), TRIP command by the breaker failure protection (50BF), opening the CB without ARC initiation, external CLOSE command
Setting ranges	
Dead time (separate for phase and ground and individual for shots 1 to 4)	0.01 to 320 s (in steps of 0.01 s)
Blocking duration for manual- CLOSE detection	0.5 s to 320 s or 0 (in steps of 0.01 s)
Blocking duration after reclosure	0.5 s to 320 s (in steps of 0.01 s)
Blocking duration after dynamic blocking	0.01 to 320 s (in steps of 0.01 s)
Start-signal monitoring time	0.01 to 320 s or ∞ (in steps of 0.01 s)
Circuit-breaker supervision time	0.1 to 320 s (in steps of 0.01 s)
Max. delay of dead-time start	0 to 1800 s or ∞ (in steps of 0.1 s)
Maximum dead time extension	0.5 to 320 s or ∞ (in steps of 0.01 s)
Action time	0.01 to 320 s or ∞ (in steps of 0.01 s)
The delay times of the following protection function can be altered individually by the ARC for shots 1 to 4 (setting value $T = T$, non-delayed $T = 0$, blocking $T = \infty$): $I_{>>>}$, $I_{>>}$, $I_{>}$, I_p , $I_{E>>>}$, $I_{E>>}$, $I_{E>}$, I_{Ep}	

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Auto-reclosure (ANSI 79) (cont'd)	
Additional functions	Lockout (final trip), delay of dead-time start via binary input (monitored), dead-time extension via binary input (monitored), co-ordination with other protection relays, circuit-breaker monitoring, evaluation of the CB contacts
Breaker failure protection (ANSI 50 BF)	
Setting ranges	
Pickup thresholds	0.2 to 5 A ¹⁾ (in steps of 0.01 A)
Delay time	0.06 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times with internal start	is contained in the delay time
Pickup times with external start	is contained in the delay time
Dropout times	Approx. 25 ms
Tolerances	
Pickup value	2 % of setting value (50 mA) ¹⁾
Delay time	1 % or 20 ms
Flexible protection functions (ANSI 47, 50, 50N)	
Operating modes/measuring quantities	
3-phase	$I, I_1, I_2, I_2/I_1, 3I_0$
1-phase	$I, I_E, I_{E\text{ sens.}}$
Without fixed phase relation	Binary input
Pickup when	Exceeding or falling below threshold value
Setting ranges	
Current $I, I_1, I_2, 3I_0, I_E$	0.15 to 200 A ¹⁾ (in steps of 0.01 A)
Current ratio I_2 / I_1	15 to 100 % (in steps of 1 %)
Sensitive ground current $I_{E\text{ sens.}}$	0.001 to 1.5 A (in steps of 0.001 A)
Dropout ratio >- stage	1.01 to 3 (in steps of 0.01)
Dropout ratio <- stage	0.7 to 0.99 (in steps of 0.01)
Pickup delay time	0 to 60 s (in steps of 0.01 s)
Trip delay time	0 to 3600 s (in steps of 0.01 s)
Dropout delay time	0 to 60 s (in steps of 0.01 s)
Times	
Pickup times, phase quantities	
With 2 times the setting value	Approx. 30 ms
With 10 times the setting value	Approx. 20 ms
Pickup times, symmetrical components	
With 2 times the setting value	Approx. 40 ms
With 10 times the setting value	Approx. 30 ms
Binary input	Approx. 20 ms
Dropout times	
Phase quantities	< 20 ms
Symmetrical components	< 30 ms
Binary input	< 10 ms
Tolerances	
Pickup threshold	
Phase quantities	1 % of setting value or 50 mA ¹⁾
Symmetrical components	2 % of setting value or 100 mA ¹⁾
Times	1 % of setting value or 10 ms
Negative-sequence current detection (ANSI 46)	
Definite-time characteristic (ANSI 46-1 and 46-2)	
Setting ranges	
Pickup current $I_{2>}, I_{2>>}$	0.5 to 15 A or ∞ (in steps of 0.01 A)
Delay times	0 to 60 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{D0}	0 to 60 s (in steps of 0.01 s)
Functional limit	All phase currents $\leq 50\text{ A}^{1)}$

Times	
Pickup times	Approx. 35 ms
Dropout times	Approx. 35 ms
Dropout ratio	Approx. 0.95 for $I_2 / I_{nom} > 0.3$
Tolerances	
Pickup thresholds	3 % of the setting value or 50 mA ¹⁾
Delay times	1 % or 10 ms
Inverse-time characteristic (ANSI 46-TOC)	
Setting ranges	
Pickup current	0.5 to 10 A ¹⁾ (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.5 to 15 s or ∞ (in steps of 0.01 s)
Functional limit	All phase currents $\leq 50\text{ A}^{1)}$
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse
ANSI	Inverse, moderately inverse, very inverse, extremely inverse
Pickup threshold	Approx. $1.1 \cdot I_{2p}$ setting value
Dropout	
IEC and ANSI (without disk emulation)	Approx. $1.05 \cdot I_{2p}$ setting value, which is approx. $0.95 \cdot$ pickup threshold
ANSI with disk emulation	Approx. $0.90 \cdot I_{2p}$ setting value
Tolerances	
Pickup threshold	3 % of the setting value or 50 mA ¹⁾
Time for $2 \leq M \leq 20$	5 % of setpoint (calculated) +2 % current tolerance, at least 30 ms
Starting time monitoring for motors (ANSI 48)	
Setting ranges	
Motor starting current $I_{STARTUP}$	2.5 to 80 A ¹⁾ (in steps of 0.01)
Pickup threshold $I_{MOTOR\ START}$	2 to 50 A ¹⁾ (in steps of 0.01)
Permissible starting time $T_{STARTUP}$, cold motor	1 to 180 s (in steps of 0.1 s)
Permissible starting time $T_{STARTUP}$, warm motor	0.5 to 180 s (in steps of 0.1 s)
Temperature threshold cold motor	0 to 80 % (in steps of 1 %)
Permissible blocked rotor time $T_{LOCKED-ROTOR}$	0.5 to 120 s or ∞ (in steps of 0.1 s)
Tripping time characteristic	
For $I > I_{MOTOR\ START}$	$t = \left(\frac{I_{STARTUP}}{I} \right)^2 \cdot T_{STARTUP}$
	$I_{STARTUP}$ = Rated motor starting current I = Actual current flowing $T_{STARTUP}$ = Tripping time for rated motor starting current t = Tripping time in seconds
Dropout ratio $I_{MOTOR\ START}$	Approx. 0.95
Tolerances	
Pickup threshold	2 % of setting value or 50 mA ¹⁾
Delay time	5 % or 30 ms
Load jam protection for motors (ANSI 51M)	
Setting ranges	
Current threshold for alarm and trip	0.25 to 60 A ¹⁾ (in steps of 0.01 A)
Delay times	0 to 600 s (in steps of 0.01 s)
Blocking duration after close signal detection	0 to 600 s (in steps of 0.01 s)
Tolerances	
Pickup threshold	2 % of setting value or 50 mA ¹⁾
Delay time	1 % of setting value or 10 ms

1) For $I_{nom} = 1\text{ A}$, all limits divided by 5.

Restart inhibit for motors (ANSI 66)	
Setting ranges	
Motor starting current relative to rated motor current	1.1 to 10 (in steps of 0.1)
$I_{\text{MOTOR START}}/I_{\text{Motor Nom}}$	
Rated motor current $I_{\text{Motor Nom}}$	1 to 6 A ¹⁾ (in steps of 0.01 A)
Max. permissible starting time	1 to 320 s (in steps of 1 s)
$T_{\text{Start Max}}$	
Equilibrium time T_{Equal}	0 min to 320 min (in steps of 0.1 min)
Minimum inhibit time	0.2 min to 120 min (in steps of 0.1 min)
$T_{\text{MIN. INHIBIT TIME}}$	
Max. permissible number of warm starts	1 to 4 (in steps of 1)
Difference between cold and warm starts	1 to 2 (in steps of 1)
Extension k-factor for cooling simulations of rotor at zero speed	0.2 to 100 (in steps of 0.1)
$k_{\text{t at STOP}}$	
Extension factor for cooling time constant with motor running	0.2 to 100 (in steps of 0.1)
$k_{\text{t RUNNING}}$	
Restarting limit	
	$\Theta_{\text{restart}} = \Theta_{\text{rot max perm}} \cdot \frac{n_c - 1}{n_c}$
	Θ_{restart} = Temperature limit below which restarting is possible
	$\Theta_{\text{rot max perm}}$ = Maximum permissible rotor overtemperature (= 100 % in operational measured value $\Theta_{\text{rot}}/\Theta_{\text{rot trip}}$)
	n_c = Number of permissible start-ups from cold state
Undercurrent monitoring (ANSI 37)	
Signal from the operational measured values	Predefined with programmable logic
Temperature monitoring box (ANSI 38)	
Temperature detectors	
Connectable boxes	1 or 2
Number of temperature detectors per box	Max. 6
Type of measuring	Pt 100 Ω or Ni 100 Ω or Ni 120 Ω
Mounting identification	"Oil" or "Environment" or "Stator" or "Bearing" or "Other"
Thresholds for indications	
For each measuring detector	
Stage 1	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)
Stage 2	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)

1) At rated frequency.

Additional functions	
Operational measured values	
Currents I_{L1}, I_{L2}, I_{L3} Positive-sequence component I_1 Negative-sequence component I_2 I_E or $3I_0$	In A (kA) primary, in A secondary or in % I_{Nom}
Range Tolerance ¹⁾	10 to 200 % I_{Nom} 1 % of measured value or 0.5 % I_{Nom}
Temperature overload protection $\Theta/\Theta_{\text{Trip}}$	In %
Range Tolerance ¹⁾	0 to 400 % 5 % class accuracy per IEC 60255-8
Temperature restart inhibit $\Theta_L/\Theta_L \text{ Trip}$	In %
Range Tolerance ¹⁾	0 to 400 % 5 % class accuracy per IEC 60255-8
Restart threshold $\Theta_{\text{Restart}}/\Theta_L \text{ Trip}$	In %
Reclose time T_{Reclose}	In min
Current of sensitive ground fault detection I_{EE}	In A (kA) primary and in mA secondary
Range Tolerance ¹⁾	0 mA to 1600 mA 2 % of measured value or 1 mA
RTD-box	See section "Temperature monitoring box"
Long-term averages	
Time window	5, 15, 30 or 60 minutes
Frequency of updates	Adjustable
Long-term averages of currents	$I_{L1\text{dmd}}, I_{L2\text{dmd}}, I_{L3\text{dmd}}, I_{1\text{dmd}}$ in A (kA)
Max./Min. report	
Report of measured values	With date and time
Reset, automatic	Time of day adjustable (in minutes, 0 to 1439 min) Time frame and starting time adjustable (in days, 1 to 365 days, and ∞)
Reset, manual	Using binary input, using keypad, via communication
Min./Max. values for current	I_{L1}, I_{L2}, I_{L3} I_1 (positive-sequence component)
Min./Max. values for overload protection	$\Theta/\Theta_{\text{Trip}}$
Min./Max. values for mean values	$I_{L1\text{dmd}}, I_{L2\text{dmd}}, I_{L3\text{dmd}}$ I_1 (positive-sequence component)
Local measured values monitoring	
Current asymmetry	$I_{\text{max}}/I_{\text{min}} >$ balance factor, for $I > I_{\text{balance limit}}$
Current phase sequence	Clockwise (ABC) / counter-clockwise (ACB)
Limit value monitoring	Predefined limit values, user-defined expansions via CFC
Fault recording	
Recording of indications of the last 8 power system faults	
Recording of indications of the last 3 power system ground faults	

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Time stamping	
Resolution for event log (operational annunciations)	1 ms
Resolution for trip log (fault annunciations)	1 ms
Maximum time deviation (internal clock)	0.01 %
Battery	Lithium battery 3 V/1 Ah, type CR 1/2 AA, message "Battery Fault" for insufficient battery charge
Oscillographic fault recording	
Maximum 8 fault records saved, memory maintained by buffer battery in case of loss of power supply	
Recording time	Total 20 s Pre-trigger and post-fault recording and memory time adjustable
Sampling rate for 50 Hz	1 sample/1.25 ms (16 samples/cycle)
Sampling rate for 60 Hz	1 sample/1.04 ms (16 samples/cycle)
Statistics	
Saved number of trips	Up to 9 digits
Number of automatic reclosing commands (segregated according to 1 st and ≥ 2 nd cycle)	Up to 9 digits
Circuit-breaker wear	
Methods	<ul style="list-style-type: none"> • ΣI^x with $x = 1 \dots 3$ • 2-point method (remaining service life) • $\Sigma i^2 t$
Operation	Phase-selective accumulation of measured values on TRIP command, up to 8 digits, phase-selective limit values, monitoring indication
Motor statistics	
Total number of motor start-ups	0 to 9999 (resolution 1)
Total operating time	0 to 99999 h (resolution 1 h)
Total down-time	0 to 99999 h (resolution 1 h)
Ratio operating time/down-time	0 to 100 % (resolution 0.1 %)
Motor start-up data: of the last 5 start-ups	
– start-up time	0.30 s to 9999.99 s (resolution 10 ms)
– start-up current (primary)	0 A to 1000 kA (resolution 1 A)
Operating hours counter	
Display range	Up to 7 digits
Criterion	Overshoot of an adjustable current threshold (BkrClosed IMIN)
Trip circuit monitoring	
With one or two binary inputs	
Commissioning aids	
Phase rotation field check, operational measured values, circuit-breaker/switching device test, creation of a test measurement report	
Clock	
Time synchronization	DCF77/IRIG-B signal (telegram format IRIG-B000), binary input, communication

Setting group switchover of the function parameters	
Number of available setting groups	4 (parameter group A, B, C and D)
Switchover performed	Via keypad, DIGSI, system (SCADA) interface or binary input
Control	
Number of switching units	Depends on the binary inputs and outputs
Interlocking	Programmable
Circuit-breaker signals	Feedback, close, open, intermediate position
Control commands	Single command / double command 1, 1 plus 1 common or 2 trip contacts
Programmable controller	CFC logic, graphic input tool
Local control	Control via menu, assignment of a function key
Remote control	Via communication interfaces, using a substation automation and control system (e.g. SICAM), DIGSI 4 (e.g. via modem)

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EG previous 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 2006/95/EG previous 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1.

The unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".



Description	Order No.
7SJ61 multifunction protection relay	7SJ61 <input type="checkbox"/> <input type="checkbox"/> - <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> - <input type="checkbox"/> <input type="checkbox"/>
Housing, binary inputs (BI) and outputs (BO)	
Housing 1/319", 4 line text display, 3 BI, 4 BO, 1 live status contact	0
Housing 1/319", 4 line text display, 8 BI, 8 BO, 1 live status contact	1
Housing 1/319", 4 line text display, 11 BI, 6 BO, 1 live status contact	2
Housing 1/219", graphic display, 8 BI, 8 BO, 1 live status contact ⁷⁾	3
Housing 1/219", graphic display, 11 BI, 6 BO, 1 live status contact ⁷⁾	4
Measuring inputs (4 x I)	
$I_{ph} = 1A^{1)}$, $I_e = 1A^{1)}$ (min. = 0.05 A) Position 15 only with A	1
$I_{ph} = 1A^{1)}$, $I_e =$ sensitive (min. = 0.001 A) Position 15 only with B	2
$I_{ph} = 5A^{1)}$, $I_e = 5A^{1)}$ (min. = 0.25 A) Position 15 only with A	5
$I_{ph} = 5A^{1)}$, $I_e =$ sensitive (min. = 0.001 A) Position 15 only with B	6
$I_{ph} = 5A^{1)}$, $I_e = 1A^{1)}$ (min. = 0.05 A) Position 15 only with A	7
Rated auxiliary voltage (power supply, indication voltage)	
DC 24 to 48 V, threshold binary input DC 19 V ³⁾	2
DC 60 to 125 V ²⁾ , threshold binary input DC 19 V ³⁾	4
DC 110 to 250 V ²⁾ , AC 115 to 230 V ⁴⁾ , threshold binary input DC 88 V ³⁾	5
DC 110 to 250 V ²⁾ , AC 115 to 230 V ⁴⁾ , threshold binary input DC 176 V ³⁾	6
Unit version	
For panel surface mounting, 2 tier terminal top/bottom	B
For panel flush mounting, plug-in terminal (2/3 pin connector)	D
For panel flush mounting, screw-type terminal (direct connection/ring-type cable lugs)	E
Region-specific default settings/function versions and language settings	
Region DE, 50 Hz, IEC, language: German, selectable	A
Region World, 50/60 Hz, IEC/ANSI, language: English (GB), selectable	B
Region US, 60 Hz, ANSI, language: English (US), selectable	C
Region FR, 50/60 Hz, IEC/ANSI, language: French, selectable	D
Region World, 50/60 Hz, IEC/ANSI, language: Spanish, selectable	E
Region IT, 50/60 Hz, IEC/ANSI, language: Italian, selectable	F
System interface (Port B): Refer to page 5/77	
No system interface	0
Protocols see page 5/77	
Service interface (Port C)	
No interface at rear side	0
DIGSI 4 / modem, electrical RS232	1
DIGSI 4 / modem / RTD-box ⁵⁾ , electrical RS485	2
DIGSI 4 / modem / RTD-box ⁵⁾⁶⁾ , optical 820 nm wavelength, ST connector	3
Measuring/fault recording	
Fault recording	1
Slave pointer, mean values, min / max values, fault recording	3

- 1) Rated current can be selected by means of jumpers.
- 2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.
- 3) The binary input thresholds can be selected per binary input by means of jumpers.
- 4) AC 230 V, starting from device version .../EE.

- 5) Temperature monitoring box 7XV5662-□AD10, refer to "Accessories".
- 6) When using the temperature monitoring box at an optical interface, the additional RS485 fiber-optic converter 7XV5650-0□A00 is required.
- 7) starting from device version .../GG and FW-Version V4.82

Overcurrent Protection / 7SJ61

Selection and ordering data

Description			Order No.	Order code
7SJ61 multifunction protection relay			7SJ61 □ □ - □ □ □ □ □ - □ □ □ □	
Designation	ANSI No.	Description		
Basic version		Control		
	50/51	Overcurrent protection $I>$, $I>>$, $I>>>$, I_p		
	50N/51N	Ground-fault protection $I_{E>}$, $I_{E>>}$, $I_{E>>>}$, I_{Ep}		
	50N/51N	Ground-fault protection via insensitive IEE function: $I_{EE>}$, $I_{EE>>}$, $I_{EEp}^{1)}$		
	50/50N	Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I_{2>}$, $I>>>>$, $I_{E>>>>}$		
	49	Overload protection (with 2 time constants)		
	46	Phase balance current protection (negative-sequence protection)		
	50BF	Breaker failure protection		
	37	Undercurrent monitoring		
	74TC	Trip circuit supervision		
		4 setting groups, cold-load pickup		
		Inrush blocking		
	86	Lockout		F A
■	IEF	Intermittent ground fault		P A
■	50Ns/51Ns 87N	Sensitive ground-fault detection (non-directional) High-impedance restricted ground fault		F B ²⁾
■	IEF 50Ns/51Ns 87N	Sensitive ground-fault detection (non-directional) High-impedance restricted ground fault Intermittent ground fault		P B ²⁾
■	Motor IEF 50Ns/51Ns 87N	Sensitive ground-fault detection (non-directional) High-impedance restricted ground fault Intermittent ground fault		
	48/14	Starting time supervision, locked rotor		
	66/86	Restart inhibit		
	51M	Load jam protection, motor statistics		R B ²⁾
■	Motor 50Ns/51Ns 87N	Sensitive ground-fault detection (non-directional) High-impedance restricted ground fault		
	48/14	Starting time supervision, locked rotor		
	66/86	Restart inhibit		
	51M	Load jam protection, motor statistics		H B ²⁾
■	Motor 48/14 66/86 51M	Starting time supervision, locked rotor Restart inhibit Load jam protection, motor statistics		H A
ARC		Without		0
	79	With auto-reclosure		1

■ Basic version included

IEF = Intermittent ground fault

1) 50N/51N only with insensitive ground-current transformer when position 7 = 1, 5, 7.

2) Sensitive ground-current transformer only when position 7 = 2, 6.

Overcurrent Protection/7SJ61

Selection and ordering data

Description	Order No.	Order code
7SJ61 multifunction protection relay	7SJ61 □ □ - □ □ □ □ □ □ - □ □ □ □ □ □ - □ □ □ □	
System interface (on rear of unit, Port B)		
No system interface	0	
IEC 60870-5-103 protocol, RS232	1	
IEC 60870-5-103 protocol, RS485	2	
IEC 60870-5-103 protocol, 820 nm fiber, ST connector	3	
PROFIBUS-FMS Slave, RS485	4	
PROFIBUS-FMS Slave, 820 nm wavelength, single ring, ST connector ¹⁾	5	
PROFIBUS-FMS Slave, 820 nm wavelength, double ring, ST connector ¹⁾	6	
PROFIBUS-DP Slave, RS485	9	L O A
PROFIBUS-DP Slave, 820 nm wavelength, double ring, ST connector ¹⁾	9	L O B
MODBUS, RS485	9	L O D
MODBUS, 820 nm wavelength, ST connector ²⁾	9	L O E
DNP 3.0, RS485	9	L O G
DNP 3.0, 820 nm wavelength, ST connector ²⁾	9	L O H
IEC 60870-5-103 protocol, redundant, RS485, RJ45 connector ²⁾	9	L O P
IEC 61850, 100 Mbit Ethernet, electrical, double, RSJ45 connector (EN 100)	9	L O R
IEC 61850, 100 Mbit Ethernet, optical, double, ST connector (EN 100) ²⁾	9	L O S
DNP3 TCP + IEC 61850, 100Mbit Eth, electrical, double, RJ45 connector ³⁾	9	L 2 R
DNP3 TCP + IEC 61850, 100Mbit Eth, optical, double, LC connector ³⁾	9	L 2 S
PROFINET + IEC 61850, 100Mbit Eth, electrical, double, RJ45 connector ³⁾	9	L 3 R
PROFINET + IEC 61850, 100Mbit Eth, optical, double, RJ45 connector ³⁾	9	L 3 S

1) Not with position 9 = "B"; if 9 = "B", please order 7SJ6 unit with RS485 port and separate fiber-optic converters.
 For single ring, please order converter 6GK1502-3AB10, not available with position 9 = "B".
 For double ring, please order converter 6GK1502-4AB10, not available with position 9 = "B".
 The converter requires a AC 24 V power supply (e.g. power supply 7XV5810-0BA00).

2) Not available with position 9 = "B".

3) Available with V4.9

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Sample order

Position	Order No. + Order code
	7SJ612 5 - 5 E C 9 1 - 3 F A 1 + L O G
6 I/O's: 11 BI/6 BO, 1 live status contact	2
7 Current transformer: 5 A	5
8 Power supply: DC 110 to 250 V, AC 115 V to AC 230 V	5
9 Unit version: Flush-mounting housing, screw-type terminals	E
10 Region: US, English language (US); 60 Hz, ANSI	C
11 Communication: System interface: DNP 3.0, RS485	9
12 Communication: DIGSI 4, electric RS232	1
13 Measuring/fault recording: Extended measuring and fault records	3
14/15 Protection function package: Basic version	F A
16 With auto-reclosure	1

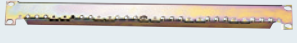




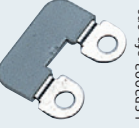

Overcurrent Protection / 7SJ61

Selection and ordering data

Accessories	Description	Order No.
	DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
	Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
	Professional + IEC 61850 Complete version: DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for control displays), DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	7XS5403-0AA00
	IEC 61850 System configurator Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM	7XS5460-0AA00
	SIGRA 4 Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000 or XP Professional Edition (generally contained in DIGSI Professional, but can be ordered additionally) Authorization by serial number. On CD-ROM.	7XS5410-0AA00
	Temperature monitoring box AC/DC 24 to 60 V	7XV5662-2AD10
	AC/DC 90 to 240 V	7XV5662-5AD10
	Varistor/Voltage Arrester Voltage arrester for high-impedance REF protection 125 Vrms; 600 A; 1S/S 256	C53207-A401-D76-1
	240 Vrms; 600 A; 1S/S 1088	C53207-A401-D77-1
	Connecting cable Cable between PC/notebook (9-pin con.) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	7XV5100-4
	Cable between temperature monitoring box and SIPROTEC 4 unit - length 5 m/16.4 ft	7XV5103-7AA05
	- length 25 m/82 ft	7XV5103-7AA25
	- length 50 m/164 ft	7XV5103-7AA50
	Manual for 7SJ61 English/German	C53000-G1140-C210-x ¹⁾
	1) x = please inquire for latest edition (exact Order No.).	

Overcurrent Protection/7SJ61

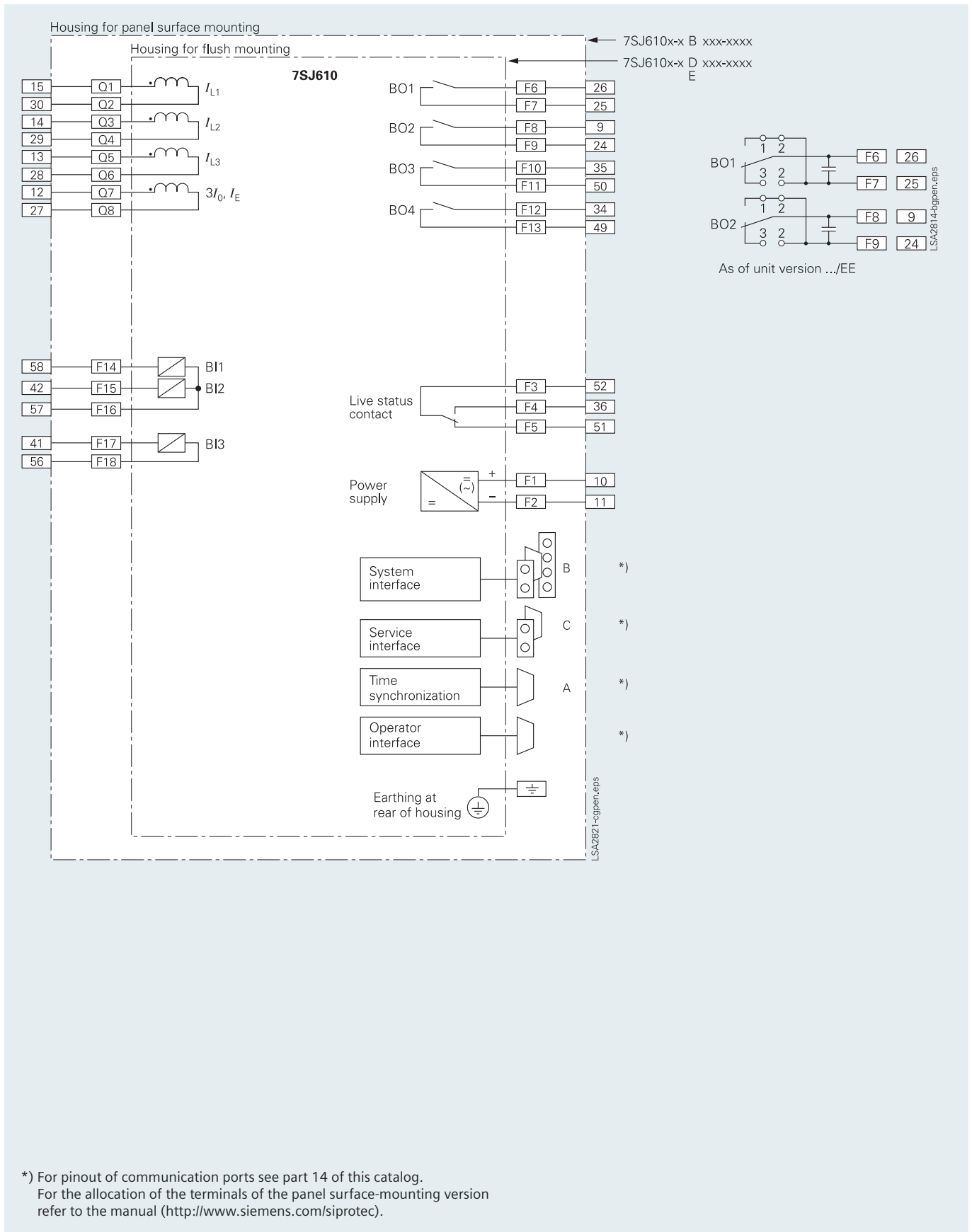
Selection and ordering data

Accessories	Description	Order No.	Size of package	Supplier
  Mounting rail 	Terminal safety cover			
	Voltage/current terminal 18-pole/12-pole	C73334-A1-C31-1	1	Siemens
	Voltage/current terminal 12-pole/8-pole	C73334-A1-C32-1	1	Siemens
	Connector 2-pin	C73334-A1-C35-1	1	Siemens
	Connector 3-pin	C73334-A1-C36-1	1	Siemens
	Crimp connector CI2 0.5 to 1 mm ²	0-827039-1	4000 taped on reel	AMP ¹⁾
 2-pin connector  3-pin connector	Crimp connector CI2 0.5 to 1 mm ²	0-827396-1	1	AMP ¹⁾
	Crimp connector: Type III+ 0.75 to 1.5 mm ²	0-163084-2	1	AMP ¹⁾
	Crimp connector: Type III+ 0.75 to 1.5 mm ²	0-163083-7	4000 taped on reel	AMP ¹⁾
	Crimping tool for Type III+ and matching female	0-539635-1	1	AMP ¹⁾
	Crimping tool for CI2 and matching female	0-539668-2	1	AMP ¹⁾
		0-734372-1	1	AMP ¹⁾
		1-734387-1	1	AMP ¹⁾
 Short-circuit links for current terminals  Short-circuit links for current terminals	Short-circuit links for current terminals	C73334-A1-C33-1	1	Siemens
	Short-circuit links for other terminals	C73334-A1-C34-1	1	Siemens
	Mounting rail for 19" rack	C73165-A63-D200-1	1	Siemens

1) Your local Siemens representative can inform you on local suppliers.

Overcurrent Protection / 7SJ61

Connection diagram



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Fig. 5/72 7SJ610 connection diagram

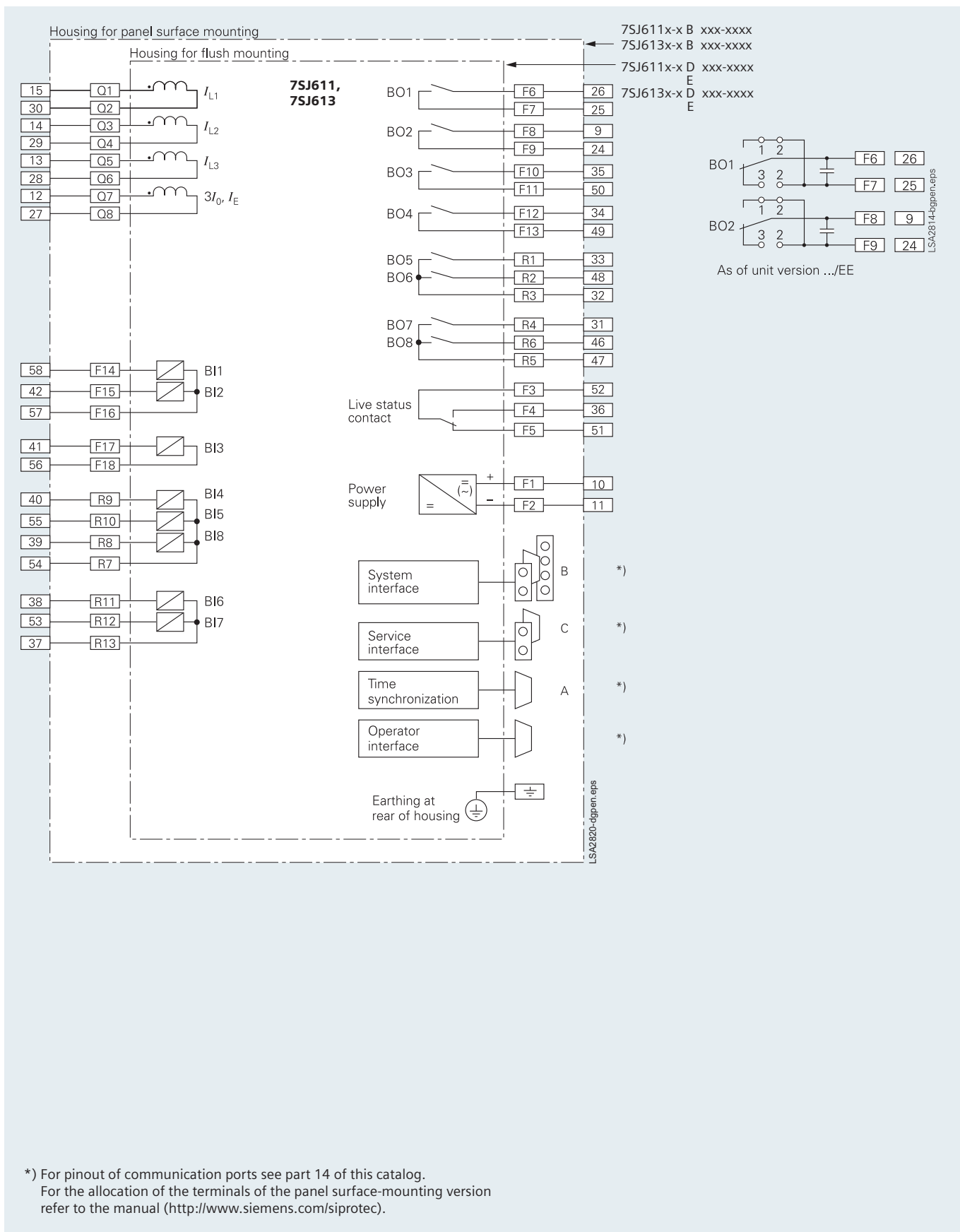
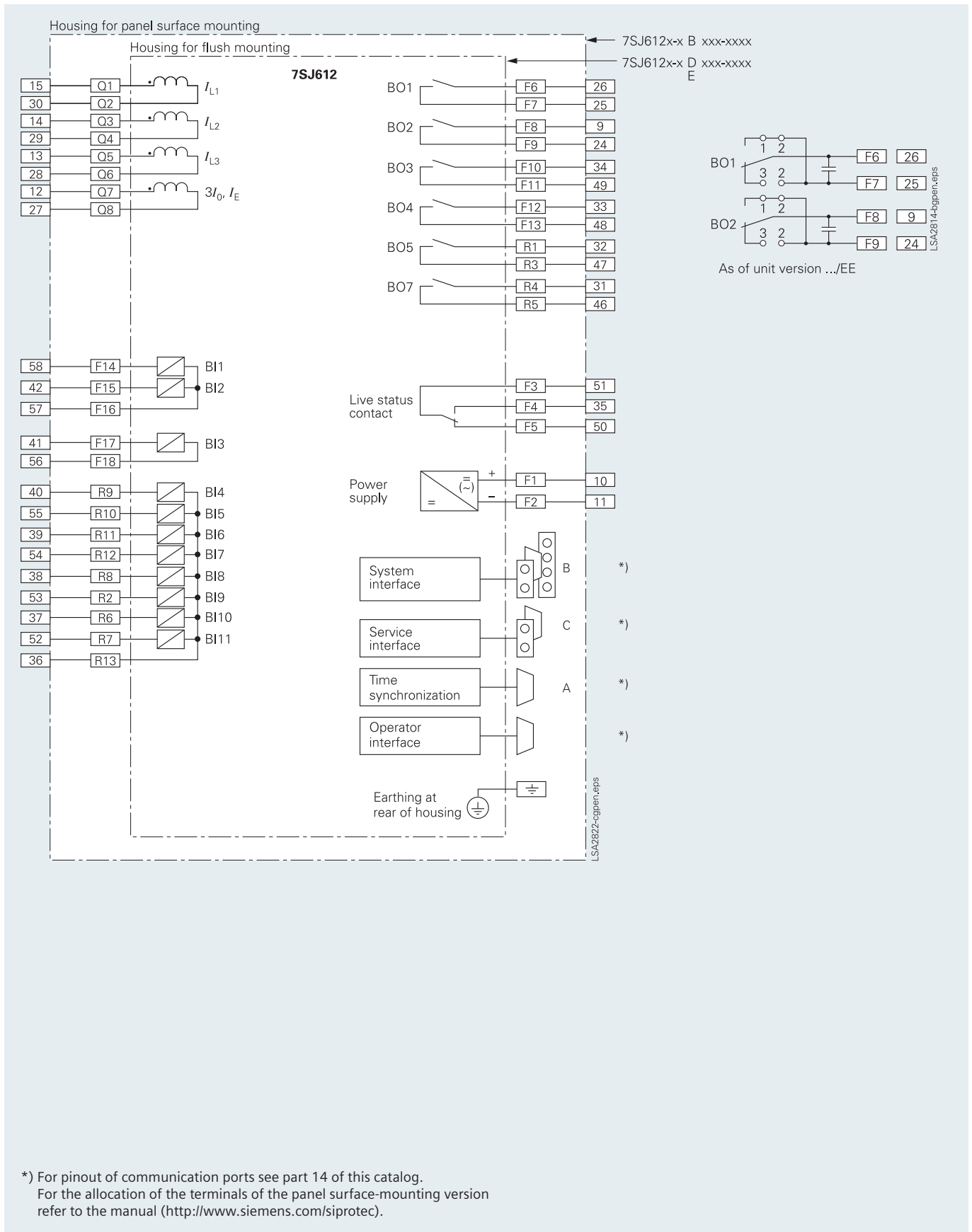


Fig. 5/73 7SJ611, 7SJ613 connection diagram

Overcurrent Protection / 7SJ61

Connection diagram



*) For pinout of communication ports see part 14 of this catalog.
For the allocation of the terminals of the panel surface-mounting version refer to the manual (<http://www.siemens.com/siprotec>).

Fig. 5/74 7SJ612, 7SJ614 connection diagram



Fig. 5/75 SIPROTEC 4 7SJ62 multifunction protection relay with text (left) and graphic display

Protection functions (continued)

- Inrush restraint
- Motor protection
- Overload protection
- Temperature monitoring
- Under-/overvoltage protection
- Under-/overfrequency protection
- Rate-of-frequency-change protection
- Power protection (e.g. reverse, factor)
- Undervoltage controlled reactive power protection
- Breaker failure protection
- Negative-sequence protection
- Phase-sequence monitoring
- Synchro-check
- Fault locator
- Lockout
- Auto-reclosure

Description

The SIPROTEC 4 7SJ62 relays can be used for line protection of high and medium voltage networks with earthed (grounded), low-resistance grounded, isolated or compensated neutral point. With regard to motor protection, the SIPROTEC 4 7SJ62 is suitable for asynchronous machines of all sizes. The relay performs all functions of backup protection supplementary to transformer differential protection.

7SJ62 is featuring the "flexible protection functions". Up to 20 protection functions can be added according to individual requirements. Thus, for example, a rate-of-frequency-change protection or reverse power protection can be implemented.

The relay provides control of the circuit-breaker, further switching devices and automation functions. The integrated programmable logic (CFC) allows the user to implement their own functions, e. g. for the automation of switchgear (interlocking). The user is also allowed to generate user-defined messages.

The flexible communication interfaces are open for modern communication architectures with control systems.

Function overview

Protection functions

- Overcurrent protection
- Directional overcurrent protection
- Sensitive directional ground-fault detection
- Displacement voltage
- Intermittent ground-fault protection
- Directional intermittent ground fault protection
- High-impedance restricted ground fault

Control functions/programmable logic

- Commands f. ctrl of CB and of isolators
- Position of switching elements is shown on the graphic display
- Control via keyboard, binary inputs, DIGSI 4 or SCADA system
- User-defined logic with CFC (e.g. interlocking)

Monitoring functions

- Operational measured values V, I, f
- Energy metering values W_p, W_q
- Circuit-breaker wear monitoring
- Slave pointer
- Trip circuit supervision
- Fuse failure monitor
- 8 oscillographic fault records
- Motor statistics

Communication interfaces

- System interface
 - IEC 60870-5-103 / IEC 61850
 - PROFIBUS-FMS / -DP
 - DNP 3.0 / DNP3 TCP / MODBUS RTU
- Service interface for DIGSI 4 (modem)
- Front interface for DIGSI 4
- Time synchronization via IRIG B / DCF77

Hardware

- 4 current transformers
- 3/4 voltage transformers
- 8/11 binary inputs
- 8/6 output relays

Overcurrent Protection / 7SJ62

Application

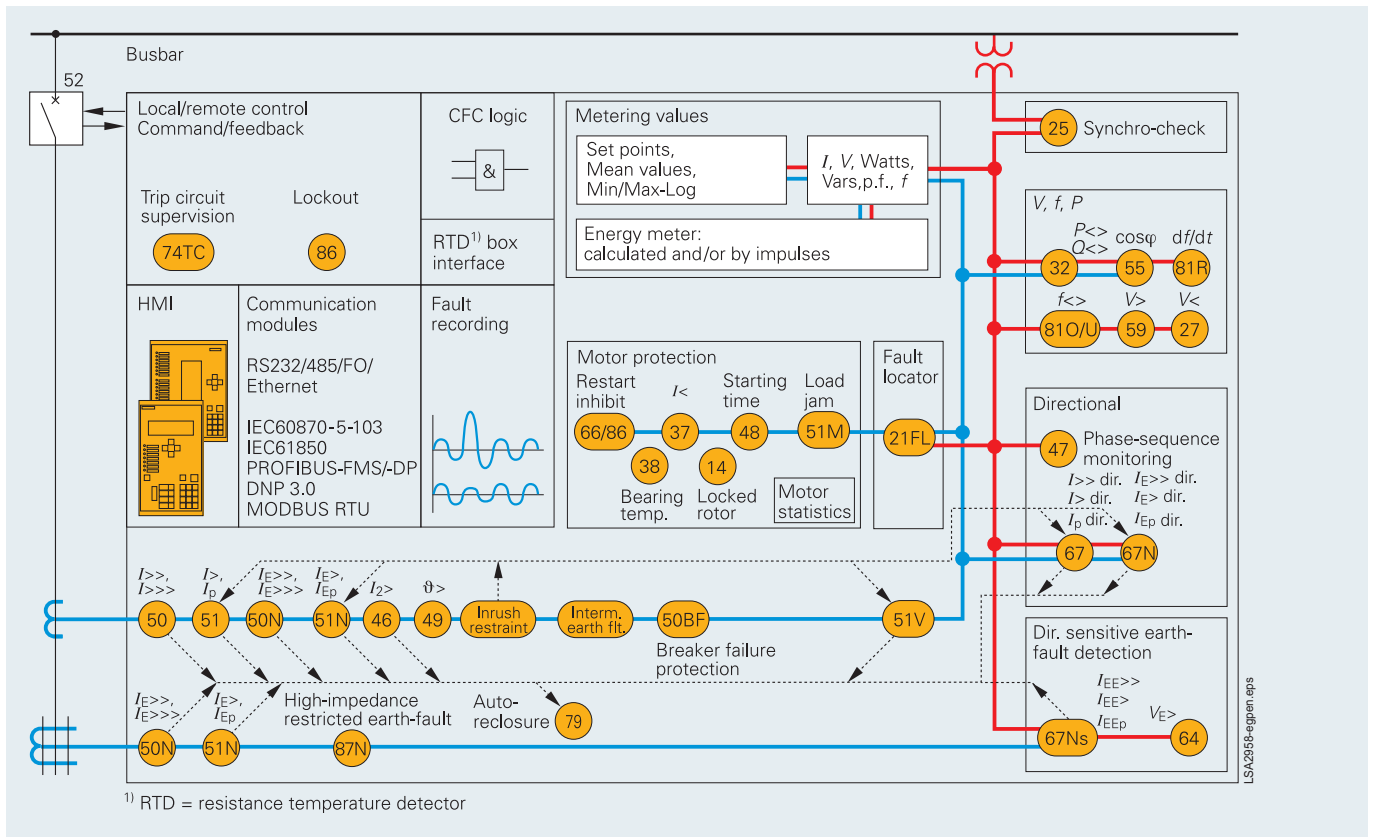


Fig. 5/76 Function diagram

Application

The SIPROTEC 4 7SJ62 unit is a numerical protection relay that also performs control and monitoring functions and therefore supports the user in cost-effective power system management, and ensures reliable supply of electric power to the customers. Local operation has been designed according to ergonomic criteria. A large, easy-to-read display was a major design aim.

Control

The integrated control function permits control of disconnect devices, grounding switches or circuit-breakers via the integrated operator panel, binary inputs, DIGSI 4 or the control and protection system (e.g. SICAM). The present status (or position) of the primary equipment can be displayed, in case of devices with graphic display. A full range of command processing functions is provided.

Programmable logic

The integrated logic characteristics (CFC) allow the user to implement their own functions for automation of switchgear (interlocking) or a substation via a graphic user interface. The user can also generate user-defined messages.

Line protection

The 7SJ62 units can be used for line protection of high and medium-voltage networks with earthed (grounded), low-resistance grounded, isolated or compensated neutral point.

Synchro-check

In order to connect two components of a power system, the relay provides a synchro-check function which verifies that switching ON does not endanger the stability of the power system.

Motor protection

When protecting motors, the 7SJ62 relay is suitable for asynchronous machines of all sizes.

Transformer protection

The relay performs all functions of backup protection supplementary to transformer differential protection. The inrush suppression effectively prevents tripping by inrush currents. The high-impedance restricted ground-fault protection detects short-circuits and insulation faults on the transformer.

Backup protection

The 7SJ62 can be used universally for backup protection.

Flexible protection functions

By configuring a connection between a standard protection logic and any measured or derived quantity, the functional scope of the relays can be easily expanded by up to 20 protection stages or protection functions.

Metering values

Extensive measured values, limit values and metered values permit improved system management.

ANSI	IEC	Protection functions
50, 50N	$I>, I>>, I>>>, I_E>, I_E>>, I_E>>>$	Definite-time overcurrent protection (phase/neutral)
50, 51V, 51N	I_p, I_{Ep}	Inverse overcurrent protection (phase/neutral), phase function with voltage-dependent option
67, 67N	$I_{dir}>, I_{dir}>>, I_{p\ dir}$ $I_{Edir}>, I_{Edir}>>, I_{Ep\ dir}$	Directional overcurrent protection (definite/inverse, phase/neutral), Directional comparison protection
67Ns/50Ns	$I_{EE}>, I_{EE}>>, I_{EEp}$	Directional / non-directional sensitive ground-fault detection
–		Cold load pick-up (dynamic setting change)
59N/64	$V_E, V_{0>}$	Displacement voltage, zero-sequence voltage
–	$I_{IE}>$	Intermittent ground fault
67Ns	$I_{IE\ dir}>$	Directional intermittent ground fault protection
87N		High-impedance restricted ground-fault protection
50BF		Breaker failure protection
79		Auto-reclosure
25		Synchro-check
46	$I_2>$	Phase-balance current protection (negative-sequence protection)
47	$V_2>, \text{phase-sequence}$	Unbalance-voltage protection and/or phase-sequence monitoring
49	$\vartheta>$	Thermal overload protection
48		Starting time supervision
51M		Load jam protection
14		Locked rotor protection
66/86		Restart inhibit
37	$I<$	Undercurrent monitoring
38		Temperature monitoring via external device (RTD-box), e.g. bearing temperature monitoring
27, 59	$V<, V>$	Undervoltage / overvoltage protection
59R	dV/dt	Rate-of-voltage-change protection
32	$P<>, Q<>$	Reverse-power, forward-power protection
27/Q	$Q>/V<$	Undervoltage-controlled reactive power protection
55	$\cos \varphi$	Power factor protection
81O/U	$f>, f<$	Overfrequency / underfrequency protection
81R	df/dt	Rate-of-frequency-change protection
21FL		Fault locator

Overcurrent Protection / 7SJ62

Construction, protection functions



Fig. 5/77 Rear view with screw-type terminals, 1/3-rack size

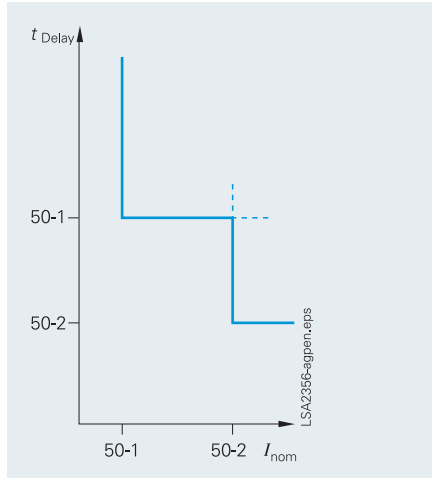


Fig. 5/78 Definite-time overcurrent protection

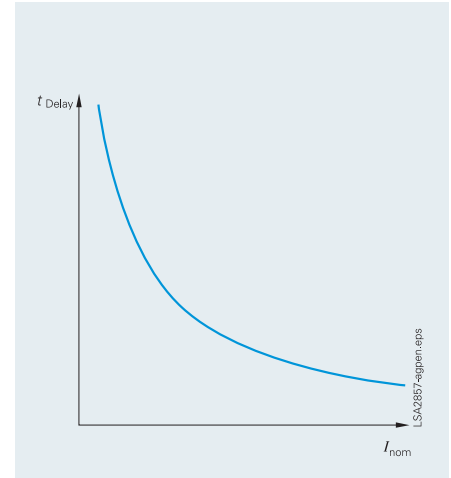


Fig. 5/79 Inverse-time overcurrent protection

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Construction

Connection techniques and housing with many advantages

1/3-rack size (text display variants) and 1/2-rack size (graphic display variants) are the available housing widths of the 7SJ62 relays, referred to a 19" module frame system. This means that previous models can always be replaced. The height is a uniform 244 mm for flush-mounting housings and 266 mm for surface-mounting housing. All cables can be connected with or without ring lugs.

In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located in a sloped case at the top and bottom of the housing.

Protection functions

Overcurrent protection (ANSI 50, 50N, 51, 51V, 51N)

This function is based on the phase-selective measurement of the three phase currents and the ground current (four transformers). Three definite-time overcurrent protection elements (DMT) exist both for the phases and for the ground. The current threshold and the delay time can be set within a wide range. In addition, inverse-time overcurrent protection characteristics (IDMTL) can be activated.

The inverse-time function provides – as an option – voltage-restraint or voltage-controlled operating modes.

Available inverse-time characteristics

Characteristics acc. to	ANSI/IEEE	IEC 60255-3
Inverse	•	•
Short inverse	•	
Long inverse	•	•
Moderately inverse	•	
Very inverse	•	•
Extremely inverse	•	•

Reset characteristics

For easier time coordination with electromechanical relays, reset characteristics according to ANSI C37.112 and IEC 60255-3 / BS 142 standards are applied.

When using the reset characteristic (disk emulation), a reset process is initiated after the fault current has disappeared. This reset process corresponds to the reverse movement of the Ferraris disk of an electromechanical relay (thus: disk emulation).

User-definable characteristics

Instead of the predefined time characteristics according to ANSI, tripping characteristics can be defined by the user for phase and ground units separately. Up to 20 current/time value pairs may be programmed. They are set as pairs of numbers or graphically in DIGSI 4.

Inrush restraint

The relay features second harmonic restraint. If the second harmonic is detected during transformer energization, pickup of non-directional and directional normal elements are blocked.

Cold load pickup/dynamic setting change

For directional and non-directional overcurrent protection functions the initiation thresholds and tripping times can be switched via binary inputs or by time control.

Directional overcurrent protection (ANSI 67, 67N)

Directional phase and ground protection are separate functions. They operate in parallel to the non-directional overcurrent elements. Their pickup values and delay times can be set separately. Definite-time and inverse-time characteristics are offered. The tripping characteristic can be rotated about ± 180 degrees.

By means of voltage memory, directionality can be determined reliably even for close-in (local) faults. If the switching device closes onto a fault and the voltage is too low to determine direction, directionality (directional decision) is made with voltage from the voltage memory. If no voltage exists in the memory, tripping occurs according to the coordination schedule.

For ground protection, users can choose whether the direction is to be determined via zero-sequence system or negative-sequence system quantities (selectable). Using negative-sequence variables can be advantageous in cases where the zero voltage tends to be very low due to unfavorable zero-sequence impedances.

Directional comparison protection (cross-coupling)

It is used for selective protection of sections fed from two sources with instantaneous tripping, i.e. without the disadvantage of time coordination. The directional comparison protection is suitable if the distances between the protection stations are not significant and pilot wires are available for signal transmission. In addition to the directional comparison protection, the directional coordinated overcurrent protection is used for complete selective backup protection. If operated in a closed-circuit connection, an interruption of the transmission line is detected.

(Sensitive) directional ground-fault detection (ANSI 64, 67Ns, 67N)

For isolated-neutral and compensated networks, the direction of power flow in the zero sequence is calculated from the zero-sequence current I_0 and zero-sequence voltage V_0 .

For networks with an isolated neutral, the reactive current component is evaluated; for compensated networks, the active current component or residual resistive current is evaluated. For special network conditions, e.g. high-resistance grounded networks with ohmic-capacitive ground-fault current or low-resistance grounded networks with ohmic-inductive current, the tripping characteristics can be rotated approximately ± 45 degrees.

Two modes of ground-fault direction detection can be implemented: tripping or "signalling only mode".

It has the following functions:

- TRIP via the displacement voltage V_E .
- Two instantaneous elements or one instantaneous plus one user-defined characteristic.
- Each element can be set in forward, reverse, or non-directional.
- The function can also be operated in the insensitive mode as an additional short-circuit protection.

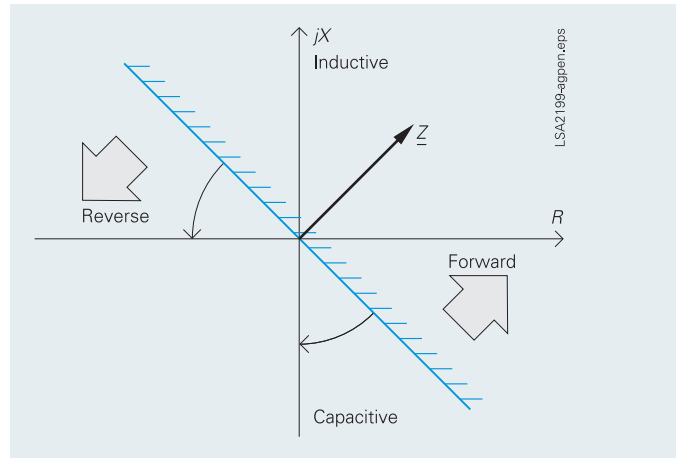


Fig. 5/80 Directional characteristic of the directional overcurrent protection

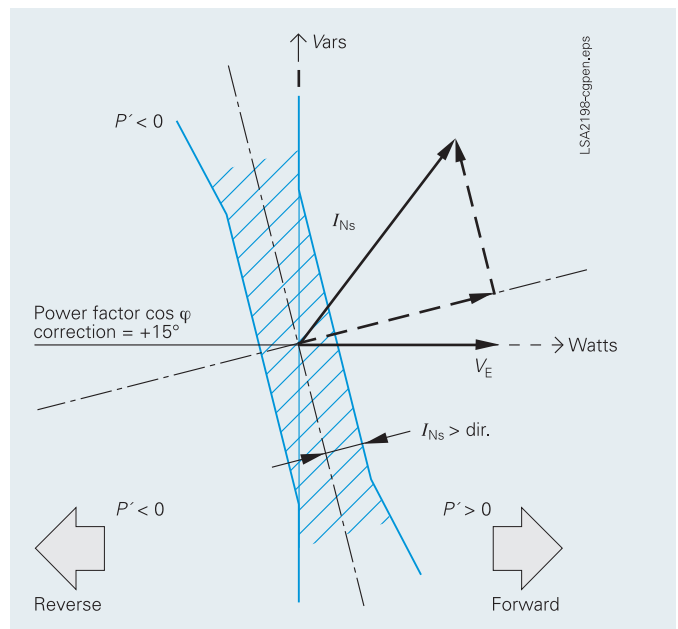


Fig. 5/81 Directional determination using cosine measurements for compensated networks

(Sensitive) ground-fault detection (ANSI 50Ns, 51Ns / 50N, 51N)

For high-resistance grounded networks, a sensitive input transformer is connected to a phase-balance neutral current transformer (also called core-balance CT).

The function can also be operated in the insensitive mode as an additional short-circuit protection.

Overcurrent Protection / 7SJ62

Protection functions

Intermittent ground-fault protection

Intermittent (re-striking) faults occur due to insulation weaknesses in cables or as a result of water penetrating cable joints. Such faults either simply cease at some stage or develop into lasting short-circuits. During intermittent activity, however, star-point resistors in networks that are impedance-grounded may undergo thermal overloading. The normal ground-fault protection cannot reliably detect and interrupt the current pulses, some of which can be very brief.

The selectivity required with intermittent ground faults is achieved by summing the duration of the individual pulses and by triggering when a (settable) summed time is reached. The response threshold I_{IE} evaluates the r.m.s. value, referred to one systems period.

Directional intermittent ground fault protection (ANSI 67Ns)

The directional intermittent ground fault protection has to detect intermittent ground faults in resonant grounded cable systems selectively. Intermittent ground faults in resonant grounded cable systems are usually characterized by the following properties:

- A very short high-current ground current pulse (up to several hundred amperes) with a duration of under 1 ms
- They are self-extinguishing and re-ignite within one halfperiod up to several periods, depending on the power system conditions and the fault characteristic.
- Over longer periods (many seconds to minutes), they can develop into static faults.

Such intermittent ground faults are frequently caused by weak insulation, e.g. due to decreased water resistance of old cables. Ground fault functions based on fundamental component measured values are primarily designed to detect static ground faults and do not always behave correctly in case of intermittent ground faults. The function described here evaluates specifically the ground current pulses and puts them into relation with the zero-sequence voltage to determine the direction.

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

In line protection, the two-element phase-balance current/negative-sequence protection permits detection on the high side of high-resistance phase-to-phase faults and phase-to-ground faults that are on the low side of a transformer (e.g. with the switch group Dy 5). This provides backup protection for high-resistance faults beyond the transformer.

Breaker failure protection (ANSI 50BF)

If a faulted portion of the electrical circuit is not disconnected upon issuance of a trip command, another command can be initiated using the breaker failure protection which operates the circuit-breaker, e.g. of an upstream (higher-level) protection relay. Breaker failure is detected if, after a trip command, current is still flowing in the faulted circuit. As an option, it is possible to make use of the circuit-breaker position indication.

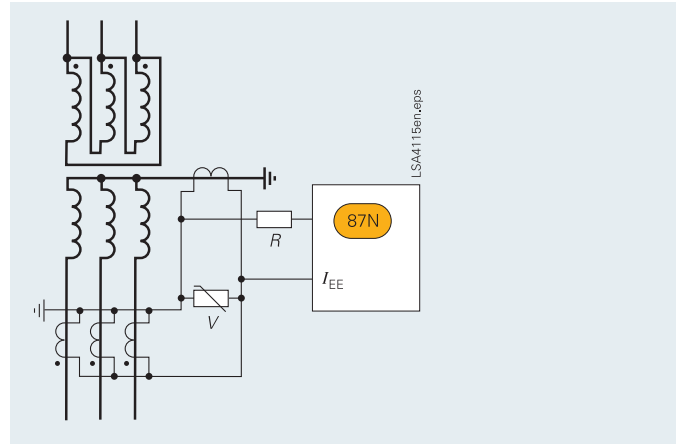


Fig. 5/82 High-impedance restricted ground-fault protection

High-impedance restricted ground-fault protection (ANSI 87N)

The high-impedance measurement principle is an uncomplicated and sensitive method for detecting ground faults, especially on transformers. It can also be applied to motors, generators and reactors when these are operated on a grounded network.

When the high-impedance measurement principle is applied, all current transformers in the protected area are connected in parallel and operated on one common resistor of relatively high R whose voltage is measured (see Fig. 5/82). In the case of 7SJ6 units, the voltage is measured by detecting the current through the (external) resistor R at the sensitive current measurement input I_{EE} . The varistor V serves to limit the voltage in the event of an internal fault. It cuts off the high momentary voltage spikes occurring at transformer saturation. At the same time, this results in smoothing of the voltage without any noteworthy reduction of the average value.

If no faults have occurred and in the event of external faults, the system is at equilibrium, and the voltage through the resistor is approximately zero. In the event of internal faults, an imbalance occurs which leads to a voltage and a current flow through the resistor R .

The current transformers must be of the same type and must at least offer a separate core for the high-impedance restricted ground-fault protection. They must in particular have the same transformation ratio and an approximately identical knee-point voltage. They should also demonstrate only minimal measuring errors.

Flexible protection functions

The 7SJ62 units enable the user to easily add on up to 20 protective functions. To this end, parameter definitions are used to link a standard protection logic with any chosen characteristic quantity (measured or derived quantity) (Fig. 5/83). The standard logic consists of the usual protection elements such as the pickup message, the parameter-definable delay time, the TRIP command, a blocking possibility, etc. The mode of operation for current, voltage, power and power factor quantities can be three-phase or single-phase. Almost all quantities can be operated as greater than or less than stages. All stages operate with protection priority.

Protection stages/functions attainable on the basis of the available characteristic quantities:

Function	ANSI No.
$I >, I_{\epsilon} >$	50, 50N
$V <, V >, V_{\epsilon} >, dV/dt$	27, 59, 59R, 64
$3I_0 >, I_1 >, I_2 >, I_2/I_1, 3V_0 >, V_1 >, V_2 >$	50N, 46, 59N, 47
$P >, Q >$	32
$\cos \varphi$ (p.f.) $>$	55
$f >$	81O, 81U
$df/dt >$	81R

For example, the following can be implemented:

- Reverse power protection (ANSI 32R)
- Rate-of-frequency-change protection (ANSI 81R)

Undervoltage-controlled reactive power protection (ANSI 27/Q)

The undervoltage-controlled reactive power protection protects the system for mains decoupling purposes. To prevent a voltage collapse in energy systems, the generating side, e.g. a generator, must be equipped with voltage and frequency protection devices. An undervoltage-controlled reactive power protection is required at the supply system connection point. It detects critical power system situations and ensures that the power generation facility is disconnected from the mains. Furthermore, it ensures that reconnection only takes place under stable power system conditions. The associated criteria can be parameterized.

Synchro-check (ANSI 25)

In case of switching ON the circuit-breaker, the units can check whether the two subnetworks are synchronized. Voltage-, frequency- and phase-angle-differences are being checked to determine whether synchronous conditions are existent.

Auto-reclosure (ANSI 79)

Multiple reclosures can be defined by the user and lockout will occur if a fault is present after the last reclosure. The following functions are possible:

- 3-pole ARC for all types of faults
- Separate settings for phase and ground faults
- Multiple ARC, one rapid auto-reclosure (RAR) and up to nine delayed auto-reclosures (DAR)

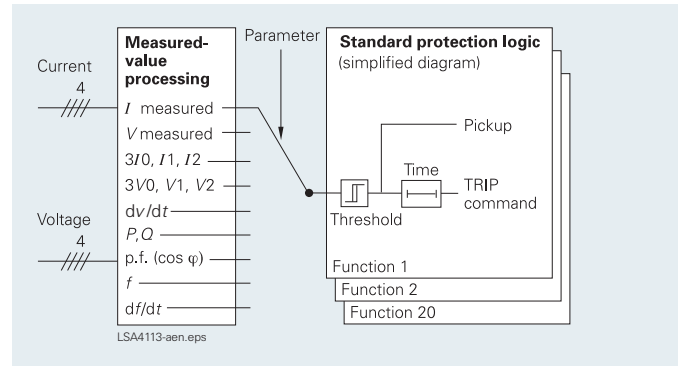


Fig. 5/83 Flexible protection functions

- Starting of the ARC depends on the trip command selection (e.g. 46, 50, 51, 67)
- Blocking option of the ARC via binary inputs
- ARC can be initiated externally or via CFC
- The directional and non-directional elements can either be blocked or operated non-delayed depending on the auto-reclosure cycle
- Dynamic setting change of the directional and non-directional elements can be activated depending on the ready AR

Thermal overload protection (ANSI 49)

For protecting cables and transformers, an overload protection with an integrated pre-warning element for temperature and current can be applied. The temperature is calculated using a thermal homogeneous-body model (according to IEC 60255-8), which takes account both of the energy entering the equipment and the energy losses. The calculated temperature is constantly adjusted accordingly. Thus, account is taken of the previous load and the load fluctuations.

For thermal protection of motors (especially the stator) a further time constant can be set so that the thermal ratios can be detected correctly while the motor is rotating and when it is stopped. The ambient temperature or the temperature of the coolant can be detected serially via an external temperature monitoring box (resistance-temperature detector box, also called RTD-box). The thermal replica of the overload function is automatically adapted to the ambient conditions. If there is no RTD-box it is assumed that the ambient temperatures are constant.

Settable dropout delay times

If the devices are used in parallel with electromechanical relays in networks with intermittent faults, the long dropout times of the electromechanical devices (several hundred milliseconds) can lead to problems in terms of time grading. Clean time grading is only possible if the dropout time is approximately the same. This is why the parameter of dropout times can be defined for certain functions such as time-over-current protection, ground short-circuit and phase-balance current protection.

Protection functions

■ Motor protection

Restart inhibit (ANSI 66/86)

If a motor is started up too many times in succession, the rotor can be subject to thermal overload, especially the upper edges of the bars. The rotor temperature is calculated from the stator current. The reclosing lockout only permits start-up of the motor if the rotor has sufficient thermal reserves for a complete start-up (see Fig. 5/84).

Emergency start-up

This function disables the reclosing lockout via a binary input by storing the state of the thermal replica as long as the binary input is active. It is also possible to reset the thermal replica to zero.

Temperature monitoring (ANSI 38)

Up to two temperature monitoring boxes with a total of 12 measuring sensors can be used for temperature monitoring and detection by the protection relay. The thermal status of motors, generators and transformers can be monitored with this device. Additionally, the temperature of the bearings of rotating machines are monitored for limit value violation. The temperatures are being measured with the help of temperature detectors at various locations of the device to be protected. This data is transmitted to the protection relay via one or two temperature monitoring boxes (see "Accessories", page 5/115).

Starting time supervision (ANSI 48/14)

Starting time supervision protects the motor against long unwanted start-ups that might occur in the event of excessive load torque or excessive voltage drops within the motor, or if the rotor is locked. Rotor temperature is calculated from measured stator current. The tripping time is calculated according to the following equation:

for $I > I_{\text{MOTOR START}}$

$$t = \left(\frac{I_A}{I} \right)^2 \cdot T_A$$

I = Actual current flowing

$I_{\text{MOTOR START}}$ = Pickup current to detect a motor start

t = Tripping time

I_A = Rated motor starting current

T_A = Tripping time at rated motor starting current
(2 times, for warm and cold motor)

The characteristic (equation) can be adapted optimally to the state of the motor by applying different tripping times T_A in dependence of either cold or warm motor state. For differentiation of the motor state the thermal model of the rotor is applied.

If the trip time is rated according to the above formula, even a prolonged start-up and reduced voltage (and reduced start-up current) will be evaluated correctly. The tripping time is inverse (current dependent).

A binary signal is set by a speed sensor to detect a blocked rotor. An instantaneous tripping is effected.

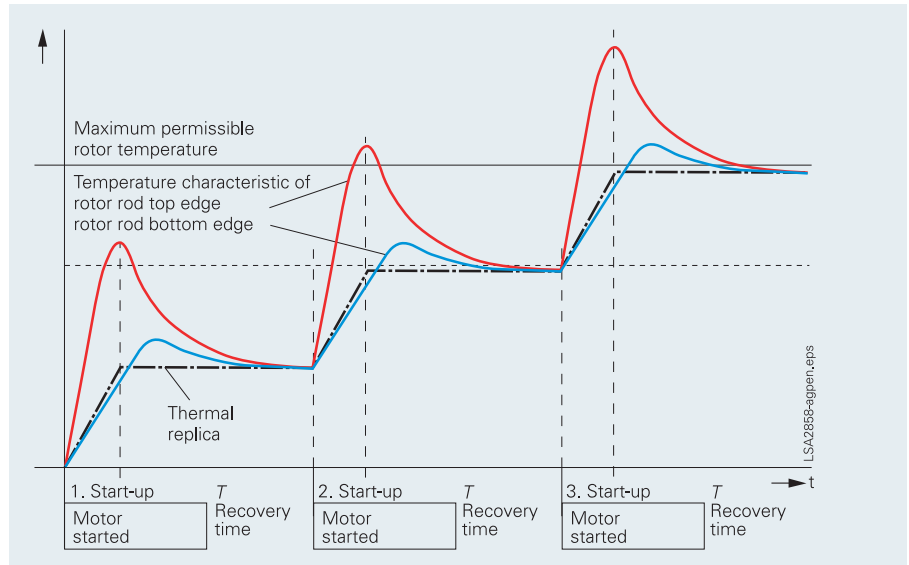


Fig. 5/84

Load jam protection (ANSI 51M)

Sudden high loads can cause slowing down and blocking of the motor and mechanical damages. The rise of current due to a load jam is being monitored by this function (alarm and tripping).

The overload protection function is too slow and therefore not suitable under these circumstances.

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

The negative-sequence / phase-balance current protection detects a phase failure or load unbalance due to network asymmetry and protects the rotor from impermissible temperature rise.

Undercurrent monitoring (ANSI 37)

With this function, a sudden drop in current, which can occur due to a reduced motor load, is detected. This may be due to shaft breakage, no-load operation of pumps or fan failure.

Motor statistics

Essential information on start-up of the motor (duration, current, voltage) and general information on number of starts, total operating time, total down time, etc. are saved as statistics in the device.

■ Voltage protection

Overvoltage protection (ANSI 59)

The two-element overvoltage protection detects unwanted network and machine overvoltage conditions. The function can operate either with phase-to-phase, phase-to-ground, positive phase-sequence or negative phase-sequence system voltage. Three-phase and single-phase connections are possible.

Undervoltage protection (ANSI 27)

The two-element undervoltage protection provides protection against dangerous voltage drops (especially for electric machines). Applications include the isolation of generators or motors from the network to avoid undesired operating states and a possible loss of stability. Proper operating conditions of electrical machines are best evaluated with the positive-sequence quantities. The protection function is active over a

wide frequency range (45 to 55, 55 to 65 Hz)¹⁾. Even when falling below this frequency range the function continues to work, however, with a greater tolerance band.

The function can operate either with phase-to-phase, phase-to-ground or positive phase-sequence voltage and can be monitored with a current criterion. Three-phase and single-phase connections are possible.

Frequency protection (ANSI 81O/U)

Frequency protection can be used for over-frequency and under-frequency protection. Electric machines and parts of the system are protected from unwanted speed deviations. Unwanted frequency changes in the network can be detected and the load can be removed at a specified frequency setting.

Frequency protection can be used over a wide frequency range (40 to 60, 50 to 70 Hz)¹⁾. There are four elements (selectable as overfrequency or underfrequency) and each element can be delayed separately. Blocking of the frequency protection can be performed if using a binary input or by using an undervoltage element.

Fault locator (ANSI 21FL)

The integrated fault locator calculates the fault impedance and the distance-to-fault. The results are displayed in Ω , kilometers (miles) and in percent of the line length.

Circuit-breaker wear monitoring

Methods for determining circuit-breaker contact wear or the remaining service life of a circuit-breaker (CB) allow CB maintenance intervals to be aligned to their actual degree of wear. The benefit lies in reduced maintenance costs.

There is no mathematically exact method of calculating the wear or the remaining service life of circuit-breakers that takes into account the arc-chamber's physical conditions when the CB opens. This is why various methods of determining CB wear have evolved which reflect the different operator philosophies. To do justice to these, the devices offer several methods:

- ΣI
- ΣI^x , with $x = 1 \dots 3$
- Σi^2t

The devices additionally offer a new method for determining the remaining service life:

- Two-point method

The CB manufacturers double-logarithmic switching cycle diagram (see Fig. 5/85) and the breaking current at the time of contact opening serve as the basis for this method. After CB opening, the two-point method calculates the number of still possible switching cycles. To this end, the two points P1 and P2 only have to be set on the device. These are specified in the CB's technical data.

All of these methods are phase-selective and a limit value can be set in order to obtain an alarm if the actual value falls below or exceeds the limit value during determination of the remaining service life.

Customized functions (ANSI 32, 51V, 55, etc.)

Additional functions, which are not time critical, can be implemented via the CFC using measured values. Typical functions include reverse power, voltage controlled overcurrent, phase angle detection, and zero-sequence voltage detection.

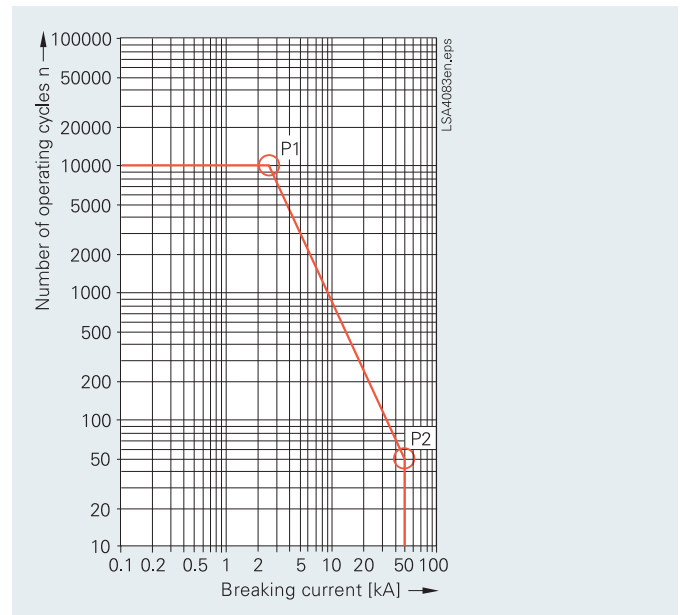


Fig. 5/85 CB switching cycle diagram

Commissioning

Commissioning could hardly be easier and is fully supported by DIGSI 4. The status of the binary inputs can be read individually and the state of the binary outputs can be set individually. The operation of switching elements (circuit-breakers, disconnect devices) can be checked using the switching functions of the bay controller. The analog measured values are represented as wide-ranging operational measured values. To prevent transmission of information to the control center during maintenance, the bay controller communications can be disabled to prevent unnecessary data from being transmitted. During commissioning, all indications with test marking for test purposes can be connected to a control and protection system.

Test operation

During commissioning, all indications can be passed to an automatic control system for test purposes.

Control and automatic functions

Control

In addition to the protection functions, the SIPROTEC 4 units also support all control and monitoring functions that are required for operating medium-voltage or high-voltage substations.

The main application is reliable control of switching and other processes.

The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated to the 7SJ62 via binary inputs. Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a fault or intermediate circuit-breaker or auxiliary contact position.

The switchgear or circuit-breaker can be controlled via:

- integrated operator panel
- binary inputs
- substation control and protection system
- DIGSI 4

1) The 45 to 55, 55 to 65 Hz range is available for $f_N = 50/60$ Hz.

Overcurrent Protection / 7SJ62

Functions

Automation/user-defined logic

With integrated logic, the user can set, via a graphic interface (CFC), specific functions for the automation of switchgear or substation. Functions are activated via function keys, binary input or via communication interface.

Switching authority

Switching authority is determined according to parameters and communication.

If a source is set to "LOCAL", only local switching operations are possible. The following sequence of switching authority is laid down: "LOCAL"; DIGSI PC program, "REMOTE".

Command processing

All the functionality of command processing is offered. This includes the processing of single and double commands with or without feedback, sophisticated monitoring of the control hardware and software, checking of the external process, control actions using functions such as runtime monitoring and automatic command termination after output. Here are some typical applications:

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable bay interlocks
- Operating sequences combining several switching operations such as control of circuit-breakers, disconnectors and grounding switches
- Triggering of switching operations, indications or alarm by combination with existing information

Assignment of feedback to command

The positions of the circuit-breaker or switching devices and transformer taps are acquired by feedback. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication change is a consequence of switching operation or whether it is a spontaneous change of state.

Chatter disable

Chatter disable feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

Indication filtering and delay

Binary indications can be filtered or delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time. In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

A further indication (or a command) can be derived from an existing indication. Group indications can also be formed. The volume of information to the system interface can thus be reduced and restricted to the most important signals.



Fig. 5/86 NXAIR panel (air-insulated)

Switchgear cubicles for high/medium voltage

All units are designed specifically to meet the requirements of high/medium-voltage applications.

In general, no separate measuring instruments (e.g., for current, voltage, frequency, ...) or additional control components are necessary.

Measured values

The r.m.s. values are calculated from the acquired current and voltage along with the power factor, frequency, active and reactive power. The following functions are available for measured value processing:

- Currents I_{L1} , I_{L2} , I_{L3} , I_E , I_{EE} (67Ns)
- Voltages V_{L1} , V_{L2} , V_{L3} , V_{L1L2} , V_{L2L3} , V_{L3L1}
- Symmetrical components I_1 , I_2 , $3I_0$; V_1 , V_2 , V_0
- Power Watts, Vars, VA/P , Q , S (P , Q : total and phase selective)
- Power factor ($\cos \varphi$), (total and phase selective)
- Frequency
- Energy \pm kWh, \pm kVarh, forward and reverse power flow
- Mean as well as minimum and maximum current and voltage values
- Operating hours counter
- Mean operating temperature of overload function
- Limit value monitoring
Limit values are monitored using programmable logic in the CFC. Commands can be derived from this limit value indication.
- Zero suppression
In a certain range of very low measured values, the value is set to zero to suppress interference.

Communication

In terms of communication, the units offer substantial flexibility in the context of connection to industrial and power automation standards. Communication can be extended or added on thanks to modules for retrofitting on which the common protocols run. Therefore, also in the future it will be possible to optimally integrate units into the changing communication infrastructure, for example in Ethernet networks (which will also be used increasingly in the power supply sector in the years to come).

Serial front interface

There is a serial RS232 interface on the front of all the units. All of the unit's functions can be set on a PC by means of the DIGSI 4 protection operation program. Commissioning tools and fault analysis are also built into the program and are available through this interface.

Rear-mounted interfaces¹⁾

A number of communication modules suitable for various applications can be fitted in the rear of the flush-mounting housing. In the flush-mounting housing, the modules can be easily replaced by the user. The interface modules support the following applications:

- Time synchronization interface
All units feature a permanently integrated electrical time synchronization interface. It can be used to feed timing telegrams in IRIG-B or DCF77 format into the units via time synchronization receivers.
- System interface
Communication with a central control system takes place through this interface. Radial or ring type station bus topologies can be configured depending on the chosen interface. Furthermore, the units can exchange data through this interface via Ethernet and IEC 61850 protocol and can also be operated by DIGSI.
- Service interface
The service interface was conceived for remote access to a number of protection units via DIGSI. On all units, it can be an electrical RS232/RS485 or an optical interface. For special applications, a maximum of two temperature monitoring boxes (RTD-box) can be connected to this interface as an alternative.

System interface protocols (retrofittable)

IEC 61850 protocol

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens was the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus is also possible with DIGSI.

IEC 60870-5-103 protocol

The IEC 60870-5-103 protocol is an international standard for the transmission of protective data and fault recordings. All messages from the unit and also control commands can be transferred by means of published, Siemens-specific extensions to the protocol.

1) For units in panel surface-mounting housings please refer to note on page 5/114.

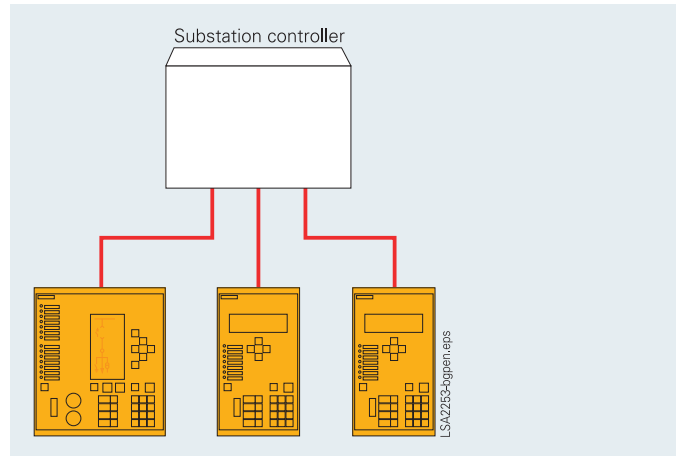


Fig. 5/87 IEC 60870-5-103: Radial fiber-optic connection

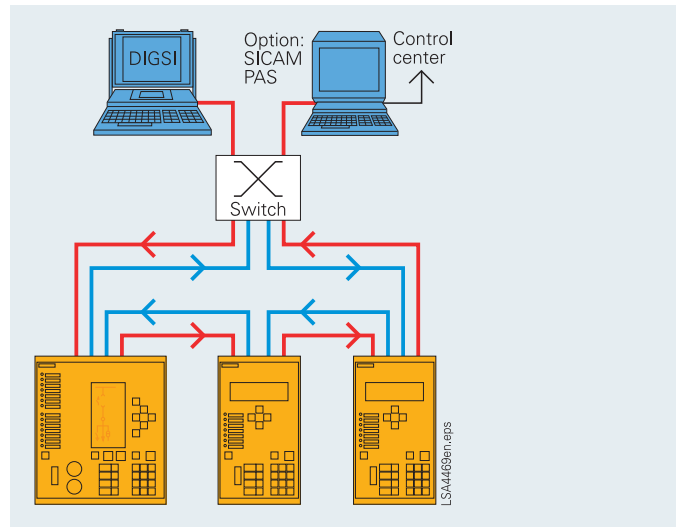


Fig. 5/88 Bus structure for station bus with Ethernet and IEC 61850, fiber-optic ring

Redundant solutions are also possible. Optionally it is possible to read out and alter individual parameters (only possible with the redundant module).

PROFIBUS-DP protocol

PROFIBUS-DP is the most widespread protocol in industrial automation. Via PROFIBUS-DP, SIPROTEC units make their information available to a SIMATIC controller or, in the control direction, receive commands from a central SIMATIC. Measured values can also be transferred.

MODBUS RTU protocol

This uncomplicated, serial protocol is mainly used in industry and by power supply corporations, and is supported by a number of unit manufacturers. SIPROTEC units function as MODBUS slaves, making their information available to a master or receiving information from it. A time-stamped event list is available.

Overcurrent Protection / 7SJ62

Communication

PROFINET

PROFINET is the ethernet-based successor of Profi bus DP and is supported in the variant PROFINET IO. The protocol which is used in industry together with the SIMATIC systems control is realized on the optical and electrical Plus ethernet modules which are delivered since November 2012. All network redundancy procedures which are available for the ethernet modules, such as RSTP, PRP or HSR, are also available for PROFINET. The time synchronization is made via SNTP. The network monitoring is possible via SNMP V2 where special MIB files exist for PROFINET. The LLDP protocol of the device also supports the monitoring of the network topology. Single-point indications, double-point indications, measured and metered values can be transmitted cyclically in the monitoring direction via the protocol and can be selected by the user with DIGSI 4. Important events are also transmitted spontaneously via configurable process alarms. Switching commands can be executed by the system control via the device in the controlling direction. The PROFINET implementation is certified. The device also supports the IEC 61850 protocol as a server on the same ethernet module in addition to the PROFINET protocol. Client server connections are possible for the intercommunication between devices, e.g. for transmitting fault records and GOOSE messages.

DNP 3.0 protocol

Power utilities use the serial DNP 3.0 (Distributed Network Protocol) for the station and network control levels. SIPROTEC units function as DNP slaves, supplying their information to a master system or receiving information from it.

DNP3 TCP

The ethernet-based TCP variant of the DNP3 protocol is supported with the electrical and optical ethernet module. Two DNP3 TCP clients are supported. Redundant ring structures can be realized for DNP3 TCP with the help of the integrated switch in the module. For instance, a redundant optical ethernet ring can be constructed. Single-point indications, double-point indications, measured and metered values can be configured with DIGSI 4 and are transmitted to the DNPI client. Switching commands can be executed in the controlling direction. Fault records of the device are stored in the binary Comtrade format and can be retrieved via the DNP 3 file transfer. The time synchronization is performed via the DNPI client or SNTP. The device can also be integrated into a network monitoring system via the SNMP V2 protocol. Parallel to the DNP3 TCP protocol the IEC 61850 protocol (the device works as a server) and the GOOSE messages of the IEC 61850 are available for the intercommunication between devices.

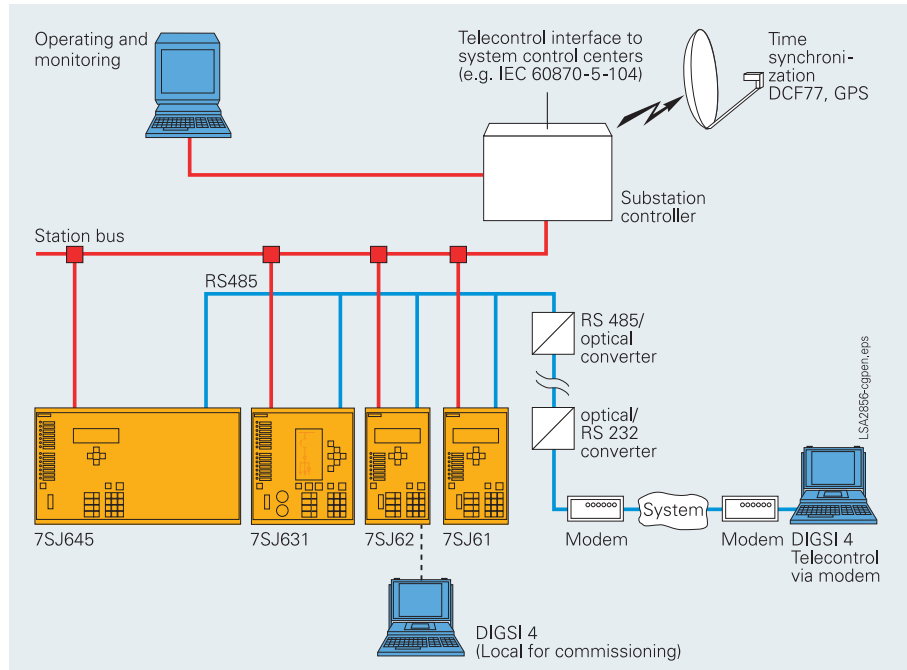


Fig. 5/89 System solution/communication

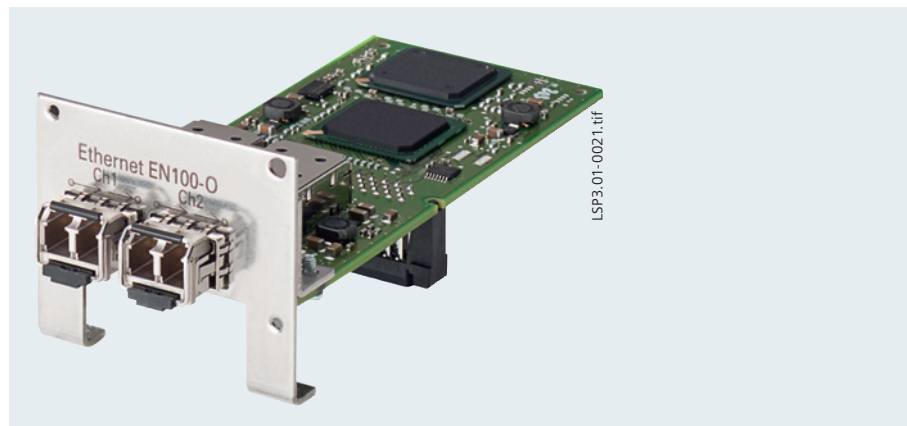


Fig. 5/90 Optical Ethernet communication module for IEC 61850 with integrated Ethernet-switch

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system.

Units featuring IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 5/87).

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to optoelectrical converters. Thus, the RS485 bus allows low-cost wiring

in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 5/88).

Typical connections

■ Connection of current and voltage transformers

Standard connection

For grounded networks, the ground current is obtained from the phase currents by the residual current circuit.



Fig. 5/91 Residual current circuit without directional element

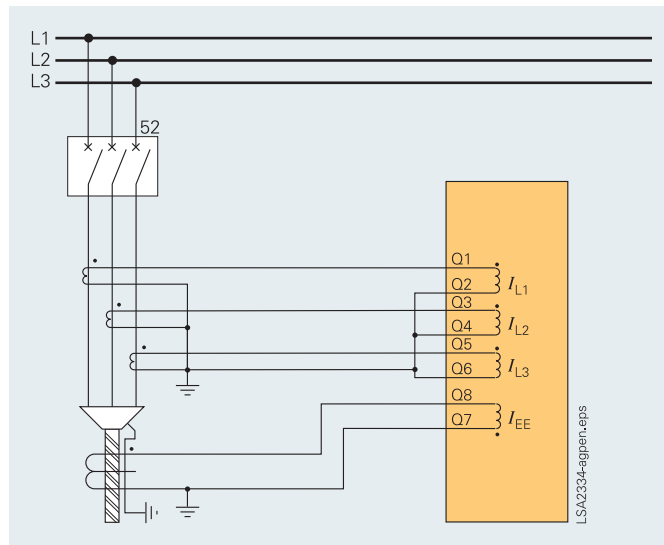


Fig. 5/92 Sensitive ground-current detection without directional element

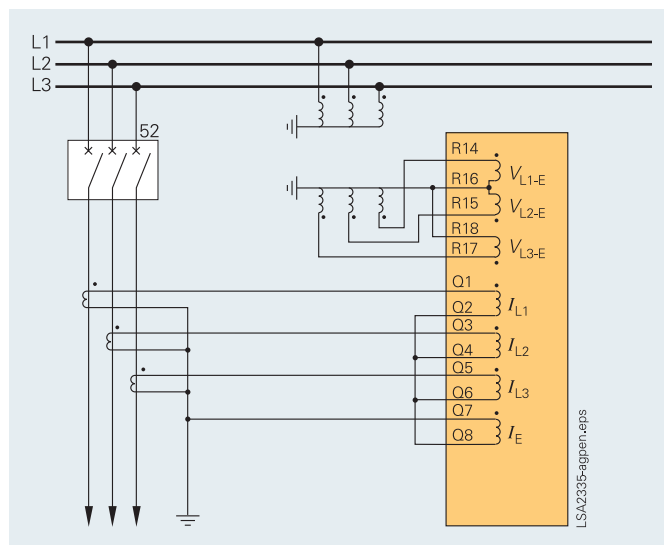


Fig. 5/93 Residual current circuit with directional element

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Typical connections

Connection for compensated networks

The figure shows the connection of two phase-to-ground voltages and the V_E voltage of the open delta winding and a phase-balance neutral current transformer for the ground current. This connection maintains maximum precision for directional ground-fault detection and must be used in compensated networks. Fig. 5/94 shows sensitive directional ground-fault detection.

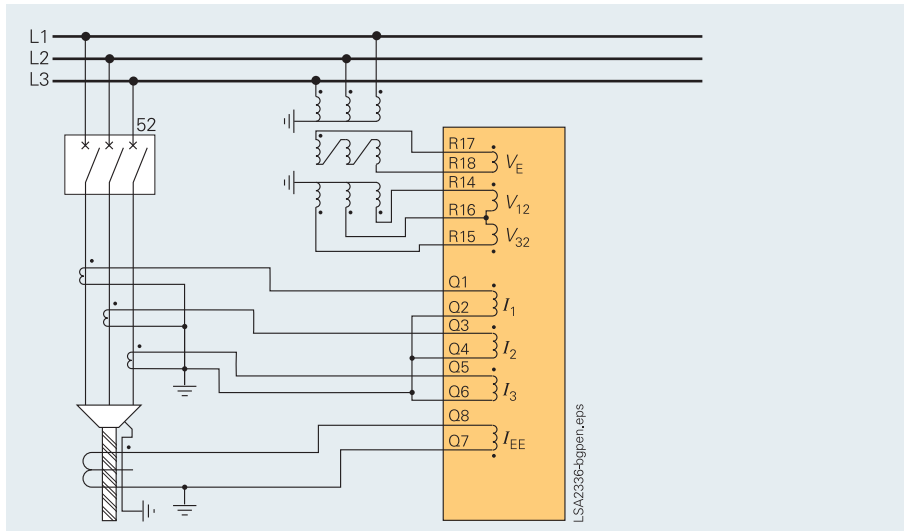


Fig. 5/94 Sensitive directional ground-fault detection with directional element for phases

Connection for isolated-neutral or compensated networks only

If directional ground-fault protection is not used, the connection can be made with only two phase current transformers. Directional phase short-circuit protection can be achieved by using only two primary transformers.

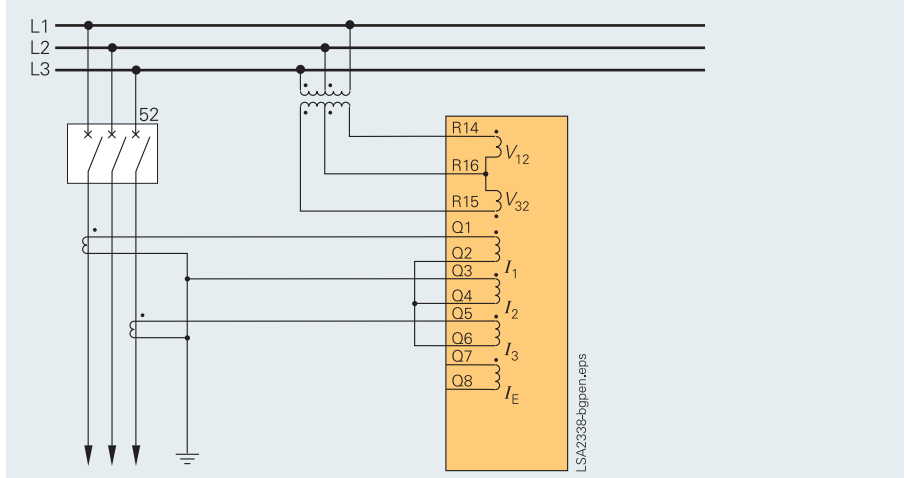


Fig. 5/95 Isolated-neutral or compensated networks

Connection for the synchro-check function

The 3-phase system is connected as reference voltage, i. e. the outgoing voltages as well as a single-phase voltage, in this case a busbar voltage, that has to be checked for synchronism.

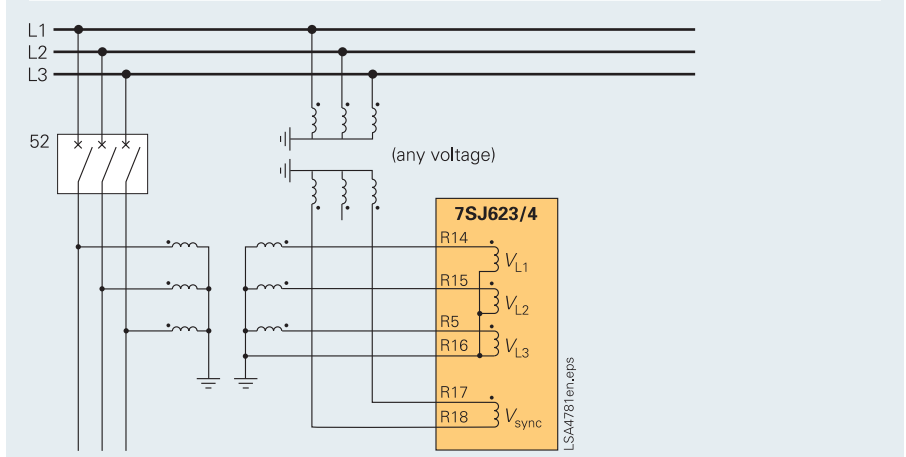


Fig. 5/96 Measuring of the busbar voltage and the outgoing feeder voltage for the synchro-check

Overview of connection types			
Type of network	Function	Current connection	Voltage connection
(Low-resistance) grounded network	Overcurrent protection phase/ground non-directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformer possible	–
(Low-resistance) grounded networks	Sensitive ground-fault protection	Phase-balance neutral current transformers required	–
Isolated or compensated networks	Overcurrent protection phases non-directional	Residual circuit, with 3 or 2 phase current transformers possible	–
(Low-resistance) grounded networks	Overcurrent protection phases directional	Residual circuit, with 3 phase-current transformers possible	Phase-to-ground connection or phase-to-phase connection
Isolated or compensated networks	Overcurrent protection phases directional	Residual circuit, with 3 or 2 phase-current transformers possible	Phase-to-ground connection or phase-to-phase connection
(Low-resistance) grounded networks	Overcurrent protection ground directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformers possible	Phase-to-ground connection required
Isolated networks	Sensitive ground-fault protection	Residual circuit, if ground current $> 0.05 I_N$ on secondary side, otherwise phase-balance neutral current transformers required	3 times phase-to-ground connection or phase-to-ground connection with open delta winding
Compensated networks	Sensitive ground-fault protection $\cos \varphi$ measurement	Phase-balance neutral current transformers required	Phase-to-ground connection with open delta winding required

Typical applications

■ Connection of circuit-breaker

Undervoltage releases

Undervoltage releases are used for automatic tripping of high-voltage motors.

Example:

DC supply voltage of control system fails and manual electric tripping is no longer possible.

Automatic tripping takes place when voltage across the coil drops below the trip limit. In Fig. 5/97, tripping occurs due to failure of DC supply voltage, by automatic opening of the live status contact upon failure of the protection unit or by short-circuiting the trip coil in event of network fault.

In Fig. 5/98 tripping is by failure of auxiliary voltage and by interruption of tripping circuit in the event of network failure. Upon failure of the protection unit, the tripping circuit is also interrupted, since contact held by internal logic drops back into open position.

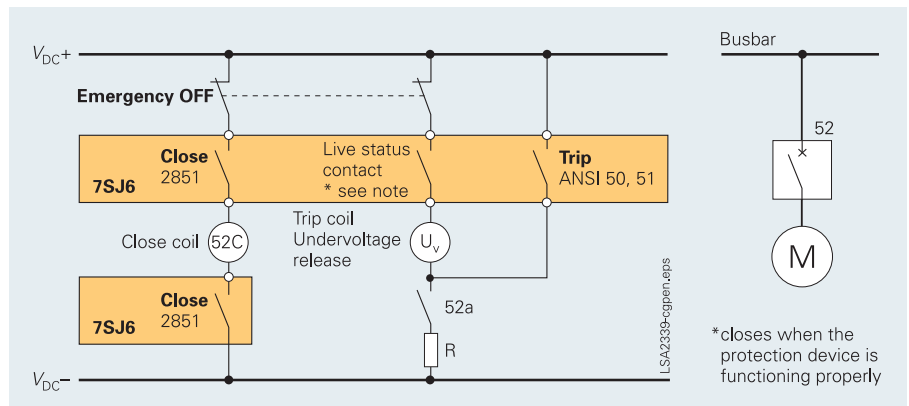


Fig. 5/97 Undervoltage release with make contact (50, 51)

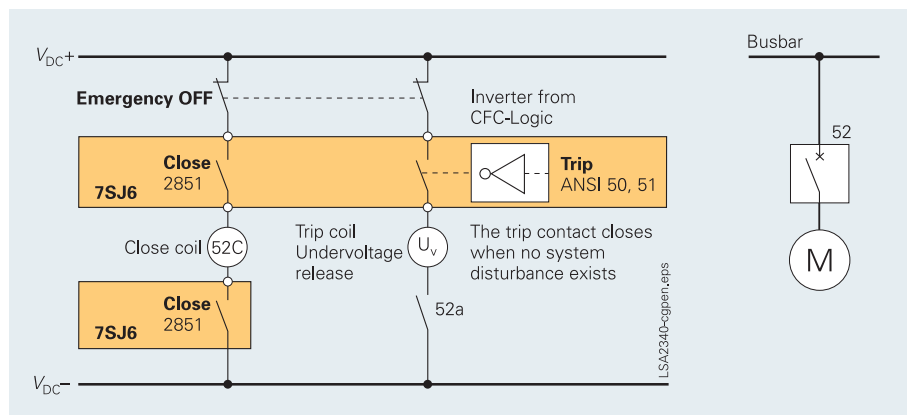


Fig. 5/98 Undervoltage trip with locking contact (trip signal 50 is inverted)

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Typical applications

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal occurs whenever the circuit is interrupted.

Lockout (ANSI 86)

All binary outputs can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only occur after the lockout state is reset.

Reverse-power protection for dual supply (ANSI 32R)

If power is fed to a busbar through two parallel infeeds, then in the event of any fault on one of the infeeds it should be selectively interrupted. This ensures a continued supply to the busbar through the remaining infeed. For this purpose, directional devices are needed which detect a short-circuit current or a power flow from the busbar in the direction of the infeed. The directional overcurrent protection is usually set via the load current. It cannot be used to deactivate low-current faults. Reverse-power protection can be set far below the rated power. This ensures that it also detects power feedback into the line in the event of low-current faults with levels far below the load current.

Reverse-power protection is performed via the "flexible protection functions" of the 7SJ62.

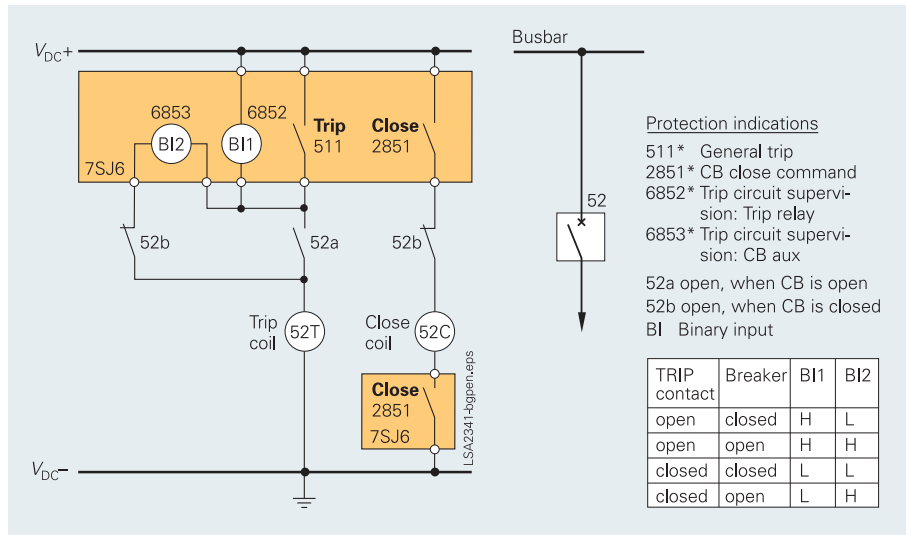


Fig. 5/99 Trip circuit supervision with 2 binary inputs

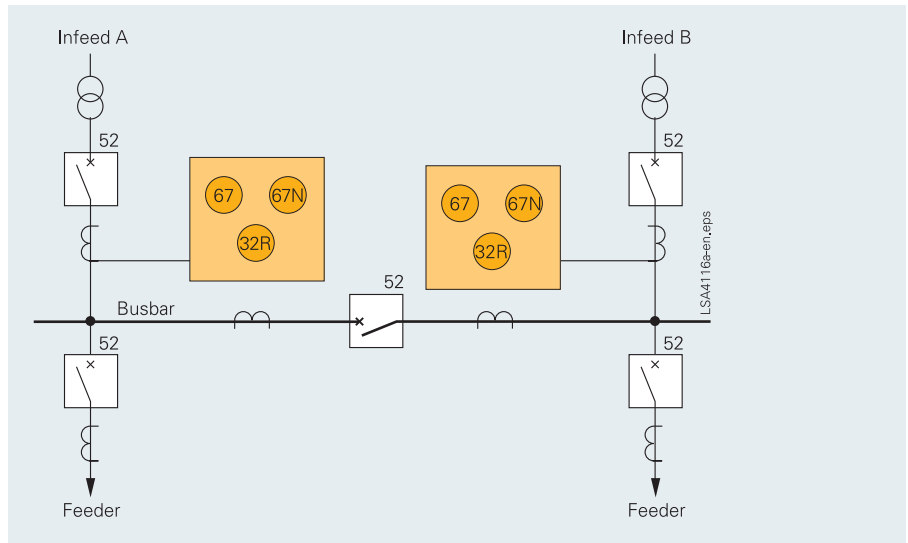


Fig. 5/100 Reverse-power protection for dual supply

General unit data	
<i>Measuring circuits</i>	
System frequency	50 / 60 Hz (settable)
<i>Current transformer</i>	
Rated current I_{nom}	1 or 5 A (settable)
Option: sensitive ground-fault CT	$I_{EE} < 1.6$ A
Power consumption	
at $I_{nom} = 1$ A	Approx. 0.05 VA per phase
at $I_{nom} = 5$ A	Approx. 0.3 VA per phase
for sensitive ground-fault CT at 1 A	Approx. 0.05 VA
Overload capability	
Thermal (effective)	500 A for 1 s 150 A for 10 s 20 A continuous
Dynamic (impulse current)	$250 \times I_{nom}$ (half cycle)
Overload capability if equipped with sensitive ground-fault CT	
Thermal (effective)	300 A for 1 s 100 A for 10 s 15 A continuous
Dynamic (impulse current)	750 A (half cycle)
<i>Voltage transformer</i>	
Type	7SJ621, 7SJ623, 7SJ625 7SJ622, 7SJ624, 7SJ626
Number	3 4 4
Rated voltage V_{nom}	100 V to 225 V
Measuring range	0 V to 170 V
Power consumption at $V_{nom} = 100$ V	< 0.3 VA per phase
Overload capability in voltage path (phase-neutral voltage)	
Thermal (effective)	230 V continuous
<i>Auxiliary voltage</i>	
Rated auxiliary voltage Vaux	DC 24/48 V 60/125 V 110/250 V AC 115/230 V
Permissible tolerance	DC 19-58 V 48-150 V 88-300 V AC 92-138 V 184-265 V
Ripple voltage, peak-to-peak	≤ 12 %
Power consumption	
Quiescent	Approx. 4 W
Energized	Approx. 7 W
Backup time during loss/short circuit of auxiliary voltage	≥ 50 ms at $V \geq$ DC 110 V ≥ 20 ms at $V \geq$ DC 24 V ≥ 200 ms at 115 V / AC 230 V
<i>Binary inputs/indication inputs</i>	
Type	7SJ621, 7SJ623, 7SJ625, 7SJ622, 7SJ624, 7SJ626
Number	8 11
Voltage range	DC 24-250 V
Pickup threshold modifiable by plug-in jumpers	
Pickup threshold	DC 19 V
For rated control voltage	24/48/60/110/125 V 110/125/DC 220/250 V
Response time/drop-out time	Approx. 3.5
Power consumption energized	1.8 mA (independent of operating voltage)

Binary outputs/command outputs	
Type	7SJ621, 7SJ622 7SJ623, 7SJ624 7SJ625, 7SJ626
Command/indication relay	8 6
Contacts per command/indication relay	1 NO / form A (Two contacts changeable to NC/form B, via jumpers)
Live status contact	1 NO / NC (jumper) / form A/B
Switching capacity	
Make	1000 W / VA
Break	30 W / VA / 40 W resistive / 25 W at $L/R \leq 50$ ms ≤ DC 250 V
Switching voltage	5 A continuous,
Permissible current	30 A for 0.5 s making current, 2000 switching cycles

Electrical tests	
<i>Specification</i>	
Standards	IEC 60255 ANSI C37.90, C37.90.1, C37.90.2, UL508

Insulation tests	
Standards	IEC 60255-5; ANSI/IEEE C37.90.0
Voltage test (100 % test) all circuits except for auxiliary voltage and RS485/RS232 and time synchronization	2.5 kV (r.m.s. value), 50/60 Hz
Auxiliary voltage	DC 3.5 kV
Communication ports and time synchronization	AC 500 V
Impulse voltage test (type test) all circuits, except communication ports and time synchronization, class III	5 kV (peak value); 1.2/50 μs; 0.5 J 3 positive and 3 negative impulses at intervals of 5 s

EMC tests for interference immunity; type tests	
Standards	IEC 60255-6; IEC 60255-22 (product standard) EN 50082-2 (generic specification) DIN 57435 Part 303
High-frequency test IEC 60255-22-1, class III and VDE 0435 Part 303, class III	2.5 kV (peak value); 1 MHz; $\tau = 15$ ms; 400 surges per s; test duration 2 s
Electrostatic discharge IEC 60255-22-2 class IV and EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air gap discharge; both polarities; 150 pF; $R_i = 330 \Omega$
Irradiation with radio-frequency field, non-modulated IEC 60255-22-3 (Report) class III	10 V/m; 27 to 500 MHz
Irradiation with radio-frequency field, amplitude-modulated IEC 61000-4-3; class III	10 V/m, 80 to 1000 MHz; AM 80 %; 1 kHz
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204; class III	10 V/m, 900 MHz; repetition rate 200 Hz, on duration 50 %
Fast transient interference/burst IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50 \Omega$; test duration 1 min

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EMC tests for interference immunity; type tests (cont'd)	
High-energy surge voltages (Surge) IEC 61000-4-5; class III Auxiliary voltage	From circuit to circuit: 2 kV; 12 Ω; 9 μF across contacts: 1 kV; 2 Ω; 18 μF
Binary inputs/outputs	From circuit to circuit: 2 kV; 42 Ω; 0.5 μF across contacts: 1 kV; 42 Ω; 0.5 μF
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; AM 80 %; 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m; 50 Hz, continuous 300 A/m; 50 Hz, 3 s 0.5 mT, 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak value), 1 to 1.5 MHz damped wave; 50 surges per s; duration 2 s, $R_i = 150$ to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per s both polarities; duration 2 s, $R_i = 80$ Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz; amplitude and pulse-modulated
Damped wave IEC 60694 / IEC 61000-4-12	2.5 kV (peak value, polarity alternating) 100 kHz, 1 MHz, 10 and 50 MHz, $R_i = 200$ Ω
EMC tests for interference emission; type tests	
Standard	EN 50081-* (generic specification)
Conducted interferences only auxiliary voltage IEC/CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC/CISPR 11	30 to 1000 MHz Limit class B
Units with a detached operator panel must be installed in a metal cubicle to maintain limit class B	

Mechanical stress tests	
Vibration, shock stress and seismic vibration	
During operation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz; ± 0.075 mm amplitude; 60 to 150 Hz; 1 g acceleration frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 5 g, duration 11 ms; 3 shocks in both directions of 3 axes
Seismic vibration IEC 60255-21-3, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 g acceleration (horizontal axis) 8 to 35 Hz: 0.5 g acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 perpendicular axe

During transportation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz; 2 g acceleration, frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, Class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 15 g, duration 11 ms 3 shocks in both directions of 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Semi-sinusoidal Acceleration 10 g, duration 16 ms 1000 shocks in both directions of 3 axes

Climatic stress tests	
Temperatures	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C / -13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	-20 °C to +70 °C / -4 °F to -158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C / +131 °F)	-5 °C to +55 °C / +25 °F to +131 °F
- Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to +131 °F
- Limiting temperature during transport	-25 °C to +70 °C / -13 °F to +158 °F
Humidity	
Permissible humidity It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average 75 % relative humidity; on 56 days a year up to 95 % relative humidity; condensation not permissible!

Unit design	
Housing	7XP20
Dimensions	See dimension drawings, part 14
Weight	
Surface-mounting housing	4.5 kg
Flush-mounting housing	4.0 kg
Degree of protection acc. to EN 60529	
Surface-mounting housing	IP 51
Flush-mounting housing	Front: IP 51, rear: IP 20;
Operator safety	IP 2x with cover

Serial interfaces	
<i>Operating interface (front of unit)</i>	
Connection	Non-isolated, RS232; front panel, 9-pin subminiature connector
Transmission rate	Factory setting 115200 baud, min. 4800 baud, max. 115200 baud
<i>Service/modem interface (rear of unit)</i>	
Isolated interface for data transfer	Port C: DIGSI 4/modem/RTD-box
Transmission rate	Factory setting 38400 baud, min. 4800 baud, max. 115200 baud
<u>RS232/RS485</u>	
Connection	9-pin subminiature connector, mounting location "C"
For flush-mounting housing/ surface-mounting housing with detached operator panel	
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	15 m /49.2 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	AC 500 V against ground
<i>System interface (rear of unit)</i>	
<i>IEC 60870-5-103 protocol</i>	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Factory setting 9600 baud, min. 1200 baud, max. 115200 baud
<u>RS232/RS485</u>	
Connection	Mounting location "B"
For flush-mounting housing/ surface-mounting housing with detached operator panel	
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	Max. 15 m/49 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	AC 500 V against ground
<u>Fiber optic</u>	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles
<i>IEC 60870-5-103 protocol, redundant</i>	
<u>RS485</u>	
Connection	Mounting location "B"
For flush-mounting housing/ surface-mounting housing with detached operator panel	
For surface-mounting housing with two-tier terminal on the top/bottom part	(not available)
Distance RS485	Max. 1 km/3300 ft
Test voltage	AC 500 V against ground

<i>Ethernet (EN 100) for DIGSI, IEC 61850, DNP3 TCP, PROFINET</i>	
<u>Electrical</u>	
Connection for flush-mounted casing	rear panel, mounting location "B" 2 x RJ45 socket contact 100BaseT acc. to IEEE802.3
Connection for surface-mounted casing	in console housing at case bottom
Test voltage (reg. socket)	500 V; 50 Hz
Transmission speed	100 Mbit/s
Bridgeable distance	65.62 feet (200 m)
<u>Optical</u>	
Connection for flush-mounted case	rear panel, slot position "B", duplex LC, 100BaseT acc. to IEEE802.3
Connection for surface-mounted case	(not available)
Transmission speed	100 Mbit/s
Optical wavelength	1300 nm
Bridgeable distance	max. 0.93 miles (1.5 km)
<i>PROFIBUS-FMS/DP</i>	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 1.5 Mbaud
<u>RS485</u>	
Connection	9-pin subminiature connector, mounting location "B"
For flush-mounting housing/ surface-mounting housing with detached operator panel	
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance	1000 m/3300 ft ≤ 93.75 kbaud; 500 m/1500 ft ≤ 187.5 kbaud; 200 m/600 ft ≤ 1.5 Mbaud; 100 m/300 ft ≤ 12 Mbaud
Test voltage	AC 500 V against ground
<u>Fiber optic</u>	
Connection fiber-optic cable	Integr. ST connector for FO connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	500 kbit/s 1.6 km/0.99 miles 1500 kbit/s 530 m/0.33 miles
<i>MODBUS RTU, ASCII, DNP 3.0</i>	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 19200 baud

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System interface (rear of unit) (cont'd)	
RS485	
Connection For flush-mounting housing/ surface-mounting housing with detached operator panel For surface-mounting housing with two-tier terminal at the top/bottom part	9-pin subminiature connector, mounting location "B" At bottom part of the housing: shielded data cable
Test voltage	AC 500 V against ground
Fiber-optic	
Connection fiber-optic cable For flush-mounting housing/ surface-mounting housing with detached operator panel For surface-mounting housing with two-tier terminal at the top/bottom part	Integrated ST connector for fiber- optic connection Mounting location "B" At the bottom part of the housing Important: Please refer to footnotes ¹⁾ and ²⁾ on page 5/136
Optical wavelength	820 nm
Permissible path attenuation	Max 8 dB. for glass fiber 62.5/125 μ m
Distance	Max. 1.5 km/0.9 miles
Time synchronization DCF77/IRIG-B signal (Format IRIG-B000)	
Connection	9-pin subminiature connector (SUB-D) (terminal with surface-mounting housing)
Voltage levels	5 V, 12 V or 24 V (optional)

Functions	
Definite-time overcurrent protection, directional/non-directional (ANSI 50, 50N, 67, 67N)	
Operating mode non-directional phase protection (ANSI 50)	3-phase (standard) or 2-phase (L1 and L3)
Number of elements (stages)	$I>$, $I>>$, $I>>>$ (phases) $I_E>$, $I_E>>$, $I_E>>>$ (ground)
Setting ranges	
Pickup phase elements	0.5 to 175 A or ∞^1 (in steps of 0.01 A)
Pickup ground elements	0.25 to 175 A or ∞^1 (in steps of 0.01 A)
Delay times T	0 to 60 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Times	
Pickup times (without inrush restraint, with inrush restraint + 10 ms)	
With twice the setting value	Non-directional Directional Approx. 30 ms 45 ms
With five times the setting value	Approx. 20 ms 40 ms
Dropout times	Approx. 40 ms
Dropout ratio	Approx. 0.95 for $III_{nom} \geq 0.3$
Tolerances	
Pickup	2 % of setting value or 50 mA ¹⁾
Delay times T , T_{DO}	1 % or 10 ms
1) At $I_{nom} = 1$ A, all limits divided by 5.	

Inverse-time overcurrent protection, directional/non-directional (ANSI 51, 51N, 67, 67N)	
Operating mode non-directional phase protection (ANSI 51)	3-phase (standard) or 2-phase (L1 and L3)
Setting ranges	
Pickup phase element I_p	0.5 to 20 A or ∞^1 (in steps of 0.01 A)
Pickup ground element I_{EP}	0.25 to 20 A or ∞^1 (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.05 to 15 s or ∞ (in steps of 0.01 s)
Undervoltage threshold $V<$ for release I_p	10.0 to 125.0 V (in steps of 0.1 V)
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse, long inverse
ANSI	Inverse, short inverse, long inverse moderately inverse, very inverse, extremely inverse, definite inverse
User-defined characteristic	Defined by a maximum of 20 value pairs of current and time delay
Dropout setting	
Without disk emulation	Approx. $1.05 \cdot$ setting value I_p for $I_p/I_{nom} \geq 0.3$, corresponds to approx. $0.95 \cdot$ pickup threshold
With disk emulation	Approx. $0.90 \cdot$ setting value I_p
Tolerances	
Pickup/dropout thresholds I_p , I_{EP}	2 % of setting value or 50 mA ¹⁾
Pickup time for $2 \leq III_p \leq 20$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms
Dropout ratio for $0.05 \leq III_p \leq 0.9$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms
Direction detection	
For phase faults	
Polarization	With cross-polarized voltages; With voltage memory for measure- ment voltages that are too low
Forward range	$V_{ref,rot} \pm 86^\circ$ - 180° to 180° (in steps of 1°)
Rotation of reference voltage $V_{ref,rot}$	For one and two-phase faults unlimited;
Direction sensitivity	For three-phase faults dynamically unlimited; Steady-state approx. 7 V phase-to- phase
For ground faults	
Polarization	With zero-sequence quantities $3V_0$, $3I_0$ or with negative-sequence quantities $3V_2$, $3I_2$
Forward range	$V_{ref,rot} \pm 86^\circ$
Rotation of reference voltage $V_{ref,rot}$	- 180° to 180° (in steps of 1°)
Direction sensitivity	Zero-sequence quantities $3V_0$, $3I_0$
	$V_E \approx 2.5$ V displacement voltage, measured; $3V_0 \approx 5$ V displacement voltage, calculated $3V_2 \approx 5$ V negative-sequence voltage; $3I_2 \approx 225$ mA negative-sequence current ¹⁾
Negative-sequence quantities $3V_2$, $3I_2$	
Tolerances (phase angle error under reference conditions) For phase and ground faults	$\pm 1^\circ$ electrical

Inrush-current detection	
Influenced functions	Time-overcurrent elements, $I>$, $I_{E>}$, I_p , I_{Ep} (directional, non-directional)
Lower function limit phases	At least one phase current (50 Hz and 100 Hz) $\geq 125 \text{ mA}^{1)}$
Lower function limit ground	Ground current (50 Hz and 100 Hz) $\geq 125 \text{ mA}^{1)}$
Upper function limit (setting range)	1.5 to 125 A ¹⁾ (in steps of 0.01 A)
Setting range $I_{2f} II$	10 to 45 % (in steps of 1 %)
Crossblock (I_{L1} , I_{L2} , I_{L3})	ON/OFF
Dynamic setting change	
Controllable function	Directional and non-directional pickup, tripping time
Start criteria	Current criteria, CB position via aux. contacts, binary input, auto-reclosure ready
Time control	3 timers
Current criteria	Current threshold (reset on dropping below threshold; monitoring with timer)
(Sensitive) ground-fault detection (ANSI 64, 50 Ns, 51Ns, 67Ns)	
Displacement voltage starting for all types of ground fault (ANSI 64)	
Setting ranges	
Pickup threshold $V_{E>}$ (measured)	1.8 to 170 V (in steps of 0.1 V)
Pickup threshold $3V_{0>}$ (calculated)	10 to 225 V (in steps of 0.1 V)
Delay time $T_{\text{Delay pickup}}$	0.04 to 320 s or ∞ (in steps of 0.01 s)
Additional trip delay $T_{V\text{DELAY}}$	0.1 to 40000 s or ∞ (in steps of 0.01 s)
Times	
Pickup time	Approx. 50 ms
Dropout ratio	0.95 or (pickup value -0.6 V)
Tolerances	
Pickup threshold V_E (measured)	3 % of setting value or 0.3 V
Pickup threshold $3V_0$ (calculated)	3 % of setting value or 3 V
Delay times	1 % of setting value or 10 ms
Phase detection for ground fault in an ungrounded system	
Measuring principle	Voltage measurement (phase-to-ground)
Setting ranges	
$V_{ph \text{ min}}$ (ground-fault phase)	10 to 100 V (in steps of 1 V)
$V_{ph \text{ max}}$ (unfaulted phases)	10 to 100 V (in steps of 1 V)
Measuring tolerance acc. to DIN 57435 part 303	3 % of setting value, or 1 V
Ground-fault pickup for all types of ground faults	
Definite-time characteristic (ANSI 50Ns)	
Setting ranges	
Pickup threshold $I_{EE>}$, $I_{EE>>}$	
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A ¹⁾ (in steps of 0.01 A)
Delay times T for $I_{EE>}$, $I_{EE>>}$	0 to 320 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{D0}	0 to 60 s (in steps of 0.01 s)
Times	
Pickup times	Approx. 50 ms
Dropout ratio	Approx. 0.95

Tolerances	
Pickup threshold	
For sensitive input	2 % of setting value or 1 mA
For normal input	2 % of setting value or 50 mA ¹⁾
Delay times	1 % of setting value or 20 ms
Ground-fault pickup for all types of ground faults	
Inverse-time characteristic (ANSI 51Ns)	
<u>User-defined characteristic</u>	Defined by a maximum of 20 pairs of current and delay time values
Setting ranges	
Pickup threshold I_{EEp}	
For sensitive input	0.001 A to 1.4 A (in steps of 0.001 A)
For normal input	0.25 to 20 A ¹⁾ (in steps of 0.01 A)
User defined	
Time multiplier T	0.1 to 4 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	Approx. 50 ms
Pickup threshold	Approx. $1.1 \cdot I_{EEp}$
Dropout ratio	Approx. $1.05 \cdot I_{EEp}$
Tolerances	
Pickup threshold	
For sensitive input	2 % of setting value or 1 mA
For normal input	2 % of setting value or 50 mA ¹⁾
Delay times in linear range	7 % of reference value for $2 \leq III_{EEp} \leq 20 + 2 \%$ current tolerance, or 70 ms
<u>Logarithmic inverse</u>	Refer to the manual
<u>Logarithmic inverse with knee point</u>	Refer to the manual
Direction detection for all types of ground-faults (ANSI 67Ns)	
<u>Measuring method "cos φ / sin φ"</u>	
Direction measurement	I_E and V_E measured or $3I_0$ and $3V_0$ calculated
Measuring principle	Active/reactive power measurement
Setting ranges	
Measuring enable $I_{\text{Release direct}}$	
For sensitive input	0.001 to 1.2 A (in steps of 0.001 A)
For normal input	0.25 to 150 A ¹⁾ (in steps of 0.01 A)
Direction phasor $\varphi_{\text{Correction}}$	- 45 ° to + 45 ° (in steps of 0.1 °)
Dropout delay $T_{\text{Reset delay}}$	1 to 60 s (in steps of 1 s)
Reduction of dir. area $\alpha_{\text{Red.dir.area}}$	1 ° to 15 ° (in steps of 0.1 °)
Tolerances	
Pickup measuring enable	
For sensitive input	2 % of setting value or 1 mA
For normal input	2 % of setting value or 50 mA ¹⁾
Angle tolerance	3 °
<u>Measuring method "$\varphi (V_0 / I_0)$"</u>	
Direction measurement	I_E and V_E measured or $3I_0$ and $3V_0$ calculated
Minimum voltage $V_{\text{min,measured}}$	0.4 to 50 V (in steps of 0.1 V)
Minimum voltage $V_{\text{min,calculated}}$	10 to 90 V (in steps of 1 V)
Phase angle φ	- 180 ° to 180 ° (in steps of 0.1 °)
Delta phase angle $\Delta \varphi$	0 ° to 180 ° (in steps of 0.1 °)
Tolerances	
Pickup threshold V_E (measured)	3 % of setting value or 0.3 V
Pickup threshold $3V_0$ (calculated)	3 % of setting value or 3 V
Angle tolerance	3 °
Angle correction for cable CT	
Angle correction F1, F2	
Current value I_1 , I_2	
For sensitive input	0 ° to 5 ° (in steps of 0.1 °)
For normal input	0.001 to 1.5 A (in steps of 0.001 A)
	0.25 to 175 A ¹⁾ (in steps of 0.01 A)

Note: Due to the high sensitivity the linear range of the measuring input IN with integrated sensitive input transformer is from 0.001 A to 1.6 A. For currents greater than 1.6 A, correct directionality can no longer be guaranteed.

1) For $I_{\text{nom}} = 1 \text{ A}$, all limits divided by 5.

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High-impedance restricted ground-fault protection (ANSI 87N) / single-phase overcurrent protection

Setting ranges	
Pickup thresholds $I_{>}$, $I_{>>}$	
For sensitive input	0.003 to 1.5 A or ∞ (in steps of 0.001 A)
For normal input	0.25 to 175 A ¹⁾ or ∞ (in steps of 0.01 A)
Delay times $T_{I>}$, $T_{I>>}$	0 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
Minimum	Approx. 20 ms
Typical	Approx. 30 ms
Dropout times	Approx. 30 ms
Dropout ratio	Approx. 0.95 for $III_{nom} \geq 0.5$
Tolerances	3 % of setting value or
Pickup thresholds	1 % rated current at $I_{nom} = 1$ or 5 A; 5 % of setting value or 3 % rated current at $I_{nom} = 0.1$ A
Delay times	1 % of setting value or 10 ms

Intermittent ground-fault protection

Setting ranges	
Pickup threshold	
For I_E $I_{IE>}$	0.25 to 175 A ¹⁾ (in steps of 0.01 A)
For $3I_0$ $I_{IE>}$	0.25 to 175 A ¹⁾ (in steps of 0.01 A)
For I_{EE} $I_{IE>}$	0.005 to 1.5 A (in steps of 0.001 A)
Pickup prolon- gation time T_V	0 to 10 s (in steps of 0.01 s)
Ground-fault accu- mulation time T_{sum}	0 to 100 s (in steps of 0.01 s)
Reset time for accumulation T_{res}	1 to 600 s (in steps of 1 s)
Number of pickups for intermittent ground fault	2 to 10 (in steps of 1)
Times	
Pickup times	
Current = 1.25 · pickup value	Approx. 30 ms
Current ≥ 2 · pickup value	Approx. 22 ms
Dropout time	Approx. 22 ms
Tolerances	
Pickup threshold $I_{IE>}$	3 % of setting value, or 50 mA ¹⁾
Times T_V , T_{sum} , T_{res}	1 % of setting value or 10 ms

Directional intermittent ground fault protection (ANSI 67Ns)

Setting ranges / Increments	
Pickup threshold $V_{gnd>} / 3V_0>$	2.0 V to 100.0 V Increments 1 V
Monitoring time after pickup detected	0.04 s ... 10.00 s Increments 0.01 s
Pulse no. for detecting the interm. E/F	2 ... 50 Increments 1
Dropout ratio	
Dropout ratio $V_{gnd>} / 3V_0>$	0,95 or (pickup value - 0,6 V)
Tolerances	
Measurement tolerance $V_{gnd>} / 3V_0>$	3 % of setting value
Times	1 % of setting value or 10 ms
Influencing Variables	
Power supply direct voltage in range	$0.8 \leq VPS/VPSNom \leq 1.15$ <1 %
Temperature in range	$23.00\text{ °F } (-5\text{ °C}) \leq \Theta_{amb} \leq 131.00\text{ °F } (55\text{ °C})$ <0.5 %/ K

Thermal overload protection (ANSI 49)

Setting ranges	
Factor k	0.1 to 4 (in steps of 0.01)
Time constant	1 to 999.9 min (in steps of 0.1 min)
Warning overtemperature $\Theta_{alarm}/\Theta_{trip}$	50 to 100 % with reference to the tripping overtemperature (in steps of 1 %)

Current warning stage I_{alarm}	0.5 to 20 A (in steps of 0.01 A)
Extension factor when stopped k_t factor	1 to 10 with reference to the time constant with the machine running (in steps of 0.1)
Rated overtemperature (for I_{nom})	40 to 200 °C (in steps of 1 °C)
Tripping characteristic For $(I/k \cdot I_{nom}) \leq 8$	$t = \tau_{th} \cdot \ln \frac{(I/k \cdot I_{nom})^2 - (I_{pre}/k \cdot I_{nom})^2}{(I/k \cdot I_{nom})^2 - 1}$

1) For $I_{nom} = 1$ A, all limits divided by 5.

Dropout ratios	
Θ/Θ_{trip}	Drops out with Θ_{Alarm}
Θ/Θ_{Alarm}	Approx. 0.99
III_{Alarm}	Approx. 0.97
Tolerances	
With reference to $k \cdot I_{nom}$	Class 5 acc. to IEC 60255-8
With reference to tripping time	5 % \pm 2 s acc. to IEC 60255-8

Auto-reclosure (ANSI 79)

Number of reclosures	0 to 9 Shot 1 to 4 individually adjustable
Program for phase fault Start-up by	Time-overcurrent elements (dir., non-dir.), negative sequence, binary input
Program for ground fault Start-up by	Time-overcurrent elements (dir., non-dir.), sensitive ground-fault protection, binary input
Blocking of ARC	Pickup of protection functions, three-phase fault detected by a pro- tective element, binary input, last TRIP command after the reclosing cycle is complete (unsuccessful reclosing), TRIP command by the breaker failure protection (50BF), opening the CB without ARC initiation, external CLOSE command
Setting ranges	
Dead time (separate for phase and ground and individual for shots 1 to 4)	0.01 to 320 s (in steps of 0.01 s)
Blocking duration for manual- CLOSE detection	0.5 s to 320 s or 0 (in steps of 0.01 s)
Blocking duration after reclosure	0.5 s to 320 s (in steps of 0.01 s)
Blocking duration after dynamic blocking	0.01 to 320 s (in steps of 0.01 s)
Start-signal monitoring time	0.01 to 320 s or ∞ (in steps of 0.01 s)
Circuit-breaker supervision time	0.1 to 320 s (in steps of 0.01 s)
Max. delay of dead-time start	0 to 1800 s or ∞ (in steps of 0.1 s)
Maximum dead time extension	0.5 to 320 s or ∞ (in steps of 0.01 s)
Action time	0.01 to 320 s or ∞ (in steps of 0.01 s)

The delay times of the following protection function can be altered individually by the ARC for shots 1 to 4 (setting value $T = T$, non-delayed $T = 0$, blocking $T = \infty$):

$I_{>>>}$, $I_{>>}$, $I_{>}$, I_p , $I_{dir>>}$, $I_{dir>}$, I_{pdir}
 $I_{E>>>}$, $I_{E>>}$, $I_{E>}$, I_{Ep} , $I_{Edir>>}$, $I_{Edir>}$, I_{Edir}

Additional functions	Lockout (final trip), delay of dead-time start via binary input (monitored), dead-time extension via binary input (monitored), co-ordination with other protection relays, circuit-breaker monitoring, evaluation of the CB contacts	Frequency of V_1 and V_2 Range Tolerance*)	f_1, f_2 in Hz $f_N \pm 5$ Hz 20 mHz
		Voltage difference ($V_2 - V_1$) Range Tolerance*)	In kV primary, in V secondary or in % V_{nom} 10 to 120 % V_{nom} ≤ 1 % of measured value or 0.5 % of V_{nom}
		Frequency difference ($f_2 - f_1$) Range Tolerance*)	In mHz $f_N \pm 5$ Hz 20 mHz
		Angle difference ($\alpha_2 - \alpha_1$) Range Tolerance*)	In ° 0 to 180 ° 0.5 °
Breaker failure protection (ANSI 50 BF)			
Setting ranges			
Pickup thresholds	0.2 to 5 A ¹⁾ (in steps of 0.01 A)		
Delay time	0.06 to 60 s or ∞ (in steps of 0.01 s)		
Times			
Pickup times with internal start	is contained in the delay time		
Pickup times with external start	is contained in the delay time		
Dropout times	Approx. 25 ms		
Tolerances			
Pickup value	2 % of setting value (50 mA) ¹⁾		
Delay time	1 % or 20 ms		
Synchro- and voltage check (ANSI 25)			
Operating mode	· Synchro-check		
Additional release conditions	· Live-bus / dead line · Dead-bus / live-line · Dead-bus and dead-line · Bypassing		
Voltages			
Max. operating voltage V_{max}	20 to 140 V (phase-to-phase) (in steps of 1 V)		
Min. operating voltage V_{min}	20 to 125 V (phase-to-phase) (in steps of 1 V)		
$V <$ for dead-line / dead-bus check	1 to 60 V (phase-to-phase) (in steps of 1 V)		
$V >$ for live-line / live-bus check	20 to 140 V (phase-to-phase) (in steps of 1 V)		
Primary rated voltage of transformer V_{2nom}	0.1 to 800 kV (in steps of 0.01 kV)		
Tolerances	2 % of pickup value or 2 V		
Drop-off to pickup ratios	approx. 0.9 ($V >$) or 1.1 ($V <$)		
ΔV -measurement			
Voltage difference	0.5 to 50 V (phase-to-phase) (in steps of 1 V)		
Tolerance	1 V		
Δf -measurement			
Df-measurement ($f_2 > f_1$; $f_2 < f_1$)	0.01 to 2 Hz (in steps of 0.01 Hz)		
Tolerance	15 mHz		
$\Delta \alpha$ -measurement			
$\Delta \alpha$ -measurement ($\alpha_2 > \alpha_1$; $\alpha_2 < \alpha_1$)	2 ° to 80 ° (in steps of 1 °)		
Tolerance	2 °		
Max. phase displacement	5 ° for $\Delta f \leq 1$ Hz 10 ° for $\Delta f > 1$ Hz		
Adaptation			
Vector group adaptation by angle	0 ° to 360 ° (in steps of 1 °)		
Different voltage transformers V_1/V_2	0.5 to 2 (in steps of 0.01)		
Times			
Minimum measuring time	Approx. 80 ms		
Max. duration $T_{SYN DURATION}$	0.01 to 1200 s; ∞ (in steps of 0.01 s)		
Supervision time $T_{SUP VOLTAGE}$	0 to 60 s (in steps of 0.01 s)		
Closing time of CB $T_{CB close}$	0 to 60 s (in steps of 0.01 s)		
Tolerance of all timers	1 % of setting value or 10 ms		
Measuring values of synchro-check function			
Reference voltage V_1 Range Tolerance*)	In kV primary, in V secondary or in % V_{nom} 10 to 120 % V_{nom} ≤ 1 % of measured value or 0.5 % of V_{nom}		
Voltage to be synchronized V_2 Range Tolerance*)	In kV primary, in V secondary or in % V_{nom} 10 to 120 % V_{nom} ≤ 1 % of measured value or 0.5 % of V_{nom}		
		Operating modes / measuring quantities	
		3-phase	$I, I_1, I_2, I_2/I_1, 3I_0, V, V_1, V_2, 3V_0, dV/dt,$
		1-phase	$P, Q, \cos \varphi I, I_E, I_{E sens.}, V, V_E, P, Q,$
		Without fixed phase relation	$\cos \varphi f, df/dt$, binary input
		Pickup when	Exceeding or falling below threshold value
		Setting ranges	
		Current $I, I_1, I_2, 3I_0, I_E$	0.15 to 200 A ¹⁾ (in steps of 0.01 A)
		Current ratio I_2/I_1	15 to 100 % (in steps of 1 %)
		Sens. ground curr. $I_{E sens.}$	0.001 to 1.5 A (in steps of 0.001 A)
		Voltages $V, V_1, V_2, 3V_0$	2 to 260 V (in steps of 0.1 V)
		Displacement voltage V_E	2 to 200 V (in steps of 0.1 V)
		Power P, Q	0.5 to 10000 W (in steps of 0.1 W)
		Power factor ($\cos \varphi$)	- 0.99 to + 0.99 (in steps of 0.01)
		Frequency	$f_N = 50$ Hz $f_N = 60$ Hz
		Rate-of-frequency change df/dt	40 to 60 Hz (in steps of 0.01 Hz) 50 to 70 Hz (in steps of 0.01 Hz)
		Voltage change dV/dt	0.1 to 20 Hz/s (in steps of 0.01 Hz/s)
		Dropout ratio $>$ - stage	4 V/s to 100 V/s (in steps of 1 V/s)
		Dropout ratio $<$ - stage	1.01 to 3 (in steps of 0.01)
		Dropout differential f	0.7 to 0.99 (in steps of 0.01)
		Pickup delay time	0.02 to 1.00 Hz (in steps of 0.01 Hz)
		Trip delay time	0 to 60 s (in steps of 0.01 s)
		Dropout delay time	0 to 3600 s (in steps of 0.01 s)
		Dropout delay time	0 to 60 s (in steps of 0.01 s)
		Times	
		Pickup times	
		Current, voltage (phase quantities)	
		With 2 times the setting value	Approx. 30 ms
		With 10 times the setting value	Approx. 20 ms
		Current, voltages (symmetrical components)	
		With 2 times the setting value	Approx. 40 ms
		With 10 times the setting value	Approx. 30 ms
		Power	
		Typical	Approx. 120 ms
		Maximum (low signals and thresholds)	Approx. 350 ms
		Power factor	300 to 600 ms
		Frequency	Approx. 100 ms
		Rate-of-frequency change	
		With 1.25 times the setting value	Approx. 220 ms
		Voltage change dV/dt	
		For 2 times pickup value	Approx. 220 ms
		Binary input	Approx. 20 ms
		*) With rated frequency.	
		1) At $I_{nom} = 1$ A, all limits divided by 5.	

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Flexible protection functions (ANSI 27, 32, 47, 50, 55, 59, 81R) (cont'd)	
Dropout times	
Current, voltage (phase quantities)	< 20 ms
Current, voltages (symmetrical components)	< 30 ms
Power	
Typical	< 50 ms
Maximum	< 350 ms
Power factor	< 300 ms
Frequency	< 100 ms
Rate-of-frequency change	< 200 ms
Voltage change	< 220 ms
Binary input	< 10 ms
Tolerances	
Pickup threshold	
Current	0.5 % of setting value or 50 mA ¹⁾
Current (symmetrical components)	1 % of setting value or 100 mA ¹⁾
Voltage	0.5 % of setting value or 0.1 V
Voltage (symmetrical components)	1 % of setting value or 0.2 V
Power	1 % of setting value or 0.3 W
Power factor	2 degrees
Frequency	5 mHz (at $V = V_N, f = f_N$) 10 mHz (at $V = V_N$)
Rate-of-frequency change	5 % of setting value or 0.05 Hz/s
Voltage change dV/dt	5 % of setting value or 1.5 V/s
Times	1 % of setting value or 10 ms
Negative-sequence current detection (ANSI 46)	
Definite-time characteristic (ANSI 46-1 and 46-2)	
Setting ranges	
Pickup current $I_{2>}, I_{2>>}$	0.25 to 15 A ¹⁾ or ∞ (in steps of 0.01 A)
Delay times	0 to 60 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{D0}	0 to 60 s (in steps of 0.01 s)
Functional limit	All phase currents ≤ 50 A ¹⁾
Times	
Pickup times	Approx. 35 ms
Dropout times	Approx. 35 ms
Dropout ratio	Approx. 0.95 for $I_2 / I_{nom} > 0.3$
Tolerances	
Pickup thresholds	3 % of the setting value or 50 mA ¹⁾
Delay times	1 % or 10 ms
Inverse-time characteristic (ANSI 46-TOC)	
Setting ranges	
Pickup current	0.25 to 10 A ¹⁾ (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.5 to 15 s or ∞ (in steps of 0.01 s)
Functional limit	All phase currents ≤ 50 A ¹⁾
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse
ANSI	Inverse, moderately inverse, very inverse, extremely inverse
Pickup threshold	Approx. $1.1 \cdot I_{2p}$ setting value
Dropout	
IEC and ANSI (without disk emulation)	Approx. $1.05 \cdot I_{2p}$ setting value, which is approx. $0.95 \cdot$ pickup threshold
ANSI with disk emulation	Approx. $0.90 \cdot I_{2p}$ setting value
Tolerances	
Pickup threshold	3 % of the setting value or 50 mA ¹⁾
Time for $2 \leq M \leq 20$	5 % of setpoint (calculated) +2 % current tolerance, at least 30 ms

Starting time monitoring for motors (ANSI 48)	
Setting ranges	
Motor starting current $I_{STARTUP}$	2.5 to 80 A ¹⁾ (in steps of 0.01)
Pickup threshold $I_{MOTOR START}$	2 to 50 A ¹⁾ (in steps of 0.01)
Permissible starting time $T_{STARTUP}$, cold motor	1 to 180 s (in steps of 0.1 s)
Permissible starting time $T_{STARTUP}$, warm motor	0.5 to 180 s (in steps of 0.1 s)
Temperature threshold cold motor	0 to 80 % (in steps of 1 %)
Permissible blocked rotor time $T_{LOCKED-ROTOR}$	0.5 to 120 s or ∞ (in steps of 0.1 s)
Tripping time characteristic	
For $I > I_{MOTOR START}$	$t = \left(\frac{I_{STARTUP}}{I} \right)^2 \cdot T_{STARTUP}$
	$I_{STARTUP}$ = Rated motor starting current I = Actual current flowing $T_{STARTUP}$ = Tripping time for rated motor starting current t = Tripping time in seconds
Dropout ratio $I_{MOTOR START}$	Approx. 0.95
Tolerances	
Pickup threshold	2 % of setting value or 50 mA ¹⁾
Delay time	5 % or 30 ms
Load jam protection for motors (ANSI 51M)	
Setting ranges	
Current threshold for alarm and trip	0.25 to 60 A ¹⁾ (in steps 0.01 A)
Delay times	0 to 600 s (in steps 0.01 s)
Blocking duration after CLOSE signal detection	0 to 600 s (in steps 0.01 s)
Tolerances	
Pickup threshold	2 % of setting value or 50 mA ¹⁾
Delay time	1 % of setting value or 10 ms
Restart inhibit for motors (ANSI 66)	
Setting ranges	
Motor starting current relative to rated motor current	1.1 to 10 (in steps of 0.1)
Rated motor current $I_{MOTOR Nom}$	1 to 6 A ¹⁾ (in steps of 0.01 A)
Max. permissible starting time $T_{Start Max}$	1 to 320 s (in steps of 1 s)
Equilibrium time T_{Equal}	0 min to 320 min (in steps of 0.1 min)
Minimum inhibit time $T_{MIN. INHIBIT TIME}$	0.2 min to 120 min (in steps of 0.1 min)
Max. permissible number of warm starts	1 to 4 (in steps of 1)
Difference between cold and warm starts	1 to 2 (in steps of 1)
Extension k-factor for cooling simulations of rotor at zero speed k_T at STOP	0.2 to 100 (in steps of 0.1)
Extension factor for cooling time constant with motor running k_T RUNNING	0.2 to 100 (in steps of 0.1)
Restarting limit	
	$\Theta_{restart} = \Theta_{rot max perm} \cdot \frac{n_c - 1}{n_c}$
$\Theta_{restart}$	= Temperature limit below which restarting is possible
$\Theta_{rot max perm}$	= Maximum permissible rotor overtemperature (= 100 % in operational measured value $\Theta_{rot}/\Theta_{rot trip}$)
n_c	= Number of permissible start-ups from cold state
1) For $I_{nom} = 1$ A, all limits divided by 5.	

Undercurrent monitoring (ANSI 37)	
Signal from the operational measured values	
Temperature monitoring box (ANSI 38)	
Temperature detectors	
Connectable boxes	1 or 2
Number of temperature detectors per box	Max. 6
Type of measuring	Pt 100 Ω or Ni 100 Ω or Ni 120 Ω
Mounting identification	"Oil" or "Environment" or "Stator" or "Bearing" or "Other"
Thresholds for indications	
For each measuring detector	
Stage 1	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)
Stage 2	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)
Undervoltage protection (ANSI 27)	
Operating modes/measuring quantities	
3-phase	Positive phase-sequence voltage or phase-to-phase voltages or phase-to-ground voltages
1-phase	Single-phase phase-ground or phase-phase voltage
Setting ranges	
Pickup thresholds $V<$, $V<<$	dependent on voltage connection and chosen measuring quantity
Dropout ratio r	1.01 to 3 (in steps of 0.01)
Delay times T	0 to 100 s or ∞ (in steps of 0.01 s)
Current Criteria "Bkr Closed I_{MIN} "	0.2 to 5 A ¹⁾ (in steps of 0.01 A)
Times	
Pickup times	Approx. 50 ms
Dropout times	As pickup times
Tolerances	
Pickup thresholds	1 % of setting value or 1 V
Times	1 % of setting value or 10 ms
Overvoltage protection (ANSI 59)	
Operating modes/measuring quantities	
3-phase	Positive phase-sequence voltage or negative phase-sequence voltage or phase-to-phase voltages or phase-to-ground voltages
1-phase	Single-phase phase-ground or phase-phase voltage
Setting ranges	
Pickup thresholds $V>$, $V>>$	dependent on voltage connection and chosen measuring quantity
Dropout ratio r	0.9 to 0.99 (in steps of 0.01)
Delay times T	0 to 100 s or ∞ (in steps of 0.01 s)
Times	
Pickup times V	Approx. 50 ms
Pickup times V_1 , V_2	Approx. 60 ms
Dropout times	As pickup times
Tolerances	
Pickup thresholds	1 % of setting value or 1 V
Times	1 % of setting value or 10 ms

1) For $I_{nom} = 1$ A, all limits divided by 5.

Frequency protection (ANSI 81)	
Number of frequency elements	4
Setting ranges	
Pickup thresholds for $f_{nom} = 50$ Hz	40 to 60 Hz (in steps of 0.01 Hz)
Pickup thresholds for $f_{nom} = 60$ Hz	50 to 70 Hz (in steps of 0.01 Hz)
Dropout differential = pickup threshold – dropout threshold	0.02 Hz to 1.00 Hz (in steps of 0.01 Hz)
Delay times	
Undervoltage blocking, with positive-sequence voltage V_1	0 to 100 s or ∞ (in steps of 0.01 s) 10 to 150 V (in steps of 1 V)
Times	
Pickup times	Approx. 150 ms
Dropout times	Approx. 150 ms
Dropout	
Ratio undervoltage blocking	Approx. 1.05
Tolerances	
Pickup thresholds	
Frequency	5 mHz (at $V = V_N$, $f = f_N$) 10 mHz (at $V = V_N$)
Undervoltage blocking	3 % of setting value or 1 V
Delay times	3 % of the setting value or 10 ms
Fault locator (ANSI 21FL)	
Output of the fault distance	in Ω primary and secondary, in km or miles line length, in % of line length
Starting signal	Trip command, dropout of a protection element, via binary input
Setting ranges	
Reactance (secondary)	0.001 to 1.9 Ω/km ¹⁾ (in steps of 0.0001) 0.001 to 3 Ω/mile ¹⁾ (in steps of 0.0001)
Tolerances	
Measurement tolerance acc. to VDE 0435, Part 303 for sinusoidal measurement quantities	2.0 % fault location, or 0.025 Ω (without intermediate infeed) for $30^\circ \leq \varphi_K \leq 90^\circ$ and $V_K/V_{nom} \geq 0.1$ and $I_K/I_{nom} \geq 1$
Undervoltage-controlled reactive power protection (ANSI 27/Q)	
Measured Values / Modes of Operation	
3-phase	I1, V, Q,
Measuring method for I, V	Fundamental wave, Pickup when Exceeding threshold value or falling below threshold value
Setting Ranges / Increments	
Pickup thresholds	
Current I1 for $I_{Nom} = 1$ A	0.01 to 0.20 A
for $I_{Nom} = 5$ A	Increments 0.01 A
Voltage V	0.05 to 1.00 A
Power Q for $I_{Nom} = 1$ A	10.0 to 210.00 V
for $I_{VAR Nom} = 5$ A	Increments 0.1 V
Pickup delay (standard)	1.0 to 100 VAR
Command delay time	Increments 0.01
Dropout delay	5.0 to 500 VAR
Function Limits	
Power measurement I1 for $I_{Nom} = 1$ A	0.00 to 60.00 s
for $I_{Nom} = 5$ A	Increments 0.01 s
Dropout times	0.00 to 3600.00 s
Binary input	Increments 0.01 s
Dropout times	
QU protection typical maximum (small signals and thresholds)	0.00 to 60.00 s
Binary input	Increments 0.01 s
Dropout times	
QU protection typical maximum	Positive sequence system current > 0.03 A
Binary input	Positive sequence system current > 0.15 A
Dropout times	
QU protection typical maximum	approx. 120 ms
Binary input	approx. 350 ms
Dropout times	
QU protection typical maximum	approx. 20 ms
Binary input	
Dropout times	
QU protection typical maximum	< 50 ms
Binary input	< 350 ms
Dropout times	< 10 ms


Overcurrent Protection / 7SJ62

Technical data

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Tolerances Pickup thresholds Current I1 for INom = 1 A for INom = 5 A Current I1 (symmetrical components) for INom = 1 A for INom = 5 A Voltage Voltage (symmetrical components) Power Times	1% of setting value or 10 mA at INom ≥ 0.03 A 2% of setting value or 20 mA at INom < 0.03 A 1% of setting value or 50 mA at INom ≥ 0.25 A 2% of setting value or 100 mA at INom < 0.25 A 2% of set value or 20 mA 2% of set value or 100 mA 1% of set value or 0.1 V 2% of set value or 0.2 V 1% of setting value or 0.3 VAR 1% of setting value or 10 ms	cos φ, power factor (p.f.) Range Tolerance ²⁾ Frequency f Range Tolerance ²⁾ Temperature overload protection Θ/Θ _{Trip} Range Tolerance ²⁾ Temperature restart inhibit Θ _L /Θ _{L Trip} Range Tolerance ²⁾ Restart threshold Θ _{Restart} /Θ _{L Trip} Reclose time T _{Reclose} Currents of sensitive ground fault detection (total, real, and reactive current) I _{EE} , I _{EE real} , I _{EE reactive} Range Tolerance ²⁾ RTD-box	Total and phase segregated - 1 to + 1 2 % for cos φ ≥ 0.707 In Hz f _{nom} ± 5 Hz 20 mHz In % 0 to 400 % 5 % class accuracy per IEC 60255-8 In % 0 to 400 % 5 % class accuracy per IEC 60255-8 In % In min In A (kA) primary and in mA secondary 0 mA to 1600 mA 2 % of measured value or 1 mA See section "Temperature monitoring box"
Influencing Variables for Pickup Values Auxiliary direct voltage in the range Temperature in the range		from 0.8 ≤ VPS/VPSNom ≤ 1.15 1 % from 23.00 °F (-5 °C) ≤ Θ _{amb} ≤ 131.00 °F (55 °C) 0.5 %/10 K from 25 Hz to 70 Hz 1 %	
Frequency in the range Harmonics up to 10 % 3rd harmonic up to 10 % 5th harmonic	1 % 1 %		
Additional functions			
Operational measured values			
Currents I _{L1} , I _{L2} , I _{L3} Positive-sequence component I ₁ Negative-sequence component I ₂ I _E or 3I ₀ Range Tolerance ²⁾ Phase-to-ground voltages V _{L1-E} , V _{L2-E} , V _{L3-E} Phase-to-phase voltages V _{L1-L2} , V _{L2-L3} , V _{L3-L1} , V _E or V ₀ Positive-sequence component V ₁ Negative-sequence component V ₂ Range Tolerance ²⁾ S, apparent power Range Tolerance ²⁾ P, active power	In A (kA) primary, in A secondary or in % I _{Nom} 10 to 200 % I _{Nom} 1 % of measured value or 0.5 % I _{Nom} In kV primary, in V secondary or in % V _{Nom} 10 to 120 % V _{Nom} 1 % of measured value or 0.5 % of V _{Nom} In kVAr (MVar or GVar) primary and in % of S _{Nom} 0 to 120 % S _{Nom} 1 % of S _{Nom} for V/V _{Nom} and I/I _{Nom} = 50 to 120 % With sign, total and phase-segregated in kW (MW or GW) primary and in % S _{Nom}		
2) At rated frequency.			
Operational measured values (cont'd)			
Range Tolerance ²⁾ Q, reactive power Range Tolerance ²⁾	0 to 120 % S _{Nom} 1 % of S _{Nom} for V/V _{Nom} and I/I _{Nom} = 50 to 120 % and cos φ = 0.707 to 1 with S _{Nom} = √3 V _{Nom} · I _{Nom} With sign, total and phase-segregated in kVAr (MVar or GVar) primary and in % S _{Nom} 0 to 120 % S _{Nom} 1 % of S _{Nom} for V/V _{Nom} and I/I _{Nom} = 50 to 120 % and sin φ = 0.707 to 1 with S _{Nom} = √3 · V _{Nom} · I _{Nom}		
Long-term averages			
Time window Frequency of updates Long-term averages of currents of real power of reactive power of apparent power	5, 15, 30 or 60 minutes Adjustable I _{L1dmd} , I _{L2dmd} , I _{L3dmd} , I _{1dmd} in A (kA) P _{dmd} in W (kW, MW) Q _{dmd} in VAR (kVAR, MVAR) S _{dmd} in VAR (kVAR, MVAR)		
Max./Min. report			
Report of measured values Reset, automatic Reset, manual Min./Max. values for current Min./Max. values for voltages Min./Max. values for power Min./Max. values for overload protection Min./Max. values for mean values	With date and time Time of day adjustable (in minutes, 0 to 1439 min) Time frame and starting time adjustable (in days, 1 to 365 days, and ∞) Using binary input, using keypad, via communication I _{L1} , I _{L2} , I _{L3} , I ₁ (positive-sequence component) V _{L1-E} , V _{L2-E} , V _{L3-E} V ₁ (positive-sequence component) V _{L1-L2} , V _{L2-L3} , V _{L3-L1} S, P, Q, cos φ, frequency Θ/Θ _{Trip} I _{L1dmd} , I _{L2dmd} , I _{L3dmd} I ₁ (positive-sequence component); S _{dmd} , P _{dmd} , Q _{dmd}		
Local measured values monitoring			
Current asymmetry Voltage asymmetry Current phase sequence Voltage phase sequence Limit value monitoring	I _{max} /I _{min} > balance factor, for I > I _{balance limit} V _{max} /V _{min} > balance factor, for V > V _{lim} Clockwise (ABC) / counter-clockwise (ACB) Clockwise (ABC) / counter-clockwise (ACB) Predefined limit values, user-defined expansions via CFC		
1) At I _{Nom} = 1 A, all limits multiplied with 5. 2) At rated frequency.			

Fuse failure monitor	
For all network types	With the option of blocking affected protection functions
Fault recording	
Recording of indications of the last 8 power system faults	
Recording of indications of the last 3 power system ground faults	
Time stamping	
Resolution for event log (operational annunciations)	1 ms
Resolution for trip log (fault annunciations)	1 ms
Maximum time deviation (internal clock)	0.01 %
Battery	Lithium battery 3 V/1 Ah, type CR 1/2 AA, message "Battery Fault" for insufficient battery charge
Oscillographic fault recording	
Maximum 8 fault records saved, memory maintained by buffer battery in case of loss of power supply	
Recording time	Total 20 s Pre-trigger and post-fault recording and memory time adjustable
Sampling rate for 50 Hz	1 sample/1.25 ms (16 samples/cycle)
Sampling rate for 60 Hz	1 sample/1.04 ms (16 samples/cycle)
Energy/power	
Meter values for power W_p , W_q (real and reactive power demand)	in kWh (MWh or GWh) and kVARh (MVARh or GVARh)
Tolerance ¹⁾	$\leq 2\%$ for $I > 0.1 I_{nom}$, $V > 0.1 V_{nom}$ and $ \cos \varphi $ (p.f.) ≥ 0.707
Statistics	
Saved number of trips	Up to 9 digits
Number of automatic reclosing commands (segregated according to 1 st and $\geq 2^{nd}$ cycle)	Up to 9 digits
Circuit-breakerwear	
Methods	<ul style="list-style-type: none"> • ΣI^x with $x = 1 \dots 3$ • 2-point method (remaining service life) • $\Sigma i^2 t$
Operation	Phase-selective accumulation of measured values on TRIP command, up to 8 digits, phase-selective limit values, monitoring indication
Motor statistics	
Total number of motor start-ups	0 to 9999 (resolution 1)
Total operating time	0 to 99999 h (resolution 1 h)
Total down-time	0 to 99999 h (resolution 1 h)
Ratio operating time/down-time	0 to 100 % (resolution 0.1 %)
Active energy and reactive energy	See operational measured values
Motor start-up data:	Of the last 5 start-ups
– Start-up time	0.30 s to 9999.99 s (resolution 10 s)
– Start-up current (primary)	0 A to 1000 kA (resolution 1 A)
– Start-up voltage (primary)	0 V to 100 kV (resolution 1 V)

Operating hours counter	
Display range	Up to 7 digits
Criterion	Overshoot of an adjustable current threshold (BkrClosed I_{MIN})
Trip circuit monitoring	
With one or two binary input	
Commissioning aids	
Phase rotation field check, operational measured values, circuit-breaker/switching device test, creation of a test measurement report	
Clock	
Time synchronization	DCF77 / IRIG-B signal (telegram format IRIG-B000), binary input, communication
Setting group switchover of the function parameters	
Number of available setting groups	4 (parameter group A, B, C and D)
Switchover performed	Via keypad, DIGSI, system (SCADA) interface or binary input
Control	
Number of switching units	Depends on the binary inputs and outputs
Interlocking	Programmable
Circuit-breaker signals	Feedback, close, open, intermediate position
Control commands	Single command / double command 1, 1 plus 1 common or 2 trip contacts
Programmable controller	CFC logic, graphic input tool
Local control	Control via menu, assignment of a function key
Remote control	Via communication interfaces, using a substation automation and control system (e.g. SICAM), DIGSI 4 (e.g. via modem)
CE conformity	
This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EG previous 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 2006/95/EG previous 73/23/EEC).	
This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).	
Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1. The unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).	
This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".	
	

Overcurrent Protection / 7SJ62

Selection and ordering data

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Description	Order No.
7SJ62 multifunction protection relay	7SJ62 <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Housing, inputs, outputs	
Housing 1/319", 4 line text display, 3 x U, 4 x I, 8 BI, 8 BO, 1 live status-contact	1
Housing 1/319", 4 line text display, 3 x U, 4 x I, 11 BI, 6 BO, 1 live status-contact	2
Housing 1/319", 4 line text display, 4 x U, 4 x I, 8 BI, 8 BO, 1 live status-contact	3
Housing 1/319", 4 line text display, 4 x U, 4 x I, 11 BI, 6 BO, 1 live status-contact	4
Housing 1/219", graphic display, 4 x U, 4 x I, 8 BI, 8 BO, 1 live status contact ⁷⁾	5
Housing 1/219", graphic display, 4 x U, 4 x I, 11 BI, 6 BO, 1 live status contact ⁷⁾	6
Measuring inputs (3 x V/4 x V, 4 x I)	
$I_{ph} = 1 A^{1)}$, $I_e = 1 A^{1)}$ (min. = 0.05 A) Position 15 only with A, C, E, G	1
$I_{ph} = 1 A^{1)}$, $I_e =$ sensitive (min. = 0.001 A) Position 15 only with B, D, F, H	2
$I_{ph} = 5 A^{1)}$, $I_e = 5 A^{1)}$ (min. = 0.25 A) Position 15 only with A, C, E, G	5
$I_{ph} = 5 A^{1)}$, $I_e =$ sensitive (min. = 0.001 A) Position 15 only with B, D, F, H	6
$I_{ph} = 5 A^{1)}$, $I_e = 1 A^{1)}$ (min. = 0.05 A) Position 15 only with A, C, E, G	7
Rated auxiliary voltage (power supply, indication voltage)	
DC 24 to 48 V, threshold binary input DC 19 V ³⁾	2
DC 60 to 125 V ²⁾ , threshold binary input DC 19 V ³⁾	4
DC 110 to 250 V ²⁾ , AC 115 to 230 V ⁴⁾ , threshold binary input DC 88 V ³⁾	5
DC 110 to 250 V ²⁾ , AC 115 to 230 V ⁴⁾ , threshold binary input DC 176 V ³⁾	6
Unit version	
For panel surfacemounting, two-tier terminal top/bottom	B
For panel flushmounting, plug-in terminal (2/3 pin connector)	D
For panel flushmounting, screw-type terminal (direct connection / ring-type cable lugs)	E
Region-specific default settings/function versions and language settings	
Region DE, 50 Hz, IEC, language: German, selectable	A
Region World, 50/60 Hz, IEC/ANSI, language: English (GB), selectable	B
Region US, 60 Hz, ANSI, language: English (US), selectable	C
Region FR, 50/60 Hz, IEC/ANSI, language: French, selectable	D
Region World, 50/60 Hz, IEC/ANSI, language: Spanish, selectable	E
Region IT, 50/60 Hz, IEC/ANSI, language: Italian, selectable	F
Region RU, 50/60 Hz, IEC/ANSI, language: Russian, selectable	G
System interface (Port B): Refer to page 5/114	
No system interface	0
Protocols see page 5/114	
Service interface (Port C)	
No interface at rear side	0
DIGSI 4 / modem, electrical RS232	1
DIGSI 4 / modem / RTD-box ⁵⁾ , electrical RS485	2
DIGSI 4 / modem / RTD-box ⁵⁾⁶⁾ , optical 820 nm wavelength, ST connector	3
Measuring / fault recording	
Fault recording	1
Slave pointer, mean values, min/max values, fault recording	3

See next page

- 1) Rated current can be selected by means of jumpers.
- 2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.
- 3) The binary input thresholds can be selected per binary input by means of jumpers.
- 4) AC 230 V, starting from device version .../EE.

- 5) Temperature monitoring box 7XV5662-□AD10, refer to "Accessories".
- 6) When using the temperature monitoring box at an optical interface, the additional RS485 fiber-optic converter 7XV5650-0□A00 is required.
- 7) Starting from device version .../GG and FW-Version V4.82

Overcurrent Protection / 7SJ62

Selection and ordering data

Description			Order No.	Order code
7SJ62 multifunction protection relay			7SJ62 □□-□□□□□□-□□□□	
Designation	ANSI No.	Description		
Basic version		Control		
	50/51	Overcurrent protection $I>$, $I>>$, $I>>>$, I_p		
	50N/51N	Ground-fault protection $I_{E>}$, $I_{E>>}$, $I_{E>>>}$, I_{EP}		
	50N/51N	Insensitive ground-fault protection via IEE function: $I_{EE>}$, $I_{EE>>}$, $I_{EEP}^{1)}$		
	50/50N	Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I_{2>}$, $I>>>>$, $I_{E>>>>}$		
	51 V	Voltage-dependent inverse-time overcurrent protection		
	49	Overload protection (with 2 time constants)		
	46	Phase balance current protection (negative-sequence protection)		
	37	Undercurrent monitoring		
	47	Phase sequence		
	59N/64	Displacement voltage		
	50BF	Breaker failure protection		
	74TC	Trip circuit supervision		
		4 setting groups, cold-load pickup		
		Inrush blocking		
	86	Lockout		
■	V, P, f	27/59 Under-/overvoltage 810/U Under-/overfrequency 27/Q Undervoltage-controlled reactive power protection ³⁾ 27/47/59(N) Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		F E
■	IEF V, P, f	27/59 Under-/overvoltage 810/U Under-/overfrequency 27/Q Undervoltage-controlled reactive power protection ³⁾ 27/47/59(N) Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection Intermittent ground fault		P E
■	Dir	67/67N Direction determination for overcurrent, phases and ground		F C
■	Dir V, P, f	67/67N Direction determination for overcurrent, phases and ground 27/59 Under-/overvoltage 810/U Under-/overfrequency 27/Q Undervoltage-controlled reactive power protection ³⁾ 27/47/59(N) Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		F G
■	Dir IEF	67/67N Direction determination for overcurrent, phases and ground Intermittent ground fault		P C
■	Dir V,P,f IEF	67/67N Direction determination for overcurrent, phases and ground Intermittent ground fault protection 27/59 Under-/overvoltage 81U/O Under-/overfrequency 27/Q Undervoltage-controlled reactive power protection ³⁾ 27/47/59(N) Flexible protection functions (quantities derived from current & voltages): 32/55/81R Voltage-/power-/p.f.-/rate of freq. change-protection Intermittent ground-fault		P G
Sens.ground-f.det.	67/67N	Direction determination for overcurrent, phases and ground		
■ Dir REF	67Ns	Directional sensitive ground-fault detection		
	67Ns	Directional intermittent ground fault protection ³⁾		
	87N	High-impedance restricted ground fault		F D ²⁾

Continued on next page

■ Basic version included

V, P, f = Voltage, power, frequency protection

Dir = Directional overcurrent protection

IEF = Intermittent ground fault

1) 50N/51N only with insensitive ground-current transformer when position 7 = 1, 5, 7.

2) Sensitive ground-current transformer only when position 7 = 2, 6.

3) available beginning with FW / Parameterset-version V4.90

Overcurrent Protection / 7SJ62

Selection and ordering data

5

Description			Order No.	Order code
7SJ62 multifunction protection relay			7SJ62	□□□□□□□□□□□□□□□□
Designation	ANSI No.	Description		
Basic version		Control		
	50/51	Overcurrent protection $I>$, $I>>$, $I>>>$, I_p		
	50N/51N	Ground-fault protection $I_{E>}$, $I_{E>>}$, $I_{E>>>}$, I_{Ep}		
	50N/51N	Insensitive ground-fault protection via IEE function: $I_{EE>}$, $I_{EE>>}$, $I_{EEp}^{1)}$		
	50/50N	Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I_{2>}$, $I_{>>>>}$, $I_{E>>>>}$		
	51 V	Voltage-dependent inverse-time overcurrent protection		
	49	Overload protection (with 2 time constants)		
	46	Phase balance current protection (negative-sequence protection)		
	37	Undercurrent monitoring		
	47	Phase sequence		
	59N/64	Displacement voltage		
	50BF	Breaker failure protection		
	74TC	Trip circuit supervision, 4 setting groups, cold-load pickup		
	86	Lockout		F F ²⁾
Sens. ground-f. det. V, P, f REF	67Ns	Directional sensitive ground-fault detection		
■	67Ns	Directional intermittent ground fault protection ³⁾		
	87N	High-impedance restricted ground fault		
	27/59	Under-/overvoltage		
	810/U	Under-/overfrequency		
	27/Q	Undervoltage-controlled reactive power protection ³⁾		
	27/47/59(N)	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		P D ²⁾
Sens. ground-f. det. Dir IEF REF	67/67N	Direction determination for overcurrent, phases and ground		
■	67Ns	Directional sensitive ground-fault detection		
	67Ns	Directional intermittent ground fault protection ³⁾		
	87N	High-impedance restricted ground fault		
	87N	Intermittent ground faults		
Sens. ground-f. det. REF	67Ns	Directional sensitive ground-fault detection		
■	67Ns	Directional intermittent ground fault protection ³⁾		
	87N	High-impedance restricted ground fault		F B ²⁾
Sens. ground-f. det. Motor V, P, f REF	67Ns	Directional sensitive ground-fault detection		
■	67Ns	Directional intermittent ground fault protection ³⁾		
	87N	High-impedance restricted ground fault		
	48/14	Starting time supervision, locked rotor		
	66/86	Restart inhibit		
	51M	Load jam protection, motor statistics		
	27/59	Under-/overvoltage		
	810/U	Under-/overfrequency		
	27/Q	Undervoltage-controlled reactive power protection ³⁾		
	27/47/59(N)	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		H F ²⁾
Sens. ground-f. det. Motor Dir V, P, f REF	67/67N	Direction determination for overcurrent, phases and ground		
	67Ns	Directional sensitive ground-fault detection		
	67Ns	Directional intermittent ground fault protection ³⁾		
	87N	High-impedance restricted ground fault		
	48/14	Starting time supervision, locked rotor		
	66/86	Restart inhibit		
	51M	Load jam protection, motor statistics		
	27/59	Under-/overvoltage		
	810/U	Under-/overfrequency		
	27/Q	Undervoltage-controlled reactive power protection ³⁾		
	27/47/59(N)	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		H H ²⁾
■ Basic version included		1) 50N/51N only with insensitive ground-current transformer when position 7 = 1, 5, 7.		
V, P, f = Voltage, power, frequency protection		2) Sensitive ground-current transformer only when position 7 = 2, 6.		
Dir = Directional overcurrent protection		3) available beginning with FW / Parameterset-version V4.90		
IEF = Intermittent ground fault				

Continued on next page

Overcurrent Protection/7SJ62

Selection and ordering data

Description			Order No.	Order code
7SJ62 multifunction protection relay			7SJ62 □□-□□□□□□-□□□□	
Designation	ANSI No.	Description		
Basic version		Control		
	50/51	Overcurrent protection $I>$, $I>>$, $I>>>$, I_p		
	50N/51N	Ground-fault protection $I_{E>}$, $I_{E>>}$, $I_{E>>>}$, I_{Ep}		
	50N/51N	Insensitive ground-fault protection via IEE function: $I_{EE>}$, $I_{EE>>}$, $I_{EEp}^{1)}$		
	50/50N	Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection, stages $I_{2>}$, $I_{2>>>}$, $I_{E>>>>}$		
	51 V	Voltage-dependent inverse-time overcurrent protection		
	49	Overload protection (with 2 time constants)		
	46	Phase balance current protection (negative-sequence protection)		
	37	Undercurrent monitoring		
	47	Phase sequence		
	59N/64	Displacement voltage		
	50BF	Breaker failure protection		
	74TC	Trip circuit supervision 4 setting groups, cold-load pickup		
	86	Inrush blocking Lockout		
Sens. ground-f. det. Motor IEF	67/67N	Direction determination for overcurrent, phases and ground		
Dir IEF V,P,f REF	67Ns	Directional sensitive ground-fault detection		
■	67Ns	Directional intermittent ground fault protection ⁵⁾		
	87N	High-impedance restricted ground fault Intermittent ground fault		
	48/14	Starting time supervision, locked rotor		
	66/86	Restart inhibit		
	51M	Load jam protection, motor statistics		
	27/59	Undervoltage/overvoltage		
	81O/U	Underfrequency/overfrequency		
	27/Q	Undervoltage-controlled reactive power protection ⁵⁾		
	27/47/59(N)	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		R H ²⁾
■ Motor V, P, f	67/67N	Direction determination for overcurrent, phases and ground		
Dir	48/14	Starting time supervision, locked rotor		
	66/86	Restart inhibit		
	51M	Load jam protection, motor statistics		
	27/59	Under-/overvoltage		
	81O/U	Under-/overfrequency		
	27/Q	Undervoltage-controlled reactive power protection ⁵⁾		
	27/47/59(N)	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		H G
■ Motor	48/14	Starting time supervision, locked rotor		
	66/86	Restart inhibit		
	51M	Load jam protection, motor statistics		H A
ARC, fault locator, synchro-check		Without		0
	79	With auto-reclosure		1
	21FL	With fault locator		2
	79, 21FL	With auto-reclosure, with fault locator		3
	25	With synchro-check ³⁾		4 ⁴⁾
	25, 79,21FL	With synchro-check ³⁾ , auto-reclosure, fault locator		7 ⁴⁾

■ Basic version included

V, P, f = Voltage, power, frequency protection

Dir = Directional overcurrent protection

IEF = Intermittent ground fault

1) 50N/51N only with insensitive ground-current transformer when position 7 = 1, 5, 7.

2) Sensitive ground-current transformer only when position 7 = 2, 6.

3) Synchro-check (no asynchronous switching), one function group; available only with devices 7SJ623 and 7SJ624

4) Ordering option only available for devices 7SJ623 and 7SJ624

5) available beginning with FW / Parameterset-version V4.90

Overcurrent Protection / 7SJ62

Selection and ordering data

5

Description	Order No.	Order code
7SJ62 multifunction protection relay	7SJ62 □□-□□□□□□-□□□□□□-□□□□	
System interface (on rear of unit, Port B)		
No system interface	0	
IEC 60870-5-103 protocol, RS232	1	
IEC 60870-5-103 protocol, RS485	2	
IEC 60870-5-103 protocol, 820 nm fiber, ST connector	3	
PROFIBUS-FMS Slave, RS485	4	
PROFIBUS-FMS Slave, 820 nm wavelength, single ring, ST connector ¹⁾	5	
PROFIBUS-FMS Slave, 820 nm wavelength, double ring, ST connector ¹⁾	6	
PROFIBUS-DP Slave, RS485	9	L O A
PROFIBUS-DP Slave, 820 nm wavelength, double ring, ST connector ¹⁾	9	L O B
MODBUS, RS485	9	L O D
MODBUS, 820 nm wavelength, ST connector ²⁾	9	L O E
DNP 3.0, RS485	9	L O G
DNP 3.0, 820 nm wavelength, ST connector ²⁾	9	L O H
IEC 60870-5-103 protocol, redundant, RS485, RJ45 connector ²⁾	9	L O P
IEC 61850, 100 Mbit Ethernet, electrical, double, RSJ45 connector (EN 100)	9	L O R
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector (EN 100)2)	9	L O S
DNP3 TCP + IEC 61850, 100Mbit Eth, electrical, double, RJ45 connector ³⁾	9	L 2 R
DNP3 TCP + IEC 61850, 100Mbit Eth, optical, double, LC connector ³⁾	9	L 2 S
PROFINET + IEC 61850, 100Mbit Eth, electrical, double, RJ45 connector ³⁾	9	L 3 R
PROFINET + IEC 61850, 100Mbit Eth, optical, double, LC connector ³⁾	9	L 3 S

1) Not with position 9 = "B"; if 9 = "B", please order 7SJ6 unit with RS485 port and separate fiber-optic converters.
 For single ring, please order converter 6GK1502-3AB10, not available with position 9 = "B".
 For double ring, please order converter 6GK1502-4AB10, not available with position 9 = "B".
 The converter requires a AC 24 V power supply (e.g. power supply 7XV5810-0BA00).

2) Not available with position 9 = "B".

3) available with V4.9

Sample order

Position	Order No. + Order code
	7SJ622 5 - 5 E C 9 1 - 3 F A 1 + L O G
6 I/O's: 11 BI/6 BO, 1 live status contact	2
7 Current transformer: 5 A	5
8 Power supply: DC 110 to 250 V, AC 115 V to AC 230 V	5
9 Unit version: Flush-mounting housing, screw-type terminals	E
10 Region: US, English language (US); 60 Hz, ANSI	C
11 Communication: System interface: DNP 3.0, RS485	9
12 Communication: DIGSI 4, electric RS232	1
13 Measuring/fault recording: Extended measuring and fault records	3
14/15 Protection function package: Basic version plus directional TOC	F C
16 With auto-reclosure	1










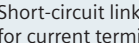
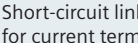
Overcurrent Protection/7SJ62

Selection and ordering data

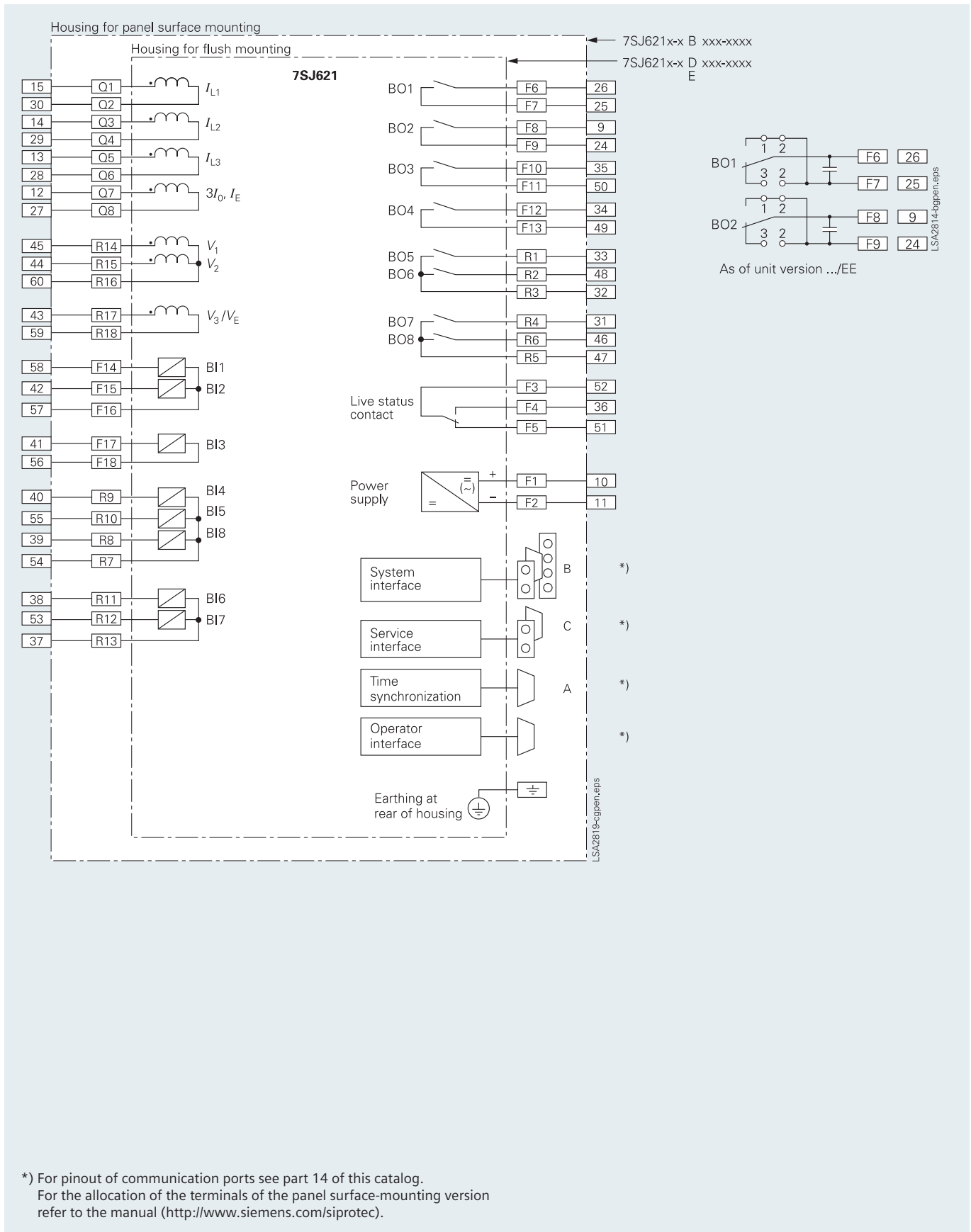
Accessories	Description	Order No.
	DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
	Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
	Professional + IEC 61850 Complete version: DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for control displays), DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	7XS5403-0AA00
	IEC 61850 System configurator Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM	7XS5460-0AA00
	SIGRA 4 Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000 or XP Professional Edition. (generally contained in DIGSI Professional, but can be ordered additionally) Authorization by serial number. On CD-ROM.	7XS5410-0AA00
	Temperature monitoring box AC/DC 24 to 60 V	7XV5662-2AD10
	AC/DC 90 to 240 V	7XV5662-5AD10
	Varistor/Voltage Arrester Voltage arrester for high-impedance REF protection 125 Vrms; 600 A; 1S/S 256	C53207-A401-D76-1
	240 Vrms; 600 A; 1S/S 1088	C53207-A401-D77-1
	Connecting cable Cable between PC/notebook (9-pin con.) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	7XV5100-4
	Cable between temperature monitoring box and SIPROTEC 4 unit - length 5 m / 16.4 ft	7XV5103-7AA05
	- length 25 m / 82 ft	7XV5103-7AA25
	- length 50 m / 164 ft	7XV5103-7AA50
	Manual for 7SJ62 English	C53000-G1140-C207-x ¹⁾
	German	C53000-G1100-C207-6
	1) x = please inquire for latest edition (exact Order No.).	

Overcurrent Protection / 7SJ62

Selection and ordering data

Accessories	Description	Order No.	Size of package	Supplier
  Mounting rail	Terminal safety cover			
	Voltage/current terminal 18-pole/12-pole	C73334-A1-C31-1	1	Siemens
  2-pin connector	Voltage/current terminal 12-pole/8-pole	C73334-A1-C32-1	1	Siemens
	Connector 2-pin	C73334-A1-C35-1	1	Siemens
	Connector 3-pin	C73334-A1-C36-1	1	Siemens
	 Crimp connector CI2 0.5 to 1 mm ²		0-827039-1	4000 taped on reel
 3-pin connector	Crimp connector CI2 0.5 to 1 mm ²	0-827396-1	1	AMP ¹⁾
	Crimp connector: Type III+ 0.75 to 1.5 mm ²	0-163084-2	1	AMP ¹⁾
 Short-circuit links for current terminals	Crimp connector: Type III+ 0.75 to 1.5 mm ²	0-163083-7	4000 taped on reel	AMP ¹⁾
	 Short-circuit links for current terminals		0-539635-1	1
 Short-circuit links for current terminals	Crimping tool for Type III+ and matching female	0-539668-2	1	AMP ¹⁾
	Crimping tool for CI2 and matching female	0-734372-1	1	AMP ¹⁾
 Short-circuit links for current terminals	Short-circuit links for current terminals	1-734387-1	1	AMP ¹⁾
	Short-circuit links for other terminals	C73334-A1-C33-1	1	Siemens
 Short-circuit links for current terminals	Short-circuit links for other terminals	C73334-A1-C34-1	1	Siemens
	Mounting rail for 19" rack	C73165-A63-D200-1	1	Siemens

1) Your local Siemens representative can inform you on local suppliers.



*) For pinout of communication ports see part 14 of this catalog.
 For the allocation of the terminals of the panel surface-mounting version refer to the manual (<http://www.siemens.com/siprotec>).

Fig. 5/101 7SJ621 connection diagram

Overcurrent Protection / 7SJ62

Connection diagram

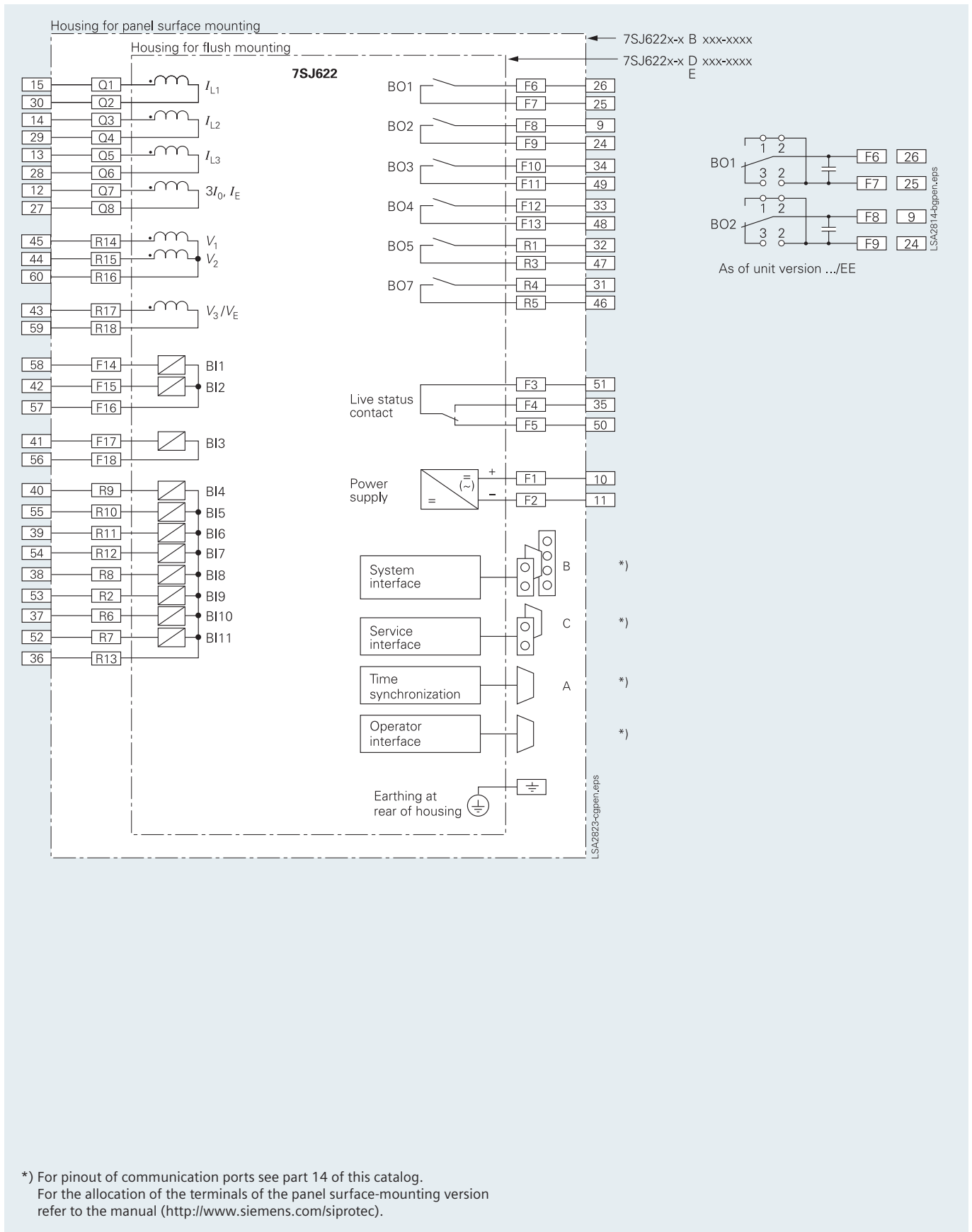


Fig. 5/102 7SJ622 connection diagram

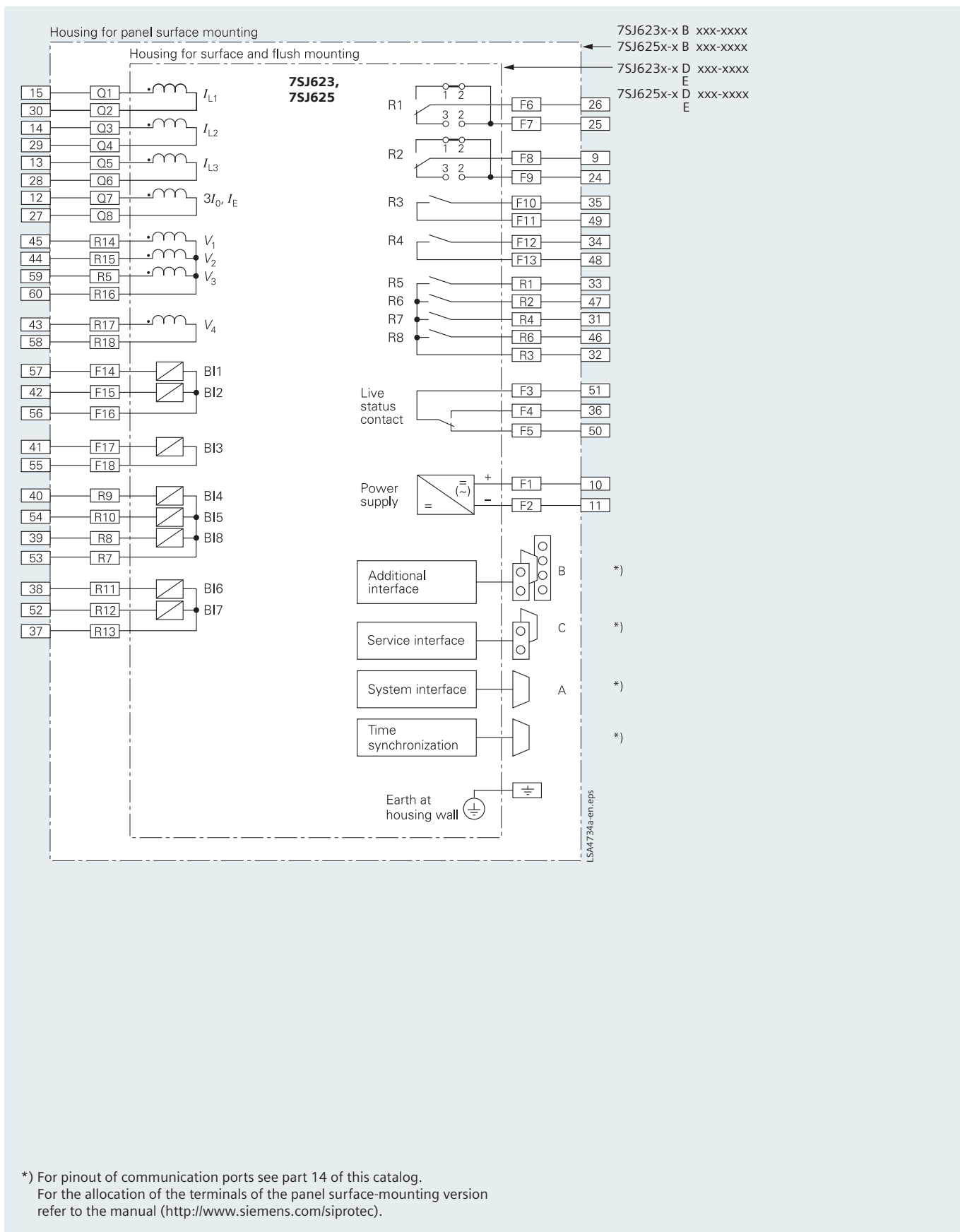


Fig. 5/103 7SJ623, 7SJ625 connection diagram

Overcurrent Protection / 7SJ62

Connection diagram

5

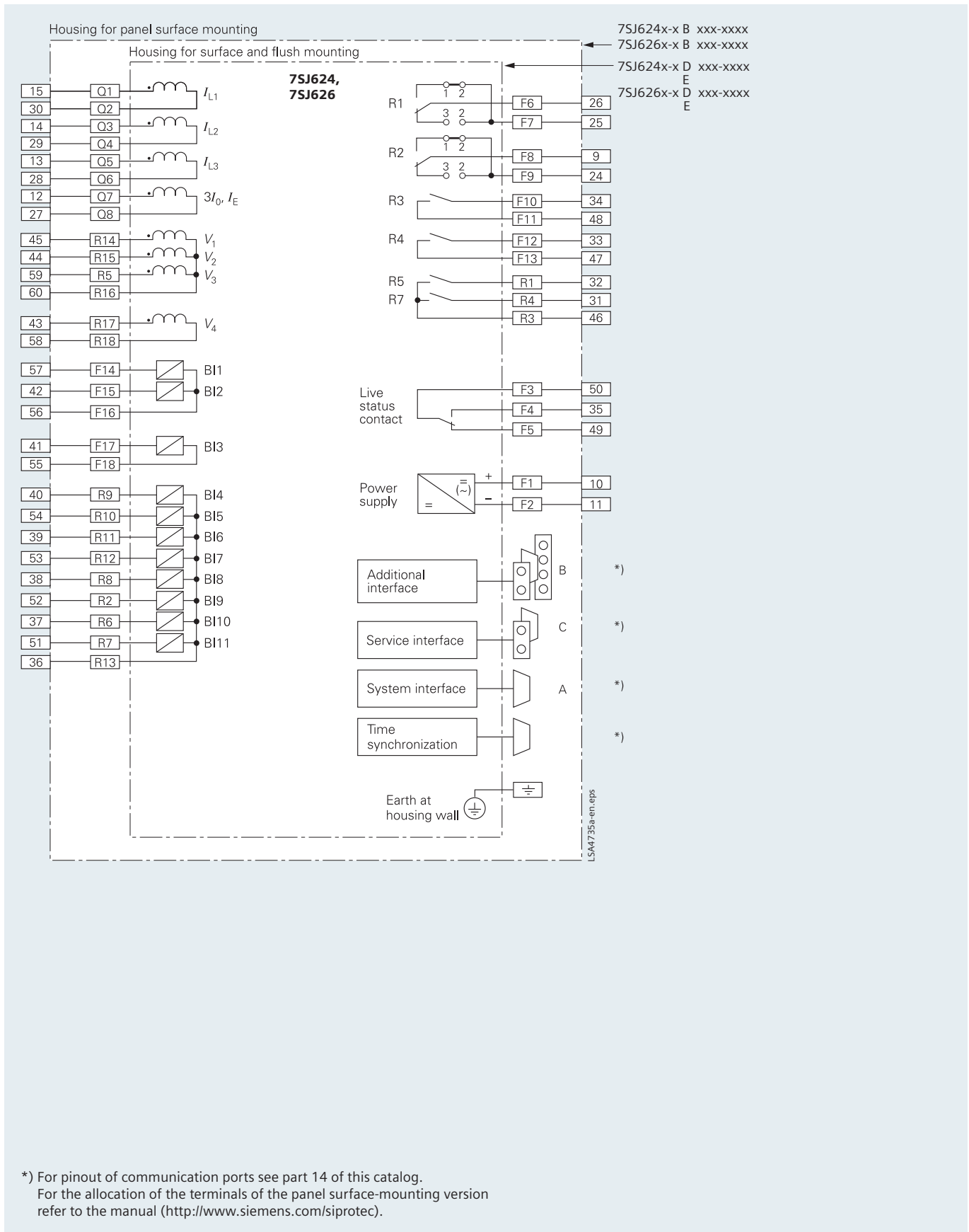


Fig. 5/104 7SJ624, 7SJ626 connection diagram

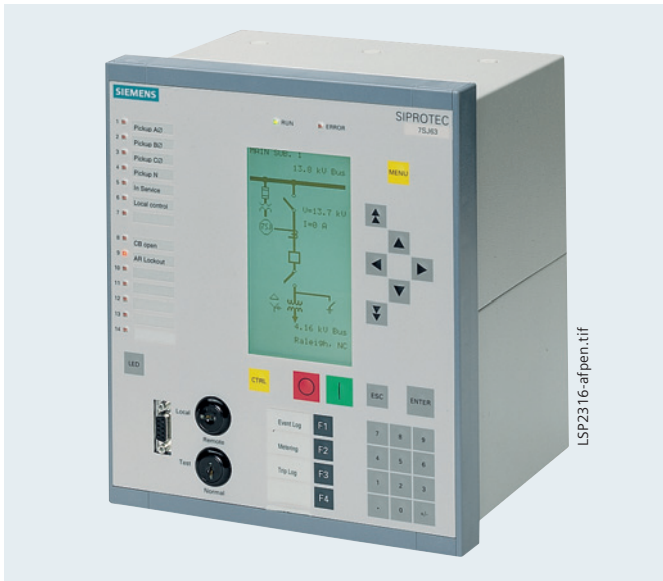


Fig. 5/105 SIPROTEC 4 7SJ63 multifunction protection relay

Description

The SIPROTEC 4 7SJ63 can be used as a protective control and monitoring relay for distribution feeders and transmission lines of any voltage in networks that are earthed (grounded), low-resistance grounded, ungrounded, or of a compensated neutral point structure. The relay is suited for networks that are radial or looped, and for lines with single or multi-terminal feeds. Regarding the time-overcurrent/directional overcurrent protection the characteristics can be either definite time, inverse time or user-defined.

The SIPROTEC 4 7SJ63 is equipped with motor protection applicable for asynchronous machines of all sizes. Motor protection comprises undercurrent monitoring, starting time supervision, restart inhibit, locked rotor.

The relay provides easy-to-use local control and automation functions. The number of controllable switchgear depends only on the number of available inputs and outputs. The integrated programmable logic (CFC) allows the user to implement their own functions, e.g. for the automation of switchgear (interlocking). The user is able to generate user-defined messages as well.

Function overview

Protection functions

- Overcurrent protection (definite-time/inverse-time/user-def.)
- Directional overcurrent protection (definite-time/inverse-time/user-def.)
- Sensitive dir./non-dir. ground-fault detection
- Displacement voltage
- Intermittent ground-fault protection
- High-impedance restricted ground fault
- Inrush restraint
- Motor protection
- Overload protection
- Temperature monitoring
- Under-/overvoltage protection
- Under-/overfrequency protection
- Breaker failure protection
- Negative-sequence protection
- Phase-sequence monitoring
- Auto-reclosure
- Fault locator
- Lockout

Control functions/programmable logic

- Flexible number of switching devices
- Position of switching elements is shown on the graphic display
- Local/remote switching via key-operated switch
- Control via keyboard, binary inputs, DIGSI 4 or SCADA system
- Extended user-defined logic with CFC (e.g. interlocking)

Monitoring functions

- Operational measured values V , I , f , ...
- Energy metering values W_p , W_q
- Circuit-breaker wear monitoring
- Slave pointer
- Trip circuit supervision
- Fuse failure monitor
- 8 oscillographic fault records

Communication interfaces

- System interface
 - IEC 60870-5-103, IEC 61850
 - PROFIBUS-FMS I-DP
 - DNP 3.0 / MODBUS RTU
- Service interface for DIGSI 4 (modem)
- Front interface for DIGSI 4
- Time synchronization via IRIG-B/DCF77

Overcurrent Protection / 7SJ63

Application

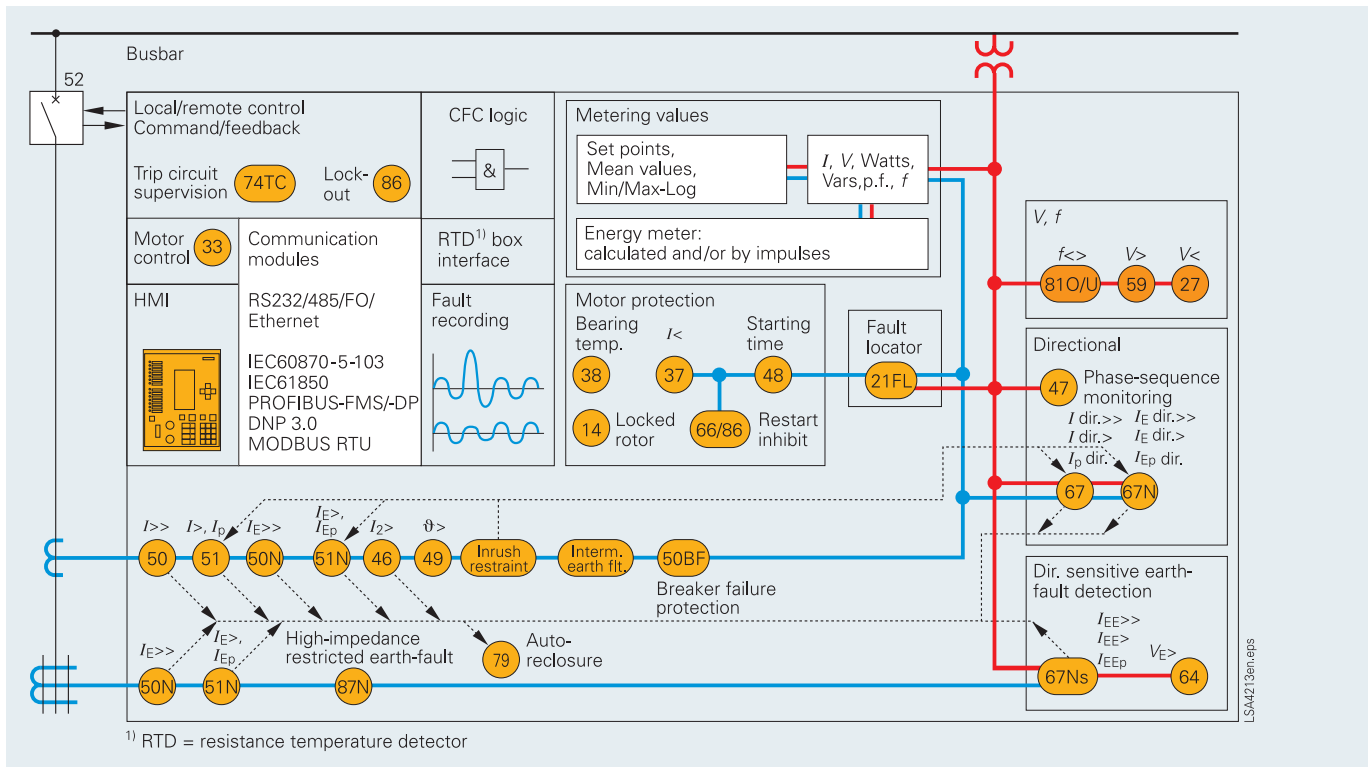


Fig. 5/106 Function diagram

Application

The SIPROTEC 4 7SJ63 unit is a numerical protection relay that also performs control and monitoring functions and therefore supports the user in cost-effective power system management, and ensures reliable supply of electric power to the customers. Local operation has been designed according to ergonomic criteria. A large, easy-to-read graphic display was a major design aim.

Control

The integrated control function permits control of disconnect devices (electrically operated/motorized switches) or circuit-breakers via the integrated operator panel, binary inputs, DIGSI 4 or the control and protection system (e.g. SICAM). The present status (or position) of the primary equipment can be displayed. 7SJ63 supports substations with single and duplicate busbars. The number of elements that can be controlled (usually 1 to 5) is only restricted by the number of inputs and outputs available. A full range of command processing functions is provided.

Programmable logic

The integrated logic characteristics (CFC) allow the user to implement their own functions for automation of switchgear (interlocking) or a substation via a graphic user interface. The user can also generate user-defined messages.

Line protection

The 7SJ63 units can be used for line protection of high and medium-voltage networks with earthed (grounded), low-resistance grounded, isolated or compensated neutral point.

Motor protection

When protecting motors, the 7SJ63 relays are suitable for asynchronous machines of all sizes.

Transformer protection

The 7SJ63 units perform all functions of backup protection supplementary to transformer differential protection. The inrush suppression effectively prevents tripping by inrush currents.

The high-impedance restricted ground-fault protection detects short-circuits and insulation faults on the transformer.

Backup protection

The relays can be used universally for backup protection.

Metering values

Extensive measured values, limit values and metering values permit improved systems management.

ANSI	IEC	Protection functions
50, 50N	$I>$, $I>>$ $I_E>$, $I_E>>$	Definite-time overcurrent protection (phase/neutral)
50, 51V, 51N	I_p , I_{Ep}	Inverse overcurrent protection (phase/neutral), phase function with voltage-dependent option
67, 67N	$I_{dir}>$, $I_{dir}>>$, $I_{p\ dir}$ $I_{Edir}>$, $I_{Edir}>>$, $I_{p\ dir}$	Directional overcurrent protection (definite/inverse, phase/neutral), Directional comparison protection
67Ns/50Ns	$I_{EE}>$, $I_{EE}>>$, I_{EEp}	Directional/non-directional sensitive ground-fault detection
-		Cold load pick-up (dynamic setting change)
59N/64	V_E , $V_0>$	Displacement voltage, zero-sequence voltage
-	$I_{IE}>$	Intermittent ground fault
87N		High-impedance restricted ground-fault protection
50BF		Breaker failure protection
79		Auto-reclosure
46	$I_2>$	Phase-balance current protection (negative-sequence protection)
47	$V_2>$, phase seq.	Unbalance-voltage protection and/or phase-sequence monitoring
49	$\vartheta>$	Thermal overload protection
48		Starting time supervision
14		Locked rotor protection
66/86		Restart inhibit
37	$I<$	Undercurrent monitoring
38		Temperature monitoring via external device (RTD-box), e.g. bearing temperature monitoring
27, 59	$V<$, $V>$	Undervoltage/overvoltage protection
81O/U	$f>$, $f<$	Overfrequency/underfrequency protection
21FL		Fault locator

Overcurrent Protection / 7SJ63

Construction

Construction

Connection techniques and housing with many advantages

½ and ¼-rack sizes

These are the available housing widths of the 7SJ63 relays, referred to a 19" module frame system. This means that previous models can always be replaced. The height is a uniform 244 mm for flush-mounting housings and 266 mm for surface-mounting housings for all housing widths. All cables can be connected with or without ring lugs. Plug-in terminals are available as an option.

It is thus possible to employ prefabricated cable harnesses. In the case of surface mounting on a panel, the connection terminals are located above and below the housing. The communication interfaces are located in a sloped case at the top and bottom of the housing. The housing can also be supplied optionally with a detached operator panel (refer to Fig. 5/109), or without operator panel, in order to allow optimum operation for all types of applications.

5

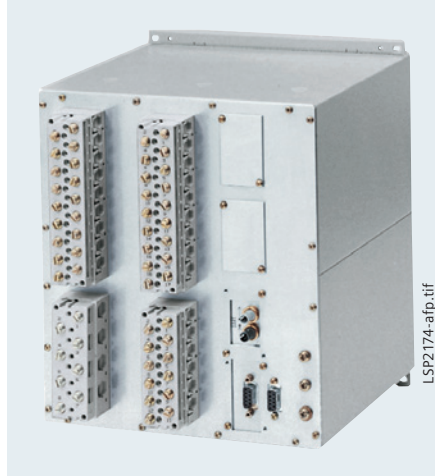


Fig. 5/107 Flush-mounting housing with screw-type terminals

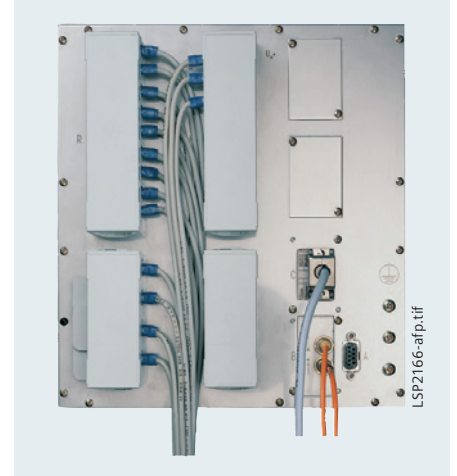


Fig. 5/108 Rear view of flush-mounting housing with covered connection terminals and wirings

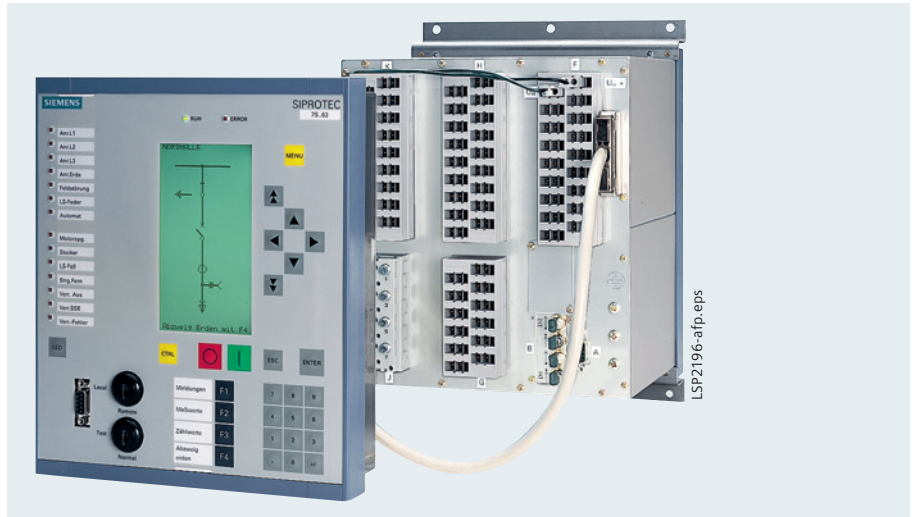


Fig. 5/109 Housing with plug-in terminals and detached operator panel



Fig. 5/110 Surface-mounting housing with screw-type terminals



Fig. 5/111 Communication interfaces in a sloped case in a surface-mounting housing

Protection functions

Overcurrent protection (ANSI 50, 50N, 51, 51N)

This function is based on the phase-selective measurement of the three phase currents and the ground current (four transformers). Two definite-time overcurrent protection elements (DMT) exist both for the phases and for the ground. The current threshold and the delay time can be set within a wide range. In addition, inverse-time overcurrent protection characteristics (IDMTL) can be activated.

Reset characteristics

For easier time coordination with electro-mechanical relays, reset characteristics according to ANSI C37.112 and IEC 60255-3/BS 142 standards are applied.

When using the reset characteristic (disk emulation), a reset process is initiated after the fault current has disappeared. This reset process corresponds to the reverse movement of the Ferraris disk of an electromechanical relay (thus: disk emulation).

User-definable characteristics

Instead of the predefined time characteristics according to ANSI, tripping characteristics can be defined by the user for phase and ground units separately. Up to 20 current/time value pairs may be programmed. They are set as pairs of numbers or graphically in DIGSI 4.

Inrush restraint

The relay features second harmonic restraint. If the second harmonic is detected during transformer energization, pickup of non-directional and directional normal elements are blocked.

Cold load pickup/dynamic setting change

For directional and non-directional overcurrent protection functions the initiation thresholds and tripping times can be switched via binary inputs or by time control.

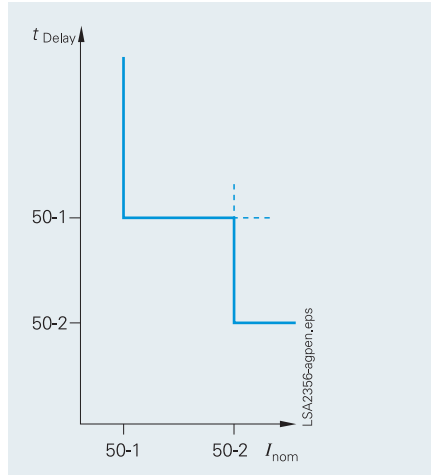


Fig. 5/112 Definite-time overcurrent protection

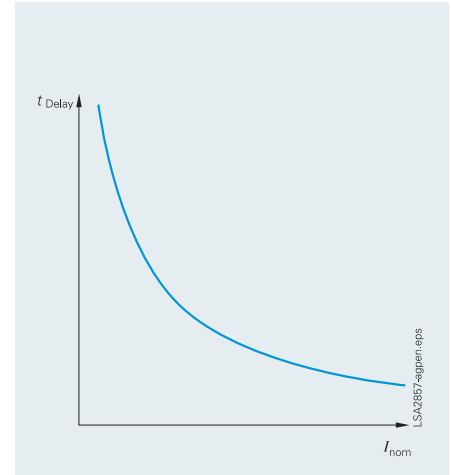


Fig. 5/113 Inverse-time overcurrent protection

Available inverse-time characteristics

Characteristics acc. to	ANSI/IEEE	IEC 60255-3
Inverse	•	•
Short inverse	•	
Long inverse	•	•
Moderately inverse	•	
Very inverse	•	•
Extremely inverse	•	•

Overcurrent Protection / 7SJ63

Protection functions

Directional overcurrent protection (ANSI 67, 67N)

Directional phase and ground protection are separate functions. They operate in parallel to the non-directional overcurrent elements. Their pickup values and delay times can be set separately. Definite-time and inverse-time characteristic is offered. The tripping characteristic can be rotated about ± 180 degrees.

By means of voltage memory, directionality can be determined reliably even for close-in (local) faults. If the switching device closes onto a fault and the voltage is too low to determine direction, directionality (directional decision) is made with voltage from the voltage memory. If no voltage exists in the memory, tripping occurs according to the coordination schedule.

For ground protection, users can choose whether the direction is to be determined via zero-sequence system or negative-sequence system quantities (selectable). Using negative-sequence variables can be advantageous in cases where the zero voltage tends to be very low due to unfavorable zero-sequence impedances.

Directional comparison protection (cross-coupling)

It is used for selective protection of sections fed from two sources with instantaneous tripping, i.e. without the disadvantage of time coordination. The directional comparison protection is suitable if the distances between the protection stations are not significant and pilot wires are available for signal transmission. In addition to the directional comparison protection, the directional coordinated overcurrent protection is used for complete selective backup protection. If operated in a closed-circuit connection, an interruption of the transmission line is detected.

(Sensitive) directional ground-fault detection (ANSI 64, 67Ns, 67N)

For isolated-neutral and compensated networks, the direction of power flow in the zero sequence is calculated from the zero-sequence current I_0 and zero-sequence voltage V_0 . For networks with an isolated neutral, the reactive current component is evaluated; for compensated networks, the active current component or residual resistive current is evaluated. For special network conditions, e.g. high-resistance grounded networks with ohmic-capacitive ground-fault current or low-resistance grounded networks with ohmic-inductive current, the tripping characteristics can be rotated approximately ± 45 degrees.

Two modes of ground-fault direction detection can be implemented: tripping or "signalling only mode".

It has the following functions:

- TRIP via the displacement voltage V_E .
- Two instantaneous elements or one instantaneous plus one user-defined characteristic.
- Each element can be set in forward, reverse, or non-directional.
- The function can also be operated in the insensitive mode as an additional short-circuit protection.

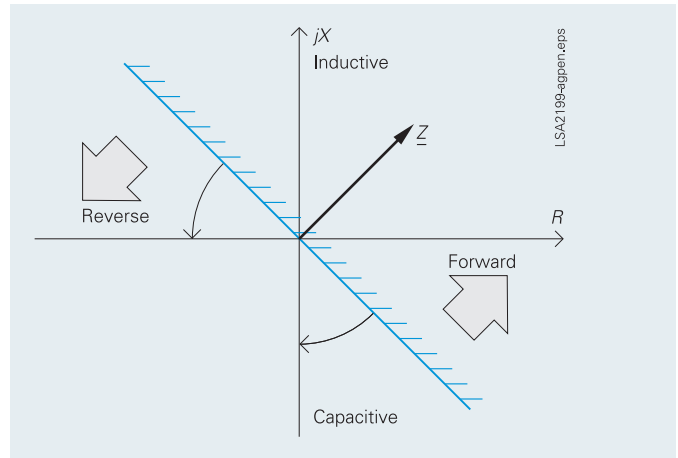


Fig. 5/114 Directional characteristic of the directional overcurrent protection

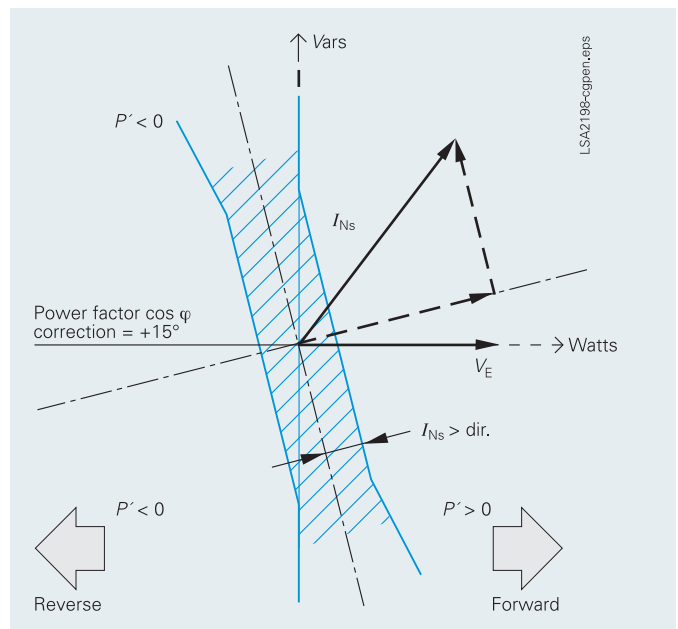


Fig. 5/115 Directional determination using cosine measurements for compensated networks

(Sensitive) ground-fault detection (ANSI 50Ns, 51Ns / 50N, 51N)

For high-resistance grounded networks, a sensitive input transformer is connected to a phase-balance neutral current transformer (also called core-balance CT).

The function can also be operated in the insensitive mode as an additional short-circuit protection.

Intermittent ground-fault protection

Intermittent (re-striking) faults occur due to insulation weaknesses in cables or as a result of water penetrating cable joints. Such faults either simply cease at some stage or develop into lasting short-circuits. During intermittent activity, however, star-point resistors in networks that are impedance-grounded may undergo thermal overloading. The normal ground-fault pro-

tection cannot reliably detect and interrupt the current pulses, some of which can be very brief.

The selectivity required with intermittent ground faults is achieved by summing the duration of the individual pulses and by triggering when a (settable) summed time is reached. The response threshold I_{IE} evaluates the r.m.s. value, referred to one systems period.

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

In line protection, the two-element phase-balance current/negative-sequence protection permits detection on the high side of high-resistance phase-to-phase faults and phase-to-ground faults that are on the low side of a transformer (e.g. with the switch group Dy 5). This provides backup protection for high-resistance faults beyond the transformer.

Breaker failure protection (ANSI 50BF)

If a faulted portion of the electrical circuit is not disconnected upon issuance of a trip command, another command can be initiated using the breaker failure protection which operates the circuit-breaker, e.g. of an upstream (higher-level) protection relay. Breaker failure is detected if, after a trip command, current is still flowing in the faulted circuit. As an option, it is possible to make use of the circuit-breaker position indication.

High-impedance restricted ground-fault protection (ANSI 87N)

The high-impedance measurement principle is an uncomplicated and sensitive method for detecting ground faults, especially on transformers. It can also be applied to motors, generators and reactors when these are operated on an grounded network.

When the high-impedance measurement principle is applied, all current transformers in the protected area are connected in parallel and operated on one common resistor of relatively high R whose voltage is measured (see Fig. 5/116). In the case of 7SJ6 units, the voltage is measured by detecting the current through the (external) resistor R at the sensitive current measurement input I_{EE} . The varistor V serves to limit the voltage in the event of an internal fault. It cuts off the high momentary voltage spikes occurring at transformer saturation. At the same time, this results in smoothing of the voltage without any noteworthy reduction of the average value.

If no faults have occurred and in the event of external faults, the system is at equilibrium, and the voltage through the resistor is approximately zero. In the event of internal faults, an imbalance occurs which leads to a voltage and a current flow through the resistor R .

The current transformers must be of the same type and must at least offer a separate core for the high-impedance restricted ground-fault protection. They must in particular have the same transformation ratio and an approximately identical knee-point voltage. They should also demonstrate only minimal measuring errors.

Auto-reclosure (ANSI 79)

Multiple reclosures can be defined by the user and lockout will occur if a fault is present after the last reclosure. The following functions are possible:

- 3-pole ARC for all types of faults
- Separate settings for phase and ground faults

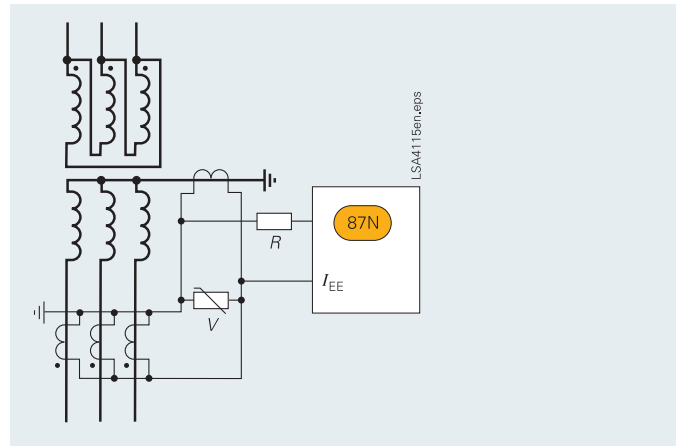


Fig. 5/116 High-impedance restricted ground-fault protection

- Multiple ARC, one rapid auto-reclosure (RAR) and up to nine delayed auto-reclosures (DAR)
- Starting of the ARC depends on the trip command selection (e.g. 46, 50, 51, 67)
- Blocking option of the ARC via binary inputs
- ARC can be initiated externally or via CFC
- The directional and non-directional elements can either be blocked or operated non-delayed depending on the auto-reclosure cycle
- Dynamic setting change of the directional and non-directional elements can be activated depending on the ready AR

Thermal overload protection (ANSI 49)

For protecting cables and transformers, an overload protection with an integrated pre-warning element for temperature and current can be applied. The temperature is calculated using a thermal homogeneous-body model (according to IEC 60255-8), which takes account both of the energy entering the equipment and the energy losses. The calculated temperature is constantly adjusted accordingly. Thus, account is taken of the previous load and the load fluctuations.

For thermal protection of motors (especially the stator) a further time constant can be set so that the thermal ratios can be detected correctly while the motor is rotating and when it is stopped. The ambient temperature or the temperature of the coolant can be detected serially via an external temperature monitoring box (resistance-temperature detector box, also called RTD-box). The thermal replica of the overload function is automatically adapted to the ambient conditions. If there is no RTD-box it is assumed that the ambient temperatures are constant.

Settable dropout delay times

If the devices are used in parallel with electromechanical relays in networks with intermittent faults, the long dropout times of the electromechanical devices (several hundred milliseconds) can lead to problems in terms of time grading. Clean time grading is only possible if the dropout time is approximately the same. This is why the parameter of dropout times can be defined for certain functions such as time-overcurrent protection, ground short-circuit and phase-balance current protection.

Overcurrent Protection / 7SJ63

Protection functions

■ Motor protection

Restart inhibit (ANSI 66/86)

If a motor is started up too many times in succession, the rotor can be subject to thermal overload, especially the upper edges of the bars. The rotor temperature is calculated from the stator current. The reclosing lockout only permits start-up of the motor if the rotor has sufficient thermal reserves for a complete start-up (see Fig. 5/117).

Emergency start-up

This function disables the reclosing lockout via a binary input by storing the state of the thermal replica as long as the binary input is active. It is also possible to reset the thermal replica to zero.

Temperature monitoring (ANSI 38)

Up to two temperature monitoring boxes with a total of 12 measuring sensors can be used for temperature monitoring and detection by the protection relay. The thermal status of motors, generators and transformers can be monitored with this device.

Additionally, the temperature of the bearings of rotating machines are monitored for limit value violation. The temperatures are being measured with the help of temperature detectors at various locations of the device to be protected. This data is transmitted to the protection relay via one or two temperature monitoring boxes (see "Accessories", page 5/153).

Starting time supervision (ANSI 48/14)

Starting time supervision protects the motor against long unwanted start-ups that might occur in the event of excessive load torque or excessive voltage drops within the motor, or if the rotor is locked. Rotor temperature is calculated from measured stator current. The tripping time is calculated according to the following equation:

for $I > I_{\text{MOTOR START}}$

$$t = \left(\frac{I_A}{I} \right)^2 \cdot T_A$$

- I = Actual current flowing
- $I_{\text{MOTOR START}}$ = Pickup current to detect a motor start
- t = Tripping time
- I_A = Rated motor starting current
- T_A = Tripping time at rated motor starting current

If the trip time is rated according to the above formula, even a prolonged start-up and reduced voltage (and reduced start-up current) will be evaluated correctly. The tripping time is inverse (current dependent).

A binary signal is set by a speed sensor to detect a blocked rotor. An instantaneous tripping is effected.

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

The negative-sequence / phase-balance current protection detects a phase failure or load unbalance due to network asymmetry and protects the rotor from impermissible temperature rise.

Undercurrent monitoring (ANSI 37)

With this function, a sudden drop in current, which can occur due to a reduced motor load, is detected. This may be due to shaft breakage, no-load operation of pumps or fan failure.

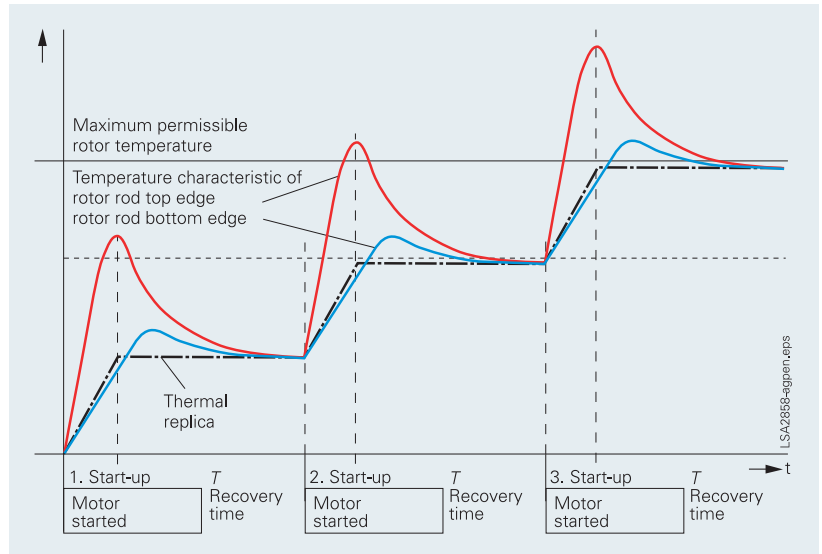


Fig. 5/117

■ Voltage protection

Overvoltage protection (ANSI 59)

The two-element overvoltage protection detects unwanted network and machine overvoltage conditions. The function can operate either with phase-to-phase voltage (default) or with the negative phase-sequence system voltage. Three-phase and single-phase connections are possible.

Undervoltage protection (ANSI 27)

The two-element undervoltage protection provides protection against dangerous voltage drops (especially for electric machines). Applications include the isolation of generators or motors from the network to avoid undesired operating states and a possible loss of stability. Proper operating conditions of electrical machines are best evaluated with the positive-sequence quantities. The protection function is active over a wide frequency range (45 to 55, 55 to 65 Hz)¹⁾. Even when falling below this frequency range the function continues to work, however, with a greater tolerance band.

The function can operate either with the positive phase-sequence system voltage (default) or with the phase-to-phase voltages, and can be monitored with a current criterion. Three-phase and single-phase connections are possible.

Frequency protection (ANSI 81O/U)

Frequency protection can be used for over-frequency and under-frequency protection. Electric machines and parts of the system are protected from unwanted speed deviations. Unwanted frequency changes in the network can be detected and the load can be removed at a specified frequency setting. Frequency protection can be used over a wide frequency range (45 to 55, 55 to 65 Hz)¹⁾. There are four elements (selectable as overfrequency or underfrequency) and each element can be delayed separately. Blocking of the frequency protection can be performed if using a binary input or by using an undervoltage element.

Fault locator (ANSI 21FL)

The fault locator specifies the distance to a fault location in kilometers or miles or the reactance of a second fault operation.

1) The 45 to 55, 55 to 65 Hz range is available for $f_N = 50/60$ Hz.

Circuit-breaker wear monitoring

Methods for determining circuit-breaker contact wear or the remaining service life of a circuit-breaker (CB) allow CB maintenance intervals to be aligned to their actual degree of wear. The benefit lies in reduced maintenance costs.

There is no mathematically exact method of calculating the wear or the remaining service life of circuit-breakers that takes into account the arc-chamber's physical conditions when the CB opens. This is why various methods of determining CB wear have evolved which reflect the different operator philosophies. To do justice to these, the devices offer several methods:

- ΣI
- ΣI^x , with $x = 1 \dots 3$

The devices additionally offer a new method for determining the remaining service life:

- Two-point method

The CB manufacturers double-logarithmic switching cycle diagram (see Fig. 5/118) and the breaking current at the time of contact opening serve as the basis for this method. After CB opening, the two-point method calculates the number of still possible switching cycles. To this end, the two points P1 and P2 only have to be set on the device. These are specified in the CB's technical data.

All of these methods are phase-selective and a limit value can be set in order to obtain an alarm if the actual value falls below or exceeds the limit value during determination of the remaining service life.

Customized functions (ANSI 32, 51V, 55, etc.)

Additional functions, which are not time critical, can be implemented via the CFC using measured values. Typical functions include reverse power, voltage controlled overcurrent, phase angle detection, and zero-sequence voltage detection.

Commissioning

Commissioning could hardly be easier and is fully supported by DIGSI 4. The status of the binary inputs can be read individually and the state of the binary outputs can be set individually. The operation of switching elements (circuit-breakers, disconnect devices) can be checked using the switching functions of the bay controller. The analog measured values are represented as wide-ranging operational measured values. To prevent transmission of information to the control center during maintenance, the bay controller communications can be disabled to prevent unnecessary data from being transmitted. During commissioning, all indications with test marking for test purposes can be connected to a control and protection system.

Test operation

During commissioning, all indications can be passed to an automatic control system for test purposes.

■ Control and automatic functions

Control

In addition to the protection functions, the SIPROTEC 4 units also support all control and monitoring functions that are required for operating medium-voltage or high-voltage substations.

The main application is reliable control of switching and other processes.

The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated to the 7SJ63 via binary inputs. Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a fault or intermediate circuit-breaker or auxiliary contact position.

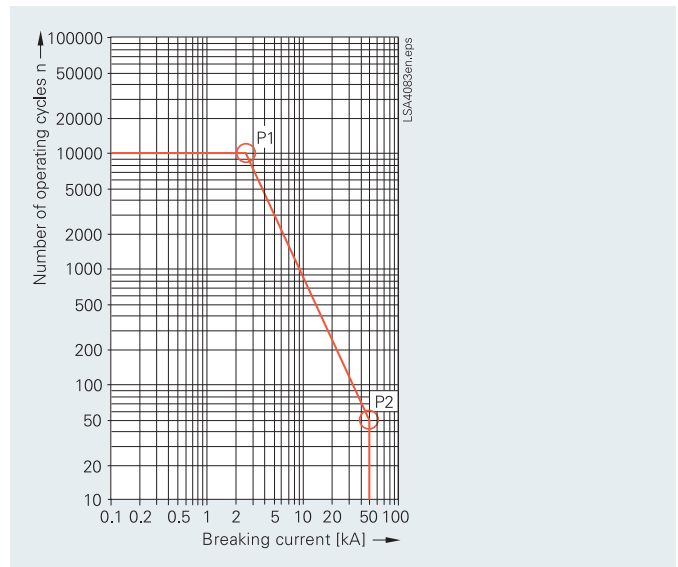


Fig. 5/118 CB switching cycle diagram

The switchgear or circuit-breaker can be controlled via:

- integrated operator panel
- binary inputs
- substation control and protection system
- DIGSI 4

Automation / user-defined logic

With integrated logic, the user can set, via a graphic interface (CFC), specific functions for the automation of switchgear or substation. Functions are activated via function keys, binary input or via communication interface.

Switching authority

Switching authority is determined according to parameters, communication or by key-operated switch (when available). If a source is set to "LOCAL", only local switching operations are possible. The following sequence of switching authority is laid down: "LOCAL"; DIGSI PC program, "REMOTE".

Key-operated switch

7SJ63 units are fitted with key-operated switch function for local/remote changeover and changeover between interlocked switching and test operation.

Command processing

All the functionality of command processing is offered. This includes the processing of single and double commands with or without feedback, sophisticated monitoring of the control hardware and software, checking of the external process, control actions using functions such as runtime monitoring and automatic command termination after output. Here are some typical applications:

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable bay interlocks
- Operating sequences combining several switching operations such as control of circuit-breakers, disconnectors and grounding switches
- Triggering of switching operations, indications or alarm by combination with existing information

Overcurrent Protection / 7SJ63

Functions

Functions

Motor control

The SIPROTEC 4 7SJ63 with high performance relays is well-suited for direct activation of the circuit-breaker, disconnector and grounding switch operating mechanisms in automated substations.

Interlocking of the individual switching devices takes place with the aid of programmable logic. Additional auxiliary relays can be eliminated. This results in less wiring and engineering effort.

Assignment of feedback to command

The positions of the circuit-breaker or switching devices and transformer taps are acquired by feedback. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication change is a consequence of switching operation or whether it is a spontaneous change of state.

Chatter disable

Chatter disable feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

Indication filtering and delay

Binary indications can be filtered or delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time. In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

A further indication (or a command) can be derived from an existing indication. Group indications can also be formed. The volume of information to the system interface can thus be reduced and restricted to the most important signals.

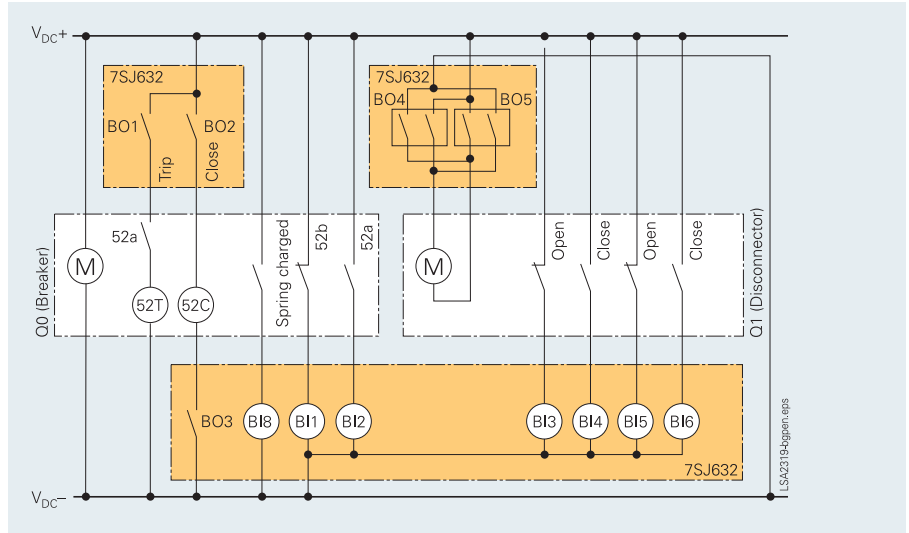


Fig. 5/119 Typical wiring for 7SJ632 motor direct control (simplified representation without fuses). Binary output BO4 and BO5 are interlocked so that only one set of contacts are closed at a time.

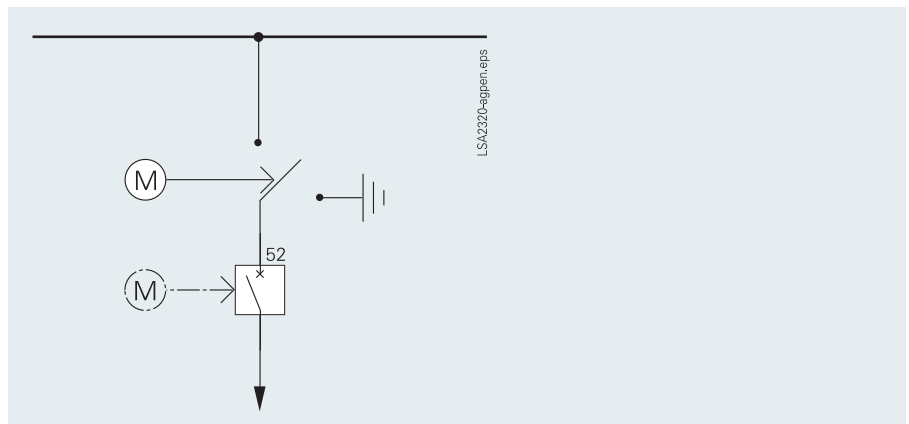


Fig. 5/120 Example: Single busbar with circuit-breaker and motor-controlled three-position switch

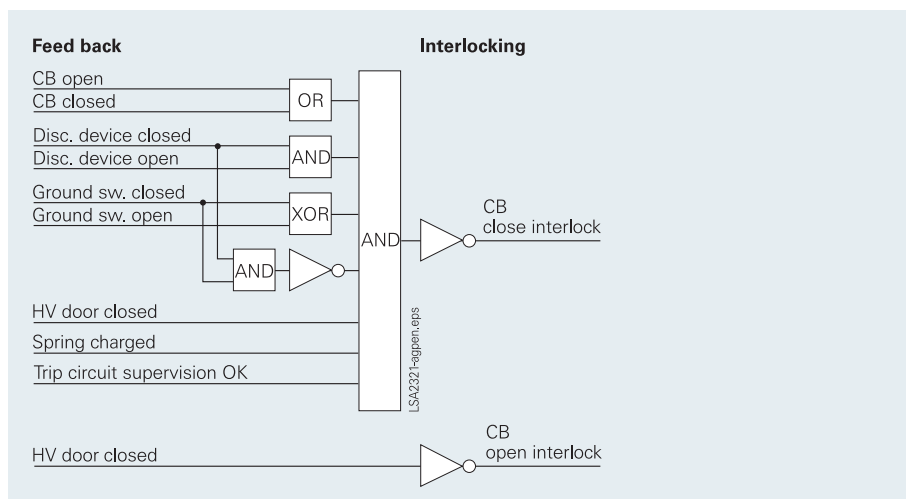


Fig. 5/121 Example: Circuit-breaker interlocking

Measured values

The r.m.s. values are calculated from the acquired current and voltage along with the power factor, frequency, active and reactive power. The following functions are available for measured value processing:

- Currents I_{L1} , I_{L2} , I_{L3} , I_E , I_{EE} (67Ns)
- Voltages V_{L1} , V_{L2} , V_{L3} , V_{L1L2} , V_{L2L3} , V_{L3L1}
- Symmetrical components I_1 , I_2 , $3I_0$; V_1 , V_2 , V_0
- Power Watts, Vars, VA/P , Q , S (P , Q : total and phase selective)
- Power factor ($\cos \varphi$), (total and phase selective)
- Frequency
- Energy \pm kWh, \pm kVarh, forward and reverse power flow
- Mean as well as minimum and maximum current and voltage values
- Operating hours counter
- Mean operating temperature of overload function
- Limit value monitoring
Limit values are monitored using programmable logic in the CFC. Commands can be derived from this limit value indication.
- Zero suppression
In a certain range of very low measured values, the value is set to zero to suppress interference.

Metered values

For internal metering, the unit can calculate an energy metered value from the measured current and voltage values. If an external meter with a metering pulse output is available, the SIPROTEC 4 unit can obtain and process metering pulses via an indication input.

The metered values can be displayed and passed on to a control center as an accumulation with reset. A distinction is made between forward, reverse, active and reactive energy.



Fig. 5/122 NX PLUS panel (gas-insulated)

Measuring transducers

- Characteristic with knee
For measuring transducers it sometimes makes sense to extend a small range of the input value, e.g. for the frequency that is only relevant in the range 45 to 55, 55 to 65 Hz. This can be achieved by using a knee characteristic.
- Live-zero monitoring
4 – 20 mA circuits are monitored for open-circuit detection.

Switchgear cubicles for high/medium voltage

All units are designed specifically to meet the requirements of high/medium-voltage applications.

In general, no separate measuring instruments (e.g. for current, voltage, frequency measuring transducer ...) or additional control components are necessary.

Overcurrent Protection / 7SJ63

Communication

Communication

In terms of communication, the units offer substantial flexibility in the context of connection to industrial and power automation standards. Communication can be extended or added on thanks to modules for retrofitting on which the common protocols run. Therefore, also in the future it will be possible to optimally integrate units into the changing communication infrastructure, for example in Ethernet networks (which will also be used increasingly in the power supply sector in the years to come).

Serial front interface

There is a serial RS232 interface on the front of all the units. All of the unit's functions can be set on a PC by means of the DIGSI 4 protection operation program. Commissioning tools and fault analysis are also built into the program and are available through this interface.

Rear-mounted interfaces¹⁾

A number of communication modules suitable for various applications can be fitted in the rear of the flush-mounting housing. In the flush-mounting housing, the modules can be easily replaced by the user.

The interface modules support the following applications:

- Time synchronization interface
All units feature a permanently integrated electrical time synchronization interface. It can be used to feed timing telegrams in IRIG-B or DCF77 format into the units via time synchronization receivers.
- System interface
Communication with a central control system takes place through this interface. Radial or ring type station bus topologies can be configured depending on the chosen interface. Furthermore, the units can exchange data through this interface via Ethernet and IEC 61850 protocol and can also be operated by DIGSI.
- Service interface
The service interface was conceived for remote access to a number of protection units via DIGSI. On all units, it can be an electrical RS232/RS485 or an optical interface. For special applications, a maximum of two temperature monitoring boxes (RTD-box) can be connected to this interface as an alternative.

System interface protocols (retrofitable)

IEC 61850 protocol

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens was the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus is also possible with DIGSI.

IEC 60870-5-103 protocol

The IEC 60870-5-103 protocol is an international standard for the transmission of protective data and fault recordings. All messages from the unit and also control commands can be transferred by means of published, Siemens-specific extensions to the protocol.

1) For units in panel surface-mounting housings please refer to note on page 5/130.

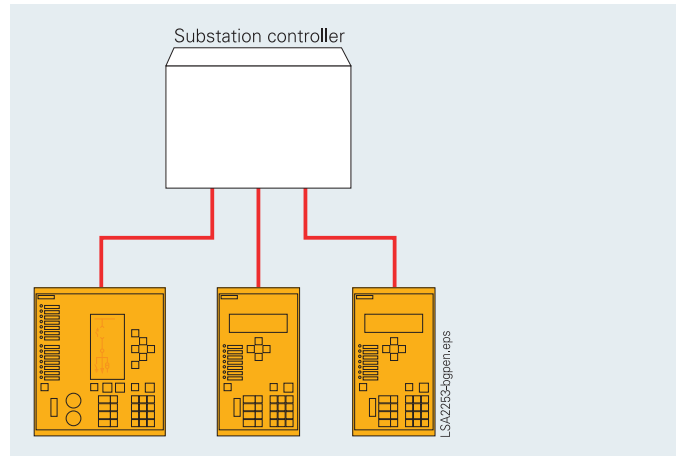


Fig. 5/123 IEC 60870-5-103: Radial fiber-optic connection

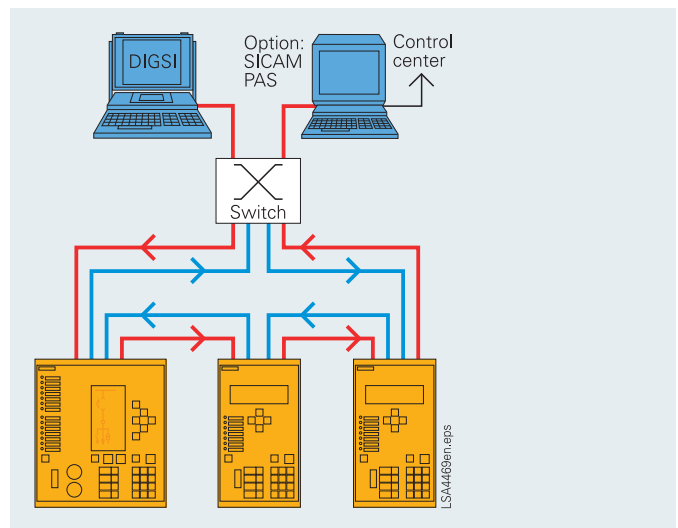


Fig. 5/124 Bus structure for station bus with Ethernet and IEC 61850, fiber-optic ring

PROFIBUS-DP protocol

PROFIBUS-DP is the most widespread protocol in industrial automation. Via PROFIBUS-DP, SIPROTEC units make their information available to a SIMATIC controller or, in the control direction, receive commands from a central SIMATIC. Measured values can also be transferred.

MODBUS RTU protocol

This uncomplicated, serial protocol is mainly used in industry and by power supply corporations, and is supported by a number of unit manufacturers. SIPROTEC units function as MODBUS slaves, making their information available to a master or receiving information from it. A time-stamped event list is available.

DNP 3.0 protocol

Power supply corporations use the serial DNP 3.0 (Distributed Network Protocol) for the station and network control levels. SIPROTEC units function as DNP slaves, supplying their information to a master system or receiving information from it.

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system.

Units featuring IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 5/123).

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 5/124).

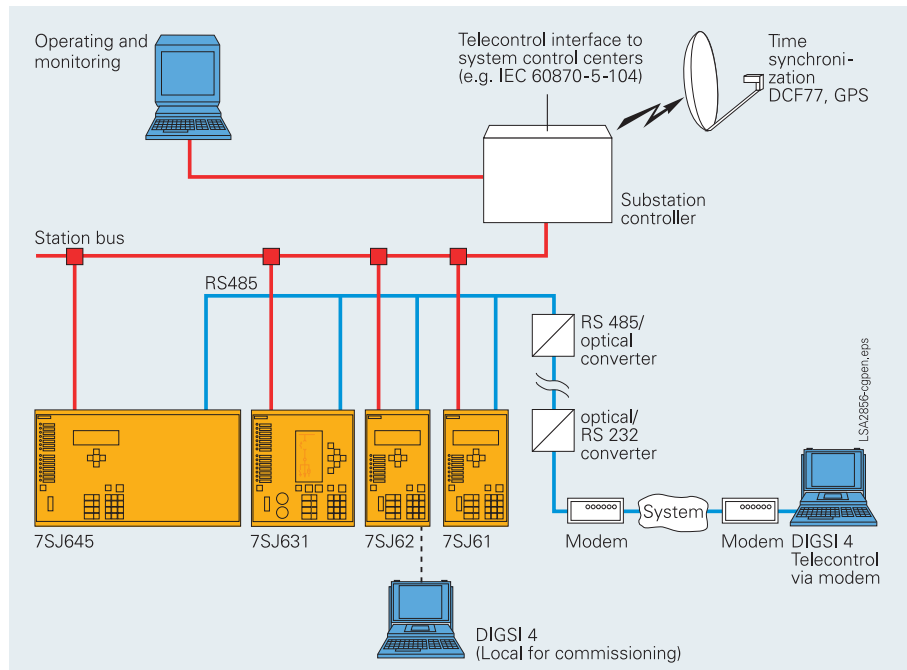


Fig. 5/125 System solution/communication

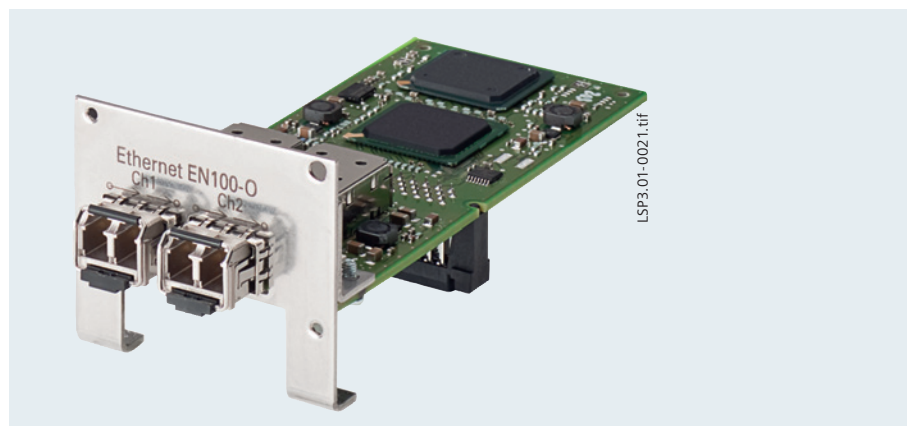


Fig. 5/126 Optical Ethernet communication module for IEC 61850 with integrated Ethernet-switch

Overcurrent Protection / 7SJ63

Typical connections

Typical connections

■ Connection of current and voltage transformers

Standard connection

For grounded networks, the ground current is obtained from the phase currents by the residual current circuit.

5

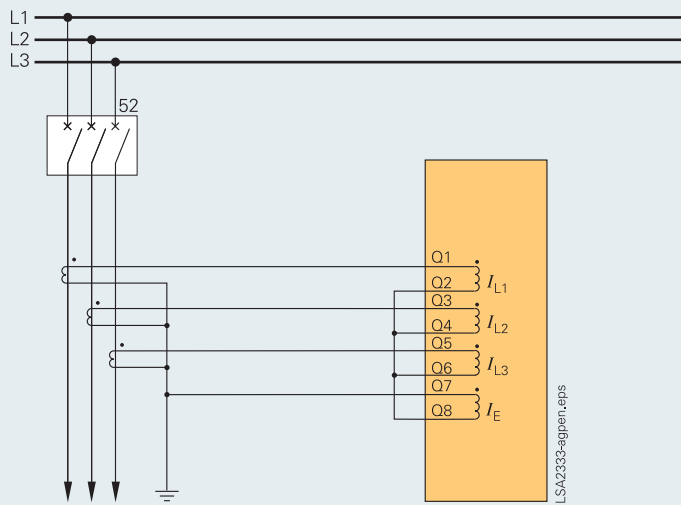


Fig. 5/127 Residual current circuit without directional element

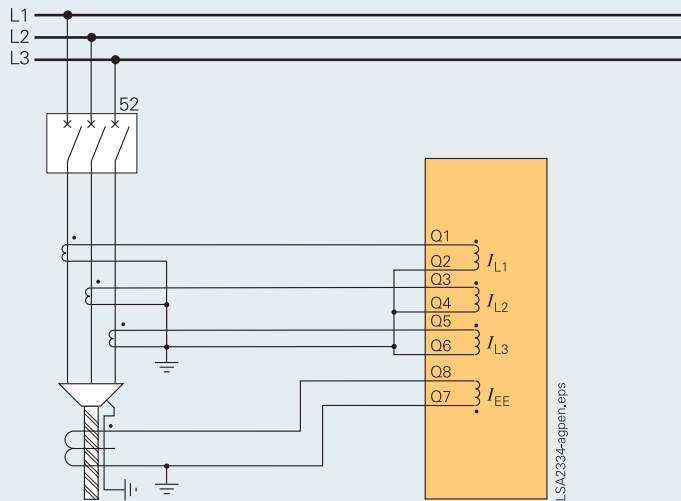


Fig. 5/128 Sensitive ground-current detection without directional element

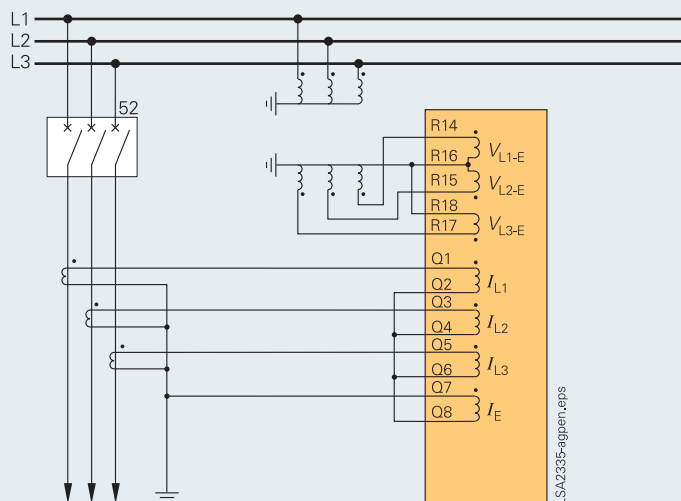


Fig. 5/129 Residual current circuit with directional element

Connection for compensated networks

The figure shows the connection of two phase-to-ground voltages and the V_E voltage of the open delta winding and a phase-balance neutral current transformer for the ground current. This connection maintains maximum precision for directional ground-fault detection and must be used in compensated networks. Figure 5/130 shows sensitive directional ground-fault detection.

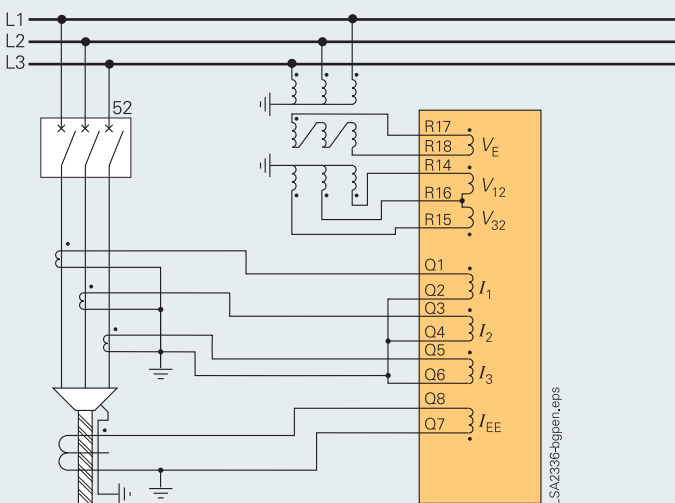


Fig. 5/130 Sensitive directional ground-fault detection with directional element for phases

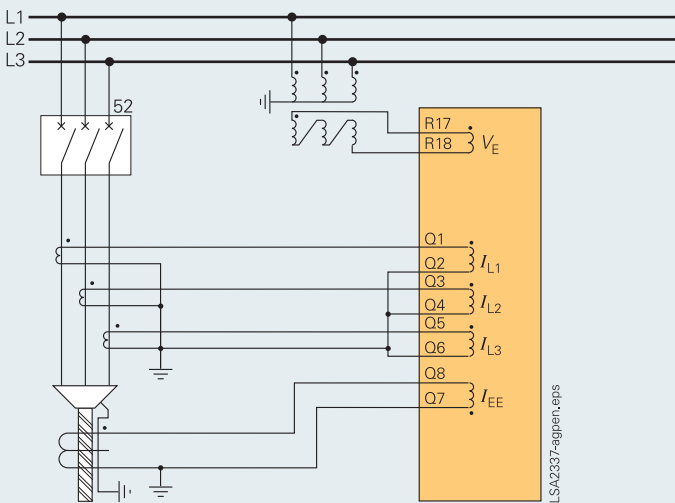


Fig. 5/131 Sensitive directional ground-fault detection

Connection for isolated-neutral or compensated networks only

If directional ground-fault protection is not used, the connection can be made with only two phase current transformers. Directional phase short-circuit protection can be achieved by using only two primary transformers.

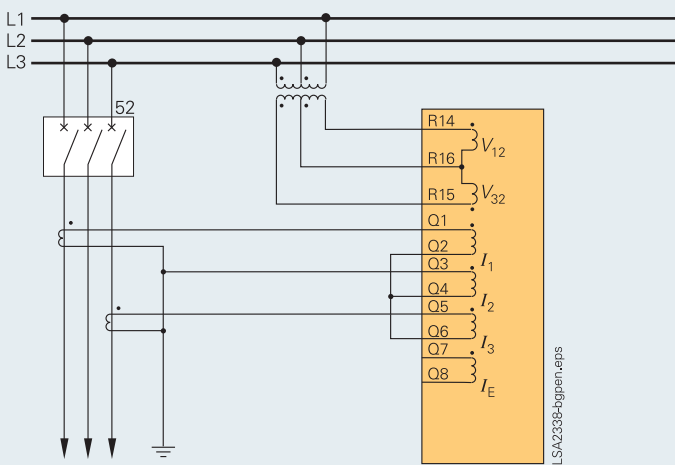


Fig. 5/132 Isolated-neutral or compensated networks

Overcurrent Protection / 7SJ63

Typical applications

5

Overview of connection types			
Type of network	Function	Current connection	Voltage connection
(Low-resistance) grounded network	Overcurrent protection phase/ground non-directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformer possible	–
(Low-resistance) grounded networks	Sensitive ground-fault protection	Phase-balance neutral current transformers required	–
Isolated or compensated networks	Overcurrent protection phases non-directional	Residual circuit, with 3 or 2 phase current transformers possible	–
(Low-resistance) grounded networks	Overcurrent protection phases directional	Residual circuit, with 3 phase-current transformers possible	Phase-to-ground connection or phase-to-phase connection
Isolated or compensated networks	Overcurrent protection phases directional	Residual circuit, with 3 or 2 phase-current transformers possible	Phase-to-ground connection or phase-to-phase connection
(Low-resistance) grounded networks	Overcurrent protection ground directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformers possible	Phase-to-ground connection required
Isolated networks	Sensitive ground-fault protection	Residual circuit, if ground current $> 0.05 I_N$ on secondary side, otherwise phase-balance neutral current transformers required	3 times phase-to-ground connection or phase-to-ground connection with open delta winding
Compensated networks	Sensitive ground-fault protection $\cos \varphi$ measurement	Phase-balance neutral current transformers required	Phase-to-ground connection with open delta winding required

Typical applications

■ Connection of circuit-breaker

Undervoltage releases

Undervoltage releases are used for automatic tripping of high-voltage motors.

Example:

DC supply voltage of control system fails and manual electric tripping is no longer possible.

Automatic tripping takes place when voltage across the coil drops below the trip limit. In Fig. 5/133, tripping occurs due to failure of DC supply voltage, by automatic opening of the live status contact upon failure of the protection unit or by short-circuiting the trip coil in event of a network fault

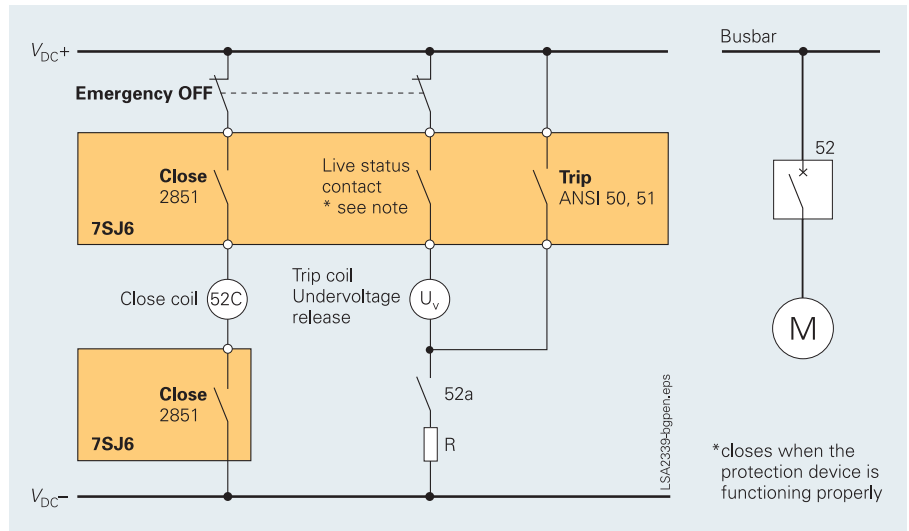


Fig. 5/133 Undervoltage release with make contact (50, 51)

In Fig. 5/134 tripping is by failure of auxiliary voltage and by interruption of tripping circuit in the event of network failure. Upon failure of the protection unit, the tripping circuit is also interrupted, since contact held by internal logic drops back into open position.

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal occurs whenever the circuit is interrupted.

Lockout (ANSI 86)

All binary outputs can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only occur after the lockout state is reset.

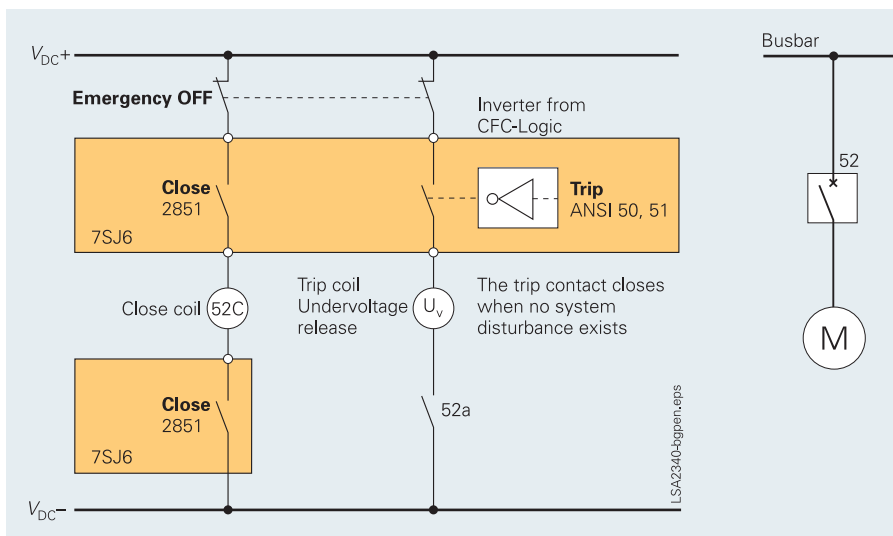


Fig. 5/134 Undervoltage release with locking contact (trip signal 50 is inverted)

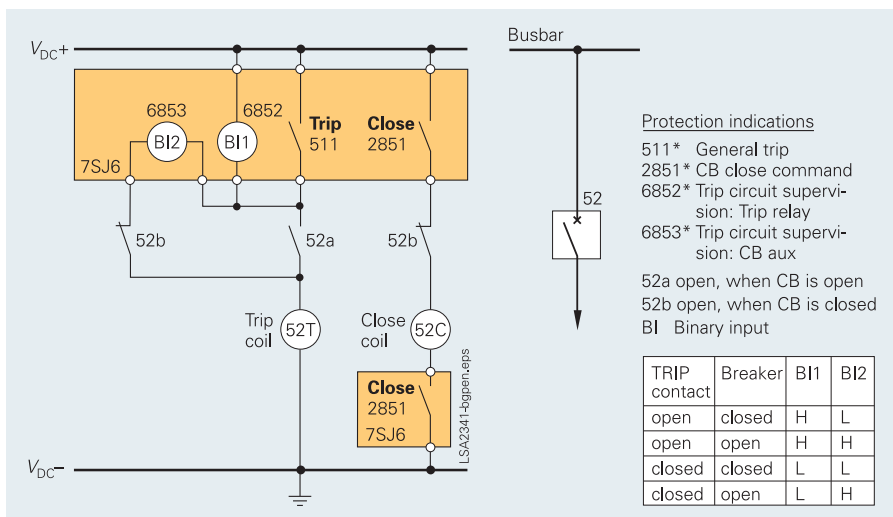


Fig. 5/135 Trip circuit supervision with 2 binary inputs

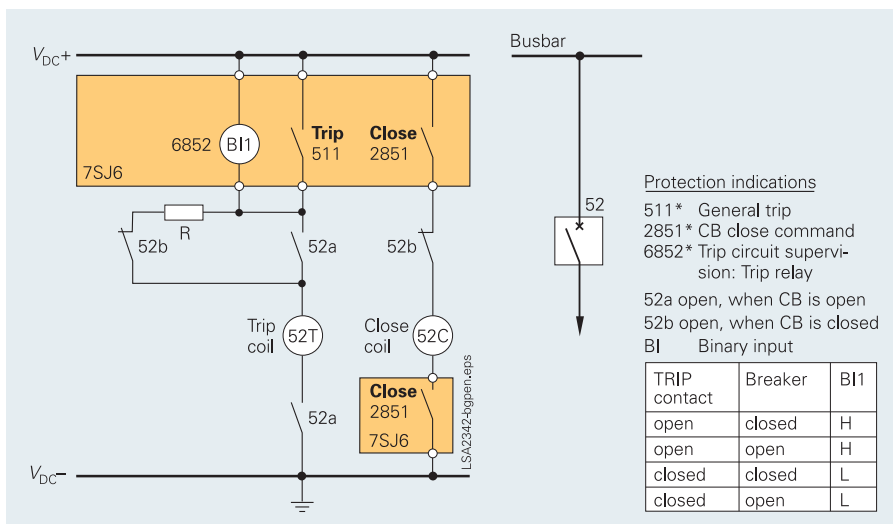


Fig. 5/136 Trip circuit supervision with 1 binary input

Overcurrent Protection / 7SJ63

Technical data

5

General unit data	
<i>Measuring circuits</i>	
System frequency	50 / 60 Hz (settable)
<i>Current transformer</i>	
Rated current I_{nom}	1 or 5 A (settable)
Option: sensitive ground-fault CT	$I_{EE} < 1.6$ A
Power consumption at $I_{nom} = 1$ A at $I_{nom} = 5$ A for sensitive ground-fault CT at 1 A	Approx. 0.05 VA per phase Approx. 0.3 VA per phase Approx. 0.05 VA
Overload capability Thermal (effective)	500 A for 1 s 150 A for 10 s 20 A continuous
Dynamic (impulse current)	$250 \times I_{nom}$ (half cycle)
Overload capability if equipped with sensitive ground-fault CT Thermal (effective)	300 A for 1 s 100 A for 10 s 15 A continuous
Dynamic (impulse current)	750 A (half cycle)
<i>Voltage transformer</i>	
Rated voltage V_{nom}	100 V to 225 V
Power consumption at $V_{nom} = 100$ V	< 0.3 VA per phase
Overload capability in voltage path (phase-neutral voltage) Thermal (effective)	230 V continuous
<i>Measuring transducer inputs</i>	
Type	7SJ633 7SJ636
Number	2 2
Input current	DC 0 – 20 mA
Input resistance	10 Ω
Power consumption	5.8 mW at 24 mA
<i>Auxiliary voltage (via integrated converter)</i>	
Rated auxiliary voltage V_{aux} DC	24/48 V 60/125 V 110/250 V
Permissible tolerance DC	19 – 58 V 48 – 150 V 88 – 300 V
Ripple voltage, peak-to-peak	≤ 12 % of rated auxiliary voltage
Power consumption	7SJ631 7SJ632 7SJ635 7SJ633 7SJ636
Quiescent Energized	Approx. 4 W 5.5 W 7 W Approx. 10 W 16 W 20 W
Backup time during loss/short-circuit of auxiliary direct voltage	≥ 50 ms at $V > DC 110$ V ≥ 20 ms at $V > DC 24$ V
Rated auxiliary voltage V_{aux} AC	115 V 230 V
Permissible tolerance AC	92 – 132 V 184 – 265 V
Power consumption	7SJ631 7SJ632 7SJ635 7SJ633 7SJ636
Quiescent Energized	Approx. 3 W 5 W 7 W Approx. 12 W 18 W 23 W
Backup time during loss/short-circuit of auxiliary alternating voltage	≥ 200 ms

Binary inputs/command inputs					
Type	7SJ631	7SJ632	7SJ633	7SJ635	7SJ636
Number (marshallable)	11	24	20	37	33
Voltage range	DC 24 – 250 V				
Pickup threshold modifiable by plug-in jumpers					
Pickup threshold DC	DC 19 V		DC 88 V		
For rated control voltage DC	24/48/60/110/ DC 125 V		DC 110/125/220/250 V		
Power consumption energized	0.9 mA (independent of operating voltage) for BI 1...6 / 8...19 / 25...36; 1.8 mA for BI 7 / 20...24 / 37				
Binary outputs/command outputs					
Type	7SJ631	7SJ632	7SJ633	7SJ635	7SJ636
Command/indication relay	8	11	11	14	14
Contacts per command/indication relay	1 NO / form A				
Live status contact	1 NO / NC (jumper) / form A / B				
Switching capacity					
Make	1000 W / VA				
Break	30 W / VA / 40 W resistive / 25 W at L/R ≤ 50 ms				
Switching voltage	$\leq DC 250$ V				
Permissible current	5 A continuous, 30 A for 0.5 s making current, 2000 switching cycles				
Power relay (for motor control)					
Type	7SJ631	7SJ632	7SJ633	7SJ635 7SJ636	
Number	0	2(4)	4 (8)		
Number of contacts/relay	2 NO / form A				
Switching capacity					
Make	1000 W / VA at 48 V ... 250 V / 500 W at 24 V				
Break	1000 W / VA at 48 V ... 250 V / 500 W at 24 V				
Switching voltage	$\leq DC 250$ V				
Permissible current	5 A continuous, 30 A for 0.5 s				

Electrical tests	
<i>Specification</i>	
Standards	IEC 60255 ANSI C37.90, C37.90.1, C37.90.2, UL508
<i>Insulation tests</i>	
Standards	IEC 60255-5; ANSI/IEEE C37.90.0
Voltage test (100 % test) all circuits except for auxiliary voltage and RS485/RS232 and time synchronization	2.5 kV (r.m.s. value), 50/60 Hz
Auxiliary voltage	DC 3.5 kV
Communication ports and time synchronization	AC 500 V
Impulse voltage test (type test) all circuits, except communication ports and time synchronization, class III	5 kV (peak value); 1.2/50 μ s; 0.5 J 3 positive and 3 negative impulses at intervals of 5 s
<i>EMC tests for interference immunity; type tests</i>	
Standards	IEC 60255-6; IEC 60255-22 (product standard) EN 50082-2 (generic specification) DIN 57435 Part 303
High-frequency test IEC 60255-22-1, class III and VDE 0435 Part 303, class III	2.5 kV (peak value); 1 MHz; $\tau = 15$ ms; 400 surges per s; test duration 2 s
Electrostatic discharge IEC 60255-22-2 class IV and EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air gap discharge; both polarities; 150 pF; $R_i = 330 \Omega$
Irradiation with radio-frequency field, non-modulated IEC 60255-22-3 (Report) class III	10 V/m; 27 to 500 MHz
Irradiation with radio-frequency field, amplitude-modulated IEC 61000-4-3; class III	10 V/m, 80 to 1000 MHz; AM 80 %; 1 kHz
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204; class III	10 V/m, 900 MHz; repetition rate 200 Hz, on duration 50 %
Fast transient interference/burst IEC 60255-22-4 and IEC 61000-4- 4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50 \Omega$; test duration 1 min
High-energy surge voltages (Surge) IEC 61000-4-5; class III Auxiliary voltage	From circuit to circuit: 2 kV; 12 Ω ; 9 μ F across contacts: 1 kV; 2 Ω ; 18 μ F
Binary inputs/outputs	From circuit to circuit: 2 kV; 42 Ω ; 0.5 μ F across contacts: 1 kV; 42 Ω ; 0.5 μ F
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; AM 80 %; 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m; 50 Hz, continuous 300 A/m; 50 Hz, 3 s 0.5 mT, 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak value), 1 to 1.5 MHz damped wave; 50 surges per s; duration 2 s, $R_i = 150$ to 200 Ω

Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per s both polarities; duration 2 s, $R_i = 80 \Omega$
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz; amplitude and pulse-modulated
Damped wave IEC 60694 / IEC 61000-4-12	2.5 kV (peak value, polarity alternating) 100 kHz, 1 MHz, 10 and 50 MHz, $R_i = 200 \Omega$
<i>EMC tests for interference emission; type tests</i>	
Standard	EN 50081-* (generic specification)
Conducted interferences only auxiliary voltage IEC/CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC/CISPR 11	30 to 1000 MHz Limit class B
Units with a detached operator panel must be installed in a metal cubicle to maintain limit class B	

Mechanical stress tests

Vibration, shock stress and seismic vibration

During operation

Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz; ± 0.075 mm amplitude; 60 to 150 Hz; 1 g acceleration frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 5 g, duration 11 ms; 3 shocks in both directions of 3 axes
Seismic vibration IEC 60255-21-3, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 g acceleration (horizontal axis) 8 to 35 Hz: 0.5 g acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 perpendicular axes

During transportation

Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz; 2 g acceleration, frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, Class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 15 g, duration 11 ms 3 shocks in both directions of 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Semi-sinusoidal Acceleration 10 g, duration 16 ms 1000 shocks in both directions of 3 axes

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<i>Climatic stress tests</i>	
<i>Temperatures</i>	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C /-13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	-20 °C to +70 °C /-4 °F to +158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C /+131 °F)	-5 °C to +55 °C /+25 °F to +131 °F
– Limiting temperature during permanent storage	-25 °C to +55 °C /-13 °F to +131 °F
– Limiting temperature during transport	-25 °C to +70 °C /-13 °F to +158 °F
<i>Humidity</i>	
Permissible humidity It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average 75 % relative humidity; on 56 days a year up to 95 % relative humidity; condensation not permissible!
<i>Unit design</i>	
Housing	7XP20
Dimensions	See dimension drawings, part 14 of this catalog
Weight in kg	Housing width 1/2 Housing width 1/1
Surface-mounting housing	7.5 15
Flush-mounting housing	6.5 13
Housing for detached operator panel	8.0 15
Detached operator panel	2.5 2.5
Degree of protection acc. to EN 60529	IP 51
Surface-mounting housing	IP 51
Flush-mounting housing	Front: IP 51, rear: IP 20;
Operator safety	IP 2x with cover

Serial interfaces	
<i>Operating interface (front of unit)</i>	
Connection	Non-isolated, RS232; front panel, 9-pin subminiature connector
Transmission rate	min. 4800 baud, max. 115200 baud
<i>Service/modem interface (rear of unit)</i>	
Isolated interface for data transfer	Port C: DIGSI 4/modem/RTD-box
Transmission rate	Factory setting 38400 baud min. 4800 baud, max. 115200 baud
<u>RS232/RS485</u>	
Connection	9-pin subminiature connector, mounting location "C"
For flush-mounting housing/ surface-mounting housing with detached operator panel	At the bottom part of the housing: shielded data cable
For surface-mounting housing with two-tier terminal at the top/bottom part	
Distance RS232	15 m /49.2 ft
Distance RS485	Max. 1 km / 3300 ft
Test voltage	AC 500 V against ground

<i>System interface (rear of unit)</i>	
<i>IEC 60870-5-103 protocol</i>	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Factory setting: 9600 baud, min. 9600 baud, max. 19200 baud
<u>RS232/RS485</u>	
Connection	Mounting location "B"
For flush-mounting housing/ surface-mounting housing with detached operator panel	
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	Max. 15 m/49 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	AC 500 V against ground
<u>Fiber optic</u>	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection Mounting location "B"
For flush-mounting housing/ surface-mounting housing with detached operator panel	
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles
<i>IEC 61850 protocol</i>	
Isolated interface for data transfer:	Port B, 100 Base T acc. to IEEE802.3
– to a control center	
– with DIGSI	
– between SIPROTEC 4 relays	
Transmission rate	100 Mbit
<u>Ethernet, electrical</u>	
Connection	Two RJ45 connectors Mounting location "B"
For flush-mounting housing/ surface-mounting housing with detached operator panel	
Distance	Max. 20 m / 65.6 ft
Test voltage	AC 500 V against ground
<u>Ethernet, optical</u>	
Connection	Integr. LC connector for FO connection Mounting location "B"
For flush-mounting housing/ surface-mounting housing with detached operator panel	
Optical wavelength	1300 nm
Distance	1.5 km/0.9 miles
<u>PROFIBUS-FMS/DP</u>	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 1.5 Mbaud

RS485	
Connection For flush-mounting housing/ surface-mounting housing with detached operator panel For surface-mounting housing with two-tier terminal on the top/bottom part Distance	9-pin subminiature connector, mounting location "B" At the bottom part of the housing: shielded data cable 1000 m/3300 ft ≤ 93.75 kbaud; 500 m/1500 ft ≤ 187.5 kbaud; 200 m/600 ft ≤ 1.5 Mbaud; 100 m/300 ft ≤ 12 Mbaud AC 500 V against ground
Test voltage	AC 500 V against ground
Fiber optic	
Connection fiber-optic cable For flush-mounting housing/ surface-mounting housing with detached operator panel For surface-mounting housing with two-tier terminal on the top/bottom part Optical wavelength Permissible path attenuation Distance	Integr. ST connector for FO connec- tion, mounting location "B" At the bottom part of the housing Important: Please refer to footnotes ¹⁾ and ²⁾ on page 5/174 820 nm Max. 8 dB, for glass fiber 62.5/125 μm 500 kB/s 1.6 km/0.99 miles 1500 kB/s 530 m/0.33 miles

MODBUS RTU, ASCII, DNP 3.0

Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 19200 baud

RS485	
Connection For flush-mounting housing/ surface-mounting housing with detached operator panel For surface-mounting housing with two-tier terminal at the top/bottom part Distance	9-pin subminiature connector, mounting location "B" At bottom part of the housing: shielded data cable Max. 1 km/3300 ft max. 32 units recommended
Test voltage	AC 500 V against ground
Fiber-optic	
Connection fiber-optic cable For flush-mounting housing/ surface-mounting housing with detached operator panel For surface-mounting housing with two-tier terminal at the top/bottom part Optical wavelength Permissible path attenuation Distance	Integrated ST connector for fiber-optic connection Mounting location "B" At the bottom part of the housing Important: Please refer to footnotes ¹⁾ and ²⁾ on page 5/174 820 nm Max 8 dB, for glass fiber 62.5/125 μm Max. 1.5 km/0.9 miles

Time synchronization DCF77/IRIG-B signal (Format IRIG-B000)

Connection	9-pin subminiature connector (SUB-D) (terminal with surface-mounting housing)
Voltage levels	5 V, 12 V or 24 V (optional)

1) At $I_{nom} = 1$ A, all limits divided by 5.

Functions

Definite-time overcurrent protection, directional/non-directional (ANSI 50, 50N, 67, 67N)

Operating mode non-directional phase protection (ANSI 50)	3-phase (standard) or 2-phase (L1 and L3)	
Setting ranges		
Pickup phase elements	0.5 to 175 A or ∞ ¹⁾ (in steps of 0.01 A)	
Pickup ground elements	0.25 to 175 A or ∞ ¹⁾ (in steps of 0.01 A)	
Delay times T	0 to 60 s or ∞ (in steps of 0.01 s)	
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)	
Times		
Pickup times (without inrush restraint, with inrush restraint + 10 ms)	Non-directional	Directional
With twice the setting value	Approx. 30 ms	45 ms
With five times the setting value	Approx. 20 ms	40 ms
Dropout times	Approx. 40 ms	
Dropout ratio	Approx. 0.95 for $III_{nom} \geq 0.3$	
Tolerances		
Pickup	2 % of setting value or 50 mA ¹⁾	
Delay times T, T_{DO}	1 % or 10 ms	

Inverse-time overcurrent protection, directional/non-directional (ANSI 51, 51N, 67, 67N)

Operating mode non-directional phase protection (ANSI 51)	3-phase (standard) or 2-phase (L1 and L3)	
Setting ranges		
Pickup phase element I_p	0.5 to 20 A or ∞ ¹⁾ (in steps of 0.01 A)	
Pickup ground element I_{EP}	0.25 to 20 A or ∞ ¹⁾ (in steps of 0.01 A)	
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)	
Time multiplier D (ANSI characteristics)	0.05 to 15 s or ∞ (in steps of 0.01 s)	
Trip characteristics		
IEC	Normal inverse, very inverse, extremely inverse, long inverse	
ANSI	Inverse, short inverse, long inverse moderately inverse, very inverse, extremely inverse, definite inverse	
User-defined characteristic	Defined by a maximum of 20 value pairs of current and time delay	
Dropout setting		
Without disk emulation	Approx. $1.05 \cdot$ setting value I_p for $I_p/III_{nom} \geq 0.3$, corresponds to approx. $0.95 \cdot$ pickup threshold	
With disk emulation	Approx. $0.90 \cdot$ setting value I_p	
Tolerances		
Pickup/dropout thresholds I_p, I_{EP}	2 % of setting value or 50 mA ¹⁾	
Pickup time for $2 \leq III_p \leq 20$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms	
Dropout ratio for $0.05 \leq III_p \leq 0.9$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms	

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Direction detection	
For phase faults	
Polarization	With cross-polarized voltages; With voltage memory for measurement voltages that are too low
Forward range	$V_{ref,rot} \pm 86^\circ$
Rotation of reference voltage $V_{ref,rot}$	- 180° to 180° (in steps of 1°)
Direction sensitivity	For one and two-phase faults unlimited; For three-phase faults dynamically unlimited; Steady-state approx. 7 V phase-to-phase
For ground faults	
Polarization	With zero-sequence quantities $3V_0, 3I_0$ or with negative-sequence quantities $3V_2, 3I_2$
Forward range	$V_{ref,rot} \pm 86^\circ$
Rotation of reference voltage $V_{ref,rot}$	- 180° to 180° (in steps of 1°)
Direction sensitivity	Zero-sequence quantities $3V_0, 3I_0$ $V_E \approx 2.5$ V displacement voltage, measured; $3V_0 \approx 5$ V displacement voltage, calculated
Negative-sequence quantities $3V_2, 3I_2$	$3V_2 \approx 5$ V negative-sequence voltage $3I_2 \approx 225$ mA negative-sequence current ¹⁾
Tolerances (phase angle error under reference conditions)	
For phase and ground faults	$\pm 3^\circ$ electrical
Inrush blocking	
Influenced functions	Time-overcurrent elements, $I>, I_E>, I_p, I_{Ep}$ (directional, non-directional)
Lower function limit	1.25 A ¹⁾
Upper function limit (setting range)	1.5 to 125 A ¹⁾ (in steps of 0.01 A)
Setting range I_{2f} / I	10 to 45 % (in steps of 1 %)
Crossblock (I_{L1}, I_{L2}, I_{L3})	ON/OFF
Dynamic setting change	
Controllable function	Directional and non-directional pickup, tripping time
Start criteria	Current criteria, CB position via aux. contacts, binary input, auto-reclosure ready
Time control	3 timers
Current criteria	Current threshold (reset on dropping below threshold; monitoring with timer)

(Sensitive) ground-fault detection (ANSI 64, 50 Ns, 51Ns, 67Ns)	
Displacement voltage starting for all types of ground fault (ANSI 64)	
Setting ranges	
Pickup threshold $V_E >$ (measured)	1.8 to 170 V (in steps of 0.1 V)
Pickup threshold $3V_0 >$ (calculated)	10 to 225 V (in steps of 0.1 V)
Delay time $T_{Delay pickup}$	0.04 to 320 s or ∞ (in steps of 0.01 s)
Additional trip delay T_{VDELAY}	0.1 to 40000 s or ∞ (in steps of 0.01 s)
Times	
Pickup time	Approx. 60 ms
Dropout ratio	0.95 or (pickup value -0.6 V)
Tolerances	
Pickup threshold V_E (measured)	3 % of setting value or 0.3 V
Pickup threshold $3V_0$ (calculated)	3 % of setting value or 3 V
Delay times	1 % of setting value or 10 ms
Phase detection for ground fault in an ungrounded system	
Measuring principle	Voltage measurement (phase-to-ground)
Setting ranges	
$V_{ph min}$ (ground-fault phase)	10 to 100 V (in steps of 1 V)
$V_{ph max}$ (unfaulted phases)	10 to 100 V (in steps of 1 V)
Measuring tolerance	3 % of setting value, or 1 V
acc. to DIN 57435 part 303	
Ground-fault pickup for all types of ground faults	
Definite-time characteristic (ANSI 50Ns)	
Setting ranges	
Pickup threshold $I_{EE>}, I_{EE>>}$	
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A ¹⁾ (in steps of 0.01 A)
Delay times T for $I_{EE>}, I_{EE>>}$	0 to 320 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Times	
Pickup times	Approx. 60 ms (non-directional) Approx. 80 ms (directional)
Dropout ratio	Approx. 0.95
Tolerances	
Pickup threshold $I_{EE>}, I_{EE>>}$	2 % of setting value or 1 mA
Delay times	1 % of setting value or 20 ms
Ground-fault pickup for all types of ground faults	
Inverse-time characteristic (ANSI 51Ns)	
User-defined characteristic	Defined by a maximum of 20 pairs of current and delay time values
Logarithmic inverse	$t = T_{IEEpmax} - T_{IEEp} \cdot \ln \frac{I}{I_{IEEp}}$
Setting ranges	
Pickup threshold I_{IEEp}	
For sensitive input	0.001 A to 1.4 A (in steps of 0.001 A)
For normal input	0.25 to 20 A ¹⁾ (in steps of 0.01 A)
User defined	
Time multiplier T	0.1 to 4 s or ∞ (in steps of 0.01 s)
Logarithmic inverse	
Time multiplier $T_{IEEp mul}$	0.05 to 15 s or ∞ (in steps of 0.01 s)
Delay time T_{IEEp}	0.1 to 4 s or ∞ (in steps of 0.01 s)
Min time delay $T_{IEEpmin}$	0 to 32 s (in steps of 0.01 s)
Max. time delay $T_{IEEpmax}$	0 to 32 s (in steps of 0.01 s)
Note: Due to the high sensitivity the linear range of the measuring input IN with integrated sensitive input transformer is from 0.001 A to 1.6 A. For currents greater than 1.6 A, correct directionality can no longer be guaranteed.	
1) For $I_{nom} = 1$ A, all limits divided by 5.	

Times	
Pickup times	Approx. 60 ms (non-directional) Approx 80 ms (directional)
Pickup threshold	Approx. $1.1 \cdot I_{EEp}$
Dropout ratio	Approx. $1.05 \cdot I_{EEp}$
Tolerances	
Pickup threshold I_{EEp}	2 % of setting value or 1 mA
Delay times in linear range	7 % of reference value for $2 \leq III_{EEp}$ $\leq 20 + 2$ % current tolerance, or 70 ms

Direction detection for all types of ground-faults (ANSI 67Ns)

Direction measurement	I_E and V_E measured or $3I_0$ and $3V_0$ calculated
Measuring principle	Active/reactive power measurement
Setting ranges	
Measuring enable $I_{Release\ direct}$	
For sensitive input	0.001 to 1.2 A (in steps of 0.001 A)
For normal input	0.25 to 150 A ¹⁾ (in steps of 0.01 A)
Measuring method	$\cos \varphi$ and $\sin \varphi$
Direction phasor $\varphi_{Correction}$	- 45 ° to + 45 ° (in steps of 0.1 °)
Dropout delay $T_{Reset\ delay}$	1 to 60 s (in steps of 1 s)
Angle correction for cable CT	
Angle correction F1, F2	0 ° to 5 ° (in steps of 0.1 °)
Current value $I1, I2$	
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A ¹⁾ (in steps of 0.01 A)
Tolerances	
Pickup measuring enable	2 % of the setting value or 1 mA
Angle tolerance	3 °

High-impedance restricted ground-fault protection (ANSI 87N) / single-phase overcurrent protection

Setting ranges	
Pickup thresholds $I_{>}, I_{>>}$	
For sensitive input	0.003 to 1.5 A or ∞ (in steps of 0.001 A)
For normal input	0.25 to 175 A ¹⁾ or ∞ (in steps of 0.01 A)
Delay times $T_{I>}, T_{I>>}$	0 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
Minimum	Approx. 20 ms
Typical	Approx. 30 ms
Dropout times	Approx. 30 ms
Dropout ratio	Approx. 0.95 for $III_{nom} \geq 0.5$
Tolerances	
Pickup thresholds	3 % of setting value or 1 % rated current at $I_{nom} = 1$ or 5 A; 5 % of setting value or 3 % rated current at $I_{nom} = 0.1$ A
Delay times	1 % of setting value or 10 ms

Intermittent ground-fault protection

Setting ranges	
Pickup threshold	
For I_E	$I_{E>}$ 0.25 to 175 A ¹⁾ (in steps of 0.01 A)
For $3I_0$	$I_{E>}$ 0.25 to 175 A ¹⁾ (in steps of 0.01 A)
For I_{EE}	$I_{E>}$ 0.005 to 1.5 A (in steps of 0.001 A)
Pickup prolon- gation time	T_V 0 to 10 s (in steps of 0.01 s)
Ground-fault accu- mulation time	T_{Sum} 0 to 100 s (in steps of 0.01 s)
Reset time for accumulation	T_{Res} 1 to 600 s (in steps of 1 s)
Number of pickups for intermittent ground fault	2 to 10 (in steps of 1)

1) At $I_{nom} = 1$ A, all limits divided by 5.

Times	
Pickup times	
Current = 1.25 · pickup value	Approx. 30 ms
Current ≥ 2 · pickup value	Approx. 22 ms
Dropout time	Approx. 22 ms
Tolerances	
Pickup threshold $I_{E>}$	3 % of setting value, or 50 mA ¹⁾
Times T_V, T_{Sum}, T_{Res}	1 % of setting value or 10 ms

Thermal overload protection (ANSI 49)

Setting ranges	
Factor k	0.1 to 4 (in steps of 0.01)
Time constant	1 to 999.9 min (in steps of 0.1 min)
Warning overtemperature	50 to 100 % with reference to the tripping overtemperature (in steps of 1 %)
$\Theta_{Alarm}/\Theta_{Trip}$	
Current warning stage I_{Alarm}	0.5 to 20 A (in steps of 0.01 A)
Extension factor when stopped	1 to 10 with reference to the time constant with the machine running (in steps of 0.1)
k_T factor	
Rated overtemperature (for I_{nom})	40 to 200 °C (in steps of 1 °C)
Tripping characteristic	
For $(I/k \cdot I_{nom}) \leq 8$	$t = \tau_{th} \cdot \ln \frac{(I/k \cdot I_{nom})^2 - (I_{pre}/k \cdot I_{nom})^2}{(I/k \cdot I_{nom})^2 - 1}$
	t = Tripping time τ_{th} = Temperature rise time constant I = Load current I_{pre} = Preload current k = Setting factor acc. to VDE 0435 Part 3011 and IEC 60255-8 I_{nom} = Rated (nominal) current of the protection relay
Dropout ratios	
Θ/Θ_{Trip}	Drops out with Θ_{Alarm}
Θ/Θ_{Alarm}	Approx. 0.99
III_{Alarm}	Approx. 0.97
Tolerances	
With reference to $k \cdot I_{nom}$	Class 5 acc. to IEC 60255-8
With reference to tripping time	5 % \pm 2 s acc. to IEC 60255-8

Auto-reclosure (ANSI 79)

Number of reclosures	0 to 9 Shot 1 to 4 individually adjustable
Program for phase fault Start-up by	Time-overcurrent elements (dir., non-dir.), negative sequence, binary input
Program for ground fault Start-up by	Time-overcurrent elements (dir., non-dir.), sensitive ground-fault protection, binary input
Blocking of ARC	Pickup of protection functions, three-phase fault detected by a protective element, binary input, last TRIP command after the reclosing cycle is complete (unsuccessful reclosing), TRIP command by the breaker failure protection (50BF), opening the CB without ARC initiation, external CLOSE command

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Auto-reclosure (ANSI 79) (cont'd)

Setting ranges	
Dead time (separate for phase and ground and individual for shots 1 to 4)	0.01 to 320 s (in steps of 0.01 s)
Blocking duration for manual-CLOSE detection	0.5 s to 320 s or 0 (in steps of 0.01 s)
Blocking duration after reclosure	0.5 s to 320 s (in steps of 0.01 s)
Blocking duration after dynamic blocking	0.01 to 320 s (in steps of 0.01 s)
Start-signal monitoring time	0.01 to 320 s or ∞ (in steps of 0.01 s)
Circuit-breaker supervision time	0.1 to 320 s (in steps of 0.01 s)
Max. delay of dead-time start	0 to 1800 s or ∞ (in steps of 0.1 s)
Maximum dead time extension	0.5 to 320 s or ∞ (in steps of 0.01 s)
Action time	0.01 to 320 s or ∞ (in steps of 0.01 s)

The delay times of the following protection function can be altered individually by the ARC for shots 1 to 4 (setting value $T = T$, non-delayed $T = 0$, blocking $T = \infty$):

$I_{>>}$, $I_{>}$, I_p , $I_{dir>>}$, $I_{dir>}$, I_{pdir}
 $I_{E>>}$, $I_{E>}$, I_{Ep} , $I_{Edir>>}$, $I_{Edir>}$, I_{Edir}

Additional functions	Lockout (final trip), delay of dead-time start via binary input (monitored), dead-time extension via binary input (monitored), co-ordination with other protection relays, circuit-breaker monitoring, evaluation of the CB contacts
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Breaker failure protection (ANSI 50 BF)

Setting ranges	
Pickup threshold CB $I_{>}$	0.2 to 5 A ¹⁾ (in steps of 0.01 A)
Delay time	0.06 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
with internal start	is contained in the delay time
start via control	is contained in the delay time
with external start	is contained in the delay time
Dropout times	Approx. 25 ms
Tolerances	
Pickup value	2 % of setting value (50 mA) ¹⁾
Delay time	1 % or 20 ms

Negative-sequence current detection (ANSI 46)

Definite-time characteristic (ANSI 46-1 and 46-2)

Setting ranges	
Pickup current $I_{2>}$, $I_{2>>}$	0.5 to 15 A or ∞ (in steps of 0.01 A)
Delay times	0 to 60 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{D0}	0 to 60 s (in steps of 0.01 s)
Functional limit	All phase currents ≤ 20 A ¹⁾
Times	
Pickup times	Approx. 35 ms
Dropout times	Approx. 35 ms
Dropout ratio	Approx. 0.95 for $I_2 / I_{nom} > 0.3$
Tolerances	
Pickup thresholds	3 % of the setting value or 50 mA ¹⁾
Delay times	1 % or 10 ms

1) At $I_{nom} = 1$ A, all limits divided by 5.

Inverse-time characteristic (ANSI 46-TOC)

Setting ranges	
Pickup current	0.5 to 10 A ¹⁾ (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.5 to 15 s or ∞ (in steps of 0.01 s)
Functional limit	All phase currents ≤ 20 A ¹⁾
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse
ANSI	Inverse, moderately inverse, very inverse, extremely inverse
Pickup threshold	Approx. $1.1 \cdot I_{2p}$ setting value
Dropout	
IEC and ANSI (without disk emulation)	Approx. $1.05 \cdot I_{2p}$ setting value, which is approx. $0.95 \cdot$ pickup threshold
ANSI with disk emulation	Approx. $0.90 \cdot I_{2p}$ setting value
Tolerances	
Pickup threshold	3 % of the setting value or 50 mA ¹⁾
Time for $2 \leq M \leq 20$	5 % of setpoint (calculated) +2 % current tolerance, at least 30 ms

Starting time monitoring for motors (ANSI 48)

Setting ranges	
Motor starting current $I_{STARTUP}$	2.5 to 80 A ¹⁾ (in steps of 0.01)
Pickup threshold $I_{MOTOR START}$	2 to 50 A ¹⁾ (in steps of 0.01)
Permissible starting time $T_{STARTUP}$	1 to 180 s (in steps of 0.1 s)
Permissible blocked rotor time $T_{LOCKED-ROTOR}$	0.5 to 120 s or ∞ (in steps of 0.1 s)
Tripping time characteristic	
For $I > I_{MOTOR START}$	$t = \left(\frac{I_{STARTUP}}{I} \right)^2 \cdot T_{STARTUP}$
	$I_{STARTUP}$ = Rated motor starting current
	I = Actual current flowing
	$T_{STARTUP}$ = Tripping time for rated motor starting current
	t = Tripping time in seconds
Dropout ratio $I_{MOTOR START}$	Approx. 0.95
Tolerances	
Pickup threshold	2 % of setting value or 50 mA ¹⁾
Delay time	5 % or 30 ms

Restart inhibit for motors (ANSI 66)	
Setting ranges	
Motor starting current relative to rated motor current	1.1 to 10 (in steps of 0.1)
$I_{MOTOR\ START}/I_{Motor\ Nom}$	
Rated motor current $I_{Motor\ Nom}$	1 to 6 A ¹⁾ (in steps of 0.01 A)
Max. permissible starting time	1 to 320 s (in steps of 1 s)
$T_{Start\ Max}$	
Equilibrium time T_{Equal}	0 min to 320 min (in steps of 0.1 min)
Minimum inhibit time	0.2 min to 120 min (in steps of 0.1 min)
$T_{MIN.\ INHIBIT\ TIME}$	
Max. permissible number of warm starts	1 to 4 (in steps of 1)
Difference between cold and warm starts	1 to 2 (in steps of 1)
Extension k-factor for cooling simulations of rotor at zero speed $k_{\tau\ at\ STOP}$	0.2 to 100 (in steps of 0.1)
Extension factor for cooling time constant with motor running $k_{\tau\ RUNNING}$	0.2 to 100 (in steps of 0.1)
Restarting limit	$\Theta_{restart} = \Theta_{rot\ max\ perm} \cdot \frac{n_c - 1}{n_c}$ <p>$\Theta_{restart}$ = Temperature limit below which restarting is possible</p> <p>$\Theta_{rot\ max\ perm}$ = Maximum permissible rotor overtemperature (= 100 % in operational measured value $\Theta_{rot}/\Theta_{rot\ trip}$)</p> <p>$n_c$ = Number of permissible start-ups from cold state</p>

Undercurrent monitoring (ANSI 37)	
Signal from the operational measured values	Predefined with programmable logic

Temperature monitoring box (ANSI 38)	
Temperature detectors	
Connectable boxes	1 or 2
Number of temperature detectors per box	Max. 6
Type of measuring	Pt 100 Ω or Ni 100 Ω or Ni 120 Ω
Mounting identification	"Oil" or "Environment" or "Stator" or "Bearing" or "Other"
Thresholds for indications	
For each measuring detector	
Stage 1	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)-
Stage 2	50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)

1) At $I_{nom} = 1\ A$, all limits divided by 5.

Undervoltage protection (ANSI 27)	
Operating modes/measuring quantities	
3-phase	Positive-sequence component or smallest of the phase-to-phase voltages
1-phase	Single-phase phase-ground or phase-phase voltage
Setting ranges	
Pickup thresholds $V<, V<<$	
3-phase, phase-ground connection	10 to 210 V (in steps of 1 V)
3-phase, phase-phase connection	10 to 120 V (in steps of 1 V)
1-phase connection	10 to 120 V (in steps of 1 V)
Dropout ratio r	1.01 to 3 (in steps of 0.01)
Delay times T	0 to 100 s or ∞ (in steps of 0.01 s)
Current Criteria "Bkr Closed I_{MIN} "	0.2 to 5 A ¹⁾ (in steps of 0.01 A)
Dropout threshold $r \cdot V<(<)$	Max. 130 V for phase-phase voltages Max. 225 V phase-ground voltages
Times	
Pickup times $V<, V<<, V_1<, V_1<<$	Approx. 50 ms
Dropout times	As pickup times
Tolerances	
Pickup thresholds	1 % of setting value or 1 V
Times	1 % of setting value or 10 ms

Overvoltage protection (ANSI 59)	
Operating modes/measuring quantities	
3-phase	Negative-sequence component or largest of the phase-to-phase voltages
1-phase	Single-phase phase-ground or phase-phase voltage
Setting ranges	
Pickup thresholds $V>, V>>$	
3-phase, phase-ground connection, largest phase-phase voltage	40 to 260 V (in steps of 1 V)
3-phase, phase-phase connection, largest phase-phase voltage	40 to 150 V (in steps of 1 V)
3-phase, negative-sequence voltage	2 to 150 V (in steps of 1 V)
1-phase connection	40 to 150 V (in steps of 1 V)
Dropout ratio r	0.9 to 0.99 (in steps of 0.01)
Delay times T	0 to 100 s or ∞ (in steps of 0.01 s)
Times	
Pickup times $V>, V>>$	Approx. 50 ms
Pickup times $V_2>, V_2>>$	Approx. 60 ms
Dropout times	As pickup times
Tolerances	
Pickup thresholds	1 % of setting value or 1 V
Times	1 % of setting value or 10 ms

Overcurrent Protection / 7SJ63

Technical data

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Frequency protection (ANSI 81)	
Number of frequency elements	4
Setting ranges	
Pickup thresholds for $f_{nom} = 50$ Hz	45.5 to 54.5 Hz (in steps of 0.01 Hz)
Pickup thresholds for $f_{nom} = 60$ Hz	55.5 to 64.5 Hz (in steps of 0.01 Hz)
Delay times	0 to 100 s or ∞ (in steps of 0.01 s)
Undervoltage blocking, with positive-sequence voltage V_1	10 to 150 V (in steps of 1 V)
Times	
Pickup times	Approx. 150 ms
Dropout times	Approx. 150 ms
Dropout	
Δf = pickup value - dropout value	Approx. 20 mHz
Ratio undervoltage blocking	Approx. 1.05
Tolerances	
Pickup thresholds	
Frequency	10 mHz
Undervoltage blocking	3 % of setting value or 1 V
Delay times	3 % of the setting value or 10 ms
Fault locator (ANSI 21FL)	
Output of the fault distance	in Ω secondary, in km / miles line length
Starting signal	Trip command, dropout of a protection element, via binary input
Setting ranges	
Reactance (secondary)	0.001 to 1.9 Ω /km ¹ (in steps of 0.0001) 0.001 to 3 Ω /mile ¹ (in steps of 0.0001)
Tolerances	
Measurement tolerance acc. to VDE 0435, Part 303 for sinusoidal measurement quantities	2.5 % fault location, or 0.025 Ω (without intermediate infeed) for $30^\circ \leq \varphi_K \leq 90^\circ$ and $V_K/V_{nom} \geq 0.1$ and $I_K/I_{nom} \geq 1$

Additional functions	
Operational measured values	
Currents	
I_{L1}, I_{L2}, I_{L3}	In A (kA) primary, in A secondary or in % I_{nom}
Positive-sequence component I_1	
Negative-sequence component I_2	
I_E or $3I_0$	
Range	10 to 200 % I_{nom}
Tolerance ²⁾	1 % of measured value or 0.5 % I_{nom}
Phase-to-ground voltages	
$V_{L1-E}, V_{L2-E}, V_{L3-E}$	In kV primary, in V secondary or in % V_{nom}
Phase-to-phase voltages	
$V_{L1-L2}, V_{L2-L3}, V_{L3-L1}, V_E$ or V_0	
Positive-sequence component V_1	
Negative-sequence component V_2	
Range	10 to 120 % V_{nom}
Tolerance ²⁾	1 % of measured value or 0.5 % of V_{nom}
S, apparent power	
Range	0 to 120 % S_{nom}
Tolerance ²⁾	1 % of S_{nom} for V/V_{nom} and $I/I_{nom} = 50$ to 120 %
P, active power	
Range	0 to 120 % S_{nom}
Tolerance ²⁾	2 % of S_{nom} for V/V_{nom} and $I/I_{nom} = 50$ to 120 % and $ \cos \varphi = 0.707$ to 1 with $S_{nom} = \sqrt{3} V_{nom} \cdot I_{nom}$

Q, reactive power	With sign, total and phase-segregated in kVAR (MVAR or GVAR) primary and in % S_{nom}
Range	0 to 120 % S_{nom}
Tolerance ²⁾	2 % of S_{nom} for V/V_{nom} and $I/I_{nom} = 50$ to 120 % and $ \sin \varphi = 0.707$ to 1 with $S_{nom} = \sqrt{3} V_{nom} \cdot I_{nom}$
cos φ , power factor (p.f.)	
Range	- 1 to + 1
Tolerance ²⁾	3 % for $ \cos \varphi \geq 0.707$
Frequency f	
Range	$f_{nom} \pm 5$ Hz
Tolerance ²⁾	20 mHz
Temperature overload protection Θ/Θ_{Trip}	
Range	0 to 400 %
Tolerance ²⁾	5 % class accuracy per IEC 60255-8
Temperature restart inhibit $\Theta_L/\Theta_{L Trip}$	
Range	0 to 400 %
Tolerance ²⁾	5 % class accuracy per IEC 60255-8
Restart threshold $\Theta_{Restart}/\Theta_{L Trip}$	
Range	In %
Reclose time $T_{Reclose}$	
Range	In min
Currents of sensitive ground fault detection (total, real, and reactive current) $I_{EE}, I_{EE real}, I_{EE reactive}$	
Range	In A (kA) primary and in mA secondary
Tolerance ²⁾	0 mA to 1600 mA 2 % of measured value or 1 mA
Measuring transducer	
Operating range	0 to 24mA
Accuracy range	1 to 20mA
Tolerance ²⁾	1.5 %, relative to rated value of 20 mA
For standard usage of the measurement transducer for pressure and temperature monitoring	
Operating measured value	Pressure in hPa
Operating range (presetting)	0 hPa to 1200 hPa
Operating measured value temperature	Temp in °C / °F
Operating range (presetting)	0 °C to 240 °C or 32 °F to 464 °F
RTD-box	
See section "Temperature monitoring box"	
Long-term averages	
Time window	5, 15, 30 or 60 minutes
Frequency of updates	Adjustable
Long-term averages of currents of real power of reactive power of apparent power	
Range	$I_{L1dmd}, I_{L2dmd}, I_{L3dmd}, I_{1dmd}$ in A (kA) P_{dmd} in W (kW, MW) Q_{dmd} in VAR (kVAR, MVAR) S_{dmd} in VAR (kVAR, MVAR)

1) At $I_{nom} = 1$ A, all limits multiplied with 5.
2) At rated frequency.

Max. / Min. report	
Report of measured values	With date and time
Reset, automatic	Time of day adjustable (in minutes, 0 to 1439 min) Time frame and starting time adjustable (in days, 1 to 365 days, and ∞)
Reset, manual	Using binary input, using keypad, via communication
Min./Max. values for current	$I_{L1}, I_{L2}, I_{L3}, I_1$ (positive-sequence component)
Min./Max. values for voltages	$V_{L1-E}, V_{L2-E}, V_{L3-E}, V_1$ (positive-sequence component) $V_{L1-L2}, V_{L2-L3}, V_{L3-L1}$
Min./Max. values for power	$S, P, Q, \cos \varphi$, frequency
Min./Max. values for overload protection	Θ/Θ_{Trip}
Min./Max. values for mean values	$I_{L1dmd}, I_{L2dmd}, I_{L3dmd}, I_1$ (positive-sequence component); $S_{dmd}, P_{dmd}, Q_{dmd}$
Local measured values monitoring	
Current asymmetry	$I_{max}/I_{min} >$ balance factor, for $I > I_{balance}$ limit
Voltage asymmetry	$V_{max}/V_{min} >$ balance factor, for $V > V_{lim}$
Current sum	$ i_{L1} + i_{L2} + i_{L3} + k_{IE} \cdot i_E >$ limit value, with $k_{IE} = \frac{I_{earth} CT PRIM / I_{earth} CT SEC}{CT PRIM / CT SEC}$
Current phase sequence	Clockwise (ABC) / counter-clockwise (ACB)
Voltage phase sequence	Clockwise (ABC) / counter-clockwise (ACB)
Limit value monitoring	Predefined limit values, user-defined expansions via CFC
Fault recording	
Recording of indications of the last 8 power system faults	
Recording of indications of the last 3 power system ground faults	
Time stamping	
Resolution for event log (operational annunciations)	1 ms
Resolution for trip log (fault annunciations)	1 ms
Maximum time deviation (internal clock)	0.01 %
Battery	Lithium battery 3 V/1 Ah, type CR 1/2 AA, message "Battery Fault" for insufficient battery charge
Oscillographic fault recording	
Maximum 8 fault records saved, memory maintained by buffer battery in case of loss of power supply	
Recording time	Total 5 s Pre-trigger and post-fault recording and memory time adjustable
Sampling rate for 50 Hz	1 sample/1.25 ms (16 samples/cycle)
Sampling rate for 60 Hz	1 sample/1.04 ms (16 samples/cycle)

Energy/power	
Meter values for power W_p, W_q (real and reactive power demand)	in kWh (MWh or GWh) and kVARh (MVARh or GVARh)
Tolerance ¹⁾	≤ 5 % for $I > 0.5 I_{nom}, V > 0.5 V_{nom}$ and $ \cos \varphi (p.f.) \geq 0.707$
Statistics	
Saved number of trips	Up to 9 digits
Number of automatic reclosing commands (segregated according to 1 st and ≥ 2 nd cycle)	Up to 9 digits
Circuit-breaker wear	
Methods	<ul style="list-style-type: none"> • ΣI^x with $x = 1 \dots 3$ • 2-point method (remaining service life)
Operation	Phase-selective accumulation of measured values on TRIP command, up to 8 digits, phase-selective limit values, monitoring indication
Operating hours counter	
Display range	Up to 7 digits
Criterion	Overshoot of an adjustable current threshold (BkrClosed I_{MIN})
Trip circuit monitoring	
With one or two binary input	
Commissioning aids	
Phase rotation field check, operational measured values, circuit-breaker/switching device test, creation of a test measurement report	
Clock	
Time synchronization	DCF77/IRIG-B signal (telegram format IRIG-B000), binary input, communication
Control	
Number of switching units	Depends on the binary inputs and outputs
Interlocking	Programmable
Circuit-breaker signals	Feedback, close, open, intermediate position
Control commands	Single command / double command 1, 1 plus 1 common or 2 trip contacts
Programmable controller	CFC logic, graphic input tool
Local control	Control via menu, assignment of a function key
Remote control	Via communication interfaces, using a substation automation and control system (e.g. SICAM), DIGSI 4 (e.g. via modem)
1) At rated frequency.	

Overcurrent Protection / 7SJ63

Technical data

Setting group switchover of the function parameters

Number of available setting groups	4 (parameter group A, B, C and D)
Switchover performed	Via keypad, DIGSI, system (SCADA) interface or binary input

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EG previous 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 2006/95/EG previous 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1. The unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".



Description	Order No.
7SJ63 multifunction protection relay	7SJ63 <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Housing, binary inputs (BI) and outputs (BO), measuring transducer	
Housing ½19", 11 BI, 8 BO, 1 live status contact	1
Housing ½19", 24 BI, 11 BO, 2 power relays (4 contacts), 1 live status contact	2
Housing ½19", 20 BI, 11 BO, 2 measuring transducer inputs, 2 power relays (4 contacts), 1 live status contact	3
Housing ½19", 37 BI, 14 BO, 4 power relays (8 contacts), 1 live status contact	5
Housing ½19", 33 BI, 14 BO, 2 measuring transducer inputs, 4 power relays (8 contacts), 1 live status contact	6
Measuring inputs (3 x V, 4 x I)	
$I_{ph} = 1 A^{1)}$, $I_e = 1 A^{1)}$ (min. = 0.05 A) Position 15 only with A, C, E, G	1
$I_{ph} = 1 A^{1)}$, $I_e =$ sensitive (min. = 0.001 A) Position 15 only with B, D, F, H	2
$I_{ph} = 5 A^{1)}$, $I_e = 5 A^{1)}$ (min. = 0.25 A) Position 15 only with A, C, E, G	5
$I_{ph} = 5 A^{1)}$, $I_e =$ sensitive (min. = 0.001 A) Position 15 only with B, D, F, H	6
$I_{ph} = 5 A^{1)}$, $I_e = 1 A^{1)}$ (min. = 0.05 A) Position 15 only with A, C, E, G	7
Rated auxiliary voltage (power supply, indication voltage)	
DC 24 to 48 V, threshold binary input DC 19 V ³⁾	2
DC 60 to 125 V ²⁾ , threshold binary input DC 19 V ³⁾	4
DC 110 to 250 V ²⁾ , AC 115 to 230 V ⁴⁾ , threshold binary input DC 88 V ³⁾	5
Unit version	
For panel surface mounting, plug-in terminals, detached operator panel	A
For panel surface mounting, two-tier terminal top/bottom	B
For panel surface mounting, screw-type terminals, detached operator panel	C
For panel flush mounting, plug-in terminal (2/3 pin connector)	D
For panel flush mounting, screw-type terminals (direct connection/ring-type cable lugs)	E
For panel flush mounting, screw-type terminal (direct connection/ring-type cable lugs) without operator panel, panel mounting in low-voltage housing	F
Surface-mounting housing, plug-in terminals, without operator panel, panel mounting in low-voltage housing	G
Region-specific default settings/function versions and language settings	
Region DE, 50Hz, IEC, language: German, selectable	A
Region World, 50/60 Hz, IEC/ANSI, language: English (GB), selectable	B
Region US, 60Hz, ANSI, language: English (US), selectable	C
Region FR, 50/60 Hz, IEC/ANSI, language: French, selectable	D
Region World, 50/60 Hz, IEC/ANSI, language: Spanish, selectable	E
System interface (Port B): Refer to page 5/152	
No system interface	0
Protocols see page 5/152	
Service interface (Port C)	
No interface at rear side	0
DIGSI 4/modem, electrical RS232	1
DIGSI 4/modem/RTD-box ⁵⁾ , electrical RS485	2
DIGSI 4/modem/RTD-box ⁵⁾⁶⁾ , optical 820 nm wavelength, ST connector	3
Measuring/fault recording	
Slave pointer, mean values, min/max values, fault recording	3

See next page

- 1) Rated current can be selected by means of jumpers.
- 2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.
- 3) The binary input thresholds can be selected per binary input by means of jumpers.
- 4) AC 230 V, starting from device version .../EE.

- 5) Temperature monitoring box 7XV5662-□AD10, refer to "Accessories".
- 6) When using the temperature monitoring box at an optical interface, the additional RS485 fiber-optic converter 7XV5650-0□A00 is required.

Overcurrent Protection / 7SJ63

Selection and ordering data

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Description			Order No.	Order code
7SJ63 multifunction protection relay			7SJ63 □ □ - □ □ □ □ □ □ - □ □ □ □	
Designation	ANSI No.	Description		
Basic version		Control		
	50/51	Overcurrent protection $I>$, $I>>$, I_p , reverse interlocking		
	50N/51N	Ground-fault protection $I_{E>}$, $I_{E>>}$, I_{EP}		
	50N/51N	Insensitive ground-fault protection via IEE function: $I_{EE>}$, $I_{EE>>}$, $I_{EEP}^{1)}$		
	49	Overload protection (with 2 time constants)		
	46	Phase balance current protection (negative-sequence protection)		
	37	Undercurrent monitoring		
	47	Phase sequence		
	59N/64	Displacement voltage		
	50BF	Breaker failure protection		
	74TC	Trip circuit supervision		
		4 setting groups, cold-load pickup		
		Inrush blocking		
	86	Lockout		F A
■	V, f	27/59 Under-/overvoltage 810/U Under-/overfrequency		F E
■	IEF V, f	27/59 Under-/overvoltage 810/U Under-/overfrequency Intermittent ground fault		P E
■	Dir	67/67N Direction determination for overcurrent, phases and ground 47 Phase sequence		F C
■	Dir V, f	67/67N Direction determination for overcurrent, phases and ground 27/59 Under-/overvoltage 810/U Under-/overfrequency		F G
■	Dir IEF	67/67N Direction determination for overcurrent, phases and ground Intermittent ground fault		P C
Directional ground-fault detection	Dir	67/67N Direction determination for overcurrent, phases and ground 67Ns Directional sensitive ground-fault detection 87N High-impedance restricted ground fault		F D ²⁾
■	Dir IEF	67/67N Direction determination for overcurrent, phases and ground 67Ns Directional sensitive ground-fault detection 87N High-impedance restricted ground fault Intermittent ground fault		P D ²⁾
Directional ground-fault detection		67Ns Directional sensitive ground-fault detection 87N High-impedance restricted ground fault		F B ²⁾
■	Motor V, f	67Ns Directional sensitive ground-fault detection 87N High-impedance restricted ground fault detection 48/14 Starting time supervision, locked rotor		
■		66/86 Restart inhibit 27/59 Under-/overvoltage 810/U Under-/overfrequency		H F ²⁾

Continued on next page

- Basic version included
- V, f = Voltage, frequency protection
- Dir = Directional overcurrent protection
- IEF = Intermittent ground fault

- 1) Only with insensitive ground-current transformer when position 7 = 1, 5, 7.
- 2) For isolated / compensated networks only with sensitive ground-current transformer when position 7 = 2, 6.

Overcurrent Protection/7SJ63

Selection and ordering data

Description			Order No.	Order code
7SJ63 multifunction protection relay			7SJ63 □ □ - □ □ □ □ □ □ - □ □ □ □	
Designation	ANSI No.	Description		
Basic version		Control		
	50/51	Overcurrent protection $I>$, $I>>$, I_p , reverse interlocking		
	50N/51N	Ground-fault protection $I_{E>}$, $I_{E>>}$, I_{EP}		
	50N/51N	Ground-fault protection via insensitive IEE function: $I_{EE>}$, $I_{EE>>}$, I_{EEP} ¹⁾		
	49	Overload protection (with 2 time constants)		
	46	Phase balance current protection (negative-sequence protection)		
	37	Undercurrent monitoring		
	47	Phase sequence		
	59N/64	Displacement voltage		
	50BF	Breaker failure protection		
	74TC	Trip circuit supervision		
		4 setting groups, cold-load pickup		
		Inrush blocking		
	86	Lockout		
Directional Motor ground-fault Dir detection	V, f	67/67N Direction determination for overcurrent, phases and ground		
		67Ns Directional sensitive ground-fault detection		
		87N High-impedance restricted ground fault		
		48/14 Starting time supervision, locked rotor		
		66/86 Restart inhibit		
		27/59 Under-/overvoltage		
		81O/U Under-/overfrequency		H H ²⁾
Directional Motor IEF V, f ground-fault Dir detection		67/67N Direction determination for overcurrent, phases and ground		
		67Ns Directional sensitive ground-fault detection		
		87N High-impedance restricted ground fault		
		Intermittent ground fault		
		48/14 Starting time supervision, locked rotor		
		66/86 Restart inhibit		
		27/59 Undervoltage/overvoltage		
		81O/U Underfrequency/overfrequency		R H ²⁾
■	Motor Dir	V, f 67/67N Direction determination for overcurrent, phases and ground		
		48/14 Starting time supervision, locked rotor		
		66/86 Restart inhibit		
		27/59 Under-/overvoltage		
		81O/U Under-/overfrequency		H G
■	Motor	48/14 Starting time supervision, locked rotor		
		66/86 Restart inhibit		H A
ARC, fault locator		Without		0
		79 With auto-reclosure		1
		21FL With fault locator		2
		79, 21FL With auto-reclosure, with fault locator		3

■ Basic version included

V, f = Voltage, power, frequency protection

Dir = Directional overcurrent protection

IEF = Intermittent ground fault

1) Only with insensitive ground-current transformer when position 7 = 1, 5, 7.

2) For isolated / compensated networks only with sensitive ground-current transformer when position 7 = 2, 6.

Overcurrent Protection / 7SJ63

Selection and ordering data

5

Description	Order No.	Order code
7SJ63 multifunction protection relay	7SJ63 □ □ - □ □ □ □ □ □ - □ □ □ □ □ □ - □ □ □ □	
System interface (on rear of unit, Port B)		
No system interface	0	
IEC 60870-5-103 protocol, RS232	1	
IEC 60870-5-103 protocol, RS485	2	
IEC 60870-5-103 protocol, 820 nm fiber, ST connector	3	
PROFIBUS-FMS Slave, RS485	4	
PROFIBUS-FMS Slave, 820 nm wavelength, single ring, ST connector ¹⁾	5	
PROFIBUS-FMS Slave, 820 nm wavelength, double ring, ST connector ¹⁾	6	
PROFIBUS-DP Slave, RS485	9	L O A
PROFIBUS-DP Slave, 820 nm wavelength, double ring, ST connector ¹⁾	9	L O B
MODBUS, RS485	9	L O D
MODBUS, 820 nm wavelength, ST connector ²⁾	9	L O E
DNP 3.0, RS485	9	L O G
DNP 3.0, 820 nm wavelength, ST connector ²⁾	9	L O H
IEC 61850, 100 Mbit Ethernet, electrical, double, RSJ45 connector (EN 100)	9	L O R
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector (EN 100) ²⁾	9	L O S

1) Not with position 9 = "B"; if 9 = "B", please order 7SJ6 unit with RS485 port and separate fiber-optic converters.
 For single ring, please order converter 6GK1502-3AB10, not available with position 9 = "B".
 For double ring, please order converter 6GK1502-4AB10, not available with position 9 = "B".
 The converter requires a AC 24 V power supply (e.g. power supply 7XV5810-0BA00).

2) Not available with position 9 = "B".

Sample order

Position	Order No. + Order code
	7SJ632 5 - 5 E C 9 1 - 3 F C 1 + L O G
6 I/O's: 24 BI/11 BO, 1 live status contact	2
7 Current transformer: 5 A	5
8 Power supply: DC 110 to 250 V, AC 115 V to AC 230 V	5
9 Unit version: Flush-mounting housing, screw-type terminals	E
10 Region: US, English language (US); 60 Hz, ANSI	C
11 Communication: System interface: DNP 3.0, RS485	9
12 Communication: DIGSI 4, electric RS232	1
13 Measuring/fault recording: Extended measuring and fault records	3
14/15 Protection function package: Basic version plus directional TOC	F C
16 With auto-reclosure	1






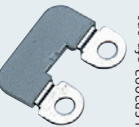

Overcurrent Protection/7SJ63

Selection and ordering data

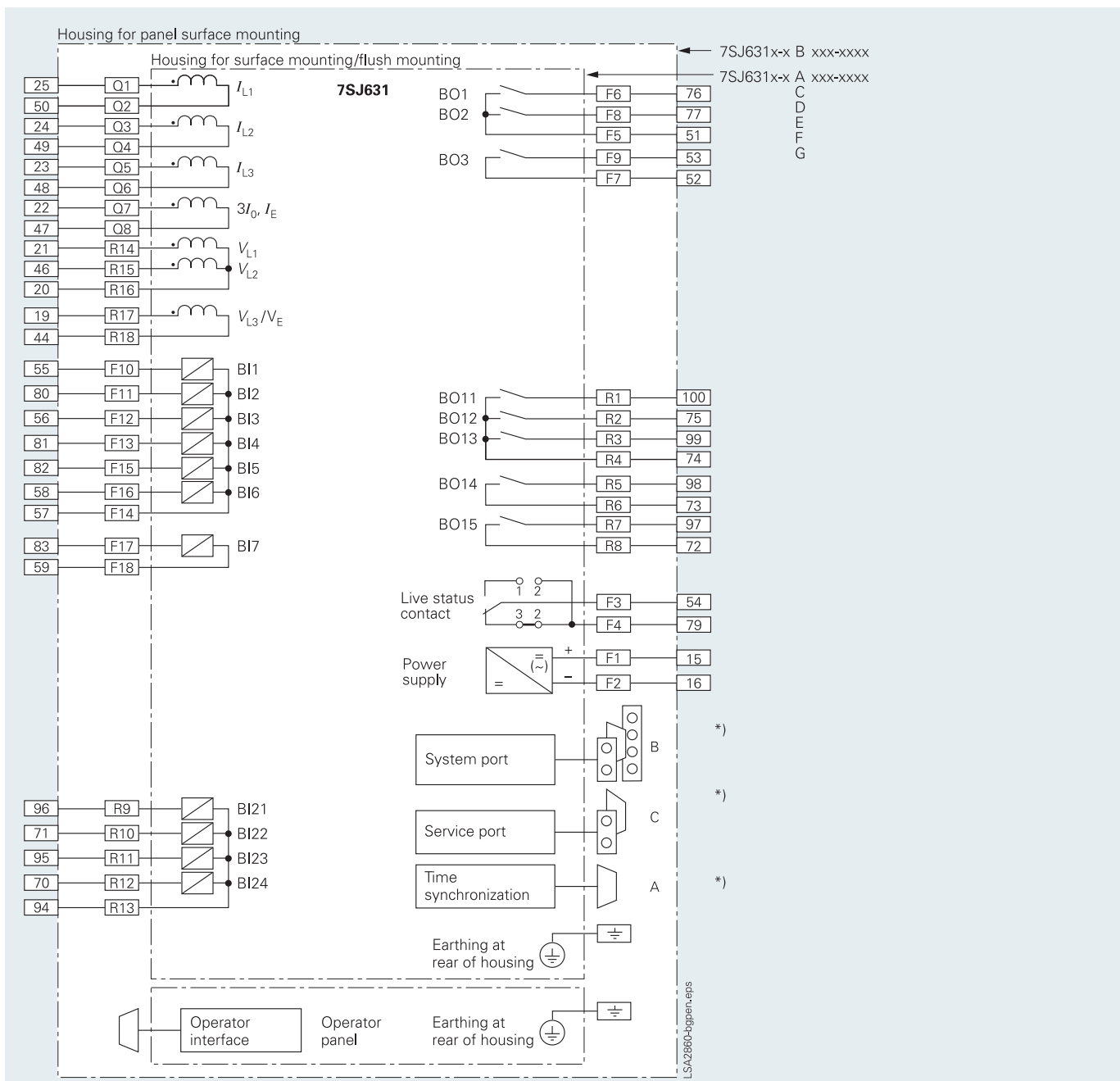
Accessories	Description	Order No.
	DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
	Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
	Professional + IEC 61850 Complete version: DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for control displays), DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	7XS5403-0AA00
	IEC 61850 System configurator Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM	7XS5460-0AA00
	SIGRA 4 Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000 or XP Professional Edition (generally contained in DIGSI Professional, but can be ordered additionally). Authorization by serial number. On CD-ROM.	7XS5410-0AA00
	Temperature monitoring box AC/DC 24 to 60 V	7XV5662-2AD10
	AC/DC 90 to 240 V	7XV5662-5AD10
	Varistor/VoltageArrester Voltage arrester for high-impedance REF protection 125 Vrms; 600 A; 1S/S 256	C53207-A401-D76-1
	240 Vrms; 600 A; 1S/S 1088	C53207-A401-D77-1
	Connecting cable Cable between PC/notebook (9-pin con.) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	7XV5100-4
	Cable between temperature monitoring box and SIPROTEC 4 unit - length 5 m / 16.4 ft	7XV5103-7AA05
	- length 25 m / 82 ft	7XV5103-7AA25
	- length 50 m / 164 ft	7XV5103-7AA50
	Manual for 7SJ63 English/German	C53000-G1140-C147-x ¹⁾
	1) x = please inquire for latest edition (exact Order No.).	

Overcurrent Protection / 7SJ63

Selection and ordering data

Accessories	Description	Order No.	Size of package	Supplier
   Mounting rail	Terminal safety cover			
	Voltage/current terminal 18-pole/12-pole	C73334-A1-C31-1	1	Siemens
	Voltage/current terminal 12-pole/8-pole	C73334-A1-C32-1	1	Siemens
	Connector 2-pin	C73334-A1-C35-1	1	Siemens
	Connector 3-pin	C73334-A1-C36-1	1	Siemens
 2-pin connector	Crimp connector CI2 0.5 to 1 mm ²	0-827039-1	4000 taped on reel	AMP ¹⁾
	Crimp connector CI2 0.5 to 1 mm ²	0-827396-1	1	AMP ¹⁾
	Crimp connector: Type III+ 0.75 to 1.5 mm ²	0-163084-2	1	AMP ¹⁾
	Crimp connector: Type III+ 0.75 to 1.5 mm ²	0-163083-7	4000 taped on reel	AMP ¹⁾
	Crimping tool for Type III+ and matching female	0-539635-1	1	AMP ¹⁾
 3-pin connector	Crimping tool for CI2 and matching female	0-539668-2	1	AMP ¹⁾
	Crimping tool for CI2 and matching female	0-734372-1	1	AMP ¹⁾
	Crimping tool for CI2 and matching female	1-734387-1	1	AMP ¹⁾
	Short-circuit links for current terminals	C73334-A1-C33-1	1	Siemens
	Short-circuit links for other terminals	C73334-A1-C34-1	1	Siemens
 Short-circuit links for current terminals	Mounting rail for 19" rack	C73165-A63-D200-1	1	Siemens
 Short-circuit links for current terminals				

1) Your local Siemens representative can inform you on local suppliers.



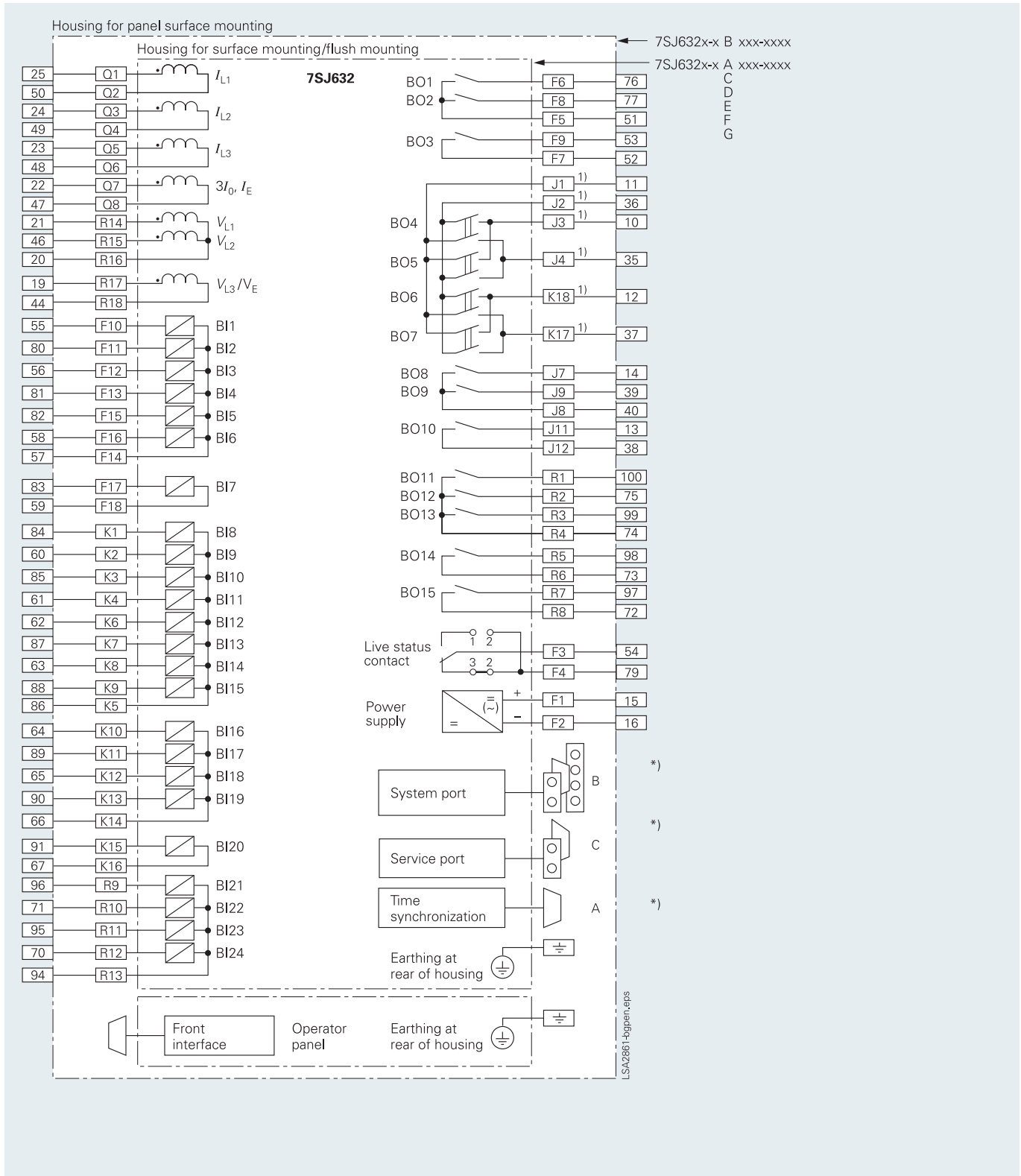
*) For pinout of communication ports see part 14 of this catalog.
 For the allocation of the terminals of the panel surface-mounting version refer to the manual (<http://www.siemens.com/siprotec>).

Fig. 5/137 7SJ631 connection diagram

Overcurrent Protection / 7SJ63

Connection diagram

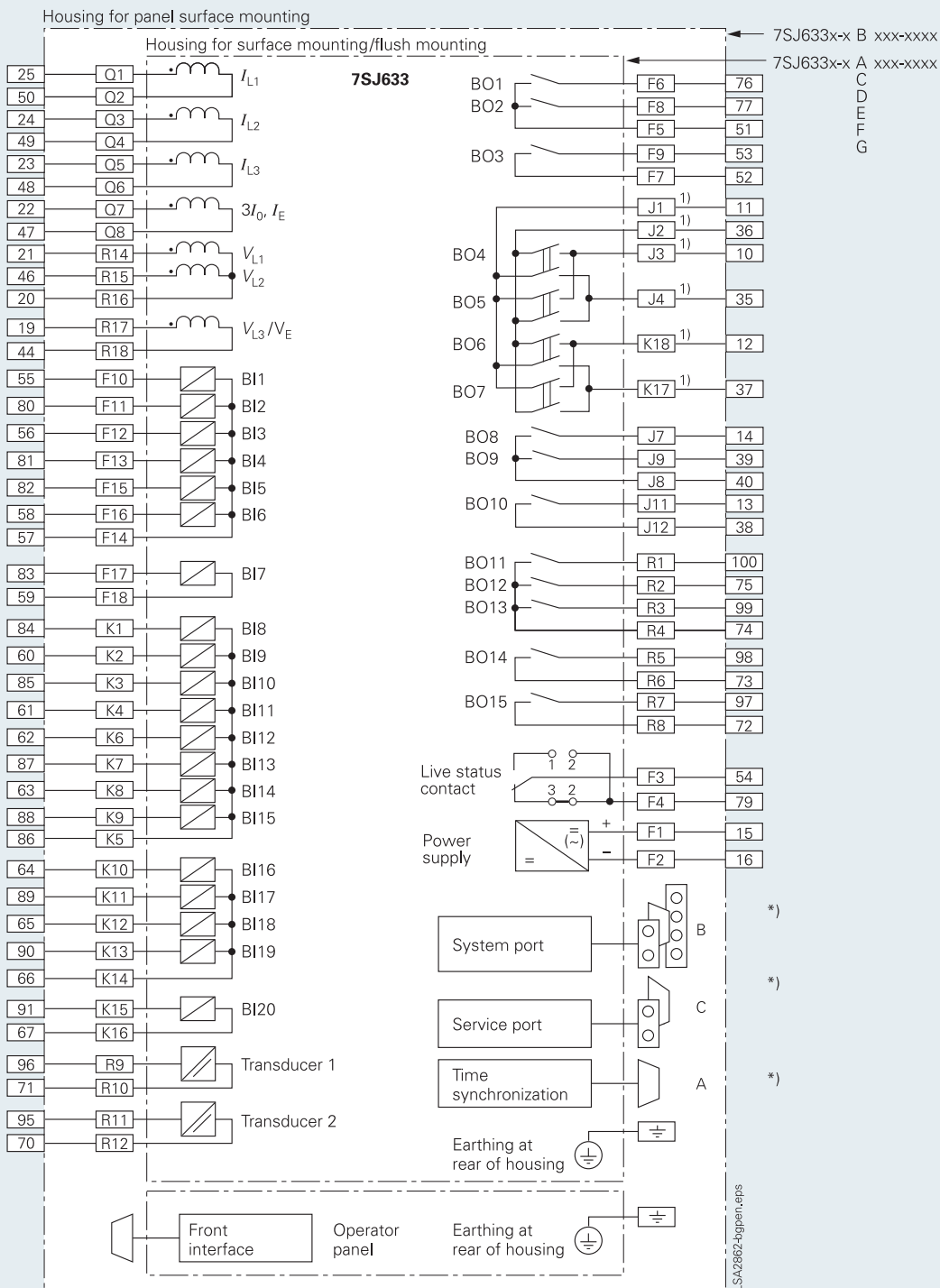
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*) For pinout of communication ports see part 14 of this catalog.
For the allocation of the terminals of the panel surface-mounting version refer to the manual (<http://www.siemens.com/siprotec>).

1) Power relays are intended to directly control motorized switches. The power relays are interlocked so only one relay of each pair can close at a time, in order to avoid shorting out the power supply. The power relay pairs are BO4/BO5, BO6/BO7. If used for protection purposes only one binary output of a pair can be used.

Fig. 5/138 7SJ632 connection diagram



*) For pinout of communication ports see part 14 of this catalog.
For the allocation of the terminals of the panel surface-mounting version refer to the manual (<http://www.siemens.com/siprotec>).

1) Power relays are intended to directly control motorized switches. The power relays are interlocked so only one relay of each pair can close at a time, in order to avoid shorting out the power supply. The power relay pairs are BO4/BO5, BO6/BO7. If used for protection purposes only one binary output of a pair can be used.

Fig. 5/139 7SJ633 connection diagram

Overcurrent Protection / 7SJ63

Connection diagram

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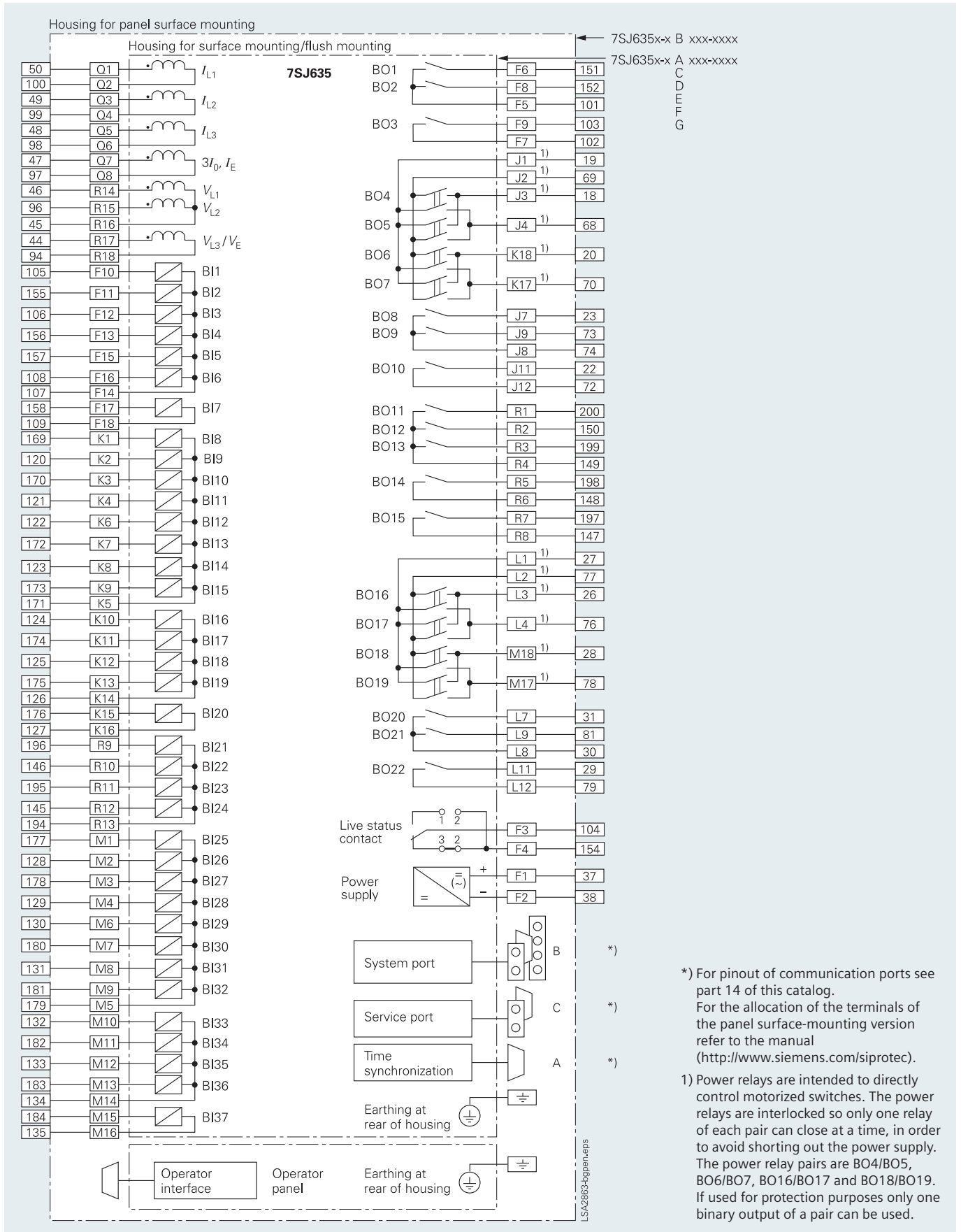


Fig. 5/140 7SJ635 connection diagram

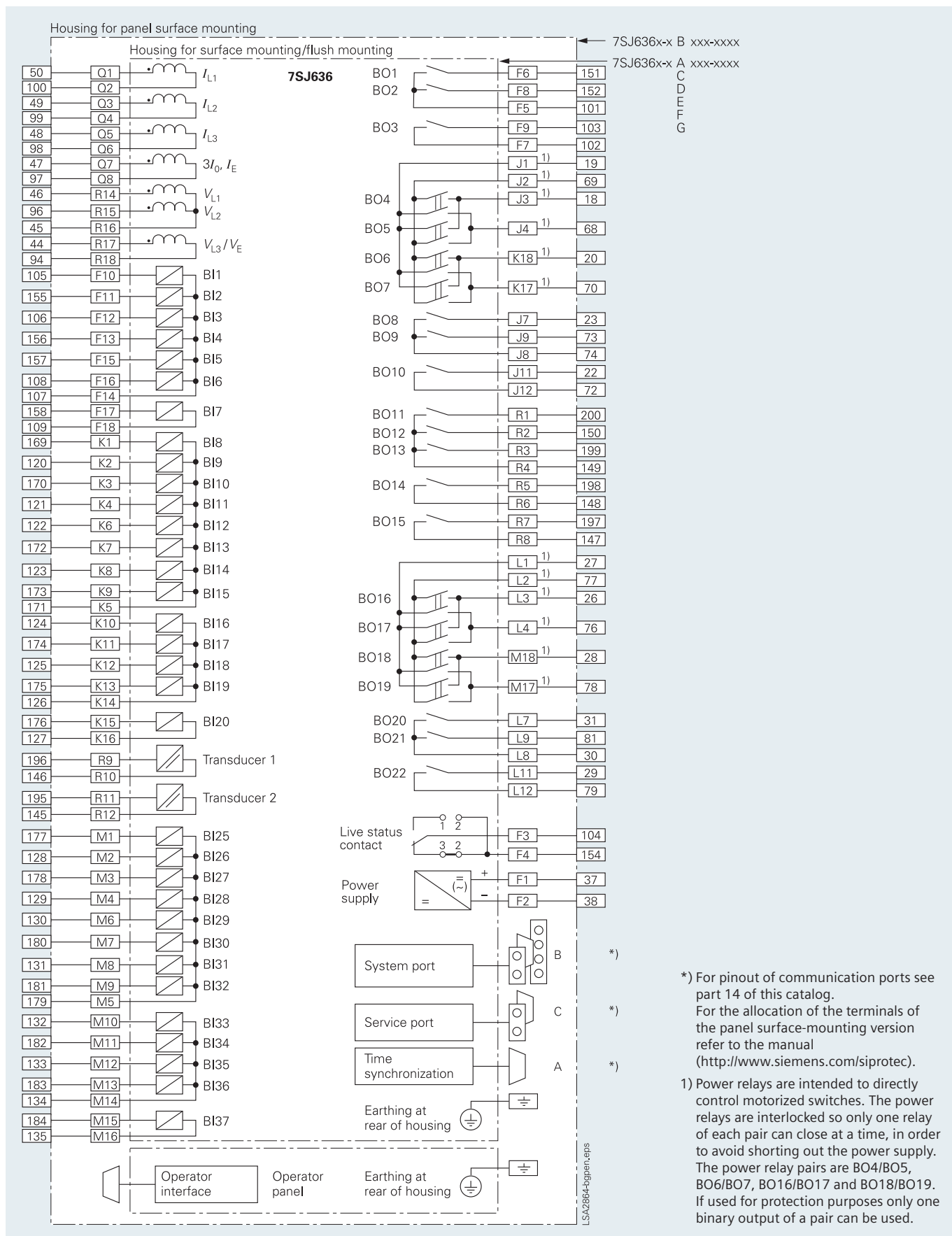


Fig. 5/141 7SJ636 connection diagram



Fig. 5/142 SIPROTEC 4 7SJ64 multifunction protection relay

Description

The SIPROTEC 4 7SJ64 can be used as a protective control and monitoring relay for distribution feeders and transmission lines of any voltage in networks that are earthed (grounded), low-resistance grounded, ungrounded, or of a compensated neutral point structure. The relay is suited for networks that are radial or looped, and for lines with single or multi-terminal feeds. The SIPROTEC 4 7SJ64 is equipped with a synchronization function which provides the operation modes 'synchronization check' (classical) and 'synchronous/asynchronous switching' (which takes the CB mechanical delay into consideration). Motor protection comprises undercurrent monitoring, starting time supervision, restart inhibit, locked rotor, load jam protection as well as motor statistics.

The 7SJ64 is featuring the "flexible protection functions". Up to 20 protection functions can be added according to individual requirements. Thus, for example, rate-of-frequency-change protection or reverse power protection can be implemented.

The relay provides easy-to-use local control and automation functions. The number of controllable switchgear depends only on the number of available inputs and outputs. The integrated programmable logic (CFC) allows the user to implement their own functions, e.g. for the automation of switchgear (interlocking). CFC capacity is much larger compared to 7SJ63 due to extended CPU power. The user is able to generate user-defined messages as well.

The flexible communication interfaces are open for modern communication architectures with control systems.

Function overview

Protection functions

- Overcurrent protection
- Directional overcurrent protection
- Sensitive dir./non-dir. ground-fault detection
- Displacement voltage
- Intermittent ground-fault protection
- Directional intermittent ground fault protection
- High-impedance restricted ground fault
- Inrush restraint
- Motor protection
- Overload protection
- Temperature monitoring
- Under-/overvoltage protection
- Under-/overfrequency protection
- Rate-of-frequency-change protection
- Power protection (e.g. reverse, factor)
- Undervoltage-controlled reactive power protection
- Breaker failure protection
- Negative-sequence protection
- Phase-sequence monitoring
- Synchronization
- Auto-reclosure
- Fault locator
- Lockout

Control functions/programmable logic

- Flexible number of switching devices
- Position of switching elements is shown on the graphic display
- Local/remote switching via key-operated switch
- Control via keyboard, binary inputs, DIGSI 4 or SCADA system
- Extended user-defined logic with CFC (e.g. interlocking)

Monitoring functions

- Operational measured values V, I, f, \dots
- Energy metering values W_p, W_q
- Circuit-breaker wear monitoring
- Slave pointer
- Trip circuit supervision
- Fuse failure monitor
- 8 oscillographic fault records
- Motor statistics

Communication interfaces

- System interface
 - IEC 60870-5-103, IEC 61850
 - PROFIBUS-FMS / DP
 - DNP 3.0 / DNP3 TCP / MODBUS RTU
- Service interface for DIGSI 4 (modem)
- Additional interface for temperature detection (RTD-box)
- Front interface for DIGSI 4
- Time synchronization via IRIG B/DCF77

Overcurrent Protection / 7SJ64

Application

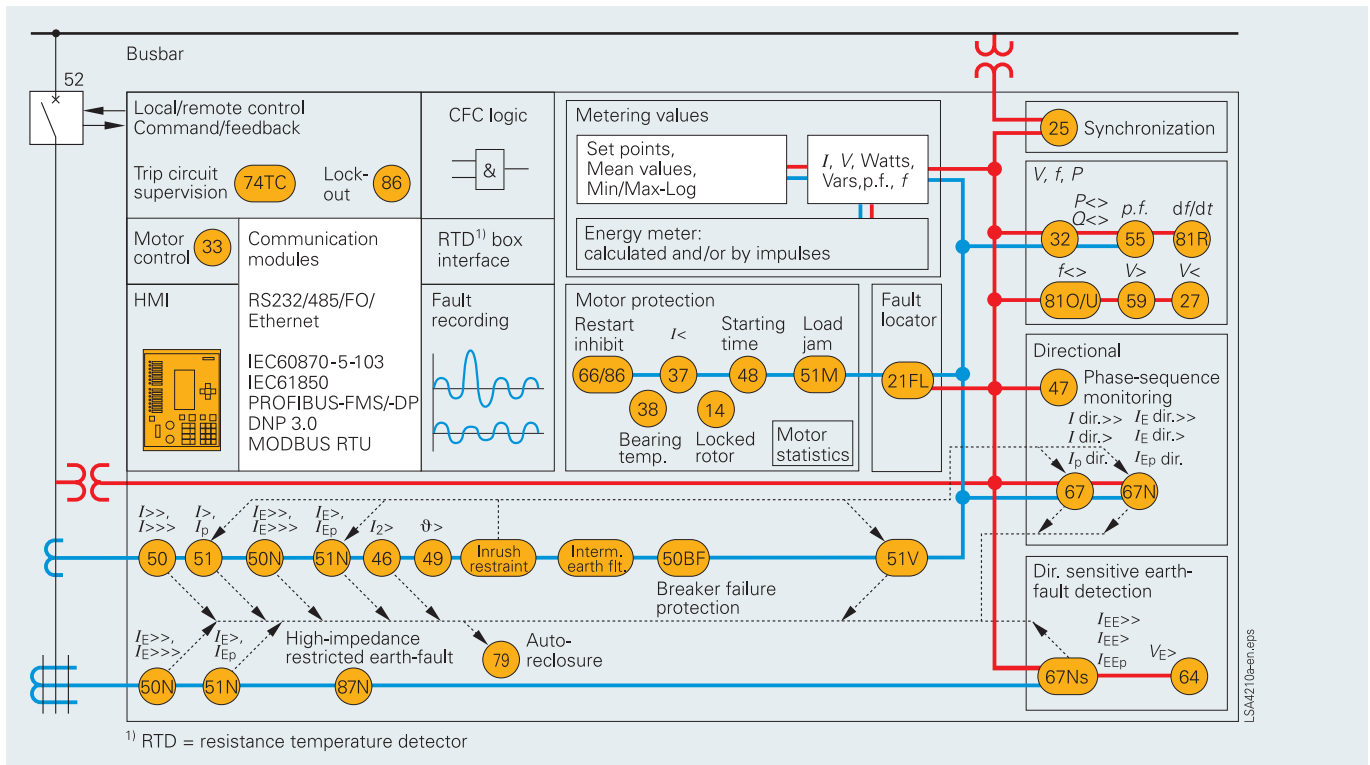


Fig. 5/143 Function diagram

Application

The SIPROTEC 4 7SJ64 unit is a numerical protection relay that also performs control and monitoring functions and therefore supports the user in cost-effective power system management, and ensures reliable supply of electric power to the customers. Local operation has been designed according to ergonomic criteria. A large, easy-to-read graphic display was a major design aim.

Control

The integrated control function permits control of disconnect devices (electrically operated/motorized switches) or circuit-breakers via the integrated operator panel, binary inputs, DIGSI 4 or the control and protection system (e.g. SICAM). The present status (or position) of the primary equipment can be displayed. 7SJ64 supports substations with single and duplicate busbars. The number of elements that can be controlled (usually 1 to 5) is only restricted by the number of inputs and outputs available. A full range of command processing functions is provided.

Programmable logic

The integrated logic characteristics (CFC) allow users to implement their own functions for automation of switchgear (interlocking) or a substation via a graphic user interface. Due to extended CPU power, the programmable logic capacity is much larger compared to 7SJ63. The user can also generate user-defined messages.

Line protection

The 7SJ64 units can be used for line protection of high and medium-voltage networks with grounded, low-resistance grounded, isolated or compensated neutral point.

Synchronization

In order to connect two components of a power system, the relay provides a synchronization function which verifies that switching ON does not endanger the stability of the power system.

The synchronization function provides the operation modes 'synchro-check' (classical) and 'synchronous/asynchronous switching' (which takes the c.-b. mechanical delay into consideration).

Motor protection

When protecting motors, the relays are suitable for asynchronous machines of all sizes.

Transformer protection

The 7SJ64 units perform all functions of backup protection supplementary to transformer differential protection. The inrush suppression effectively prevents tripping by inrush currents.

The high-impedance restricted ground-fault protection detects short-circuits and insulation faults of the transformer.

Backup protection

The relays can be used universally for backup protection.

Flexible protection functions

By configuring a connection between a standard protection logic and any measured or derived quantity, the functional scope of the relays can be easily expanded by up to 20 protection stages or protection functions.

Metering values

Extensive measured values, limit values and metered values permit improved system management.

ANSI	IEC	Protection functions
50, 50N	$I>, I>>, I>>>$ $I_{E>}, I_{E>>}, I_{E>>>}$	Definite-time overcurrent protection (phase/neutral)
50, 50N	$I>>>>, I_2>$ $I_{E>>>>}$	Additional definite-time overcurrent protection stages (phase/neutral) via flexible protection functions
51, 51V, 51N	I_p, I_{Ep}	Inverse overcurrent protection (phase/neutral), phase function with voltage-dependent option
67, 67N	$I_{dir>}, I_{dir>>}, I_{p\ dir}$ $I_{E_{dir>}}, I_{E_{dir>>}}, I_{Ep\ dir}$	Directional overcurrent protection (definite/inverse, phase/neutral), Directional comparison protection
67Ns/50Ns	$I_{EE>}, I_{EE>>}, I_{EEp}$	Sensitive ground-fault protection
–		Cold load pick-up (dynamic setting change)
59N/64	$V_E, V_{0>}$	Displacement voltage, zero-sequence voltage
–	$I_{IE>}$	Intermittent ground fault
67Ns	$I_{IE\ dir>}$	Directional intermittent ground fault protection
87N		High-impedance restricted ground-fault protection
50BF		Breaker failure protection
79M		Auto-reclosure
25		Synchronization
46	$I_2>$	Phase-balance current protection (negative-sequence protection)
47	$V_2>, \text{phase seq.}$	Unbalance-voltage protection and/or phase-sequence monitoring
49	$\vartheta>$	Thermal overload protection
48		Starting time supervision
51M		Load jam protection
14		Locked rotor protection
66/86		Restart inhibit
37	$I<$	Undercurrent monitoring
38		Temperature monitoring via external device (RTD-box), e.g. bearing temperature monitoring
27, 59	$V<, V>$	Undervoltage/overvoltage protection
59R	dV/dt	Rate-of-voltage-change protection
32	$P<>, Q<>$	Reverse-power, forward-power protection
27/Q	$Q>/V<$	Undervoltage-controlled reactive power protection
35	$\cos \varphi$	Power factor protection
81O/U	$f>, f<$	Overfrequency/underfrequency protection
81R	df/dt	Rate-of-frequency-change protection
21FL		Fault locator

Overcurrent Protection / 7SJ64

Construction

Construction

Connection techniques and housing with many advantages

$\frac{1}{3}$, $\frac{1}{2}$ and $\frac{1}{4}$ -rack sizes

These are the available housing widths of the 7SJ64 relays, referred to a 19" module frame system. This means that previous models can always be replaced. The height is a uniform 244 mm for flush-mounting housings and 266 mm for surface-mounting housings for all housing widths. All cables can be connected with or without ring lugs. Plug-in terminals are available as an option.

It is thus possible to employ prefabricated cable harnesses. In the case of surface mounting on a panel, the connection terminals are located above and below the housing. The communication interfaces are located in a sloped case at the top and bottom of the housing. The housing can also be supplied optionally with a detached operator panel (refer to Fig. 5/146), or without operator panel, in order to allow optimum operation for all types of applications.

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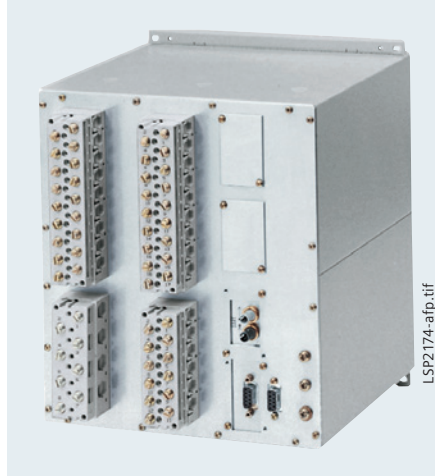


Fig. 5/144 Flush-mounting housing with screw-type terminals



Fig. 5/145 Front view of 7SJ64 with $\frac{1}{3} \times 19$ " housing

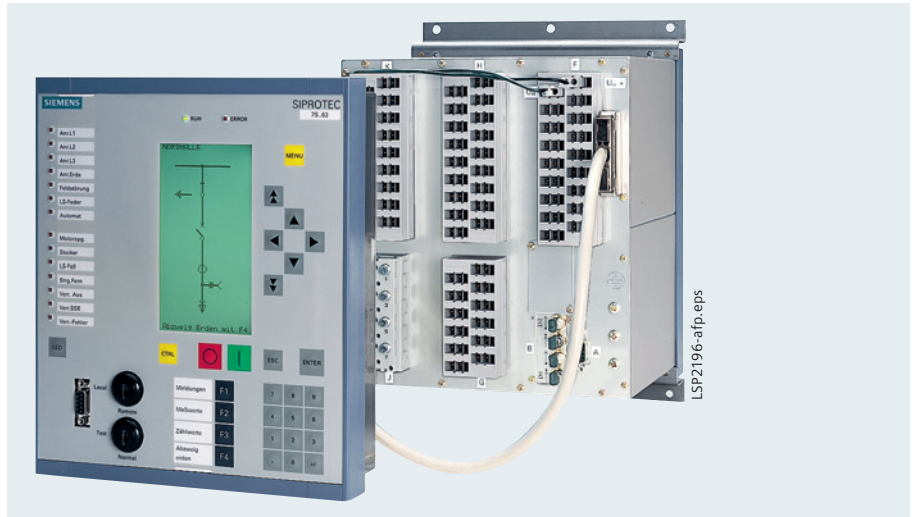


Fig. 5/146 Housing with plug-in terminals and detached operator panel



Fig. 5/147 Surface-mounting housing with screw-type terminals



Fig. 5/148 Communication interfaces in a sloped case in a surface-mounting housing

Protection functions

Overcurrent protection (ANSI 50, 50N, 51,51V, 51N)

This function is based on the phase-selective measurement of the three phase currents and the ground current (four transformers). Three definite-time overcurrent protection elements (DMT) exist both for the phases and for the ground. The current threshold and the delay time can be set in a wide range. In addition, inverse-time overcurrent protection characteristics (IDMTL) can be activated. The inverse-time function provides – as an option – voltage-restraint or voltage-controlled operating modes.

With the "flexible protection functions", further definite-time overcurrent stages can be implemented in the 7SJ64 unit.

Reset characteristics

For easier time coordination with electro-mechanical relays, reset characteristics according to ANSI C37.112 and IEC 60255-3 / BS 142 standards are applied.

When using the reset characteristic (disk emulation), a reset process is initiated after the fault current has disappeared. This reset process corresponds to the reverse movement of the Ferraris disk of an electromechanical relay (thus: disk emulation).

User-definable characteristics

Instead of the predefined time characteristics according to ANSI, tripping characteristics can be defined by the user for phase and ground units separately. Up to 20 current / time value pairs may be programmed. They are set as pairs of numbers or graphically in DIGSI 4.

Inrush restraint

The relay features second harmonic restraint. If the second harmonic is detected during transformer energization, pickup of non-directional and directional normal elements are blocked.

Cold load pickup/dynamic setting change

For directional and nondirectional overcurrent protection functions the initiation thresholds and tripping times can be switched via binary inputs or by time control.

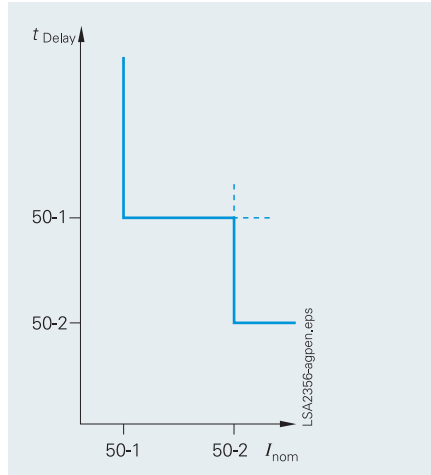


Fig. 5/149 Definite-time overcurrent protection

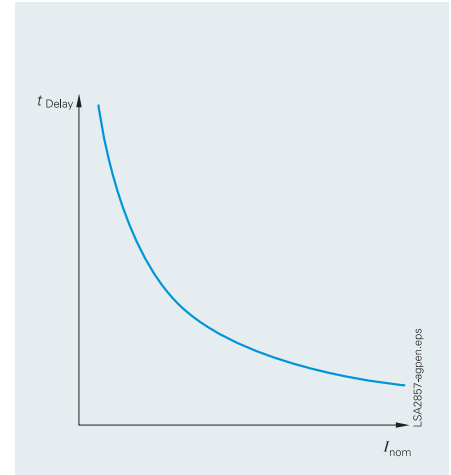


Fig. 5/150 Inverse-time overcurrent protection

Available inverse-time characteristics

Characteristics acc. to	ANSI/IEEE	IEC 60255-3
Inverse	•	•
Short inverse	•	
Long inverse	•	•
Moderately inverse	•	
Very inverse	•	•
Extremely inverse	•	•
Definite inverse	•	

Overcurrent Protection / 7SJ64

Protection functions

Directional overcurrent protection (ANSI 67, 67N)

Directional phase and ground protection are separate functions. They operate in parallel to the non-directional overcurrent elements. Their pickup values and delay times can be set separately. Definite-time and inverse-time characteristic is offered. The tripping characteristic can be rotated about ± 180 degrees.

By means of voltage memory, directionality can be determined reliably even for close-in (local) faults. If the switching device closes onto a fault and the voltage is too low to determine direction, directionality (directional decision) is made with voltage from the voltage memory. If no voltage exists in the memory, tripping occurs according to the coordination schedule.

For ground protection, users can choose whether the direction is to be determined via zero-sequence system or negative-sequence system quantities (selectable).

Using negative-sequence variables can be advantageous in cases where the zero voltage tends to be very low due to unfavorable zero-sequence impedances.

Directional comparison protection (cross-coupling)

It is used for selective protection of sections fed from two sources with instantaneous tripping, i.e. without the disadvantage of time coordination. The directional comparison protection is suitable if the distances between the protection stations are not significant and pilot wires are available for signal transmission. In addition to the directional comparison protection, the directional coordinated overcurrent protection is used for complete selective backup protection. If operated in a closed-circuit connection, an interruption of the transmission line is detected.

(Sensitive) directional ground-fault detection (ANSI 64, 67Ns/67N)

For isolated-neutral and compensated networks, the direction of power flow in the zero sequence is calculated from the zero-sequence current I_0 and zero-sequence voltage V_0 . For networks with an isolated neutral, the reactive current component is evaluated; for compensated networks, the active current component or residual resistive current is evaluated.

For special network conditions, e.g. high-resistance grounded networks with ohmic-capacitive ground-fault current or low-resistance grounded networks with ohmic-inductive current, the tripping characteristics can be rotated approximately ± 45 degrees.

Two modes of ground-fault direction detection can be implemented: tripping or "signalling only mode".

It has the following functions:

- TRIP via the displacement voltage V_E .
- Two instantaneous elements or one instantaneous plus one user-defined characteristic.
- Each element can be set in forward, reverse, or non-directional.
- The function can also be operated in the insensitive mode, as an additional short-circuit protection.

(Sensitive) ground-fault detection (ANSI 50Ns, 51Ns/50N, 51N)

For high-resistance grounded networks, a sensitive input transformer is connected to a phase-balance neutral current transformer (also called core-balance CT).

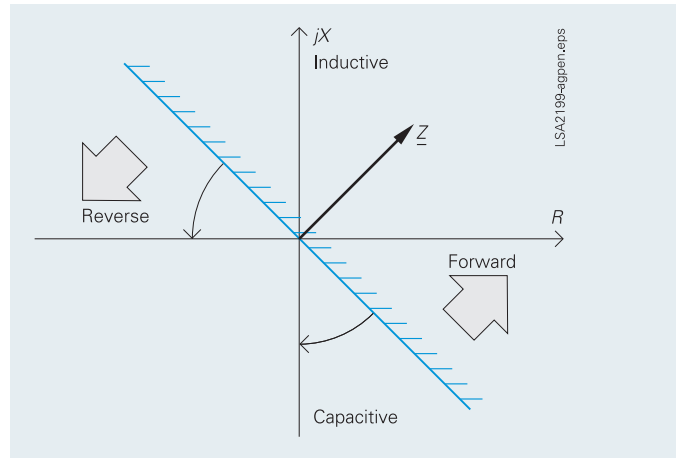


Fig. 5/151 Directional characteristic of the directional overcurrent protection

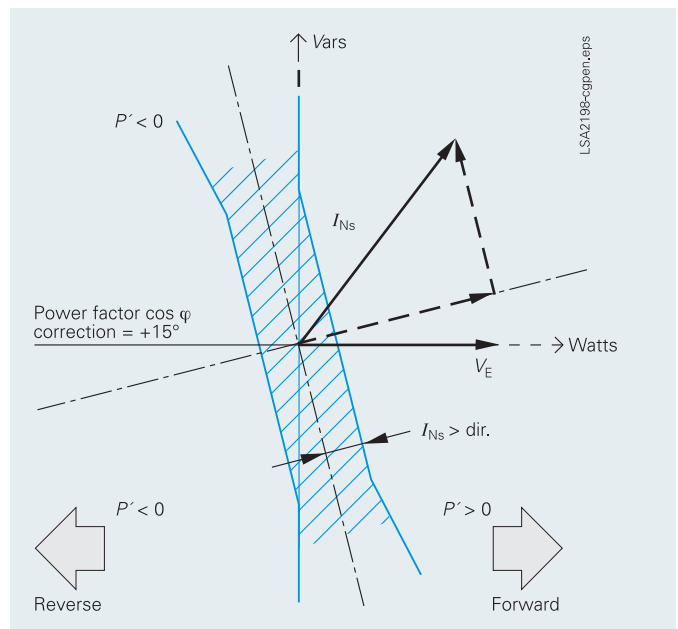


Fig. 5/152 Directional determination using cosine measurements for compensated networks

The function can also be operated in the insensitive mode, as an additional short-circuit protection.

Intermittent ground-fault protection

Intermittent (re-striking) faults occur due to insulation weaknesses in cables or as a result of water penetrating cable joints. Such faults either simply cease at some stage or develop into lasting short-circuits. During intermittent activity, however, star-point resistors in networks that are impedance-grounded may undergo thermal overloading. The normal ground-fault protection cannot reliably detect and interrupt the current pulses, some of which can be very brief.

The selectivity required with intermittent ground faults is achieved by summing the duration of the individual pulses and by triggering when a (settable) summed time is reached. The response threshold $I_{IE>}$ evaluates the r.m.s. value, referred to one systems period.

Directional intermittent ground fault protection (ANSI 67Ns)

The directional intermittent ground fault protection has to detect intermittent ground faults in resonant grounded cable systems selectively. Intermittent ground faults in resonant grounded cable systems are usually characterized by the following properties:

- A very short high-current ground current pulse (up to several hundred amperes) with a duration of under 1 ms
- They are self-extinguishing and re-ignite within one halfperiod up to several periods, depending on the power system conditions and the fault characteristic.
- Over longer periods (many seconds to minutes), they can develop into static faults.

Such intermittent ground faults are frequently caused by weak insulation, e.g. due to decreased water resistance of old cables. Ground fault functions based on fundamental component measured values are primarily designed to detect static ground faults and do not always behave correctly in case of intermittent ground faults. The function described here evaluates specifically the ground current pulses and puts them into relation with the zero-sequence voltage to determine the direction.

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

In line protection, the two-element phase-balance current/negative-sequence protection permits detection on the high side of high-resistance phase-to-phase faults and phase-to-ground faults that are on the low side of a transformer (e.g. with the switch group Dy 5). This provides backup protection for high-resistance faults beyond the transformer.

Breaker failure protection (ANSI 50BF)

If a faulted portion of the electrical circuit is not disconnected upon issuance of a trip command, another command can be initiated using the breaker failure protection which operates the circuit-breaker, e.g. of an upstream (higher-level) protection relay. Breaker failure is detected if, after a trip command, current is still flowing in the faulted circuit. As an option, it is possible to make use of the circuit-breaker position indication.

Auto-reclosures (ANSI 79)

Multiple reclosures can be defined by the user and lockout will occur if a fault is present after the last reclosure. The following functions are possible:

- 3-pole ARC for all types of faults
- Separate settings for phase and ground faults
- Multiple ARC, one rapid auto-reclosure (RAR) and up to nine delayed auto-reclosures (DAR)
- Starting of the ARC depends on the trip command selection (e.g. 46, 50, 51, 67)
- Blocking option of the ARC via binary inputs
- ARC can be initiated externally or via CFC
- The directional and non-directional elements can either be blocked or operated non-delayed depending on the auto-reclosure cycle
- Dynamic setting change of the directional and non-directional elements can be activated depending on the ready AR
- The AR CLOSE command can be given synchronous by use of the synchronization function.

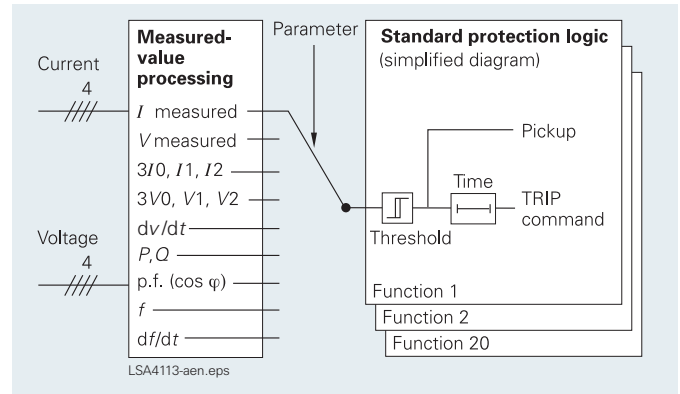


Fig. 5/153 Flexible protection functions

Flexible protection functions

The 7SJ64 units enable the user to easily add on up to 20 protective functions. To this end, parameter definitions are used to link a standard protection logic with any chosen characteristic quantity (measured or derived quantity) (Fig. 5/153). The standard logic consists of the usual protection elements such as the pickup message, the parameter-definable delay time, the TRIP command, a blocking possibility, etc. The mode of operation for current, voltage, power and power factor quantities can be three-phase or single-phase. Almost all quantities can be operated as greater than or less than stages. All stages operate with protection priority.

Protection stages/functions attainable on the basis of the available characteristic quantities:

Function	ANSI No.
$I >, I_E >$	50, 50N
$V <, V >, V_E >, dV/dt$	27, 59, 59R, 64
$3I_0 >, I_1 >, I_2 >, I_2/I_1, 3V_0 >, V_1 < >, V_2 < >$	50N, 46, 59N, 47
$P < >, Q < >$	32
$\cos \varphi \text{ (p.f.)} < >$	55
$f < >$	810, 81U
$df/dt < >$	81R

For example, the following can be implemented:

- Reverse power protection (ANSI 32R)
- Rate-of-frequency-change protection (ANSI 81R)

Undervoltage-controlled reactive power protection (ANSI 27/Q)

The undervoltage-controlled reactive power protection protects the system for mains decoupling purposes. To prevent a voltage collapse in energy systems, the generating side, e.g. a generator, must be equipped with voltage and frequency protection devices. An undervoltage-controlled reactive power protection is required at the supply system connection point. It detects critical power system situations and ensures that the power generation facility is disconnected from the mains. Furthermore, it ensures that reconnection only takes place under stable power system conditions. The associated criteria can be parameterized.

Overcurrent Protection / 7SJ64

Protection functions

Synchronization (ANSI 25)

- In case of switching ON the circuit-breaker, the units can check whether the two subnetworks are synchronized (classic synchro-check). Furthermore, the synchronizing function may operate in the "Synchronous/asynchronous switching" mode. The unit then distinguishes between synchronous and asynchronous networks:
In synchronous networks, frequency differences between the two subnetworks are almost non-existent. In this case, the circuit-breaker operating time does not need to be considered. Under asynchronous condition, however, this difference is markedly larger and the time window for switching is shorter. In this case, it is recommended to consider the operating time of the circuit-breaker.

The command is automatically pre-dated by the duration of the operating time of the circuit-breaker, thus ensuring that the contacts of the CB close at exactly the right time.

5

Up to 4 sets of parameters for the synchronizing function can be stored in the unit. This is an important feature when several circuit-breakers with different operating times are to be operated by one single relay.

Thermal overload protection (ANSI 49)

For protecting cables and transformers, an overload protection with an integrated pre-warning element for temperature and current can be applied. The temperature is calculated using a thermal homogeneous-body model (according to IEC 60255-8), which takes account both of the energy entering the equipment and the energy losses. The calculated temperature is constantly adjusted accordingly. Thus, account is taken of the previous load and the load fluctuations.

For thermal protection of motors (especially the stator), a further time constant can be set so that the thermal ratios can be detected correctly while the motor is rotating and when it is stopped. The ambient temperature or the temperature of the coolant can be detected serially via an external temperature monitoring box (resistance-temperature detector box, also called RTD-box). The thermal replica of the overload function is automatically adapted to the ambient conditions. If there is no RTD-box it is assumed that the ambient temperatures are constant.

High-impedance restricted ground-fault protection (ANSI 87N)

The high-impedance measurement principle is an uncomplicated and sensitive method for detecting ground faults, especially on transformers. It can also be applied to motors, generators and reactors when these are operated on an grounded network.

When the high-impedance measurement principle is applied, all current transformers in the protected area are connected in parallel and operated on one common resistor of relatively high R whose voltage is measured (see Fig. 5/154). In the case of 7SJ6 units, the voltage is measured by detecting the current through the (external) resistor R at the sensitive current measurement input I_{EE} .

The varistor V serves to limit the voltage in the event of an internal fault. It cuts off the high momentary voltage spikes occurring at transformer saturation. At the same time, this results in smoothing of the voltage without any noteworthy reduction of the average value. If no faults have occurred and in the event of external faults, the system is at equilibrium, and the voltage through the resistor is approximately zero. In the

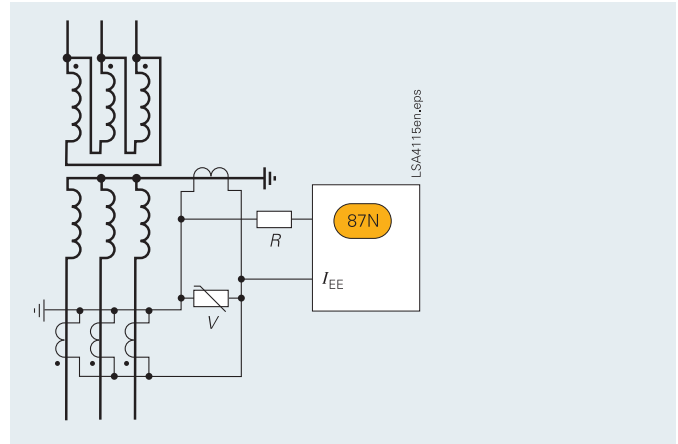


Fig. 5/154 High-impedance restricted ground-fault protection

event of internal faults, an imbalance occurs which leads to a voltage and a current flow through the resistor R .

The current transformers must be of the same type and must at least offer a separate core for the high-impedance restricted ground-fault protection. They must in particular have the same transformation ratio and an approximately identical knee-point voltage. They should also demonstrate only minimal measuring errors.

Settable dropout delay times

If the devices are used in parallel with electromechanical relays in networks with intermittent faults, the long dropout times of the electromechanical devices (several hundred milliseconds) can lead to problems in terms of time grading. Clean time grading is only possible if the dropout time is approximately the same. This is why the parameter of dropout times can be defined for certain functions such as time-overcurrent protection, ground short-circuit and phase-balance current protection.

■ Motor protection

Restart inhibit (ANSI 66/86)

If a motor is started up too many times in succession, the rotor can be subject to thermal overload, especially the upper edges of the bars. The rotor temperature is calculated from the stator current. The reclosing lockout only permits start-up of the motor if the rotor has sufficient thermal reserves for a complete start-up (see Fig. 5/155).

Emergency start-up

This function disables the reclosing lockout via a binary input by storing the state of the thermal replica as long as the binary input is active. It is also possible to reset the thermal replica to zero.

Temperature monitoring (ANSI 38)

Up to two temperature monitoring boxes with a total of 12 measuring sensors can be used for temperature monitoring and detection by the protection relay. The thermal status of motors, generators and transformers can be monitored with this device. Additionally, the temperature of the bearings of rotating machines are monitored for limit value violation. The temperatures are being measured with the help of temperature

detectors at various locations of the device to be protected. This data is transmitted to the protection relay via one or two temperature monitoring boxes (see "Accessories", page 5/197).

Starting time supervision (ANSI 48/14)

Starting time supervision protects the motor against long unwanted start-ups that might occur in the event of excessive load torque or excessive voltage drops within the motor, or if the rotor is locked. Rotor temperature is calculated from measured stator current. The tripping time is calculated according to the following equation:

for $I > I_{\text{MOTOR START}}$

$$t = \left(\frac{I_A}{I} \right)^2 \cdot T_A$$

I = Actual current flowing

$I_{\text{MOTOR START}}$ = Pickup current to detect a motor start

t = Tripping time

I_A = Rated motor starting current

T_A = Tripping time at rated motor starting current (2 times, for warm and cold motor)

The characteristic (equation) can be adapted optimally to the state of the motor by applying different tripping times T_A in dependence of either cold or warm motor state. For differentiation of the motor state the thermal model of the rotor is applied.

If the trip time is rated according to the above formula, even a prolonged start-up and reduced voltage (and reduced start-up current) will be evaluated correctly. The tripping time is inverse (current dependent).

A binary signal is set by a speed sensor to detect a blocked rotor. An instantaneous tripping is effected.

Load jam protection (ANSI 51M)

Sudden high loads can cause slowing down and blocking of the motor and mechanical damages. The rise of current due to a load jam is being monitored by this function (alarm and tripping).

The overload protection function is too slow and therefore not suitable under these circumstances.

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

The negative-sequence / phase-balance current protection detects a phase failure or load unbalance due to network asymmetry and protects the rotor from impermissible temperature rise.

Undercurrent monitoring (ANSI 37)

With this function, a sudden drop in current, which can occur due to a reduced motor load, is detected. This may be due to shaft breakage, no-load operation of pumps or fan failure.

1) The 45 to 55, 55 to 65 Hz range is available for $f_N = 50/60$ Hz.

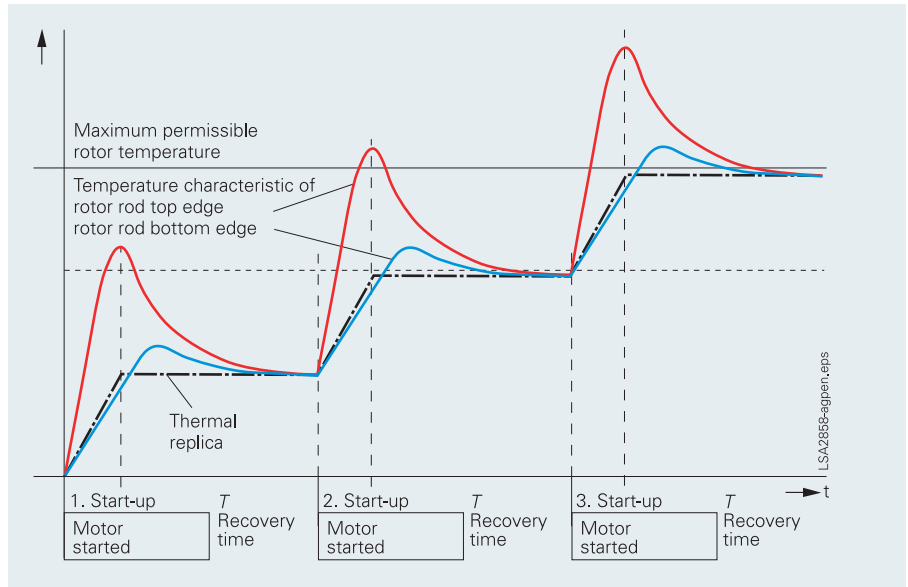


Fig. 5/155

Motor statistics

Essential information on start-up of the motor (duration, current, voltage) and general information on number of starts, total operating time, total down time, etc. are saved as statistics in the device.

■ Voltage protection

Overvoltage protection (ANSI 59)

The two-element overvoltage protection detects unwanted network and machine overvoltage conditions. The function can operate either with phase-to-phase, phase-to-ground, positive phase-sequence or negative phase-sequence voltage. Three-phase and single-phase connections are possible.

Undervoltage protection (ANSI 27)

The two-element undervoltage protection provides protection against dangerous voltage drops (especially for electric machines). Applications include the isolation of generators or motors from the network to avoid undesired operating states and a possible loss of stability. Proper operating conditions of electrical machines are best evaluated with the positive-sequence quantities. The protection function is active over a wide frequency range (45 to 55, 55 to 65 Hz)¹⁾. Even when falling below this frequency range the function continues to work, however, with a greater tolerance band.

The function can operate either with phase-to-phase, phase-to-ground or positive phase-sequence voltage, and can be monitored with a current criterion. Three-phase and single-phase connections are possible.

Frequency protection (ANSI 81O/U)

Frequency protection can be used for over-frequency and under-frequency protection. Electric machines and parts of the system are protected from unwanted speed deviations. Unwanted frequency changes in the network can be detected and the load can be removed at a specified frequency setting. Frequency protection can be used over a wide frequency range (40 to 60, 50 to

Overcurrent Protection / 7SJ64

Protection functions, functions

70 Hz)¹⁾. There are four elements (selectable as overfrequency or underfrequency) and each element can be delayed separately. Blocking of the frequency protection can be performed if using a binary input or by using an undervoltage element.

Fault locator (ANSI 21FL)

The integrated fault locator calculates the fault impedance and the distance-to-fault. The results are displayed in Ω , kilometers (miles) and in percent of the line length.

Circuit-breaker wear monitoring

Methods for determining circuit-breaker contact wear or the remaining service life of a circuit-breaker (CB) allow CB maintenance intervals to be aligned to their actual degree of wear. The benefit lies in reduced maintenance costs.

There is no mathematically exact method of calculating the wear or the remaining service life of circuit-breakers that takes into account the arc-chamber's physical conditions when the CB opens. This is why various methods of determining CB wear have evolved which reflect the different operator philosophies. To do justice to these, the devices offer several methods:

- ΣI
- ΣI^x , with $x = 1 \dots 3$
- ΣI^2t

The devices additionally offer a new method for determining the remaining service life:

- Two-point method

The CB manufacturers double-logarithmic switching cycle diagram (see Fig. 5/156) and the breaking current at the time of contact opening serve as the basis for this method. After CB opening, the two-point method calculates the number of still possible switching cycles. To this end, the two points P1 and P2 only have to be set on the device. These are specified in the CB's technical data. All of these methods are phase-selective and a limit value can be set in order to obtain an alarm if the actual value falls below or exceeds the limit value during determination of the remaining service life.

Commissioning

Commissioning could hardly be easier and is fully supported by DIGSI 4. The status of the binary inputs can be read individually and the state of the binary outputs can be set individually. The operation of switching elements (circuit-breakers, disconnect devices) can be checked using the switching functions of the bay controller. The analog measured values are represented as wide-ranging operational measured values. To prevent transmission of information to the control center during maintenance, the bay controller communications can be disabled to prevent unnecessary data from being transmitted. During commissioning, all indications with test marking for test purposes can be connected to a control and protection system.

Test operation

During commissioning, all indications can be passed to an automatic control system for test purposes.

1) The 40 to 60, 50 to 70 Hz range is available for $f_N = 50/60$ Hz.

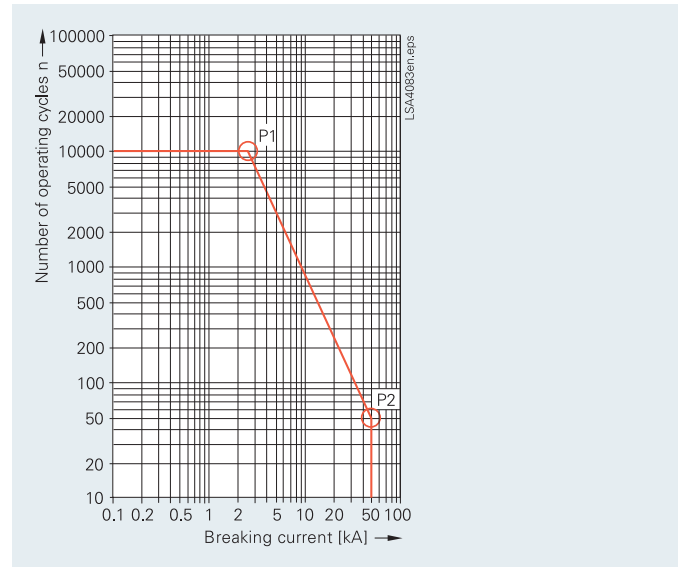


Fig. 5/156 CB switching cycle diagram

Functions

Control and automatic functions

Control

In addition to the protection functions, the SIPROTEC 4 units also support all control and monitoring functions that are required for operating medium-voltage or high-voltage substations.

The main application is reliable control of switching and other processes.

The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated to the 7SJ64 via binary inputs. Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a fault or intermediate circuit-breaker or auxiliary contact position.

The switchgear or circuit-breaker can be controlled via:

- integrated operator panel
- binary inputs
- substation control and protection system
- DIGSI 4

Automation / user-defined logic

With integrated logic, the user can set, via a graphic interface (CFC), specific functions for the automation of switchgear or substation. Functions are activated via function keys, binary input or via communication interface.

Switching authority

Switching authority is determined according to parameters, communication or by key-operated switch (when available). If a source is set to "LOCAL", only local switching operations are possible. The following sequence of switching authority is laid down: "LOCAL"; DIGSI PC program, "REMOTE".

Key-operated switch

7SJ64 units are fitted with key-operated switch function for local/remote changeover and changeover between interlocked switching and test operation.

Command processing

All the functionality of command processing is offered. This includes the processing of single and double commands with or without feedback, sophisticated monitoring of the control hardware and software, checking of the external process, control actions using functions such as runtime monitoring and automatic command termination after output. Here are some typical applications:

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable bay interlocks
- Operating sequences combining several switching operations such as control of circuit-breakers, disconnectors and grounding switches
- Triggering of switching operations, indications or alarm by combination with existing information

Motor control

The SIPROTEC 4 7SJ64 with high performance relays is well-suited for direct activation of the circuit-breaker, disconnector and grounding switch operating mechanisms in automated substations.

Interlocking of the individual switching devices takes place with the aid of programmable logic. Additional auxiliary relays can be eliminated. This results in less wiring and engineering effort.

Assignment of feedback to command

The positions of the circuit-breaker or switching devices and transformer taps are acquired by feedback. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication change is a consequence of switching operation or whether it is a spontaneous change of state.

Chatter disable

Chatter disable feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

Indication filtering and delay

Binary indications can be filtered or delayed.

Filtering serves to suppress brief changes in potential at the indication input. The

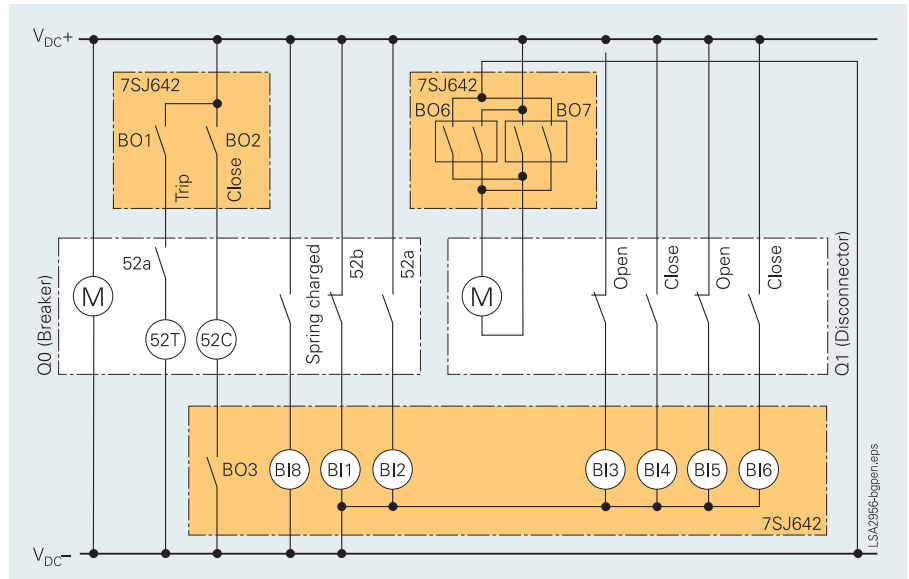


Fig. 5/157 Typical wiring for 7SJ642 motor direct control (simplified representation without fuses). Binary output BO6 and BO7 are interlocked so that only one set of contacts are closed at a time.

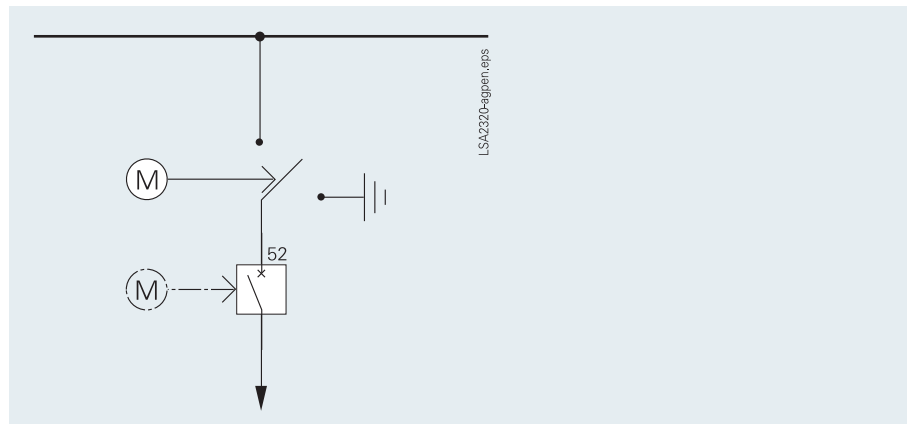


Fig. 5/158 Example: Single busbar with circuit-breaker and motor-controlled three-position switch

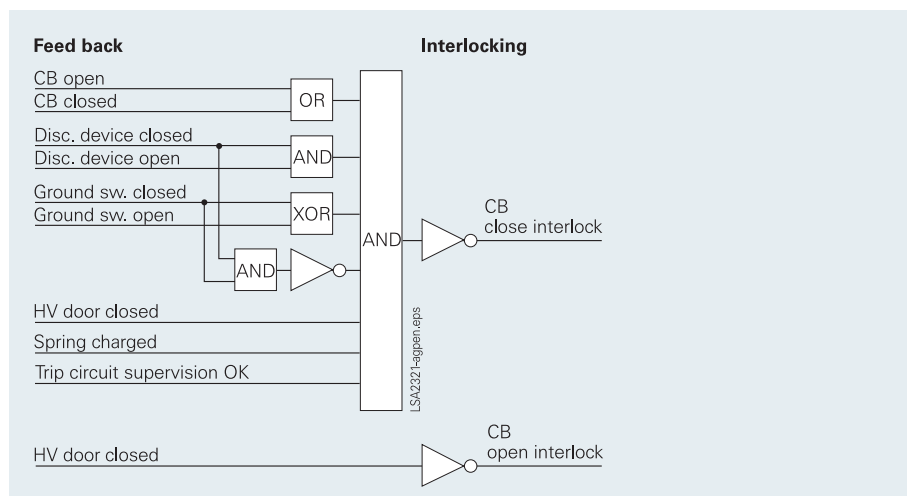


Fig. 5/159 Example: Circuit-breaker interlocking

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Functions

indication is passed on only if the indication voltage is still present after a set period of time.

In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

A further indication (or a command) can be derived from an existing indication. Group indications can also be formed. The volume of information to the system interface can thus be reduced and restricted to the most important signals.

Measured values

The r.m.s. values are calculated from the acquired current and voltage along with the power factor, frequency, active and reactive power. The following functions are available for measured value processing:

- Currents I_{L1} , I_{L2} , I_{L3} , I_E , I_{EE} (67Ns)
- Voltages V_{L1} , V_{L2} , V_{L3} , V_{L1L2} , V_{L2L3} , V_{L3L1} , V_{syn}
- Symmetrical components I_1 , I_2 , $3I_0$; V_1 , V_2 , V_0
- Power Watts, Vars, VA/P, Q , S (P , Q : total and phase selective)
- Power factor ($\cos \varphi$), (total and phase selective)
- Frequency
- Energy \pm kWh, \pm kVarh, forward and reverse power flow
- Mean as well as minimum and maximum current and voltage values
- Operating hours counter
- Mean operating temperature of overload function
- Limit value monitoring
Limit values are monitored using programmable logic in the CFC. Commands can be derived from this limit value indication.
- Zero suppression
In a certain range of very low measured values, the value is set to zero to suppress interference.

Metered values

For internal metering, the unit can calculate an energy metered value from the measured current and voltage values. If an external meter with a metering pulse output is available, the SIPROTEC 4 unit can obtain and process metering pulses via an indication input.

The metered values can be displayed and passed on to a control center as an accumulation with reset. A distinction is made between forward, reverse, active and reactive energy.

Switchgear cubicles for high/medium voltage

All units are designed specifically to meet the requirements of high/medium-voltage applications.

In general, no separate measuring instruments (e.g. for current, voltage, frequency measuring transducer ...) or additional control components are necessary.



Fig. 5/160 NX PLUS panel (gas-insulated)

Communication

In terms of communication, the units offer substantial flexibility in the context of connection to industrial and power automation standards. Communication can be extended or added on thanks to modules for retrofitting on which the common protocols run. Therefore, also in the future it will be possible to optimally integrate units into the changing communication infrastructure, for example in Ethernet networks (which will also be used increasingly in the power supply sector in the years to come).

Serial front interface

There is a serial RS232 interface on the front of all the units. All of the unit's functions can be set on a PC by means of the DIGSI 4 protection operation program. Commissioning tools and fault analysis are also built into the program and are available through this interface.

Rear-mounted interfaces¹⁾

A number of communication modules suitable for various applications can be fitted in the rear of the flush-mounting housing. In the flush-mounting housing, the modules can be easily replaced by the user.

The interface modules support the following applications:

- Time synchronization interface
All units feature a permanently integrated electrical time synchronization interface. It can be used to feed timing telegrams in IRIG-B or DCF77 format into the units via time synchronization receivers.
- System interface
Communication with a central control system takes place through this interface. Radial or ring type station bus topologies can be configured depending on the chosen interface. Furthermore, the units can exchange data through this interface via Ethernet and IEC 61850 protocol and can also be operated by DIGSI.
- Service interface
The service interface was conceived for remote access to a number of protection units via DIGSI. It can be an electrical RS232/RS485 interface. For special applications, a maximum of two temperature monitoring boxes (RTD-box) can be connected to this interface as an alternative.
- Additional interface
Up to 2 RTD-boxes can be connected via this interface.

System interface protocols (retrofittable)

IEC 61850 protocol

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens was the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus is also possible with DIGSI. It is also possible to retrieve operating and fault messages and fault recordings via a browser. This Web monitor also provides a few items of unit-specific information in browser windows.

1) For units in panel surface-mounting housings please refer to note on page 5/193.

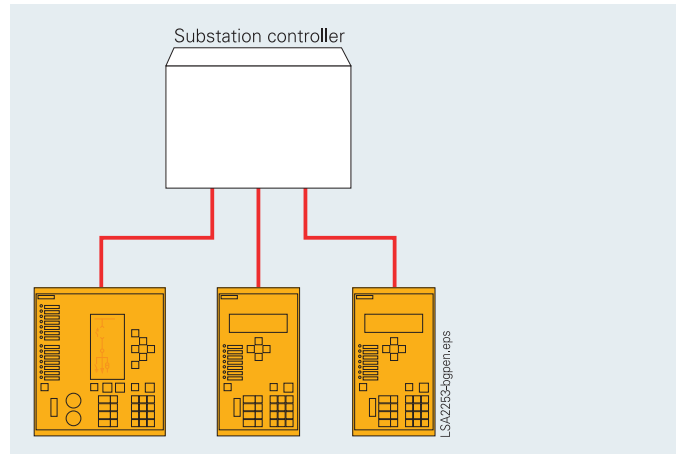


Fig. 5/161 IEC 60870-5-103: Radial fiber-optic connection

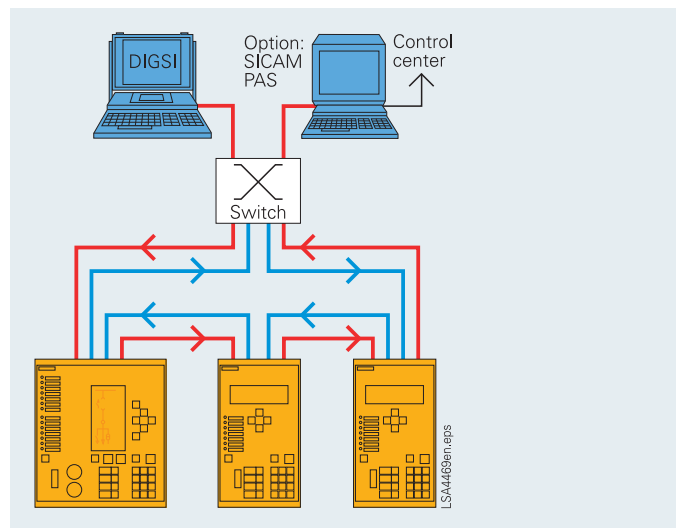


Fig. 5/162 Bus structure for station bus with Ethernet and IEC 61850, fiber-optic ring

IEC 60870-5-103 protocol

The IEC 60870-5-103 protocol is an international standard for the transmission of protective data and fault recordings. All messages from the unit and also control commands can be transferred by means of published, Siemens-specific extensions to the protocol.

Redundant solutions are also possible. Optionally it is possible to read out and alter individual parameters (only possible with the redundant module).

PROFIBUS-DP protocol

PROFIBUS-DP is the most widespread protocol in industrial automation. Via PROFIBUS-DP, SIPROTEC units make their information available to a SIMATIC controller or, in the control direction, receive commands from a central SIMATIC. Measured values can also be transferred.

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Communication

MODBUS RTU protocol

This uncomplicated, serial protocol is mainly used in industry and by power supply corporations, and is supported by a number of unit manufacturers. SIPROTEC units function as MODBUS slaves, making their information available to a master or receiving information from it. A time-stamped event list is available.

PROFINET

PROFINET is the ethernet-based successor of Profibus DP and is supported in the variant PROFINET IO. The protocol which is used in industry together with the SIMATIC systems control is realized on the optical and electrical Plus ethernet modules which are delivered since November 2012. All network redundancy procedures which are available for the ethernet modules, such as RSTP, PRP or HSR, are also available for PROFINET. The time synchronization is made via SNTP. The network monitoring is possible via SNMP V2 where special MIB files exist for PROFINET. The LLDP protocol of the device also supports the monitoring of the network topology. Single-point indications, double-point indications, measured and metered values can be transmitted cyclically in the monitoring direction via the protocol and can be selected by the user with DIGSI 4. Important events are also transmitted spontaneously via configurable process alarms. Switching commands can be executed by the system control via the device in the controlling direction. The PROFINET implementation is certified. The device also supports the IEC 61850 protocol as a server on the same ethernet module in addition to the PROFINET protocol. Client server connections are possible for the intercommunication between devices, e.g. for transmitting fault records and GOOSE messages.

DNP 3.0 protocol

Power utilities use the serial DNP 3.0 (Distributed Network Protocol) for the station and network control levels. SIPROTEC units function as DNP slaves, supplying their information to a master system or receiving information from it.

DNP3 TCP

The ethernet-based TCP variant of the DNP3 protocol is supported with the electrical and optical ethernet module. Two DNP3 TCP clients are supported. Redundant ring structures can be realized for DNP3 TCP with the help of the integrated switch in the module. For instance, a redundant optical ethernet ring can be constructed. Single-point indications, double-point indications, measured and metered values can be configured with DIGSI 4 and are transmitted to the DNPi client. Switching commands can be executed in the controlling direction. Fault records of the device are stored in

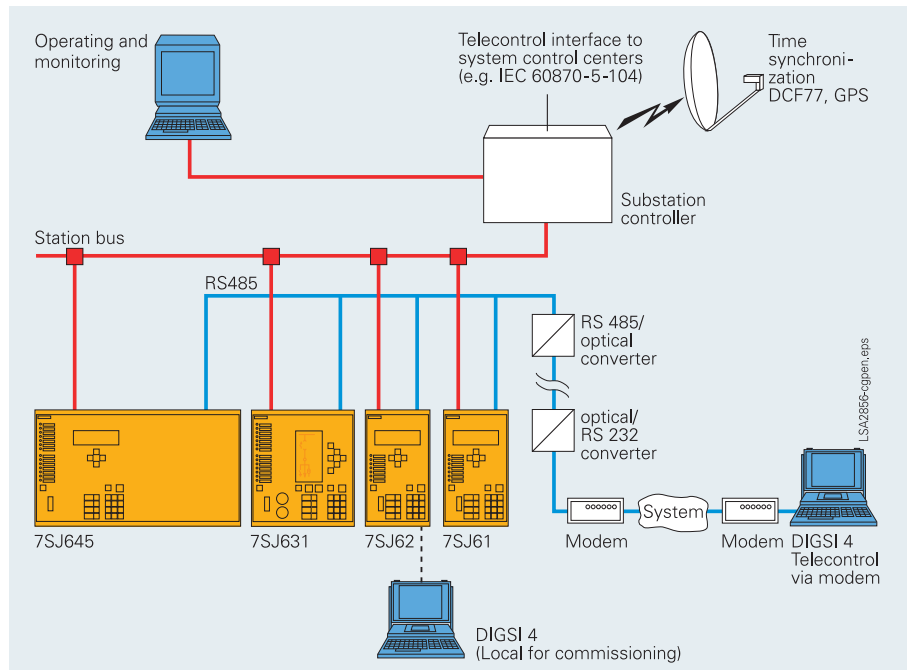


Fig. 5/163 System solution/communication

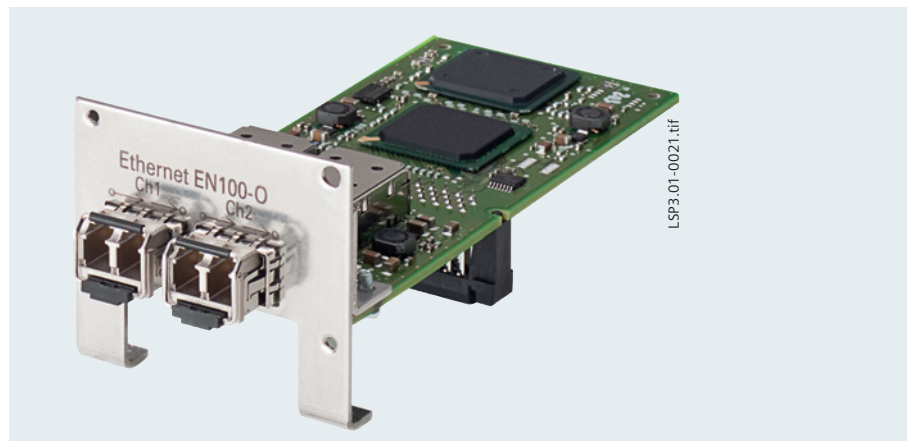


Fig. 5/164 Optical Ethernet communication module for IEC 61850 with integrated Ethernet-switch

the binary Comtrade format and can be retrieved via the DNP3 file transfer. The time synchronization is performed via the DNP3 TCP client or SNTP. The device can also be integrated into a network monitoring system via the SNMP V2 protocol. Parallel to the DNP3 TCP protocol the IEC 61850 protocol (the device works as a server) and the GOOSE messages of the IEC 61850 are available for the intercommunication between devices.

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system.

Units featuring IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or radially by fiber-optic link.

Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 5/161).

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 5/162).

Typical connections

■ Connection of current and voltage transformers

Standard connection

For grounded networks, the ground current is obtained from the phase currents by the residual current circuit.

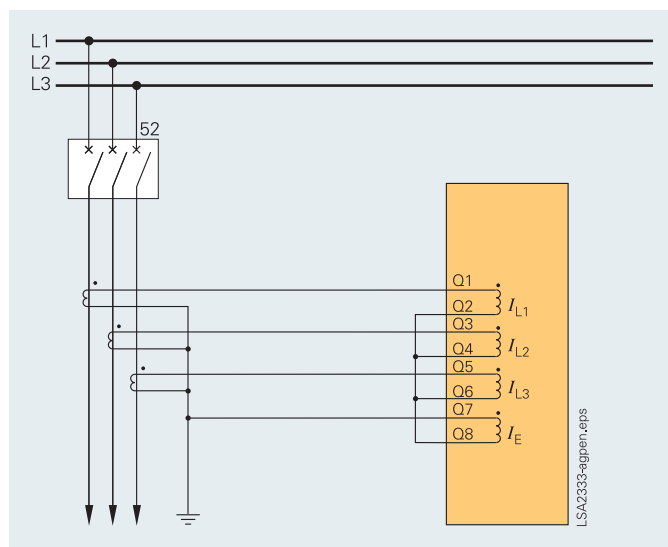


Fig. 5/165 Residual current circuit without directional element

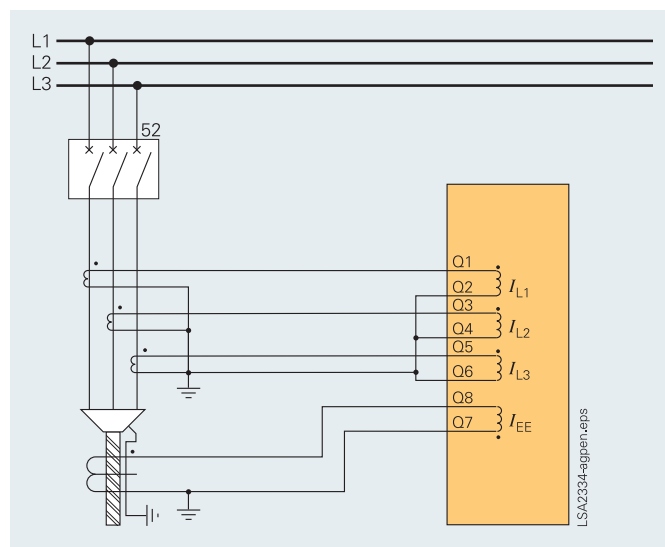


Fig. 5/166 Sensitive ground current detection without directional element

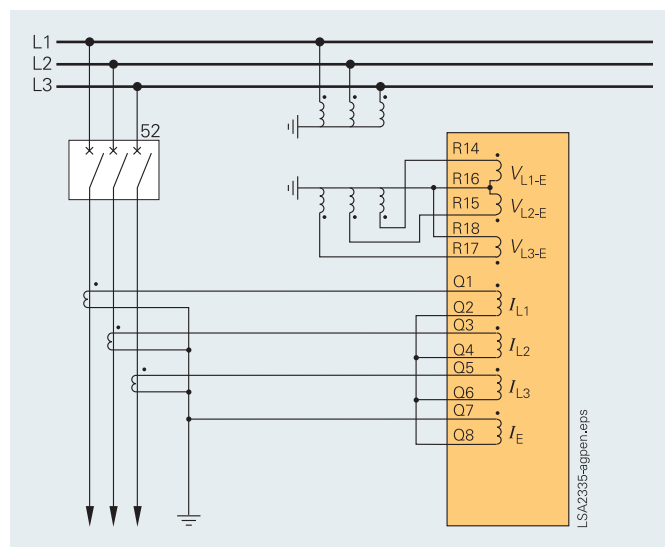


Fig. 5/167 Residual current circuit with directional element

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Typical connections

Connection for compensated networks

The figure shows the connection of two phase-to-ground voltages and the V_E voltage of the open delta winding and a phase-ground neutral current transformer for the ground current. This connection maintains maximum precision for directional ground-fault detection and must be used in compensated networks. Fig. 5/168 shows sensitive directional ground-fault detection.

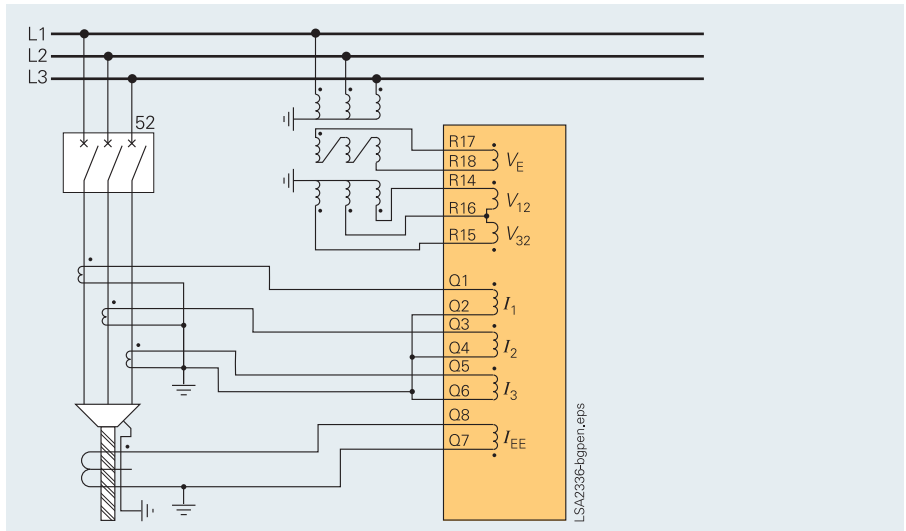


Fig. 5/168 Sensitive directional ground-fault detection with directional element for phases

5

Connection for isolated-neutral or compensated networks only

If directional ground-fault protection is not used, the connection can be made with only two phase current transformers. Directional phase short-circuit protection can be achieved by using only two primary transformers.

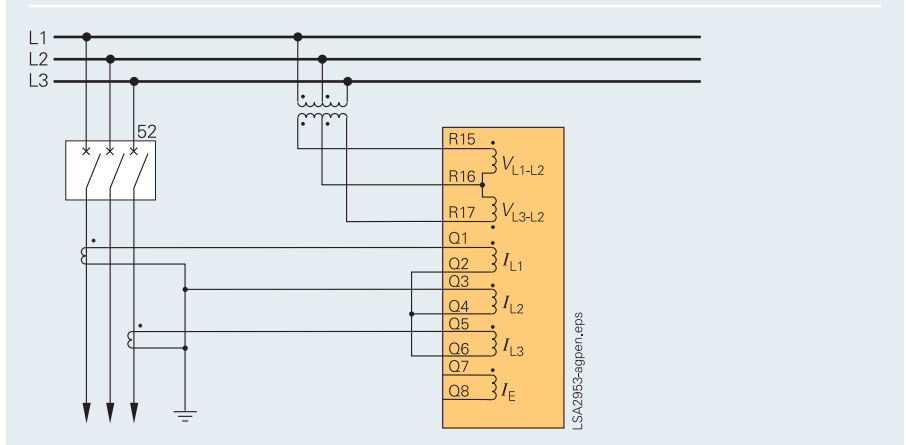


Fig. 5/169 Isolated-neutral or compensated networks

Connection for the synchronization function

The 3-phase system is connected as reference voltage, i. e. the outgoing voltages as well as a single-phase voltage, in this case a busbar voltage, that has to be synchronized.

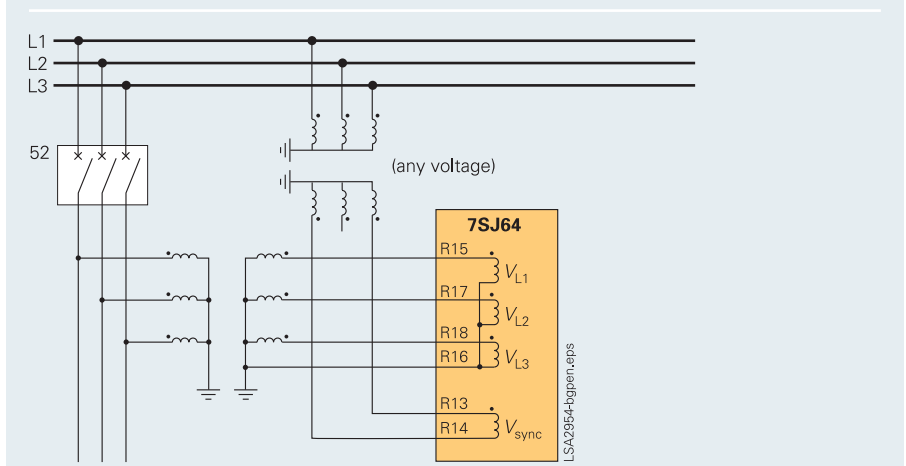


Fig. 5/170 Measuring of the busbar voltage and the outgoing feeder voltage for synchronization

Overview of connection types			
Type of network	Function	Current connection	Voltage connection
(Low-resistance) grounded network	Overcurrent protection phase/ground non-directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformer possible	–
(Low-resistance) grounded networks	Sensitive ground-fault protection	Phase-balance neutral current transformers required	–
Isolated or compensated networks	Overcurrent protection phases non-directional	Residual circuit, with 3 or 2 phase current transformers possible	–
(Low-resistance) grounded networks	Overcurrent protection phases directional	Residual circuit, with 3 phase-current transformers possible	Phase-to-ground connection or phase-to-phase connection
Isolated or compensated networks	Overcurrent protection phases directional	Residual circuit, with 3 or 2 phase-current transformers possible	Phase-to-ground connection or phase-to-phase connection
(Low-resistance) grounded networks	Overcurrent protection ground directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformers possible	Phase-to-ground connection required
Isolated networks	Sensitive ground-fault protection	Residual circuit, if ground current $> 0.05 I_N$ on secondary side, otherwise phase-balance neutral current transformers required	3 times phase-to-ground connection or phase-to-ground connection with open delta winding
Compensated networks	Sensitive ground-fault protection $\cos \varphi$ measurement	Phase-balance neutral current transformers required	Phase-to-ground connection with open delta winding required

Typical applications

Application examples

Synchronization function

When two subnetworks must be interconnected, the synchronization function monitors whether the subnetworks are synchronous and can be connected without risk of losing stability.

As shown in Fig. 5/171, load is being fed from a generator to a busbar via a transformer. It is assumed that the frequency difference of the 2 subnetworks is such that the device determines asynchronous system conditions.

The voltages of the busbar and the feeder should be the same when the contacts are made; to ensure this condition the synchronism function must run in the "synchronous/asynchronous switching" mode. In this mode, the operating time of the CB can be set within the relay. Differences between angle and frequency can then be calculated by the relay while taking into account the operating time of the CB. From these differences, the unit derives the exact time for issuing the CLOSE command under asynchronous conditions. When the contacts close, the voltages will be in phase.

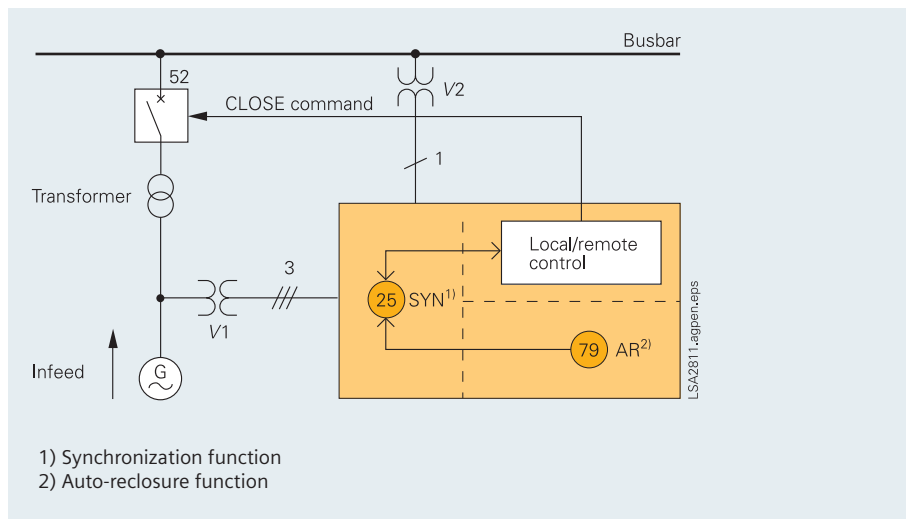


Fig. 5/171 Measuring of busbar and feeder voltages for synchronization

The vector group of the transformer can be considered by setting parameters. Thus no external circuits for vector group adaptation are required.

This synchronism function can be applied in conjunction with the auto-reclosure function as well as with the control function CLOSE commands (local/remote).

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Typical applications

■ Connection of circuit-breaker

Undervoltage releases

Undervoltage releases are used for automatic tripping of high-voltage motors.

Example:

DC supply voltage of control system fails and manual electric tripping is no longer possible.

Automatic tripping takes place when voltage across the coil drops below the trip limit. In Figure 5/172, tripping occurs due to failure of DC supply voltage, by automatic opening of the live status contact upon failure of the protection unit or by short-circuiting the trip coil in event of a network fault.

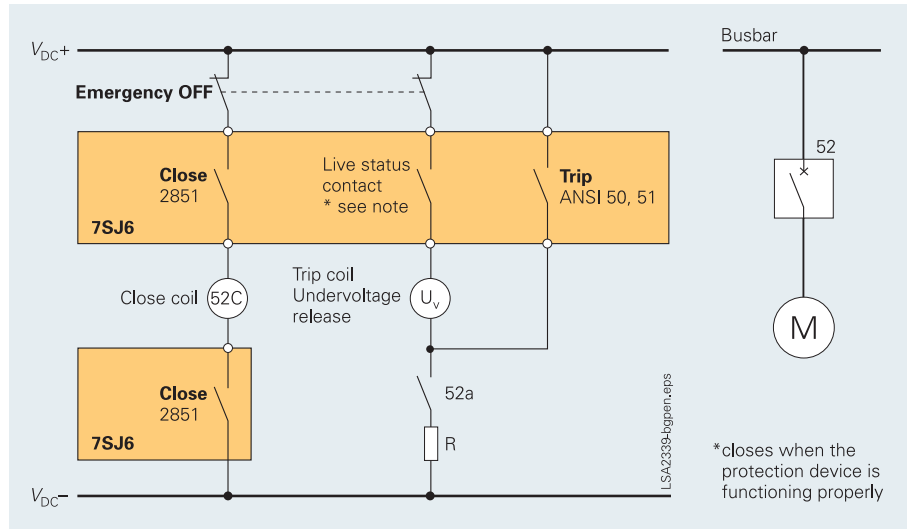


Fig. 5/172 Undervoltage release with make contact 50, 51

In Fig. 5/173 tripping is by failure of auxiliary voltage and by interruption of tripping circuit in the event of network failure. Upon failure of the protection unit, the tripping circuit is also interrupted, since contact held by internal logic drops back into open position.

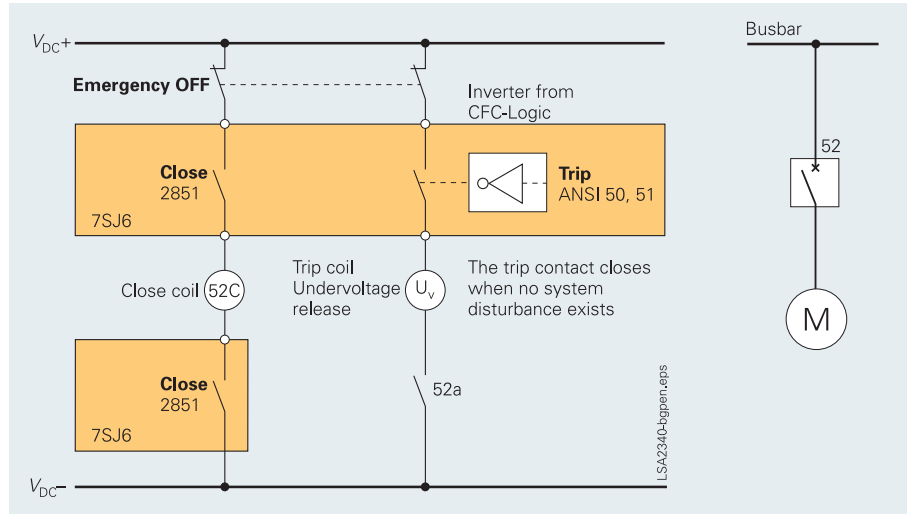


Fig. 5/173 Undervoltage release with locking contact (trip signal 50 is inverted)

5

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal occurs whenever the circuit is interrupted.

Lockout (ANSI 86)

All binary outputs can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only occur after the lockout state is reset.

Reverse-power protection for dual supply (ANSI 32R)

If power is fed to a busbar through two parallel infeeds, then in the event of any fault on one of the infeeds it should be selectively interrupted. This ensures a continued supply to the busbar through the remaining infeed. For this purpose, directional devices are needed which detect a short-circuit current or a power flow from the busbar in the direction of the infeed. The directional overcurrent protection is usually set via the load current. It cannot be used to deactivate low-current faults. Reverse-power protection can be set far below the rated power. This ensures that it also detects power feedback into the line in the event of low-current faults with levels far below the load current. Reverse-power protection is performed via the "flexible protection functions" of the 7SJ64.

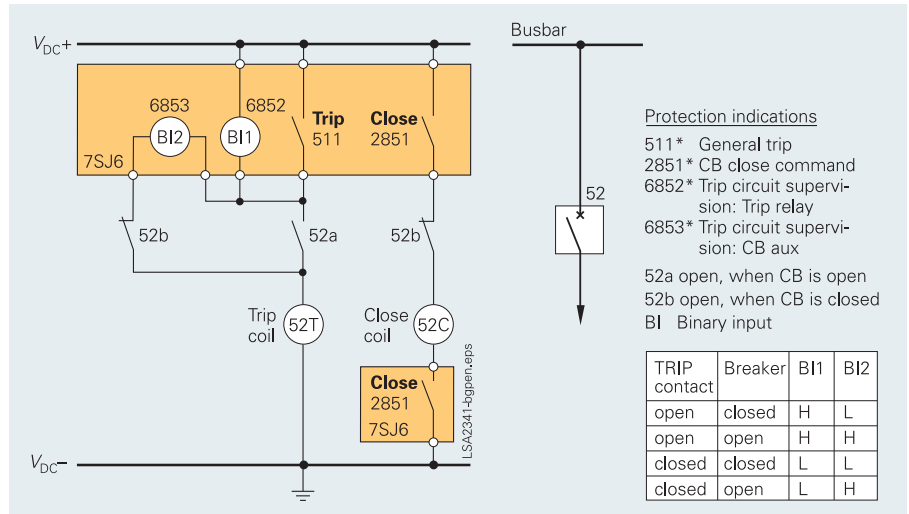


Fig. 5/174 Trip circuit supervision with 2 binary inputs

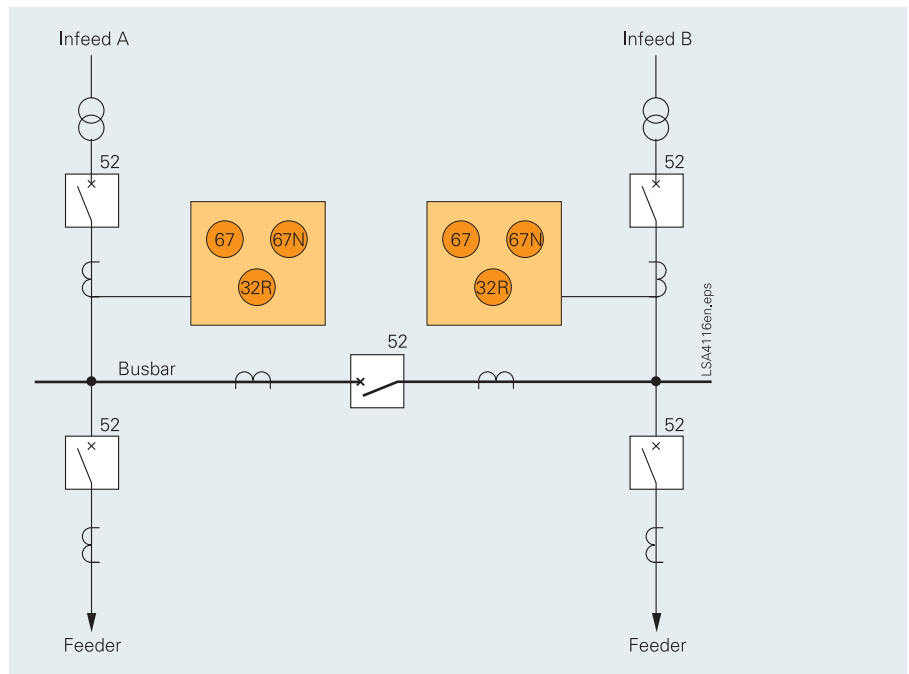


Fig. 5/175 Reverse-power protection for dual supply

Overcurrent Protection / 7SJ64

Technical data

5

General unit data	
<i>Measuring circuits</i>	
System frequency	50 / 60 Hz (settable)
<i>Current transformer</i>	
Rated current I_{nom}	1 or 5 A (settable)
Option: sensitive ground-fault CT	$I_{EE} < 1.6 A$
Power consumption at $I_{nom} = 1 A$ at $I_{nom} = 5 A$ for sensitive ground-fault CT at 1 A	Approx. 0.05 VA per phase Approx. 0.3 VA per phase Approx. 0.05 VA
Overload capability Thermal (effective)	500 A for 1 s 150 A for 10 s 20 A continuous
Dynamic (impulse current)	$250 \times I_{nom}$ (half cycle)
Overload capability if equipped with sensitive ground-fault CT Thermal (effective)	300 A for 1 s 100 A for 10 s 15 A continuous
Dynamic (impulse current)	750 A (half cycle)
<i>Voltage transformer</i>	
Rated voltage V_{nom}	100 V to 225 V
Measuring range	0 V to 200 V
Power consumption at $V_{nom} = 100 V$	< 0.3 VA per phase
Overload capability in voltage path (phase-neutral voltage) Thermal (effective)	230 V continuous
<i>Auxiliary voltage (via integrated converter)</i>	
Rated auxiliary voltage V_{aux} DC	24/48 V 60/125 V 110/250 V
Permissible tolerance DC	19 – 58 V 48 – 150 V 88 – 300 V
Ripple voltage, peak-to-peak	≤ 12 % of rated auxiliary voltage
Power consumption	7SJ640 7SJ641 7SJ645 7SJ647 7SJ642
Quiescent Energized	Approx. 5 W 9 W 5.5 W 12.5 W 6.5 W 15 W 7.5 W 21 W
Backup time during loss/short-circuit of auxiliary direct voltage	≥ 50 ms at $V > DC 110 V$ ≥ 20 ms at $V > DC 24 V$
Rated auxiliary voltage V_{aux} AC	115 V / 230 V
Permissible tolerance AC	92 – 32 V / 184 – 265 V
Power consumption	7SJ640 7SJ641 7SJ645 7SJ647 7SJ642
Quiescent Energized	Approx. 7 W 12 W 9 W 19 W 12 W 23 W 16 W 33 W
Backup time during loss/short-circuit of auxiliary alternating voltage	≥ 200 ms

Binary outputs/command outputs					
Type	7SJ640	7SJ641	7SJ642	7SJ645	7SJ647
Number (marshallable)	7	15	20	33	48
Voltage range	DC 24 – 250 V				
Pickup threshold modifiable by plug-in jumpers					
Pickup threshold DC	DC 19 V		DC 88 V		
For rated control voltage DC	DC 24/48/60/110/125 V DC 110/125/220/250 V				
Power consumption energized	0.9 mA (independent of operating voltage) for BI 8...19 / 21...32; 1.8 mA for BI 1...7 / 20/33...48				
<i>Binary outputs/command outputs</i>					
Type	7SJ640	7SJ641	7SJ642	7SJ645	7SJ647
Command/indication relay	5	13	8	11	21
Contacts per command/indication relay	1 NO / form A				
Live status contact	1 NO / NC (jumper) / form A / B				
Switching capacity					
Make	1000 W / VA				
Break	30 W / VA / 40 W resistive / 25 W at L/R ≤ 50 ms				
Switching voltage	≤ DC 250 V				
Permissible current	5 A continuous, 30 A for 0.5 s making current, 2000 switching cycles				
<i>Power relay (for motor control)</i>					
Type	7SJ640	7SJ642	7SJ645	7SJ647	
Number	0	2 (4)	4 (8)	4 (8)	
Number of contacts/relay	2 NO / form A				
Switching capacity					
Make	1000 W / VA at 48 V ... 250 V / 500 W at 24 V				
Break	1000 W / VA at 48 V ... 250 V / 500 W at 24 V				
Switching voltage	≤ DC 250 V				
Permissible current	5 A continuous, 30 A for 0.5 s				

Electrical tests	
<i>Specification</i>	
Standards	IEC 60255 ANSI C37.90, C37.90.1, C37.90.2, UL508
<i>Insulation tests</i>	
Standards	IEC 60255-5; ANSI/IEEE C37.90.0
Voltage test (100 % test) all circuits except for auxiliary voltage and RS485/RS232 and time synchronization	2.5 kV (r.m.s. value), 50/60 Hz
Auxiliary voltage	DC 3.5 kV
Communication ports and time synchronization	AC 500 V
Impulse voltage test (type test) all circuits, except communication ports and time synchronization, class III	5 kV (peak value); 1.2/50 μ s; 0.5 J 3 positive and 3 negative impulses at intervals of 5 s
<i>EMC tests for interference immunity; type tests</i>	
Standards	IEC 60255-6; IEC 60255-22 (product standard) EN 50082-2 (generic specification) DIN 57435 Part 303
High-frequency test IEC 60255-22-1, class III and VDE 0435 Part 303, class III	2.5 kV (peak value); 1 MHz; $\tau = 15$ ms; 400 surges per s; test duration 2 s
Electrostatic discharge IEC 60255-22-2 class IV and EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air gap discharge; both polarities; 150 pF; $R_i = 330 \Omega$
Irradiation with radio-frequency field, non-modulated IEC 60255-22-3 (Report) class III	10 V/m; 27 to 500 MHz
Irradiation with radio-frequency field, amplitude-modulated IEC 61000-4-3; class III	10 V/m, 80 to 1000 MHz; AM 80 %; 1 kHz
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204; class III	10 V/m, 900 MHz; repetition rate 200 Hz, on duration 50 %
Fast transient interference/burst IEC 60255-22-4 and IEC 61000-4- 4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50 \Omega$; test duration 1 min
High-energy surge voltages (Surge) IEC 61000-4-5; class III Auxiliary voltage	From circuit to circuit: 2 kV; 12 Ω ; 9 μ F across contacts: 1 kV; 2 Ω ; 18 μ F
Binary inputs/outputs	From circuit to circuit: 2 kV; 42 Ω ; 0.5 μ F across contacts: 1 kV; 42 Ω ; 0.5 μ F
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; AM 80 %; 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m; 50 Hz, continuous 300 A/m; 50 Hz, 3 s 0.5 mT, 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak value), 1 to 1.5 MHz damped wave; 50 surges per s; duration 2 s, $R_i = 150$ to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per s both polarities; duration 2 s, $R_i = 80 \Omega$

Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz; amplitude and pulse-modulated
Damped wave IEC 60694 / IEC 61000-4-12	2.5 kV (peak value, polarity alternating) 100 kHz, 1 MHz, 10 and 50 MHz, $R_i = 200 \Omega$
<i>EMC tests for interference emission; type tests</i>	
Standard	EN 50081-* (generic specification)
Conducted interferences only auxiliary voltage IEC/CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC/CISPR 11	30 to 1000 MHz Limit class B
Units with a detached operator panel must be installed in a metal cubicle to maintain limit class B	

Mechanical stress tests	
<i>Vibration, shock stress and seismic vibration</i>	
<u>During operation</u>	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz; ± 0.075 mm amplitude; 60 to 150 Hz; 1 g acceleration frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 5 g, duration 11 ms; 3 shocks in both directions of 3 axes
Seismic vibration IEC 60255-21-3, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 g acceleration (horizontal axis) 8 to 35 Hz: 0.5 g acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 perpendicular axes
<u>During transportation</u>	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz; 2 g acceleration, frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, Class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 15 g, duration 11 ms 3 shocks in both directions of 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Semi-sinusoidal Acceleration 10 g, duration 16 ms 1000 shocks in both directions of 3 axes

Overcurrent Protection / 7SJ64

Technical data

<i>Climatic stress tests</i>			
<i>Temperatures</i>			
Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C / -13 °F to +185 °F		
Temporarily permissible operating temperature, tested for 96 h	-20 °C to +70 °C / -4 °F to +158 °F		
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C / +131 °F)	-5 °C to +55 °C / +25 °F to +131 °F		
– Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to +131 °F		
– Limiting temperature during transport	-25 °C to +70 °C / -13 °F to +158 °F		
<i>Humidity</i>			
Permissible humidity It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average 75 % relative humidity; on 56 days a year up to 95 % relative humidity; condensation not permissible!		
<i>Unit design</i>			
Type	7SJ640 7SJ642	7SJ641	7SJ645 7SJ647
Housing	7XP20		
Dimensions	See dimension drawings, part 14 of this catalog		
Weight in kg	Housing width $\frac{1}{3}$	Housing width $\frac{1}{2}$	Housing width $\frac{1}{1}$
Surface-mounting housing	8	11	15
Flush-mounting housing	5	6	10
Housing for detached operator panel	–	8	12
Detached operator panel	–	2.5	2.5
Degree of protection acc. to EN 60529	IP 51		
Surface-mounting housing	Front: IP 51, rear: IP 20;		
Flush-mounting housing	IP 2x with cover		
Operator safety			

Serial interfaces	
<i>Operating interface (front of unit)</i>	
Connection	Non-isolated, RS232; front panel, 9-pin subminiature connector
Transmission rate	Factory setting 115200 baud, min. 4800 baud, max. 115200 baud
<i>Service/modem interface (rear of unit)</i>	
Isolated interface for data transfer	Port C: DIGSI 4 / modem / RTD-box
Transmission rate	Factory setting 38400 baud min. 4800 baud, max. 115200 baud
RS232/RS485	
Connection	9-pin subminiature connector, mounting location "C"
For flush-mounting housing / surface-mounting housing with detached operator panel	
For surface-mounting housing with two-tier terminal at the top / bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	15 m / 49.2 ft
Distance RS485	Max. 1 km / 3300 ft
Test voltage	AC 500 V against ground
<i>Additional interface (rear of unit)</i>	
Isolated interface for data transfer	Port D: RTD-box
Transmission rate	Factory setting 38400 baud, min. 4800 baud, max. 115200 baud
RS485	
Connection	9-pin subminiature connector, mounting location "D"
For flush-mounting housing / surface-mounting housing with detached operator panel	
For surface-mounting housing with two-tier terminal at the top / bottom part	At the bottom part of the housing: shielded data cable
Distance	Max. 1 km / 3300 ft
Test voltage	AC 500 V against ground
Fiber optic	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection Mounting location "D"
For flush-mounting housing / surface-mounting housing with detached operator panel	
For surface-mounting housing with two-tier terminal at the top / bottom part	At the bottom part of the housing
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 μ m
Distance	Max. 1.5 km / 0.9 miles

<i>System interface (rear of unit)</i>	
<i>IEC 60870-5-103 protocol</i>	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Factory setting: 9600 baud, min. 1200 baud, max. 115200 baud
<u>RS232/RS485</u>	
Connection For flush-mounting housing / surface-mounting housing with detached operator panel	Mounting location "B"
For surface-mounting housing with two-tier terminal on the top / bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	Max. 15 m / 49 ft
Distance RS485	Max. 1 km / 3300 ft
Test voltage	AC 500 V against ground
<u>Fiber optic</u>	
Connection fiber-optic cable For flush-mounting housing / surface-mounting housing with detached operator panel	Integrated ST connector for fiber-optic connection Mounting location "B"
For surface-mounting housing with two-tier terminal on the top / bottom part	At the bottom part of the housing
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	Max. 1.5 km / 0.9 miles
<i>IEC 60870-5-103 protocol, redundant</i>	
<u>RS485</u>	
Connection For flush-mounting housing / surface-mounting housing with detached operator panel	Mounting location "B"
For surface-mounting housing with two-tier terminal on the top / bottom part	(not available)
Distance RS485	Max. 1 km / 3300 ft
Test voltage	AC 500 V against ground
<i>Ethernet (EN 100) for DIGSI, IEC 61850, DNP3 TCP, PROFINET</i>	
<u>Electrical</u>	
Connection for flush-mounted casing	rear panel, mounting location "B" 2 x RJ45 socket contact 100BaseT acc. to IEEE802.3
Connection for surface-mounted casing	in console housing at case bottom
Test voltage (reg. socket)	500 V; 50 Hz
Transmission speed	100 Mbit/s
Bridgeable distance	65.62 feet (200 m)
<u>Optical</u>	
Connection for flush-mounted case	rear panel, slot position "B", duplex LC, 100BaseT acc. to IEEE802.3
Connection for surface-mounted case	(not available)
Transmission speed	100 Mbit/s
Optical wavelength	1300 nm
Bridgeable distance	max. 0.93 miles (1.5 km)

<i>PROFIBUS-FMS/DP</i>	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 1.5 Mbaud
<u>RS485</u>	
Connection For flush-mounting housing / surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location "B"
For surface-mounting housing with two-tier terminal on the top / bottom part	At the bottom part of the housing: shielded data cable
Distance	1000 m / 3300 ft ≤ 93.75 kbaud; 500 m / 1500 ft ≤ 187.5 kbaud; 200 m / 600 ft ≤ 1.5 Mbaud; 100 m / 300 ft ≤ 12 Mbaud
Test voltage	AC 500 V against ground
<u>Fiber optic</u>	
Connection fiber-optic cable For flush-mounting housing / surface-mounting housing with detached operator panel	Integr. ST connector for FO connection, mounting location "B"
For surface-mounting housing with two-tier terminal on the top / bottom part	At the bottom part of the housing Important: Please refer to footnotes ¹⁾ and ²⁾ on page 5/215
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	500 kB/s 1.6 km / 0.99 miles 1500 kB/s 530 m / 0.33 miles
<i>MODBUS RTU, ASCII, DNP 3.0</i>	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 19200 baud
<u>RS485</u>	
Connection For flush-mounting housing / surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location "B"
For surface-mounting housing with two-tier terminal at the top / bottom part	At bottom part of the housing: shielded data cable
Distance	Max. 1 km / 3300 ft max. 32 units recommended
Test voltage	AC 500 V against ground
<u>Fiber-optic</u>	
Connection fiber-optic cable For flush-mounting housing / surface-mounting housing with detached operator panel	Integrated ST connector for fiber-optic connection Mounting location "B"
For surface-mounting housing with two-tier terminal at the top / bottom part	At the bottom part of the housing Important: Please refer to footnotes ¹⁾ and ²⁾ on page 5/174
Optical wavelength	820 nm
Permissible path attenuation	Max 8 dB. for glass fiber 62.5/125 µm
Distance	Max. 1.5 km / 0.9 miles
1) At $I_{nom} = 1 A$, all limits divided by 5.	

Overcurrent Protection / 7SJ64

Technical data

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Time synchronization DCF77/IRIG-B signal (Format IRIG-B000)	
Connection	9-pin subminiature connector (SUB-D) (terminal with surface-mounting housing)
Voltage levels	5 V, 12 V or 24 V (optional)

Functions	
Definite-time overcurrent protection, directional/non-directional (ANSI 50, 50N, 67, 67N)	
Operating mode non-directional phase protection (ANSI 50)	3-phase (standard) or 2-phase (L1 and L3)
Number of elements (stages)	$I>$, $I>>$, $I>>>$ (phases) $I_E>$, $I_E>>$, $I_E>>>$ (ground)
Setting ranges	
Pickup phase elements	0.5 to 175 A or $\infty 1$ (in steps of 0.01 A)
Pickup ground elements	0.25 to 175 A or $\infty 1$ (in steps of 0.01 A)
Delay times T	0 to 60 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Times	
Pickup times (without inrush restraint, with inrush restraint + 10 ms)	
With twice the setting value	Non-directional: Approx. 30 ms Directional: 45 ms
With five times the setting value	Non-directional: Approx. 20 ms Directional: 40 ms
Dropout times	Approx. 40 ms
Dropout ratio	Approx. 0.95 for $III_{nom} \geq 0.3$
Tolerances	
Pickup	2 % of setting value or 50 mA ¹⁾
Delay times T , T_{DO}	1 % or 10 ms

Inverse-time overcurrent protection, directional/non-directional (ANSI 51, 51N, 67, 67N)	
Operating mode non-directional phase protection (ANSI 51)	3-phase (standard) or 2-phase (L1 and L3)
Setting ranges	
Pickup phase element I_P	0.5 to 20 A or $\infty 1$ (in steps of 0.01 A)
Pickup ground element I_{EP}	0.25 to 20 A or $\infty 1$ (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.05 to 15 s or ∞ (in steps of 0.01 s)
Undervoltage threshold $V <$ for release I_P	10.0 to 125.0 V (in steps of 0.1 V)
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse, long inverse
ANSI	Inverse, short inverse, long inverse moderately inverse, very inverse, extremely inverse, definite inverse
User-defined characteristic	Defined by a maximum of 20 value pairs of current and time delay
Dropout setting	
Without disk emulation	Approx. $1.05 \cdot$ setting value I_P for $I_P/III_{nom} \geq 0.3$, corresponds to approx. $0.95 \cdot$ pickup threshold
With disk emulation	Approx. $0.90 \cdot$ setting value I_P

1) For $I_{nom} = 1$ A, all limits divided by 5.

Tolerances	
Pickup/dropout thresholds I_P , I_{EP}	2 % of setting value or 50 mA ¹⁾
Pickup time for $2 \leq III_P \leq 20$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms
Dropout ratio for $0.05 \leq III_P \leq 0.9$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms

Direction detection	
For phase faults	
Polarization	With cross-polarized voltages; With voltage memory for measurement voltages that are too low
Forward range	$V_{ref,rot} \pm 86^\circ$
Rotation of reference voltage $V_{ref,rot}$	- 180° to 180° (in steps of 1°)
Direction sensitivity	For one and two-phase faults unlimited; For three-phase faults dynamically unlimited; Steady-state approx. 7 V phase-to-phase
For ground faults	
Polarization	With zero-sequence quantities $3V_0$, $3I_0$ or with negative-sequence quantities $3V_2$, $3I_2$
Forward range	$V_{ref,rot} \pm 86^\circ$
Rotation of reference voltage $V_{ref,rot}$	- 180° to 180° (in steps of 1°)
Direction sensitivity	
Zero-sequence quantities $3V_0$, $3I_0$	$V_E \approx 2.5$ V displacement voltage, measured; $3V_0 \approx 5$ V displacement voltage, calculated
Negative -sequence quantities $3V_2$, $3I_2$	$3V_2 \approx 5$ V negative-sequence voltage $3I_2 \approx 225$ mA negative-sequence current ¹⁾
Tolerances (phase angle error under reference conditions)	
For phase and ground faults	$\pm 1^\circ$ electrical

Inrush blocking	
Influenced functions	Time-overcurrent elements, $I>$, $I_E>$, I_P , I_{EP} (directional, non-directional)
Lower function limit phases	At least one phase current (50 Hz and 100 Hz) ≥ 125 mA ¹⁾
Lower function limit ground	Ground current (50 Hz and 100 Hz) ≥ 125 mA ¹⁾
Upper function limit (setting range)	1.5 to 125 A ¹⁾ (in steps of 0.01 A)
Setting range $I_{2f} II$	10 to 45 % (in steps of 1 %)
Crossblock (I_{L1} , I_{L2} , I_{L3})	ON/OFF

Dynamic setting change	
Controllable function	Directional and non-directional pickup, tripping time
Start criteria	Current criteria, CB position via aux. contacts, binary input, auto-reclosure ready
Time control	3 timers
Current criteria	Current threshold (reset on dropping below threshold; monitoring with timer)

<i>(Sensitive) ground-fault detection (ANSI 64, 50 Ns, 51Ns, 67Ns)</i>	
<i>Displacement voltage starting for all types of ground fault (ANSI 64)</i>	
Setting ranges	
Pickup threshold $V_{E>}$ (measured)	1.8 to 170 V (in steps of 0.1 V)
Pickup threshold $3V_{0>}$ (calculated)	10 to 225 V (in steps of 0.1 V)
Delay time $T_{\text{Delay pickup}}$	0.04 to 320 s or ∞ (in steps of 0.01 s)
Additional trip delay T_{VDELAY}	0.1 to 40000 s or ∞ (in steps of 0.01 s)
Times	
Pickup time	Approx. 50 ms
Dropout ratio	0.95 or (pickup value -0.6 V)
Tolerances	
Pickup threshold V_E (measured)	3 % of setting value or 0.3 V
Pickup threshold $3V_0$ (calculated)	3 % of setting value or 3 V
Delay times	1 % of setting value or 10 ms
<i>Phase detection for ground fault in an ungrounded system</i>	
Measuring principle	Voltage measurement (phase-to-ground)
Setting ranges	
$V_{\text{ph min}}$ (ground-fault phase)	10 to 100 V (in steps of 1 V)
$V_{\text{ph max}}$ (unfaulted phases)	10 to 100 V (in steps of 1 V)
Measuring tolerance acc. to DIN 57435 part 303	3 % of setting value, or 1 V
<i>Ground-fault pickup for all types of ground faults</i>	
<i>Definite-time characteristic (ANSI 50Ns)</i>	
Setting ranges	
Pickup threshold $I_{EE>}, I_{EE>>}$	
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A ¹⁾ (in steps of 0.01 A)
Delay times T for $I_{EE>}, I_{EE>>}$	0 to 320 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Times	
Pickup times	Approx. 50 ms
Dropout ratio	Approx. 0.95
Tolerances	
Pickup threshold	
For sensitive input	2 % of setting value or 1 mA
For normal input	2 % of setting value or 50mA ¹⁾
Delay times	1 % of setting value or 20 ms
<i>Ground-fault pickup for all types of ground faults</i>	
<i>Inverse-time characteristic (ANSI 51Ns)</i>	
User-defined characteristic	Defined by a maximum of 20 pairs of current and delay time values
Setting ranges	
Pickup threshold I_{EEP}	
For sensitive input	0.001 A to 1.4 A (in steps of 0.001 A)
For normal input	0.25 to 20 A ¹⁾ (in steps of 0.01 A)
User defined	
Time multiplier T	0.1 to 4 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	Approx. 50 ms
Pickup threshold	Approx. $1.1 \cdot I_{\text{EEP}}$
Dropout ratio	Approx. $1.05 \cdot I_{\text{EEP}}$
Tolerances	
Pickup threshold	
For sensitive input	2 % of setting value or 1 mA
For normal input	2 % of setting value or 50mA ¹⁾
Note: Due to the high sensitivity the linear range of the measuring input IN with integrated sensitive input transformer is from 0.001 A to 1.6 A. For currents greater than 1.6 A, correct directionality can no longer be guaranteed.	
1) For $I_{\text{nom}} = 1$ A, all limits divided by 5.	

Delay times in linear range	7 % of reference value for $2 \geq III_{\text{EEP}} \geq 20 + 2$ % current tolerance, or 70 ms
<u>Logarithmic inverse</u>	Refer to the manual
<u>Logarithmic inverse with knee point</u>	Refer to the manual
<i>Direction detection for all types of ground-faults (ANSI 67Ns)</i>	
<u>Measuring method "cos φ / sin φ"</u>	
Direction measurement	I_E and V_E measured or $3I_0$ and $3V_0$ calculated
Measuring principle	Active/reactive power measurement
Setting ranges	
Measuring enable $I_{\text{Release direct}}$	
For sensitive input	0.001 to 1.2 A (in steps of 0.001 A)
For normal input	0.25 to 150 A ¹⁾ (in steps of 0.01 A)
Direction phasor $\varphi_{\text{Correction}}$	-45 ° to +45 ° (in steps of 0.1 °)
Dropout delay $T_{\text{Reset delay}}$	1 to 60 s (in steps of 1 s)
Tolerances	
Pickup measuring enable	
For sensitive input	2 % of setting value or 1 mA
For normal input	2 % of setting value or 50 mA ¹⁾
Angle tolerance	3 °
<u>Measuring method "φ (V_0/I_0)"</u>	
Direction measurement	I_E and V_E measured or $3I_0$ and $3V_0$ calculated
Minimum voltage V_{min} , measured	0.4 to 50 V (in steps of 0.1 V)
Minimum voltage V_{min} , calculated	10 to 90 V (in steps of 1 V)
Phase angle φ	-180° to 180° (in steps of 0.1°)
Delta phase angle $\Delta\varphi$	0° to 180° (in steps of 0.1°)
Tolerances	
Pickup threshold V_E (measured)	3 % of setting value or 0.3 V
Pickup threshold $3V_0$ (calculated)	3 % of setting value or 3 V
Angle tolerance	3 °
<u>Angle correction for cable CT</u>	
Angle correction F1, F2	0 ° to 5 ° (in steps of 0.1°)
Current value I_1, I_2	
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A ¹⁾ (in steps of 0.01 A)
<i>High-impedance restricted ground-fault protection (ANSI 87N) / single-phase overcurrent protection</i>	
Setting ranges	
Pickup thresholds $I>, I>>$	
For sensitive input	0.003 to 1.5 A or ∞ (in steps of 0.001 A)
For normal input	0.25 to 175 A ¹⁾ or ∞ (in steps of 0.01 A)
Delay times $T_1>, T_1>>$	0 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
Minimum	Approx. 20 ms
Typical	Approx. 30 ms
Dropout times	Approx. 30 ms
Dropout ratio	Approx. 0.95 for $III_{\text{nom}} \geq 0.5$
Tolerances	
Pickup thresholds	3 % of setting value or 1 % rated current at $I_{\text{nom}} = 1$ or 5 A; 5 % of setting value or 3 % rated current at $I_{\text{nom}} = 0.1$ A
Delay times	1 % of setting value or 10 ms

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Intermittent ground-fault protection	
Setting ranges	
Pickup threshold	
For I_E	$I_{E>}$ 0.25 to 175 A ¹⁾ (in steps of 0.01 A)
For $3I_0$	$I_{E>}$ 0.25 to 175 A ¹⁾ (in steps of 0.01 A)
For I_{EE}	$I_{E>}$ 0.005 to 1.5 A (in steps of 0.001 A)
Pickup prolongation time	T_V 0 to 10 s (in steps of 0.01 s)
Ground-fault accumulation time	T_{sum} 0 to 100 s (in steps of 0.01 s)
Reset time for accumulation	T_{res} 1 to 600 s (in steps of 1 s)
Number of pickups for intermittent ground fault	2 to 10 (in steps of 1)
Times	
Pickup times	
Current = 1.25 · pickup value	Approx. 30 ms
Current $\geq 2 \cdot$ pickup value	Approx. 22 ms
Dropout time	Approx. 22 ms
Tolerances	
Pickup threshold $I_{E>}$	3 % of setting value, or 50 mA ¹⁾
Times T_V, T_{sum}, T_{res}	1 % of setting value or 10 ms
Directional intermittent ground fault protection (ANSI 67Ns)	
Setting ranges / Increments	
Pickup threshold	
$V_{gnd> / 3V0>}$	2.0 V to 100.0 V Increments 1 V
Monitoring time after pickup detected	0.04 s ... 10.00 s Increments 0.01 s
Pulse no. for detecting the interm. E/F	2 ... 50 Increments 1
Dropout ratio	
Dropout ratio $V_{gnd> / 3V0>}$	0,95 or (pickup value - 0,6 V)
Tolerances	
Measurement tolerance	
$V_{gnd> / 3V0>}$	3 % of setting value
Times	1 % of setting value or 10 ms
Influencing Variables	
Power supply direct voltage in range	$0.8 \leq VPS/VPSNom \leq 1.15$ <1 %
Temperature in range	$23.00 \text{ }^\circ\text{F} (-5 \text{ }^\circ\text{C}) \leq \Theta_{amb} \leq 131.00 \text{ }^\circ\text{F} (55 \text{ }^\circ\text{C})$ <0.5 %/K
Thermal overload protection (ANSI 49)	
Setting ranges	
Factor k	0.1 to 4 (in steps of 0.01)
Time constant	1 to 999.9 min (in steps of 0.1 min)
Warning overtemperature	50 to 100 % with reference to the tripping overtemperature (in steps of 1 %)
Current warning stage I_{alarm}	0.5 to 20 A (in steps of 0.01 A)
Extension factor when stopped k_t factor	1 to 10 with reference to the time constant with the machine running (in steps of 0.1)
Rated overtemperature (for I_{nom})	40 to 200 °C (in steps of 1 °C)
Tripping characteristic	
For $(I/k \cdot I_{nom}) \leq 8$	$t = \tau_{th} \cdot \ln \frac{(I/k \cdot I_{nom})^2 - (I_{pre}/k \cdot I_{nom})^2}{(I/k \cdot I_{nom})^2 - 1}$
	t = Tripping time
	τ_{th} = Temperature rise time constant
	I = Load current
	I_{pre} = Preload current
	k = Setting factor acc. to VDE 0435 Part 3011 and IEC 60255-8
	I_{nom} = Rated (nominal) current of the protection relay
1) At $I_{nom} = 1$ A, all limits divided by 5.	

Dropout ratios	
Θ/Θ_{Trip}	Drops out with Θ_{Alarm}
Θ/Θ_{Alarm}	Approx. 0.99
III_{Alarm}	Approx. 0.97
Tolerances	
With reference to $k \cdot I_{nom}$	Class 5 acc. to IEC 60255-8
With reference to tripping time	5 % \pm 2 s acc. to IEC 60255-8
Auto-reclosure (ANSI 79)	
Number of reclosures	
	0 to 9
	Shot 1 to 4 individually adjustable
Program for phase fault Start-up by	
	Time-overcurrent elements (dir., non-dir.), sensitive ground-fault protection, binary input
Blocking of ARC	
	Pickup of protection functions, three-phase fault detected by a protective element, binary input, last TRIP command after the reclosing cycle is complete (unsuccessful reclosing), TRIP command by the breaker failure protection (50BF), opening the CB without ARC initiation, external CLOSE command
Setting ranges	
Dead time (separate for phase and ground and individual for shots 1 to 4)	0.01 to 320 s (in steps of 0.01 s)
Blocking duration for manual-CLOSE detection	0.5 s to 320 s or 0 (in steps of 0.01 s)
Blocking duration after reclosure	0.5 s to 320 s (in steps of 0.01 s)
Blocking duration after dynamic blocking	0.01 to 320 s (in steps of 0.01 s)
Start-signal monitoring time	0.01 to 320 s or ∞ (in steps of 0.01 s)
Circuit-breaker supervision time	0.1 to 320 s (in steps of 0.01 s)
Max. delay of dead-time start	0 to 1800 s or ∞ (in steps of 0.1 s)
Maximum dead time extension	0.5 to 320 s or ∞ (in steps of 0.01 s)
Action time	0.01 to 320 s or ∞ (in steps of 0.01 s)
The delay times of the following protection function can be altered individually by the ARC for shots 1 to 4 (setting value $T = T$, non-delayed $T = 0$, blocking $T = \infty$):	
$I>>>, I>>, I>, I_p, I_{dir}>>, I_{dir}>, I_{pdir}$	
$I_E>>>, I_E>>, I_E>, I_{Ep}, I_{Edir}>>, I_{Edir}>, I_{Edir}$	
Additional functions	
	Lockout (final trip), delay of dead-time start via binary input (monitored), dead-time extension via binary input (monitored), co-ordination with other protection relays, circuit-breaker monitoring, evaluation of the CB contacts
Breaker failure protection (ANSI 50 BF)	
Setting ranges	
Pickup threshold	0.2 to 5 A ¹⁾ (in steps of 0.01 A)
Delay time	0.06 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
with internal start	is contained in the delay time
with external start	is contained in the delay time
Dropout times	Approx. 25 ms
Tolerances	
Pickup value	2 % of setting value (50 mA) ¹⁾
Delay time	1 % or 20 ms
Synchro- and voltage check (ANSI 25)	
Operating modes	
	<ul style="list-style-type: none"> • Synchrocheck • Asynchronous/synchronous
Additional release conditions	
	<ul style="list-style-type: none"> • Live-bus / dead line • Dead-bus / live-line • Dead-bus and dead-line • Bypassing

Voltages	
Max. operating voltage V_{max}	20 to 140 V (phase-to-phase) (in steps of 1 V)
Min. operating voltage V_{min}	20 to 125 V (phase-to-phase) (in steps of 1 V)
$V<$ for dead-line / dead-bus check	1 to 60 V (phase-to-phase) (in steps of 1 V)
$V>$ for live-line / live-bus check	20 to 140 V (phase-to-phase) (in steps of 1 V)
Primary rated voltage of transformer V_{2nom}	0.1 to 800 kV (in steps of 0.01 kV)
Tolerances	2 % of pickup value or 2 V
Drop-off to pickup ratios	approx. 0.9 ($V>$) or 1.1 ($V<$)
ΔV-measurement	
Voltage difference	0.5 to 50 V (phase-to-phase) (in steps of 1 V)
Tolerance	1 V
Δf-measurement	
Δf -measurement ($f_2 > f_1$; $f_2 < f_1$)	0.01 to 2 Hz (in steps of 0.01 Hz)
Tolerance	15 mHz
$\Delta \alpha$-measurement	
$\Delta \alpha$ -measurement ($\alpha_2 > \alpha_1$; $\alpha_2 < \alpha_1$)	2 ° to 80 ° (in steps of 1 °)
Tolerance	2 °
Max. phase displacement	5 ° for $\Delta f \leq 1$ Hz 10 ° for $\Delta f > 1$ Hz
Circuit-breaker operating time	
CB operating time	0.01 to 0.6 s (in steps of 0.01 s)
Threshold ASYN ↔ SYN	
Threshold synchronous / asynchronous	0.01 to 0.04 Hz (in steps of 0.01 Hz)
Adaptation	
Vector group adaptation by angle	0 ° to 360 ° (in steps of 1 °)
Different voltage transformers V_1/V_2	0.5 to 2 (in steps of 0.01)
Times	
Minimum measuring time	Approx. 80 ms
Max. duration $T_{SYN DURATION}$	0.01 to 1200 s; ∞ (in steps of 0.01 s)
Supervision time $T_{SUP VOLTAGE}$	0 to 60 s (in steps of 0.01 s)
Closing time of CB $T_{CB close}$	0 to 60 s (in steps of 0.01 s)
Tolerance of all timers	1 % of setting value or 10 ms
Measuring values of synchro-check function	
Reference voltage V_1	
Range	In kV primary, in V secondary or in % V_{nom}
Range	10 to 120 % V_{nom}
Tolerance*)	≤ 1 % of measured value or 0.5 % of V_{nom}
Voltage to be synchronized V_2	
Range	In kV primary, in V secondary or in % V_{nom}
Range	10 to 120 % V_{nom}
Tolerance*)	≤ 1 % of measured value or 0.5 % of V_{nom}
Frequency of V_1 and V_2	
Range	f_1, f_2 in Hz
Range	$f_N \pm 5$ Hz
Tolerance*)	20 mHz
Voltage difference ($V_2 - V_1$)	
Range	In kV primary, in V secondary or in % V_{nom}
Range	10 to 120 % V_{nom}
Tolerance*)	≤ 1 % of measured value or 0.5 % of V_{nom}
Frequency difference ($f_2 - f_1$)	
Range	In mHz
Range	$f_N \pm 5$ Hz
Tolerance*)	20 mHz
Angle difference ($\alpha_2 - \alpha_1$)	
Range	In °
Range	0 to 180 °
Tolerance*)	0.5 °

Negative-sequence current detection (ANSI 46)	
Definite-time characteristic (ANSI 46-1 and 46-2)	
Setting ranges	
Pickup current $I_{2>}, I_{2>>}$	0.25 to 15 A ¹⁾ or ∞ (in steps of 0.01 A)
Delay times	0 to 60 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Functional limit	
All phase currents ≤ 20 A ¹⁾	
Times	
Pickup times	Approx. 35 ms
Dropout times	Approx. 35 ms
Dropout ratio	Approx. 0.95 for $I_2 / I_{nom} > 0.3$
Tolerances	
Pickup thresholds	3 % of the setting value or 50 mA ¹⁾
Delay times	1 % or 10 ms
Inverse-time characteristic (ANSI 46-TOC)	
Setting ranges	
Pickup current	0.25 to 10 A ¹⁾ (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.5 to 15 s or ∞ (in steps of 0.01 s)
Functional limit	
All phase currents ≤ 50 A ¹⁾	
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse
ANSI	Inverse, moderately inverse, very inverse, extremely inverse
Pickup threshold	Approx. 1.1 · I_{2p} setting value
Dropout	
IEC and ANSI (without disk emulation)	Approx. 1.05 · I_{2p} setting value, which is approx. 0.95 · pickup threshold
ANSI with disk emulation	Approx. 0.90 · I_{2p} setting value
Tolerances	
Pickup threshold	3 % of the setting value or 50 mA ¹⁾
Time for 2 ≤ M ≤ 20	5 % of setpoint (calculated) +2 % current tolerance, at least 30 ms
Flexible protection functions (ANSI 27, 32, 47, 50, 55, 59, 81R)	
Operating modes / measuring quantities	
3-phase	$I, I_1, I_2, I_2I_1, 3I_0, V, V_1, V_2, 3V_0, dV/dt, P, Q, \cos \varphi$
1-phase	$I, I_E, I_{E sens.}, V, V_E, P, Q, \cos \varphi$
Without fixed phase relation	$f, df/dt$, binary input
Pickup when	Exceeding or falling below threshold value
Setting ranges	
Current $I, I_1, I_2, 3I_0, I_E$	0.15 to 200 A ¹⁾ (in steps of 0.01 A)
Current ratio I_2/I_1	15 to 100 % (in steps of 1 %)
Sens. ground curr. $I_{E sens.}$	0.001 to 1.5 A (in steps of 0.001 A)
Voltages $V, V_1, V_2, 3V_0$	2 to 260 V (in steps of 0.1 V)
Displacement voltage V_E	2 to 200 V (in steps of 0.1 V)
Power P, Q	0.5 to 10000 W (in steps of 0.1 W)
Power factor ($\cos \varphi$)	- 0.99 to + 0.99 (in steps of 0.01)
Frequency $f_N = 50$ Hz	40 to 60 Hz (in steps of 0.01 Hz)
$f_N = 60$ Hz	50 to 70 Hz (in steps of 0.01 Hz)
Rate-of-frequency change df/dt	0.1 to 20 Hz/s (in steps of 0.01 Hz/s)
Voltage change dV/dt	4 V/s to 100 V/s (in steps of 1 V/s)
Dropout ratio >- stage	1.01 to 3 (in steps of 0.01)
Dropout ratio <- stage	0.7 to 0.99 (in steps of 0.01)
Dropout differential f	0.02 to 1.00 Hz (in steps of 0.01 Hz)
Pickup delay time	0 to 60 s (in steps of 0.01 s)
Trip delay time	0 to 3600 s (in steps of 0.01 s)
Dropout delay time	0 to 60 s (in steps of 0.01 s)
*) With rated frequency.	
1) At $I_{nom} = 1$ A, all limits divided by 5.	

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Flexible protection functions (ANSI 27, 32, 47, 50, 55, 59, 81R) (cont'd)

Times	
Pickup times	
Current, voltage (phase quantities)	
With 2 times the setting value	Approx. 30 ms
With 10 times the setting value	Approx. 20 ms
Current, voltages (symmetrical components)	
With 2 times the setting value	Approx. 40 ms
With 10 times the setting value	Approx. 30 ms
Power	
Typical	Approx. 120 ms
Maximum (low signals and thresholds)	Approx. 350 ms
Power factor	300 to 600 ms
Frequency	Approx. 100 ms
Rate-of-frequency change with 1.25 times the setting value	Approx. 220 ms
Voltage change dV/dt for 2 times pickup value	Approx. 220 ms
Binary input	Approx. 20 ms
Dropout times	
Current, voltage (phase quantities)	< 20 ms
Current, voltages (symmetrical components)	< 30 ms
Power	
Typical	< 50 ms
Maximum	< 350 ms
Power factor	< 300 ms
Frequency	< 100 ms
Rate-of-frequency change	< 200 ms
Voltage change	< 220 ms
Binary input	< 10 ms
Tolerances	
Pickup threshold	
Current	0.5 % of setting value or 50 mA ¹⁾
Current (symmetrical components)	1 % of setting value or 100 mA ¹⁾
Voltage	0.5 % of setting value or 0.1 V
Voltage (symmetrical components)	1 % of setting value or 0.2 V
Power	1 % of setting value or 0.3 W
Power factor	2 degrees
Frequency	5 mHz (at $V = V_N, f = f_N$) 10 mHz (at $V = V_N$)
Rate-of-frequency change	5 % of setting value or 0.05 Hz/s
Voltage change dV/dt	5 % of setting value or 2 V/s
Times	1 % of setting value or 10 ms

Starting time monitoring for motors (ANSI 48)

Setting ranges	
Motor starting current $I_{STARTUP}$	2.5 to 80 A ¹⁾ (in steps of 0.01)
Pickup threshold $I_{MOTOR START}$	2 to 50 A ¹⁾ (in steps of 0.01)
Permissible starting time $T_{STARTUP, COLD MOTOR}$	1 to 180 s (in steps of 0.1 s)
Permissible starting time $T_{STARTUP, WARM MOTOR}$	0.5 to 180 s (in steps of 0.1 s)
Temperature threshold cold motor	0 to 80 % (in steps of 1 %)
Permissible blocked rotor time $T_{BLOCKED-ROTOR}$	0.5 to 120 s or ∞ (in steps of 0.1 s)

1) At $I_{nom} = 1 A$, all limits divided by 5.

Tripping time characteristic	
For $I > I_{MOTOR START}$	$t = \left(\frac{I_{STARTUP}}{I} \right)^2 \cdot T_{STARTUP}$
	$I_{STARTUP}$ = Rated motor starting current
	I = Actual current flowing
	$T_{STARTUP}$ = Tripping time for rated motor starting current
	t = Tripping time in seconds
Dropout ratio $I_{MOTOR START}$	Approx. 0.95
Tolerances	
Pickup threshold	2 % of setting value or 50 mA ¹⁾
Delay time	5 % or 30 ms

Load jam protection for motors (ANSI 51M)

Setting ranges	
Current threshold for alarm and trip	0.25 to 60 A ¹⁾ (in steps of 0.01 A)
Delay times	0 to 600 s (in steps of 0.01 s)
Blocking duration after CLOSE signal detection	0 to 600 s (in steps of 0.01 s)
Tolerances	
Pickup threshold	2 % of setting value or 50 mA ¹⁾
Delay time	1 % of setting value or 10 ms

Restart inhibit for motors (ANSI 66)

Setting ranges	
Motor starting current relative to rated motor current	1.1 to 10 (in steps of 0.1)
$I_{MOTOR START} / I_{Motor Nom}$	
Rated motor current $I_{Motor Nom}$	1 to 6 A ¹⁾ (in steps of 0.01 A)
Max. permissible starting time $T_{Start Max}$	1 to 320 s (in steps of 1 s)
Equilibrium time T_{Equal}	0 min to 320 min (in steps of 0.1 min)
Minimum inhibit time $T_{MIN. INHIBIT TIME}$	0.2 min to 120 min (in steps of 0.1 min)
Max. permissible number of warm starts	1 to 4 (in steps of 1)
Difference between cold and warm starts	1 to 2 (in steps of 1)
Extension k-factor for cooling simulations of rotor at zero speed $k_{T at STOP}$	0.2 to 100 (in steps of 0.1)
Extension factor for cooling time constant with motor running $k_{T RUNNING}$	0.2 to 100 (in steps of 0.1)
Restarting limit	$\Theta_{restart} = \Theta_{rot max perm} \cdot \frac{n_c - 1}{n_c}$
	$\Theta_{restart}$ = Temperature limit below which restarting is possible
	$\Theta_{rot max perm}$ = Maximum permissible rotor overtemperature (= 100 % in operational measured value $\Theta_{rot}/\Theta_{rot trip}$)
	n_c = Number of permissible start-ups from cold state

Undercurrent monitoring (ANSI 37)

Signal from the operational measured values	Predefined with programmable logic
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Temperature monitoring box (ANSI 38)	
Temperature detectors	
Connectable boxes	1 or 2
Number of temperature detectors per box	Max. 6
Type of measuring	Pt 100 Ω or Ni 100 Ω or Ni 120 Ω
Mounting identification	"Oil" or "Environment" or "Stator" or "Bearing" or "Other"
Thresholds for indications	
For each measuring detector	
Stage 1	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)
Stage 2	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)
Undervoltage protection (ANSI 27)	
Operating modes/measuring quantities	
3-phase	Positive phase-sequence voltage or phase-to-phase voltages or phase-to-ground voltages
1-phase	Single-phase phase-ground or phase-phase voltage
Setting ranges	
Pickup thresholds $V<$, $V<<$ dependent on voltage connection and chosen measuring quantity	10 to 120 V (in steps of 1 V) 10 to 210 V (in steps of 1 V)
Dropout ratio r	1.01 to 3 (in steps of 0.01)
Delay times T	0 to 100 s or ∞ (in steps of 0.01 s)
Current Criteria "Bkr Closed I_{MIN} "	0.2 to 5 A ¹⁾ (in steps of 0.01 A)
Times	
Pickup times	Approx. 50 ms
Dropout times	As pickup times
Tolerances	
Pickup thresholds	1 % of setting value or 1 V
Times	1 % of setting value or 10 ms
Overvoltage protection (ANSI 59)	
Operating modes/measuring quantities	
3-phase	Positive phase-sequence voltage or negative phase-sequence voltage or phase-to-phase voltages or phase-to-ground voltages
1-phase	Single-phase phase-ground or phase-phase voltage
Setting ranges	
Pickup thresholds $V>$, $V>>$ dependent on voltage connection and chosen measuring quantity	40 to 260 V (in steps of 1 V) 40 to 150 V (in steps of 1 V) 2 to 150 V (in steps of 1 V)
Dropout ratio r	0.9 to 0.99 (in steps of 0.01)
Delay times T	0 to 100 s or ∞ (in steps of 0.01 s)
Times	
Pickup times $V>$, $V>>$	Approx. 50 ms
Pickup times $V_1>$, $V_2>>$	Approx. 60 ms
Dropout times	As pickup times
Tolerances	
Pickup thresholds	1 % of setting value or 1 V
Times	1 % of setting value or 10 ms

1) At $I_{nom} = 1$ A, all limits divided by 5.

2) At $I_{nom} = 1$ A, all limits multiplied with 5.

Frequency protection (ANSI 81)	
Number of frequency elements	4
Setting ranges	
Pickup thresholds for $f_{nom} = 50$ Hz	40 to 60 Hz (in steps of 0.01 Hz)
Pickup thresholds for $f_{nom} = 60$ Hz	50 to 70 Hz (in steps of 0.01 Hz)
Dropout differential = pickup threshold – dropout threshold	0.02 Hz to 1.00 Hz (in steps of 0.01 Hz)
Delay times	
Undervoltage blocking, with positive-sequence voltage V_1	0 to 100 s or ∞ (in steps of 0.01 s) 10 to 150 V (in steps of 1 V)
Times	
Pickup times	Approx. 80 ms
Dropout times	Approx. 75 ms
Dropout	
Ratio undervoltage blocking	Approx. 1.05
Tolerances	
Pickup thresholds	5 mHz (at $V = V_N$, $f = f_N$) 10 mHz (at $V = V_N$)
Undervoltage blocking	3 % of setting value or 1 V
Delay times	3 % of the setting value or 10 ms
Fault locator (ANSI 21FL)	
Output of the fault distance	in Ω primary and secondary, in km or miles line length, in % of line length
Starting signal	Trip command, dropout of a protection element, via binary input
Setting ranges	
Reactance (secondary)	0.001 to 1.9 Ω/km ² (in steps of 0.0001) 0.001 to 3 Ω/mile ² (in steps of 0.0001)
Tolerances	
Measurement tolerance acc. to VDE 0435, Part 303 for sinusoidal measurement quantities	2.0 % fault location, or 0.025 Ω (without intermediate infeed) for $30^\circ \leq \varphi_K \leq 90^\circ$ and $V_K/V_{nom} \geq 0.1$ and $I_K/I_{nom} \geq 1$
Undervoltage-controlled reactive power protection (ANSI 27/Q)	
Measured Values / Modes of Operation	
3-phase	I1, V, Q,
Measuring method for I, V	Fundamental wave, Pickup when Exceeding threshold value or falling below threshold value
Setting Ranges / Increments	
Pickup thresholds	
Current I1 for $I_{Nom} = 1$ A	0.01 to 0.20 A
for $I_{Nom} = 5$ A	Increments 0.01 A 0.05 to 1.00 A
Voltage V	10.0 to 210.00 V
Power Q for $I_{Nom} = 1$ A	Increments 0.1 V 1.0 to 100 VAR
for I VAR $Nom = 5$ A	Increments 0.01 5.0 to 500 VAR
Pickup delay (standard)	0.00 to 60.00 s
Command delay time	Increments 0.01 s 0.00 to 3600.00 s
Dropout delay	Increments 0.01 s 0.00 to 60.00 s
Function Limits	
Power measurement I1 for $I_{Nom} = 1$ A	Positive sequence system current > 0.03 A
for $I_{Nom} = 5$ A	Positive sequence system current > 0.15 A
Times	
Pickup times:	
QU protection typical maximum (small signals and thresholds)	approx. 120 ms
Binary input	approx. 350 ms
Dropout times:	
QU protection typical maximum	approx. 20 ms
Binary input	< 50 ms < 350 ms < 10 ms

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Tolerances Pickup thresholds Current I1 for INom = 1 A for INom = 5 A Current I1 (symmetrical components) for INom = 1 A for INom = 5 A Voltage Voltage (symmetrical components) Power Times Influencing Variables for Pickup Values Auxiliary direct voltage in the range Temperature in the range Frequency in the range Harmonics up to 10 % 3rd harmonic up to 10 % 5th harmonic	1% of setting value or 10 mA at INom ≥ 0.03 A 2% of setting value or 20 mA at INom < 0.03 A 1% of setting value or 50 mA at INom ≥ 0.25 A 2% of setting value or 100 mA at INom < 0.25 A 2% of set value or 20 mA 2% of set value or 100 mA 1% of set value or 0.1 V 2% of set value or 0.2 V 1% of setting value or 0.3 VAR 1% of setting value or 10 ms from 0.8 ≤ VPS/VPSNom ≤ 1.15 1 % from 23.00 °F (-5 °C) ≤ Θamb ≤ 131.00 °F (55 °C) 0.5 %/10 K from 25 Hz to 70 Hz 1 % 1 % 1 %	cos φ, power factor (p.f.) Range Tolerance ¹⁾ Frequency f Range Tolerance ¹⁾ Temperature overload protection Θ/ΘTrip Range Tolerance ¹⁾ Temperature restart inhibit ΘL/ΘL Trip Range Tolerance ¹⁾ Restart threshold ΘRestart/ΘL Trip Reclose time TReclose Currents of sensitive ground fault detection (total, real, and reactive current) IEE, IEE real, IEE reactive Range Tolerance ¹⁾ RTD-box Synchronism and voltage check	Total and phase segregated - 1 to + 1 2 % for cos φ ≥ 0.707 In Hz f _{nom} ± 5 Hz 20 mHz In % 0 to 400 % 5 % class accuracy per IEC 60255-8 In % 0 to 400 % 5 % class accuracy per IEC 60255-8 In % In min In A (kA) primary and in mA secondary 0 mA to 1600 mA 2 % of measured value or 1 mA See section "Temperature monitoring box" See section "Synchronism and voltage check"
Additional functions		Long-term averages	
Operational measured values		Time window Frequency of updates Long-term averages of currents of real power of reactive power of apparent power	
Currents I _{L1} , I _{L2} , I _{L3} Positive-sequence component I ₁ Negative-sequence component I ₂ I _E or 3I ₀ Range Tolerance ¹⁾ Phase-to-ground voltages V _{L1-E} , V _{L2-E} , V _{L3-E} Phase-to-phase voltages V _{L1-L2} , V _{L2-L3} , V _{L3-L1} , V _{SYN} , V _E or V ₀ Positive-sequence component V ₁ Negative-sequence component V ₂ Range Tolerance ¹⁾ S, apparent power Range Tolerance ¹⁾	In A (kA) primary, in A secondary or in % I _{Nom} 10 to 200 % I _{Nom} 1 % of measured value or 0.5 % I _{Nom} In kV primary, in V secondary or in % V _{Nom} 10 to 120 % V _{Nom} 1 % of measured value or 0.5 % of V _{Nom} In kVAR (MVAR or GVAR) primary and in % of S _{Nom} 0 to 120 % S _{Nom} 1 % of S _{Nom} for V/V _{Nom} and I/I _{Nom} = 50 to 120 %	5, 15, 30 or 60 minutes Adjustable I _{L1dmd} , I _{L2dmd} , I _{L3dmd} , I _{1dmd} in A (kA) P _{dmd} in W (kW, MW) Q _{dmd} in VAR (kVAR, MVAR) S _{dmd} in VAR (kVAR, MVAR)	Max. /Min. report
Operational measured values (cont'd)		Report of measured values Reset, automatic Reset, manual Min./Max. values for current Min./Max. values for voltages Min./Max. values for power Min./Max. values for overload protection Min./Max. values for mean values	
P, active power Range Tolerance ¹⁾ Q, reactive power Range Tolerance ¹⁾	With sign, total and phase-segregated in kW (MW or GW) primary and in % S _{Nom} 0 to 120 % S _{Nom} 1 % of S _{Nom} for V/V _{Nom} and I/I _{Nom} = 50 to 120 % and cos φ = 0.707 to 1 with S _{Nom} = √3 V _{Nom} · I _{Nom} With sign, total and phase-segregated in kVAR (MVAR or GVAR) primary and in % S _{Nom} 0 to 120 % S _{Nom} 1 % of S _{Nom} for V/V _{Nom} and I/I _{Nom} = 50 to 120 % and sin φ = 0.707 to 1 with S _{Nom} = √3 V _{Nom} · I _{Nom}	With date and time Time of day adjustable (in minutes, 0 to 1439 min) Time frame and starting time adjustable (in days, 1 to 365 days, and ∞) Using binary input, using keypad, via communication I _{L1} , I _{L2} , I _{L3} , I ₁ (positive-sequence component) voltages V _{L1-E} , V _{L2-E} , V _{L3-E} V ₁ (positive-sequence component) V _{L1-L2} , V _{L2-L3} , V _{L3-L1} S, P, Q, cos φ, frequency Θ/ΘTrip I _{L1dmd} , I _{L2dmd} , I _{L3dmd} I ₁ (positive-sequence component); S _{dmd} , P _{dmd} , Q _{dmd}	Local measured values monitoring
		Current asymmetry Voltage asymmetry Current phase sequence Voltage phase sequence Limit value monitoring 1) At rated frequency.	

Fuse failure monitor	
For all types of networks	With the option of blocking affected protection functions
Fault recording	
Recording of indications of the last 8 power system faults	
Recording of indications of the last 3 power system ground faults	
Time stamping	
Resolution for event log (operational annunciations)	1 ms
Resolution for trip log (fault annunciations)	1 ms
Maximum time deviation (internal clock)	0.01 %
Battery	Lithium battery 3 V/1 Ah, type CR ½ AA, message "Battery Fault" for insufficient battery charge
Oscillographic fault recording	
Maximum 8 fault records saved, memory maintained by buffer battery in case of loss of power supply	
Recording time	Total 20 s Pre-trigger and post-fault recording and memory time adjustable
Sampling rate for 50 Hz	1 sample/1.25 ms (16 samples/cycle)
Sampling rate for 60 Hz	1 sample/1.04 ms (16 samples/cycle)
Energy/power	
Meter values for power W_p , W_q (real and reactive power demand)	in kWh (MWh or GWh) and kVARh (MVARh or GVARh)
Tolerance ¹⁾	$\leq 2\%$ for $I > 0.1 I_{nom}$, $V > 0.1 V_{nom}$ and $ \cos \phi $ (p.f.) ≥ 0.707
Statistics	
Saved number of trips	Up to 9 digits
Number of automatic reclosing commands (segregated according to 1 st and $\geq 2^{nd}$ cycle)	Up to 9 digits
Circuit-breaker wear	
Methods	<ul style="list-style-type: none"> • ΣI^x with $x = 1 \dots 3$ • 2-point method (remaining service life) • $\Sigma I^2 t$
Operation	Phase-selective accumulation of measured values on TRIP command, up to 8 digits, phase-selective limit values, monitoring indication
Motor statistics	
Total number of motor start-ups	0 to 9999 (resolution 1)
Total operating time	0 to 99999 h (resolution 1 h)
Total down-time	0 to 99999 h (resolution 1 h)
Ratio operating time/down-time	0 to 100 % (resolution 0.1 %)
Active energy and reactive energy	See operational measured values
Motor start-up data	Of the last 5 start-ups
– Start-up time	0.30 s to 9999.99 s (resolution 10 ms)
– Start-up current (primary)	0 A to 1000 kA (resolution 1 A)
– Start-up voltage (primary)	0 V to 100 kV (resolution 1 V)
1) At rated frequency.	

Operating hours counter	
Display range	Up to 7 digits
Criterion	Overshoot of an adjustable current threshold (BkrClosed I_{MIN})
Trip circuit monitoring	
With one or two binary input	
Commissioning aids	
Phase rotation field check, operational measured values, circuit-breaker/switching device test, creation of a test measurement report	
Clock	
Time synchronization	DCF77/IRIG-B signal (telegram format IRIG-B000), binary input, communication
Setting group switchover of the function parameters	
Number of available setting groups	4 (parameter group A, B, C and D)
Switchover performed	Via keypad, DIGSI, system (SCADA) interface or binary input
Control	
Number of switching units	Depends on the binary inputs and outputs
Interlocking	Programmable
Circuit-breaker signals	Feedback, close, open, intermediate position
Control commands	Single command / double command 1, 1 plus 1 common or 2 trip contacts
Programmable controller	CFC logic, graphic input tool
Local control	
Units with small display	Control via menu, assignment of a function key
Units with large display	Control via menu, control with control keys
Remote control	Via communication interfaces, using a substation automation and control system (e.g. SICAM), DIGSI 4 (e.g. via modem)

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EG previous 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 2006/95/EG previous 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1. The unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".



Overcurrent Protection / 7SJ64

Selection and ordering data

Description	Order No.
7SJ64 multifunction protection relay with synchronization	7SJ64 <input type="checkbox"/> <input type="checkbox"/> - <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> - <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Housing, binary inputs and outputs	
Housing 1/3 19", 7 BI, 5 BO, 1 live status contact, text display 4 x 20 character (only for 7SJ640) 9th position only with: B, D, E	0
Housing 1/2 19", 15 BI, 13 BO (1 NO/NC or 1a/b contact), 1 live status contact, graphic display	1
Housing 1/2 19", 20 BI, 8 BO, 2 power relays (4 contacts), 1 live status contact, graphic display	2
Housing 1/1 19", 33 BI, 11 BO, 4 power relays (8 contacts), 1 live status contact, graphic display	5
Housing 1/1 19", 48 BI, 21 BO, 4 power relays (8 contacts), 1 live status contact, graphic display	7
Measuring inputs (4 x V, 4 x I)	
$I_{ph} = 1 A^{1)}$, $I_e = 1 A^{1)}$ (min. = 0.05 A) Position 15 only with A, C, E, G	1
$I_{ph} = 1 A^{1)}$, $I_e = \text{sensitive}$ (min. = 0.001 A) Position 15 only with B, D, F, H	2
$I_{ph} = 5 A^{1)}$, $I_e = 5 A^{1)}$ (min. = 0.25 A) Position 15 only with A, C, E, G	5
$I_{ph} = 5 A^{1)}$, $I_e = \text{sensitive}$ (min. = 0.001 A) Position 15 only with B, D, F, H	6
$I_{ph} = 5 A^{1)}$, $I_e = 1 A^{1)}$ (min. = 0.05 A) Position 15 only with A, C, E, G	7
Rated auxiliary voltage (power supply, binary inputs)	
DC 24 to 48 V, threshold binary input DC 19 V ³⁾	2
DC 60 to 125 V ²⁾ , threshold binary input DC 19 V ³⁾	4
DC 110 to 250 V ²⁾ , AC 115 to 230 V, threshold binary input DC 88 V ³⁾	5
Unit version	
Surface-mounting housing, plug-in terminals, detached operator panel, panel mounting in low-voltage housing	A
Surface-mounting housing, 2-tier terminals on top/bottom	B
Surface-mounting housing, screw-type terminals (direct connection/ring-type cable lugs), detached operator panel, panel mounting in low-voltage housing	C
Flush-mounting housing, plug-in terminals (2/3 pin connector)	D
Flush-mounting housing, screw-type terminals (direct connection/ring-type cable lugs)	E
Surface-mounting housing, screw-type terminals (direct connection/ring-type cable lugs), without operator panel, panel mounting in low-voltage housing	F
Surface-mounting housing, plug-in terminals, without operator panel, panel mounting in low-voltage housing	G
Region-specific default settings / function versions and language settings	
Region DE, 50 Hz, IEC, language: German (language selectable)	A
Region World, 50/60 Hz, IEC/ANSI, language: English (GB) (language selectable)	B
Region US, 60 Hz, ANSI, language: English (US) (language selectable)	C
Region FR, 50/60 Hz, IEC/ANSI, language: French (language selectable)	D
Region World, 50/60 Hz, IEC/ANSI, language: Spanish (language selectable)	E
Region IT, 50/60 Hz, IEC/ANSI, language: Italian (language selectable)	F
Region RU, 50/60 Hz, IEC/ANSI, language: Russian (language can be changed)	G

See next page

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- 1) Rated current can be selected by means of jumpers.
- 2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.
- 3) The binary input thresholds can be selected per binary input by means of jumpers.

Overcurrent Protection/7SJ64

Selection and ordering data

Description	Order No.	Order code	
7SJ64 multifunction protection relay with synchronization	7SJ64 □ □ - □ □ □ □ □ □ - □ □ □ □ □ □ - □ □ □ □ □ □		
System interface (on rear of unit, Port B)			
No system interface	0		
IEC 60870-5-103 protocol, RS232	1	See following pages	
IEC 60870-5-103 protocol, RS485	2		
IEC 60870-5-103 protocol, 820 nm fiber, ST connector	3		
PROFIBUS-FMS Slave, RS485	4		
PROFIBUS-FMS Slave, 820 nm wavelength, single ring, ST connector ¹⁾	5		
PROFIBUS-FMS Slave, 820 nm wavelength, double ring, ST connector ¹⁾	6		
PROFIBUS-DP Slave, RS485	9		L O A
PROFIBUS-DP Slave, 820 nm wavelength, double ring, ST connector ¹⁾	9		L O B
MODBUS, RS485	9		L O D
MODBUS, 820 nm wavelength, ST connector ²⁾	9		L O E
DNP 3.0, RS485	9	L O G	
DNP 3.0, 820 nm wavelength, ST connector ²⁾	9	L O H	
IEC 60870-5-103 protocol, redundant, RS485, RJ45 connector ²⁾	9	L O P	
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector (EN 100)	9	L O R	
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector (EN 100) ²⁾	9	L O S	
DNP3 TCP + IEC 61850, 100Mbit Eth, electrical, double, RJ45 connector ⁴⁾	9	L 2 R	
DNP3 TCP + IEC 61850, 100Mbit Eth, optical, double, LC connector ⁴⁾	9	L 2 S	
PROFINET + IEC 61850, 100Mbit Eth, electrical, double, RJ45 connector ⁴⁾	9	L 3 R	
PROFINET + IEC 61850, 100Mbit Eth, optical, double, LC connector ⁴⁾	9	L 3 S	
Only Port C (service interface)			
DIGSI 4/modem, electrical RS232	1		
DIGSI 4/modem/RTD-box ³⁾ , electrical RS485	2		
Port C and D (service and additional interface)	9	M □ □	
Port C (service interface)			
DIGSI 4/modem, electrical RS232		1	
DIGSI 4/modem/RTD-box ³⁾ , electrical RS485		2	
PortD(additional interface)			
RTD-box ³⁾ , 820 nm fiber, ST connector ⁵⁾		A	
RTD-box ³⁾ , electrical RS485		F	
Measuring/fault recording			
Fault recording	1		
Slave pointer, mean values, min/max values, fault recording	3		

1) Not with position 9 = "B"; if 9 = "B", please order 7SJ6 unit with RS485 port and separate fiber-optic converters.
 For single ring, please order converter 6GK1502-2CB10, not available with position 9 = "B".
 For double ring, please order converter 6GK1502-3CB10, not available with position 9 = "B".
 The converter requires a AC 24 V power supply (e.g. power supply 7XV5810-0BA00).

2) Not available with position 9 = "B".
 3) Temperature monitoring box 7XV5662-□AD10, refer to "Accessories".
 4) Available with V4.9
 5) When using the temperature monitoring box at an optical interface, the additional RS485 fiber-optic converter 7XV5650-0□A00 is required.

Overcurrent Protection / 7SJ64

Selection and ordering data

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Description			Order No.	Order code
7SJ64 multifunction protection relay with synchronization			7SJ64 □ □ - □ □ □ □ □ □ - □ □ □ □ □ □ - □ □ □ □ □ □	
Designation	ANSI No.	Description		
Basic version		Control		
	50/51	Overcurrent protection $I>$, $I>>$, $I>>>$, I_p		
	50N/51N	Ground-fault protection $I_{E>}$, $I_{E>>}$, $I_{E>>>}$, I_{EP}		
	50N/51N	Insensitive ground-fault protection through IEE function: $I_{EE>}$, $I_{EE>>}$, $I_{EEP}^{1)}$		
	50/50N	Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I_{2>}$, $I>>>>$, $I_{E>>>>}$		
	51 V	Voltage-dependent inverse-time overcurrent protection		
	49	Overload protection (with 2 time constants)		
	46	Phase balance current protection (negative-sequence protection)		
	37	Undercurrent monitoring		
	47	Phase sequence		
	59N/64	Displacement voltage		
	50BF	Breaker failure protection		
	74TC	Trip circuit supervision		
		4 setting groups, cold-load pickup, Inrush blocking		
	86	Lockout		F A
■	V, P, f	27/59 Under-/overvoltage 810/U Under-/overfrequency 27/Q Undervoltage-controlled reactive power protection ³⁾ 27/47/59(N) Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		F E
■	IEF V, P, f	27/59 Under-/overvoltage 810/U Under-/overfrequency 27/Q Undervoltage-controlled reactive power protection ³⁾ 27/47/59(N) Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection Intermittent ground fault		P E
■	Dir	67/67N Direction determination for overcurrent, phases and ground		F C
■	Dir V, P, f	67/67N Direction determination for overcurrent, phases and ground 27/59 Under-/overvoltage 810/U Under-/overfrequency 27/Q Undervoltage-controlled reactive power protection ³⁾ 27/47/59(N) Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		F G
■	Dir V,P,f IEF	67/67N Direction determination for overcurrent, phases and ground Intermittent ground fault protection 27/59 Under-/overvoltage 81U/O Under-/overfrequency 27/Q Undervoltage-controlled reactive power protection ³⁾ 27/47/59(N) Flexible protection functions (quantities derived from current & voltages) 32/55/81R Voltage-/power-/p.f.-/rate of freq. change-protection Intermittent ground-fault		P G
■	Dir IEF	67/67N Direction determination for overcurrent, phases and ground Intermittent ground fault		P C
Sens.ground-f.det. Motor Dir V,P,f REF	67/67N	Direction determination for overcurrent, phases and ground		
	67Ns	Directional sensitive ground-fault detection		
■	67Ns	Directional intermittent ground fault protection ³⁾		F D ²⁾
	87N	High-impedance restricted ground fault		

Continued on next page

■ Basic version included

V, P, f = Voltage, power, frequency protection

Dir = Directional overcurrent protection

IEF = Intermittent ground fault

1) Only with insensitive ground-current transformer when position 7 = 1, 5, 7.

2) For isolated/compensated networks only with sensitive ground-current transformer when position 7 = 2, 6.

3) available with V4.9

Overcurrent Protection / 7SJ64

Selection and ordering data

Description			Order No.	Order code
7SJ64 multifunction protection relay with synchronization			7SJ64	□□-□□□□□□-□□□□-□□□□
Designation	ANSI No.	Description		
Basic version		Control		
	50/51	Overcurrent protection $I>$, $I>>$, $I>>>$, I_p		
	50N/51N	Ground-fault protection $I_{E>}$, $I_{E>>}$, $I_{E>>>}$, I_{EP}		
	50N/51N	Insensitive ground-fault protection via IEE function: $I_{EE>}$, $I_{EE>>}$, $I_{EEp}^{1)}$		
	50/50N	Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I_{2>}$, $I>>>>$, $I_{E>>>>}$		
	51 V	Voltage-dependent inverse-time overcurrent protection		
	49	Overload protection (with 2 time constants)		
	46	Phase balance current protection (negative-sequence protection)		
	37	Undercurrent monitoring		
	47	Phase sequence		
	59N/64	Displacement volt		
	50BF	Breaker failure protection		
	74TC	Trip circuit supervision		
		4 setting groups, cold-load pickup		
		Inrush blocking		
	86	Lockout		
Sens. ground-f. det. Motor Dir V,P,f REF	67Ns	Directional sensitive ground-fault detection		
■	67Ns	Directional intermittent ground fault protection ³⁾		
	87N	High-impedance restricted ground fault		
	27/59	Under-/overvoltage		
	81O/U	Under-/overfrequency		
	27/Q	Undervoltage-controlled reactive power protection ³⁾		
	27/47/59(N)	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		F F ²⁾
Sens. ground-f. det. Motor IEF Dir V,P,f REF	67/67N	Directional sensitive ground-fault detection, phases and ground		
■	67Ns	Directional sensitive ground-fault detection		
	67Ns	Directional intermittent ground fault protection ³⁾		
	87N	High-impedance restricted ground fault Intermittent ground fault		P D ²⁾
Sens. ground-f. det. Motor Dir V,P,f REF	67Ns	Directional sensitive ground-fault detection		
■	67Ns	Directional intermittent ground fault protection ³⁾		
	87N	High-impedance restricted ground fault		F B ²⁾
Sens. ground-f. det. Motor Dir V,P,f REF	67Ns	Directional sensitive ground-fault detection		
■	67Ns	Directional intermittent ground fault protection ³⁾		
	87N	High-impedance restricted ground fault		
	48/14	Starting time supervision, locked rotor		
	66/86	Restart inhibit		
	51M	Load jam protection, motor statistics		
	27/59	Under-/overvoltage		
	81O/U	Under-/overfrequency		
	27/Q	Undervoltage-controlled reactive power protection ³⁾		
	27/47/59(N)	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		H F ²⁾
Sens. ground-f. det. Motor Dir V,P,f REF	67/67N	Direction determination for overcurrent, phases and ground		
	67Ns	Directional sensitive ground-fault detection		
	67Ns	Directional intermittent ground fault protection ³⁾		
	87N	High-impedance restricted ground fault		
	48/14	Starting time supervision, locked rotor		
	66/86	Restart inhibit		
	51M	Load jam protection, motor statistics		
	27/59	Under-/overvoltage		
	81O/U	Under-/overfrequency		
	27/Q	Undervoltage-controlled reactive power protection ³⁾		
	27/47/59(N)	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		H H ²⁾
■ Basic version included		1) Only with insensitive ground-current transformer when position 7 = 1, 5, 7.		
V, P, f = Voltage, power, frequency protection		2) For isolated/compensated networks only with sensitive ground-current transformer when position 7 = 2, 6.		
Dir = Directional overcurrent protection		3) available with V4.9		
IEF = Intermittent ground fault				

Continued on next page

Overcurrent Protection / 7SJ64

Selection and ordering data

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Description			Order No.	Order code
7SJ64 multifunction protection relay with synchronization			7SJ64 □ □ - □ □ □ □ □ □ - □ □ □ □ □ □ - □ □ □ □ □ □	
Designation	ANSI No.	Description		
Basic version		Control		
	50/51	Overcurrent protection $I>$, $I>>$, $I>>>$, I_p		
	50N/51N	Ground-fault protection $I_{E>}$, $I_{E>>}$, $I_{E>>>}$, I_{Ep}		
	50N/51N	Insensitive ground-fault protection via IEE function: $I_{EE>}$, $I_{EE>>}$, $I_{EEp}^{1)}$		
	50/50N	Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I_{2>}$, $I_{>>>>}$, $I_{E>>>>}$		
	51 V	Voltage-dependent inverse-time overcurrent protection		
	49	Overload protection (with 2 time constants)		
	46	Phase balance current protection (negative-sequence protection)		
	37	Undercurrent monitoring		
	47	Phase sequence		
	59N/64	Displacement voltage		
	50BF	Breaker failure protection		
	74TC	Trip circuit supervision 4 setting groups, cold-load pickup Inrush blocking		
	86	Lockout		
Sens. ground-f. det. Motor Dir V,P,f REF	67/67N	Direction determination for overcurrent, phases and ground		
■	67Ns	Directional sensitive ground-fault detection		
	67Ns	Directional intermittent ground fault protection ³⁾		
	87N	High-impedance restricted ground fault Intermittent ground fault		
	48/14	Starting time supervision, locked rotor		
	66/86	Restart inhibit		
	51M	Load jam protection, motor statistics		
	27/59	Undervoltage/overvoltage		
	810/U	Underfrequency/overfrequency		
	27/Q	Undervoltage-controlled reactive power protection ³⁾		
	27/47/59(N)	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		R H ²⁾
■	Motor Dir V, P, f	67/67N	Direction determination for overcurrent, phases and ground	
		48/14	Starting time supervision, locked rotor	
		66/86	Restart inhibit	
		51M	Load jam protection, motor statistics	
		27/59	Under-/overvoltage	
		810/U	Under-/overfrequency	
		27/Q	Undervoltage-controlled reactive power protection ³⁾	
		27/47/59(N)	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	H G
■	Motor	48/14	Starting time supervision, locked rotor	
		66/86	Restart inhibit	
		51M	Load jam protection, motor statistics	H A
ARC, fault locator, synchronization				
		Without		0
		79	With auto-reclosure	1
		21FL	With fault locator	2
		79, 21FL	With auto-reclosure, with fault locator	3
		25	With synchronization	4
		25, 79, 21FL	With synchronization, auto-reclosure, fault locator	7
ATEX100 Certification For protection of explosion-protected motors (increased-safety type of protection "e")				Z X 9 9 ²⁾

■ Basic version included

V, P, f = Voltage, power, frequency protection

Dir = Directional overcurrent protection

1) Only with insensitive ground-current transformer when position 7 = 1, 5, 7.

2) This variant might be supplied with a previous firmware version.

3) available with V4.9










Overcurrent Protection/7SJ64

Selection and ordering data

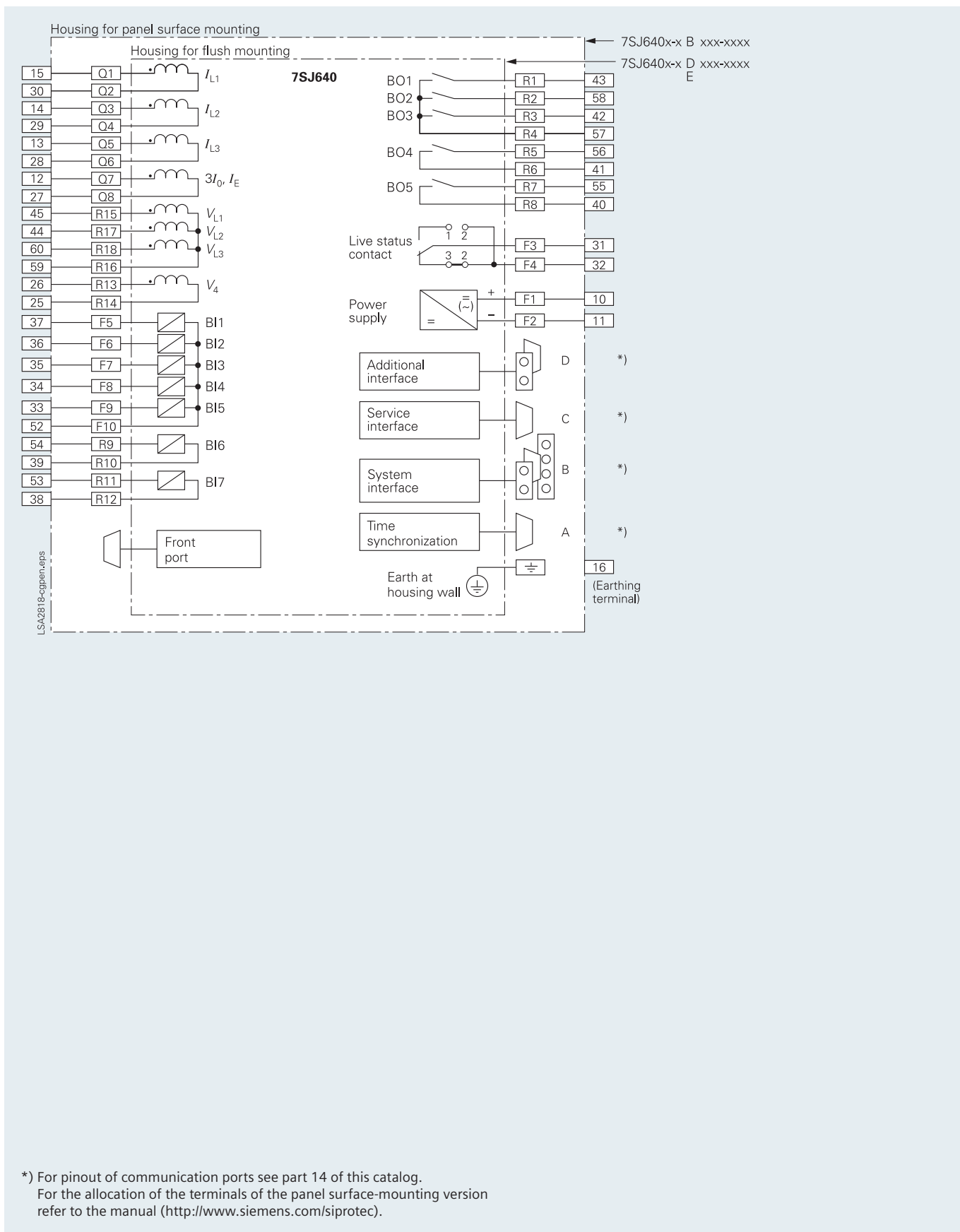
Accessories	Description	Order No.
	DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
	Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
	Professional + IEC 61850 Complete version: DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for control displays), DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	7XS5403-0AA00
	IEC 61850 Systemconfigurator Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM	7XS5460-0AA00
	SIGRA 4 Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000 or XP Professional Edition. (generally contained in DIGSI Professional, but can be ordered additionally) Authorization by serial number. On CD-ROM.	7XS5410-0AA00
	Temperature monitoring box AC/DC 24 to 60 V	7XV5662-2AD10
	AC/DC 90 to 240 V	7XV5662-5AD10
	Varistor/VoltageArrester Voltage arrester for high-impedance REF protection 125 Vrms; 600 A; 1S/S 256	C53207-A401-D76-1
	240 Vrms; 600 A; 1S/S 1088	C53207-A401-D77-1
	Connecting cable Cable between PC/notebook (9-pin con.) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	7XV5100-4
	Cable between temperature monitoring box and SIPROTEC 4 unit - length 5 m / 16.4 ft	7XV5103-7AA05
	- length 25 m / 82 ft	7XV5103-7AA25
	- length 50 m / 164 ft	7XV5103-7AA50
	Manual for 7SJ64 English /German	C53000-G1100-C147-x ¹⁾
	1) x = please inquire for latest edition (exact Order No.).	

Overcurrent Protection / 7SJ64

Selection and ordering data

Accessories	Description	Order No.	Size of package	Supplier
  Mounting rail 	Terminal safety cover	C73334-A1-C31-1	1	Siemens
	Voltage/current terminal 18-pole/12-pole	C73334-A1-C32-1	1	Siemens
 2-pin connector  3-pin connector	Connector 2-pin	C73334-A1-C35-1	1	Siemens
	Connector 3-pin	C73334-A1-C36-1	1	Siemens
	Crimp connector CI2 0.5 to 1 mm ²	0-827039-1	4000 taped on reel	AMP ¹⁾
	Crimp connector CI2 0.5 to 1 mm ²	0-827396-1	1	AMP ¹⁾
 Short-circuit links for current terminals  Short-circuit links for current terminals	Crimp connector: Type III+ 0.75 to 1.5 mm ²	0-163084-2	1	AMP ¹⁾
	Crimp connector: Type III+ 0.75 to 1.5 mm ²	0-163083-7	4000 taped on reel	AMP ¹⁾
	Crimping tool for Type III+ and matching female	0-539635-1	1	AMP ¹⁾
	Crimping tool for CI2 and matching female	0-539668-2	1	AMP ¹⁾
	Crimping tool for CI2 and matching female	0-734372-1	1	AMP ¹⁾
	Crimping tool for CI2 and matching female	1-734387-1	1	AMP ¹⁾
 Short-circuit links for current terminals  Short-circuit links for other terminals	Short-circuit links for current terminals	C73334-A1-C33-1	1	Siemens
	Short-circuit links for other terminals	C73334-A1-C34-1	1	Siemens
	Mounting rail for 19" rack	C73165-A63-D200-1	1	Siemens

1) Your local Siemens representative can inform you on local suppliers.



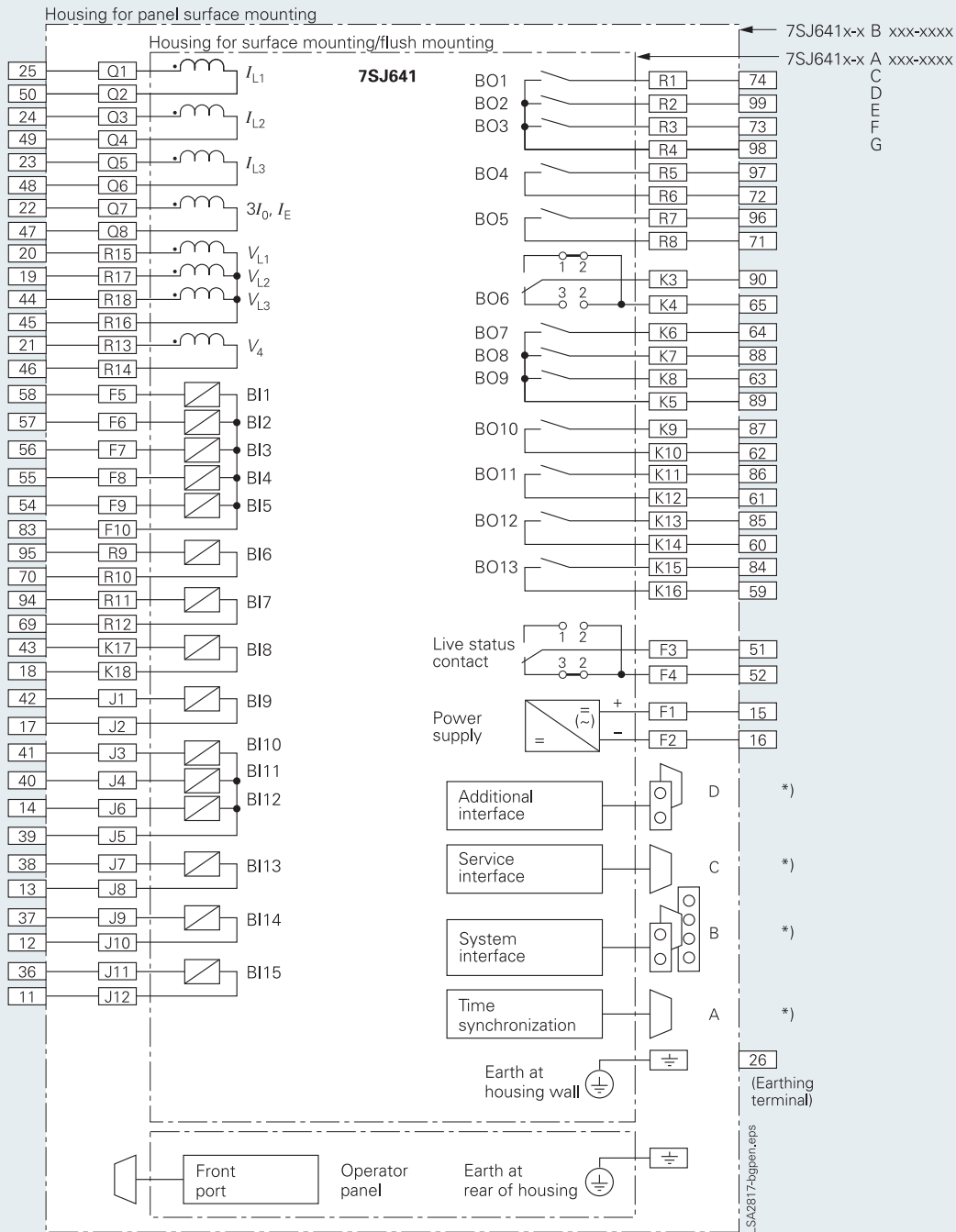
*) For pinout of communication ports see part 14 of this catalog.
For the allocation of the terminals of the panel surface-mounting version refer to the manual (<http://www.siemens.com/siprotec>).

Fig. 5/176 7SJ640 connection diagram

Overcurrent Protection / 7SJ64

Connection diagram

5



*) For pinout of communication ports see part 14 of this catalog.
 For the allocation of the terminals of the panel surface-mounting version refer to the manual (<http://www.siemens.com/siprotec>).

Fig. 5/177 7SJ641 connection diagram

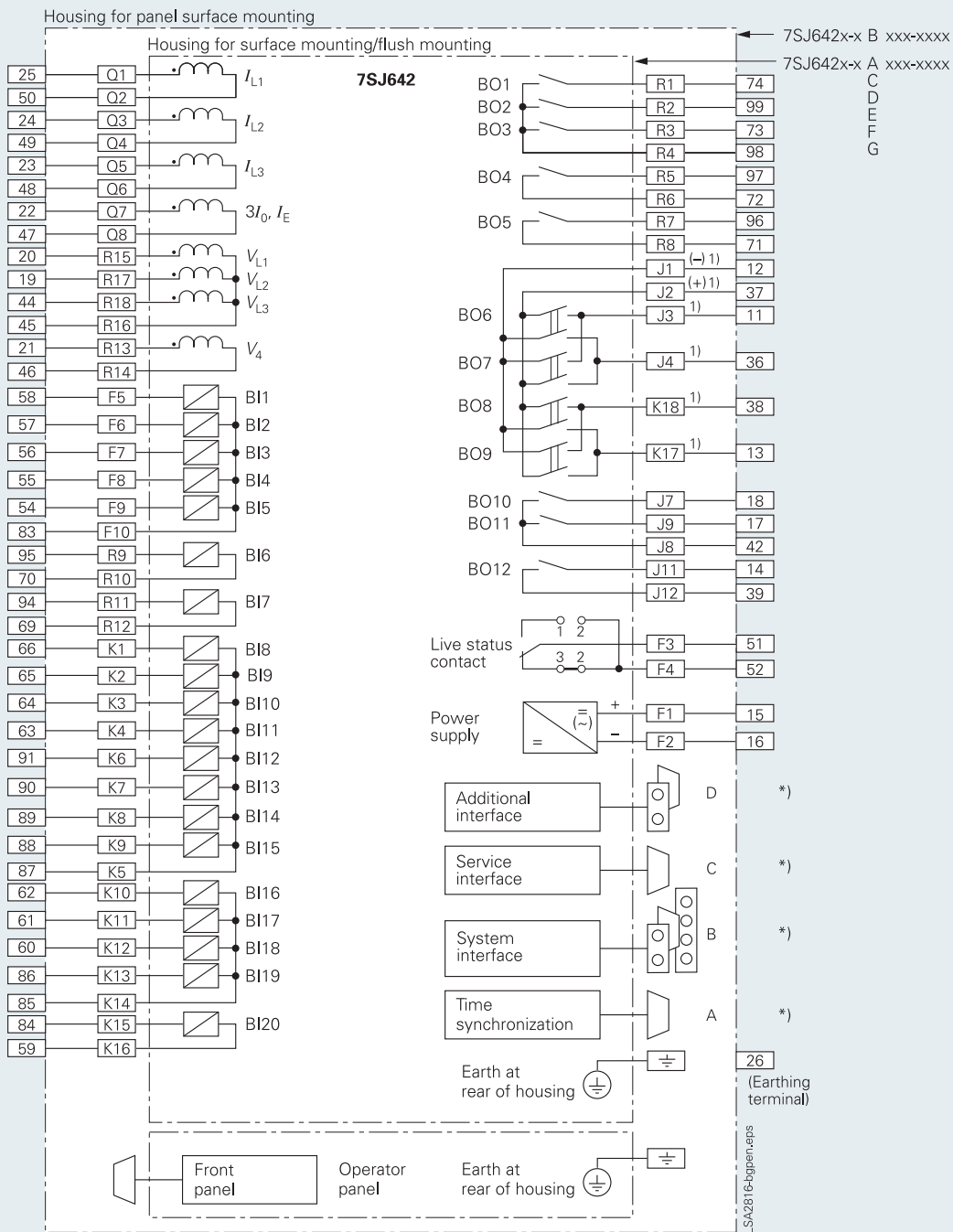
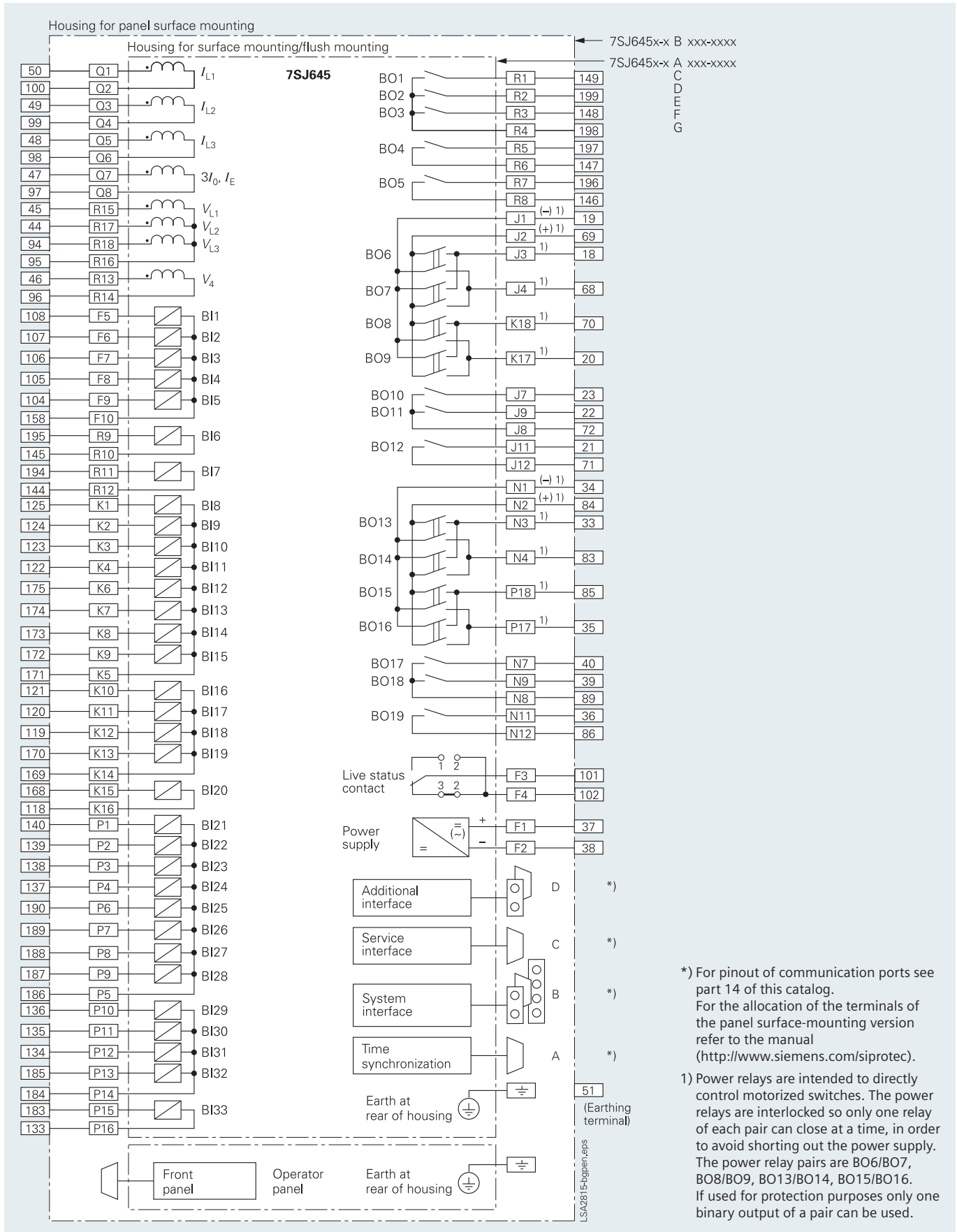


Fig. 5/178 7SJ642 connection diagram

Overcurrent Protection / 7SJ64

Connection diagram

5



*) For pinout of communication ports see part 14 of this catalog. For the allocation of the terminals of the panel surface-mounting version refer to the manual (<http://www.siemens.com/siprotec>).

1) Power relays are intended to directly control motorized switches. The power relays are interlocked so only one relay of each pair can close at a time, in order to avoid shorting out the power supply. The power relay pairs are BO6/BO7, BO8/BO9, BO13/BO14, BO15/BO16. If used for protection purposes only one binary output of a pair can be used.

Fig. 5/179 7SJ645 connection diagram

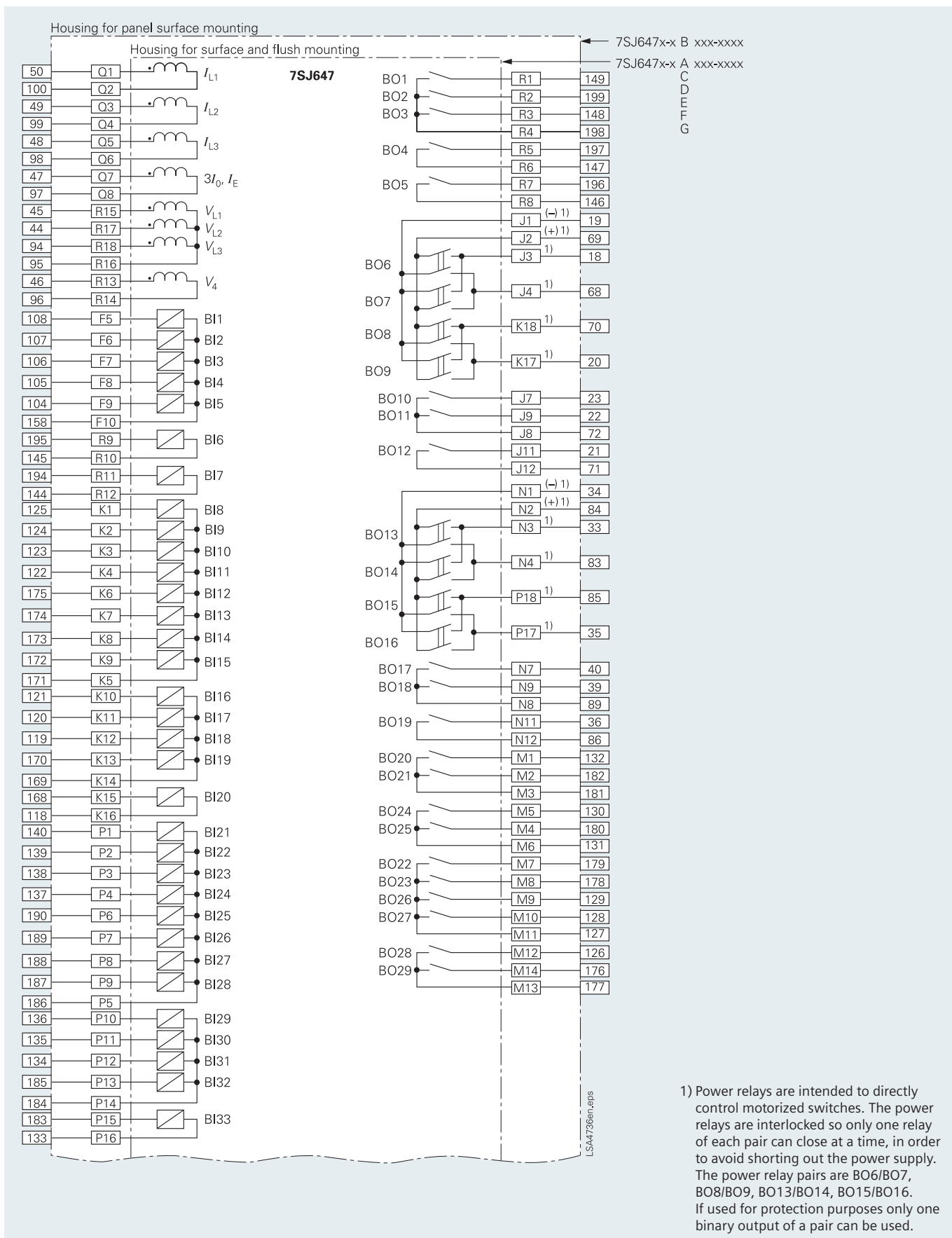


Fig. 5/180 7SJ647 connection diagram part 1; continued on following page

1) Power relays are intended to directly control motorized switches. The power relays are interlocked so only one relay of each pair can close at a time, in order to avoid shorting out the power supply. The power relay pairs are BO6/BO7, BO8/BO9, BO13/BO14, BO15/BO16. If used for protection purposes only one binary output of a pair can be used.

Overcurrent Protection / 7SJ64

Connection diagram

5

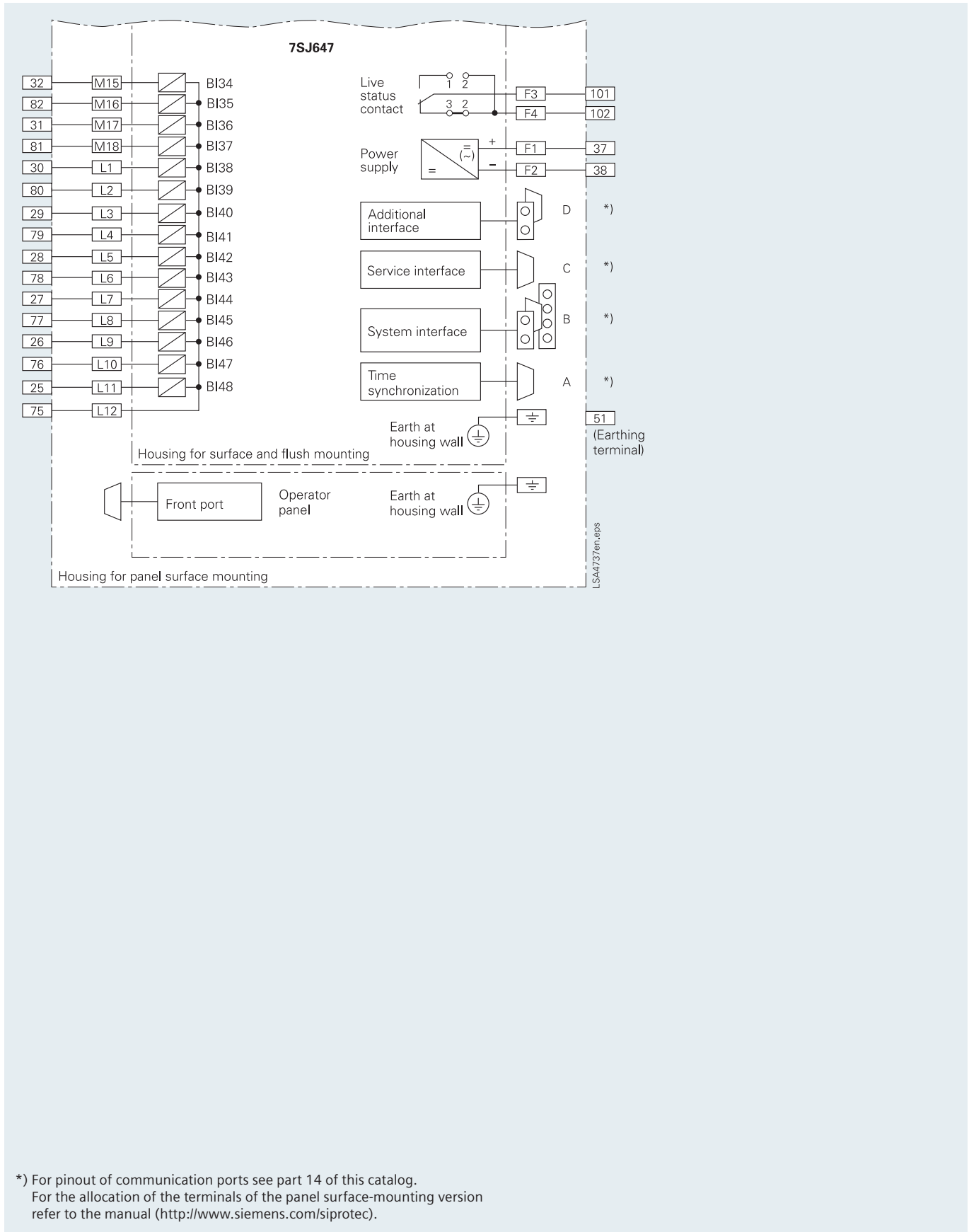


Fig. 5/181 7SJ647 connection diagram part 2

Distance Protection

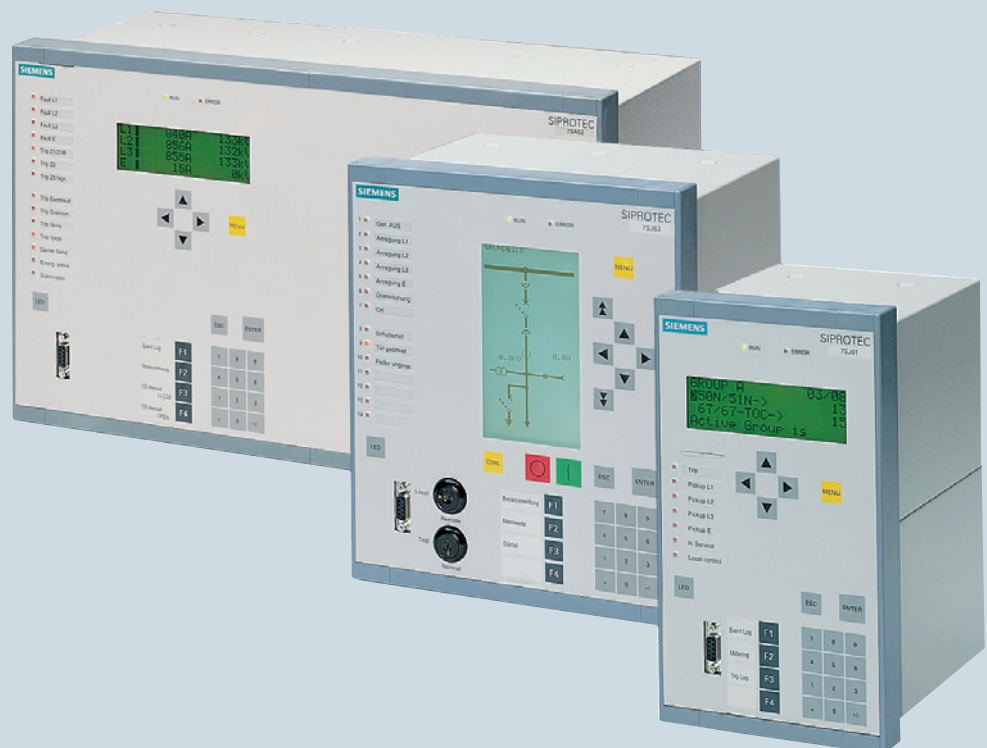
Page

SIPROTEC 4 7SA6 distance protection relay
for all voltage levels

6/3

SIPROTEC 4 7SA522 distance protection relay
for transmission lines

6/45



Distance Protection 7SA6

SIPROTEC 4 7SA6 distance protection relay for all voltage levels

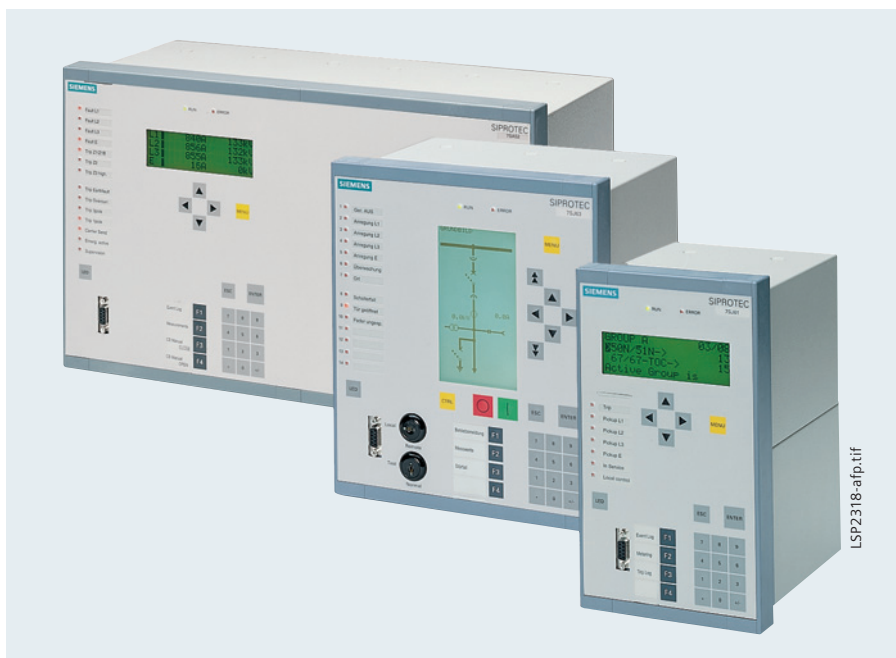


Fig. 6/1 SIPROTEC 4 7SA6 distance protection relay

Description

The SIPROTEC 4 7SA6 distance protection relay is a universal device for protection, control and automation on the basis of the SIPROTEC 4 system. Its high level of flexibility makes it suitable to be implemented at all voltage levels. With this relay you are ideally equipped for the future: it offers security of investment and also saves on operating costs.

- High-speed tripping time
- Impedance setting range allows very small settings for the protection of very short lines
- Self-setting detection for power swing frequencies up to 7 Hz
- Current transformer saturation detector prevents non-selective tripping by distance protection in the event of CT saturation.
- Phase-segregated teleprotection for improved selectivity and availability
- Digital relay-to-relay communication by means of an integrated serial protection data interface
- Adaptive auto-reclosure (ADT)

Function overview

Protection functions

- Non-switched distance protection with 6 measuring systems (21/21N)
- High resistance ground-fault protection for single and three-pole tripping (50N, 51N, 67N)
- Ground-fault detection in isolated and resonant-grounded networks
- Tele (pilot) protection (85)
- Fault locator (FL)
- Power-swing detection/tripping (68/68T)
- Phase overcurrent protection (50/51/67)
- Switch-onto-fault protection (50HS)
- STUB bus overcurrent protection (50STUB)
- Overvoltage/undervoltage protection (59/27)
- Over/underfrequency protection 81O/U)
- Auto-reclosure (79)

- Synchro-check (25)
- Breaker failure protection (50BF)
- Thermal overload protection (49)

Control function

- Commands for control of CBs and isolators

Monitoring functions

- Trip circuit supervision (74TC)
- Self-supervision of the relay
- Measured-value supervision
- Event logging/fault logging
- Oscillographic fault recording
- Switching statistics

Front design

- Easy operation with numeric keys
- Function keys
- LEDs for local alarm
- PC front port for convenient relay setting

Communication interfaces

- Front interface for connecting a PC
- System interface for connecting to a control system via various protocols
 - IEC 61850 Ethernet
 - IEC 60870-5-103 protocol
 - PROFIBUS-FMS/DP
 - DNP 3.0
- 1 serial protection data interface for teleprotection
- Rear-side service/modem interface
- Time synchronization via
 - IRIG-B or DCF 77 or
 - system interface

Distance Protection 7SA6

Application

Application

The distance protection relay 7SA6 is non-switched incorporating all the additional functions for protection of overhead lines and cables at all voltage levels from 5 to 765 kV.

All methods of neutral point connection (resonant grounding, isolated, solid or low-resistance grounding) are reliably dealt with. The unit can issue single or three-pole TRIP commands as well as CLOSE commands. Consequently both single-pole, three-pole and multiple auto-reclosure is possible.

Teleprotection functions as well as ground-fault protection and sensitive ground-fault detection are included. Power swings are detected reliably and non-selective tripping is prevented. The unit operates reliably and selectively even under the most difficult network conditions.

Cost-effective power system management

The SIPROTEC 4 units are numerical relays which also provide control and monitoring functions and therefore support the user in view of a cost-effective power system management. The security and reliability of power supply is increased as a result of minimizing the use of hardware.

The local operation has been designed according to ergonomic criteria. Large, easy-to-read backlit displays are provided.

The SIPROTEC 4 units have a uniform design and a degree of functionality which represents a benchmark-level of performance in protection and control. If the requirements for protection, control or interlocking change, it is possible in the majority of cases to implement such changes by means of parameterization using DIGSI 4 without having to change the hardware.

The use of powerful microcontrollers and the application of digital measured-value conditioning and processing largely suppresses the influence of higher-frequency transients, harmonics and DC components.

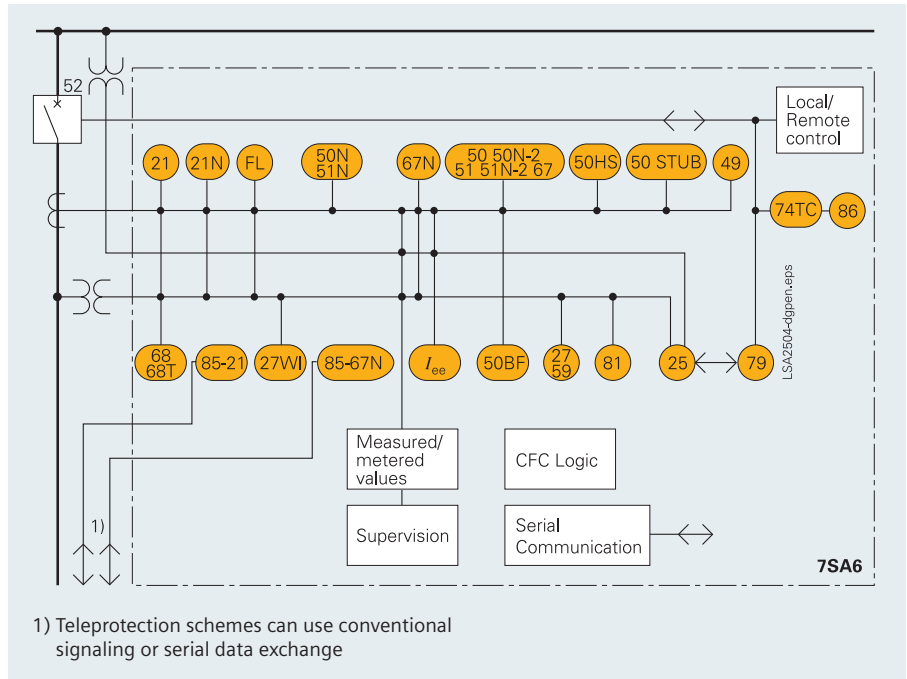


Fig. 6/2 Function diagram

ANSI	Protection functions
21/21N	Distance protection
FL	Fault locator
50N/51N/67N	Directional ground-fault protection
50/51/67	Backup overcurrent protection
50 STUB	STUB-bus overcurrent stage
68/68T	Power swing detection/tripping
85/21	Teleprotection for distance protection
27WI	Weak-infeed protection
85/67N	Teleprotection for ground-fault protection
50HS	Switch-onto-fault protection
50BF	Breaker-failure protection
59/27	Overvoltage/undervoltage protection
81O/U	Over/underfrequency protection
25	Synchro-check
79	Auto-reclosure
74TC	Trip circuit supervision
86	Lockout (CLOSE command interlocking)
49	Thermal overload protection
I _{EE}	Sensitive ground-fault detection

Construction

Connection techniques and housing with many advantages

$\frac{1}{3}$, $\frac{1}{2}$, $\frac{2}{3}$, and $\frac{1}{1}$ -rack sizes:

These are the available housing widths of the 7SA6 relays, referred to a 19" module frame system. This means that previous models can always be replaced. The height is a uniform 245 mm for flush-mounting housings and 266 mm for surface-mounting housings for all housing widths. All cables can be connected with or without ring lugs. Plug-in terminals are available as an option.

It is thus possible to employ prefabricated cable harnesses. In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located in a sloped case at the top and bottom of the housing. The housing can also be supplied optionally with a detached operator panel (refer to Fig. 6/5), in order to allow optimum operation for all types of applications.

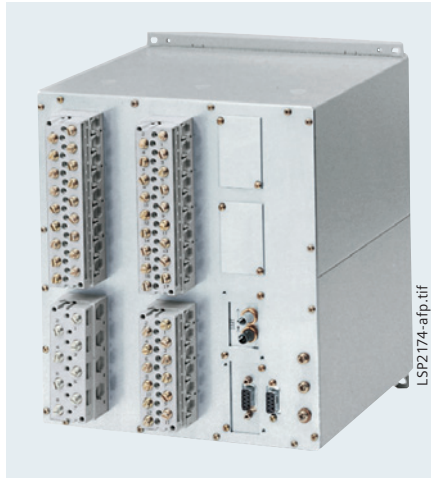


Fig. 6/3 Flush-mounting housing with screw-type terminals

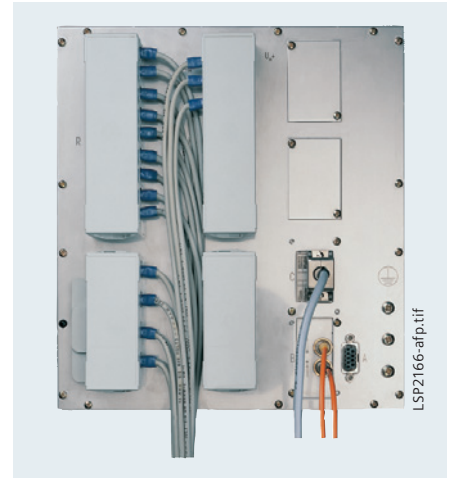


Fig. 6/4 Rear view of flush-mounting housing with covered connection terminals and wirings



Fig. 6/5 Flush-mounting housing with plug-in terminals and detached operator panel



Fig. 6/6 Surface-mounting housing with screw-type terminals



Fig. 6/7 Communication interfaces in a sloped case in a surface-mounting housing

Distance Protection 7SA6

Protection functions

Protection functions

Distance protection (ANSI 21, 21N)

The main function of the 7SA6 is a non-switched distance protection. By parallel calculation and monitoring of all six impedance loops, a high degree of sensitivity and selectivity is achieved for all types of fault. The shortest tripping time is less than one cycle. All methods of neutral-point connection (resonant grounding, isolated, solid or low-resistance grounding) are reliably dealt with. Single-pole and three-pole tripping is possible. Overhead lines can be equipped with or without series capacitor compensation.

Four pickup methods

The following pickup methods can be employed alternatively:

- Overcurrent pickup $I >>$
- Voltage-dependent overcurrent pickup V/I
- Voltage-dependent and phase angle-dependent overcurrent pickup $V/I/\varphi$
- Impedance pickup $Z <$

Load zone

The pickup mode with quadrilateral impedance pickup ($Z <$) is fitted with a variable load zone. In order to guarantee a reliable discrimination between load operation and short-circuit (especially on long high loaded lines), the relay is equipped with a selectable load encroachment characteristic. Impedances within this load encroachment characteristic prevent the distance zones from unwanted tripping.

Absolute phase-selectivity

The 7SA6 distance protection incorporates a well-proven, highly sophisticated phase selection algorithm. The pickup of unfaulted phases is reliably eliminated. This phase selection algorithm achieves single-pole tripping and correct distance measurement in a wide application range. Interference to distance measurement caused by parallel lines can be compensated by taking the ground current of the parallel system into account.

This parallel line compensation can be taken into account both for distance measurement and for fault locating.

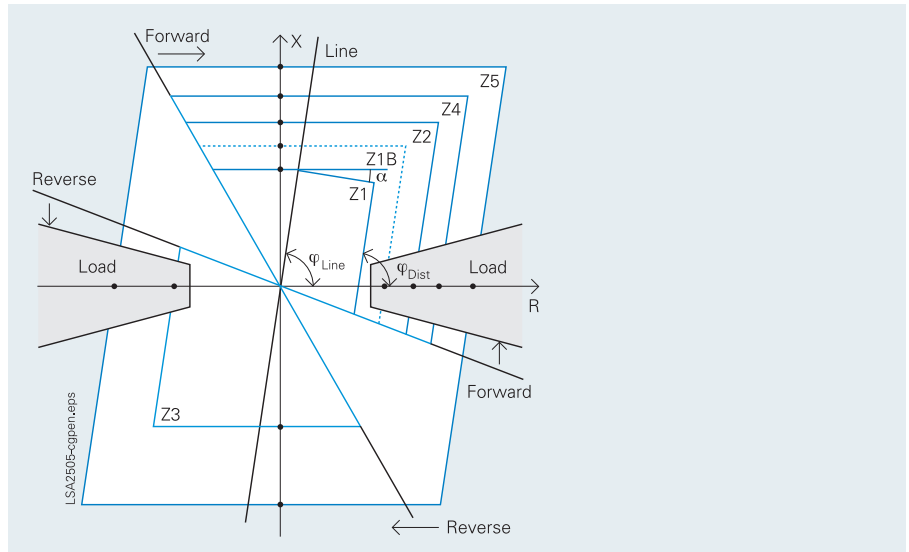


Fig. 6/8 Impedance fault detection $Z <$ with quadrilateral characteristic

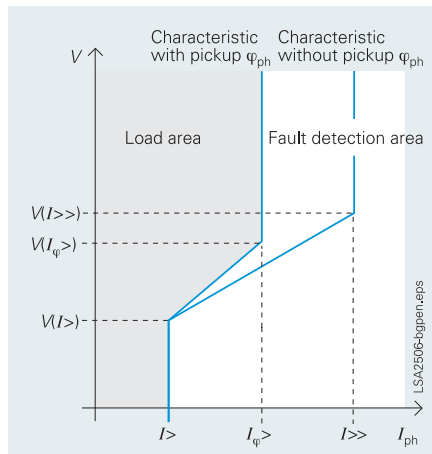


Fig. 6/9 Voltage and angle-dependent overcurrent fault detection $V/I/\varphi$

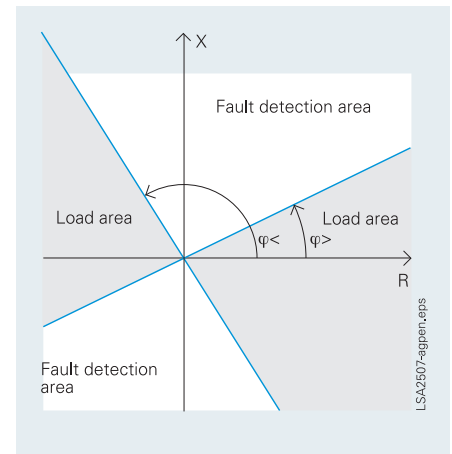


Fig. 6/10 Angle pickup for the $V/I/\varphi$ fault detection

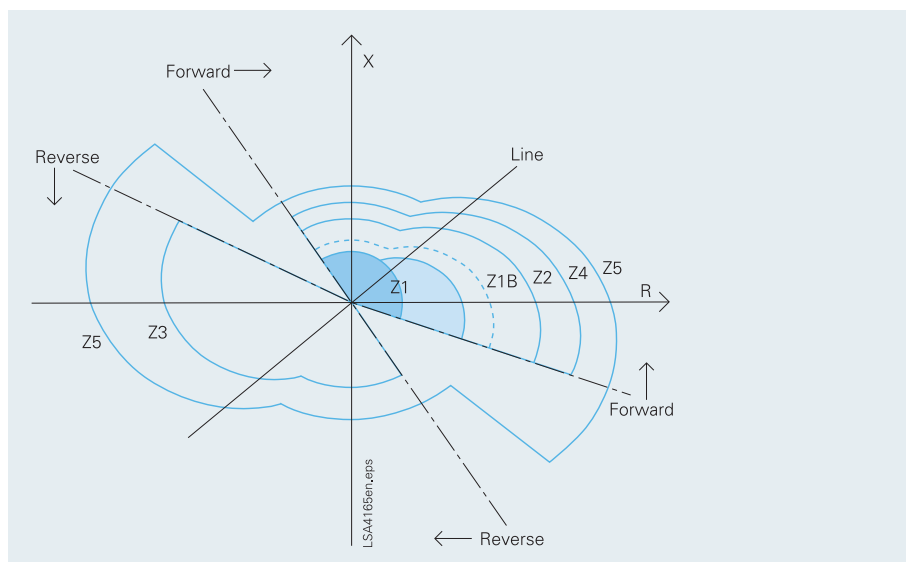


Fig. 6/11 Distance zones with circle characteristic

Seven distance zones

Six independent distance zones and one separate overreach zone are available. Each distance zone has dedicated time stages, partially separate for single-phase and three-phase faults. Ground faults are detected by monitoring the ground current $3I_0$ and the zero-sequence voltage $3V_0$. The quadrilateral tripping characteristic allows use of separate settings for the X and the R directions. Different R settings can be employed for ground and phase faults. This characteristic offers advantages in the case of faults with fault resistance. For applications to medium-voltage cables with low line angles, it may be advantageous to select the distance zones with the optional circle characteristic.

All the distance protection zones can be set to forward, reverse or non-directional.

Optimum direction detection

Use of voltages, which are not involved with the short-circuit loop, and of voltage memories for determination of the fault direction ensure that the results are always reliable.

Elimination of interference signals

Digital filters render the unit immune to interference signals contained in the measured values. In particular, the influence of DC components, capacitive voltage transformers and frequency changes is considerably reduced. A special measuring method is employed in order to assure protection selectivity during saturation of the current transformers.

Measuring voltage monitoring

Tripping of the distance protection is blocked automatically in the event of failure of the measuring voltage, thus preventing spurious tripping. The measuring voltage is monitored by the integrated fuse failure monitor. Distance protection is blocked if either the fuse failure monitor or the auxiliary contact of the voltage transformer protection switch operates and in this case the EMERGENCY definite-time overcurrent protection can be activated.

Fault locator

The integrated fault locator calculates the fault impedance and the distance-to-fault. The results are displayed in ohms, kilometers (miles) and in percent of the line length. Parallel line compensation and load current compensation for high-resistance faults is also available.

Power swing detection (ANSI 68, 68T)

Dynamic transient reactions, for instance short-circuits, load fluctuations, auto-reclosures or switching operations can cause power swings in the transmission network. During power swings, large currents along with small voltages can cause unwanted tripping of distance protection relays. To avoid uncontrolled tripping of the distance protection and to achieve controlled tripping in the event of loss of synchronism, the 7SA6 relay is equipped with an efficient power swing detection function. Power swings can be detected under symmetrical load conditions as well as during single-pole auto-reclosures.

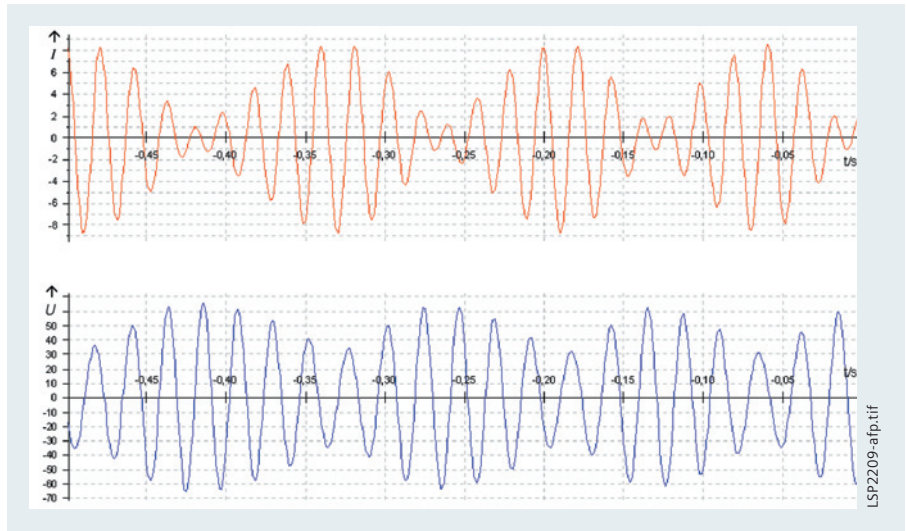


Fig. 6/12 Power swing current and voltage wave forms

Tele (pilot) protection for distance protection (ANSI 85-21)

A teleprotection function is available for fast clearance of faults up to 100 % of the line length. The following operating modes may be selected:

- POTT
- Directional comparison pickup
- Unblocking
- PUTT acceleration with pickup
- PUTT acceleration with Z1B
- Blocking
- Pilot-wire comparison
- Reverse interlocking
- DUTT, direct underreaching zone transfer trip (together with Direct Transfer Trip function).

The carrier send and receive signals are available as binary inputs and outputs and can be freely assigned to each physical relay input or output. At least one channel is required for each direction.

Common transmission channels are powerline carrier, microwave radio and fiber-optic links. A serial protection data interface for direct connection to a digital communication network or fiber-optic link is available.

7SA6 also permits the transfer of phase-selective signals. This feature is particularly advantageous as it ensures reliable single-pole tripping, if single-pole faults occur on different lines. The transmission methods are suitable also for lines with three ends (three-terminal lines). Phase-selective transmission is also possible with multi-end application, if some user-specific linkages are implemented by way of the integrated CFC logic.

During disturbances in the signaling channel receiver or on the transmission circuit, the teleprotection function can be blocked via a binary input signal without losing the zone selectivity.

The control of the overreach zone Z1B (zone extension) can be switched over to the auto-reclosure function. Transient blocking (current reversal guard) is provided for all the release and blocking methods in order to suppress interference signals during tripping of parallel lines.

Distance Protection 7SA6

Protection functions

Direct transfer tripping

Under certain conditions on the power system it is necessary to execute remote tripping of the circuit-breaker. The 7SA6 relay is equipped with phase-selective "external trip inputs" that can be assigned to the received inter-trip signal for this purpose.

Weak-infeed protection: echo and/or trip (ANSI 27 WI)

To prevent delayed tripping of permissive schemes during weak or zero infeed situations, an echo function is provided. If no fault detector is picked up at the weak-infeed end of the line, the signal received here is returned as echo to allow accelerated tripping at the strong infeed end of the line. It is also possible to initiate phase-selective tripping at the weak-infeed end. A phase-selective single-pole or three-pole trip is issued if a permissive trip signal (POTT or Unblocking) is received and if the phase-ground voltage drops correspondingly. As an option, the weak infeed logic can be equipped according to a French specification.

Overvoltage protection, undervoltage protection (ANSI 59, 27)

A voltage rise can occur on long lines that are operating at no-load or that are only lightly loaded. The 7SA6 contains a number of overvoltage measuring elements. Each measuring element is of two-stage design. The following measuring elements are available:

- Phase-to-ground overvoltage
- Phase-to-phase overvoltage
- Zero-sequence overvoltage
The zero-sequence voltage can be connected to the 4th voltage input or be derived from the phase voltages.
- Positive-sequence overvoltage of the local end or calculated for the remote end of the line (compounding)
- Negative-sequence overvoltage

Tripping by the overvoltage measuring elements can be effected either at the local circuit-breaker or at the remote station by means of a transmitted signal.

The 7SA6 is fitted, in addition, with three two-stage undervoltage measuring elements:

- Phase-to-ground undervoltage
- Phase-to-phase undervoltage
- Positive-sequence undervoltage

The undervoltage measuring elements can be blocked by means of a minimum current criterion and by means of binary inputs.

Frequency protection (ANSI 81O/U)

Frequency protection can be used for overfrequency and underfrequency protection. Unwanted frequency changes in the network can be detected and the load can be removed at a specified frequency setting. Frequency protection can be used

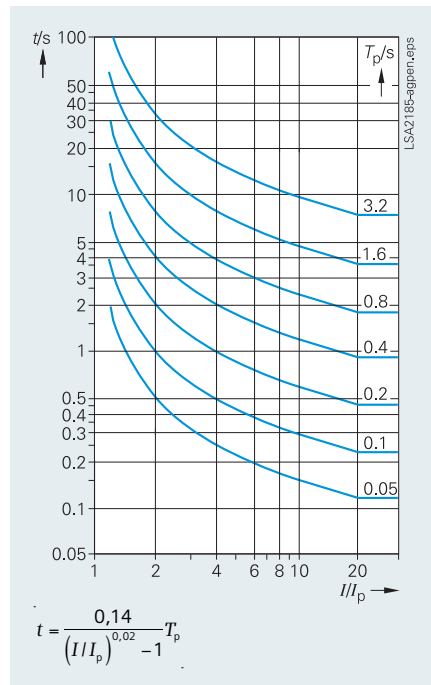


Fig. 6/13 Normal inverse



Fig. 6/14 Transient ground-fault relay 7SN60

over a wide frequency range (45 to 55, 55 to 65 Hz). There are four elements (selectable as overfrequency or underfrequency) and each element can be delayed separately.

Directional ground-fault protection for high-resistance faults (ANSI 50N, 51N, 67N)

In an grounded network it may happen that the distance protection's sensitivity is not sufficient to detect high-resistance ground faults. The 7SA6 protection relay therefore offers protection functions for faults of this nature.

The ground-fault protection can be used with three definite-time stages and one inverse-time stage (IDMT).

Inverse-time characteristics according to IEC 60255-3 and ANSI/IEEE are provided (see "Technical data"). A 4th definite-time stage can be applied instead of the 1st inverse-time stage.

An additional logarithmic inverse-time characteristic is also available.

The direction decision is determined by the ground current and the zero-sequence voltage or by the negative-sequence components V_2 and I_2 . In addition or as an alternative, the direction can be determined with the ground current of an grounded power transformer and the zero-sequence voltage. Dual polarization applications can therefore be fulfilled. Alternatively, the direction can be determined by evaluation of zero-sequence power. Each overcurrent stage can be set in forward or reverse direction or in both directions (non-directional).

The function is equipped with special digital filter algorithms, providing the elimination of higher harmonics. This feature is particularly important for small zero-sequence fault currents which usually have a high content of 3rd and 5th harmonic.

Inrush stabilization and instantaneous switch-onto-fault tripping can be activated separately for each stage as well.

Different operating modes can be selected. The ground-fault protection is suitable for three-phase and, optionally, for single-phase tripping by means of a sophisticated phase selector. It may be blocked during the dead time of single-pole auto-reclose cycles or during pickup of the distance protection.

Tele (pilot) protection for directional ground-fault protection (ANSI 85-67N)

The directional ground-fault protection can be combined with the available signaling methods:

- Directional comparison
- BLOCKING
- UNBLOCKING

The transient blocking function (current reversal guard) is also provided in order to suppress interference signals during tripping of parallel lines.

The pilot functions for distance protection and for ground-fault protection can use the same signaling channel or two separate and redundant channels.

Backup overcurrent protection (ANSI 50, 50N, 51, 51N, 67)

The 7SA6 provides a backup overcurrent protection. Two definite-time stages and one inverse-time stage (IDMTL) are available, separately for phase currents and for the ground current. The application can be extended to a directional overcurrent protection (ANSI 67) by taking into account the decision of the available direction detection elements. Two operating modes are selectable. The function can run in parallel to the distance protection or only during failure of the voltage in the VT secondary circuit (emergency operation).

The secondary voltage failure can be detected by the integrated fuse failure monitor or via a binary input from a VT miniature circuit-breaker (VT m.c.b. trip).

Inverse-time characteristics according to IEC 60255-3 and ANSI/IEEE are provided (see "Technical data").

Instantaneous high-speed switch-onto-fault overcurrent protection (ANSI 50HS)

Instantaneous tripping is required when energizing a faulty line. In the event of large fault currents, the high-speed switch-onto-fault overcurrent stage can initiate very fast three-pole tripping.

With smaller fault currents, instantaneous tripping after switch-onto-fault is also possible with the overreach distance zone Z1B or with pickup.

The switch-onto-fault initiation can be detected via the binary input "manual close" or automatically via measurement.

Ground-fault detection in systems with a star-point that is not effectively grounded

In systems with an isolated or resonant grounded (grounded) star-point, single-phase ground faults can be detected. The following functions are integrated for this purpose:

- Detection of an ground fault by monitoring of the displacement voltage

- Determination of the faulted phase by measurement of the phase-to-ground voltage
- Determination of the ground-fault direction by highly accurate measurement of the active and reactive power components in the residual ground fault current.
- Alarm or trip output can be selected in the event of an ground-fault in the forward direction.
- Operation measurement of the active and reactive component in the residual ground current during an ground-fault.

Ground-fault direction detection can also be effected on the basis of the transient ground-fault principle by interfacing with the additional unit 7SN60 (see Fig. 6/14). Procedures for logging, time stamping and event recording for the network control system are standardized by the 7SA6.

Breaker failure protection (ANSI 50BF)

The 7SA6 relay incorporates a two-stage breaker failure protection to detect failures of tripping command execution, for example, due to a defective circuit-breaker. The current detection logic is phase-selective and can therefore also be used in single-pole tripping schemes. If the fault current is not interrupted after a settable time delay has expired, a retrip command or a busbar trip command will be generated. The breaker failure protection can be initiated by all integrated protection functions, as well as by external devices via binary input signals.

STUB bus overcurrent protection (ANSI 50(N)-STUB)

The STUB bus overcurrent protection is a separate definite-time overcurrent stage. It can be activated via a binary input signaling that the line isolator (disconnect) is open.

Separate settings are available for phase and ground faults.

Auto-reclosure (ANSI 79)

The 7SA6 relay is equipped with an auto-reclosure function (AR). The function includes several operating modes:

- 3-pole auto-reclosure for all types of faults; different dead times are available depending on the type of fault
- 1-pole auto-reclosure for 1-phase faults, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and for 2-phase faults without ground, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase and 3-pole auto-reclosure for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and 2-phase faults without ground and 3-pole auto-reclosure for multi-phase faults
- Multiple-shot auto-reclosure
- Interaction with an external device for auto-reclosure via binary inputs and outputs
- Control of the internal AR function by external protection
- Interaction with the internal or an external synchro-check
- Monitoring of the circuit-breaker auxiliary contacts

In addition to the above-mentioned operating modes, several other operating principles can be employed by means of the integrated programmable logic (CFC).

Distance Protection 7SA6

Protection functions

Auto-reclosure (continued) (ANSI 79)

Integration of auto-reclosure in the feeder protection allows evaluation of the line-side voltages. A number of voltage-dependent supplementary functions are thus available:

- **DLC**
By means of dead-line check, reclosure is effected only when the line is deenergized (prevention of asynchronous breaker closure).
- **ADT**
The adaptive dead time is employed only if auto-reclosure at the remote station was successful (reduction of stress on equipment).
- **RDT**
Reduced dead time is employed in conjunction with auto-reclosure where no teleprotection method is employed: When faults within the zone extension but external to the protected line are switched off for rapid auto-reclosure (RAR), the RDT function decides on the basis of measurement of the return voltage from the remote station which has not tripped whether or not to reduce the dead time.

Synchronism check (ANSI 25)

Where two network sections are switched in by control command or following a 3-pole auto-reclosure, it must be ensured that both network sections are mutually synchronous. For this purpose a synchro-check function is provided. After verification of the network synchronism, the function releases the CLOSE command. Alternatively, reclosing can be enabled for different criteria, e.g. checking that the busbar or line is not carrying a voltage (dead line or dead bus).

Fuse failure monitoring and other supervision functions

The 7SA6 relay provides comprehensive supervision functions covering both hardware and software. Furthermore, the measured values are continuously checked for plausibility. Therefore the current and voltage transformers are also included in this supervision system.

If any measured voltage is not present due to short-circuit or open circuit in the voltage transformer secondary circuit, the distance protection would respond with an unwanted trip due to this loss of voltage.

This secondary voltage interruption can be detected by means of the integrated fuse failure monitor. Immediate blocking of distance protection and switching to the backup-emergency overcurrent protection is provided for all types of secondary voltage failures.

Additional measurement supervision functions are

- Symmetry of voltages and currents
- Broken-conductor supervision
- Summation of currents and voltages
- Phase-sequence supervision.

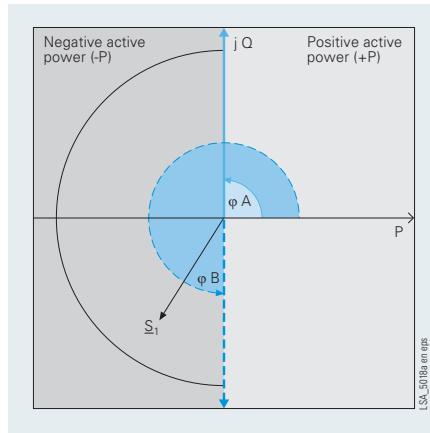


Fig. 6/15 Monitoring of active power direction

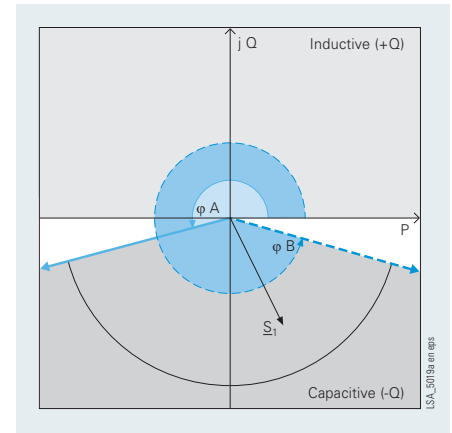


Fig. 6/16 Monitoring of reactive power

Directional power protection

The 7SA6 has a function for detecting the power direction by measuring the phase angle of the positive-sequence system's power. Fig. 6/15 shows an application example displaying negative active power. An indication is issued in the case when the measured angle φ (S_1) of the positive-sequence system power is within the P - Q - level sector. This sector is between angles φA and φB . Via CFC the output signal of the directional monitoring can be linked to the "Direct Transfer Trip (DTT)" function and thus, as reverse power protection, initiate tripping of the CB.

Fig. 6/16 shows another application displaying capacitive reactive power. In the case of overvoltage being detected due to long lines under no-load conditions it is possible to select the lines where capacitive reactive power is measured.

Trip circuit supervision (ANSI 74TC)

One or two binary inputs for each circuit-breaker pole can be used for monitoring the circuit-breaker trip coils including the connecting cables. An alarm signal is issued whenever the circuit is interrupted.

Lockout (ANSI 86)

Under certain operating conditions it is advisable to block CLOSE commands after a TRIP command of the relay has been issued. Only a manual "RESET" command unblocks the CLOSE command. The 7SA6 is equipped with such an interlocking logic.

Thermal overload protection (ANSI 49)

For thermal protection of cables and transformers an overload protection with an early-warning stage is provided. The thermal replica can be generated with the maximum or mean value of the respective overtemperatures in the three phases, or with the overtemperature corresponding to the maximum phase current.

The tripping time characteristics are exponential functions according to IEC 60255-8 and they take account of heat loss due to the load current and the accompanying drop in temperature of the cooling medium. The previous load is therefore taken into account in the tripping time with overload. A settable alarm stage can output a current or temperature-dependent indication before the tripping point is reached.

BCD-coded output of fault location

The fault location calculated by the unit can be output for remote indication in BCD code. The output of the fault location is made in percent of the set line length with 3 decimal digits.

Analog output 0 to 20 mA

Some measured values can be output as analog values (0 to 20 mA). On a plug-in module (Fig. 6/24) two analog channels are made available. Up to two plug-in modules can be installed in the 7SA6. As an option, 2, 4 or no analog channels are available (please refer to the selection and ordering data). The measured values available for output are listed in the technical data.

Commissioning and fault event analyzing

Special attention has been paid to commissioning. All binary inputs and outputs can be displayed and activated directly. This can simplify the wiring check significantly for the user. The operational and fault events and the fault records are clearly arranged. For applications with serial protection data interface, all currents, voltages and phases are available via communication link at each local unit, displayed at the front of the unit with DIGSI 4 or with WEB Monitor. A common time tagging facilitates the comparison of events and fault records.

WEB Monitor – Internet technology simplifies visualization

In addition to the universal DIGSI 4 operating program, the relay contains a WEB server that can be accessed via a telecommunication link using a browser (e.g. Internet Explorer). The advantage of this solution is to operate the unit with standard software tools and at the same time make use of the Intranet/Internet infrastructure. Apart from numeric values, graphical displays in particular provide clear information and a high degree of operating reliability. Of course, it is also possible to call up detailed measured value displays and annunciation buffers. By emulation of the integrated unit operation on the PC it is also possible to adjust selected settings for commissioning purposes.

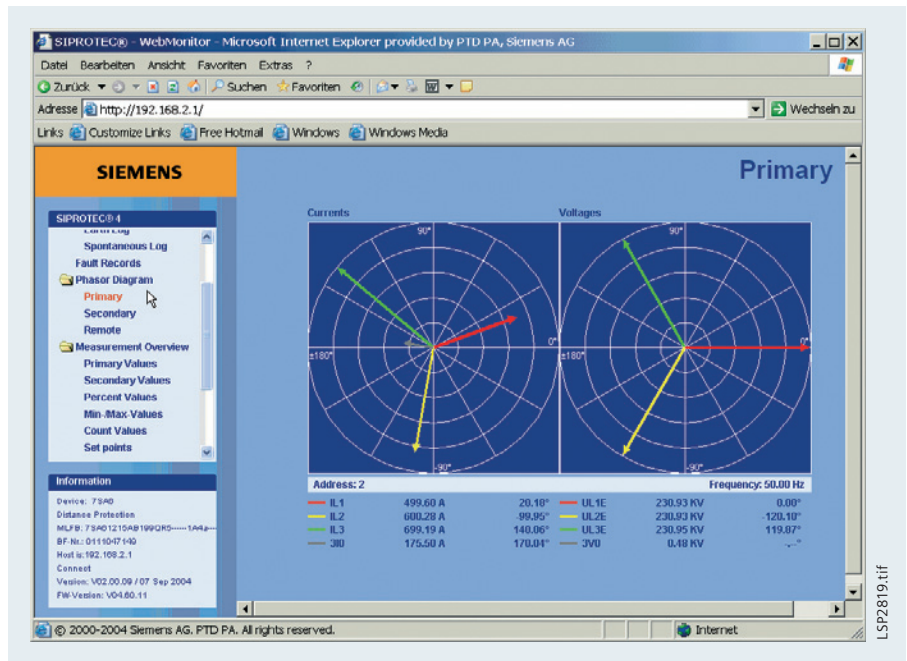


Fig. 6/17 Web Monitor: Supported commissioning by phasor diagram

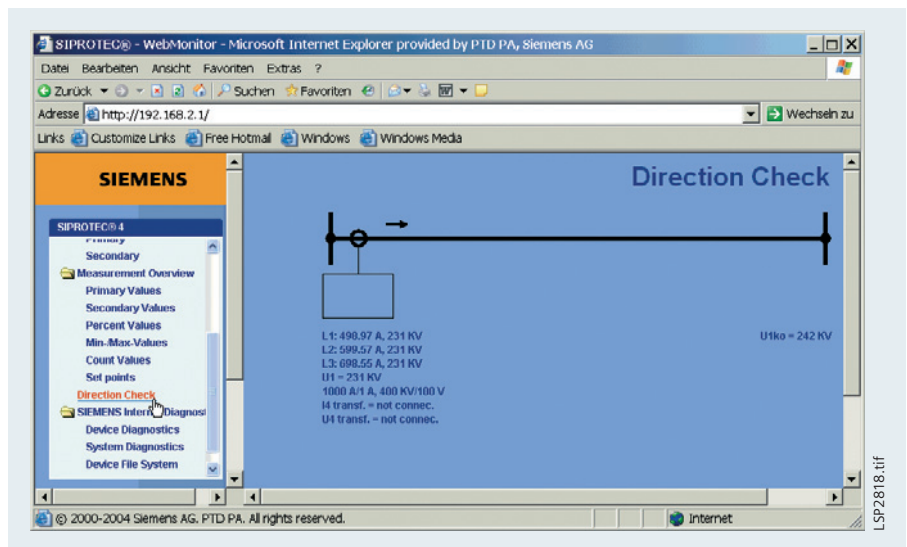


Fig. 6/18 Web Monitor: Display of the protection direction

Distance Protection 7SA6

Communication

Communication

With respect to communication, particular emphasis is placed on the customer requirements in energy automation:

- Every data item is time-stamped at the source, i.e. where it originates.
- Already during the process of communication, information is assigned to the cause thereof (e.g. assignment of the indication "circuit-breaker TRIP" to the corresponding command).
- The communication system automatically handles the transfer of large data blocks (e.g. fault recordings or parameter data files). The user has access to these features without any additional programming effort.
- For the safe execution of a control command the corresponding data telegram is initially acknowledged by the unit which will execute the command. After the release and execution of the command a feedback signal is generated. At every stage of the control command execution particular conditions are checked. If these are not satisfied, command execution may be terminated in a controlled manner.

The units offer a high degree of flexibility by supporting different standards for connection to industrial and power automation systems. By means of the communication modules, on which the protocols run, exchange and retrofit is possible. Therefore, the units will also in future allow for optimal adaptation to changing communication infrastructure such as the application of Ethernet networks which are already widely applied in the power supply sector.

Local PC interface

The serial RS232 PC interface accessible from the front of the unit permits quick access to all parameters and fault event data. The use of the DIGSI 4 operating program is particularly advantageous during commissioning.

Service/modem interface

7SA6 units are always fitted with a rear-side hardwired service interface, optionally as RS232 or RS485. In addition to the front-side operator interface, a PC can be connected here either directly or via a modem.

Time synchronization interface

The time synchronization interface is a standard feature in all units. The supported formats are IRIG-B and DCF77.

Reliable bus architecture

- RS485 bus
With this data transmission via copper conductors, electromagnetic fault influences are largely eliminated by the use of twisted-pair conductors. Upon failure of a unit, the remaining system continues to operate without any problem.
- Fiber-optic double ring circuit
The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without disturbance. It is usually impossible to communicate with a unit that has failed. Should a unit fail, there is no effect on the communication with the rest of the system.

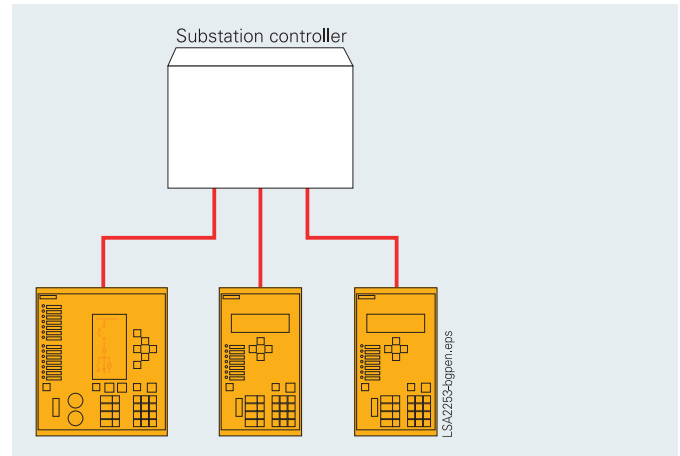


Fig. 6/19 IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

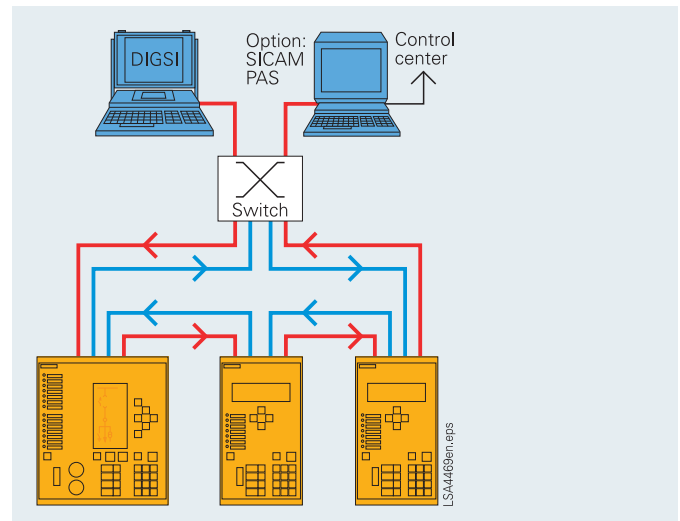


Fig. 6/20 Bus structure for station bus with Ethernet and IEC 61850

Retrofitting: Modules for every type of communication

Communication modules for retrofitting are available for the entire SIPROTEC 4 unit range. These ensure that, where different communication protocols (IEC 61850, IEC 60870-5-103, PROFIBUS, DNP, etc.) are required, such demands can be met. For fiber-optic communication, no external converter is required for SIPROTEC 4.

IEC 61850 protocol

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens was the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet but is also possible with DIGSI. It is also possible to retrieve operating and fault records as well as fault recordings via a browser. This Web monitor will also provide a few items of unit-specific information in browser windows.

IEC 60870-5-103 protocol

IEC 60870-5-103 is an internationally standardized protocol for efficient communication with protection relays. IEC 60870-5-103 is supported by a number of protection device manufacturers and is used worldwide. Supplements for control functions are defined in the manufacturer-specific part of this standard.

PROFIBUS-DP

PROFIBUS-DP is an industrial communications standard and is supported by a number of PLC and protection device manufacturers.

DNP 3.0

DNP 3.0 (Distributed Network Protocol, Version 3) is an internationally recognized protection and bay unit communication protocol. SIPROTEC 4 units are Level 1 and Level 2 compatible.

Analog outputs 0 to 20 mA

2 or 4 analog output interfaces for transmission of measured or fault location values are available for the 7SA6. Two analog output interfaces are provided in an analog output module. Up to two analog output modules can be inserted per unit.

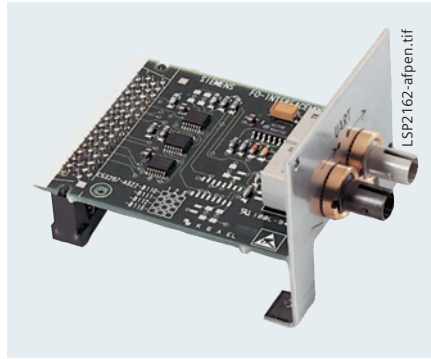


Fig. 6/21 820 nm fiber-optic communication module

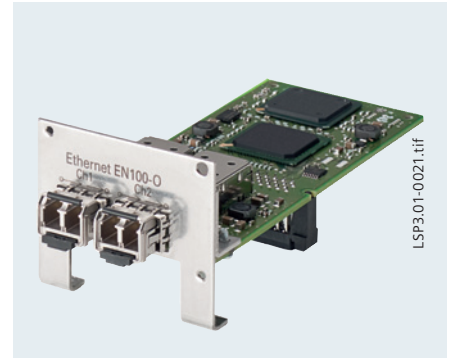


Fig. 6/22 Fiber-optic Ethernet communication module for IEC 61850 with integrated Ethernet switch

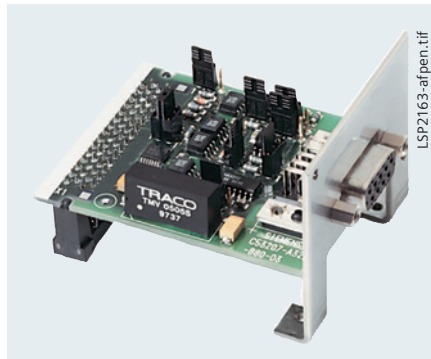


Fig. 6/23 RS232/RS485 electrical communication module

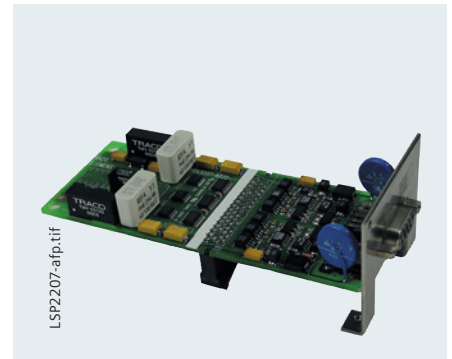


Fig. 6/24 Output module 0 to 20 mA, 2 channels

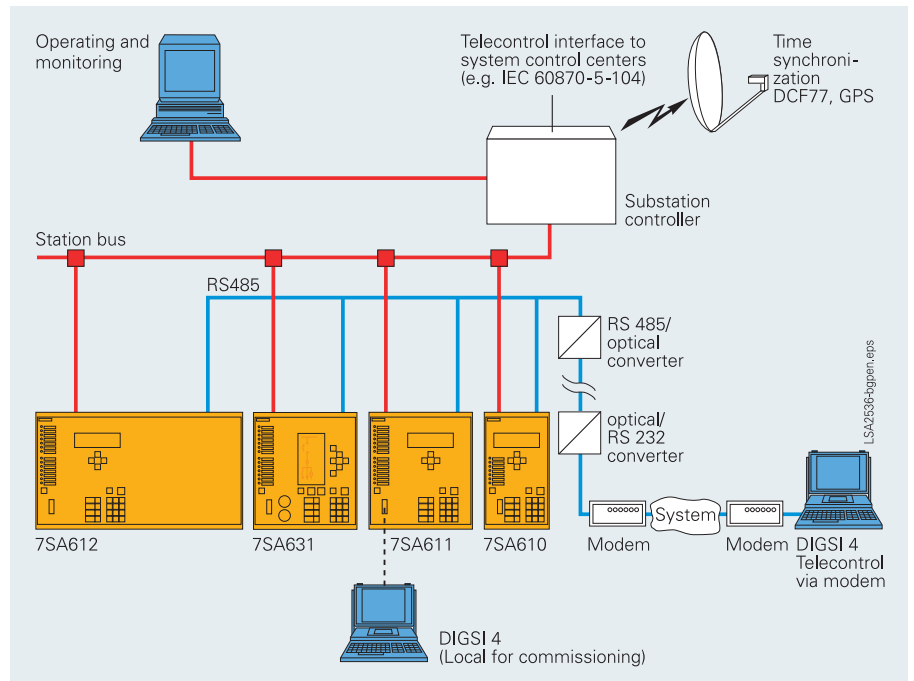


Fig. 6/25 Communication

Distance Protection 7SA6

Communication

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system. Units equipped with IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or connected in star by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 6/25).

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems. Units with an IEC 60870-5-103 interface are connected with PAS via the Ethernet station bus by means of serial/Ethernet converters. DIGSI and the Web monitor can also be used via the same station bus.

Serial protection data interface

The tele (pilot) protection schemes can be implemented using digital serial communication. The 7SA6 is capable of remote relay communication via direct links or multiplexed digital communication networks. The serial protection data interface has the following features:

- Fast phase-selective teleprotection signaling for distance protection, optionally with POTT or PUTT schemes
- Signaling for directional ground-fault protection – directional comparison for high resistance faults in solidly grounded systems
- Echo-function
- Two and three-terminal line applications can be implemented without additional logic
- Inter-close command transfer with the auto-reclosure "Adaptive dead time" (ADT) mode
- 28 remote signals for fast transfer of binary signals
- Flexible utilisation of the communication channels by means of the programmable CFC logic
- Display of the operational measured values of the opposite terminal(s) with phase-angle information relative to a common reference vector
- Clock synchronization: the clock in only one of the relays must be synchronized from an external so called "Absolute Master" when using the serial protection data interface. This relay will then synchronize the clock of the other (or the two other relays in 3 terminal applications) via the protection data interface.
- 7SA522 and 7SA6 can be combined via the protection data interface.

The communication possibilities are identical to those for the line differential protection relays 7SD5 and 7SD610. The following options are available:

- FO5¹⁾, OMA1²⁾ module: Optical 820 nm, 2 ST connectors, FO cable length up to 1.5 km for link to communication networks via communication converters or for direct FO cable connection
- FO6¹⁾, OMA2²⁾ module: Optical 820 nm, 2 ST connectors, FO cable length up to 3.5 km, for direct connection via multi-mode FO cable
- FO17¹⁾: For direct connection up to 24 km³⁾, 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO18¹⁾: For direct connection up to 60 km³⁾ 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO19¹⁾: For direct connection up to 100 km³⁾ 1550 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO30¹⁾: For transmission with the IEEE C37.94 standard.

The link to a multiplexed communication network is made by separate communication converters (7XV5662). These have a fiber-optic interface with 820 nm and ST connectors to the protection relay. The link to the communication network is optionally an electrical X21 or a G703.1 interface. If the connection to the multiplexor supports IEEE C37.94, a direct fibre optic connection to the relay is possible using the FO30 module.

For operation via copper wire communication (pilot wires), a modern communication converter for copper cables is available. This operates with both the two-wire and three-wire copper connections which were used by conventional differential protection systems before. The communication converter for copper cables is designed for 5 kV insulation voltage. An additional 20 kV isolation transformer can extend the field of applications of this technique into ranges with higher insulation voltage requirements. With SIPROTEC 4 and the communication converter for copper cables a digital follow-up technique is available for two-wire protection systems (typical 15 km) and all three-wire protection systems using existing copper communication links.

Communication data:

- Supported network interfaces G703.1 with 64 kBit/s; X21/RS422 with 64 or 128 or 512 kBit/s; IEEE C37.94
- Max. channel delay time 0.1 ms to 30 ms (in steps of 0.1 ms)
- Protocol HDLC
- 32-bit CRC-check according to CCITT and ITU
- Each protection relay possesses a unique relay address
- Continuous communication link supervision: Individual faulty data telegrams do not constitute an immediate danger, if they occur only sporadically. The statistical availability, per minute and hour, of the serial protection data interface can be displayed.

Figure 6/26 shows four applications for the serial protection data interface on a two-terminal line.

- 1) For flush-mounting housing.
- 2) For surface-mounting housing.
- 3) For surface-mounting housing the internal fiber-optic module OMA1 will be delivered together with an external repeater.

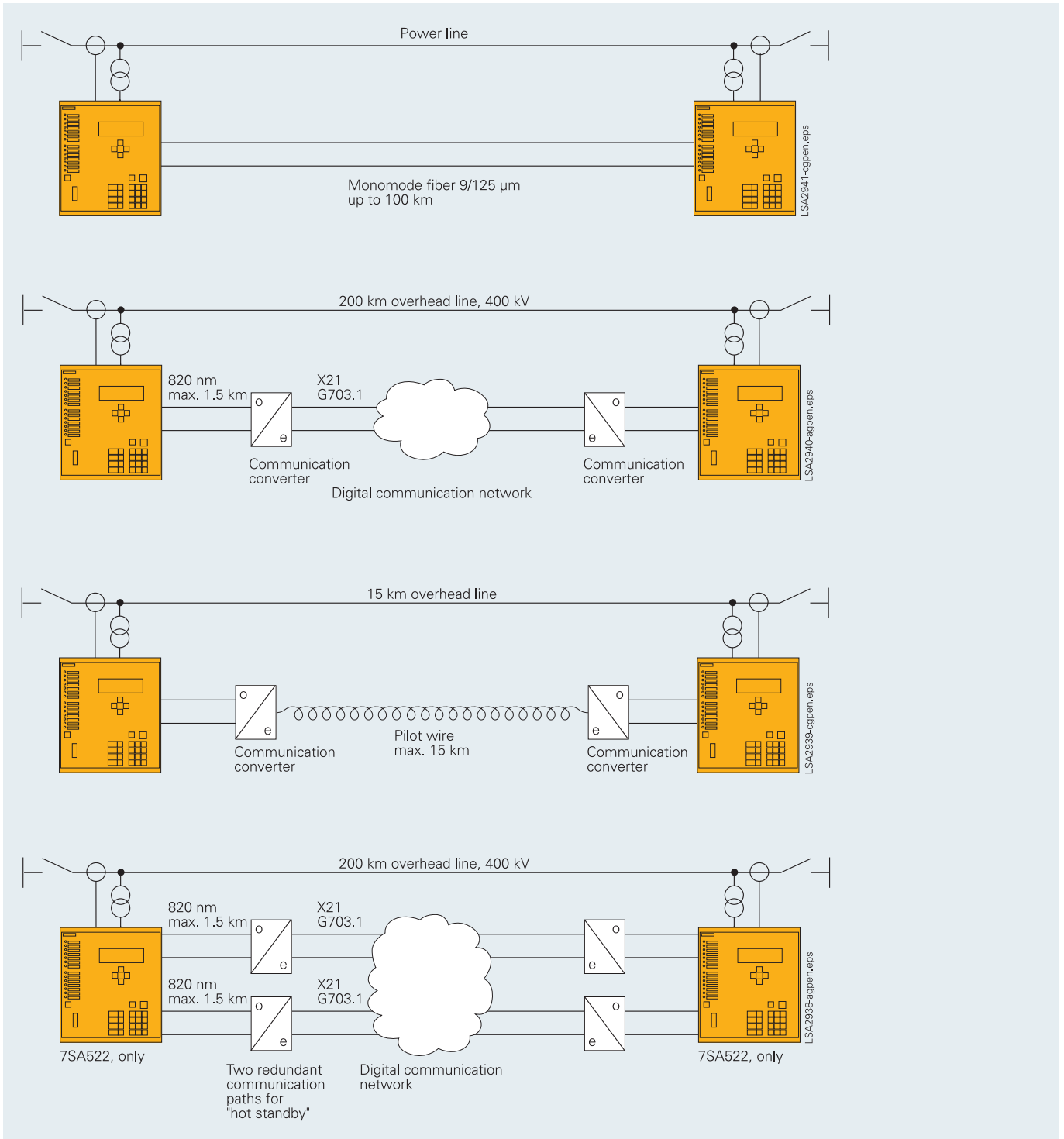


Fig. 6/26 Communication topologies for the serial protection data interface on a two-terminal line

Distance Protection 7SA6

Communication

Three-terminal lines can also be protected with a tele (pilot) protection scheme by using SIPROTEC 4 distance protection relays. The communication topology may then be a ring or a chain topology, see Fig. 6/27. In a ring topology a loss of one data connection is tolerated by the system. The topology is re-routed to become a chain topology within less than 100 ms. To reduce communication links and to save money for communications, a chain topology may be generally applied.

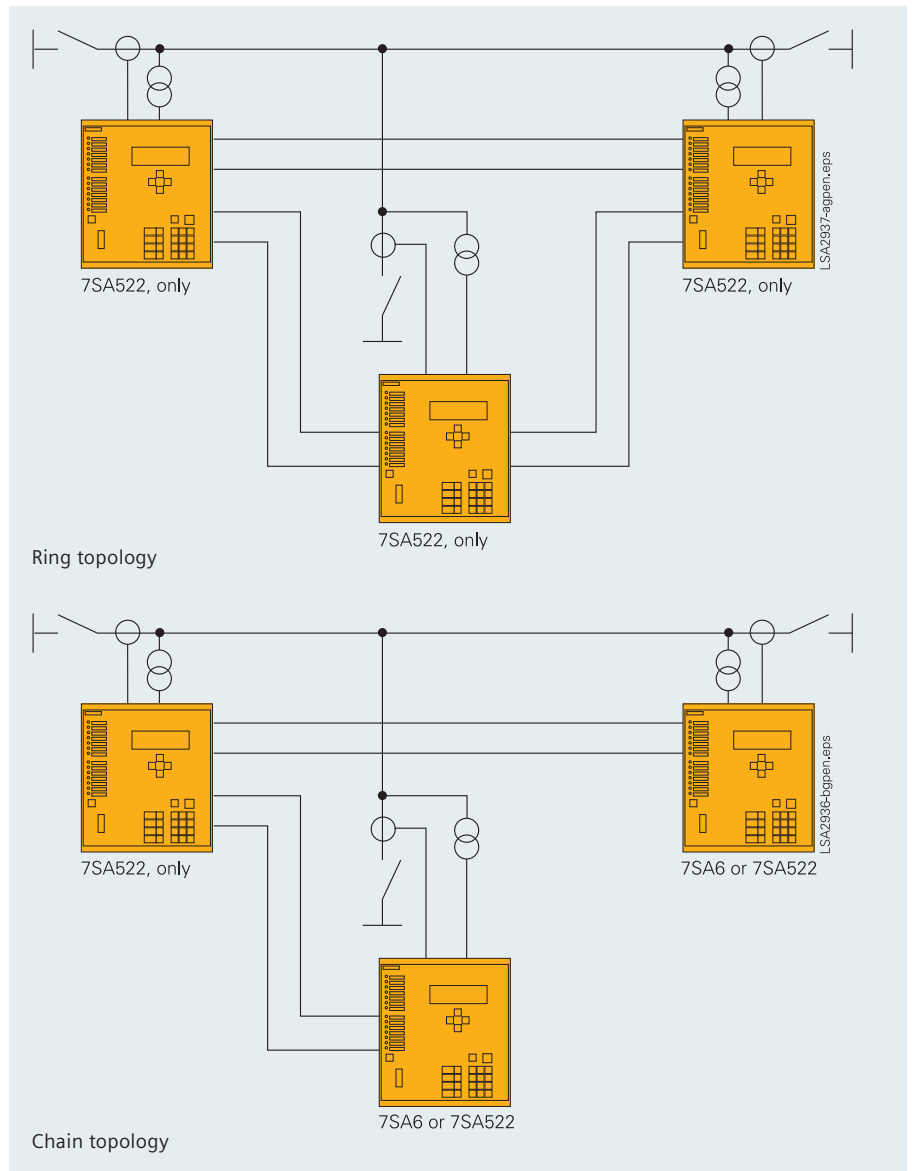


Fig. 6/27 Ring or chain communication topology

Typical connection

Connection of current and voltage transformers

3 phase current transformers with neutral point in the line direction, I_4 connected as summation current transformer ($= 3I_0$): Holmgreen circuit

3 voltage transformers, without connection of the broken (open) delta winding on the line side; the $3V_0$ voltage is derived internally.

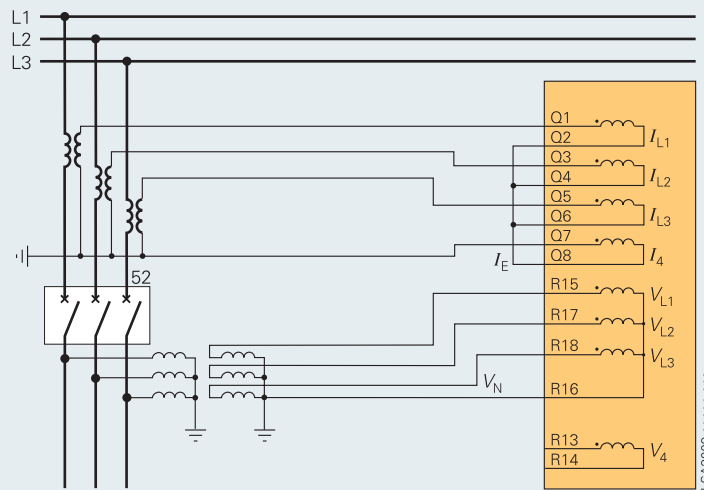


Fig. 6/28 Example of connection for current and voltage transformers

Alternative current measurement

The 3 phase current transformers are connected in the usual manner. The neutral point is in line direction. I_4 is connected to a separate neutral core-balance CT, thus permitting a high sensitive $3I_0$ measurement.

Note: Terminal Q7 of the I_4 transformer must be connected to the terminal of the core balance CT pointing in the same direction as the neutral point of the phase current transformers (in this case in line direction). The voltage connection is effected in accordance with Fig. 6/28, 6/32 or 6/33.

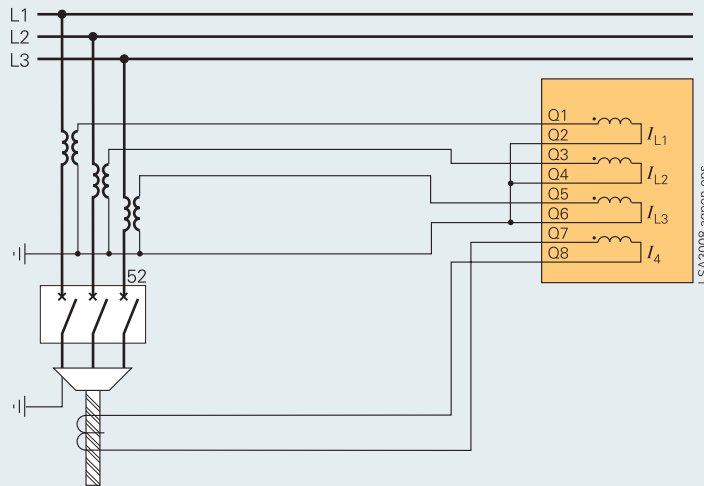


Fig. 6/29 Alternative connection of current transformers for sensitive ground-current measuring with core-balance current transformers

Distance Protection 7SA6

Typical connection

Alternative current connection

3 phase current transformers with neutral point in the line direction, I_4 connected to a current transformer in the neutral point of an grounded transformer for directional ground-fault protection. The voltage connection is effected in accordance with Fig. 6/28, 6/32 or 6/33.

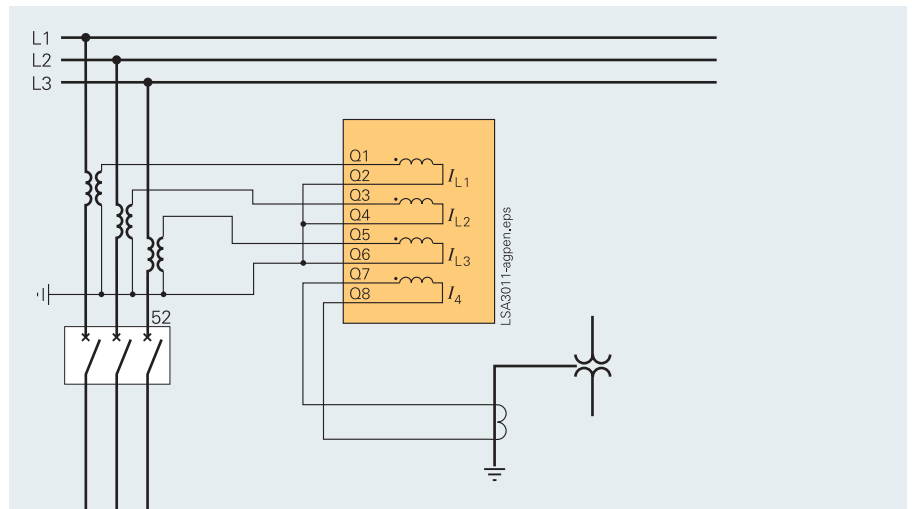


Fig. 6/30 Alternative connection of current transformers for measuring neutral current of a grounded power transformer

6

Alternative current connection

3 phase current transformers with neutral point in the line direction, I_4 connected to summation current of the parallel line for parallel line compensation on overhead lines. The voltage connection is effected in accordance with Fig. 6/28, 6/32 or 6/33.

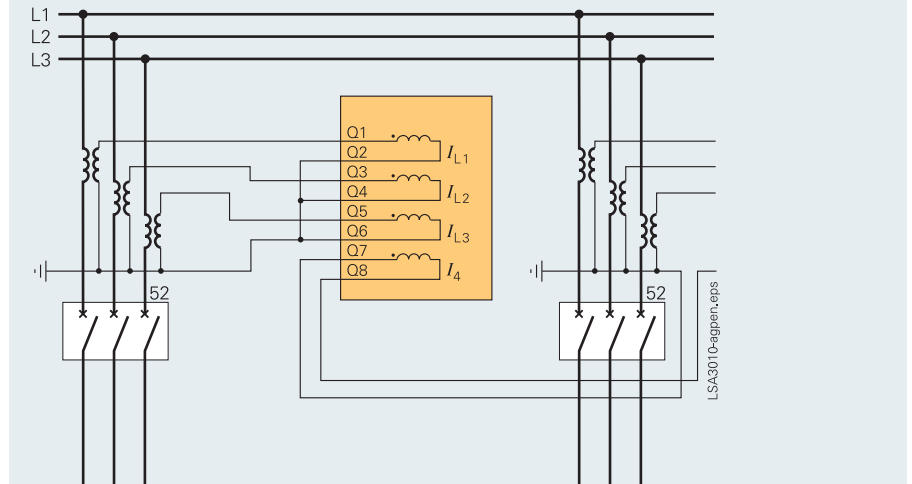


Fig. 6/31 Alternative connection of current transformers for measuring the ground current of a parallel line

Alternative voltage connection

3 phase voltage transformers, V_4 connected to broken (open) delta winding (V_{en}) for additional summation voltage monitoring and ground-fault directional protection.

The current connection is effected in accordance with Fig. 6/28, 6/29, 6/30 and 6/31.

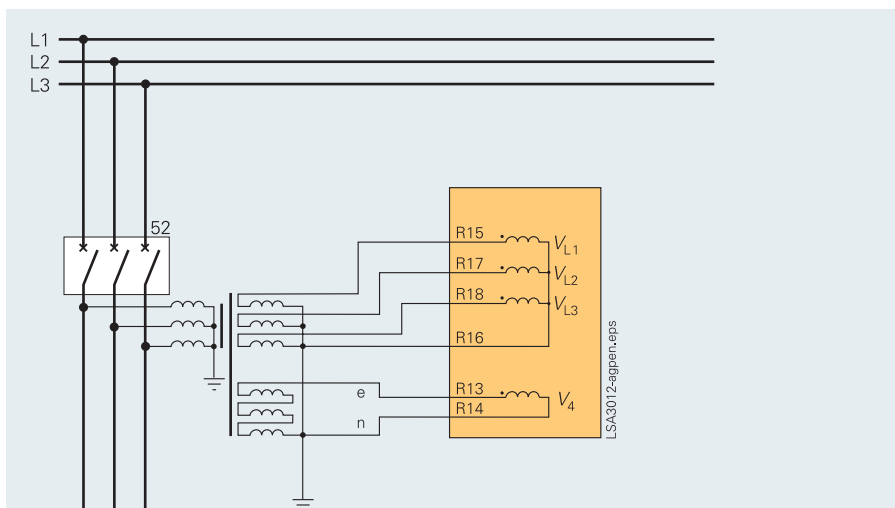


Fig. 6/32 Alternative connection of voltage transformers for measuring the displacement voltage (e-n voltage)

Alternative voltage connection

3 phase voltage transformers, V_4 connected to busbar voltage transformer for synchro-check.

Note: Any phase-to-phase or phase-to-ground voltage may be employed as the busbar voltage. Parameterization is carried out on the unit. The current connection is effected in accordance with Fig. 6/28, 6/29, 6/30 and 6/31.

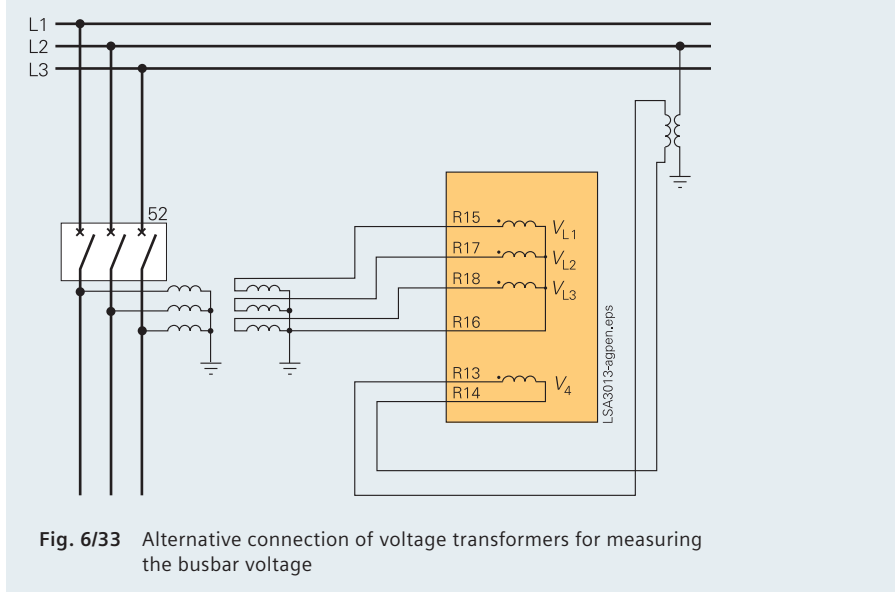


Fig. 6/33 Alternative connection of voltage transformers for measuring the busbar voltage

Distance Protection 7SA6

Technical data

General unit data	
Analog inputs	
Rated frequency	50 or 60 Hz (selectable)
Rated current I_{nom}	1 or 5 A (selectable)
Rated voltage V_{nom}	80 to 125 V (selectable)
Power consumption	
With $I_{nom} = 1\text{ A}$	Approx. 0.05 VA
With $I_{nom} = 5\text{ A}$	Approx. 0.30 VA
For I_E , sensitive with 1 A	Approx. 0.05 VA
Voltage inputs	≤ 0.10 VA
Overload capacity of current circuit (r.m.s.)	
Thermal	500 A for 1 s 150 A for 10 s 20 A continuous 1250 A (half cycle)
Dynamic (peak value)	
Ground current	
Sensitive	300 A for 1 s 100 A for 10 s 15 A continuous 750 A (half cycle)
Dynamic (peak value)	
Thermal overload capacity of voltage circuit	230 V continuous
Auxiliary voltage	
Rated voltages	DC 24 to 48 V DC 60 to 125 V DC 110 to 250 V and AC 115 to 230 V (50/60 Hz)
Permissible tolerance	-20 % to +20 %
Superimposed AC voltage (peak-to-peak)	≤ 15 %
Power consumption	
Quiescent	Approx. 5 W
Energized	Approx. 12 W to 18 W, depending on design
Bridging time during failure of the auxiliary voltage	
For $V_{aux} = 48\text{ V}$ and $V_{aux} \geq 110\text{ V}$	≥ 50 ms
For $V_{aux} = 24\text{ V}$ and $V_{aux} = 60\text{ V}$	≥ 20 ms
Binary inputs	
Quantity	
7SA610*-*A/E/J	5
7SA610*-*B/F/K	7
7SA6*1*-*A/E/J	13
7SA6*1*-*B/F/K	20
7SA6*2*-*A/E/J	21
7SA6*2*-*B/F/K	29
7SA6*2*-*C/G/L	33
Rated voltage range	24 to 250 V, bipolar
Pickup threshold	DC 17 or 73 or 154 V, bipolar
Functions are freely assignable	1
Pickup/reset voltage thresholds	DC 9 V/ DC 10 V or DC 88 V/ DC 44 V, or DC 176 V/ DC 88 V bipolar (3 nominal ranges DC 17/73/154 V)
Ranges are settable by means of jumpers for each binary input	
Maximum permissible voltage	DC 300 V
Current consumption, energized	Approx. 1.8 mA
Input impulse suppression	220 nF coupling capacitance at 220 V with a recovery time >60 ms

Output contacts	
"Unit ready" contact (live status contact)	1 NC/NO contact ¹⁾
Command/indication relay	
Quantity	
7SA610*-*A/E/J	5 NO contacts, 3 NC/NO contact ¹⁾
7SA610*-*B/F/K	5 NO contacts,
7SA6*1*-*A/E/J	12 NO contacts, 4 NC/NO contacts ¹⁾
7SA6*1*-*B/F/K	8 NO contacts, 4 power relays ²⁾
7SA6*2*-*A/E/J	19 NO contacts, 5 NC/NO contacts ¹⁾
7SA6*2*-*B/F/K	26 NO contacts, 6 NC/NO contacts ¹⁾
7SA6*2*-*C/G/L	11 NO contacts, 8 power relays ²⁾
NO/NC contact	
Switching capacity	
Make	1000 W / VA
Break, high-speed trip outputs	1000 W / VA
Break, contacts	30 VA
Break, contacts (for resistive load)	40 W
Break, contacts (for $\tau = L/R \leq 50\text{ ms}$)	25 VA
Switching voltage	250 V
Permissible total current	30 A for 0.5 seconds 5 A continuous
Operating time, approx.	
NO contact	8 ms
NO/NC contact (selectable)	8 ms
Fast NO contact	5 ms
High-speed NO trip outputs	< 1 ms
Power relay	
for direct control of disconnector actuator motors	
Switching capacity	
Make for 48 to 250 V	1000 W/ VA
Break for 48 to 250 V	1000 W/ VA
Make for 24 V	500 W/ VA
Break for 24 V	500 W/ VA
Switching voltage	250 V
Permissible total current	30 A for 0.5 seconds 5 A continuous
Max. operating time	30 s
Permissible relative operating time	1 %
LEDs	
	Quantity
RUN (green)	1
ERROR (red)	1
LED (red), function can be assigned	
7SA610	7
7SA6*1/2/3	14

1) Can be set via jumpers.

2) Each pair of power relays is mechanically interlocked to prevent simultaneous closing.

Unit design		
Housing	7XP20	
Dimensions	Refer to part 14 for dimension drawings	
Degree of protection acc. to EN 60529	IP 51	
Surface-mounting housing	IP 51	
Flush-mounting housing	IP 51	
Front	IP 51	
Rear	IP 50	
For the terminals	IP 20 with terminal cover put on	
Weight		
Flush-mounting housing	1/3 x 19"	4 kg
	1/2 x 19"	6 kg
	2/3 x 19"	8 kg
	1/1 x 19"	10 kg
Surface-mounting housing	1/3 x 19"	6 kg
	1/2 x 19"	11 kg
	1/1 x 19"	19 kg

Serial interfaces		
Operating interface for DIGSI 4 (front of unit)		
Connection	Non-isolated, RS232, 9-pin subminiature connector (SUB-D)	
Baud rate	4800 to 115200 baud setting as supplied: 38400 baud; parity 8E1	
Time synchronization		
DCF77/IRIG-B signal (format IRIG-B000)		
Connection	9-pin subminiature connector (SUB-D) (terminal with surface-mounting housing)	
Voltage levels	5 V, 12 V or 24 V (optional)	
Service/modem interface for DIGSI4/modem/service		
Isolated RS232/RS485	9-pin subminiature connector (SUB-D)	
Dielectric test	500 V / 50 Hz	
Distance for RS232	Max. 15 m	
Distance for RS485	Max. 1000 m	
System interface		
	IEC 61850 Ethernet IEC 60870-5-103 protocol PROFIBUS-FMS PROFIBUS-DP DNP 3.0	
Isolated RS232/RS485	9-pin subminiature connector (SUB-D)	
Baud rate	4800 to 38400 baud	
Dielectric test	500 V / 50 Hz	
Distance for RS232	Max. 15 m	
Distance for RS485	Max. 1000 m	
PROFIBUS RS485		
Dielectric test	500 V / 50 Hz	
Baud rate	Max. 12 Mbaud	
Distance	1 km at 93.75 kBd; 100 m at 12 MBd	

- 1) For flush-mounting housing.
- 2) For surface-mounting housing.
- 3) For surface-mounting housing the internal fiber-optic module (OMA1) will be delivered together with an external repeater.

PROFIBUS fiber-optic Only for flush-mounting housing	ST connector
For surface-mounting housing	Optical interface with OLM ⁴⁾
Baud rate	Max. 1.5 Mbaud
Optical wavelength	$\lambda = 820 \text{ nm}$
Permissible attenuation	Max. 8 dB for 62.5/125 μm fiber
Distance	500 kbit/s 1.6 km 1500 kbit/s 530 m

Protection data interface	
Quantity	1
FO5 ¹⁾ , OMA1 ²⁾ : Fiber-optic interface with clock recovery for direct connection up to 1.5 km or for connection to a communication converter, 820 nm	For multi-mode fiber 62.5/125 μm , ST connectors Permissible fiber attenuation 8 dB
FO6 ¹⁾ , OMA2 ²⁾ : Fiber-optic interface for direct connection up to 3.5 km, 820 nm	For multi-mode fiber 62.5/125 μm , ST connectors Permissible fiber attenuation 16 dB
FO30 ¹⁾ : for direct fibre-optic connection to a multiplexor using IEEE C37.94 standard	For multi-mode fiber 62.5/125 μm , ST connectors Permissible fiber attenuation 8 dB
FO17 ¹⁾ : for direct connection up to 24 km ³⁾ , 1300 nm	For mono-mode fiber 9/125 μm , LC-Duplex connector Permissible fiber attenuation 13 dB
FO18 ¹⁾ : for direct connection up to 60 km ³⁾ , 1300 nm	For mono-mode fiber 9/125 μm , LC-Duplex connector Permissible fiber attenuation 29 dB
FO19 ¹⁾ : for direct connection up to 100 km ³⁾ , 1550 nm	For mono-mode fiber 9/125 μm , LC-Duplex connector Permissible fiber attenuation 29 dB

Relay communication equipment	
External communication converter 7XV5662-0AA00 with X21/RS422 or G703.1 interface	
External communication converter for linking the optical 820 nm interface of the unit (FO5/OMA1 option with clock recovery) to the X21/RS422/G703.1 interface of the communication network	Electrical X21/RS422 or G703.1 interface settable by jumper Baud rate settable by jumper
FO interface with 820 nm with clock recovery	Max. 1.5 km with 62.5/125 μm multi-mode fiber to protection relay
Electrical X21/RS422 interface	64/128/512 kbit (settable by jumper) max. 800 m, 15-pin connector to the communication network
Electrical G703.1 interface	64 kbit/s max. 800 m, screw-type terminal to the communication network

External communication converter 7XV5662-0AC00 for pilot wires	
External communication converter for linking the optical 820 nm interface of the unit (FO5/OMA1 option with clock recovery) to pilot wires.	Typical distance: 15 km max.
FO interface for 820 nm with clock recovery	Max. 1.5 km with 62.5/125 μm multimode fiber to protection relay, 128 kbit
Electrical interface to pilot wires	5 kV-isolated

- 4) Conversion with external OLM
For fiber-optic interface please complete order number at 11th position with **4** (FMS RS485) or **9** and Order Code **L0A** (DP RS485) or **9** and Order Code **L0G** (DNP 3.0) and additionally a suitable external repeater.

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Technical data

Electrical tests	
<i>Specifications</i>	
Standards	IEC 60255 (product standards) IEEE Std C37.90.0/1.1/2; UL 508 VDE 0435 Further standards see "Individual functions"
<i>Insulation tests</i>	
Standards	IEC 60255-5 and 60870-2-1
High-voltage test (routine test) All circuits except for power supply, binary inputs, high-speed outputs, communication and time synchronization interfaces	2.5 kV (r.m.s.), 50 Hz
Auxiliary voltage, binary inputs and high-speed outputs (routine test)	DC 3.5 kV
only isolated communication interfaces and time synchronization interface (routine test)	500 V (r.m.s.), 50 Hz
Impulse voltage test (type test) All circuits except for communication interfaces and time synchronization interface, class III	5 kV (peak); 1.2/50 μ s; 0.5 Ws, 3 positive and 3 negative impulses in intervals of 5 s
<i>EMC tests for noise immunity; type tests</i>	
Standards	IEC 60255-6/-22 (product standard) EN 61000-6-2 (generic standard), VDE 0435 part 301 DIN VDE 0435-110
High-frequency test IEC 60255-22-1 class III and VDE 0435 Section 303, class III	2.5 kV (peak); 1 MHz; $\tau = 15$ ms; 400 surges per s; test duration 2 s, $R_i = 200 \Omega$
Electrostatic discharge IEC 60255-22-2 class IV and IEC 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; $R_i = 330 \Omega$
Irradiation with HF field, frequency sweep IEC 60255-22-3 (report) class III	10 V/m; 80 to 1000 MHz: 80 % AM; 1 kHz 10 V/m; 800 to 960 MHz: 80 % AM; 1 kHz
IEC 61000-4-3, class III	10 V/m; 1.4 to 2 GHz: 80 % AM; 1 kHz
Irradiation with HF field, single frequencies IEC 60255-22-31, IEC 61000-4-3, class III amplitude/pulse modulated	10 V/m; 80, 160, 450, 900 MHz; 80 % AM; 1 kHz; duty cycle > 10 s 900 MHz; 50 % PM, repetition frequency 200 Hz
Fast transient disturbance/bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50 \Omega$; test duration 1 min
High-energy surge voltages (SURGE), IEC 61000-4-5 installation class III Auxiliary supply	Impulse: 1.2/50 μ s Common mode: 2 kV; 12 Ω ; 9 μ F Differential mode: 1 kV; 2 Ω ; 18 μ F
Analog measurement inputs, binary inputs, relays output	Common mode: 2 kV; 42 Ω ; 0.5 μ F Differential mode: 1 kV; 42 Ω ; 0.5 μ F
Line-conducted HF, amplitude- modulated, IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Power system frequency magnetic field IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz

Oscillatory surge withstand capability, IEEE Std C37.90.1	2.5 kV (peak); 1 MHz $\tau = 50 \mu$ s; 400 surges per second, test duration 2 s, $R_i = 200 \Omega$
Fast transient surge withstand capability, IEEE Std C37.90.1	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms repetition rate 300 ms; ; both polarities; test duration 1 min; $R_i = 50 \Omega$
Radiated electromagnetic interference IEEE Std C37.90.2	35 V/m; 25 to 1000 MHz, amplitude and pulse-modulated
Damped oscillations IEC 60694, IEC 61000-4-12	2.5 kV (peak value); polarity alternating 100 kHz; 1 MHz; 10 and 50 MHz; $R_i = 200 \Omega$
<i>EMC tests for noise emission; type test</i>	
Standard	EN 61000-6-3 (generic standard)
Radio noise voltage to lines, only auxiliary voltage IEC-CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC-CISPR 22	30 to 1000 MHz Limit class B
Harmonic currents on the network lead at AC 230 V, IEC 61000-3-2	Class A limits are observed
Voltage fluctuations and flicker on the network incoming feeder at AC 230 V, IEC 61000-3-3	Limits are observed

Mechanical stress test	
<i>Vibration, shock stress and seismic vibration</i>	
<i>During operation</i>	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 g acceleration frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 5 g, duration 11 ms, 3 shocks on each of the 3 axes in both directions
Seismic vibration IEC 60255-21-2, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 g acceleration (horizontal axis) 8 to 35 Hz: 0.5 g acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
<i>During transport</i>	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 g acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 15 g, duration 11 ms, 3 shocks on each of the 3 axes in both directions
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Semi-sinusoidal Acceleration 10 g, duration 16 ms, 1000 shocks on each of the 3 axes in both directions

Climatic stress tests		Inclination angle for quadrilateral characteristic	
Standard	IEC 60255-6	Zone setting Z_r (for circle characteristic)	30° to 90° (step 1°)
Temperatures		Threshold angle α for increased resistance tolerance (circle charac.)	0.050 to 600 Ω (1A) / 0.010 to 120 Ω (5A) (step 0.001 Ω)
Type-tested acc. to IEC 60068-2-1 and -2, test Bd	-25 °C to +85 °C / -13 °F to +185 °F	Overcurrent pickup $I_{>>}$ (for $I_{>>}$, $V<I>$, $V<I>/\varphi$)	10 to 90 ° (step 1°)
Temporarily permissible operating temperature, tested for 96 h (Legibility of display may be impaired above +55 °C / +131 °F)	-20 °C to +70 °C / -4 °F to +158 °F	Minimum current pickup $I_{>}$ (for $V<I>$, $V<I>/\varphi$ and $Z<$)	0.25 to 10 A (1A) / 1.25 to 50 A (5A) (step 0.01 A)
Recommended permanent operating temperature acc. to IEC 60255-6	-5 °C to +55 °C / +23 °F to +131 °F	Minimum current pickup I_{φ} (for $V<I>/\varphi$)	0.05 to 4 A (1A) / 0.25 to 20 A (5A) (step 0.01 A)
– Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to 131 °F	Undervoltage pickup (for $V<I>$ and $V<I>/\varphi$)	0.1 to 8 A (1A) / 0.5 to 40 A (5A) (step 0.01 A)
– Limiting temperature during transport	-25 °C to +70 °C / -13 °F to +158 °F	$V_{PH-e<}$ $V_{PH-PH<}$	20 to 70 V (step 1 V) 40 to 130 V (step 1 V)
Humidity		Load angle pickup (for $V<I>/\varphi$)	
Permissible humidity stress: It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average on ≤ 75 % relative humidity; on 56 days per year up to 93 % relative humidity; condensation is not permitted.	Load angle φ Load angle φ	30° to 80° 90° to 120°
Functions		Load zone (for $Z<$)	Impedances within the load zone do not cause pickup in pickup mode $Z<$; Load zones for phase-to-phase and phase-to-ground faults can be set separately
Distance protection (ANSI 21, 21N)		Load angle Resistance	20° to 60° 0.1 to 600 Ω (1A) / 0.02 to 120 Ω (5A)
Types of pickup	Overcurrent pickup ($I_{>}$); Voltage-dependent overcurrent pickup ($V< I_{>}$); Voltage-dependent and phase angle-dependent overcurrent pickup ($V< I_{> / \varphi$); Impedance pickup ($Z<$)	Ground-fault detection Ground current $3I_{0>}$	0.05 to 4 A (1A) / 0.25 A to 20 A (5A) (step 0.01 A)
Types of tripping	Three-pole for all types of faults; Single-pole for single-phase faults / otherwise three-pole; Single-pole for single-phase faults and two-pole phase-to-phase faults / otherwise three-pole	Zero-sequence voltage $3V_{0>}$ for grounded networks for resonant-grounded networks	1 to 100 V (step 1 V) or deactivated 10 to 200 V (step 1 V) or deactivated
Characteristic	Quadrilateral or circle	Ground impedance matching Parameter formats Separately settable for R_E/R_L and X_E/X_L k_0 and φ (k_0)	R_E/R_L and X_E/X_L or k_0 and φ (k_0) Distance protection zone Z1 and higher distance zones (Z1B, Z2 to Z6) -0.33 to +7.00 (step 0.01) 0 to 4 (step 0.01) and - 135 ° to 135 ° (step 0.01 °)
Distance protection zones	7, 1 of which as controlled zone All zones can be set to forward, reverse, non-directional or inactive	Parallel line matching R_M/R_L and X_M/X_L	For parallel compensation 0 to 8 (step 0.01)
Timer stages for tripping delay	7 for multi-phase faults 3 for single-phase faults	Phase preference on double ground-faults in resonant-grounded / non-grounded networks	Phase preference or no preference (selectable)
Setting range	0 to 30 s or deactivated (steps 0.01 s)	Direction decision for all types of faults Direction sensitivity	With fault-free voltages and/or voltage memory Dynamically unlimited
Zone setting X (for distance zones and $Z<$ starting)	0.050 to 600 Ω (1A) / 0.01 to 120 Ω (5A) (step 0.001 Ω)		
Resistance setting (for quadrilateral distance zones and $Z<$ starting)			
Phase-to-phase faults and phase-to-ground faults	0.05 to 600 Ω (1A) / 0.01 to 120 Ω (5A) (step 0.001 Ω)		
Line angle	10 ° to 89 °		

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Technical data

Times	
Shortest trip time (measured at the fast relay; refer to the terminal connection diagram)	Approx. 17 ms for $f_N = 50$ Hz Approx. 15 ms for $f_N = 60$ Hz
Shortest trip time (measured at the high-speed trip outputs)	Approx. 12 ms at 50 Hz Approx. 10 ms at 60 Hz
Reset time	Approx. 30 ms
Tolerances	
Response values (in conformity with DIN 57435, Part 303) V and I Angle (φ)	For sinusoidal measured variables $\leq 5\%$ of setting value $\leq 3^\circ$
Impedances (in conformity with DIN 57435, Part 303)	$\left \frac{\Delta X}{X} \right \leq 5\%$ for $30^\circ \leq \varphi_{SC} \leq 90^\circ$ $\left \frac{\Delta R}{R} \right \leq 5\%$ for $0^\circ \leq \varphi_{SC} \leq 60^\circ$
Time stages	1 % of setting value or 10 ms
Fault locator	
Output of the distance to fault	X, R (secondary) in Ω X, R (primary) in Ω Distance in kilometers or in % of line length
Start of calculation	With trip, with reset of pickup, with binary input
Reactance per unit length	0.005 to 6.5 $\Omega/\text{km}_{(1A)}$ / 0.001 to 1.3 $\Omega/\text{km}_{(5A)}$
Tolerance	(step 0.001 Ω/km) For sinusoidal quantities $\leq 2.5\%$ line length for $30^\circ \leq \varphi_{SC} \leq 90^\circ$ and $V_{SC}/V_{nom} > 0.1$
BCD-coded output of fault location	
Indicated value	Fault location in % of the line length
Output signals	Max. 10: d[1 %], d[2 %], d[4 %], d[8 %], d[10 %], d[20 %], d[40 %], d[80 %], d[100 %], d[release]
Indication range	0 % to 195 %
Tele (pilot) protection for distance protection (ANSI 85-21)	
Modes of operation	PUTT (Z1B acceleration); DUTT; PUTT (acceleration with pickup); POTT; Directional comparison; Reverse interlocking Pilot-wire comparison; Unblocking; Blocking
Additional functions	Echo function (refer to weak-infeed function) Transient blocking for schemes with measuring range extension
Transmission and reception signals	Phase-selective signals available for maximum selectivity with single-pole tripping; signals for 2- and 3-end-lines

Weak-infeed protection (ANSI 27-WI)	
Operating modes with carrier (signal) reception and no fault detection	Echo Echo and trip with undervoltage
Undervoltage phase-ground	2 to 70 V (step 1 V)
Time delay	0 to 30 s (step 0.01 s)
Echo impulse	0 to 30 s (step 0.01 s)
Tolerances	
Voltage threshold	$\leq 5\%$ of setting value or 0.5 V
Timer	1 % of setting value or 10 ms
Direct transfer trip (DTT)	
Direct phase-selective tripping via binary input	Alternatively with or without auto-reclosure
Trip time delay	0 to 30 s (step 0.01 s)
Timer tolerance	1 % of setting value or 10 ms
Power swing detection (ANSI 68, 68T)	
Power swing detection principle	Measurement of the rate of change of the impedance vector and monitoring of the vector path
Max. detectable power swing frequency	Approx. 7 Hz
Operating modes	Power swing blocking and/or power swing tripping for out-of-step conditions
Power swing blocking programs	All zones blocked; Z1/Z1B blocked; Z2 to Z6 blocked; Z1, Z1B, Z2 blocked
Detection of faults during power swing blocking	Reset of power swing blocking for all types of faults
Backup overcurrent protection (ANSI 50 (N), 51 (N), 67)	
Operating modes	Active only with loss of VT secondary circuit or always active
Characteristic	2 definite-time stages / 1 inverse-time stage, 1 definite-time Stub-protection stage
Instantaneous trip after switch-onto-fault	Selectable for every stage
Definite-time stage (ANSI 50, 50N)	
Phase current pickup $I_{PH}>>$	0.1 to 25 A $_{(1A)}$ / 0.5 to 125 A $_{(5A)}$ (step 0.01 A)
Ground current pickup $3I_{0}>>$	0.05 to 25 A $_{(1A)}$ / 0.25 to 125 A $_{(5A)}$ (step 0.01 A)
Phase current pickup $I_{PH}>$	0.1 to 25 A $_{(1A)}$ / 0.5 to 125 A $_{(5A)}$ (step 0.01 A)
Ground current pickup $3I_{0}>$	0.05 to 25 A $_{(1A)}$ / 0.25 to 125 A $_{(5A)}$ (step 0.01 A)
Time delay	0 to 30 s (step 0.01 s) or deactivated
Tolerances	
Current pickup	$\leq 3\%$ of setting value or 1 % I_N
Delay times	1 % of setting value or 10 ms
Operating time	Approx. 25 ms

Inverse-time stage (ANSI 51, 51N)	
Phase current pickup I_p	0.1 to 4 A ^(1A) / 0.5 to 20 A ^(5A) (step 0.01 A)
Ground current pickup $3I_{OP}$	0.05 to 4 A ^(1A) / 0.25 to 20 A ^(5A) (step 0.01 A)
Tripping time characteristics acc. to IEC 60255-3	Normal inverse; very inverse; extremely inverse; long time inverse
Tripping time characteristics acc. to ANSI/IEEE (not for DE region, see selection and ordering data 10 th position)	Inverse; short inverse; long inverse; moderately inverse; very inverse; extremely inverse; definite inverse
Time multiplier for IEC charac. T	$T_p = 0.05$ to 3 s (step 0.01 s)
Time multiplier for ANSI charac. D	$D_{IP} = 0.5$ to 15 s (step 0.01 s)
Pickup threshold	Approx. 1.1 III_p (ANSI: $III_p = M$)
Reset threshold	Approx. 1.05 x II_p (ANSI: $II_p = M$)
Tolerances	
Operating time for $2 \leq III_p \leq 20$	$\leq 5\%$ of setpoint ± 15 ms
Directional ground-fault overcurrent protection for high-resistance faults in systems with grounded star point (ANSI 50N, 51N, 67N)	
Characteristic	3 definite-time stages/1 inverse-time stage or 4 definite-time stages or 3 definite-time stages/1 $V_{0invers.}$ stage
Phase selector	Permits 1-pole tripping for single-phase faults or 3-pole tripping for multi-phase faults selectable for every stage
Inrush restraint	Selectable for every stage
Instantaneous trip after switch-onto-fault	Selectable for every stage
Influence of harmonics	
Stages 1 and 2 ($I_{>>>}$ and $I_{>>}$)	3 rd and higher harmonics are completely suppressed by digital filtering
Stages 3 and 4 ($I_{>}$ and inverse 4 th stage)	2 nd and higher harmonics are completely suppressed by digital filtering
Definite-time stage (ANSI 50N)	
Pickup value $3I_{0>>>}$	0.5 to 25 A ^(1A) / 2.5 to 125 A ^(5A) (step 0.01 A)
Pickup value $3I_{0>>}$	0.2 to 25 A ^(1A) / 1 to 125 A ^(5A) (step 0.01 A)
Pickup value $3I_{0>}$	0.05 to 25 A ^(1A) / 0.25 to 125 A ^(5A) (step 0.01 A) Neutral (residual) current transformer with normal sensitivity (refer to ordering data, position 7); 0.003 to 25 A ^(1A) / 0.015 to 125 A ^(5A) (step 0.001 A) Neutral (residual) current transformer with high sensitivity (refer to ordering data, position 7)
Pickup value $3I_0$, 4 th stage	0.05 to 25 A ^(1A) / 0.25 to 125 A ^(5A) (step 0.01 A) Neutral (residual) current transformer with normal sensitivity (refer to ordering data, position 7); 0.003 to 25 A ^(1A) / 0.015 to 125 A ^(5A) (step 0.001 A) Neutral (residual) current transformer with high sensitivity (refer to ordering data, position 7)
Time delay for definite-time stages	0 to 30 s (step 0.01 s) or deactivated
Tolerances	
Current pickup	$\leq 3\%$ of setting value or 1 % I_{nom}
Delay times	1 % of setting value or 10 ms
Command / pickup times $3I_{0>>>}$ and $3I_{0>>}$	Approx. 30 ms
Command / pickup times $3I_{0>}$ and $3I_0$, 4 th stage	Approx. 40 ms
Inverse-time stage (ANSI 51N)	
Ground-current pickup $3I_{OP}$	0.05 to 4 A ^(1A) / 0.25 to 20 A ^(5A) (step 0.01 A) Neutral (residual) current transformer with normal sensitivity (refer to ordering data, position 7) 0.003 to 4 A ^(1A) / 0.015 to 20 A ^(5A) (step 0.001 A) Neutral (residual) current transformer with high sensitivity (refer to ordering data, position 7)
Tripping characteristics acc. to IEC 60255-3	Normal inverse; very inverse; extremely inverse; long time
ANSI/IEEE tripping characteristic (not for region DE, see selection and ordering data, position 10)	Inverse; short inverse; long inverse; moderately inverse; very inverse; extremely inverse; definite inverse
Inverse logarithmic tripping characteristics (not for regions DE and US, see selection and ordering data, position 10)	$t = T_{3I_{OPmax}} - T_{3I_{OP}} \ln \frac{3I_0}{3I_{OP}}$
Pickup threshold	1.1 to 4.0 x III_p (step 0.1 s)
Time multiplier for IEC charac. T	$T_p = 0.05$ to 3 s (step 0.01 s)
Time multiplier for ANSI charac. D	$D_{IOP} = 0.5$ to 15 s (step 0.01 s)
Pickup threshold	Approx. 1.1 II_p (ANSI: $II_p = M$)
Inverse logarithmic pickup threshold	1.1 to 4.0 x III_{OP} (step 0.1)
Reset threshold	Approx. 1.05 III_{OP} (ANSI: $III_p = M$)
Tolerance	
Operating time for $2 \leq III_p \leq 20$	$\leq 5\%$ of setpoint ± 15 ms
Zero-sequence voltage protection V	
Tripping characteristic	$t = \frac{2s}{\frac{V_0}{4} - V_{0inv min}}$
Zero-sequence power-dependent stage	
Compensated zero-sequence power	$S_r = 3I_0 \times 3V_0 \times \cos(\varphi - \varphi_{comp.})$
Direction decision (ANSI 67N)	
Measured signals for direction decision	$3I_0$ and $3V_0$ or $3I_0$ and $3V_0$ and I_Y (star point current of a grounded power transformer) or $3I_2$ and $3V_2$ (negative-sequence system) or zero-sequence power S_r or automatic selection of zero-sequence or negative-sequence quantities dependent on the magnitude of the component voltages
Min. zero-sequence voltage $3V_0$	0.5 to 10 V (step 0.1 V)
Min. current I_Y (of grounded transformers)	0.05 to 1 A ^(1A) / 0.25 to 5 A ^(5A) (step 0.01 A)
Min. negative-sequence voltage $3V_2$	0.5 to 10 V (step 0.1 V)
Min. negative-sequence current $3I_2$	0.05 to 1 A ^(1A) / 0.25 to 5 A ^(5A) (step 0.01 A)

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Technical data

<i>Inrush current blocking, capable of being activated for each stage</i>	
Component of the 2 nd harmonic	10 to 45 % of the fundamental (step 1 %)
Max. current, which cancels inrush current blocking	0.5 to 25 A _(1A) / 2.5 to 125 A _(5A) (step 0.01 A)
<i>Tele (pilot) protection</i>	
<i>For directional ground-fault protection (ANSI 85-67N)</i>	
Operating modes	Directional comparison, blocking, unblocking
Additional functions	Echo (see function "weak infeed"); transient blocking for schemes with parallel lines
Send and receive signals	Suitable for 2 and 3 end-lines
<i>Instantaneous high-speed switch-onto-fault overcurrent protection (ANSI 50HS)</i>	
Operating mode	Active only after CB closing; instantaneous trip after pickup
Pickup current $I_{>>>}$	1 to 25 A _(1A) / 5 to 125 A _(5A) (step 0.01 A)
Reset ratio	Approx. 0.90
Tolerances Current starting	≤ 3 % of setting value or 1 % I_N
Shortest tripping time With reference to fast relays With high-speed trip to outputs	Approx. 12 ms Approx. 8 ms
<i>Voltage protection (ANSI 59, 27)</i>	
Operating modes	Local tripping and/or carrier trip for remote end
<i>Overvoltage protection</i>	
Pickup values $V_{PH-E>>}$, $V_{PH-E>}$ (phase-ground overvoltage)	1 to 170 V (step 0.1 V)
Pickup values $V_{PH-PH>>}$, $V_{PH-PH>}$ (phase-phase overvoltage)	2 to 220 V (step 0.1 V)
Pickup values $3V_{0>>}$, $3V_{0>}$ ($3V_0$ can be measured via V4 transformers or calculated by the relay) (zero-sequence overvoltage)	1 to 220 V (step 0.1 V)
Pickup values $V_{1>>}$, $V_{1>}$ (positive-sequence overvoltage) Measured voltage	2 to 220 V (step 0.1 V) Local positive-sequence voltage or calculated remote positive-sequence voltage (compounding)
Pickup values $V_{2>>}$, $V_{2>}$ (negative-sequence overvoltage)	2 to 220 V (step 0.1 V)
Reset ratio (settable)	0.5 to 0.98 (step 0.01)
<i>Undervoltage protection</i>	
Pickup values $V_{PH-E<<}$, $V_{PH-E<}$ (phase-ground undervoltage)	1 to 100 V (step 0.1 V)
Pickup values $V_{PH-PH<<}$, $V_{PH-PH<}$ (phase-phase undervoltage)	1 to 170 V (step 0.1 V)
Pickup values $V_{1<<}$, $V_{1<}$ (positive-sequence undervoltage)	1 to 100 V (step 0.1 V)
Blocking of undervoltage prot. stages	Minimum current; binary input stages
Reset ratio (settable)	1.01 to 1.20 (step 0.01)

<i>Time delays</i>	
Time delay for all stages	0 to 100 s (step 0.01 s) or deactivated
Command / pickup time	Approx. 30 ms
Command/pickup time for $3V_0$ stages	Approx. 30 ms or 65 ms (settable)
Tolerances Voltage limit values Time stages	≤ 3 % of setting value or 1 V 1 % of setting value or 10 ms
<i>Frequency protection (ANSI 81)</i>	
Number of frequency elements	4
Setting range	45.5 to 54.5 Hz (in steps of 0.01) at $f_{nom} = 50$ Hz 55.5 to 64.5 Hz (in steps of 0.01) at $f_{nom} = 60$ Hz
Delay times	0 to 600 s or ∞ (in steps of 0.01 s)
Operating voltage range	6 to 230 V (phase-to-ground)
Pickup times	Approx. 80 ms
Dropout times	Approx. 80 ms
Hysteresis	Approx. 20 mHz
Dropout condition	Voltage = 0 V and current = 0 A
Tolerances Frequency Delay times	15 mHz for V_{PH-PH} : 50 to 230 V 1 % of the setting value or 10 ms
<i>Thermal overload protection (ANSI 49)</i>	
Factor k acc. to IEC 60255-8	0.1 to 4 (steps 0.01)
Time constant τ	1 to 999.9 min (steps 0.1 min)
Thermal alarm stage $\Theta_{Alarm}/\Theta_{Trip}$	50 to 100 % referred to tripping temperature (steps 1 %)
Current-based alarm stage I_{Alarm}	0.1 to 4 A _(1A) / 0.5 to 20 A _(5A) (steps 0.01 A)
Calculating mode for overtemperature	Θ_{max} , Θ_{mean} , Θ with I_{max}
Pickup time characteristic	$t = t \ln \frac{I^2 - I_{pre}^2}{I^2 - (kI_{nom})^2}$
Reset ratio Θ/Θ_{Alarm} Θ/Θ_{Trip} I/I_{Alarm}	Approx. 0.99 Approx. 0.99 Approx. 0.97
Overload measured values	Θ/Θ_{Trip} L1; Θ/Θ_{Trip} L2; Θ/Θ_{Trip} L3; Θ/Θ_{Trip}
Tolerances	Class 10 % acc. to IEC 60255-8
<i>Breaker failure protection (ANSI 50BF)</i>	
Number of stages	2
Pickup of current element	0.05 to 20 A _(1A) / 0.25 to 100 A _(5A) (step 0.01 A)
Time delays $T_{1\ phase}$, $T_{1\ 3\ phase}$, T_2	0 to 30 s (steps 0.01 s) or deactivated
Additional functions	End-fault protection CB pole discrepancy monitoring
Drop-off (overshoot) time, internal	≤ 15 ms, typical; 25 ms, max.
Tolerances Current limit value Time stages	≤ 5 % of setting value or 1 % I_{nom} 1 % of setting value or 10 ms

Auto-reclosure (ANSI 79)	
Number of auto-reclosures	Up to 8
Operating mode	Only 1-pole; only 3-pole, 1 or 3-pole
Operating modes with line voltage check	DLC – dead-line check ADT – adaptive dead time RDT – reduced dead time
Dead times T_{1-PH} , T_{3-PH} , T_{Seq}	0 to 1800 s (step 0.01 s) or deactivated
Action times	0.01 to 300 s (step 0.01 s) or deactivated
Reclaim times	0.5 to 300 s (step 0.01 s)
Start-signal monitoring time	0.01 to 300 s (step 0.01 s)
Additional functions	Synchro-check request 3-phase intertripping InterCLOSE command to the remote end Check of CB ready state Blocking with manual CLOSE
Voltage limit values for DLC, ADT, RDT	
Healthy line voltage V_{PH-E}	30 to 90 V (step 1 V)
Dead line voltage V_{PH-E}	2 to 70 V (step 1 V)
Tolerances	
Time stages	1 % of setting value or 10 ms
Voltage limit values	≤ 3 % of setting value or 1 V
Synchro-check (ANSI 25)	
Initiate options	Auto-reclosure; Manual CLOSE control Control commands
Operating modes With auto-reclosure	Synchro-check Line dead/busbar live Line live/busbar dead Line and busbar dead Bypassing
For manual closure and control commands	As for auto-reclosure
Permissible voltage difference	1 to 60 V (step 0.1 V)
Permissible frequency difference	0.03 to 2 Hz (step 0.01 Hz)
Permissible angle difference	2 to 80 ° (step 1°)
Max. duration of synchronization	0.01 to 600 s (step 0.01 s) or deactivated
Release delay with synchronous networks	0 to 30 s (step 0.01 s)
Minimum measuring time	Approx. 80 ms
Tolerances	
Time stages	1 % of setting value or 10 ms
Voltage limit values	≤ 2 % of setting value or 1 V
Ground-fault detection for compensated / isolated networks	
Zero-sequence voltage $3V_0$	1 to 150 V (step 1 V)
Phase selection with phase voltages $V<$ and $V>$	10 to 100 V (step 1 V)
Directional determination	Active / reactive power measurements
Minimum current for directional determination	3 to 1000 mA (steps 1 mA)
Angle correction for core-balance CT	0 to 5 ° at 2 operating points (step 0.1 °)
Operating modes	Only indication; indication and trip

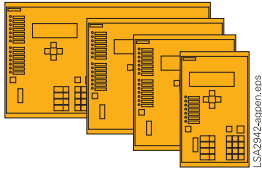
Delay times	0 to 320 s (step 0.01 s)
Pickup time	Approx. 50 ms
Ground-fault measured values	Active and reactive component of ground-fault current I_{EEac} , I_{EErac}
Tolerances	
Voltage limit values	≤ 5 % of setting value or 1 V
Current limit values	≤ 10 % of setting value
Time stages	1 % of setting value or 10 ms
Trip circuit supervision (ANSI 74TC)	
Number of supervisable trip circuits	Up to 3
Number of required binary inputs per trip circuit	1 or 2
Indication relay	1 to 30 s (step 1 s)

Additional functions	
Operational measured values	
Representation	Primary, secondary and percentage referred to rated value
Currents	$3 \times I_{Phase}$; $3I_0$; I_E sensitive; I_1 ; I_2 ; I_Y ; $3I_{OPAR}$
Tolerances	Typ. 0.3 % of indicated measured value or 0.5 % I_{nom}
Voltages	$3 \times V_{Phase-Ground}$; $3 \times V_{Phase-Phase}$; $3V_0$, V_1 , V_2 , V_{SYNC} , V_{en}
Tolerances	Typ. 0.25 % of indicated measured value or 0.01 % V_{nom}
Power with direction indication	P , Q , S
Tolerances	
P: for $ \cos \varphi = 0.7$ to 1 and V/V_{nom} , $I/I_{nom} = 50$ to 120 %	Typical ≤ 1 %
Q: for $ \sin \varphi = 0.7$ to 1 and V/V_{nom} , $I/I_{nom} = 50$ to 120 %	Typical ≤ 1 %
S: for V/V_{nom} , $I/I_{nom} = 50$ to 120 %	Typical ≤ 1 %
Frequency	f
Tolerance	≤ 10 mHz
Power factor	p.f. ($\cos \varphi$)
Tolerance for $ \cos \varphi = 0.7$ to 1	Typical ≤ 0.02
Load impedances with directional indication	$3 \times R_{Phase-Ground}$, $X_{Phase-Ground}$ $3 \times R_{Phase-Phase}$, $X_{Phase-Phase}$
Ground-fault measured values	Active and reactive component of ground-fault current I_{EEac} , I_{EErac}
Overload measured values	Θ/Θ_{Trip} L1; Θ/Θ_{Trip} L2; Θ/Θ_{Trip} L3; Θ/Θ_{Trip}
Long-term mean values	
Interval for derivation of mean value	15 min / 1 min; 15 min / 3 min; 15 min / 15 min
Synchronization instant	Every ¼ hour; every ½ hour; every hour
Values	$3 \times I_{Phase}$; I_1 ; P ; $P+$; $P-$; Q ; $Q+$; $Q-$; S

Distance Protection 7SA6

Technical data

Minimum/maximum memory		Further additional functions	
Indication	Measured values with date and time	Measured value supervision	Current sum Current symmetry Voltage sum Voltage symmetry Phase sequence Fuse failure monitor Power direction
Resetting	Cyclically Via binary input Via the keyboard Via serial interface		
Values		Indications	Buffer size 200 Storage of indications of the last 8 faults, buffer size 600
Min./max. of measured values	$3 \times I_{\text{Phase}}; I_1; 3 \times V_{\text{Phase-Ground}};$ $3 \times V_{\text{Phase-to-phase}}; 3V_0; V_1;$ $P+; P-; Q+; Q-; S; f;$ power factor (+); power factor (-)		
Min./max. of mean values	$3 \times I_{\text{Phase}}; I_1; P; Q; S$	Operational indications	Storage of indications of the last 8 faults, buffer size 200
Energy meters		System disturbance indication	
Four-quadrant meters	$W_{P+}; W_{P-}; W_{Q+}; W_{Q-}$	Ground-fault indication	Storage of indications of the last 8 faults, buffer size 200
Tolerance for $ \cos \varphi > 0.7$ and $V > 50\%$ V_{nom} and $I > 50\%$ I_{nom}	5 %	Switching statistics	Number of breaking operations per CB pole Sum of breaking current per phase Breaking current of last trip operation Max. breaking current per phase
Analog measured value output 0 to 20 mA		Circuit-breaker test	TRIP/CLOSE cycle, 3 phases TRIP/CLOSE per phase
Number of analog channels	2 per plug-in module Alternatively 1 or 2 or no plug-in module (Refer to ordering data, position 11 and Order code for position 12)	Dead time for CB TRIP / CLOSE cycle	0 to 30 s (steps 0.01 s)
Indication range	0 to 22 mA	Commissioning support	Operational measured values, c.-b. test, status display of binary inputs, setting of output relays, generation of indications for testing serial interfaces
Selectable measured values	Fault location [%]; fault location [km]; V_{L23} [%]; I_{L2} [%]; $ P $ [%]; $ Q $ [%]; breaking current $I_{\text{max-primary}}$	Phase rotation adjustment	Clockwise or anti-clockwise
Max. burden	350 Ω	CE conformity	
Oscillographic fault recording		This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 73/23/EEC).	
Analog channels	$3 \times I_{\text{Phase}}, 3I_0, 3I_0 \text{ PAR}$ $3 \times V_{\text{Phase}}, 3\pm 0, V_{\text{SYNG}}, V_{\text{en}}$	This conformity is proved by tests conducted by Siemens AG in accordance with Article 10 of the Council Directive in agreement with the generic standards EN 61000-6-2 and EN 61000-6-4 for the EMC directive and with the standard EN 60255-6 for the low-voltage directive.	
Max. number of available recordings	8, backed-up by battery if auxiliary voltage supply fails	This device is designed and produced for industrial use.	
Sampling intervals	20 samplings per cycle	The product conforms with the international standard of the series IEC 60255 and the German standard VDE 0435.	
Total storage time	> 15 s		
Binary channels	Pickup and trip information; number and contents can be freely configured by the user		
Max. number of displayed binary channels	100		
Control			
Number of switching units	Depends on the number of binary/indication inputs and indication/command outputs		
Control commands	Single command / double command 1, 1 plus 1 common or 2 pole		
Feed back	CLOSE, TRIP, intermediate position		
Interlocking	Freely configurable		
Local control	Control via menu, function keys, control keys (if available)		
Remote control	Control protection, DIGSI, pilot wires		



- Operator panel with:
- 4-line backlit display,
 - function keys,
 - numerical keys,
 - PC interface

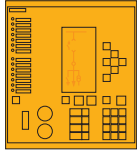
Description								Order No.
7SA61 distance protection relay for all voltage levels								7SA61
Housing, number of LEDs								
Housing width 1/3 19", 7 LEDs								0
Housing width 1/2 19", 14 LEDs								1
Housing width 2/3 19", 14 LEDs								2
Housing width 7/8 19", 14 LEDs								3
Measuring inputs (4 x V/4 x I)								
$I_{ph} = 1 A^{1)}$, $I_e = 1 A^{1)}$ (min. = 0.05 A)								1
$I_{ph} = 1 A^{1)}$, $I_e = \text{sensitive}$ (min. = 0.003 A)								2
$I_{ph} = 5 A^{1)}$, $I_e = 5 A$ (min. = 0.25 A)								5
$I_{ph} = 5 A^{1)}$, $I_e = \text{sensitive}$ (min. = 0.003 A)								6
Rated auxiliary voltage (power supply, binary inputs)								
DC 24 to 48 V, binary input threshold 17 V ³⁾								2
DC 60 to 125 V ²⁾ , binary input threshold 17 V ³⁾								4
DC 110 to 250 V ²⁾ , AC 115 to 230 V, binary input threshold 73 V ³⁾								5
Binary/indication inputs	Indication/command outputs incl. live status contact	Fast relay ⁴⁾	High-speed trip output	Power relay ⁵⁾	Flush-mounting housing/screw-type terminals	Flush-mounting housing/plug-in terminals	Surface-mounting housing/screw-type terminals	
For 7SA610								
5	4	5			■			A
5	4	5					■	E
5	4	5				■		J
7	6				■			B
7	6						■	F
7	6					■		K
For 7SA611								
13	5	12			■			A
13	5	12					■	E
13	5	12				■		J
13	4	8	5		■			M
13	4	8	5				■	N
13	4	8	5			■		P
20	9			4	■			B
20	9			4			■	F
20	9			4		■		K
For 7SA612								
21	13	12			■			A
21	13	12					■	E
21	13	12				■		J
21	12	8	5		■			M
21	12	8	5				■	P
21	12	8	5			■		R
29	21	12			■			B
29	21	12					■	F
29	21	12				■		K
29	20	8	5		■			N
29	20	8	5				■	Q
29	20	8	5			■		S
33	12			8	■			C
33	12			8			■	G
33	12			8		■		L
For 7SA613								
21	13	12			■			A
21	12	8	5		■			M

see pages 6/32 to 6/35

- Rated current can be selected by means of jumpers.
- Transition between the two auxiliary voltage ranges can be selected by means of jumpers.
- The binary input thresholds are selectable in three stages by means of jumpers, exception: versions with power relays have some binary inputs with only two binary input thresholds.
- Fast relays are identified in the terminal connection diagram.
- Power relay for direct control of disconnector actuator motors. Each pair of contacts is mechanically interlocked to prevent simultaneous closure.

Distance Protection 7SA6

Selection and ordering data



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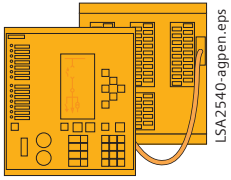
- Operator panel with:
- backlit graphic display for single-line diagram
 - control keys,
 - key-operated switches,
 - function keys,
 - numerical keys,
 - PC interface

Description								Order No.
7SA63 distance protection relay for all voltage levels								7SA63
Housing, number of LEDs								
Housing width 1/2 19", 14 LEDs								1
Housing width 1/1 19", 14 LEDs								2
Measuring inputs (4 x V/4 x I)								
$I_{ph} = 1 A^{1)}$, $I_e = 1 A^{1)}$ (min. = 0.05 A)								1
$I_{ph} = 1 A^{1)}$, $I_e = \text{sensitive}$ (min. = 0.003 A)								2
$I_{ph} = 5 A^{1)}$, $I_e = 5 A$ (min. = 0.25 A)								5
$I_{ph} = 5 A^{1)}$, $I_e = \text{sensitive}$ (min. = 0.003 A)								6
Rated auxiliary voltage (power supply, binary inputs)								
DC 24 to 48 V, binary input threshold 17 V ³⁾								2
DC 60 to 125 V ²⁾ , binary input threshold 17 V ³⁾								4
DC 110 to 250 V ²⁾ , AC 115 to 230 V, binary input threshold 73 V ³⁾								5
Binary/indication inputs	Indication/command outputs incl. live status contact	Fast relay ⁴⁾	High-speed trip output	Power relay ⁵⁾	Flush-mounting housing/ screw-type terminals	Flush-mounting housing/ plug-in terminals	Surface-mounting housing/ screw-type terminals	
For 7SA632								
13	5	12			■			A
13	5	12					■	E
13	5	12				■		J
13	4	8	5		■			M
13	4	8	5				■	N
13	4	8	5			■		P
20	9			4	■			B
20	9			4			■	F
20	9			4		■		K
For 7SA632								
21	13	12			■			A
21	13	12					■	E
21	13	12				■		J
21	12	8	5		■			M
21	12	8	5				■	P
21	12	8	5			■		R
29	21	12			■			B
29	21	12					■	F
29	21	12				■		K
29	20	8	5		■			N
29	20	8	5				■	Q
29	20	8	5			■		S
33	12			8	■			C
33	12			8			■	G
33	12			8		■		L

see pages 6/32 to 6/35

- 1) Rated current can be selected by means of jumpers.
- 2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.
- 3) The binary input thresholds are selectable in three stages by means of jumpers, exception: versions with power relays have some binary inputs with only two binary input thresholds.

- 4) Fast relays are identified in the terminal connection diagram.
- 5) Power relay for direct control of disconnecter actuator motors. Each pair of contacts is mechanically interlocked to prevent simultaneous closure.



Units with detached operator panel with:

- backlit graphic display
- control keys,
- key-operated switches,
- function keys,
- numerical keys,
- PC interface

Description							Order No.
7SA64 distance protection relay for all voltage levels							7SA64
Housing, number of LEDs							
Housing width ½ 19", 14 LEDs							1
Housing width ⅓ 19", 14 LEDs							2
Measuring inputs (4 x V/4 x I)							
$I_{ph} = 1 A^{1)}$, $I_e = 1 A^{1)}$ (min. = 0.05 A)							1
$I_{ph} = 1 A^{1)}$, $I_e = \text{sensitive}$ (min. = 0.003 A)							2
$I_{ph} = 5 A^{1)}$, $I_e = 5 A$ (min. = 0.25 A)							5
$I_{ph} = 5 A^{1)}$, $I_e = \text{sensitive}$ (min. = 0.003 A)							6
Rated auxiliary voltage (power supply, binary inputs)							
DC 24 to 48 V, binary input threshold 17 V ³⁾							2
DC 60 to 125 V ²⁾ , binary input threshold 17 V ³⁾							4
DC 110 to 250 V ²⁾ , AC 115 to 230 V, binary input threshold 73 V ³⁾							5
Binary/indication inputs	Indication/command outputs incl. live status contact	Fast relay ⁴⁾	High-speed trip output	Power relay ⁵⁾	Flush-mounting housing/ screw-type terminals	Flush-mounting housing/ plug-in terminals	
For 7SA641							
13	5	12			■		A
13	5	12				■	J
13	4	8	5		■		M
13	4	8	5			■	P
20	9			4	■		B
20	9			4		■	K
For 7SA642							
21	13	12			■		A
21	13	12				■	J
21	12	8	5		■		M
21	12	8	5			■	R
29	21	12			■		B
29	21	12				■	K
29	20	8	5		■		N
29	20	8	5			■	S
29	12			8	■		C
33	12			8		■	L

see pages 6/32 to 6/35

- 1) Rated current can be selected by means of jumpers.
- 2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.
- 3) The binary input thresholds are selectable in three stages by means of jumpers, exception: versions with power relays have some binary inputs with only two binary input thresholds.

- 4) Fast relays are identified in the terminal connection diagram.
- 5) Power relay for direct control of disconnector actuator motors. Each pair of contacts is mechanically interlocked to prevent simultaneous closure.

Distance Protection 7SA6

Selection and ordering data

Description	Order No.	Order code
7SA6 distance protection relay for all voltage levels	7SA6□□□-□□□□□□□□□□□□□□	
Region-specific default settings / language settings ¹⁾		
Region DE, language: German	A	see pages 6/33 to 6/35
Region World, language: English (GB)	B	
Region US, language: English (US)	C	
Region FR, French	D	
Region World, Spanish	E	
Region World, Italian	F	
Region World, language: Russian	G	
Region World, language: Polish	H	
Port B		
Empty	0	
System interface, IEC 60870-5-103 protocol, electrical RS232	1	
System interface, IEC 60870-5-103 protocol, electrical RS485	2	
System interface, IEC 60870-5-103 protocol, optical 820 nm, ST connector	3	
System interface, PROFIBUS-FMS Slave ²⁾ , electrical RS485	4	
System interface, PROFIBUS-FMS Slave ²⁾ , optical ³⁾ , double ring ³⁾ , ST connector	6	
2 analog outputs, each 0.....20 mA	7	
System interface, PROFIBUS-DP, electrical RS485	9	L O A
System interface, PROFIBUS-DP, optical 820 nm, double ring ³⁾ , ST connector	9	L O B
System interface, DNP 3.0, electrical RS485	9	L O G
System interface, DNP 3.0, optical 820 nm, ST connector ³⁾	9	L O H
System interface, IEC 61850, 100 Mbit/s Ethernet, electrical, duplicate, RJ45 plug connectors	9	L O R
System interface, IEC 61850, 100 Mbit/s Ethernet, optical, double, LC connector ⁴⁾	9	L O S

1) Definitions for region-specific default settings and functions:

Region DE: preset to $f = 50$ Hz and line length in km, only IEC inverse characteristic can be selected, directional earth (ground) fault protection: no logarithmic inverse characteristic, no direction decision with zero-sequence power S_r ; distance protection can be selected with quadrilateral or circle characteristic.

Region US: preset to $f = 60$ Hz and line length in miles, ANSI inverse characteristic only, directional earth (ground) fault protection: no logarithmic inverse characteristic, no direction decision with zero-sequence power S_r , no U_0 inverse characteristic.

Region World: preset to $f = 50$ Hz and line length in km, directional earth (ground) fault protection: no direction decision with zero-sequence power S_r , no U_0 inverse characteristic.

Region FR: preset to $f = 50$ Hz and line length in km, directional earth (ground) fault protection: no U_0 inverse characteristic, no logarithmic inverse characteristic, weak infeed logic selectable between French specification and world specification.

2) For SICAM energy automation systems.

3) Optical double ring interfaces are not available with surface mounting housings.

4) For surface mounting housing applications please order the relay with electrical Ethernet interface and use a separate fiber-optic switch.

Distance Protection 7SA6

Selection and ordering data

Description	Order No.	Order code
7SA6 distance protection relay for all voltage levels	7SA6□□□-□□□□□-□□□□□□□□□□	
Port C and port D		
Port C: DIGSI/modem, electrical RS232, Port D: empty	1	↑ ↑ ↑ ↑ ↑ see pages 6/34 and 6/35
Port C: DIGSI/modem, electrical RS485, Port D: empty	2	
Port C and Port D installed	9	
		M □ □
Port C		
DIGSI/modem, electrical RS232		1
DIGSI/modem, electrical RS485		2
Port D		
Protection data interface: optical 820 nm, two ST connectors, FO cable length up to 1.5 km For direct connection via multi-mode FO cable or communication networks ¹⁾		A
Protection data interface: optical 820 nm, two ST connectors, FO cable length up to 3.5 km For direct connection via multi-mode FO cable		B
Two analog outputs, each 0...20 mA		K
Protection data interface: optical 1300 nm, LC-Duplex connector FO cable length up to 24 km for direct connection via mono-mode FO cable ²⁾		G
Protection data interface: optical 1300 nm, LC-Duplex connector FO cable length up to 60 km for direct connection via mono-mode FO cable ²⁾³⁾		H
Protection data interface: optical 1550 nm, LC-Duplex connector FO cable length up to 100 km for direct connection via mono-mode FO cable ²⁾⁴⁾		J
FO30 optical 820 nm, 2-ST-connector, length of optical fibre up to 1.5 km for multimode fibre, for communication networks with IEEEC37.94 interface or direct optical fibre connection (not available for surface-mounted housing)		S

6

1) For suitable communication converters 7XV5662 (optical to G703.1/X21/RS422 or optical to pilot wire) see "Accessories".
 2) For surface-mounting housing applications an internal fiber-optic module 820 nm will be delivered in combination with an external repeater.
 3) For distances less than 25 km, two optical attenuators 7XV5107-0AA00 are required to avoid optical saturation of the receiver element.
 4) For distances less than 50 km, two optical attenuators 7XV5107-0AA00 are required to avoid optical saturation of the receiver element.

Distance Protection 7SA6

Selection and ordering data

Description				Order No.
7SA6 distance protection relay for all voltage levels				7SA6□□□-□□□□□-□□□□
Functions 1				
Trip mode	Thermal overload protection (ANSI 49)	BCD-coded output for fault location		
3-pole				0
3-pole		■		1
3-pole	■			2
3-pole	■	■		3
1/3-pole				4
1/3-pole		■		5
1/3-pole	■			6
1/3-pole	■	■		7
Functions 2				
Distance protection pickup (ANSI 21, 21N)	Power swing detection (ANSI 68, 68T)	Parallel line compensation		
$I >$				A
$V < I >$				B
Quadrilateral ($Z <$)				C
Quadrilateral ($Z <$), $V < I > / \varphi$				D
Quadrilateral ($Z <$)	■			F
Quadrilateral ($Z <$), $V < I > / \varphi$	■			G
$V < I >$		■ 1)		J
Quadrilateral ($Z <$)		■ 1)		K
Quadrilateral ($Z <$), $V < I > / \varphi$		■ 1)		L
Quadrilateral ($Z <$)	■	■ 1)		N
Quadrilateral ($Z <$), $V < I > / \varphi$	■	■ 1)		P
Functions 3				
Auto-reclosure (ANSI 79)	Synchro-check (ANSI 25)	Breaker failure protection (ANSI 50BF)	Over/undervoltage protection $V >$, $V <$ (ANSI 27, 59) Over/underfrequency protection (ANSI 81)	
			■	A
		■		B
		■	■	C
	■		■	D
	■		■	E
	■	■		F
	■	■	■	G
■		■	■	H
■			■	J
■		■		K
■		■	■	L
■	■			M
■	■		■	N
■	■	■		P
■	■	■	■	Q
■	■	■	■	R
Functions 4				
Directional ground-fault protection, grounded networks (ANSI 50N, 51N, 67N)	Ground-fault detection compensated/ isolated networks	Measured values extended Min, max, mean		
				0
		■		1
	■ 2)			2
	■ 2)	■		3
■				4
■		■		5
■	■ 2)			6
■	■ 2)	■		7

1) Only with position 7 of Order No. = 1 or 5.

2) Only with position 7 of Order No. = 2 or 6.

Distance Protection 7SA6

Selection and ordering data

Description													Order No.					
7SA6 distance protection relay for all voltage levels													7SA6□□□-□□□□□-□□□□					
Preferential types Functions 1																		
Trip mode, 3-pole	Trip mode 1 or 3-pole	Pickup $I >$	Pickup $V < I / >$	$Z < \text{(quadrilateral)} V < I > \varphi$	Power swing detection	Parallel line compensation	Auto-reclosure	Synchro-check	Breaker failure protection	Voltage protection Frequency protection	Ground-fault protection directional for grounded networks	Ground-fault directional for compensated isolated networks	Overload protection	Measured values, extended, min. max. mean				
<i>Basic version</i>																		
<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>								<input checked="" type="checkbox"/>								1 A B 0
<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>								<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>				1 A B 1
<i>Medium voltage, cables</i>																		
<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>						<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> 1)	<input checked="" type="checkbox"/>					3 B D 6
<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>						<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> 1)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>				1 B D 7
<i>Medium voltage, overhead lines</i>																		
<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> 1)	<input checked="" type="checkbox"/>					3 B M 6
<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> 1)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>				3 B M 7
<i>High voltage, cables</i>																		
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<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>				3 G H 5
<i>High voltage, overhead lines</i>																		
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> 2)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>					7 P R 4
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> 2)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>				7 P R 5

1) Only with position 7 of Order No. = 2 or 6.




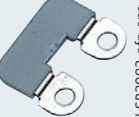

2) Only with position 7 of Order No. = 1 or 5.

Distance Protection 7SA6

Selection and ordering data

Accessories	Description	Order No.
	DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
	Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
	Professional + IEC 61850 Complete version: DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for control displays), DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	7XS5403-0AA00
	IEC 61850 System configurator Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM	7XS5460-0AA00
	SIGRA 4 Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000 or XP Professional Edition (generally contained in DIGSI Professional, but can be ordered additionally). Authorization by serial number. On CD-ROM.	7XS5410-0AA00
	Connecting cable (copper) Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	7XV5100-4
	Voltage transformer miniature circuit-breaker Rated current 1.6 A; thermal overload release 1.6 A; overcurrent trip 6 A	3RV1611-1AG14
	Manual for 7SA6 English, V4.70 and higher	C53000-G1176-C156-7
	German, V4.70	C53000-G1100-C156-8

Accessories	Description	Order No.
	Opto-electric communication converters	
	Optical to X21/RS422 or G703.1	7XV5662-0AA00
	Optical to pilot wires	7XV5662-0AC00
	Additional interface modules	
	Protection data interface FO 5, OMA1, 820 nm, multi-mode FO cable, ST connector, 1.5 km	C53207-A351-D651-1
	Protection data interface FO 6, OMA2, 820 nm, multi-mode FO cable, ST connector, 3.5 km	C53207-A351-D652-1
	Protection data interface FO 17, 1300 nm, mono-mode FO cable, LC-Duplex connector, 24 km	C53207-A322-B115-3
	Protection data interface FO 18, 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	C53207-A322-B116-3
	Protection data interface FO 19, 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	C53207-A322-B117-3
	Optical repeaters	
	Serial repeater (2-channel), opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 24 km	7XV5461-0BG00
	Serial repeater (2-channel), opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	7XV5461-0BH00
	Serial repeater (2-channel), opt. 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	7XV5461-0BJ00

Accessories	Description	Order No.	Size of package	Supplier	Fig.
 <p>Fig. 6/34 Mounting rail for 19" rack</p> <p>LSP2289-afp.eps</p>	Connector	2-pin 3-pin	1 1	Siemens Siemens	6/35 6/36
	 <p>Fig. 6/35 2-pin connector</p> <p>LSP2090-afp.eps</p>  <p>Fig. 6/36 3-pin connector</p> <p>LSP2091-afp.eps</p>	Crimp connector	CI2 0.5 to 1 mm ²	4000 1	AMP ¹⁾ AMP ¹⁾
CI2 0.5 to 2.5 mm ²			4000 1	AMP ¹⁾ AMP ¹⁾	
Type III+ 0.75 to 1.5 mm ²			4000 1	AMP ¹⁾ AMP ¹⁾	
For type III+ and matching female			1	AMP ¹⁾	
 <p>Fig. 6/37 Short-circuit link for current contacts</p> <p>LSP2093-afp.eps</p>  <p>Fig. 6/38 Short-circuit link for voltage contacts/indications contacts</p> <p>LSP2092-afp.eps</p>	Crimping tool	For CI2 and matching female	1	AMP ¹⁾	
		For CI2 and matching female	1	AMP ¹⁾	
	19"-mounting rail	C73165-A63-D200-1	1	Siemens	6/34
	Short-circuit links	For current terminals	1	Siemens	6/37
		For other terminals	1	Siemens	6/38
	Safety cover for terminals	large	1	Siemens	6/4
		small	1	Siemens	6/4

1) Your local Siemens representative can inform you on local suppliers.

Distance Protection 7SA6

Connection diagram

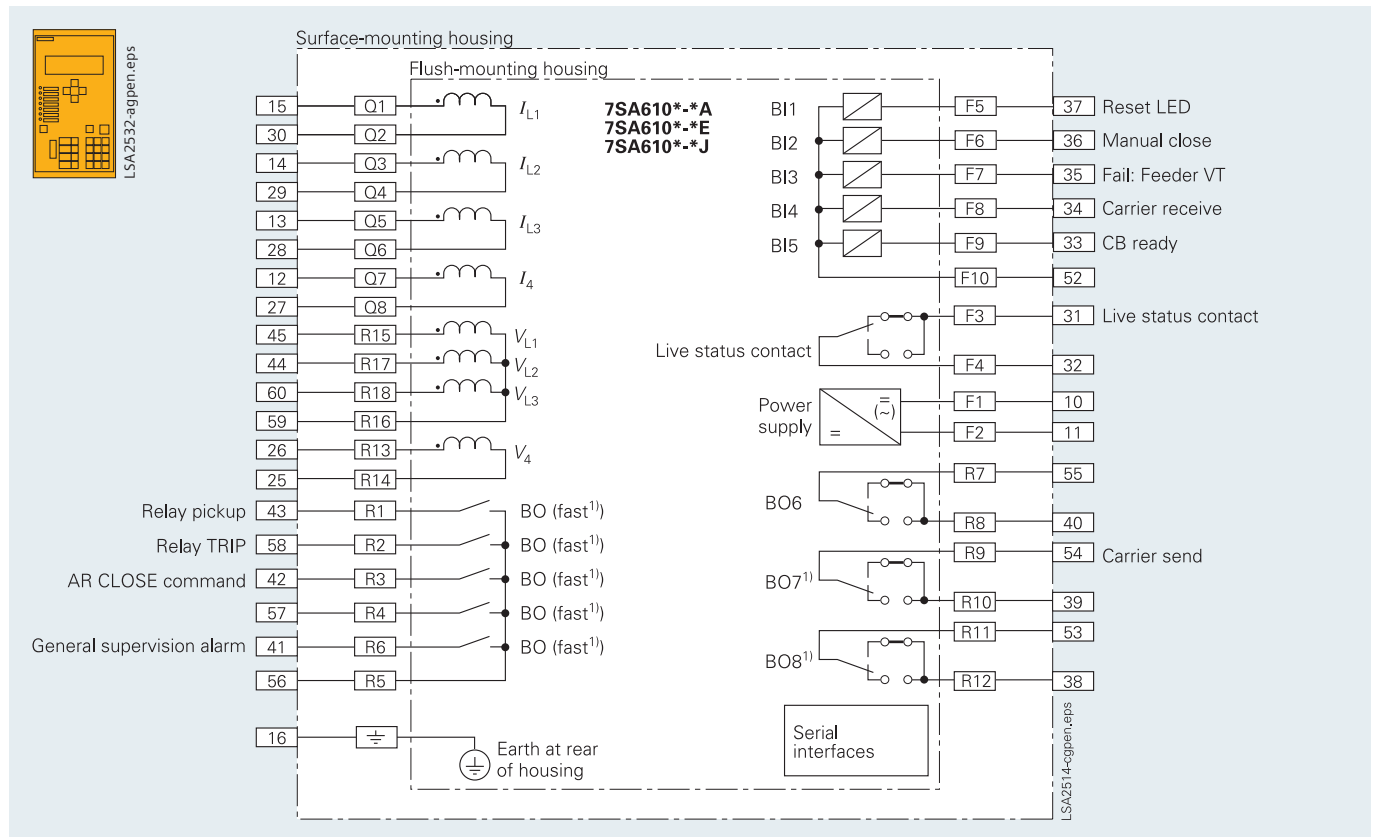


Fig. 6/39 Connection diagram

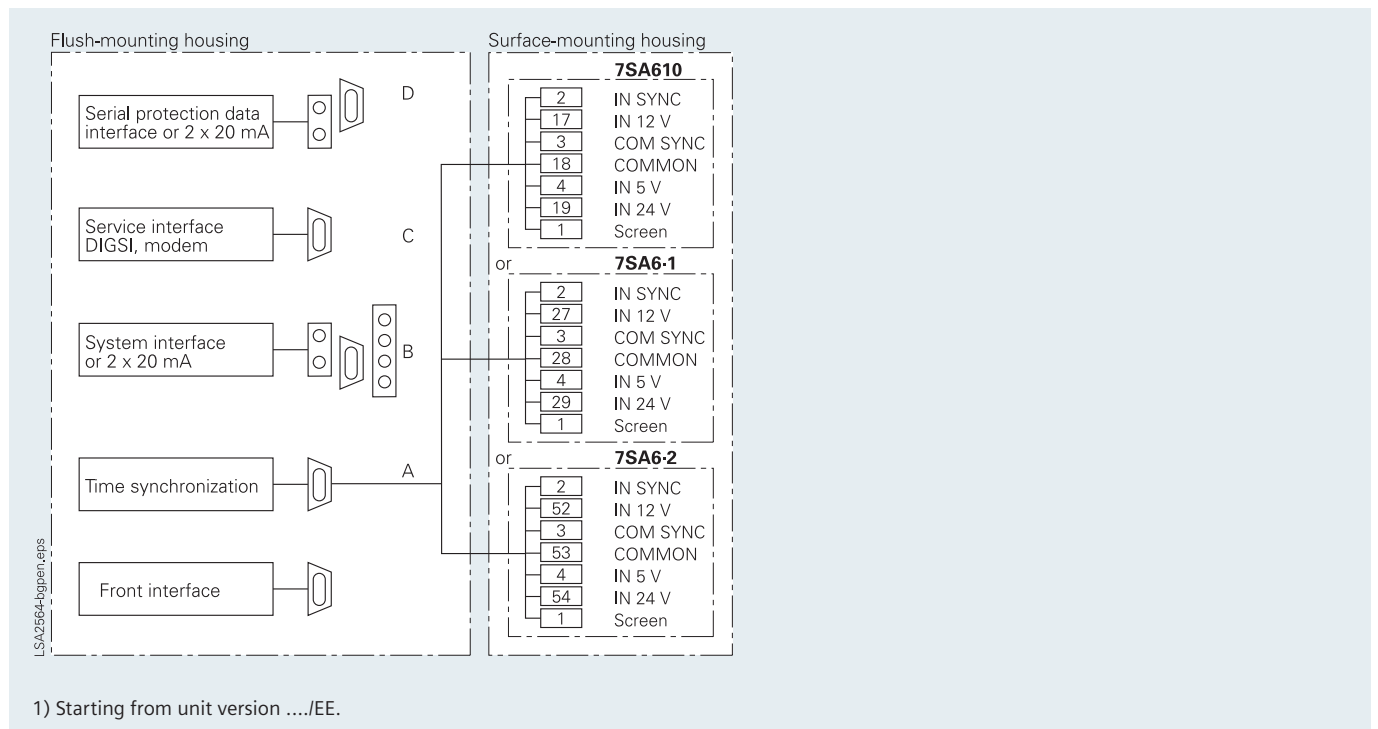


Fig. 6/40 Serial interfaces

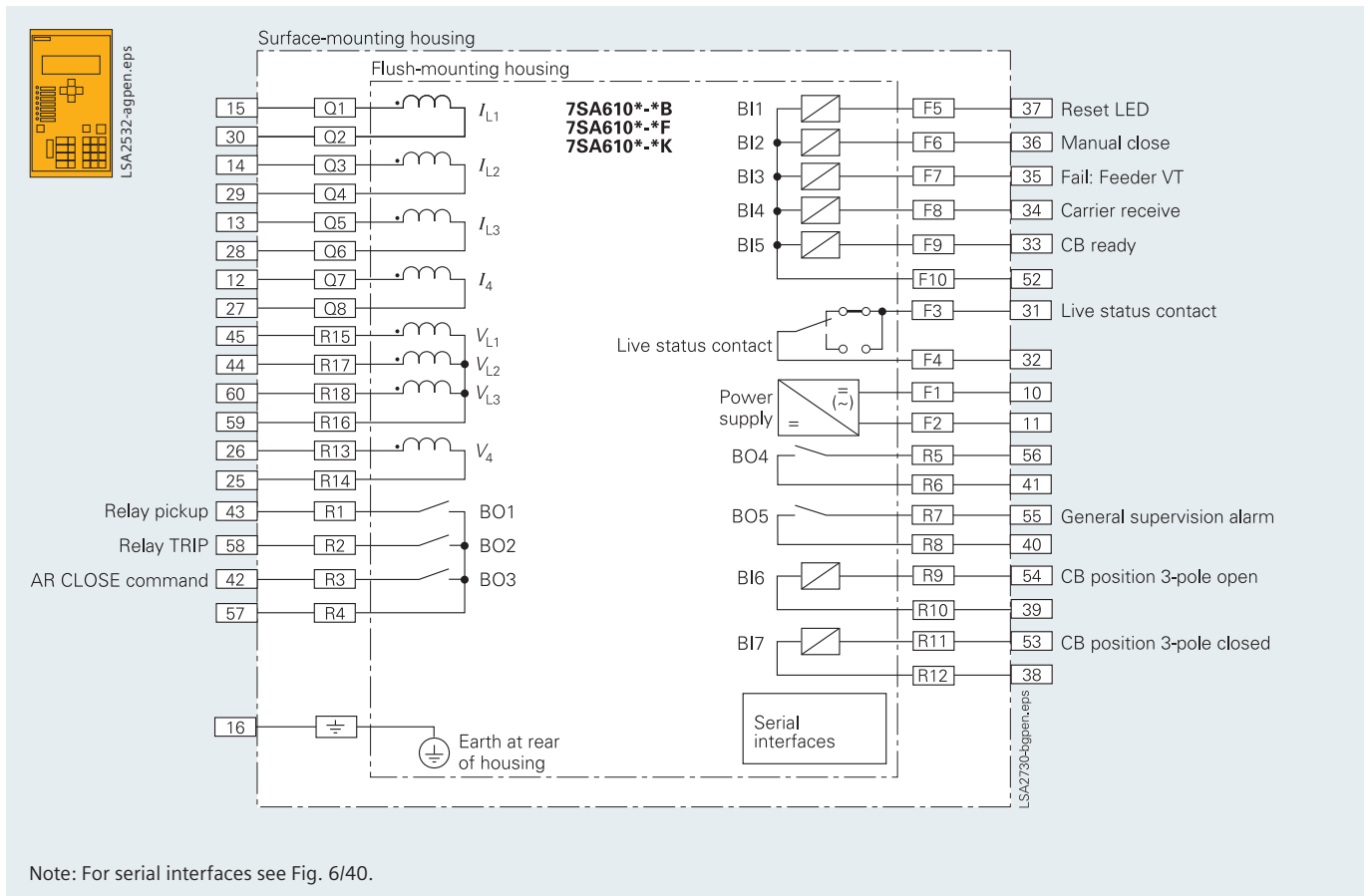
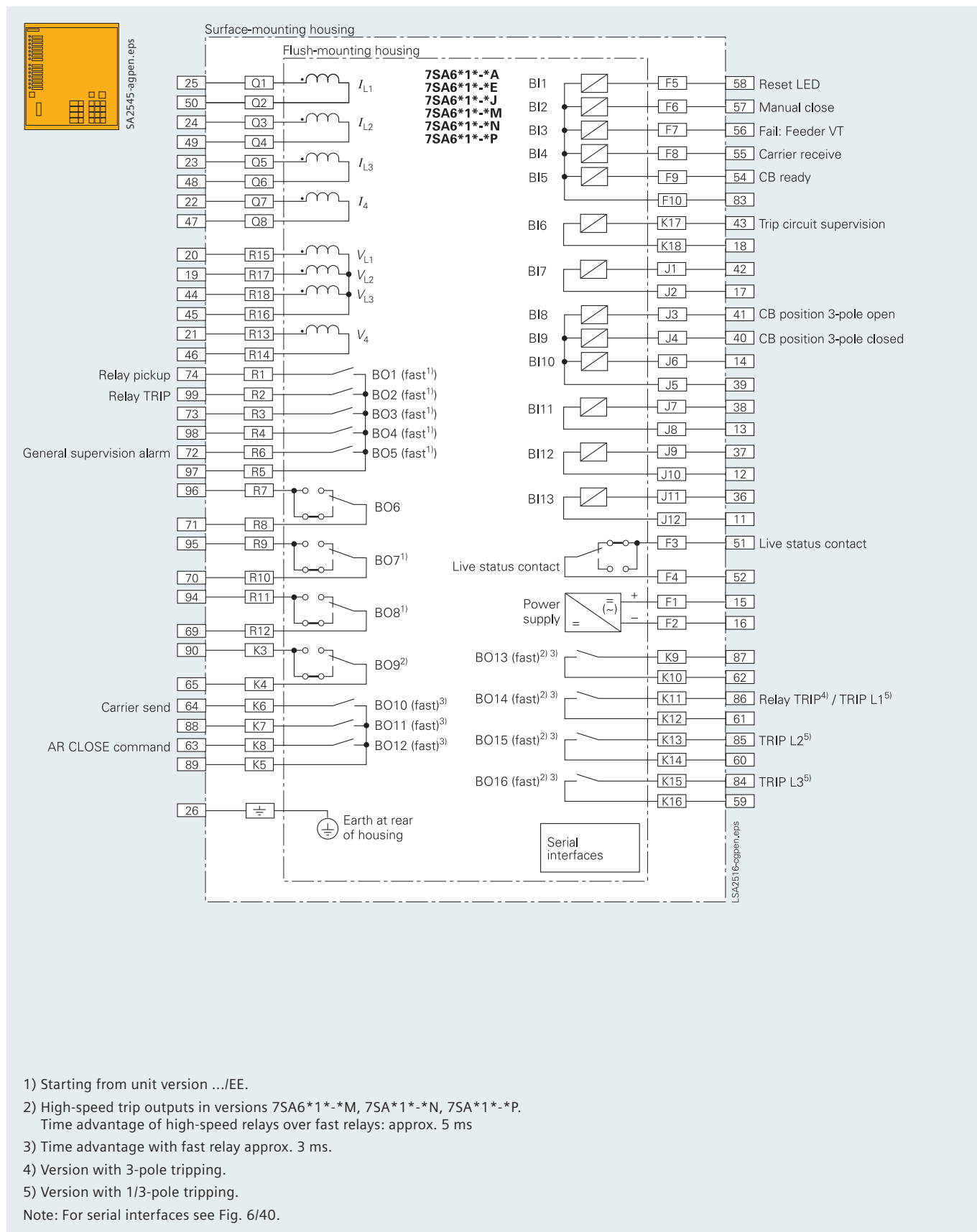


Fig. 6/41 Connection diagram

Distance Protection 7SA6

Connection diagram



1) Starting from unit version .../EE.

2) High-speed trip outputs in versions 7SA6*1*-*M, 7SA*1*-*N, 7SA*1*-*P.
Time advantage of high-speed relays over fast relays: approx. 5 ms

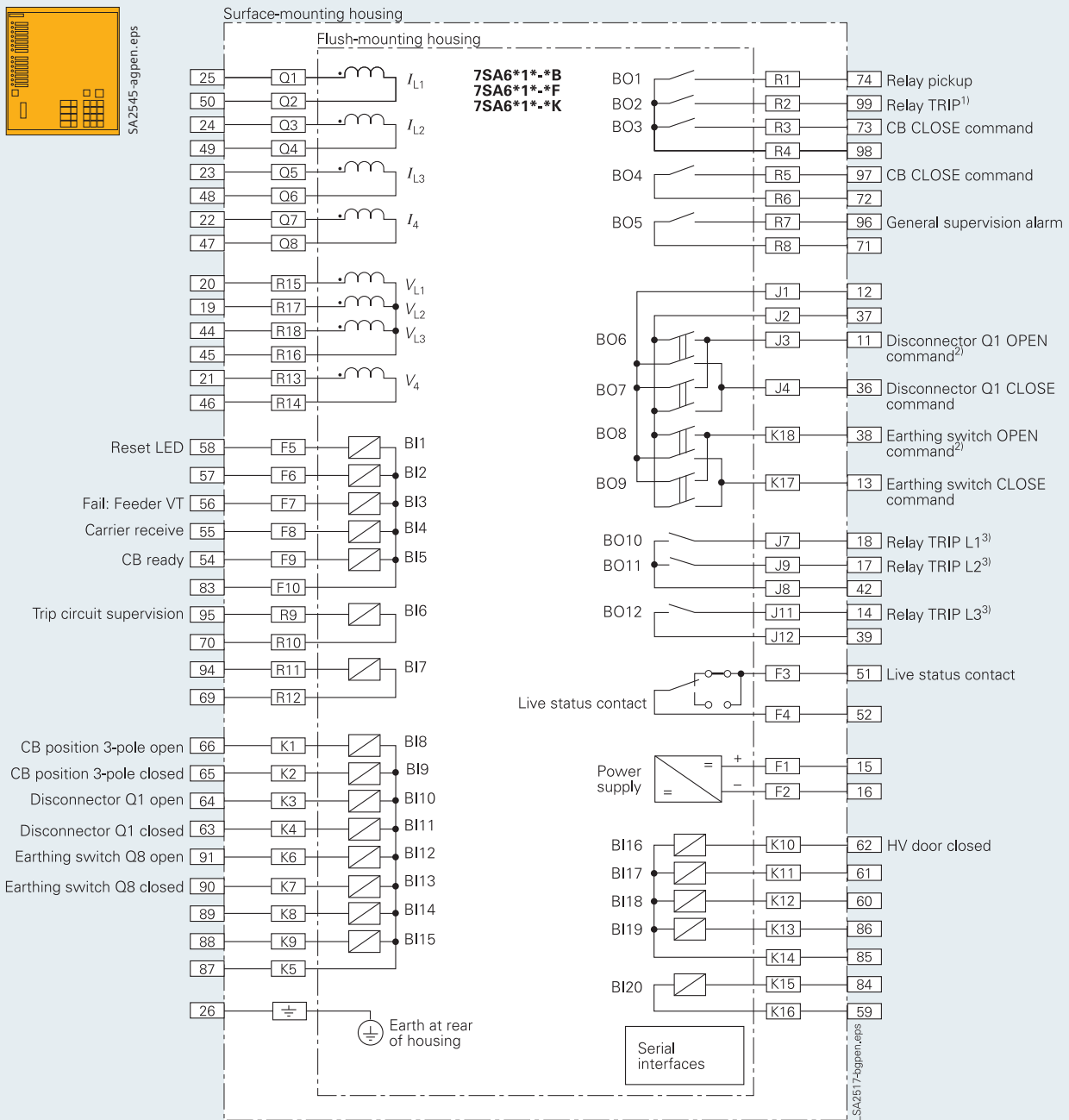
3) Time advantage with fast relay approx. 3 ms.

4) Version with 3-pole tripping.

5) Version with 1/3-pole tripping.

Note: For serial interfaces see Fig. 6/40.

Fig. 6/42 Connection diagram

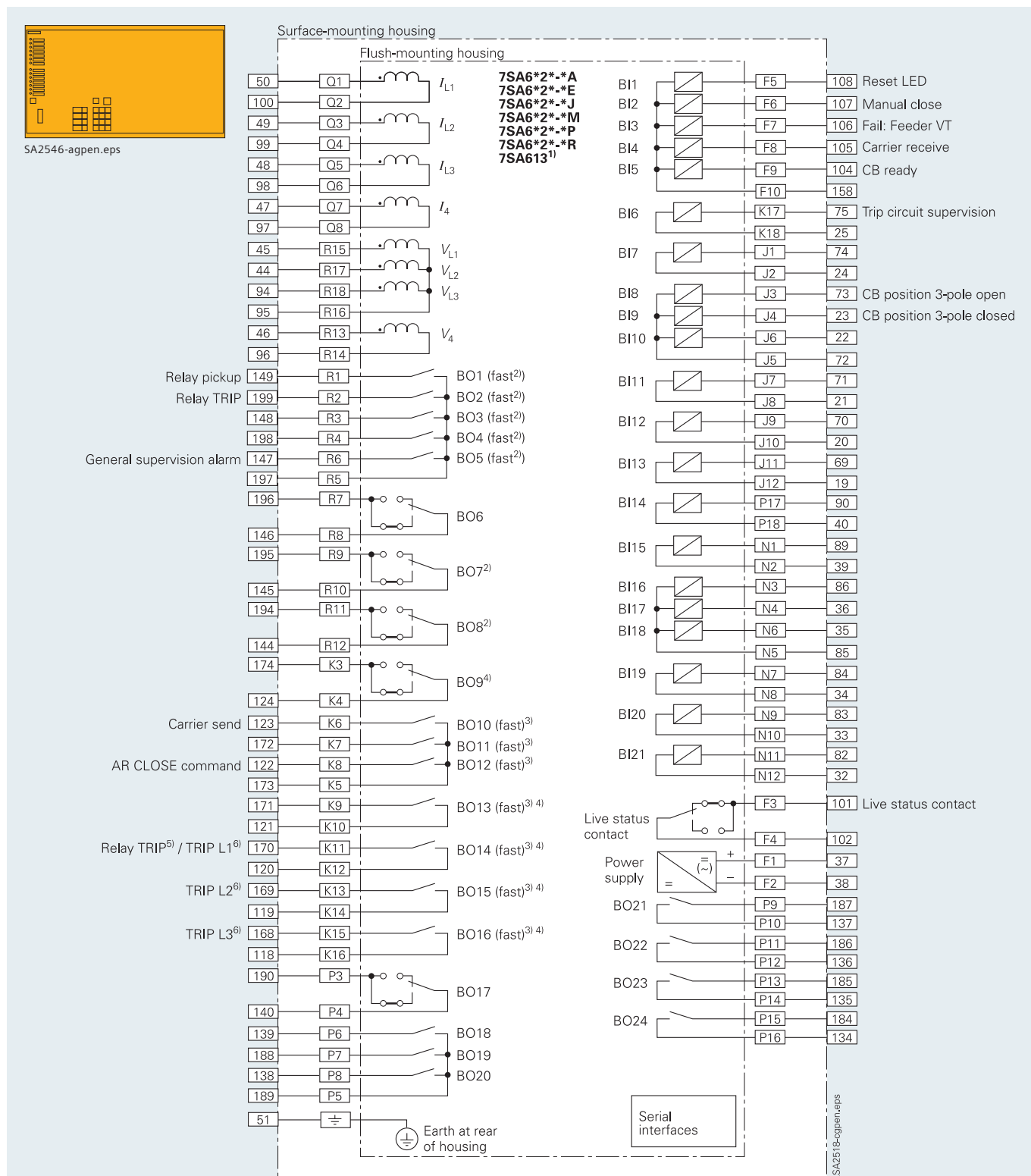


- 1) Version with 3-pole tripping.
 - 2) Each pair of contacts is mechanically interlocked to prevent simultaneous closure.
 - 3) Version with 1/3-pole tripping.
- Note: For serial interfaces see Fig. 6/40.

Fig. 6/43 Connection diagram

Distance Protection 7SA6

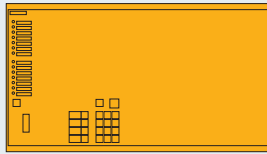
Connection diagram



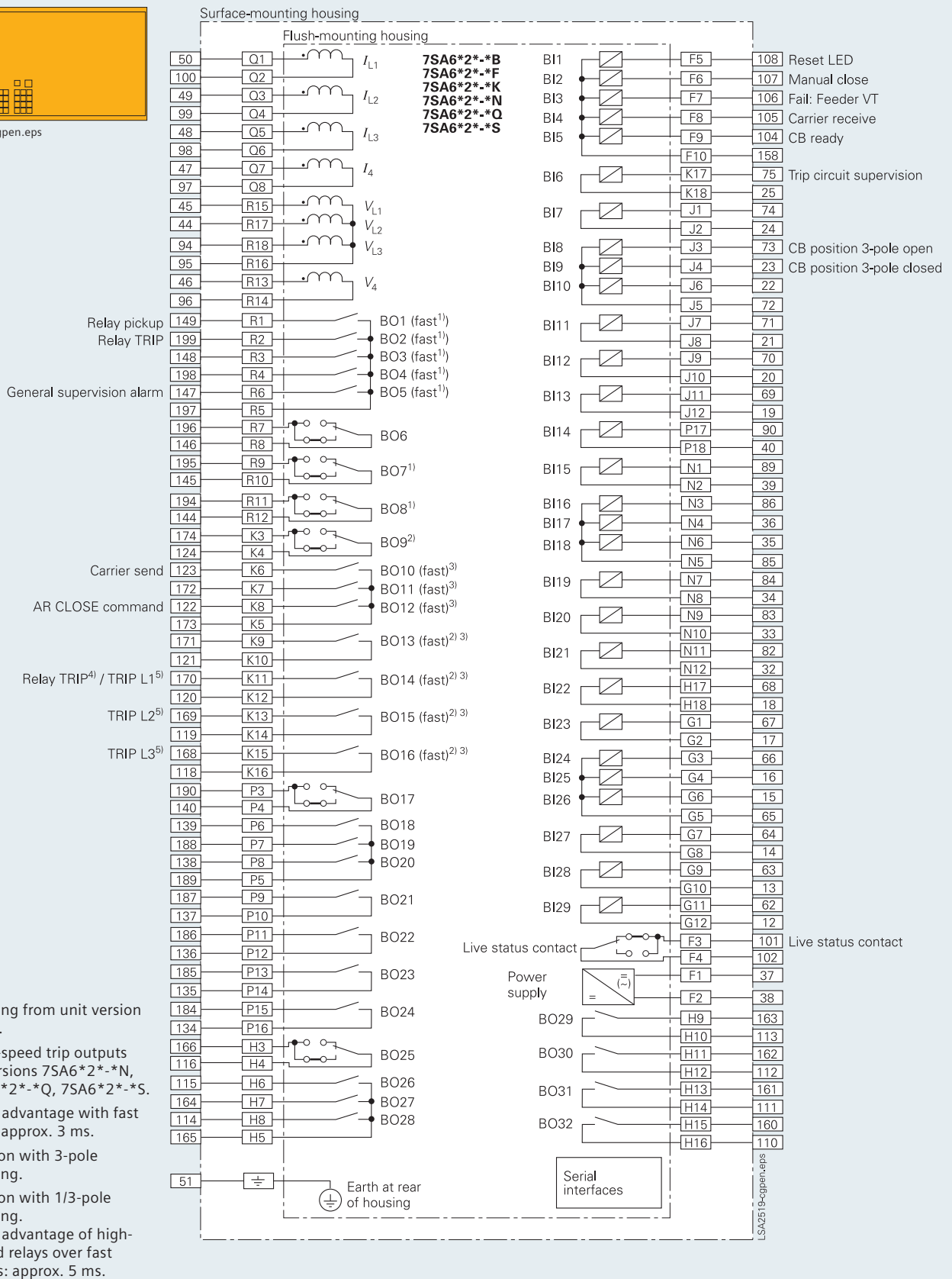
- 1) 7SA613 is only available in a 2/3 x 19" flush-mounting housing.
- 2) Starting from unit version .../EE
- 3) Time advantage with fast relay approx. 3 ms.
- 4) High-speed trip outputs in versions 7SA6*2*-*M, 7SA6*2*-*P, 7SA6*2*-*R.
Time advantage of high-speed relays over fast relays: approx. 5 ms

- 5) Version with 3-pole tripping.
 - 6) Version with 1/3-pole tripping.
- Note: For serial interfaces see Fig. 6/40.

Fig. 6/44 Connection diagram



SA2546-agpen.eps



- Starting from unit version .../EE.
 - High-speed trip outputs in versions 7SA6*2*-*N, 7SA6*2*-*Q, 7SA6*2*-*S.
 - Time advantage with fast relay approx. 3 ms.
 - Version with 3-pole tripping.
 - Version with 1/3-pole tripping. Time advantage of high-speed relays over fast relays: approx. 5 ms.
- Note: For serial interfaces see Fig. 6/40.

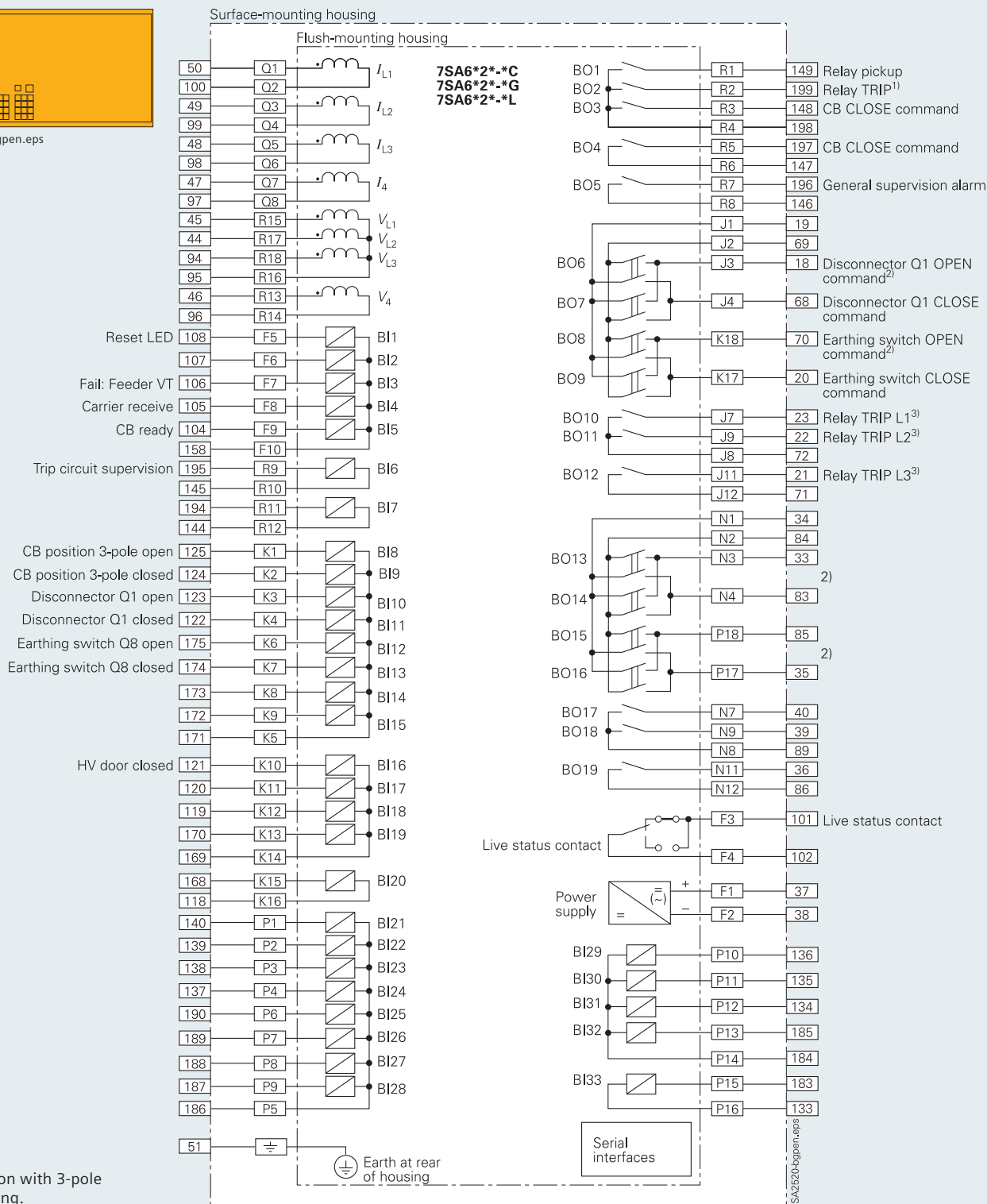
Fig. 6/45 Connection diagram

Distance Protection 7SA6

Connection diagram



SA2546-agpen.eps



1) Version with 3-pole tripping.

2) Each pair of contacts is mechanically interlocked to prevent simultaneous closure.

3) Version with 1/3-pole tripping.

Note: For serial interfaces see Fig. 6/40.

Fig. 6/46 Connection diagram

Distance Protection 7SA522

SIPROTEC 4 7SA522 distance protection relay for transmission lines



Fig. 6/47 SIPROTEC 4 7SA522 distance protection relay

Description

The SIPROTEC 4 7SA522 relay provides full-scheme distance protection and incorporates all functions usually required for the protection of a power line. The relay is designed to provide fast and selective fault clearance on transmission and subtransmission cables and overhead lines with or without series capacitor compensation. The power system star point can be solid or resistance grounded (earthed), resonant-grounded via Peterson coil or isolated. The 7SA522 is suitable for single-pole and three-pole tripping applications with and without tele (pilot) protection schemes.

- The 7SA522 incorporates several protective functions usually required for transmission line protection.
- High-speed tripping time
- Suitable for cables and overhead lines with or without series capacitor compensation
- Self-setting power swing detection for power swing frequencies up to 7 Hz
- Digital relay-to-relay communication for two and three terminal topologies
- Adaptive auto-reclosure (ADT)

Function overview

Protection functions

- Non-switched distance protection with 6 measuring systems (21/21N)
- High resistance ground (earth)-fault protection for single- and three-pole tripping (50N/51N/67N)
- Tele (pilot) protection (85)
- Fault locator (FL)
- Power swing detection/tripping (68/68T)
- Phase-overcurrent protection (50/51/67)
- STUB bus overcurrent protection (50 STUB)
- Switch-onto-fault protection (50HS)
- Over/undervoltage protection (59/27)
- Over/underfrequency protection (81O/U)
- Auto-reclosure (79)
- Synchro-check (25)
- Breaker failure protection (50BF)

Control functions

- Commands for control of CB and isolators

Monitoring functions

- Trip circuit supervision (74TC)
- Self-supervision of the relay
- Measured-value supervision
- Event logging/fault logging
- Oscillographic fault recording
- Switching statistics

Front design

- User-friendly local operation with numeric keys
- LEDs for local alarm
- PC front port for convenient relay setting
- Function keys

Communication interfaces

- Front interface for connecting a PC
- System interface for connecting to a control system via various protocols
 - IEC 61850 Ethernet
 - IEC 60870-5-103 protocol
 - PROFIBUS-FMS/-DP
 - DNP 3.0
- 2 serial protection data interfaces for tele (pilot) protection
- Rear-side service/modem interface
- Time synchronization via IRIG B or DCF77 or system interface

Hardware

- Binary inputs: 8/16/24
- Output relays: 16/24/32
- High-speed trip outputs: 5 (optional)

Distance Protection 7SA522

Application

Application

The 7SA522 relay provides full-scheme distance protection and incorporates all functions usually required for the protection of a power line. The relay is designed to provide fast and selective fault clearance on transmission and subtransmission cables and overhead lines with or without series capacitor compensation. This contributes towards improved stability and availability of your electrical power transmission system. The power system star point can be solid or impedance grounded (earthed), resonant-grounded via Peterson coil or isolated. The 7SA522 is suitable for single and three-pole tripping applications with and without tele (pilot) protection schemes.

The effect of apparent impedances in unfaulted fault loops is eliminated by a sophisticated and improved method which uses pattern recognition with symmetrical components and load compensation. The correct phase selection is essential for selective tripping and reliable fault location.

During network power swings, an improved power swing blocking feature prevents the distance protection from unwanted tripping and optionally provides controlled tripping in the event of loss of synchronism (out of step). This function guarantees power transmission even under critical network operating conditions.

Cost-effective power system management

The SIPROTEC 4 units are numerical relays which also provide control and monitoring functions and therefore support the user in view of a cost-effective power system management. The security and reliability of power supply is increased as a result of minimizing the use of hardware.

The local operation has been designed according to ergonomic criteria. Large, easy-to-read backlit displays are provided.

The SIPROTEC 4 units have a uniform design and a degree of functionality which represents a benchmark-level of performance in protection and control. If the requirements for protection, control and interlocking change, it is possible in the majority of the cases to implement such changes by means of parameterization using DIGSI 4 without having to change the hardware.

The use of powerful microcontrollers and the application of digital measured-value conditioning and processing largely suppresses the influence of higher-frequency transients, harmonics and DC components.

Features

- High speed tripping time
- Suitable for cables and overhead lines with or without series capacitor compensation
- Self setting power swing detection frequencies up to 7 Hz
- Digital relay-to-relay communication for two and three terminal topologies
- Adaptive auto-reclosure (ADT)

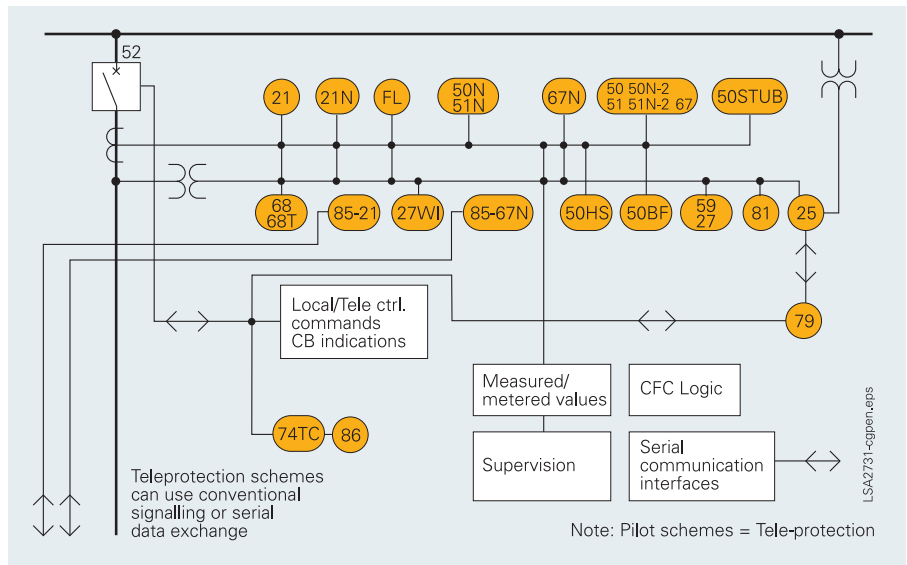


Fig. 6/48 Single-line diagram

ANSI	Protection functions
21/21N	Distance protection
FL	Fault locator
50N/51N/67N	Directional earth(ground)-fault protection
50/51/67	Backup overcurrent protection
50 STUB	STUB-bus overcurrent stage
68/68T	Power swing detection/tripping
85/21	Teleprotection for distance protection
27WI	Weak-infeed protection
85/67N	Teleprotection for earth(ground)-fault protection
50HS	Switch-onto-fault protection
50BF	Breaker-failure protection
59/27	Oversvoltage/undersvoltage protection
81O/U	Over/underfrequency protection
25	Synchro-check
79	Auto-reclosure
74TC	Trip circuit supervision
86	Lockout (CLOSE command interlocking)

Construction

Connection techniques and housing with many advantages

½ and ¼-rack sizes

These are the available housing widths of the SIPROTEC 4 7SA522 relays, referred to a 19" module frame system. This means that previous models can always be replaced. The height is a uniform 245 mm for flush-mounting housings and 266 mm for surface-mounting housings for all housing widths. All cables can be connected with or without ring lugs. Plug-in terminals are available as an option.

It is thus possible to employ prefabricated cable harnesses. In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located in a sloped case at the top and bottom of the housing.

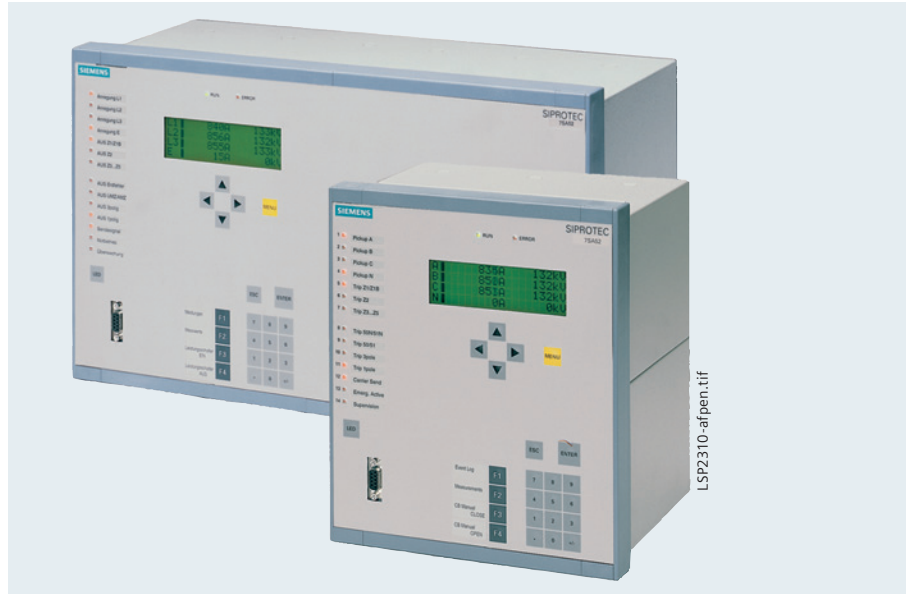


Fig. 6/49 Housing widths ½ × 19" and ¼ × 19"

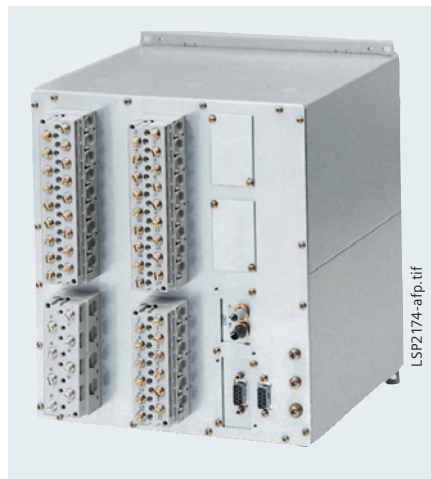


Fig. 6/50 Rear view with screw-type terminals and serial interfaces

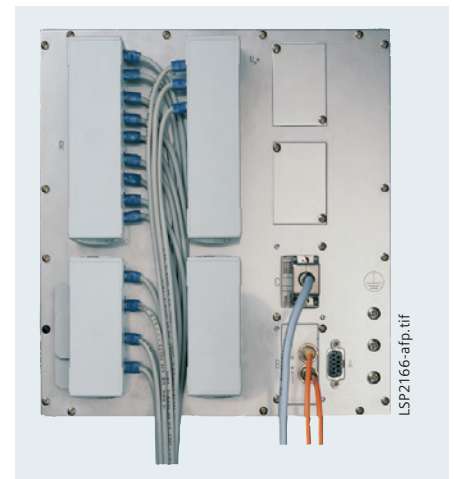


Fig. 6/51 Rear view with terminal covers and wiring

Distance Protection 7SA522

Protection functions

Protection functions

Distance protection (ANSI 21, 21N)

The main function of the 7SA522 is a full-scheme distance protection. By parallel calculation and monitoring of all six impedance loops, a high degree of sensitivity and selectivity is achieved for all types of faults. The shortest tripping time is less than one cycle. Single-pole and three-pole tripping is possible. The distance protection is suitable for cables and overhead lines with or without series capacitor compensation.

Mho and quadrilateral characteristics

The 7SA522 relay provides quadrilateral as well as mho zone characteristics. Both characteristics can be used separately for phase and ground (earth) faults. Resistance ground (earth) faults can, for instance, be covered with the quadrilateral characteristic and phase faults with the mho characteristic.

Load zone

In order to guarantee a reliable discrimination between load operation and short-circuit - especially on long high loaded lines - the relay is equipped with a selectable load encroachment characteristic. Impedances within this load encroachment characteristic prevent the distance zones from unwanted tripping.

Absolute phase-selectivity

The 7SA522 distance protection incorporates a well-proven, highly sophisticated phase selection algorithm. The pickup of unfaulted loops is reliably eliminated to prevent the adverse influence of currents and voltages in the fault-free loops. This phase selection algorithm achieves single-pole tripping and correct distance measurement in a wide application range.

Parallel line compensation

The influence of wrong distance measurement due to parallel lines can be compensated by feeding the neutral current of the parallel line to the relay. Parallel line compensation can be used for distance protection as well as for the fault locator.

7 distance zones

Six independent distance zones and one separate overreach zone are available. Each distance zone has dedicated time stages, partly separate for single-phase or multi-phase faults. Ground (earth) faults are detected by monitoring the neutral current $3I_0$ and the zero-sequence voltage $3V_0$.

The quadrilateral tripping characteristic permits separate setting of the reactance X and the resistance R . The resistance section R can be set separately for faults with and without ground involvement. This characteristic has therefore an optimal performance in case of faults with fault resistance. The distance zones can be set forward, reverse or non-directional. Sound phase polarization and voltage memory provides a dynamically unlimited directional sensitivity.

Mho

The mho tripping characteristic provides sound phase respectively memory polarization for all distance zones. The diagram shows characteristic without the expansion due to polarizing. During a forward fault the polarizing expands the mho circle towards the source so that the origin is included. This mho circle expansion guarantees safe and selective operation for all types of faults, even for close-in faults.

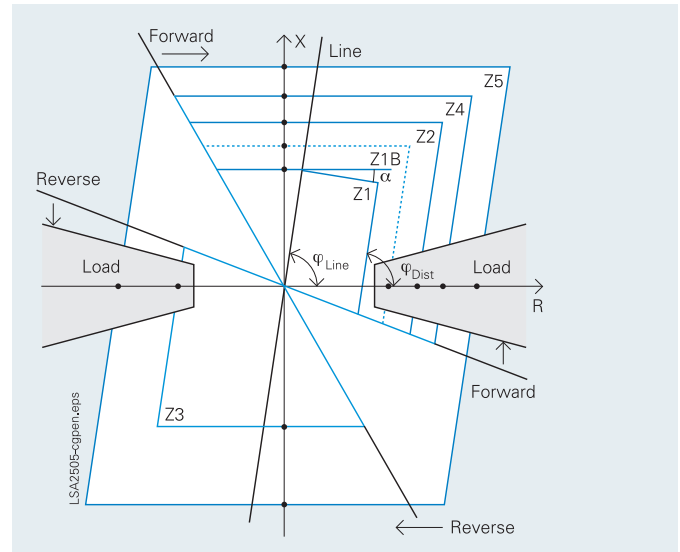


Fig. 6/52 Distance protection: quadrilateral characteristic

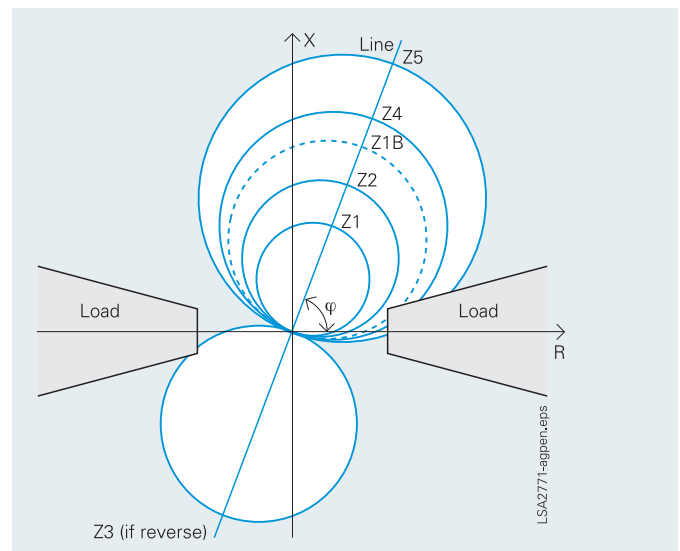


Fig. 6/53 Distance protection: mho characteristic

Elimination of interference signals

Digital filters render the unit immune to interference signals contained in the measured values. In particular, the influence of DC components, capacitive voltage transformers and frequency changes is considerably reduced. A special measuring method is employed in order to assure protection selectivity during saturation of the current transformers.

Measuring voltage monitoring

Tripping of the distance protection is blocked automatically in the event of failure of the measuring voltage, thus preventing spurious tripping.

The measuring voltage is monitored by the integrated fuse failure monitor. Distance protection is blocked if either the fuse failure monitor or the auxiliary contact of the voltage transformer protection switch operates and, in this case, the EMERGENCY definite-time overcurrent protection can be activated.

Fault locator

The integrated fault locator calculates the fault impedance and the distance-to-fault. The result is displayed in ohms, miles, kilometers or in percent of the line length. Parallel line and load current compensation is also available.

Power swing detection (ANSI 68, 68T)

Dynamic transient reactions, for instance short-circuits, load fluctuations, auto-reclosures or switching operations can cause power swings in the transmission network. During power swings, large currents along with small voltages can cause unwanted tripping of distance protection relays. To avoid uncontrolled tripping of the distance protection and to achieve controlled tripping in the event of loss of synchronism, the 7SA522 relay is equipped with an efficient power swing detection function. Power swings can be detected under symmetrical load conditions as well as during single-pole auto-reclosures.

Tele (pilot) protection for distance protection (ANSI 85-21)

A teleprotection function is available for fast clearance of faults up to 100 % of the line length. The following operating modes may be selected:

- PUTT, permissive underreaching zone transfer trip
- POTT, permissive overreaching zone transfer trip
- UNBLOCKING
- BLOCKING
- DUTT, direct underreaching zone transfer trip (together with Direct Transfer Trip function)

The carrier send and receive signals are available as binary inputs and outputs and can be freely assigned to each physical relay input or output. At least one channel is required for each direction.

Common transmission channels are power-line carrier, microwave radio and fiber-optic links. A serial protection data interface for direct connection to a digital communication network or fiber-optic link is available as well.

7SA522 also permits the transfer of phase-selective signals. This feature is particularly advantageous as it ensures reliable single-pole tripping, if two single-pole faults occur on different lines. The transmission methods are suitable also for lines with three ends (three-terminal lines).

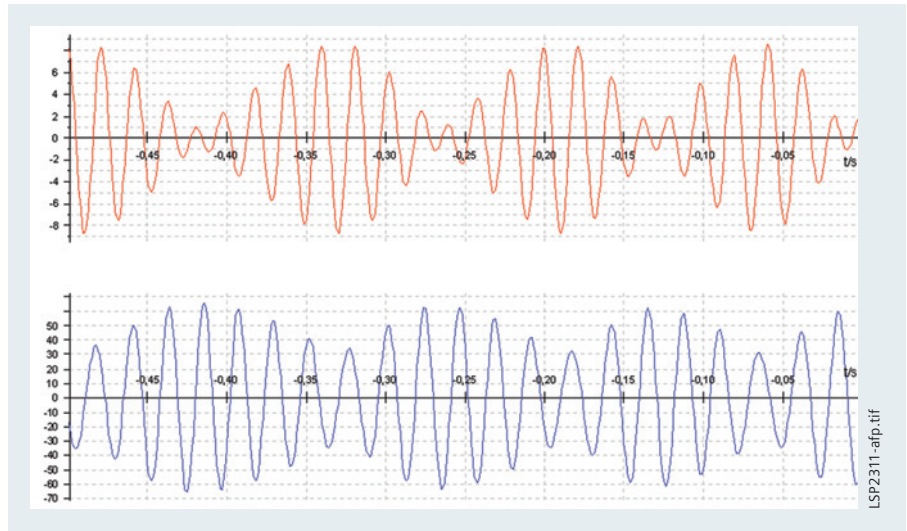


Fig. 6/54 Power swing current and voltage wave forms

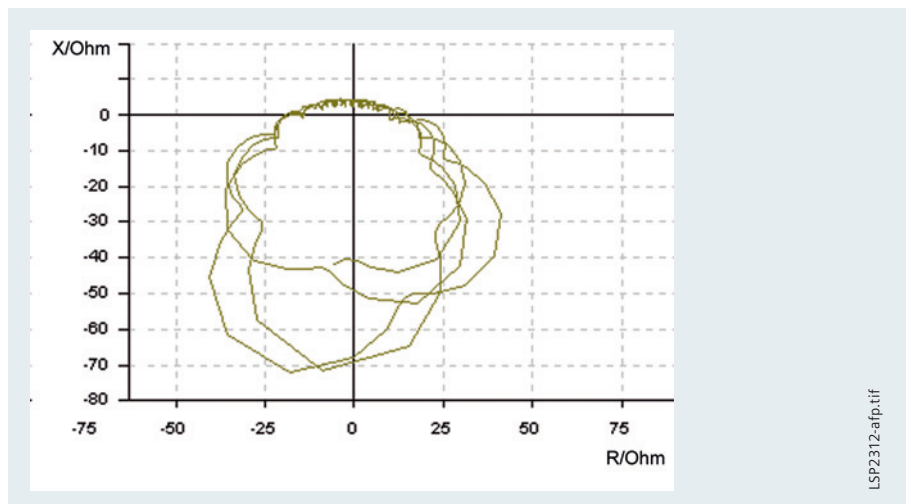


Fig. 6/55 Power swing circle diagram

Phase-selective transmission is also possible with multi-end applications, if some user-specific linkages are implemented by way of the integrated CFC logic. During disturbances in the transmission receiver or on the transmission circuit, the teleprotection function can be blocked by a binary input signal without losing the zone selectivity. The control of the overreach zone Z1B (zone extension) can be switched over to the auto-reclosure function. A transient blocking function (Current reversal guard) is provided in order to suppress interference signals during tripping of parallel lines.

Direct transfer tripping

Under certain conditions on the power system it is necessary to execute remote tripping of the circuit-breaker. The 7SA522 relay is equipped with phase-selective "external trip inputs" that can be assigned to the received inter-trip signal for this purpose.

Distance Protection 7SA522

Protection functions

Weak-infeed protection: echo and/or trip (ANSI 27 WI)

To prevent delayed tripping of permissive schemes during weak or zero infeed situations, an echo function is provided. If no fault detector is picked up at the weak-infeed end of the line, the signal received here is returned as echo to allow accelerated tripping at the strong infeed end of the line. It is also possible to initiate tripping at the weak-infeed end. A phase-selective 1-pole or 3-pole trip is issued if a permissive trip signal (POTT or Unblocking) is received and if the phase-ground voltage drops correspondingly. As an option, the weak infeed logic can be equipped according to a French specification.

Directional ground(earth)-fault protection for high-resistance faults (ANSI 50N, 51N, 67N)

In grounded (earthed) networks, it may happen that the distance protection sensitivity is not sufficient to detect high-resistance ground (earth) faults. The 7SA522 protection relay therefore has protection functions for faults of this nature.

The ground (earth)-fault overcurrent protection can be used with 3 definite-time stages and one inverse-time stage (IDMT). A 4th definite-time stage can be applied instead of the one inverse-time stage.

Inverse-time characteristics according to IEC 60255-3 and ANSI/IEEE are provided (see "Technical data"). An additional logarithmic inverse-time characteristic is also available.

The direction decision can be determined by the neutral current and the zero-sequence voltage or by the negative-sequence components V_2 and I_2 . In addition or as an alternative to the directional determination with zero-sequence voltage, the star-point current of a grounded (earthed) power transformer may also be used for polarization. Dual polarization applications can therefore be fulfilled.

Alternatively, the direction can be determined by evaluation of zero-sequence power. Each overcurrent stage can be set in forward or reverse direction or for both directions (non-directional).

As an option, the 7SA522 relay can be provided with a sensitive neutral (residual) current transformer. This feature provides a measuring range for the neutral (residual) current from 5 mA to 100 A with a nominal relay current of 1 A and from 5 mA to 500 A with a nominal relay current of 5 A. Thus the ground (earth)- fault overcurrent protection can be applied with extreme sensitivity.

The function is equipped with special digital filter algorithms, providing the elimination of higher harmonics. This feature is particularly important for low zero-sequence fault currents which usually have a high content of 3rd and 5th harmonics. Inrush stabilization and instantaneous switch-onto-fault trip can be activated separately for each stage as well.

Different operating modes can be selected. The ground(earth)-fault protection is suitable for three-phase and, optionally, for single-phase tripping by means of a sophisticated phase selector. It may be blocked during the dead time of single-pole auto-reclose cycles or during pickup of the distance protection.

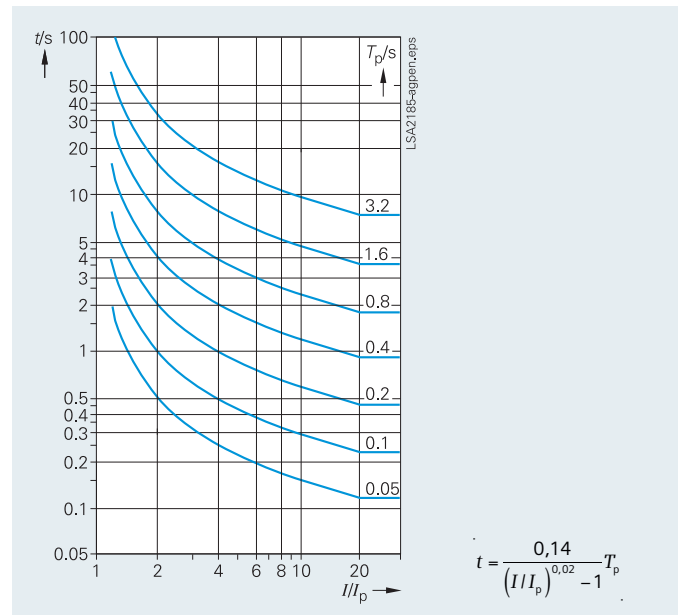


Fig. 6/56 Normal inverse

Tele (pilot) protection for directional ground(earth)-fault protection (ANSI 85-67N)

The directional ground(earth)-fault overcurrent protection can be combined with one of the following teleprotection schemes:

- Directional comparison
- BLOCKING
- UNBLOCKING

The transient blocking function (current reversal guard) is also provided in order to suppress interference signals during tripping of parallel lines.

The pilot functions for distance protection and for ground (earth)-fault protection can use the same signaling channel or two separate and redundant channels.

Backup overcurrent protection (ANSI 50, 50N, 51, 51N, 67)

The 7SA522 provides a backup overcurrent protection. Two definite-time stages and one inverse-time stage (IDMTL) are available, separately for phase currents and for the neutral (residual) current.

The application can be extended to a directional overcurrent protection (ANSI 67) by taking into account the decision of the available direction detection elements.

Two operating modes are selectable. The function can run in parallel to the distance protection or only during failure of the voltage in the VT secondary circuit (emergency operation).

The secondary voltage failure can be detected by the integrated fuse failure monitor or via a binary input from a VT miniature circuit-breaker (VT m.c.b. trip).

Inverse-time characteristics according to IEC 60255-3 and ANSI/IEEE are provided (see "Technical data").

STUB bus overcurrent protection (ANSI 50(N)-STUB)

The STUB bus overcurrent protection is a separate definite-time overcurrent stage. It can be activated from a binary input signaling that the line isolator (disconnecter) is open. Settings are available for phase and ground(earth)-faults.

Instantaneous high-speed switch-onto-fault overcurrent protection (ANSI 50HS)

Instantaneous tripping is possible when energizing a faulty line. In the event of large fault currents, the high-speed switch-onto-fault overcurrent stage can initiate very fast 3-pole tripping.

With lower fault currents, instantaneous tripping after switch-onto-fault is also possible with the overreach distance zone Z1B or just with pickup in any zone.

The switch-onto-fault initiation can be detected via the binary input "manual close" or automatically via measurement.

Overvoltage protection, undervoltage protection (ANSI 59, 27)

A voltage rise can occur on long lines that are operating at no-load or that are only lightly loaded. The 7SA522 contains a number of overvoltage measuring elements. Each measuring element is of two-stage design. The following measuring elements are available:

- Phase-to-ground overvoltage
- Phase-to-phase overvoltage
- Zero-sequence overvoltage
- The zero-sequence voltage can be connected to the 4th voltage input or be derived from the phase voltages.
- Positive-sequence overvoltage of the local end or calculated for the remote end of the line (compounding).
- Negative-sequence overvoltage

Tripping by the overvoltage measuring elements can be effected either at the local circuit-breaker or at the remote station by means of a transmitted signal.

The 7SA522 is fitted, in addition, with three two-stage undervoltage measuring elements:

- Phase-to-ground undervoltage
- Phase-to-phase undervoltage
- Positive-sequence undervoltage

The undervoltage measuring elements can be blocked by means of a minimum current criterion and by means of binary inputs.

Frequency protection (ANSI 81O/U)

Frequency protection can be used for over-frequency and underfrequency protection. Unwanted frequency changes in the network can be detected and the load can be removed at a specified frequency setting. Frequency protection can be used over a wide frequency range (45 to 55, 55 to 65 Hz). There are four elements (selectable as overfrequency or underfrequency) and each element can be delayed separately.

Breaker failure protection (ANSI 50BF)

The 7SA522 relay incorporates a two-stage circuit-breaker failure protection to detect failures of tripping command execution, for example due to a defective circuit-breaker. The current detection logic is phase-segregated and can therefore also be used in single-pole tripping schemes.

If the fault current is not interrupted after a time delay has expired, a retrip command or the busbar trip command will be generated. The breaker failure protection can be initiated by all integrated protection functions as well as by external devices via binary input signals.

Auto-reclosure (ANSI 79)

The 7SA522 relay is equipped with an auto-reclose function (AR). The function includes several operating modes:

- 3-pole auto-reclosure for all types of faults; different dead times are available depending the type of fault
- 1-pole auto-reclosure for 1-phase faults, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and for 2-phase faults without ground, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase and 3-pole auto-reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and 2-phase faults without ground and 3-pole auto-reclosure for other faults
- Multiple-shot auto-reclosure
- Interaction with an external device for auto-reclosure via binary inputs and outputs
- Control of the integrated AR function by external protection
- Interaction with the internal or an external synchro-check
- Monitoring of the circuit-breaker auxiliary contacts

In addition to the above-mentioned operating modes, several other operating principles can be employed by means of the integrated programmable logic (CFC).

Integration of auto-reclosure in the feeder protection allows evaluation of the line-side voltages. A number of voltage-dependent supplementary functions are thus available:

- **DLC**
By means of dead-line check, reclosure is effected only when the line is deenergized (prevention of asynchronous breaker closure).
- **ADT**
The adaptive dead time is employed only if auto-reclosure at the remote station was successful (reduction of stress on equipment).
- **RDT**
Reduced dead time is employed in conjunction with auto-reclosure where no tele-protection method is employed:

When faults within the zone extension, but external to the protected line, are switched off for rapid auto-reclosure (RAR), the RDT function decides on the basis of measurement of the return voltage from the remote station which has not tripped whether or not to reduce the dead time.

Distance Protection 7SA522

Protection functions

Synchronism check (ANSI 25)

Where two network sections are switched in by control command or following a 3-pole, it must be ensured that both network sections are mutually synchronous. For this purpose, a synchronism-check function is provided. After verification of the network synchronism the function releases the CLOSE command. Alternatively, reclosing can be enabled for different criteria, e.g., checking that the busbar or line is not carrying a voltage (dead line or dead bus). Fuse failure monitoring and other supervision functions

The 7SA522 relay provides comprehensive monitoring functions covering both hardware and software. Furthermore, the measured values are continuously checked for plausibility. Therefore the current and voltage transformers are also included in this monitoring system.

If any measured voltage is not present due to short-circuit or open circuit in the voltage transformer secondary circuit, the distance protection would respond with an unwanted trip due to this loss of voltage. This secondary voltage interruption can be detected by means of the integrated fuse failure monitor. Immediate blocking of distance protection and switching to the backup-emergency protection is provided for all types of secondary voltage failures.

Additional measurement supervision functions are

- Symmetry of voltages and currents
- Broken-conductor supervision
- Summation of currents and voltages
- Phase-sequence supervision

Directional power protection

The 7SA522 has a function for detecting the power direction by measuring the phase angle of the positive-sequence system's power. Fig. 6/57 shows an application example displaying negative active power. An indication is issued in the case when the measured angle φ (S_1) of the positive-sequence system power is within the P - Q - level sector. This sector is between angles φA and φB .

Via CFC the output signal of the directional monitoring can be linked to the "Direct Transfer Trip (DTT)" function and thus, as reverse power protection, initiate tripping of the CB.

Fig.6/58 shows another application displaying capacitive reactive power. In the case of overvoltage being detected due to long lines under no-load conditions it is possible to select the lines where capacitive reactive power is measured.

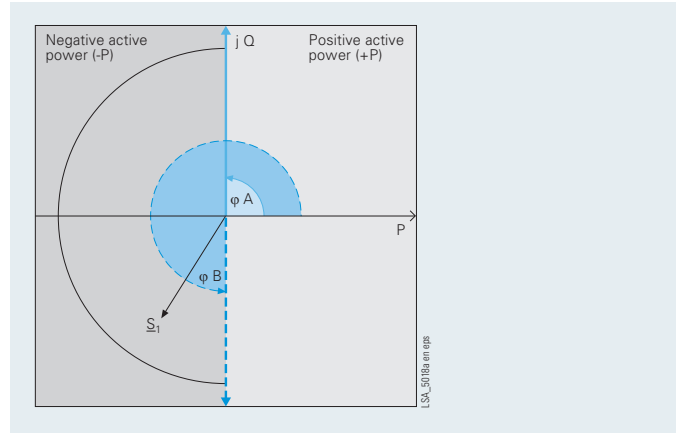


Fig. 6/57 Monitoring of active power direction

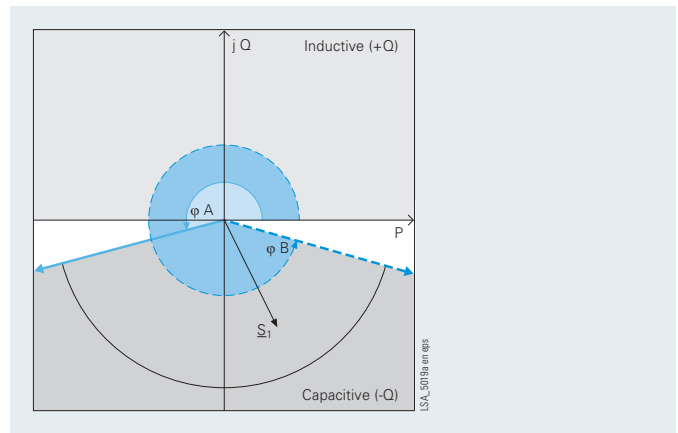


Fig. 6/58 Monitoring of reactive power

Trip circuit supervision (ANSI 74TC)

One or two binary inputs for each circuit-breaker pole can be used for monitoring the circuit-breaker trip coils including the connecting cables. An alarm signal is issued whenever the circuit is interrupted.

Lockout (ANSI 86)

Under certain operating conditions, it is advisable to block CLOSE commands after a TRIP command of the relay has been issued. Only a manual "Reset" command unblocks the CLOSE command. The 7SA522 is equipped with such an interlocking logic.

Commissioning and fault event analyzing

Special attention has been paid to commissioning. All binary inputs and outputs can be displayed and activated directly. This can simplify the wiring check significantly for the user. The operational and fault events and the fault records are clearly arranged. For applications with serial protection data interface, all currents, voltages and phases are available via communication link at each local unit, displayed at the front of the unit with DIGSI 4 or with WEB Monitor. A common time tagging facilitates the comparison of events and fault records.

WEB Monitor – Internet technology simplifies visualization

In addition to the universal DIGSI 4 operating program, the relay contains a WEB server that can be accessed via a telecommunication link using a browser (e.g. Internet Explorer). The advantage of this solution is to operate the unit with standard software tools and at the same time make use of the Intranet/Internet infrastructure. Apart from numeric values, graphical displays in particular provide clear information and a high degree of operating reliability. Of course, it is also possible to call up detailed measured value displays and annunciation buffers. By emulation of the integrated unit operation on the PC it is also possible to adjust selected settings for commissioning purposes.

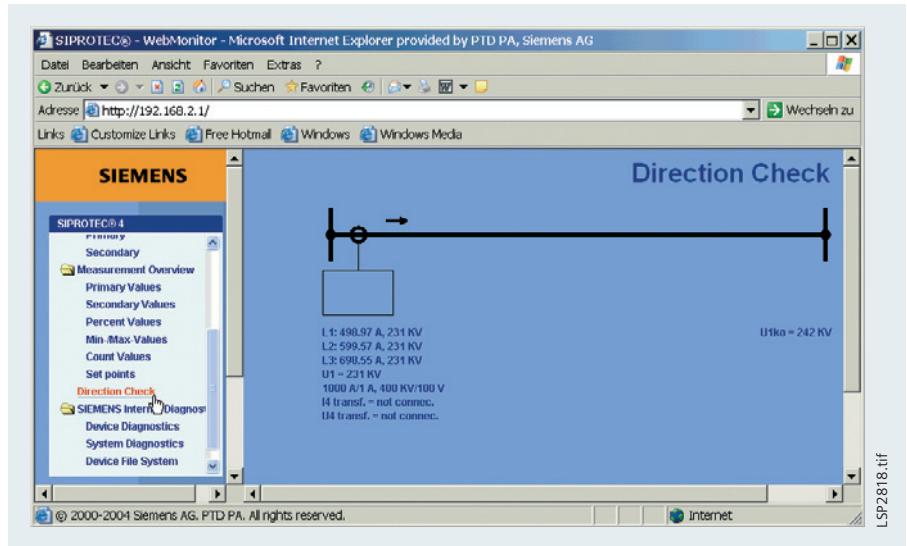


Fig. 6/59 Web Monitor: Display of the protection direction

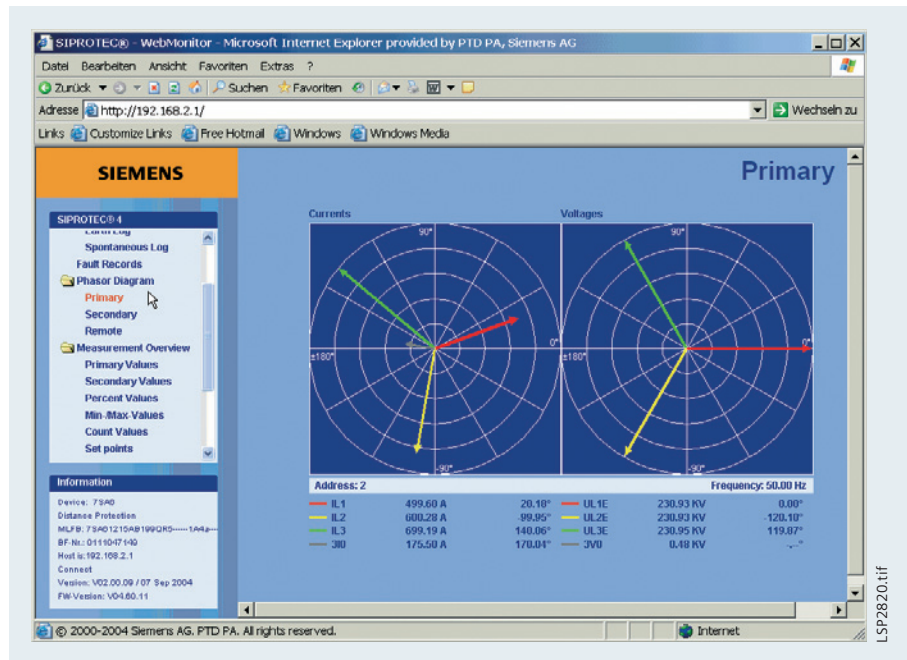


Fig. 6/60 Web monitor: Supported commissioning by phasor diagram

Distance Protection 7SA522

Communication

Communication

With respect to communication, particular emphasis is placed on the customer requirements in energy automation:

- Every data item is time-stamped at the source, i.e. where it originates.
- The communication system automatically handles the transfer of large data blocks (e.g. fault recordings or parameter data files). The user has access to these features without any additional programming effort.
- For the safe execution of a control command the corresponding data telegram is initially acknowledged by the device which will execute the command. After the release and execution of the command a feedback signal is generated. At every stage of the control command execution particular conditions are checked. If these are not satisfied, command execution may be terminated in a controlled manner.

The units offer a high degree of flexibility by supporting different standards for connection to industrial and power automation systems. By means of the communication modules, on which the protocols run, exchange and retrofit is possible. Therefore, the units will also in future allow for optimal adaptation to changing communication infrastructure such as the application of Ethernet networks which are already widely applied in the power supply sector.

Local PC interface

The serial RS232 PC interface accessible from the front of the unit permits quick access to all parameters and fault event data. The use of the DIGSI 4 operating program is particularly advantageous during commissioning.

Service/modem interface

By means of the RS 485/RS 232 interface, it is possible to efficiently operate a number of protection units centrally via DIGSI 4. Remote operation is possible on connection of a modem. This offers the advantage of rapid fault clarification, especially in the case of unmanned power plants. With the optical version, centralized operation can be implemented by means of a star coupler.

Time synchronization

The time synchronization interface is a standard feature in all units. The supported formats are IRIG-B and DCF77.

Reliable bus architecture

- RS485 bus
With this data transmission via copper conductors, electromagnetic fault influences are largely eliminated by the use of twisted-pair conductors. Upon failure of a unit, the remaining system continues to operate without any problems.
- Fiber-optic double ring circuit
The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without disturbance.
It is usually impossible to communicate with a unit that has failed. Should the unit fail, there is no effect on the communication with the rest of the system.

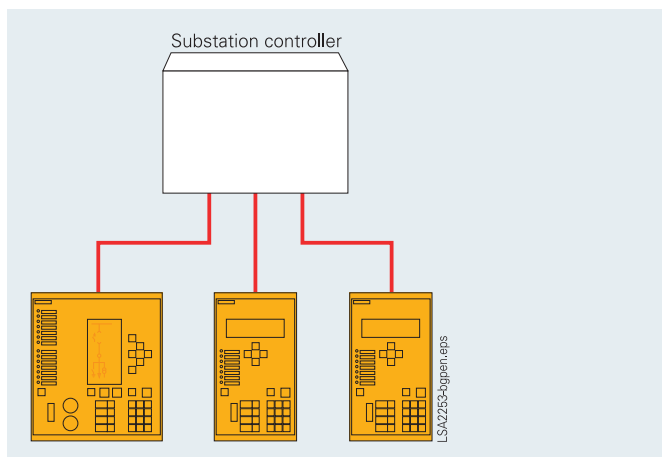


Fig. 6/61 IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

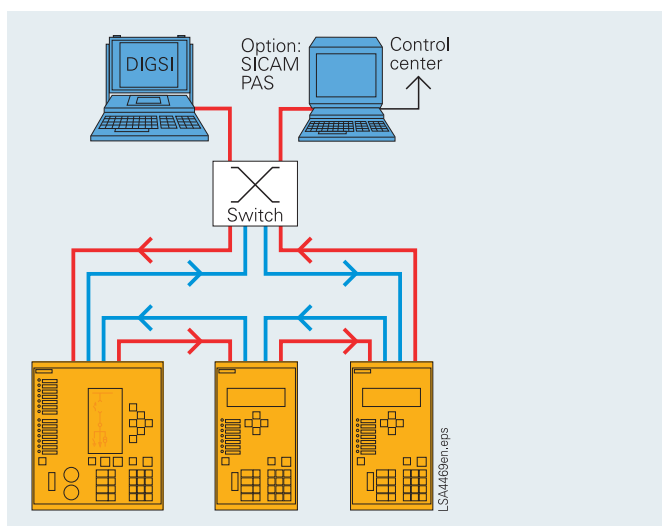


Fig. 6/62 Bus structure for station bus with Ethernet and IEC 61850

Retrofitting: Modules for every type of communication

Communication modules for retrofitting are available for the entire SIPROTEC 4 unit range. These ensure that, where different communication protocols (IEC 61850, IEC 60870-5-103, PROFIBUS, DNP, etc) are required, such demands can be met. For fiber-optic communication, no external converter is required for SIPROTEC 4.

IEC 61850 protocol

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens was the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet but is also possible with DIGSI. It is also possible to retrieve operating and fault records as well as fault recordings via a browser. This Web monitor will also provide a few items of unit-specific information in browser windows.

IEC 60870-5-103 protocol

IEC 60870-5-103 is an internationally standardized protocol for efficient communication with protection relays. IEC 60870-5-103 is supported by a number of protection relay manufacturers and is used worldwide. Supplements for control functions are defined in the manufacturer-specific part of this standard.

PROFIBUS-DP

PROFIBUS-DP is an industrial communication standard and is supported by a number of PLC and protection relay manufacturers.

DNP 3.0

DNP 3.0 (Distributed Network Protocol, Version 3) is an internationally recognized protection and bay unit communication protocol. SIPROTEC 4 units are Level 1 and Level 2 compatible.

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system. Units equipped with IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or connected in star by fiber-optic link.

Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 6/67).

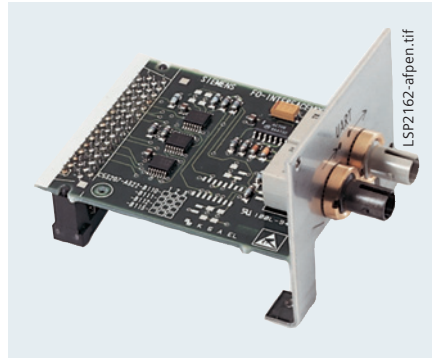


Fig. 6/63 820 nm fiber-optic communication module

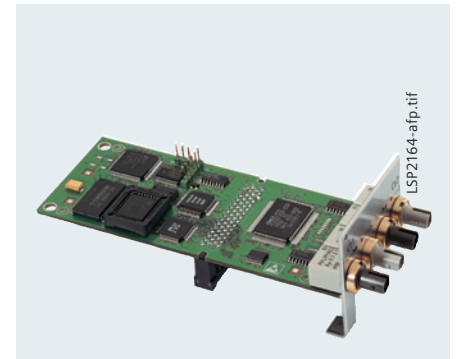


Fig. 6/64 PROFIBUS fiber-optic double ring communication module

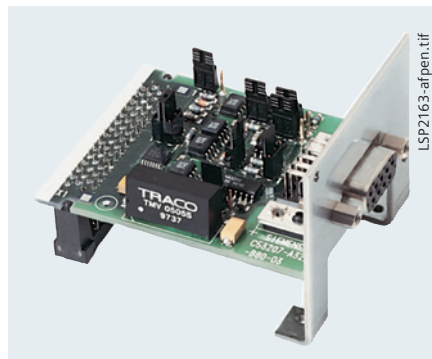


Fig. 6/65 RS232/RS485 electrical communication module

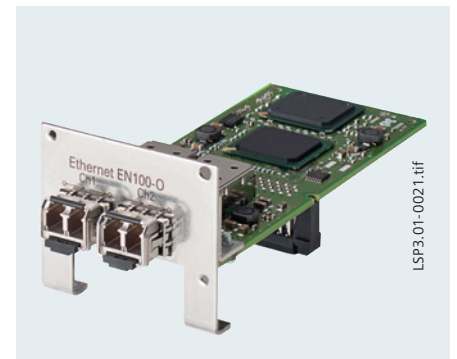


Fig. 6/66 Fiber-optic Ethernet communication module for IEC 61850 with integrated Ethernet switch

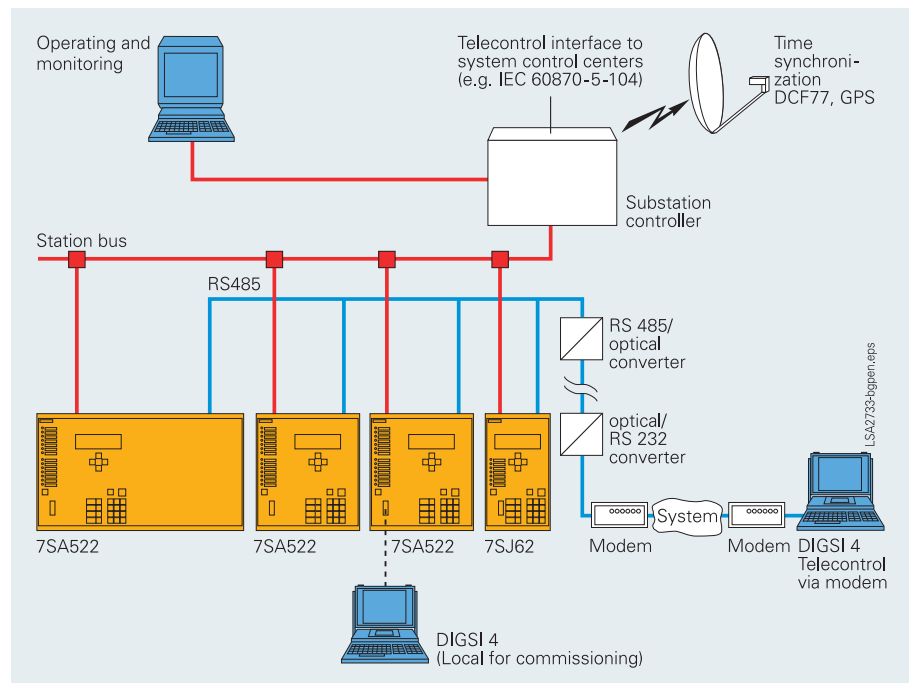


Fig. 6/67 Communication

Distance Protection 7SA522

Communication

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems. Units with an IEC 60870-5-103 interface are connected with PAS via the Ethernet station bus by means of serial/Ethernet converters. DIGSI and the Web monitor can also be used via the same station bus.

Serial protection data interface

The tele (pilot) protection schemes can be implemented using digital serial communication. The 7SA522 is capable of remote relay communication via direct links or multiplexed digital communication networks. The serial protection data interface has the following features:

- Fast phase-selective teleprotection signaling for distance protection, optionally with POTT or PUTT schemes
- Signaling for directional ground(earth)- fault protection – directional comparison for high-resistance faults in solidly grounded systems.
- Echo-function
- Two and three-terminal line applications can be implemented without additional logic
- Inter-close command transfer with the auto-reclosure "Adaptive dead time" (ADT) mode
- Redundant communication path switchover is possible with the 7SA522 when 2 serial protection data interfaces are installed
- 28 remote signals for fast transfer of binary signals
- Flexible utilization of the communication channels by means of the programmable CFC logic
- Display of the operational measured values of the opposite terminal(s) with phase-angle information relative to a common reference vector
- Clock synchronization: the clock in only one of the relays must be synchronized from an external so called "Absolute Master" when using the serial protection data interface. This relay will then synchronize the clock of the other (or the two other relays in 3 terminal applications) via the protection data interface.
- 7SA522 and 7SA6 can be combined via the protection data interface.

The communication possibilities are identical to those for the line differential protection relays 7SD5 and 7SD610. The following options are available:

- FO5¹⁾, OMA1²⁾ module: Optical 820 nm, 2 ST connectors, FO cable length up to 1.5 km for link to communication networks via communication converters or for direct FO cable connection
- FO6¹⁾, OMA2²⁾ module: Optical 820 nm, 2 ST connectors, FO cable length up to 3.5 km, for direct connection via multi-mode FO cable
- FO17¹⁾: for direct connection up to 24 km³⁾, 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO18¹⁾: for direct connection up to 60 km³⁾, 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO19¹⁾: for direct connection up to 100 km³⁾, 1550 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO30¹⁾: for transmission with the IEEE C37.94 standard

The link to a multiplexed communication network is made by separate communication converters (7XV5662). These have a fiber-optic interface with 820 nm and 2 ST connectors to the protection relay. The link to the communication network is optionally an electrical X21 or a G703.1 interface. If the connection to the multiplexor supports IEEE C37.94 a direct fibre optic connection to the relay is possible using the FO30 module.

For operation via copper wire communication (pilot wires), a modern communication converter for copper cables is available. This operates with both the two-wire and three-wire copper connections which were used by conventional differential protection systems before. The communication converter for copper cables is designed for 5 kV insulation voltage. An additional 20 kV isolation transformer can extend the field of applications of this technique into ranges with higher insulation voltage requirements. With SIPROTEC 4 and the communication converter for copper cables a digital follow-up technique is available for two-wire protection systems (typical 15 km) and all three-wire protection systems using existing copper communication links.

Communication data:

- Supported network interfaces G703.1 with 64 kbit/s; X21/RS422 with 64 or 128 or 512 kbit/s; IEEE C37.94
- Max. channel delay time 0.1 ms to 30 ms (in steps of 0.1 ms)
- Protocol HDLC
- 32-bit CRC-check according to CCITT and ITU
- Each protection relay possesses a unique relay address
- Continuous communication link supervision: Individual faulty data telegrams do not constitute an immediate danger, if they occur only sporadically. The statistical availability, per minute and hour, of the serial protection data interface can be displayed.

Figure 6/68 shows four applications for the serial protection data interface on a two-terminal line.

- 1) For flush-mounting housing.
- 2) For surface-mounting housing.
- 3) For surface-mounting housing the internal fiber-optic module (OMA1) will be delivered together with an external repeater.

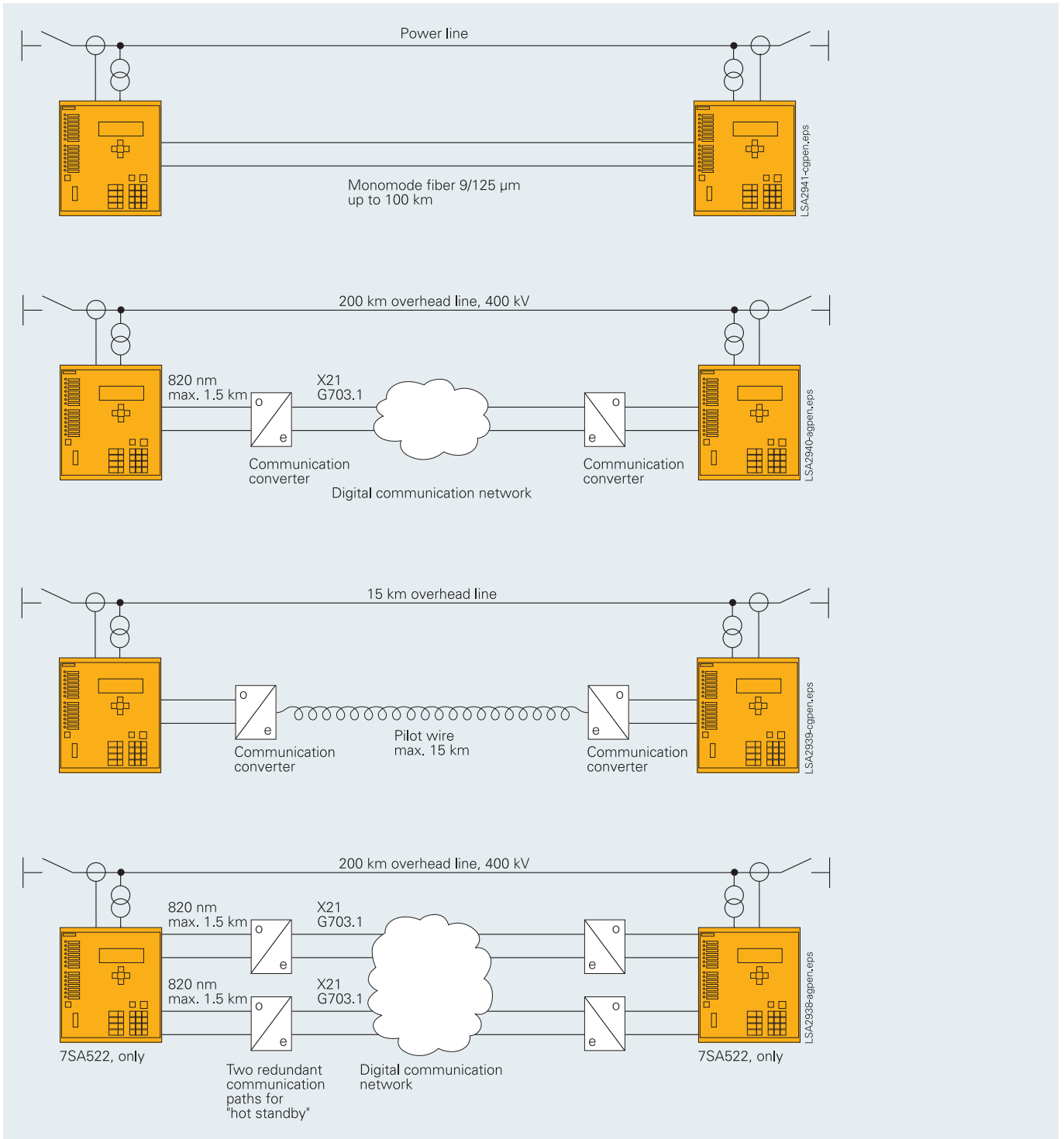


Fig. 6/68 Communication topologies for the serial protection data interface on a two-terminal line

Distance Protection 7SA522

Communication

Three-terminal lines can also be protected with a tele (pilot) protection scheme by using SIPROTEC 4 distance protection relays. The communication topology may then be a ring or a chain topology, see Fig. 6/69. In a ring topology a loss of one data connection is tolerated by the system. The topology is re-routed to become a chain topology within less than 100 ms.

To reduce communication links and to save money for communications, a chain topology may be generally applied.

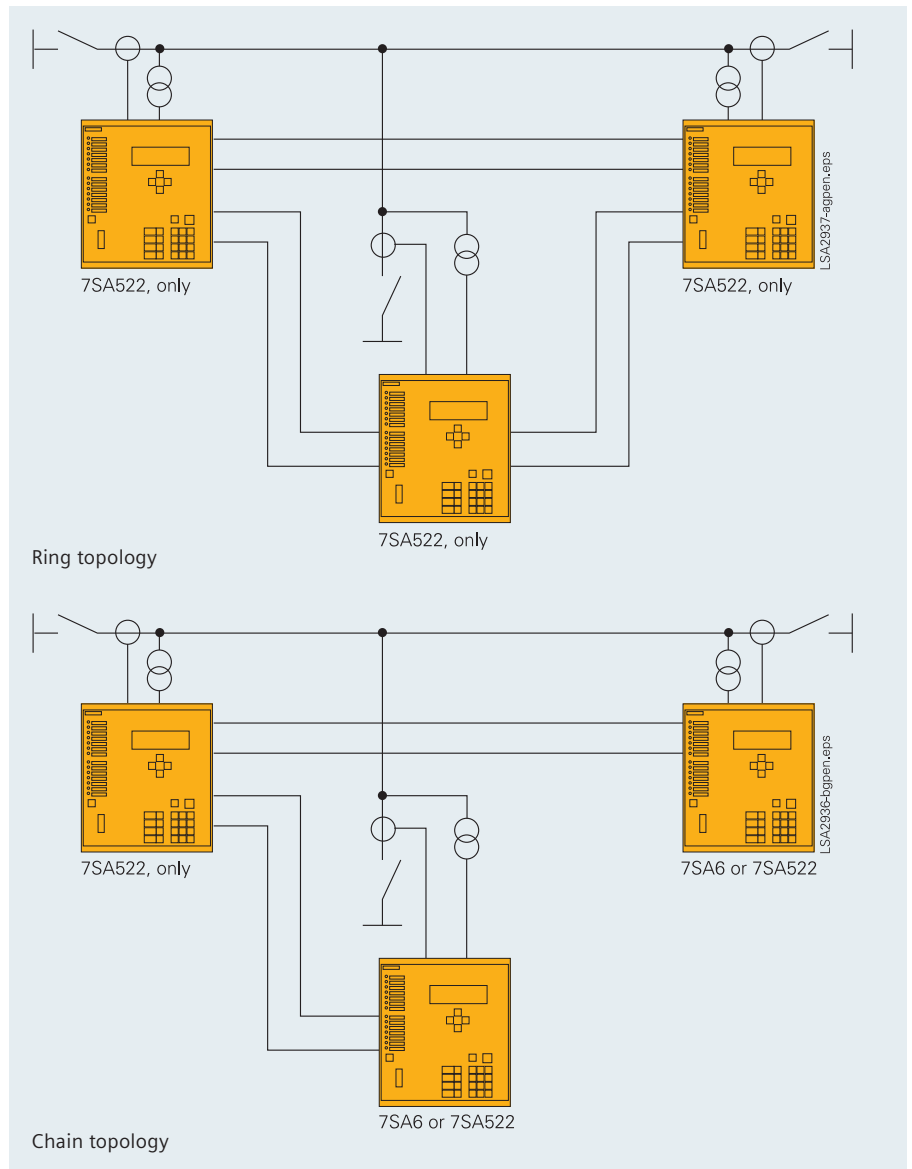


Fig. 6/69 Ring or chain communication topology

Typical connection

Connection of current and voltage transformers

3 phase current transformers with neutral point in the line direction, I_4 connected as summation current transformer ($= 3I_0$): Holmgreen circuit

3 voltage transformers, without connection of the broken (open) delta winding on the line side; the $3V_0$ voltage is derived internally.

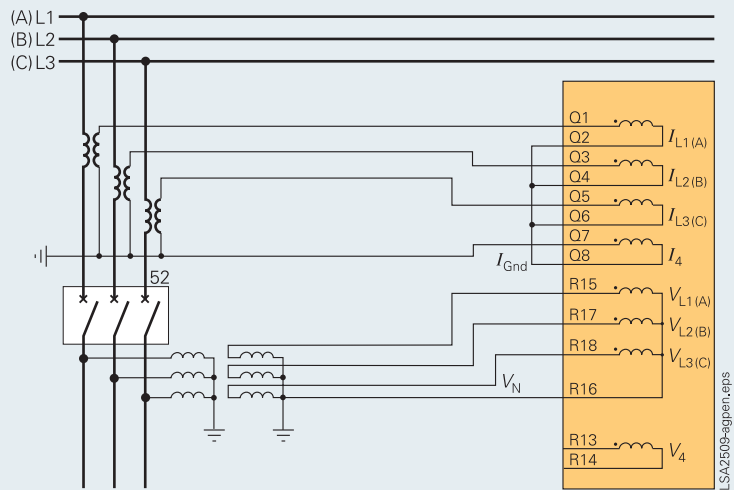


Fig. 6/70 Example of connection for current and voltage transformers

Alternative current measurement

The 3 phase current transformers are connected in the usual manner. The neutral point is in line direction. I_4 is connected to a separate neutral core-balance CT, thus permitting a high sensitive $3I_0$ measurement.

Note: Terminal Q7 of the I_4 transformer must be connected to the terminal of the core balance CT pointing in the same direction as the neutral point of the phase current transformers (in this case in line direction). The voltage connection is effected in accordance with Fig. 66/70, 6/74 or 6/75.

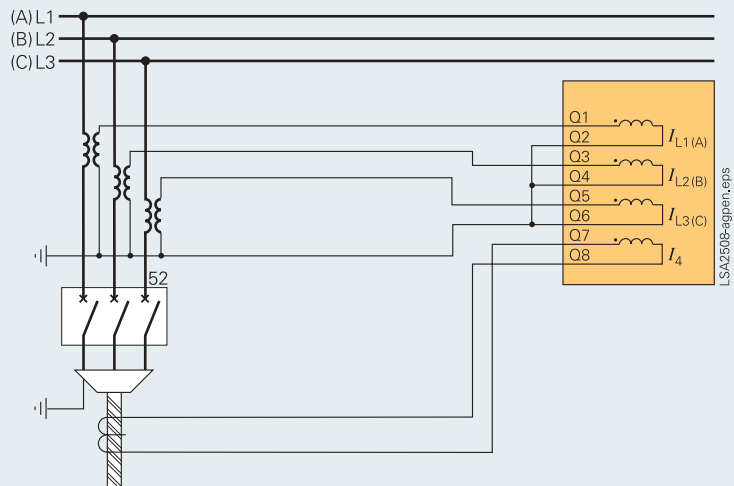


Fig. 6/71 Alternative connection of current transformers for sensitive ground-current measuring with core-balance current transformers

Distance Protection 7SA522

Typical connection

Alternative current connection

3 phase current transformers with neutral point in the line direction, I_4 connected to a current transformer in the neutral point of a grounded (earthed) transformer for directional ground(earth)-fault protection. The voltage connection is effected in accordance with Fig. 6/70, 6/74 or 6/75.

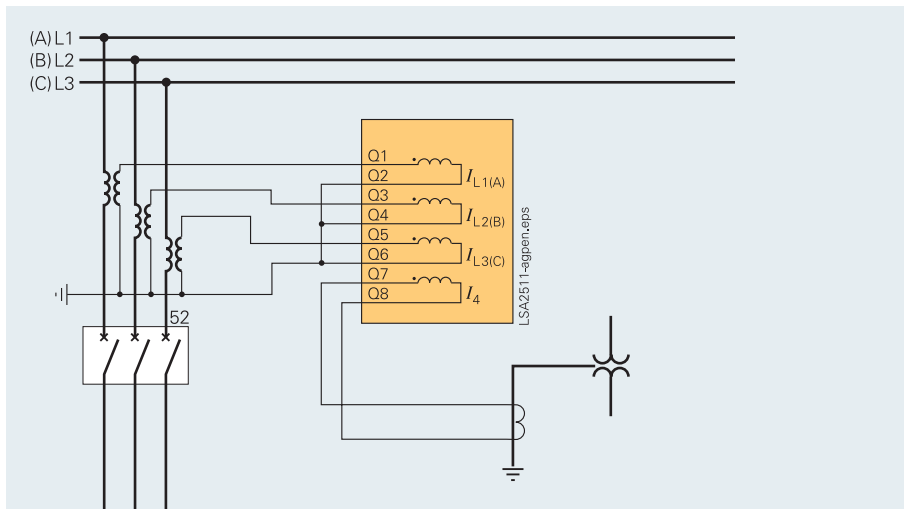


Fig. 6/72 Alternative connection of current transformers for measuring neutral current of a grounded (earthed) power transformer

Alternative current connection

3 phase current transformers with neutral point in the line direction, I_4 connected to the summation current of the parallel line for parallel line compensation on overhead lines. The voltage connection is effected in accordance with Fig. 6/70, 6/74 or 6/75.

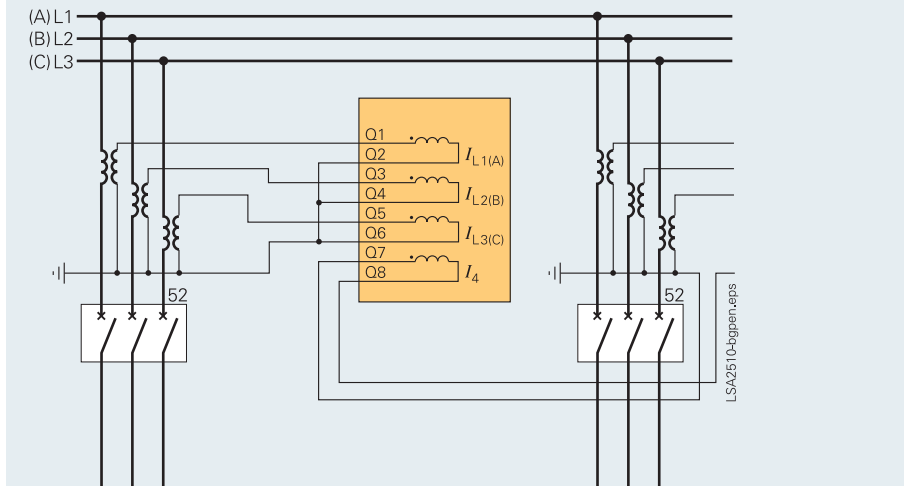


Fig. 6/73 Alternative connection of current transformers for measuring the ground (earth) current of a parallel line

Alternative voltage connection

3 phase voltage transformers, V_4 connected to broken (open) delta winding (V_{en}) for additional summation voltage monitoring and ground(earth)-fault directional protection.

The current connection is effected in accordance with Fig. 6/70, 6/71, 6/72 and 6/73.

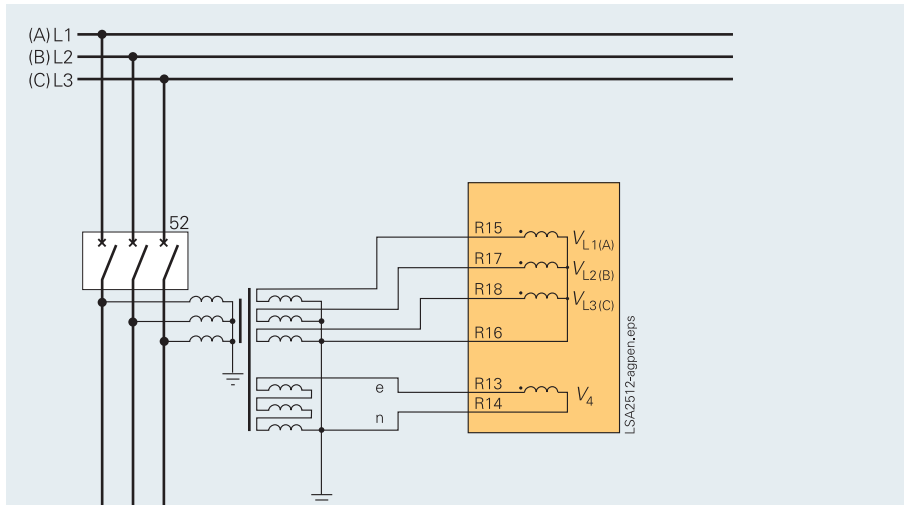


Fig. 6/74 Alternative connection of voltage transformers for measuring the displacement voltage (e-n voltage)

Alternative voltage connection

3 phase voltage transformers, V_4 connected to busbar voltage transformer for synchro-check.

Note: Any phase-to-phase or phase-to-ground (earth) voltage may be employed as the busbar voltage. Parameterization is carried out on the unit. The current connection is effected in accordance with Fig. 6/70, 6/71, 6/72 and 6/73.

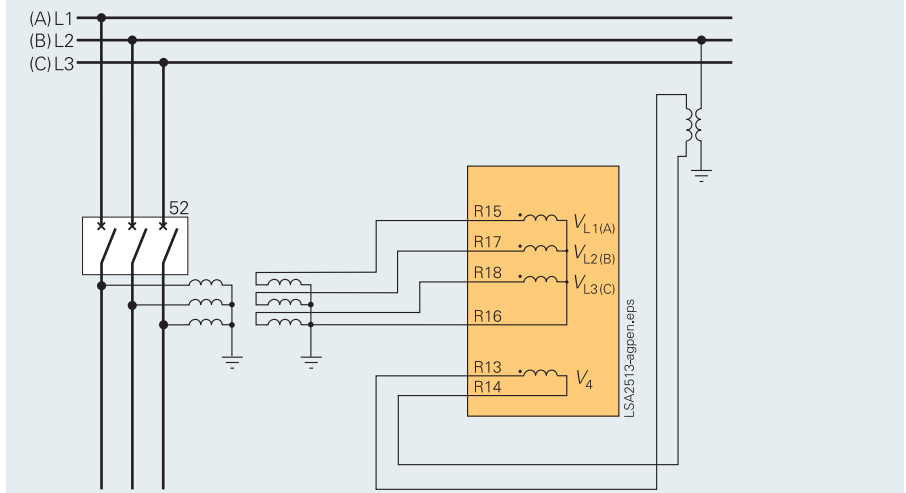


Fig. 6/75 Alternative connection of voltage transformers for measuring the busbar voltage

Distance Protection 7SA522

Technical data

General unit data		Output contacts	
Analog inputs		Quantity Function can be assigned	
Rated frequency	50 or 60 Hz (selectable)		8 or 16 or 24 (refer to ordering code)
Rated current I_{nom}	1 or 5 A (selectable)	Switching capacity	
Rated voltage	80 to 125 V (selectable)	Make	1000 W/VA
Power consumption		Break, high-speed trip outputs	1000 W/VA
In CT circuits with $I_{nom} = 1$ A	Approx. 0.05 VA	Break, contacts	30 VA
In CT circuits with $I_{nom} = 5$ A	Approx. 0.30 VA	Break, contacts (for resistive load)	40 W
In the CT circuit for high sensitive ground(earth)-fault protection (refer to ordering code) at 1 A	Approx. 0.05 VA	Break, contacts (for $\tau = L/R \leq 50$ ms)	25 VA
In VT circuits	Approx. 0.10 VA	Switching voltage	250 V
Thermal overload capacity		Permissible current	30 A for 0.5 s 5 A continuous
In CT circuits	500 A for 1 s 150 A for 10 s 20 A continuous	Operating time, approx.	
In the CT circuit for high sensitive ground(earth)-fault protection (refer to ordering code)	300 A for 1 s 100 A for 10 s 15 A continuous	NO contact	8 ms
In VT circuits	230 V continuous per phase	NO/NC contact (selectable)	8 ms
Dynamic overload capacity		Fast NO contact	5 ms
In CT circuits	1250 A (one half cycle)	High-speed NO trip outputs	< 1 ms
In the CT circuit for high sensitive ground(earth)-fault protection (refer to ordering code)	750 A (one half cycle)	LEDs	
Auxiliary voltage		Quantity	
Rated auxiliary voltage	DC 24 to 48 V DC 60 to 125 V DC 110 to 250 V and AC 115 V with 50/60 Hz	RUN (green)	1
Permissible tolerance of the rated auxiliary voltage	-20 % to +20 %	ERROR (red)	1
Max. superimposed AC voltage (peak-to-peak)	≤ 15 %	Indication (red), function can be assigned	14
Power consumption		Unit design	
During normal operation	Approx. 8 W	Housing	7XP20
During pickup with all inputs and outputs activated	Approx. 18 W	Dimension	1/2 x 19" or 1/1 x 19" Refer to ordering code, and see dimension drawings, part 14
Bridging time during auxiliary voltage failure		Degree of protection acc. to EN 60529	
$V_{aux} = 48$ V and $V_{aux} \geq 110$ V	≥ 50 ms	Surface-mounting housing	IP 51
Binary inputs		Flush-mounting housing	
Quantity	8 or 16 or 24 (refer to ordering code)	Front	IP 51
Functions are freely assignable		Rear	IP 50
Pickup/Reset voltage thresholds	DC 19 V/ DC 10 V or DC 88 V/ DC 44 V or DC 176 V/ DC 88 V, bipolar (3 nominal ranges DC 17/73/154 V)	For the terminals	IP 20 with terminal cover put on
Ranges are settable by means of jumpers for each binary input		Weight	
Maximum permissible voltage	DC 300 V	Flush-mounting housing	
Current consumption, energized	Approx. 1.8 mA	1/2 x 19"	6 kg
Input impulse suppression	220 nF coupling capacitance at 220 V with a recovery time > 60 ms.	1/4 x 19"	10 kg
		Surface-mounting housing	
		1/2 x 19"	11 kg
		1/4 x 19"	19 kg
		Serial interfaces	
		Operating interface, front of unit for DIGSI 4	
		Connection	Non-isolated, RS232, 9-pin subminiature connector (SUB-D)
		Baud rate	4800 to 115200 baud setting as supplied: 38400 baud; parity 8E1
		Time synchronization	
		DCF77/IRIG-B signal (Format IRIG-B000)	
		Connection	9-pin subminiature connector (SUB-D) (terminal with surface-mounting housing)
		Voltage levels	5 V, 12 V or 24 V (optional)

Service/modem interface (operating interface 2)	
(refer to ordering code)	For DIGSI 4 / modem / service
Isolated RS232/RS485	9-pin subminiature connector
Dielectric test	500 V/ 50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m
Fiber-optic	Integrated ST connector
Optical wavelength	$\lambda = 820$ nm
Permissible attenuation	Max. 8 dB for 62.5/125 μ m fiber
Distance max.	1.5 km
System interface	
(refer to ordering code)	IEC 61850 Ethernet IEC 60870-5-103 PROFIBUS-FMS PROFIBUS-DP DNP 3.0
Isolated RS232/RS485	9-pin subminiature connector
Baud rate	4800 to 38400 baud
Dielectric test	500 V/50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m
PROFIBUS RS485	
Dielectric test	500 V/50 Hz
Baud rate	Max. 12 Mbaud
Distance	1000 m at 93.75 kbaud; 100 m at 12 Mbaud
PROFIBUS fiber-optic ²⁾	ST connector
Only for flush-mounting housing	
For surface-mounting housing	Optical interface with OLM ⁴⁾
Baud rate	Max. 1.5 Mbaud
Optical wavelength	$\lambda = 820$ nm
Permissible attenuation	Max. 8 dB for 62.5/125 μ m fiber
Distance	500 kbit/s 1.6 km 1500 kbit/s 530 m

Protection data relay interfaces

Quantity	Max. 2 (refer to ordering code)
FO5 ¹⁾ , OMA1 ²⁾ : Fiber-optic interface	For multi-mode fiber 62.5/125 μ m, ST connectors
with clock recovery for direct connection up to 1.5 km or for connection to a communication converter, 820 nm	
FO6 ¹⁾ , OMA2 ²⁾ : Fiber-optic interface for direct connection up to 3.5 km, 820 nm	For multi-mode fiber 62.5/125 μ m, ST connectors
FO30 ¹⁾ : for direct fibre-optic connection to a multiplexor using IEEE C37.94 standard	For multi-mode fiber 62.5/125 μ m, ST connectors
FO17 ¹⁾ : for direct connection up to 24 km ³⁾ , 1300 nm	For mono-mode fiber 9/125 μ m, LC-Duplex connector
FO18 ¹⁾ : for direct connection up to 60 km ³⁾ , 1300 nm	For mono-mode fiber 9/125 μ m, LC-Duplex connector
FO19 ¹⁾ : for direct connection up to 100 km ³⁾ , 1550 nm	For mono-mode fiber 9/125 μ m, LC-Duplex connector

1) For flush-mounting housing.

2) For surface-mounting housing.

3) For surface-mounting housing the internal fiber-optic module (OMA1) will be delivered together with an external repeater.

4) Conversion with external OLM

For fiber-optic interface please complete order number at 11th position with **4** (FMS RS485) or **9** and Order Code **L0A** (DP RS485) or **9** and Order Code **L0G** (DNP 3.0) and additionally a suitable external repeater.

Relay communication equipment

External communication converter 7XV5662-0AA00 with X21/RS422 or G703.1 interface	
External communication converter for linking the optical 820 nm interface of the unit (FO5/OMA1 with clock recovery) to the X21/RS422/G703.1 interface of the communication network	Electrical X21/RS422 or G703.1 interface settable by jumper Baud rate settable by jumper
FO interface with 820 nm with clock recovery	Max. 1.5 km with 62.5/125 μ m multi-mode fiber to protection relay
Electrical X21/RS422 interface	64/128/512 kbit (settable by jumper) max. 800 m, 15-pin connector to the communication network
Electrical G703.1 interface	64 kbit/s max. 800 m, screw-type terminal to the communication network
External communication converter 7XV5662-0AC00 for pilotwires	
External communication converter for linking the optical 820 nm interface of the unit (FO5/OMA1 option w. clock recovery) to pilot wires.	Typical distance: 15 km
FO interface for 820 nm with clock recovery	Max. 1.5 km with 62.5/125 μ m multi-mode fiber to protection relay, 128 kbit
Electrical interface to pilot wires	5 kV-isolated

Electrical tests

Specifications	
Standards	IEC 60255 (product standards) IEEE Std C37.90.0/.1/.2; UL 508 VDE 0435 Further standards see "Individual functions"

Insulation tests

Standards	IEC 60255-5 and 60870-2-1
High-voltage test (routine test)	
All circuits except for power supply, binary inputs, high-speed outputs, communication and time synchronization interfaces	2.5 kV (r.m.s.), 50 Hz
Auxiliary voltage, binary inputs and high-speed outputs (routine test)	DC 3.5 kV
only isolated communication interfaces and time synchronization interface (routine test)	500 V (r.m.s.), 50 Hz
Impulse voltage test (type test)	
All circuits except for communication interfaces and time synchronization interface, class III	5 kV (peak); 1.2/50 μ s; 0.5 Ws, 3 positive and 3 negative impulses in intervals of 5 s

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Electrical tests (cont'd)		Mechanical stress test	
EMC tests for noise immunity; type tests		Vibration, shock stress and seismic vibration	
Standards	IEC 60255-6/-22 (product standard) EN 61000-6-2 (generic standard), VDE 0435 part 301 DIN VDE 0435-110	During operation	
High-frequency test IEC 60255-22-1 class III and VDE 0435 Section 303, class III	2.5 kV (peak); 1 MHz; $\tau = 15$ ms; 400 surges per s; test duration 2 s, $R_i = 200 \Omega$	Standards	IEC 60255-21 and IEC 60068-2
Electrostatic discharge IEC 60255-22-2 class IV and IEC 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; $R_i = 330 \Omega$	Vibration	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 g acceleration frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Irradiation with HF field, frequency sweep IEC 60255-22-3 (report) class III	10 V/m; 80 to 1000 MHz: 80 % AM; 1 kHz 10 V/m; 800 to 960 MHz: 80 % AM; 1 kHz	Shock	Semi-sinusoidal Acceleration 5 g, duration 11 ms, 3 shocks on each of the 3 axes in both directions
IEC 61000-4-3, class III	10 V/m; 1.4 to 2 GHz: 80 % AM; 1 kHz	Seismic vibration	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 g acceleration (horizontal axis) 8 to 35 Hz: 0.5 g acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
Irradiation with HF field, single frequencies IEC 60255-22-31, IEC 61000-4-3, class III amplitude/pulse modulated	10 V/m; 80, 160, 450, 900 MHz; 80 % AM; 1 kHz; duty cycle > 10 s 900 MHz; 50 % PM, repetition frequency 200 Hz	During transport	
Fast transient disturbance/bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50 \Omega$; test duration 1 min	Standards	IEC 60255-21 and IEC 60068-2
High-energy surge voltages (SURGE), IEC 61000-4-5 installation class III Auxiliary supply	Impulse: 1.2/50 μ s	Vibration	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 g acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Analog measurement inputs, binary inputs, relays output	Common mode: 2 kV; 12 Ω ; 9 μ F Differential mode: 1 kV; 2 Ω ; 18 μ F	Shock	Semi-sinusoidal Acceleration 15 g, duration 11 ms, 3 shocks on each of the 3 axes in both directions
Line-conducted HF, amplitude- modulated, IEC 61000-4-6, class III	Common mode: 2 kV; 42 Ω ; 0.5 μ F Differential mode: 1 kV; 42 Ω ; 0.5 μ F	Continuous shock	Semi-sinusoidal Acceleration 10 g, duration 16 ms, 1000 shocks on each of the 3 axes in both directions
Power system frequency magnetic field IEC 61000-4-8, class IV; IEC 60255-6	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz 30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz		
Oscillatory surge withstand capability, IEEE Std C37.90.1	2.5 kV (peak); 1 MHz $\tau = 50 \mu$ s; 400 surges per second, test duration 2 s, $R_i = 200 \Omega$		
Fast transient surge withstand capability, IEEE Std C37.90.1	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms repetition rate 300 ms; ; both polarities; test duration 1 min; $R_i = 50 \Omega$		
Radiated electromagnetic inter- ference IEEE Std C37.90.2	35 V/m; 25 to 1000 MHz, amplitude and pulse-modulated		
Damped oscillations IEC 60694, IEC 61000-4-12	2.5 kV (peak value); polarity alterna- ting 100 kHz; 1 MHz; 10 and 50 MHz; $R_i = 200 \Omega$		
EMC tests for noise emission; type test		Climatic stress tests	
Standard	EN 61000-6-3 (generic standard)	Standard	IEC 60255-6
Radio noise voltage to lines, only auxiliary voltage IEC-CISPR 22	150 kHz to 30 MHz Limit class B	Temperatures	
Radio interference field strength IEC-CISPR 22	30 to 1000 MHz Limit class B	Type-tested acc. to IEC 60068-2-1 and -2, test Bd	-25 °C to +85 °C / -13 °F to +185 °F
Harmonic currents on the network lead at AC 230 V, IEC 61000-3-2	Class A limits are observed	Temporarily permissible operating temperature, tested for 96 h (Legibility of display may be impaired above +55 °C / +131 °F)	-20 °C to +70 °C / -4 °F to +158 °F
Voltage fluctuations and flicker on the network incoming feeder at AC 230 V, IEC 61000-3-3	Limits are observed	Recommended permanent operating temperature acc. to IEC 60255-6	-5 °C to +55 °C / +23 °F to +131 °F
		- Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to 131 °F
		- Limiting temperature during transport	-25 °C to +70 °C / -13 °F to +158 °F
		Humidity	
		Permissible humidity stress: It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average on ≤ 75 % relative humidity; on 56 days per year up to 93 % relative humidity; condensation is not permitted.

Certifications	
UL listing	7SA522*-*A*
Models with threaded terminals	7SA522*-*C*
	7SA522*-*D*
UL recognition	7SA522*-*J*
Models with plug-in terminals	7SA522*-*L*
	7SA522*-*M*

Functions	
<i>Distance protection (ANSI 21, 21N)</i>	
Distance protection zones	7, 1 of which as controlled zone, all zones can be set forward or/and reverse
Time stages for tripping delay	7 for multi-phase faults
Setting range 0 to 30 s or deactivated (steps 0.01 s)	3 for single-phase faults
Characteristic	(refer to ordering code) quadrilateral and/or MHO
Selectable separately for phase and ground (earth) faults	
Time range	0.00 to 30 s (step 0.01 s) or deactivated
Line angle φ_L	10° to 89° (step 1°)
Inclination angle for quadrilateral characteristic	30° to 90° (step 1°)
Quadrilateral reactance reach X	0.05 to 600 Ω ^(1A) / 0.01 to 120 Ω ^(5A) (step 0.001 Ω)
Quadrilateral resistance reach R for phase-to-phase faults and phase-to-ground(earth) faults	0.05 to 600 Ω ^(1A) / 0.01 to 120 Ω ^(5A) (step 0.001 Ω)
MHO impedance reach ZR	0.05 to 200 Ω ^(1A) / 0.01 to 40 Ω ^(5A) (step 0.01 Ω)
Minimum phase current I	0.05 to 4 A ^(1A) / 0.25 to 20 A ^(5A) (step 0.01 A)
Ground(earth)-fault pickup	
Neutral (residual) current $3I_0$ (Ground current)	0.05 to 4 A ^(1A) / 0.25 to 20 A ^(5A) (step 0.01 A)
Zero-sequence voltage $3V_0$	1 to 100 V (step 1V) or deactivated
Zero-sequence compensation selectable input formats	R_E/R_L and X_E/X_L k_0 and $\varphi(k_0)$
Separately selectable for zones	Z1 higher zones (Z1B, Z2 to Z5)
R_E/R_L and X_E/X_L	-0.33 to 7 (step 0.01)
k_0	0 to 4 (step 0.001)
$\varphi(k_0)$	-135 to 135° (steps 0.01°)
Parallel line mutual compensation	(refer to ordering code)
R_M/R_L and X_M/X_L	0.00 to 8 (step 0.01)
Load encroachment	
Minimum load resistance	0.10 to 600 Ω ^(1A) / 0.02 to 120 Ω ^(5A) (step 0.001 Ω) or deactivated
Maximum load angle	20 to 60° (step 1°)
Directional decision for all types of faults	With sound phase polarization and/or voltage memory
Directional sensitivity	Dynamically unlimited

Tolerances	For sinusoidal quantities
	$\left \frac{\Delta X}{X} \right \leq 5\% \text{ for } 30^\circ \leq \varphi_{SC} \leq 90^\circ$
	$\left \frac{\Delta R}{R} \right \leq 5\% \text{ for } 0^\circ \leq \varphi_{SC} \leq 60^\circ$
	$\left \frac{\Delta Z}{Z} \right \leq 5\% \text{ for } -30^\circ \leq (\varphi_{SC} - \varphi_{line}) \leq +30^\circ$
Timer tolerance	$\pm 1\%$ of set value or 10 ms
Operating times	
Minimum trip time with fast relays	Approx. 17 ms at 50 Hz
Minimum trip time with high-speed relays	Approx. 15 ms at 60 Hz
Reset time	Approx. 12 ms at 50 Hz
	Approx. 10 ms at 60 Hz
	Approx. 30 ms
Fault locator	
Output of the distance to fault	X, R (secondary) in Ω X, R (primary) in Ω Distance in kilometers or miles Distance in % of line length
Start of calculation	With trip, with pickup reset
Reactance per unit length	0.005 to 6.5 Ω / km ^(1A) / 0.001 to 1.3 Ω / km ^(5A) or 0.005 to 10 Ω / mile ^(1A) / 0.001 to 2 Ω / mile ^(5A) (step 0.001 Ω / unit)
Tolerance	For sinusoidal quantities $\leq 2.5\%$ line length for $30^\circ \leq \varphi_{SC} \leq 90^\circ$ and $V_{SC}/V_N > 0.10$
BCD-coded output of fault location	
Indicated value	Fault location in % of the line length
Output signals	Max. 10: d[1 %], d[2 %], d[4 %], d[8 %], d[10 %], d[20 %], d[40 %], d[80 %], d[100 %], d[release]
Indication range	0 % to 195 %
Power swing detection (ANSI 68, 68T)	
Power swing detection principle	Measurement of the rate of impedance vector change and monitoring of the vector path
Max. detectable power swing frequency	Approx. 7 Hz
Operating modes	Power swing blocking and/or power swing tripping (out-of-step tripping)
Power swing blocking programs	All zones blocked Z1/Z1B blocked Z2 to Z6 blocked Z1, Z1B, Z2 blocked
Detection of faults during power swing blocking	Reset of power swing blocking for all types of faults

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Tele (pilot) protection for distance protection (ANSI 85-21)		Inverse-time stage	
Operating modes	POTT PUTT, DUTT Directional comparison: Blocking Directional comparison: Unblocking Directional comparison hybrid (POTT and echo with weak-feed protection)	Current starting inverse-time stage $3I_0$	0.05 to 4 $A_{(1A)}$ / 0.25 to 20 $A_{(5A)}$ (step 0.01 A) With normal neutral (residual) current CT (refer to ordering code) 0.003 to 4 $A_{(1A)}$ / 0.015 to 20 $A_{(5A)}$ (step 0.001 A) With high sensitive neutral (residual) current CT (refer to ordering code)
Transient blocking logic (current reversal guard)	For overreaching schemes	Characteristics according to IEC 60255-3	Normal inverse, very inverse, extremely inverse, long time inverse,
Send and receive signals	Suitable for 2- and 3- terminal lines, phase-segregated signals for selective single-phase tripping selectable	Time multiplier for IEC T characteristics	$T_p = 0.05$ to 3 s (step 0.01s) or deactivated
Direct transfer trip (DTT)		Pickup threshold	Approx. $1.1 \times III_p$
Direct phase-selective tripping via binary input	Alternatively with or without auto-reclosure	Reset threshold	Approx. $1.05 \times III_p$
Trip time delay	0.00 to 30 s (step 0.01 s) or deactivated	Tolerances	
Timer tolerance	$\pm 1\%$ of setting value or 10 ms	Operating time for $2 \leq III_p \leq 20$	$\leq 5\%$ of setpoint ± 15 ms
Directional ground(earth)-fault overcurrent protection (ANSI 50N, 51N, 67N)		Characteristics according to ANSI/IEEE	Inverse, short inverse, long inverse, moderately inverse, very inverse, extremely inverse, definite inverse
Characteristics	3 definite-time stages/1 inverse-time stage or 4 definite-time stages	Time dial	0.50 to 15 s (step 0.01) or deactivated
Phase selector	Permits 1-pole tripping for single-phase faults or 3-pole tripping for multi-phase faults selectable for every stage	Pickup threshold	Approx. $1.1 \times M$
Inrush restraint	Selectable for every stage	Reset threshold	Approx. $1.05 \times M$
Instantaneous trip after switch-onto-fault	Selectable for every stage	Tolerances	
Influence of harmonics		Operating time for $2 \leq M \leq 20$	$\leq 5\%$ of setpoint ± 15 ms
Stages 1 and 2 ($I_{>>>}$ and $I_{>>}$)	3 rd and higher harmonics are completely suppressed by digital filtering	Characteristic according to logarithmic inverse characteristic	$t = T_{3I_{0p, \max}} - T_{3I_{0p}} \ln \frac{3I_0}{3I_{0p}}$
Stages 3 and 4 ($I_{>}$ and inverse 4 th stage)	2 nd and higher harmonics are completely suppressed by digital filtering	Pickup threshold	1.1 to $4.0 \times III_p$ (step 0.1)
Definite-time stage		Characteristic according to compensated zero-sequence power	$S_r = 3I_0 \times 3V_0 \times \cos(\varphi - \varphi_{\text{comp}})$
Pickup definite-time stage 1, $3I_0$	0.05 to 25 $A_{(1A)}$ / 0.25 to 125 $A_{(5A)}$ (step 0.01 A)	Polarizing quantities for directional decision	$3I_0$ and $3V_0$ or $3I_0$ and $3V_0$ and I_E (grounded (earthed) power transformer) or $3I_2$ and $3V_2$ (negative sequence) or zero-sequence power S_r or automatic selection of zero-sequence or negative-sequence quantities dependent on the magnitude of the component voltages
Pickup definite-time stage 2, $3I_0$	0.05 to 25 $A_{(1A)}$ / 0.25 to 125 $A_{(5A)}$ (step 0.01 A)	Min. zero-sequence voltage $3V_0$	0.5 to 10 V (step 0.1 V)
Pickup definite-time stage 3, $3I_0$	0.05 to 25 $A_{(1A)}$ / 0.25 to 125 $A_{(5A)}$ (step 0.01 A) With normal neutral (residual) current CT (refer to ordering code) 0.003 to 25 $A_{(1A)}$ / 0.015 to 125 $A_{(5A)}$ (step 0.01 A) With high sensitive neutral (residual) current CT (refer to ordering code)	Ground (earth) current I_E of grounded (earthed) power transformer	0.05 to 1 $A_{(1A)}$ / 0.25 to 5 $A_{(5A)}$ (step 0.01 A)
Pickup definite-time stage 4, $3I_0$	0.05 to 4 $A_{(1A)}$ / 0.25 to 20 $A_{(5A)}$ (step 0.01 A) With normal neutral (residual) current CT (refer to ordering code) 0.003 to 4 $A_{(1A)}$ / 0.015 to 20 $A_{(5A)}$ (step 0.01 A) With high sensitive neutral (residual) current CT (refer to ordering code)	Min. negative-sequence voltage $3V_2$	0.5 to 10 V (step 0.1 V)
Time delay for definite-time stages	0.00 to 30 s (step 0.01 s) or deactivated	Min. negative-sequence current $3I_2$	0.05 to 1 $A_{(1A)}$ / 0.25 to 5 $A_{(5A)}$ (step 0.01 A)
Tolerances		2 nd harmonic ratio for inrush restraint	10 to 45 % of fundamental (step 1 %)
Current starting	$\leq 3\%$ of setting value or 1 % of I_{nom}	Maximum current, overriding inrush restraint	0.5 to 25 $A_{(1A)}$ / 2.5 to 125 $A_{(5A)}$ (step 0.01 A)
Delay times	$\pm 1\%$ of setting value or 10 ms	Tele (pilot) protection for directional ground(earth)-fault overcurrent protection (ANSI 85-67N)	
Pickup times		Operating modes	Directional comparison: Pickup Directional comparison: Blocking Directional comparison: Unblocking
Definite-time stages 1 and 2	Approx. 30 ms	Transient blocking logic	For schemes with parallel lines
Definite-time stages 3 and 4	Approx. 40 ms	Send and receive signals	Suitable for 2- and 3- terminal lines

<i>Weak-infeed protection with undervoltage (ANSI 27WI)</i>		<i>STUB bus overcurrent protection (ANSI 50(N)STUB)</i>	
Operating modes with carrier (signal) reception	Echo Echo and trip with undervoltage	Operating modes	Active only with open isolator position (signaled via binary input)
Undervoltage phase – ground (earth)	2 to 70 V (step 1 V)	Characteristic	1 definite-time stage
Time delay	0.00 to 30 s (step 0.01 s)	Instantaneous trip after switch-onto-fault	Selectable
Echo impulse	0.00 to 30 s (step 0.01 s)	Pickup phase current	0.1 to 25 A _(1A) / 0.5 to 125 A _(5A) (step 0.01 A)
Tolerances		Pickup neutral (residual) current	0.05 to 25 A _(1A) / 0.25 to 125 A _(5A) (step 0.01 A)
Voltage threshold	≤ 5 % of setting value or 0.5 V	Time delay, separate for phase and ground (earth) stage	0.00 to 30 s (step 0.01 s) or deactivated
Timer	± 1 % of setting value or 10 ms	Reset ratio	Approx. 0.95
<i>Backup overcurrent protection (ANSI 50N, 51N, 67)</i>		Tolerances	
Operating modes	Active only with loss of VT secondary circuit or always active	Current starting	≤ 3 % of setting value or 1 % of I _{nom}
Characteristic	2 definite-time stages / 1 inverse-time stage, 1 definite-time Stub-protection stage	Delay times	± 1 % of setting value or 10 ms
Instantaneous trip after switch-onto-fault	Selectable for every stage	<i>Instantaneous high-speed switch-onto-fault overcurrent protection (ANSI 50HS)</i>	
<i>Definite-time stage</i>		Operating mode	Active only after CB closing; instantaneous trip after pickup
Pickup definite-time stage 1, phase current	0.1 to 25 A _(1A) / 0.5 to 125 A _(5A) (step 0.01 A)	Pickup current	1 to 25 A _(1A) / 5 to 125 A _(5A) (step 0.01 A)
Pickup definite-time stage 1, neutral (residual) current	0.05 to 25 A _(1A) / 0.25 to 125 A _(5A) (step 0.01A)	Reset ratio	Approx. 0.95
Pickup definite-time stage 2, phase current	0.1 to 25 A _(1A) / 0.5 to 125 A _(5A) (step 0.01A)	Tolerances	
Pickup definite-time stage 2, neutral (residual) current	0.05 to 25 A _(1A) / 0.25 to 125 A _(5A) (step 0.01 A)	Current starting	≤ 3 % of setting value or 1 % of I _{nom}
Time delay for definite-time stages	0.0 to 30 s (step 0.01 s) or deactivated	Operating time	
Tolerances		With fast relays	Approx. 13 ms
Current starting	≤ 3 % of setting value or 1 % of I _{nom}	With high-speed trip outputs	Approx. 8 ms
Delay times	± 1 % of setting value or 10 ms	<i>Voltage protection (ANSI 59, 27)</i>	
Operating time	Approx. 25 ms	Operating modes	Local tripping and/or carrier trip impulse for remote end, only indication
<i>Inverse-time stage</i>		<i>Overvoltage protection</i>	
Phase current starting for inverse-time stage	0.1 to 4 A _(1A) / 0.5 to 20 A _(5A) (step 0.01 A)	Pickup values V _{PH-Gnd>>} , V _{PH-Gnd>} (phase-ground overvoltage)	1 to 170 V (step 0.1 V)
Neutral (residual) current starting for inverse-time stage	0.05 to 4 A _(1A) / 0.25 to 20 A _(5A) (step 0.01 A)	Pickup values V _{PH-PH>>} , V _{PH-PH>} (phase-phase overvoltage)	2 to 220 V (step 0.1 V)
Characteristic according to IEC 60255-3	Normal inverse, very inverse, extremely inverse, long time inverse	Pickup values 3V _{0>>} , 3V _{0>} (3V ₀ can be measured via V ₄ transformers or calculated by the relay) (zero-sequence overvoltage)	1 to 220 V (step 0.1 V)
Time multiplier	T _p = 0.05 to 3 s (step 0.01 s) or deactivated	Pickup values V _{1>>} , V _{1>} (positive-sequence overvoltage)	2 to 220 V (step 0.1 V)
Pickup threshold	Approx. 1.1 × III _p	Measured voltage	Local positive-sequence voltage or calculated remote positive-sequence voltage (compounding)
Reset threshold	Approx. 1.05 × III _p	Pickup values V _{2>>} , V _{2>} (negative-sequence overvoltage)	2 to 220 V (step 0.1 V)
Tolerances		Reset ratio (settable)	0.5 to 0.98 (step 0.01)
Operating time for 2 ≤ III _p ≤ 20	≤ 5 % of setpoint ± 15 ms		
Characteristics according to ANSI/IEEE	Inverse, short inverse, long inverse, moderately inverse, very inverse, extremely inverse, definite inverse		
Time dial	D _{IP} 0.50 to 15 s (step 0.01) or deactivated		
Pickup threshold	Approx. 1.1 × M (M = III _p)		
Reset threshold	Approx. 1.05 × M		
Tolerances			
Operating time for 2 ≤ M ≤ 20	≤ 5 % of setpoint ± 15 ms		

Distance Protection 7SA522

Technical data

Undervoltage protection		Auto-reclosure (ANSI 79)	
Pickup values $V_{PH-E<<}$, $V_{PH-E<}$ (phase-ground undervoltage)	1 to 100 V (step 0.1 V)	Number of auto-reclosures	Up to 8
Pickup values $V_{PH-PH<<}$, $V_{PH-PH<}$ (phase-phase undervoltage)	1 to 170 V (step 0.1 V)	Operating mode	Only 1-pole; only 3-pole, 1- or 3-pole
Pickup values $V_{1<<}$, $V_{1<}$ (positive-sequence undervoltage)	1 to 100 V (step 0.1 V)	Operating modes with line voltage check	DLC – dead-line check ADT – adaptive dead time RDT – reduced dead time
Blocking of undervoltage protection stages	Minimum current; binary input	Dead times T_{1-PH} , T_{3-PH} , T_{Seq}	0 to 1800 s (step 0.01 s) or deactivated
Reset ratio (settable)	1.01 to 1.20 (step 0.01)	Action times	0.01 to 300 s (step 0.01 s) or deactivated
Time delays		Reclaim times	0.5 to 300 s (step 0.01 s)
Time delay for 3 V_0 stages	0 to 100 s (step 0.01 s) or deactivated	Start-signal monitoring time	0.01 to 300 s (step 0.01 s)
Time delay for all other over- and undervoltage stages	0 to 30 s (steps 0.01 s) or deactivated	Additional functions	Synchro-check request 3-phase intertripping InterCLOSE command to the remote end Check of CB ready state Blocking with manual CLOSE
Command / pickup time	Approx. 30 ms	Voltage limit values for DLC, ADT, RDT	
Command/pickup time for 3 V_0 stages	Approx. 30 ms or 65 ms (settable)	Healthy line voltage	30 to 90 V (step 1 V)
Tolerances		Dead line	2 to 70 V (step 1 V)
Voltage limit values	≤ 3 % of setting value or 0.5 V	Tolerances	
Time stages	1 % of setting value or 10 ms	Time stages	1 % of setting value or 10 ms
Frequency protection (ANSI 81)		Voltage limit values	≤ 3 % of setting value or 0.5 V
Number of frequency elements	4	Synchro-check (ANSI 25)	
Setting range	45.5 to 54.5 Hz (in steps of 0.01) at $f_{nom} = 50$ Hz 55.5 to 64.5 Hz (in steps of 0.01) at $f_{nom} = 60$ Hz	Initiate options	Auto-reclosure; Manual CLOSE control Control commands
Delay times	0 to 600 s or (in steps of 0.01 s)	Operating modes with auto-reclosure	Synchro-check Line dead/busbar live Line live/busbar dead Line and busbar dead Bypassing
Operating voltage range	6 to 230 V (phase-to-ground)	For manual closure and control commands	As for auto-reclosure
Pickup times	Approx. 80 ms	Permissible voltage difference	1 to 60 V (step 0.1 V)
Dropout times	Approx. 80 ms	Permissible frequency difference	0.03 to 2 Hz (step 0.01 Hz)
Hysteresis	Approx. 20 mHz	Permissible angle difference	2 to 80 ° (step 1 °)
Dropout condition	Voltage = 0 V and current = 0 A	Max. duration of synchronization	0.01 to 600 s (step 0.01 s) or deactivated
Tolerances		Release delay with synchronous networks	0 to 30 s (step 0.01 s)
Frequency	15 mHz for V_{PH-PH} : 50 to 230 V	Tolerances	
Delay times	1 % of the setting value or 10 ms	Time stages	1 % of setting value or 10 ms
Breaker failure protection (ANSI 50BF)		Voltage limit values	≤ 2 % of setting value or 2 V
Number of stages	2	Trip circuit supervision (ANSI 74TC)	
Pickup of current element	0.05 to 20 $A_{(1A)}$ / 0.25 to 100 $A_{(5A)}$ (step 0.01 A)	Number of supervisable trip circuits	Up to 3
Time delays $T_{1\text{phase}}$, $T_{3\text{phase}}$, T_2	0 to 30 s (steps 0.01 s) or deactivated	Number of required binary inputs per trip circuit	1 or 2
Additional functions	End-fault protection CB pole discrepancy monitoring	Indication relay	1 to 30 s (step 1 s)
Reset time	12 ms, typical; 25 ms max.		
Tolerances			
Current limit value	≤ 5 % of setting value or 1 % I_{nom}		
Time stages	1 % of setting value or 10 ms		

Additional functions	
<i>Operational measured values</i>	
Representation	Primary, secondary and percentage referred to rated value
Currents	$3 \times I_{\text{Phase}}$; $3I_0$; $I_{\text{Gnd sensitive}}$; I_1 ; I_2 ; I_Y ; $3I_0_{\text{PAR}}$
Tolerances	Typical 0.3 % of indicated measured value or 0.5 % I_{Nom}
Voltages	$3 \times V_{\text{Phase-Ground}}$; $3 \times V_{\text{Phase-Phase}}$; $3V_0$, V_1 , V_2 , V_{SYNC} , V_{En}
Tolerances	Typical 0.25 % of indicated measured value or 0.01 V_{Nom}
Power with direction indication	P , Q , S
Tolerances	
P : for $ \cos \varphi = 0.7$ to 1 and V/V_{Nom} , $III_{\text{Nom}} = 50$ to 120 %	Typical ≤ 1 %
Q : for $ \sin \varphi = 0.7$ to 1 and V/V_{Nom} , $III_{\text{Nom}} = 50$ to 120 %	Typical ≤ 1 %
S : for V/V_{Nom} , $III_{\text{Nom}} = 50$ to 120 %	Typical ≤ 1 %
Frequency	f
Tolerance	≤ 20 mHz
Power factor	p.f. ($\cos \varphi$)
Tolerance for $ \cos \varphi = 0.7$ to 1	Typical ≤ 3 %
Load impedances with directional indication	$3 \times R_{\text{Phase-Ground}}$, $X_{\text{Phase-Ground}}$ $3 \times R_{\text{Phase-Phase}}$, $X_{\text{Phase-Phase}}$
<i>Long-term mean values</i>	
Interval for derivation of mean value	15 min / 1 min; 15 min / 3 min; 15 min / 15 min
Synchronization instant	Every $\frac{1}{4}$ hour; every $\frac{1}{2}$ hour; every hour
Values	$3 \times I_{\text{Phase}}$; I_1 ; P ; $P+$; $P-$; Q ; $Q+$; $Q-$; S
<i>Minimum / maximum memory</i>	
Indication	Measured values with date and time
Resetting	Cyclically Via binary input Via the keyboard Via serial interface
Values	
Min./max. of measured values	$3 \times I_{\text{Phase}}$; I_1 ; $3 \times V_{\text{Phase-Ground}}$; $3 \times V_{\text{Phase-to-phase}}$; $3V_0$; V_1 ; $P+$; $P-$; $Q+$; $Q-$; S ; f ; power factor (+); power factor (-)
Min./max. of mean values	$3 \times I_{\text{Phase}}$; I_1 ; P ; Q ; S
<i>Energy meters</i>	
Four-quadrant meters	W_{P+} ; W_{P-} ; W_{Q+} ; W_{Q-}
Tolerance	
for $ \cos \varphi > 0.7$ and $V > 50$ % V_{Nom} and $I > 50$ % I_{Nom}	5 %
<i>Oscillographic fault recording</i>	
Analog channels	$3 \times I_{\text{Phase}}$, $3I_0$, $3I_0_{\text{PAR}}$ $3 \times V_{\text{Phase}}$, $3V_0$, V_{SYNC} , V_{En}
Max. number of available recordings	8, backed-up by battery if auxiliary voltage supply fails
Sampling intervals	20 samplings per cycle
Total storage time	> 15 s
Binary channels	Pickup and trip information; number and contents can be freely configured by the user
Max. number of displayed binary channels	100

Control	
Number of switching units	Depends on the number of binary / indication inputs and indication / command outputs
Control commands	Single command / double command 1, 1 plus 1 common or 2 pole
Feed back	CLOSE, TRIP, intermediate position
Interlocking	Freely configurable
Local control	Control via menu, function keys
Remote control	Control protection, DIGSI, pilot wires
<i>Further additional functions</i>	
Measurement supervision	Current sum Current symmetry Voltage sum Voltage symmetry Voltage phase sequence Fuse failure monitor Power direction
Annunciations	
Event logging	Buffer size 200
Fault logging	Storage of signals of the last 8 faults, buffer size 600
Switching statistics	Number of breaking operations per CB pole Sum of breaking current per phase Breaking current of last trip operation Max. breaking current per phase
Circuit-breaker test	TRIP/CLOSE cycle 3-phase TRIP/CLOSE cycle per phase
Setting range	
Dead time for c.b. TRIP/CLOSE cycle	0.00 to 30 s (step 0.01 s)
Commissioning support	Operational measured values, CB test, status display of binary indication inputs, setting of output relays, generation of indications for testing serial interfaces
Phase rotation adjustment	Clockwise or anti-clockwise

CE conformity	
This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EG previous 89/336/EEC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2006/95/EG previous 73/23/EEC).	
This conformity is proved by tests conducted by Siemens AG in accordance with Article 10 of the Council Directive in agreement with the generic standards EN 61000-6-2 and EN 61000-6-4 for the EMC directive and with the standard EN 60255-6 for the low-voltage directive.	
This device is designed and produced for industrial use.	
The product conforms with the international standard of the series IEC 60255 and the German standard VDE 0435.	

Distance Protection 7SA522

Selection and ordering data

Description								Order No.
7SA522 distance protection relay or transmission lines								7SA522-□□□□□□□□□□□□□□□□
Current transformer								
$I_{ph} = 1 \text{ A}^1, I_{Gnd} = 1 \text{ A}^1$ (min. = 0.05 A)								1
$I_{ph} = 1 \text{ A}^1, I_{Gnd} = \text{high sensitive}$ (min. = 0.003 A)								2
$I_{ph} = 5 \text{ A}^1, I_{Gnd} = 5 \text{ A}$ (min. = 0.25 A)								5
$I_{ph} = 5 \text{ A}^1, I_{Gnd} = \text{high sensitive}$ (min. = 0.003 A)								6
Rated auxiliary voltage (power supply, binary inputs)								
DC 24 to 48 V, binary input threshold DC 17 V ³⁾								2
DC 60 to 125 V ²⁾ , binary input threshold DC 17 V ³⁾								4
DC 110 to 250 V ²⁾ , AC 115 V, binary input threshold DC 73 V ³⁾								5
DC 220 to 250 V ²⁾ , AC 115 V, binary input threshold DC 154 V ³⁾								6
Binary/indication inputs	Signal/command outputs incl. live status contact	Fast relay	High-speed trip output	Housing width referred to 19"	Flush-mounting housing/ screw-type terminals	Flush-mounting housing/ plug-in terminals	Surface-mounting housing/ screw-type terminals	
8	4	12	–	½	■			A
8	4	12	–	½			■	E
8	4	12	–	½		■		J
16	12	12	–	½	■			C
16	12	12	–	½			■	G
16	12	12	–	½		■		L
16	4	15	5	½	■			N
16	4	15	5	½			■	Q
16	4	15	5	½		■		S
24	20	12	–	½	■			D
24	20	12	–	½			■	H
24	20	12	–	½		■		M
24	12	15	5	½	■			P
24	12	15	5	½			■	R
24	24	3	5			■		T
22	32	12	–		■			U
24	4	18	10		■			W
Region-specific default settings/language settings (language selectable)								
Region DE, language: German								A
Region World, language: English (GB)								B
Region US, language: English (US)								C
Region FR, language: French								D
Region World, language: Spanish								E
Region World, language: Italian								F
Region World, language: Russian								G
Region World, language: Polish								H
Regulation on region-specific presets and function versions:								
Region DE:	preset to $f = 50 \text{ Hz}$ and line length in km, only IEC, directional ground-(earth) fault protection: no logarithmic inverse characteristic, no direction decision with zero-sequence power S_r							
Region US:	preset to $f = 60 \text{ Hz}$ and line length in miles, ANSI inverse characteristic only, directional ground-(earth) fault protection: no logarithmic inverse characteristic, no direction decision with zero-sequence power S_r , no U_0 inverse characteristic							
Region World:	preset to $f = 50 \text{ Hz}$ and line length in km, directional ground-(earth) fault protection: no direction decision with zero-sequence S_r , no U_0 inverse characteristic							
Region FR:	preset to $f = 50 \text{ Hz}$ and line length in km, directional ground-(earth) fault protection: no U_0 inverse characteristic, no logarithmic inverse characteristic, weak infeed logic selectable between French specification and World specification.							
								<p>1) Rated current can be selected by means of jumpers.</p> <p>2) Transition between the three auxiliary voltage ranges can be selected by means of jumpers.</p> <p>3) The binary input thresholds can be selected by means of jumpers.</p>

see following pages

Distance Protection 7SA522

Selection and ordering data

Description	Order No.	Order Code	
7SA522 distance protection relay for transmission lines	7SA522□□□-□□□□□-□□□□□□□□		
Port B			
Empty	0	see following pages	
System interface, IEC 60870-5-103 protocol, electrical RS232	1		
System interface, IEC 60870-5-103 protocol, electrical RS485	2		
System interface, IEC 60870-5-103 protocol, optical 820 nm, ST connector	3		
System interface, PROFIBUS-FMS Slave, electrical RS485 ¹⁾	4		
System interface, PROFIBUS-FMS Slave, optical, double ring, ST connector ^{1) 2)}	6		
System interface, PROFIBUS-DP, electrical RS485	9		L O A
System interface, PROFIBUS-DP, optical 820 nm, double ring, ST connector ²⁾	9		L O B
System interface, DNP 3.0, electrical RS485	9		L O G
System interface, DNP 3.0, optical 820 nm, ST connector ²⁾	9		L O H
System interface, IEC 61850, 100 Mbit/s Ethernet, electrical, duplicate, RJ45 plug connectors	9		L O R
System interface, IEC 61850, 100 Mbit/s Ethernet, optical, double, LC connector ⁵⁾	9		L O S
Port C and/or Port D			
Empty	0		
Port C: DIGSI / modem, electrical RS232; Port D: empty	1		
Port C: DIGSI / modem, electrical RS485; Port D: empty	2		
Port C: DIGSI / modem, optical 820 nm, ST connector; Port D: empty	3		
With Port D	9	M □ □	
Port C			
Empty	0		
DIGSI / modem, electrical RS232	1		
DIGSI / modem, electrical RS485	2		
DIGSI / modem, optical 820 nm, ST connector	3		
Port D			
Protection data interface: optical 820 nm, two ST connectors, FO cable length up to 1.5 km For direct connection via multi-mode FO cable or communication networks ³⁾		A	
Protection data interface: optical 820 nm, two ST connectors, FO cable length up to 3.5 km For direct connection via multi-mode FO cable		B	
Protection data interface: optical 1300 nm, LC-Duplex connector FO cable length up to 24 km for direct connection via mono-mode FO cable ⁴⁾		G	
Protection data interface: optical 1300 nm, LC-Duplex connector FO cable length up to 60 km for direct connection via mono-mode FO cable ^{4) 6)}		H	
Protection data interface: optical 1550 nm, LC-Duplex connector FO cable length up to 100 km for direct connection via mono-mode FO cable ^{4) 7)}		J	
FO30 optical 820 nm, 2 ST-connectors, length of optical fibre up to 1.5 km for multimode fibre, for communication networks with IEEE C37.94 interface or direct optical fibre connection (not available for surface-mounted housing)		S	

1) For SICAM energy automation system.
 2) Optical double ring interfaces are not available with surface-mounting housings. Please, order the version with RS485 interface and a separate electrical/ optical converter.
 3) Suitable communication converters 7XV5662 (optical to G703.1/X21/RS422 or optical to pilot wire or optical to ISDN) see "Accessories".
 4) For surface-mounting housing applications an internal fiber-optic module 820 nm will be delivered in combination with an external repeater.

5) For surface-mounting housing applications please order the relay with electrical Ethernet interface and use a separate fiber-optic switch.
 6) For distances less than 25 km, two optical attenuators 7XV5107-0AA00 are required to avoid optical saturation of the receiver element.
 7) For distances less than 50 km, two optical attenuators 7XV5107-0AA00 are required to avoid optical saturation of the receiver element.

Distance Protection 7SA522

Selection and ordering data

Description	Order No.	Order code
7SA522 distance protection relay for transmission lines	7SA522□-□□□□□-□□□□□□□□	
Functions 1 and Port E		
Trip mode 3-pole; Port E: empty	0	see next page
Trip mode 3-pole; BCD-coded output for fault location, Port E: empty	1	
Trip mode 1 and 3-pole; Port E: empty	4	
Trip mode 1 and 3-pole; BCD-coded output for fault location, Port E: empty	5	
With Port E	9	
Functions 1		
Trip mode 3-pole	0	↑
Trip mode 3-pole; BCD-coded output for fault location	1	
Trip mode 1 and 3-pole	4	
Trip mode 1 and 3-pole; BCD-coded output for fault location	5	
Port E		
Protection data interface: FO5: Optical 820 nm, 2 ST connectors, FO cable length up to 1.5 km for communication networks ¹⁾ or direct connection via multi-mode FO cable		A
FO6: Optical 820 nm, 2 ST connectors, FO cable length up to 3.5 km for direct connection via multi-mode FO cable		B
FO17: Optical 1300 nm, LC-Duplex connector FO cable length up to 24 km for direct connection via mono-mode FO cable ²⁾		G
FO18: Optical 1300 nm, LC-Duplex connector FO cable length up to 60 km or direct connection via mono-mode FO cable ^{2) 3)}		H
FO19: Optical 1550 nm, LC-Duplex connector FO cable length up to 100 km for direct connection via mono-mode FO cable ^{2) 4)}		J
FO30: Optical 820 nm, 2 ST connectors, length of optical fibre up to 1.5 km for multimode fibre, for communication networks with IEEE C37.94 interface or direct optical fibre connection (not available for surface-mounted housing)		S

6

1) Suitable communication converters 7XV5662 (optical to G703.1/X21/RS422 or optical to pilot wire) see "Accessories".

2) For surface-mounting housing applications an internal fiber-optic module 820 nm will be delivered in combination with an external repeater.

3) For distances less than 25 km, two optical attenuators 7XV5107-0AA00 are required to avoid optical saturation of the receiver element.

4) For distances less than 50 km, two optical attenuators 7XV5107-0AA00 are required to avoid optical saturation of the receiver element.

Distance Protection 7SA522

Selection and ordering data

Description				Order No.	Order code
7SA522 distance protection relay for transmission lines				7SA522	□-□□□□□-□□□□ □□□
Functions 2					
Distance protection characteristic (ANSI 21, 21N)	Power swing detection (ANSI 68, 68T)	Parallel line compensation			
Quadrilateral					C
Quadrilateral and / or MHO					E
Quadrilateral	■				F
Quadrilateral and / or MHO	■				H
Quadrilateral		■ 1)			K
Quadrilateral and / or MHO		■ 1)			M
Quadrilateral	■	■ 1)			N
Quadrilateral and / or MHO	■	■ 1)			Q
Functions 3					
Auto-reclosure (ANSI 79)	Synchro-check (ANSI 25)	Breaker failure protection (ANSI 50BF)	Over- / undervoltage protection (ANSI 27, 59) Over- / underfrequency protection (ANSI 81)		
					A
			■		B
		■			C
		■	■		D
	■				E
	■		■		F
	■	■			G
	■	■	■		H
■					J
■			■		K
■		■			L
■		■	■		M
■	■				N
■	■		■		P
■	■	■			Q
■	■	■	■		R
Functions 4					
Direction ground(earth)-fault protection, grounded (earthed) networks (ANSI 50N, 51N, 67N)		Measured values, extended Min, max, mean			
					0
		■			1
■					4
■		■			5

1) Only with position 7 of Order No. = 1 or 5.

Distance Protection 7SA522

Selection and ordering data


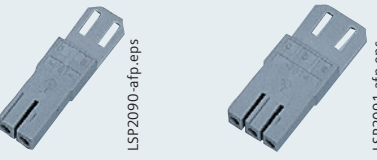


Accessories	Description	Order No.
	DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
	Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
	Professional + IEC 61850 Complete version: DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for control displays), DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	7XS5403-0AA00
	IEC 61850 System configurator Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM	7XS5460-0AA00
	SIGRA 4 Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000 or XP Professional Edition (generally contained in DIGSI Professional, but can be ordered additionally). Authorization by serial number. On CD-ROM.	7XS5410-0AA00
	Connecting cable (copper) Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	7XV5100-4
	Voltage transformer miniature circuit-breaker Rated current 1.6 A; thermal overload release 1.6 A; overcurrent trip 6 A	3RV1611-1AG14
	Manual for 7SA522 English, V4.61 and higher	C53000-G1176-C155-5
	German, V4.70	C53000-G1100-C155-8

Distance Protection 7SA522

Selection and ordering data

Accessories	Description	Order No.
	Opto-electric communication converters	
	Optical to X21/RS422 or G703.1	7XV5662-0AA00
	Optical to pilot wires	7XV5662-0AC00
	Additional interface modules	
	Protection data interface FO 5, OMA1, 820 nm, multi-mode FO cable, ST connector, 1.5 km	C53207-A351-D651-1
	Protection data interface FO 6, OMA2, 820 nm, multi-mode FO cable, ST connector, 3.5 km	C53207-A351-D652-1
	Protection data interface FO 17, 1300 nm, mono-mode FO cable, LC-Duplex connector, 25 km	C53207-A322-B115-3
	Protection data interface FO 18, 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	C53207-A322-B116-3
	Protection data interface FO 19, 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	C53207-A322-B117-3
	Optical repeaters	
	Serial repeater (2-channel), opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 25 km	7XV5461-0BG00
	Serial repeater (2-channel), opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	7XV5461-0BH00
	Serial repeater (2-channel), opt. 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	7XV5461-0BJ00

6

Accessories	Description	Order No.	Size of package	Supplier	Fig.	
 <p>Fig. 6/76 Mounting rail for 19" rack</p>	Connector	2-pin 3-pin	1 1	Siemens Siemens	6/77 6/78	
	 <p>Fig. 6/77 2-pin connector</p> <p>Fig. 6/78 3-pin connector</p>	Crimp connector	CI2 0.5 to 1 mm ²	4000 1	AMP ¹⁾ AMP ¹⁾	
CI2 0.5 to 2.5 mm ²			4000 1	AMP ¹⁾ AMP ¹⁾		
Type III+ 0.75 to 1.5 mm ²			4000 1	AMP ¹⁾ AMP ¹⁾		
For type III+ and matching female			1	AMP ¹⁾		
 <p>Fig. 6/79 Short-circuit link for current contacts</p>  <p>Fig. 6/80 Short-circuit link for voltage contacts/indications contacts</p>	19"-mounting rail	C73165-A63-D200-1	1	Siemens	6/76	
	Short-circuit links	For current terminals For other terminals	C73334-A1-C33-1 C73334-A1-C34-1	1 1	Siemens Siemens	6/79 6/80
	Safety cover for terminals	large small	C73334-A1-C31-1 C73334-A1-C32-1	1 1	Siemens Siemens	6/51 6/51

1) Your local Siemens representative can inform you on local suppliers.

Distance Protection 7SA522

Connection diagram, IEC

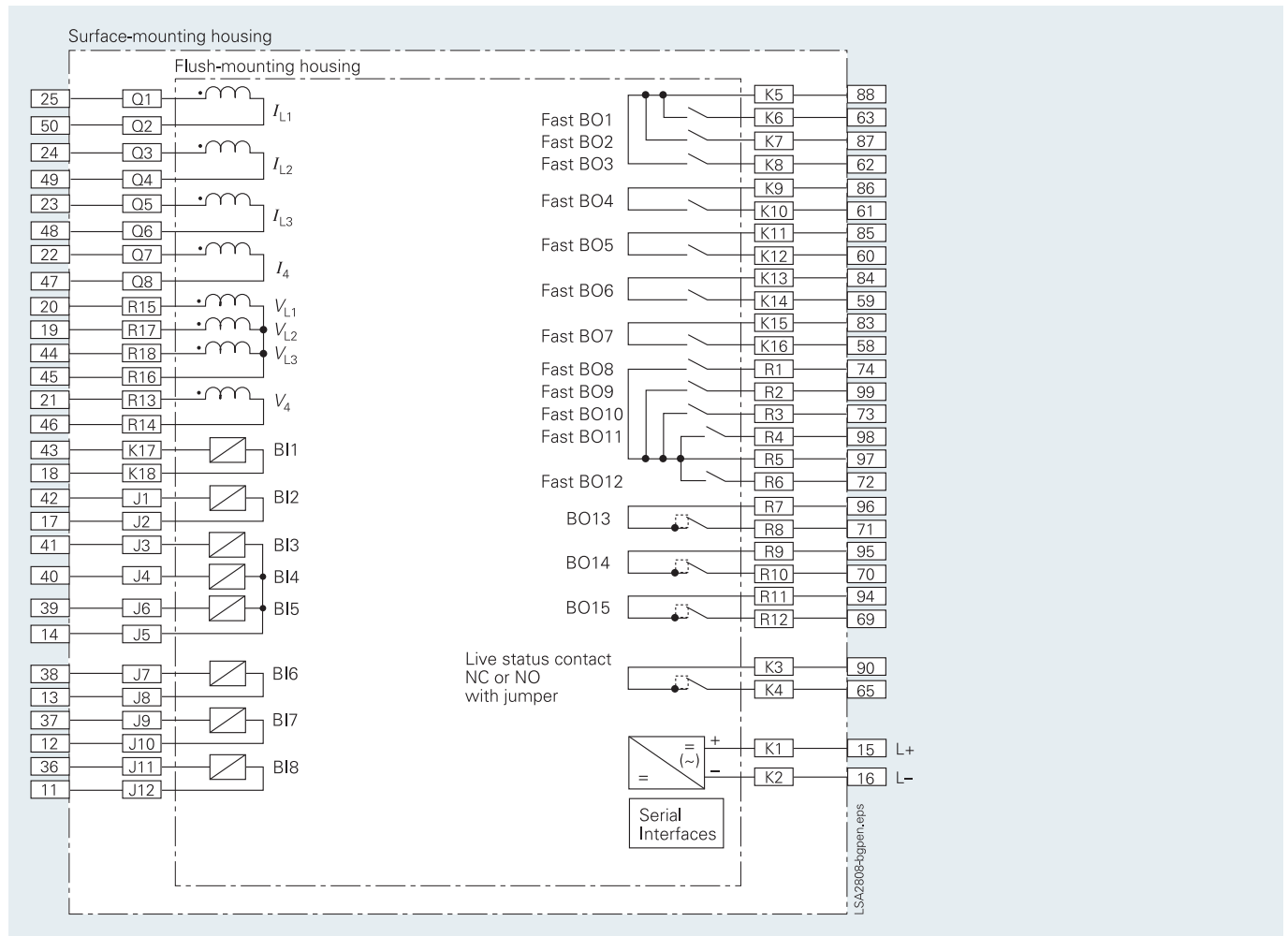


Fig. 6/81 Housing 1/2 x 19", basic version 7SA522x-xA, 7SA522x-xE and 7SA522x-xJ with 8 binary inputs and 16 binary outputs, hardware version .../FF

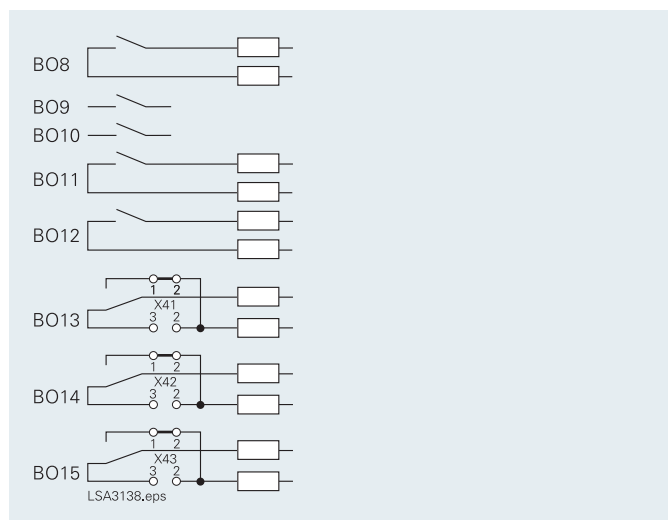


Fig. 6/81a Additional setting by jumpers: Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82. Switching of BO13, BO14, BO15 as NO contact or NC contact with jumpers.

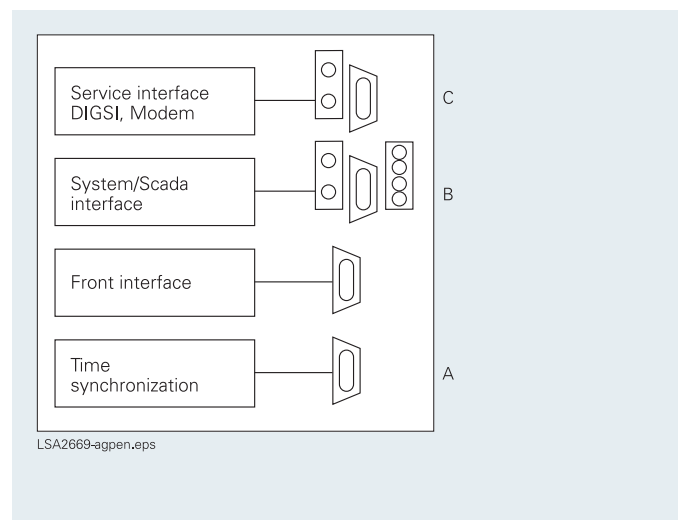
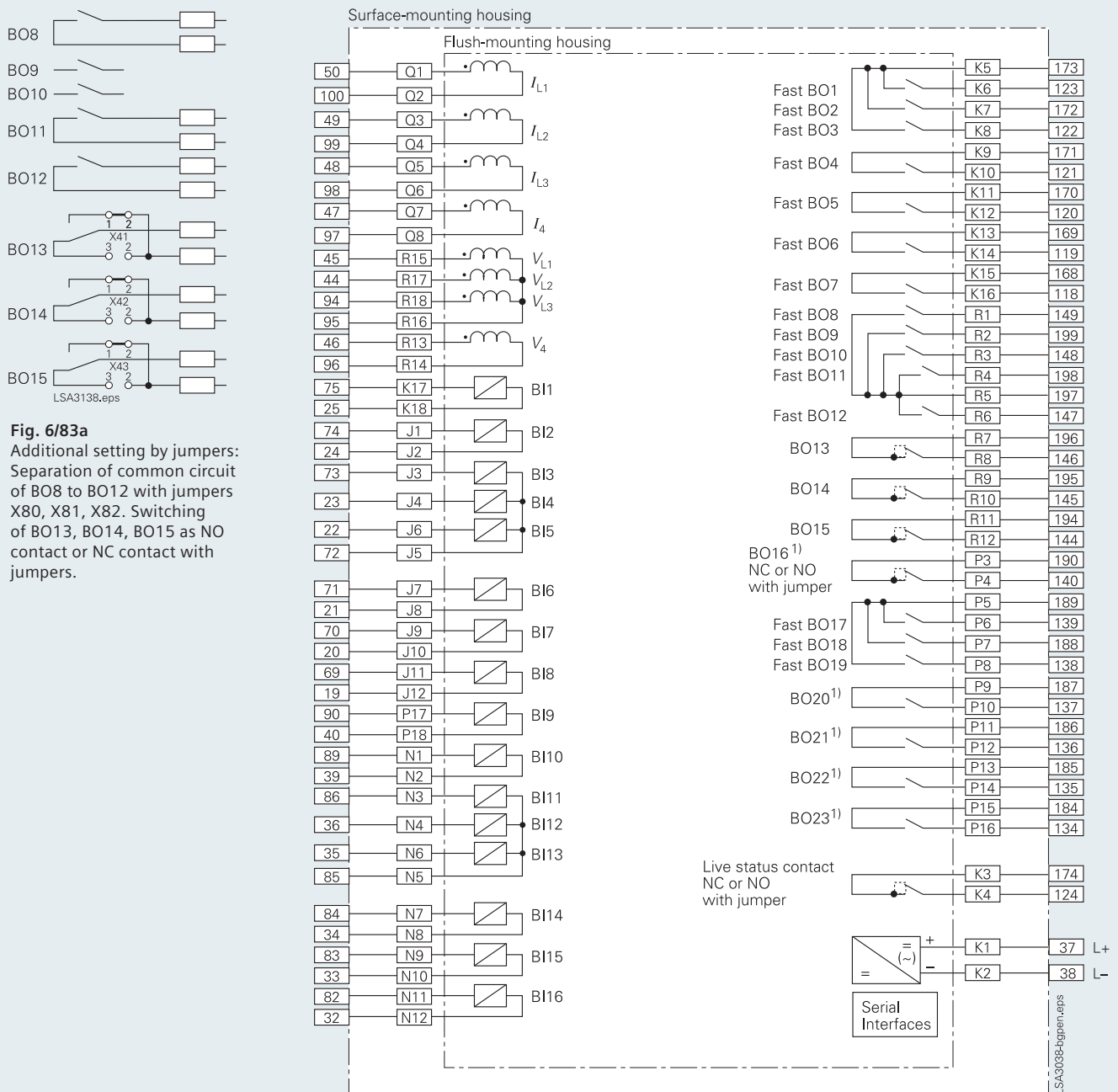


Fig. 6/82 Serial interfaces



1) High-speed trip outputs in versions 7SA522x-xN, 7SA522x-xQ, 7SA522x-xS.

Note: For serial interfaces see Figure 6/82.

Fig. 6/83 Housing 1/4 x 19", medium version 7SA522x-xC, 7SA522x-xG, 7SA522x-xL, 7SA522x-xN, 7SA522x-xQ and 7SA522x-xS with 16 binary inputs and 24 binary outputs, hardware version .../FF

Distance Protection 7SA522

Connection diagram, IEC

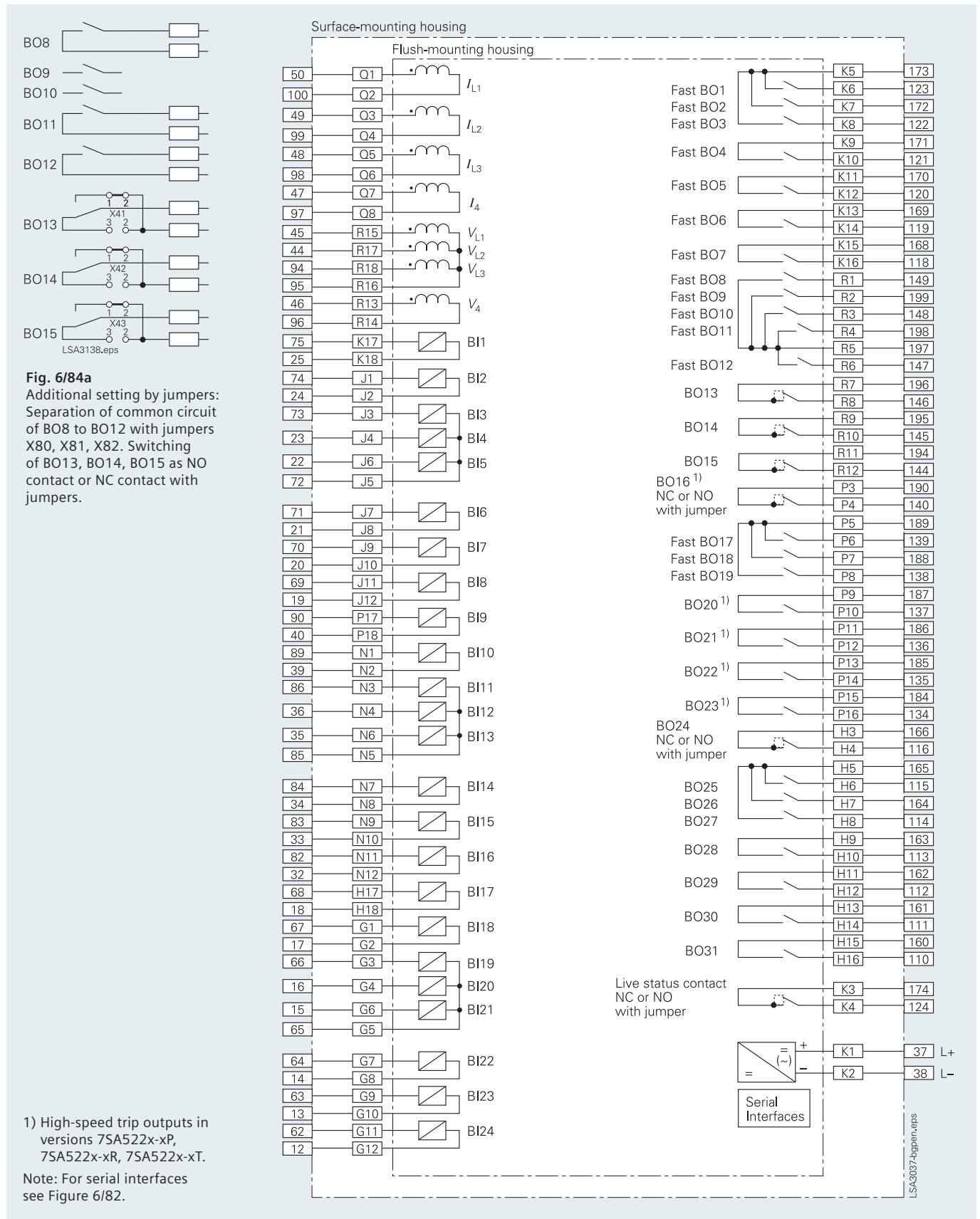


Fig. 6/84 Housing 1/4 x 19", maximum version 7SA522x-xD, 7SA522x-xH, 7SA522x-xM, 7SA522x-xP, 7SA522x-xR and 7SA522x-xT with 24 binary inputs and 32 binary outputs, hardware version .../FF

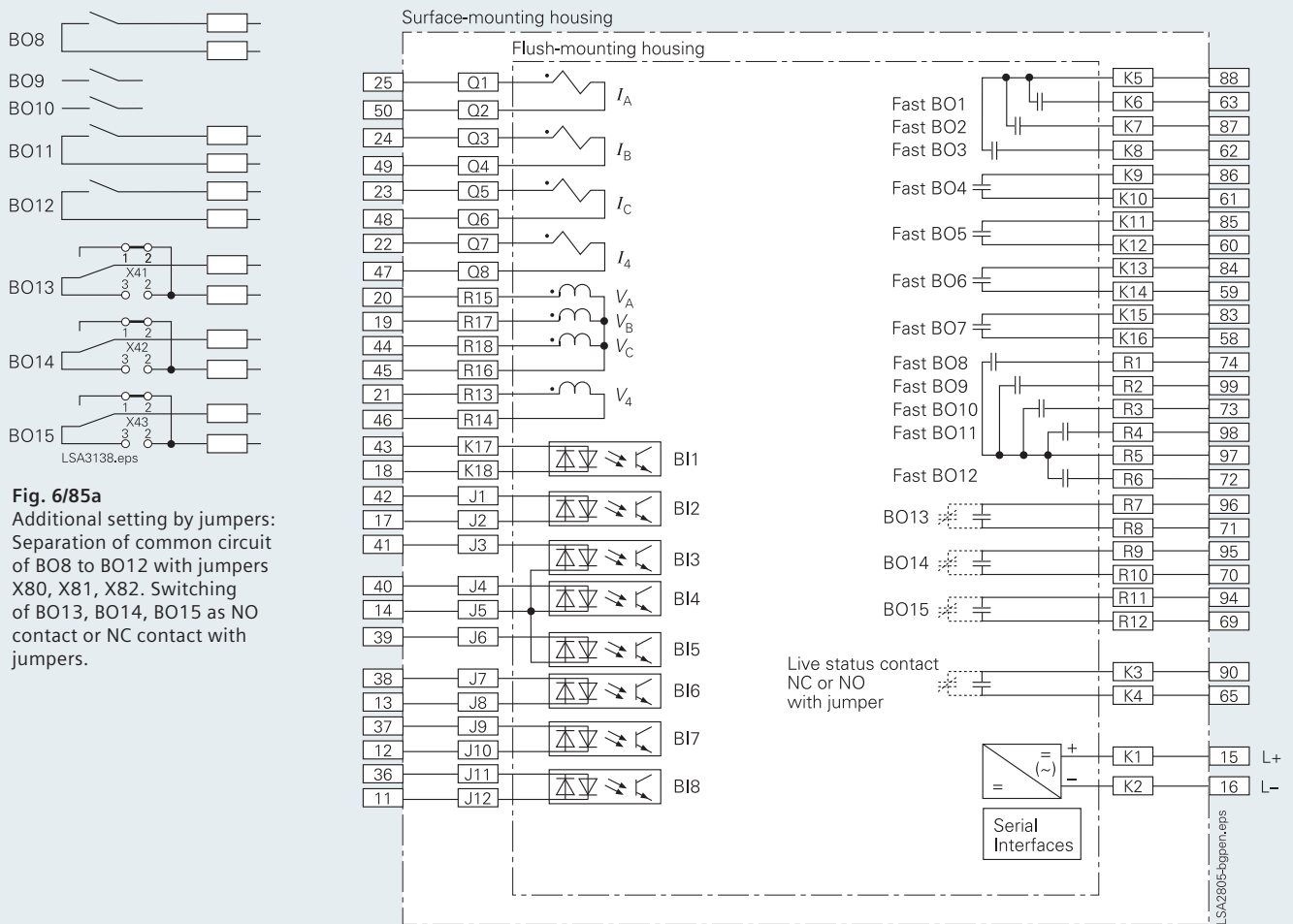


Fig. 6/85a
Additional setting by jumpers:
Separation of common circuit
of BO8 to BO12 with jumpers
X80, X81, X82. Switching
of BO13, BO14, BO15 as NO
contact or NC contact with
jumpers.

Note: For serial interfaces see Figure 6/82.

Fig. 6/85 Housing ½ x 19", basic version 7SA522x-xA, 7SA522x-xE and 7SA522x-xJ
with 8 binary inputs and 16 binary outputs, hardware version .../FF

Distance Protection 7SA522

Connection diagram, ANSI

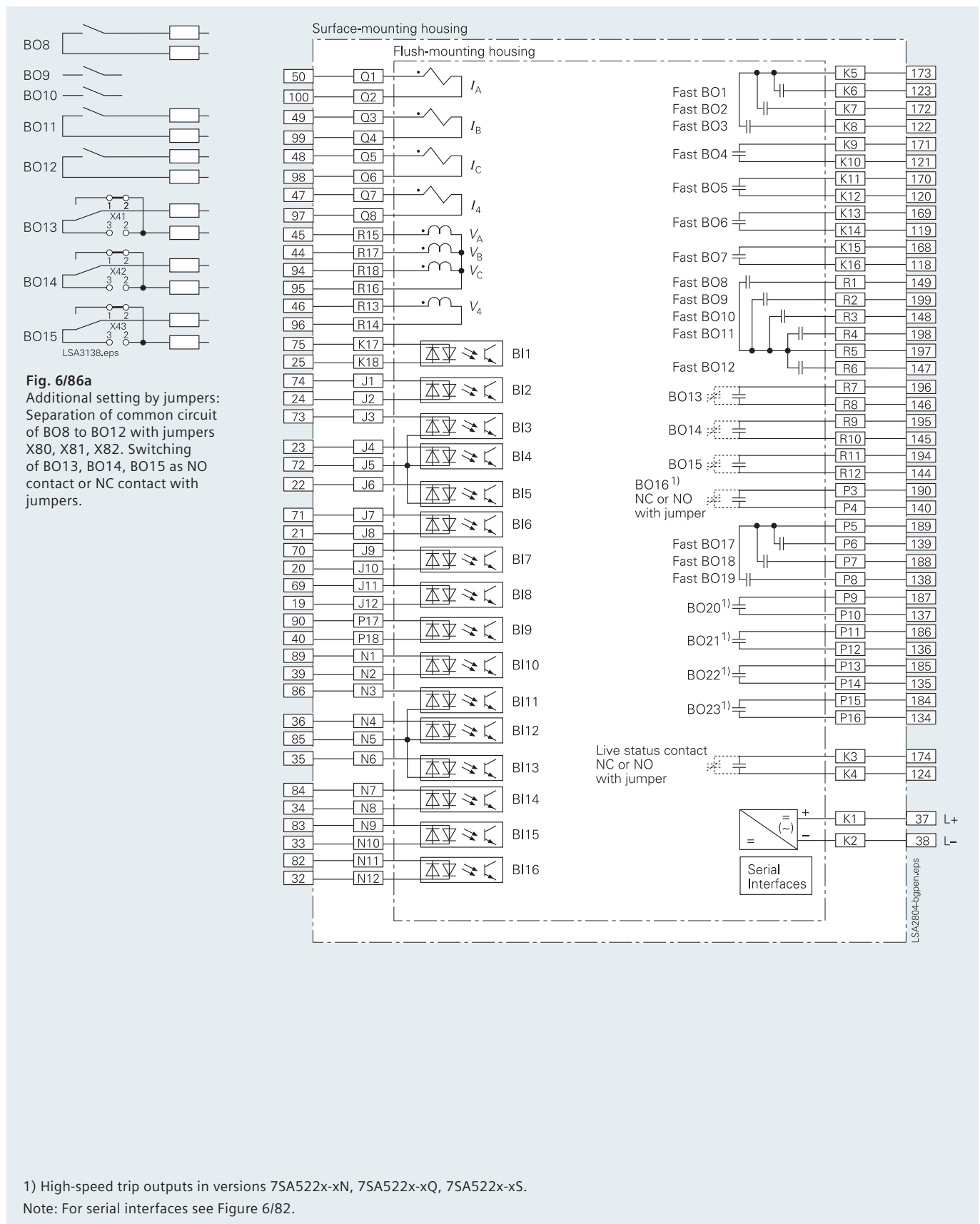


Fig. 6/86 Housing 1/4 x 19", medium version 7SA522x-xC, 7SA522x-xG, 7SA522x-xL, 7SA522x-xN, 7SA522x-xQ and 7SA522x-xS with 16 binary inputs and 24 binary outputs, hardware version .../FF

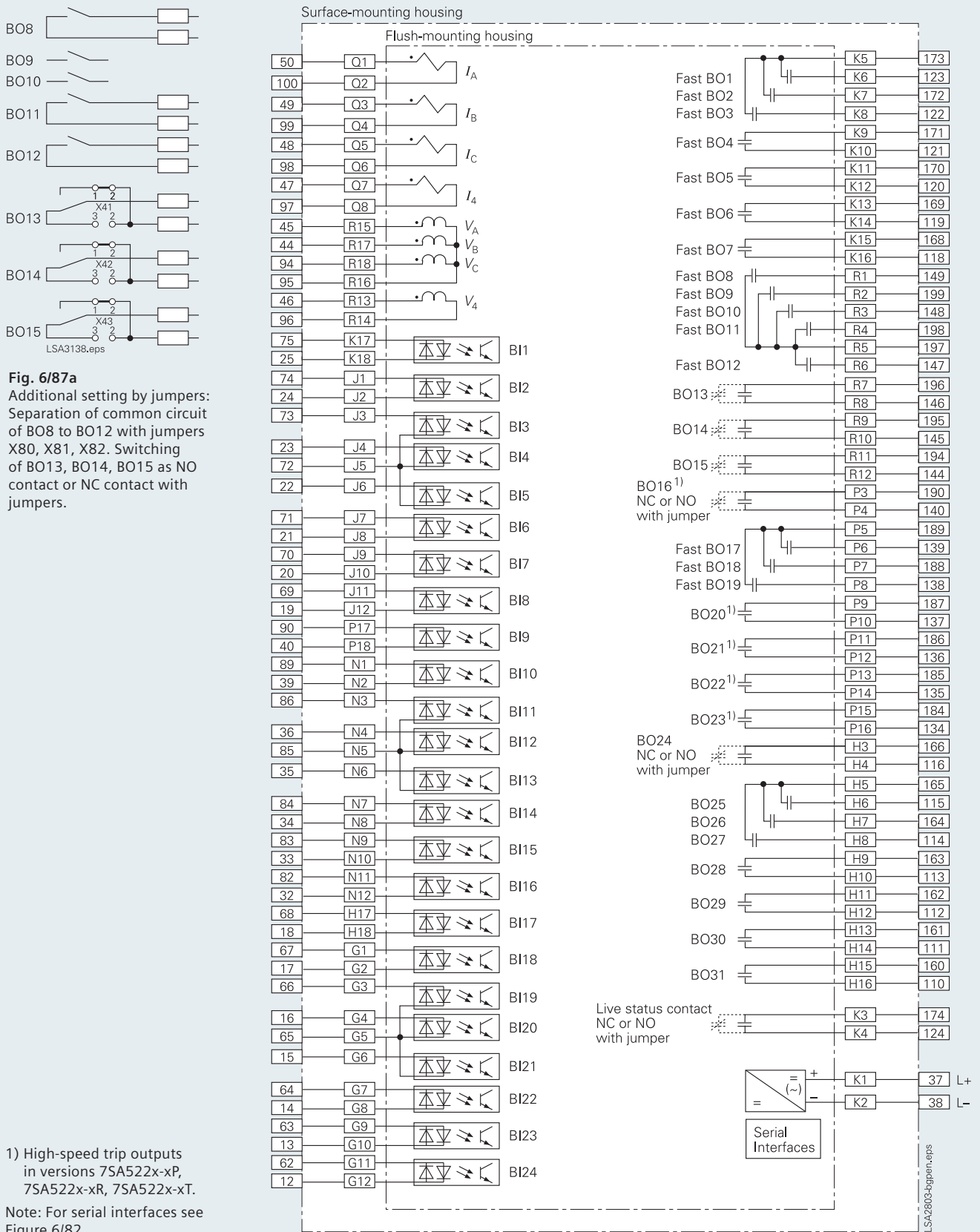


Fig. 6/87 Housing 1/4 x 19", maximum version 7SA522x-xD, 7SA522x-xH and 7SA522x-xM with 24 binary inputs and 32 binary outputs, hardware version ..FF

Line Differential Protection

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multi-end differential and distance
protection in one relay 7/43



Line Differential Protection/7SD60

SIPROTEC 7SD60 numerical pilot-wire current differential protection relay



Fig. 7/1 SIPROTEC 7SD600 numerical current differential protection relay

Description

The 7SD600 relay is a numerical current differential protection relay, simple to set, operating in conjunction with the remote station via a two pilot-wire link. It is connected to the primary current transformers via an external summation current transformer. The primary field of application of the relay is protection of short overhead lines and cables with two line ends. However, transformers and reactors may be located within the protection zone. Features like inrush restraint, lockout, modern PCM-intertrip facilities, full self-monitoring facilities, local and remote interrogation are integrated in the unit.

Function overview

Differential protection relay for overhead lines and cables

- Current differential protection with external summation current transformer 4AM49 (87L)
- Suitable for use for distances of approx. 12 km max. via two pilot wires (1200 Ω loop resistance)
- Differential protection can be combined with an overcurrent release
- Pilot-wire monitoring function
- Bidirectional remote tripping
- Circuit-breaker intertripping at the remote station
- Seal-in of the TRIP command until manual reset (Lockout function)
- Minimal current transformer requirements due to integrated saturation detector
- Restraint against inrush/undelayed trip for high differential fault currents
- Emergency overcurrent protection

Operational measured values

- Local and remote current
- Differential current
- Restraint current

Monitoring functions

- Hardware
- Firmware
- Spill current supervision

Communication

- Via personal computer and DIGSI 3
- Via RS232 \leftrightarrow RS485 converter
- With modem
- With substation control system via IEC 60870-5-103 protocol
- 2 kV isolated RS485 interface, bus connection possible

Hardware

- Local operation by means of integrated keyboard
- LCD display for settings and analysis
- Housing
 - Flush-mounting housing $\frac{1}{8}$ 19" 7XP20
 - Surface-mounting housing $\frac{1}{8}$ 19" 7XP20

Line Differential Protection / 7SD60

Application, construction

Application

The 7SD60 relay is a numerical current differential protection relay, simple to set, and is operated in conjunction with the remote station via a two pilot-wire link.

It is connected to the primary current transformers via an external summation current transformer. The unit operates internally on the summated current taken from the secondary side of the summation current transformer. The link to the remote station is realized by means of a pair of symmetrical pilot wires allowing distances of up to approximately 12 km. Adaptation to the pilot-wire resistance is effected by means of software within the unit. Therefore, matching is not necessary.

The primary field of application of the unit is protection of short overhead lines and cables with two line ends. However, transformers and reactors may be located within the protection zone. The unit can be fitted with inrush restraint in such cases. A differential protection instantaneous tripping stage is also provided in this case. Vector group adaptation is not effected inside the unit and must, if necessary, be effected by means of a matching current transformer.

The 7SD60 can be fitted with a pilot-wire monitoring function. In addition to monitoring the pilot-wire link to the remote station, this also includes bidirectional circuit-breaker intertripping and a remote tripping command.

If the differential protection becomes inactive due to a pilot-wire failure, the relay has an emergency overcurrent function as an option. It includes one definite-time overcurrent stage and can be delayed.

This unit substitutes the 7SD24 steady-state differential protection. However, direct interoperation with the 7SD24 is not possible. On replacement of a 7SD24, its external summation current transformer can be used as the input transformer for the 7SD60.

ANSI	Protection functions
87L/87T	ΔI for lines/cables, transformers
85	Intertrip, remote trip
86	Lockout function
50	Single-stage, definite-time emergency overcurrent protection



Fig. 7/2 Rear view flush-mounting housing

Construction

The compact 7SD60 protection relay contains all the components for:

- Measured-value acquisition and evaluation
- Operation and LCD indications
- Alarm and command contacts
- Input and evaluation of binary signals
- Data transmission via the RS485 bus interface to DIGSI or a substation control system
- Auxiliary voltage supply

The primary current transformers are connected to the 4AM49 summation current transformer. At the rated current value of either 1 A or 5 A, the latter outputs a current of 20 mA which is measured by the 7SD60 unit. The summation current transformer is supplied together with the protection unit, if so ordered.

The unit can be supplied in two different housings. The one for flush mounting in a panel or cubicle has connection terminals at the rear.

The version for panel surface mounting is supplied with terminals accessible from the front. Alternatively, the unit can be supplied with two-tier terminals arranged above and below the unit.

Protection functions

Mode of operation of the differential protection relay

An external summation current transformer 4AM49, which can be supplied as an accessory either in a 1 A or a 5 A version, allows any secondary currents of the primary current transformers (see Fig. 7/3) to be connected. The standard ratios of the three primary windings of the summation current transformer are $IL1:IL2:IL3 = 5:3:4$ ($IL1:IL3:IL0 = 2:1:3$) (see Fig. 7/6). In consequence, the sensitivity of the tripping characteristic for single-phase faults is appreciably higher compared to that for two-phase and three-phase faults. Since the current on such faults is often weak, an amplification factor of 1.7 to 2.8 referred to the symmetrical response value is achieved.

Other sensitivity values can, however, be obtained by altering the connections at the summation CT.

With a symmetrical three-phase current of $1 \times I_{N, \text{Line}}$, the secondary current of the summation current transformer is 20 mA.

The 7SD60 measures and digitalizes the current I_{M1} of the local relay by means of a sensitive current input (see Fig. 7/6). A voltage drop occurs across a fixed-value resistor R_b installed in the unit. With a through-flowing load or a through-flowing short-circuit current, the voltage drop at both ends of the line is approximately equal but of opposite polarity, so that no current flows through the pilot wire. On occurrence of an internal fault, different values are obtained for the voltage drop across R_b at both ends. In consequence, a current I_a flows through the pilot wire, which is measured by means of the current transformer. In conjunction with the pilot-wire resistance (available as a parameter in the unit) and the internal resistor R_a , it is possible to calculate the differential current from the measured current flowing through the pilot wire. As soon as an adjustable value is reached, the protection relay trips the line at both ends.

Matching of the sensitivity of the unit for different values of pilot-wire resistance is effected by the firmware of the unit during parameter setting, so that time-consuming matching of the pilot-wire resistance is unnecessary.

Trip characteristic of the differential protection relay

The main function of the unit is current comparison protection. The trip characteristic is fixed and takes into account both the linear and the non-linear errors of the current transformers. It

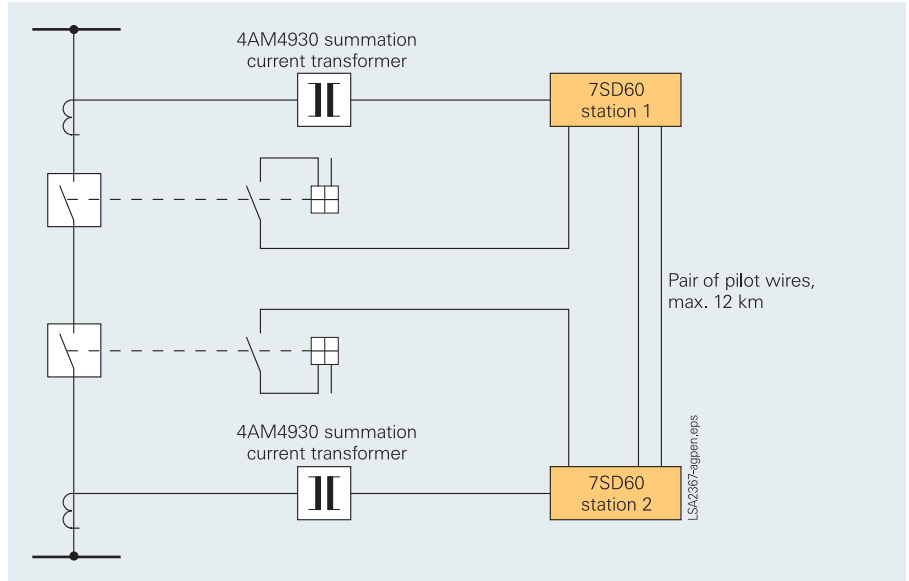


Fig. 7/3 7SD60 line differential protection for operation with two pilotwires

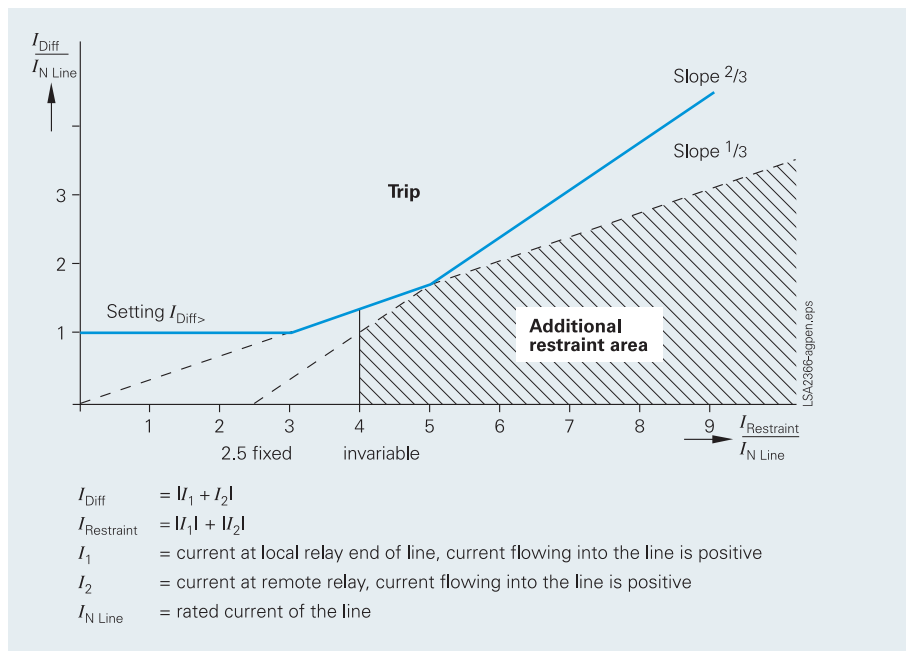


Fig. 7/4 Trip characteristic of differential protection

is only necessary to set the tripping value $I_{\text{Diff}} >$, although the standard setting is suitable for most applications. It should be parameterized according to the rated current of the line; sensitive setting is possible even when the current transformer rated currents and the line rated currents differ by as much as a factor of 2. Differences in the current transformation ratios at the ends of the line must, however, be compensated for by means of external matching current transformers.

In some cases, this can be realized by the summation current transformer.

Line Differential Protection / 7SD60

Protection functions

Overcurrent release / differential current monitoring

The differential protection function can be combined with an additional overcurrent release. To this end, the criteria "overcurrent" and "differential current" are linked logically so that a TRIP command is given out by the differential function only when a differential current and an overcurrent coexist.

By this means it is often possible to avoid malfunctioning due to pilot-wire short-circuit or wire-break of a connection between a current transformer and the summation current transformer. For this purpose, the 7SD60 is fitted with an additional differential current monitoring function, which can effectively block the differential protection after a delay of some seconds on reaching of an adjustable value of differential current in conjunction with simultaneous operational current I_{M1} within the load range.

Saturation detector

Improved stability on single-ended saturation of the primary current transformers is ensured by means of an integrated saturation detector. It provides additional stability during external faults. 5 ms are enough time to measure an external fault due to a high restraint and small differential current. Indication is done within the additional restraint area (see Fig. 7/4). If – due to CT saturation – the differential current flows into the trip area, the differential trip is blocked for a certain time. Transient saturation of current transformers caused by decaying DC components in the short-circuit current can thus be recognized.

As a result, the requirements on the current transformers are reduced so that they are only required to conduct the steady-state through-flowing short-circuit current without saturation.

Pilot-wire link / pilot-wire monitoring

The link to the remote station comprises a symmetrical pair of wires (e.g. telephone lines). The maximum permissible distance between two stations is approximately 12 km. 7XR9513 (20 kV) or 7XR9515 (5 kV) isolation transformers can be employed for potential isolation against interference induced by longitudinal voltages where the pilot wires run parallel to power cables over long distances.

Since the pilot wires form an integral part of the differential protection, these are normally monitored continuously. This function is available as an option. To achieve this, 2 kHz pulses with a defined pulse width ratio are transmitted to the remote relay via the pilot wires. Detection of a fault in the pilot-wire link results in blocking of the differential protection.

Emergency overcurrent protection

If the differential protection becomes inactive due to a pilot-wire failure or an internal or external blocking of the differential function, the relay offers a single-stage, definite-time overcurrent function. It works with the local flowing operational current I_{M1} . The pickup value and the delay time are settable via parameters in the device.

Circuit-breaker intertripping / remote tripping

Normally, tripping is effected at both stations as a result of current comparison. Tripping at one end only can occur when an overcurrent release is used or with short-circuit currents only slightly above the tripping value. Circuit-breaker intertripping can be parameterized in the unit with integral pilot-wire monitor, so that definite tripping at both ends of the line is assured.

In addition, it is possible by means of a binary input to output a remote tripping command for both directions. The command transmission time is approximately 80 ms.

Lockout of the TRIP command with manual reset

The TRIP command can be locked-out after tripping. In particular, in the case of transformers within the protection zone, reclosure of the line is normally effected only after the cause of the fault has been ascertained by the user. Manual reset is possible either via the operator panel (with password) or via a binary input. As a result, premature reclosure of the circuit-breaker is prevented. The logic state of the TRIP command remains stored even during failure of the auxiliary supply voltage, so that it is still present on restoration of the auxiliary supply voltage.

Inrush restraint / instantaneous tripping stage

Where transformers or reactors are located within the protection zone, inrush restraint can be supplied as an option. This inrush restraint evaluates the second harmonic of the differential current, which is typical for inrush phenomena. If the second harmonic value of the differential current referred to the fundamental frequency exceeds a preset value, tripping by the differential protection is blocked. In the case of high-current internal faults, whose amplitude exceeds the inrush current peak, tripping can be carried out instantaneously.

Vector group adaptation is not effected inside the unit and must, where necessary, be brought about by means of an external matching transformer scheme.

Features

Serial data transmission

As standard, the unit is fitted with an RS485 interface. This is suitable for connection to a bus and allows up to 32 devices to be connected via a two-wire serial interface (use of a third core for ground is recommended). A PC is connected via this interface using an RS232 ↔ RS485 converter, thus allowing the DIGSI operator program to be used, by means of which PC-aided planning, parameter setting and evaluation can be performed. By this readout, it is also possible to output the fault recordings stored by the unit on occurrence of faults.

Using an RS485 ↔ 820 nm optical converter as an accessory (7XV5650, 7XV5651), it is possible to provide an interference-free and isolated link to a central control system or a remote control system employing DIGSI, thus allowing economically viable configurations to be used, e.g. for remote diagnostics.

The serial interface can also be set to the IEC 60870-5-103 protocol (VDEW - Association of German Utilities - interface), thus allowing the unit to be integrated in a substation control system. However, only 2 messages (ready for operation and the trip signal) and the fault recording are available.

For this reason, it is recommended to use the 7SD610 unit combined with an external communication converter for pilot wires in those cases in which integration in the substation control system is a prime consideration.

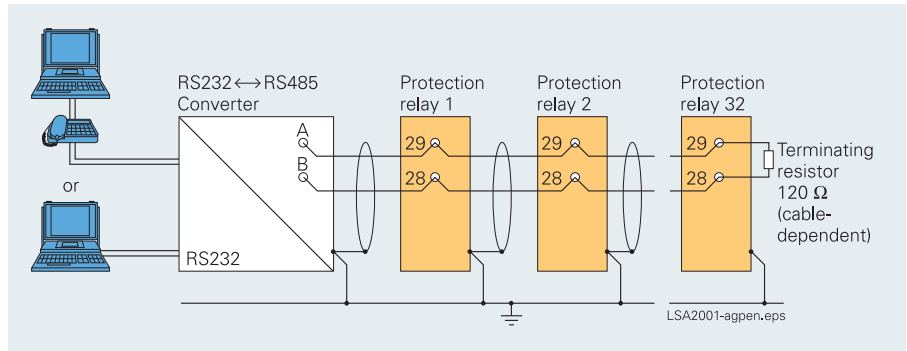


Fig. 7/5 Bus communication via RS485 interface
For convenient wiring of RS485 bus, use bus cable system 7XV5103
(see part 13 of this catalog).

Line Differential Protection / 7SD60

Connection diagrams

Connection diagrams

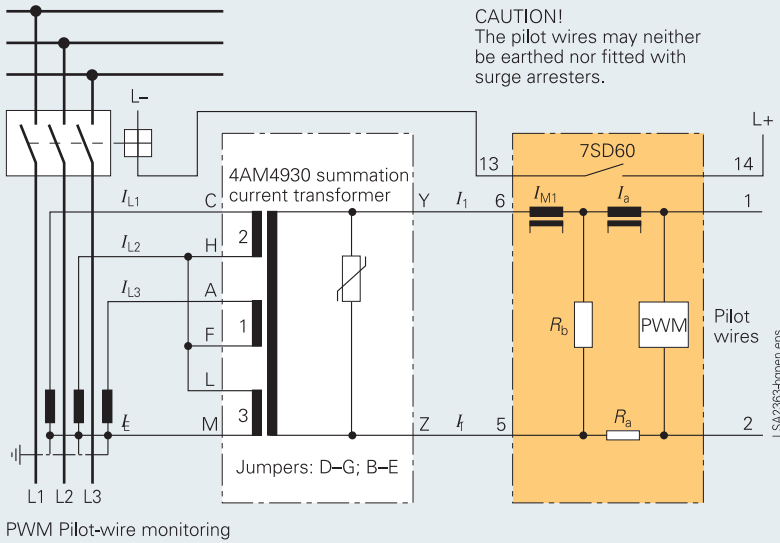


Fig. 7/6 Standard connection L1-L3-E, suitable for all types of networks

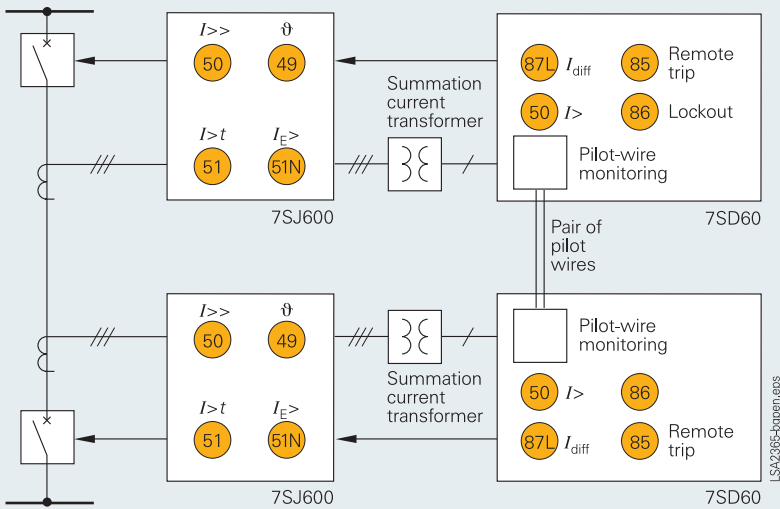


Fig. 7/7 Protection configuration with main (7SD60) and backup overcurrent (7SJ600) protection

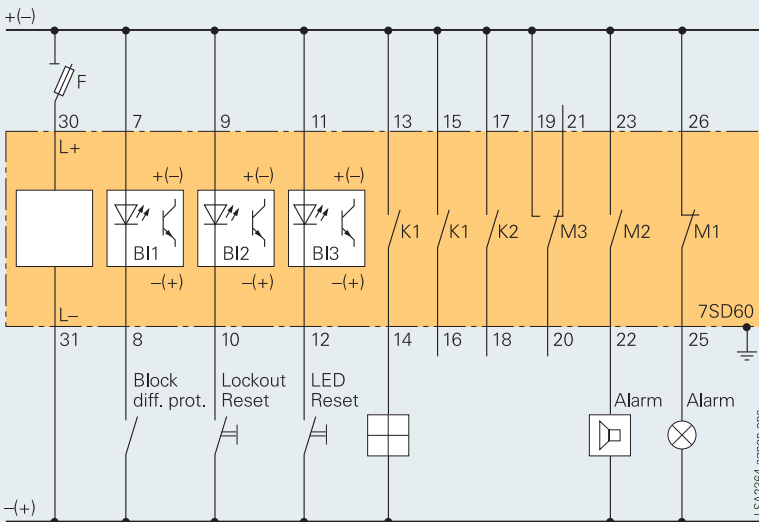


Fig. 7/8 Typical circuit for auxiliary voltage supply

Line Differential Protection/7SD60

Technical data

General unit data		Binary inputs	
<i>Input circuits</i>		Number	3 (marshallable)
Rated current I_N	20 mA without summation current transformer 1 or 5 A with summation current transformer	Operating voltage	DC 24 to 250 V
Rated frequency f_N	50/60 Hz parameterizable	Current consumption, energized	Approx. 2.5 mA independent of operating voltage
Thermal overload capability current path		Pick-up threshold reconnectable	By solder bridges
Continuous	$2 \times I_N$	Rated aux. voltages DC 24/48/60 V	
For 10 s	$30 \times I_N$	$V_{pick-up}$	\geq DC 17 V
For 1 s	$100 \times I_N$	$V_{drop-off}$	$<$ DC 8 V
<i>Auxiliary voltage</i>		Rated aux. voltages DC 110/125/220/250 V	
Auxiliary voltage via integrated DC/DC converter		$V_{pick-up}$	DC 74 V
Rated auxiliary DC voltage/ permissible variations	DC 24/48 V / DC 19 to 58 V DC 60/110/125 V / DC 48 to 150 V DC 220/250 V / DC 176 to 300 V	$V_{drop-off}$	$<$ DC 45 V
Superimposed AC voltage V_{aux} Peak-to-peak	\leq 12 % at rated voltage \leq 6 % at limits of admissible voltage	<i>Unit design</i>	
Power consumption		Housing	7XP20
Quiescent	Approx. 2 W	Dimensions	For dimensions, see dimension drawings, part 14
Energized	Approx. 4 W	Weight	
Bridging time during failure/ short-circuit of auxiliary voltage	\geq 50 ms (at $V_{aux} \geq$ AC/DC 100 V) \geq 20 ms (at $V_{aux} \geq$ 2 DC 4 V)	With housing for surface mounting	Approx. 4.5 kg
Rated auxiliary voltage AC V_{aux} / permissible variations	AC 115 V / AC 88 to 133 V	With housing for flush mounting/cubicle mounting	Approx. 4 kg
<i>Command contacts</i>		Degree of protection acc. to EN 60529	
Number of relays	2 (marshallable)	Housing	IP 51
Contacts per relay	2 NO or 1 NO	Terminals	IP 21
Switching capacity		<i>Serial interface (Isolated)</i>	
Make	1000 W/VA	Standard	RS485
Break	30 W/VA	Test voltage	DC 2.8 kV for 1 min
Switching voltage	250 V	Connection	Via wire to housing terminals, 2 data transmission lines, 1 grounding cable for connection to an RS485 \leftrightarrow RS232 converter, cables have to be shielded, screen has to be grounded Setting at supply: 9600 baud
Permissible current		Baud rate	Min. 1200 baud; max. 19200 baud
Continuous	5 A		
For 0.5 s	30 A		
<i>Signal contacts</i>			
Number of relays	3 (2 marshallable)		
Contacts per relay	1 CO		
Switching capacity			
Make	1000 W/VA		
Break	30 W/VA		
Switching voltage	AC/DC 250 V		
Permissible current	5 A		

Line Differential Protection/7SD60

Technical data

Electrical tests		EMC tests for interference emission; type tests	
<i>Specification</i>			
Standards	IEC 60255-5 ANSI/IEEE C37.90.0	Standard	EN 50081- (generic standard)
<i>Insulation tests</i>		Conducted interference voltage on lines, auxiliary voltage only, EN 55022, VDE 0878 Part 22, CISPR 22, limit value, limit class B	150 kHz to 30 MHz
Voltage test (routine test) All circuits except DC voltage supply and RS485 Only DC voltage supply and RS485	2 kV (r.m.s.), 50 Hz DC 2.8 kV	Interference field strength EN 55011, VDE 0875 Part 11, IEC CISPR 11, limit value, limit class A	30 to 1000 MHz
Impulse voltage test (type test) All circuits, class III	5 kV (peak), 1.2/50 μ s, 0.5 J; 3 positive and 3 negative impulses at intervals of 5 s		
Test crosswise: Measurement circuits, pilot wire connections, power supply, binary inputs, class III, (no tests crosswise over open contacts, RS458 interface terminals)			
EMC tests for noise immunity; type tests		Mechanical dynamic tests	
Standards	IEC 60255-6; IEC 60255-22 (international product standard) EN 50082-2 (generic standard) VDE 0435, Part 303 (German product standard)	<i>Vibration, shock stress and seismic vibration</i>	
High-frequency test IEC 60255-22-1, VDE 0435 Part 303; class III	2.5 kV (peak); 1 MHz; $\tau = 15$ ms; 400 surges; duration 2 s	<u>During operation</u>	
Electrostatic discharge IEC 60255-22-2, EN 61000-4-2; class III	4/6 kV contact discharge; 8 kV air discharge; both polarities; 150 pF; $R_i = 330 \Omega$	Standards	IEC 60255-21; IEC 60068-2
Irradiation with RF field, non-modulated IEC 60255-22-3 class III	10 V/m 27 to 500 MHz	Vibration IEC 60255-21-1, class I IEC 60068-2-6	Sinusoidal 10 to 60 Hz; ± 0.035 mm amplitude; 60 to 150 Hz; 0.5 g acceleration; sweep rate 1 octave/min; 20 cycles in 3 orthogonal axes
Irradiation with RF field, amplitude-modulated IEC 61000-4-3; class III	10 V/m 80 to 1000 MHz; AM 80 %; 1 kHz	Shock IEC 60255-21-2, class I	Half-sine 5 g acceleration, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
Irradiation with RF field, pulse-modulated IEC 61000-4-3/ENV 50204; class III	10 V/m, 900 MHz; repetition rate 200 Hz, duty cycle 50 %	Seismic vibration IEC 60255-21-3, class I IEC 60068-2-6	Sinusoidal 1 to 8 Hz; ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz; ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz; 1 g acceleration (horizontal axis) 8 to 35 Hz; 0.5 g acceleration (vertical axis) Sweep rate 1 octave/min 1 cycle in 3 orthogonal axes
Fast transients/bursts IEC 60255-22-3, IEC 61000-4-4, class IV	2 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50 \Omega$; duration 1 min	<u>During transport</u>	
Line-conducted RF amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; AM 80 %; 1 kHz	Standards	IEC 60255-21; IEC 60068-2
Power frequency magnetic field IEC 61000-4-8; class IV; EN 60255-6	30 A/m; 50 Hz, continuous 300 A/m for 3 s; 50 Hz; 0.5 mT, 50 Hz	Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 5 Hz to 8 Hz: ± 7.5 mm amplitude 8 Hz to 150 Hz: 2 g acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Oscillatory surge withstand capability ANSI/IEEE C37.90.1 (common mode)	2.5 to 3 kV (peak), 1 MHz to 1.5 MHz decaying oscillation; 50 shots per s; duration 2 s; $R_i = 150 \Omega$ to 200 Ω	Shock IEC 60255-21-2, class I IEC 60068-2-27	Half-sine Acceleration 15 g, duration 11 ms, 3 shocks Shocks in each direction of 3 orthogonal axes
Fast transient surge withstand capability ANSI/IEEE C37.90.1 (common mode)	4 to 5 kV; 10/150 ns; 50 shots per s both polarities; duration 2 s; $R_i = 80 \Omega$	Continuous shock IEC 60255-21-2, class I IEC 60068-2-29	Half-sine Acceleration 10 g, duration 16 ms, 1000 shocks in each direction of 3 orthogonal axes
Radiated electromagnetic interference ANSI/IEEE C37.90.2	10 to 20 V/m; 25 to 1000 MHz; amplitude and pulse-modulated		
High-frequency test Document 17C (SEC) 102	2.5 kV (peak, alternating polarity) 100 kHz, 1 MHz, 10 and 50 MHz, decaying oscillation; $R_i = 50 \Omega$		

Climatic stress test	
<i>Temperatures</i>	
Standards	EN 60255-6, IEC 60255-6 DIN VDE 0435 Part 303
Recommended temperature	-5 to +55 °C (>55 °C/131 °F decreased display contrast)
Limit temperature	
During service	-20 to +70 °C -4 to +158 °F
During storage	-25 to +55 °C -13 to +131 °F
During transport (Storage and transport with standard works packing!)	-25 to +70 °C -13 to +158 °F
<i>Humidity</i>	
It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation	Mean value per year ≤ 75 % relative humidity, on 30 days a year up to 95 % relative humidity, condensation not permissible!

Functions	
<i>Line differential protection</i>	
Note	All current values refer to the symmetrical current using standard connection
Setting ranges	
Current threshold I_1 (release by local station current)	I/I_N Line: 0 to 1.5 (step 0.01)
Differential current	I/I_N Line: 0.5 to 2.5 (step 0.01)
Delay time t	0 to 60 s (step 0.01 s)
Restrained by 2 nd harmonic (see Fig. 7/4)	
$2f_N / f_N$	10 to 80 %
Reset ratio	Approx. 0.7 – drop-off ratio ($I_{\text{restraint}} = 0$)
Inherent delays	
TRIP time for two-end supply at 4 x set value	Approx. 20 to 28 ms without restraint by 2 nd harmonic Approx. 32 to 42 ms with restraint by 2 nd harmonic
Drop-off time	Approx. 35 ms
Tolerances at preset values under reference conditions	
Local station current threshold	± 3 % of setpoint, min. $0.02 \times I_N$
Differential current	± 5 % of setpoint, min. $0.02 \times I_N$
Influence parameters	
Auxiliary supply voltage $0.8 \leq V_{\text{aux}}/V_{\text{auxN}} \leq 1.15$	≤ 1 %
Temperature in range $0 \text{ °C} \leq \Theta_{\text{amb}} \leq 40 \text{ °C}$	≤ 1 %/10 K
Frequency in range $0.9 \leq f/f_N \leq 1.1$	≤ 4 %
Pilot wires	
Number	2 Symmetric telephone pairs are recommended with loop resistance 73 Ω/km and capacitance 60 nF/km
Core-to-core asymmetry at 800 Hz	Max. 10^{-3}
Maximum loop resistance	1200 Ω
Permissible induced longitudinal voltages	
On direct connection of the pilot wires	≤ 1.2 kV, however, max. 60 % of the test voltage of the pilot wires
For connection via isolating transformer	≥ 1.2 kV, however, max. 60 % of the test voltage of the pilot wires and max. 60 % of the test voltage of the isolating transformers

Pilot-wire monitoring and intertripping (optional)	
Monitoring signal	2000 Hz, pulse-code modulation
Alarm signal delay	1 to 60 s (step 1 s)
Inherent delay time of intertripping	Approx. 65 ms
Extension of the intertripping signal	0 to 5 s (step 0.01 s)
<i>Emergency overcurrent protection</i>	
Setting ranges	
Overcurrent pickup value $I_{M1} / I_{N\text{line}}$	0.1 to 15 (step 0.1)
Delay time	0.0 to 60 s (step 0.01 s)
<i>Remote trip</i>	
Note	Tripping of the remote end circuit-breaker for units with pilot-wire monitoring only
Setting ranges	
Prolongation time for transmission to remote station	0 to 60 s (step 0.01 s)
Delay time for reception from the remote station	0 to 60 s (step 0.01 s)
Prolongation time for reception from the remote station	0 to 60 s (step 0.01 s)
Tolerances	1 % and 10 ms respectively
Delay time/release delay	
Inherent delay	
Transmission time without delay	Approx. 80 ms
<i>Lockout function</i>	
Lockout seal-in of trip command	For differential protection and remote trip until reset
Lockout reset	By means of binary input and/or local operator panel/DIGSI

Additional functions	
Operational measured values	
Operational currents	$I_1, I_2, I_{\text{Diff}}, I_{\text{restraint}}$
Measurement range	0 to 240 % I_N
Tolerance (I_1)	3 % of rated value or of measured value
Fault event recording	Storage of the events relating to the last 8 faults
Time-tagging	
Resolution for operational events	1 s
for fault events	1 ms
Fault recording (max. 8 faults)	
Storage time (from response or trip command)	Total of 5 s max., pre-trigger and post-fault time settable
Maximum length per recording T_{max}	0.30 to 5.00 s (step 0.01 s)
Pre-trigger time T_{pre}	0.05 to 0.50 s (step 0.01 s)
Post-fault time T_{post}	0.05 to 0.50 s (step 0.01 s)
Time resolution at 50 Hz	1 instantaneous value per 1.66 ms
Time resolution at 60 Hz	1 instantaneous value per 1.38 ms
Circuit-breaker test	Using test circuit

Line Differential Protection / 7SD60

Technical data

4AM4930 summation current transformer

Power consumption in the circuit with standard connection L1-L3-E (Fig. 7/6) referred to the through-flowing rated current 7SD600 unit in operation).

I_N		in phase (approx. VA)		
		L1	L2	L3
1 A	Single-phase	2.2	1.3	1.7
	Symmetrical three-phase	0.6	0.2	0.35
2 A	Single-phase	3.5	1.5	2.2
	Symmetrical three-phase	0.7	0.2	0.5

CT rated current	Connections	4AM4930-7DB $I_N = 1 \text{ A}$	4AM4930-6DB $I_N = 5 \text{ A}$
Number of turns Primary windings	A to B	5	1
	C to D	10	2
	E to F	15	3
	G to H	30	6
	I to K	30	6
	K to L	30	6
	L to M	60	12
	Secondary windings	Y to Z	1736
Thermal rating Continuous current in Amperes	A to B	4.5	20
	C to D	4.5	20
	E to F	4.5	20
	G to H	4.5	20
	I to K	1.2	6.5
	K to L	1.2	6.5
	L to M	1.2	6.5
	Y to Z	0.2	0.2
Secondary rated current with standard connection (see Fig. 7/6) and symmetrical 3-phase current	Y to Z	20 mA	20 mA

Requirements for the current transformers (CT)

$$K'_{ssc} \geq \frac{I_{scc \max(\text{ext. fault})}}{I_{pn}}$$

and:

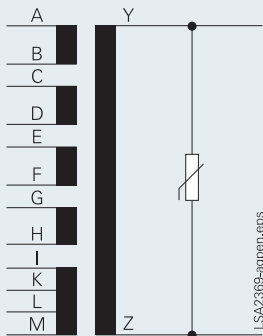
$$\frac{3}{4} \leq \frac{(K'_{ssc} \cdot I_{pn})_{\text{end1}}}{(K'_{ssc} \cdot I_{pn})_{\text{end2}}} \leq \frac{4}{3}$$

K'_{ssc1} = effective symmetrical short-circuit current factor end 1

K'_{ssc2} = effective symmetrical short-circuit current factor end 2

$I_{scc \max}$ = maximum symmetrical short-circuit current

I_{pn} = CT rated primary current



CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EG previous 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 2006/95/EG previous 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".

Line Differential Protection / 7SD60

Selection and ordering data

Accessories	Description	Order No.
	DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000 / XP Professional Edition Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
	Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
	Professional + IEC 61850 Complete version: DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for control displays), DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	7XS5403-0AA00
	SIGRA 4 Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000 or XP Professional Edition. (generally contained in DIGSI Professional, but can be ordered additionally) Authorization by serial number. On CD-ROM.	7XS5410-0AA00
	Connecting cable Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	7XV5100-4
	Voltage transformer miniature circuit-breaker Rated current 1.6 A; thermal overload release 1.6 A; overcurrent trip 6 A	3RV1611-1AG14
	Converter R232 (V.24) ↔ RS485* With connecting cable 1m, PC adapter, with plug-in power supply unit AC 230 V	7XV5700-0□□□00 ¹⁾
	With plug-in power supply unit AC 110 V	7XV5700-1□□□00 ¹⁾
	Converter RS485 ↔ FO Rated auxiliary voltage DC 24 to 250 V and AC 250 V Single optical interface	7XV5650-0BA00
	Double optical interface (cascadable)	7XV5651-0BA00
	Summation current transformer 1 A, 50/60 Hz, for 7SD600	4AM4930-7DB00-0AN2
	5 A, 50/60 Hz, for 7SD600	4AM4930-6DB00-0AN2
	Isolating transformer Up to 20 kV	7XR9513
	Up to 5 kV	7XR9515
	Manual for 7SD60 English	E50417-G1176-C069-A3
	1) Possible versions see part 13. * RS485 bus system up to 115 kbaud RS485 bus cable and adaptor 7XV5103-□AA□□; see part 13.	

Line Differential Protection/7SD60

Connection diagram

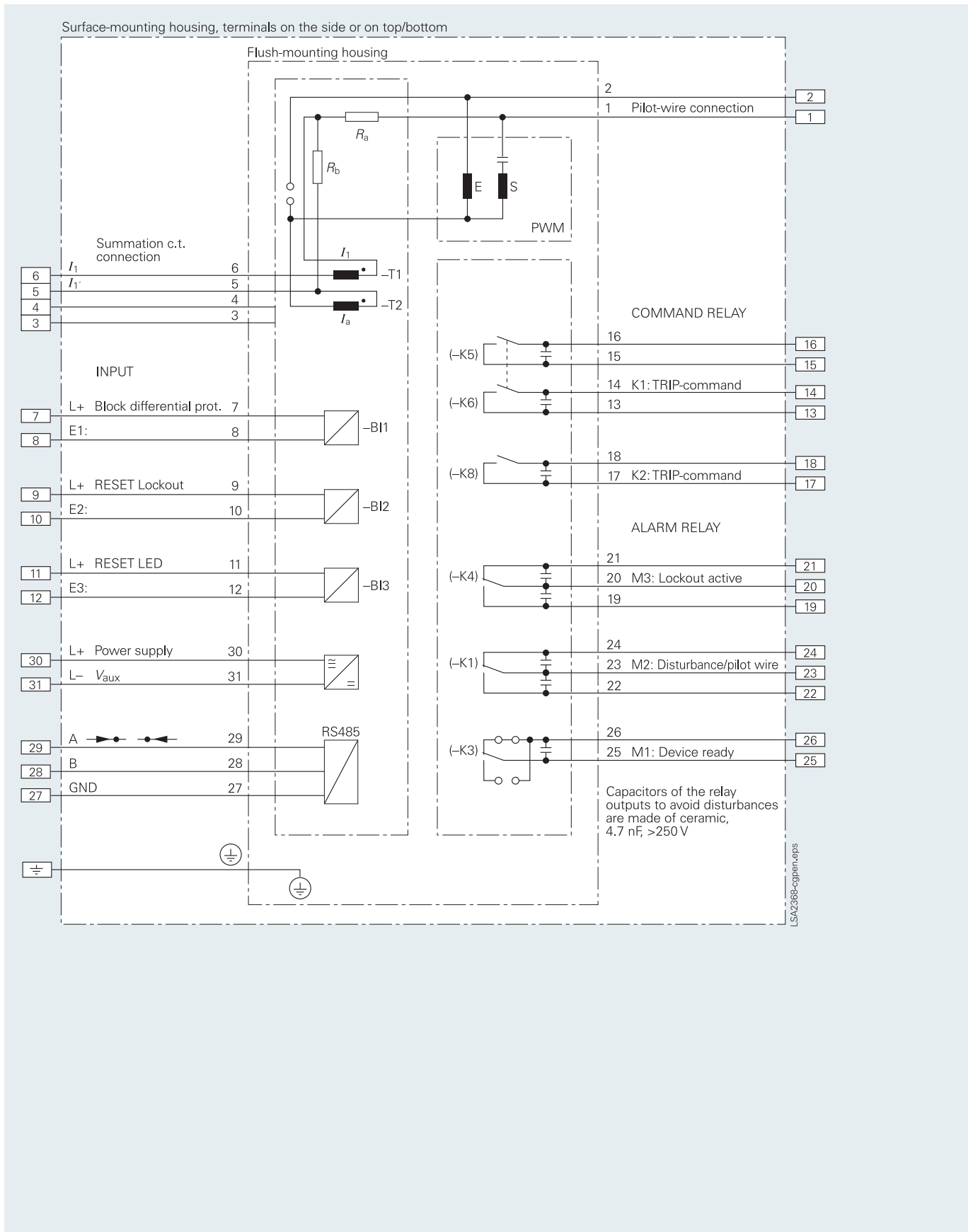


Fig. 7/9 Connection diagram of the 7SD60 current differential protection

Line Differential Protection / 7SD60

Line Differential Protection/7SD61

SIPROTEC 4 7SD61 differential protection relay for two line ends



Fig. 7/10 SIPROTEC 4 7SD61 differential protection relay

Description

The 7SD610 relay is a differential protection relay suitable for all types of applications and incorporating all those functions required for differential protection of lines, cables and transformers. Transformers and compensation coils within the differential protection zone are protected by means of integrated functions, which were previously to be found only in transformer differential protection. It is also well-suited for complex applications such as series and parallel compensation of lines and cables.

It is designed to provide differential and directional back-up protection for all voltage levels and types of networks. The relay features high speed and phase-selective short-circuit measurement. The unit is thus suitable for single-phase and three-phase fault clearance.

Digital data communication for differential current measurement is effected via fiber-optic cables, networks or pilot wires connections, so that the line ends can be quite far apart. The serial protection interface (R2R interface) of the relay can flexibly be adapted to the requirements of all existing communication media. If the communication method is changed, flexible retrofitting of communication modules to the existing configuration is possible.

Apart from the main protection function, i.e. the differential protection, the 7SD610 has a full range of configurable emergency and / or back-up protection functions such as phase and ground overcurrent protection with directional elements if voltage transformers are connected. Overload, under- and over-voltage/frequency and breaker-failure protection round off the functional scope of the 7SD610.

Function overview

Protection functions

- Differential protection for universal use with power lines and cables on all voltage levels with phase-segregated measurement (87L)
- Two line ends capability
- Suitable for transformers in protected zones (87T)
- Restricted ground-fault protection (87N) if a transformer is within the protection zone
- Well-suited for serial compensated lines
- Two independent differential stages: one stage for sensitive measuring for high-resistance faults and one stage for high-current faults and fast fault clearance
- Breaker-failure protection (50BF)
- Phase and ground overcurrent protection with directional element (50, 50N, 51, 51N, 67, 67N)
- Phase-selective intertripping (85)
- Overload protection (49)
- Over/undervoltage protection (59/27)
- Over/underfrequency protection (81O/U)
- Auto-reclosure single/three-pole (79)

Control functions

- Command and inputs for control of CB and disconnectors (isolators)

Monitoring functions

- Self-supervision of the relay
- Trip circuit supervision (74TC)
- 8 oscillographic fault records
- CT-secondary current supervision
- Event logging / fault logging
- Switching statistics

Front design

- User-friendly local operation
- PC front port for convenient relay setting
- Function keys and 8 LEDs for local alarm

Communication interfaces

- 1 serial protection data (R2R) interface
- Front interface for PC connection
- System interface
 - IEC 61850 Ethernet
 - IEC 60870-5-103 protocol
 - PROFIBUS-DP, DNP 3.0 and MODBUS
- Service / modem interface (rear)
- Time synchronization via IRIG-B, DCF77 or system interface

Features

- Browser-based commissioning tool
- Direct connection to digital communication networks

Line Differential Protection / 7SD61

Application

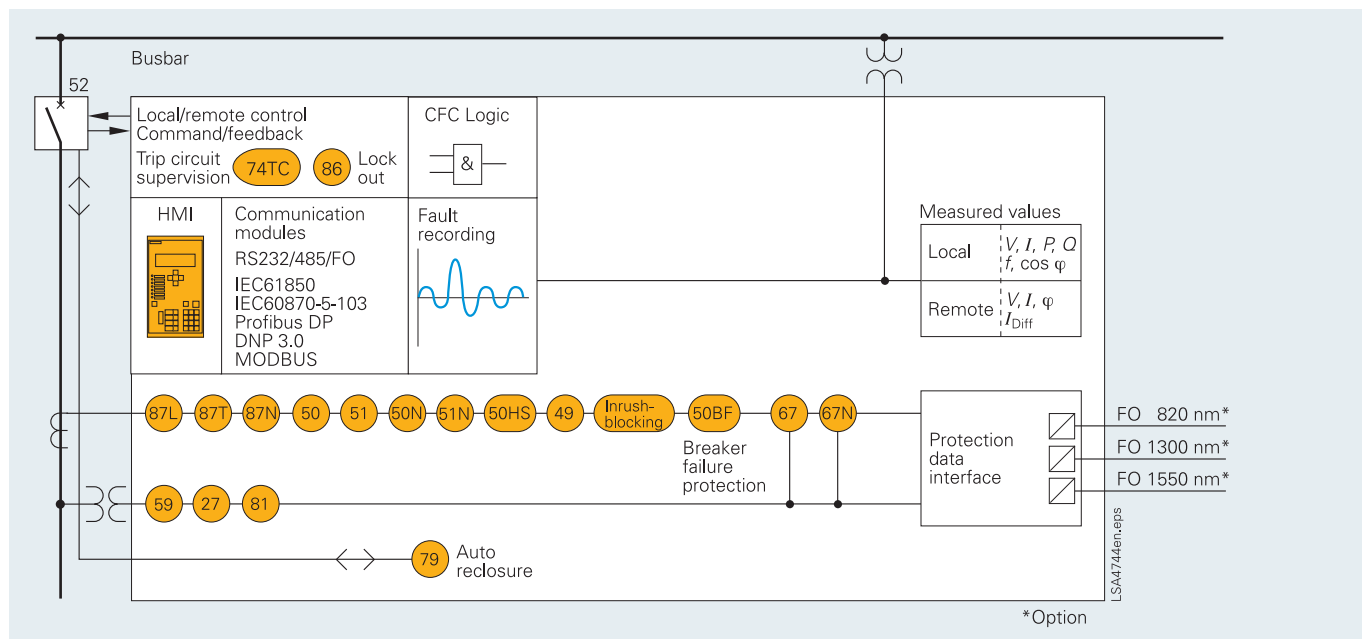


Fig. 7/11

Application

The 7SD610 relay is a differential protection relay suitable for all types of applications and incorporating all those functions required for differential protection of lines, cables and transformers.

Transformers and compensation coils within the differential protection zone are protected by means of integrated functions, which were previously to be found only in transformer differential protection. It is also well-suited for complex applications such as series and parallel compensation of lines and cables.

It is designed to provide protection for all voltage levels and types of networks; two line ends may lie within the protection zone. The relay features very high-speed and phase-selective short-circuit measurement. The unit is thus suitable for single and three-phase fault clearance. The necessary restraint current for secure operation is calculated from the current transformer data by the differential protection unit itself.

Digital data communication for differential current measurement is effected via fiber-optic cables, digital communication networks or pilot wires, so that the line ends can be quite far apart. Thanks to special product characteristics, the relay is particularly suitable for use in conjunction with digital communication networks.

The units measure the delay time in the communication network and adaptively match their measurements accordingly. The units can be operated through pilot wires or twisted telephone pairs at typical distances of 8 km by means of special converters.

The serial communication interfaces for data transmission between the ends are replaceable by virtue of plug-in modules and can easily be adapted to multi-mode and mono-mode fiber-optic cables and to leased lines within the communication networks. Secure, selective and sensitive protection of two-end lines can now be provided by means of these relays.

ANSI	Protection functions
87L	ΔI for lines/cables
87T	ΔI for lines/cables with transformers
87N	Restricted ground-fault protection
85	Phase-selective intertrip, remote trip
86	Lockout function
50/50N	Overcurrent protection with directional elements
51/51N/67/67N	
50HS	Instantaneous high-current tripping (switch-onto-fault)
79	Single or three-pole auto-reclosure with new adaptive technology
49	Overload protection
50BF	Breaker-failure protection
59/27	Overvoltage/undervoltage protection
81O/U	Overfrequency/underfrequency protection
74TC	Trip circuit supervision

Typical applications employing fiber-optic cables or communication networks

Five applications are shown in Fig. 7/12. The 7SD610 differential protection relay is connected to the current transformers and to the voltage transformers at one end of the cable, although only the currents are required for the differential protection function. The voltage connection improves, among other things, the frequency measurement and allows the measured values and the fault records to be extended. Direct connection to the other units is effected via mono-mode fiber-optic cables and is thus immune to interference.

Five different modules are available. In the case of direct connection via fiber-optic cables, data communication is effected at 512 kbit/s and the command time of the protection unit is reduced to 15 ms. Parallel compensation (for the load currents) is provided within the protection zone of the cable. By means of the integrated inrush restraint, the differential protection relay can tolerate the surge on switching-on of the cable and the compensation reactors, and thus allows sensitive settings to be used under load conditions.

7SD610 offers many features to reliably and safely handle data exchange via communication networks.

Depending on the bandwidth available a communication converter for G703-64 kbit/s or X21-64/128/512 kbit/s can be selected. For higher communication speed a communication converter with G703-E1 (2,048 kbit/s) or G703-T1 (1,554 kbit/s) is available. Furthermore the 7SD610 supports the IEEE C37.94 interface with 1/2/4 and 8 timeslots.

The connection to the communication converter is effected via a cost-effective 820 nm interface with multi-mode fiber. This communication converter converts the optical input to electrical signals in accordance to the specified telecommunication interface.

The fourth example shows the relays being connected via a twisted pilot pair. Data exchange and transmission is effected via pilot wires of a typical length of 15 km. Here a transformer is in the protected zone. In this application, 7SD610 is set like a transformer differential relay. Vector group matching and inrush restraint is provided by the relay.

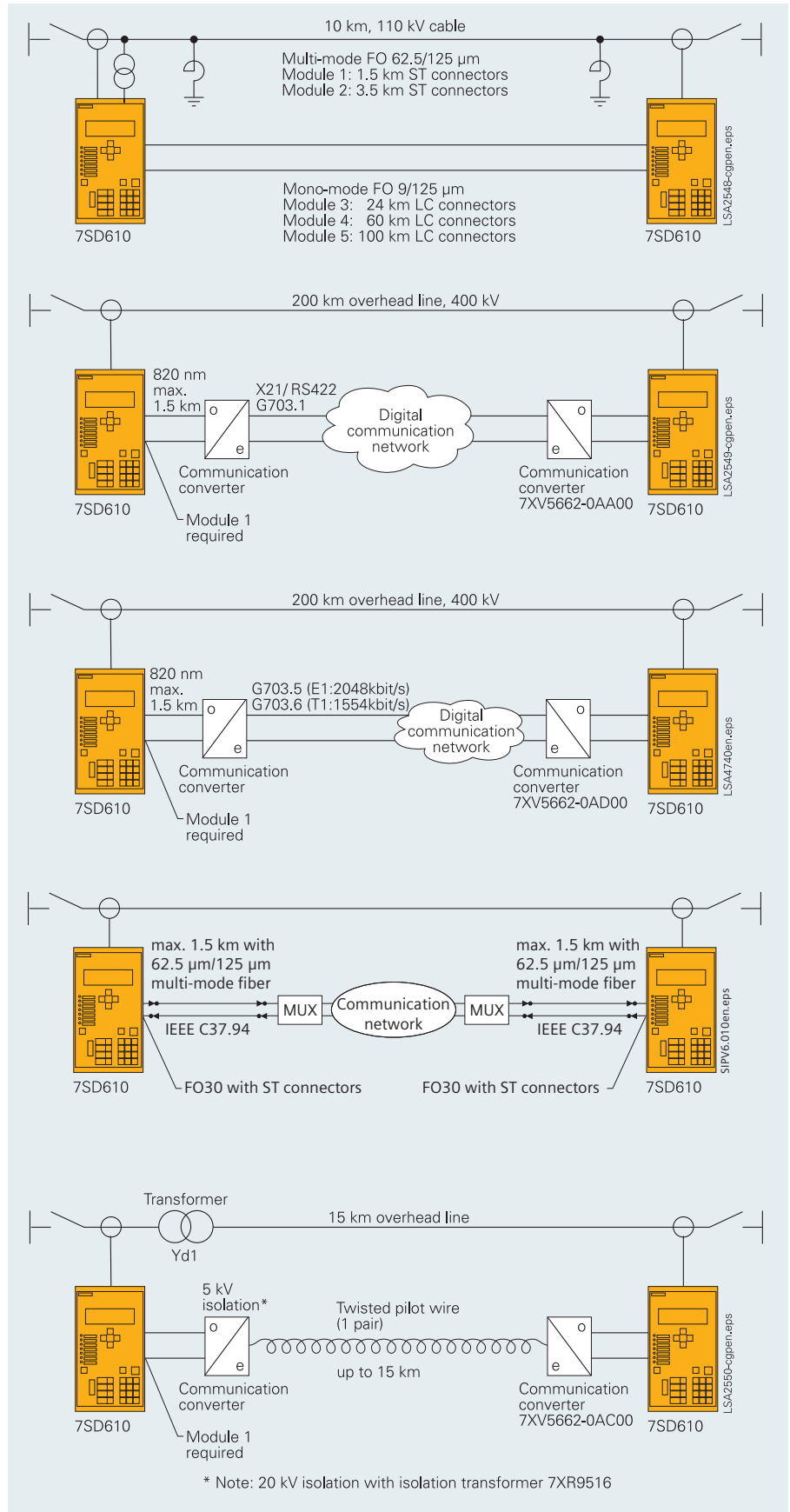


Fig. 7/12 Typical applications

Line Differential Protection/7SD61

Construction, protection functions



Fig. 7/13

Construction

The 7SD610 is available in a housing width of 1/3, referred to a 19" module frame system. The height is a uniform 245 mm for flush-mounting housings and 266 mm for surface-mounting housings.

All cables can be connected with or without cable ring lugs. Plug-in terminals are available as an option, it is thus possible to employ prefabricated cable harnesses. In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located on the same sides of the housing. For dimensions, please refer to "Dimension drawings".

Protection functions

Differential protection (ANSI 87L, 87T, 87N)

The differential protection function has the following features:

- Measurements are performed separately for each phase; thus the trip sensitivity is independent of the fault type.
 - An adaptive measurement method with high sensitivity for differential fault currents below the rated current offers the detection of highly resistive faults. This trip element uses special filters, which offer high security even with high level DC components in the short-circuit current. The trip time of this stage is about 35 ms, the pickup value is about 10 % of the rated current.
 - A high-set differential trip stage which clears differential fault currents higher than the rated current within 15 ms offers fast tripping time and high-speed fault clearance time. A high-speed charging comparison method is employed for this function.
 - When a long line or cable is switched on at one end, transient peaks of the charge current load the line. To avoid a higher setting of the sensitive differential trip stage, this setpoint may be increased for a settable time. This offers greater sensitivity under normal load conditions.
- A special feature of the unit is parameterization of the current transformer data. The unit automatically calculates the necessary restraint current by means of the previously entered current transformer error. The unit thus adaptively matches the working point on the tripping characteristic so that it is no longer necessary for the user to enter characteristic settings.
 - Different current-transformer ratios may be employed at the ends of the line. A mismatch of 1: 8 is permissible.
 - Differential protection tripping can be guarded with overcurrent pickup. In this case, pickup of the protection relay is initiated only on simultaneous presence of differential current and overcurrent.
 - Easy to set tripping characteristic. Because the relay works adaptively, only the set-point $I_{Diff>}$ (sensitive stage) and $I_{Diff>>}$ (high-set current differential stage) must be set according to the charge current of the line/cable.
 - Differential and restraint current are monitored continuously during normal operation and are displayed as operational measured values.
 - High stability during external faults even with different current transformers saturation level. For an external fault, only 5 ms of saturation-free time are necessary to guarantee the stability of the differential protection.
 - Single-phase short-circuits within the protection zone can be cleared using a time delay, whereas multi-phase faults are cleared instantaneously. Because of this function, the unit is optimally suited for applications in inductively compensated networks, where differential current can occur as a result of charge transfer phenomena on occurrence of a single-phase ground fault within the protection zone, thus resulting in undesired tripping by the differential protection relay. Undesired tripping of the differential protection can be suppressed by making use of the provision for introduction of a time delay on occurrence of single-phase faults.
 - With transformers or compensation coils in the protection zone, the sensitive response threshold $I_{Diff>}$ can be blocked by an inrush detection function. Like in transformer differential protection, it works with the second harmonic of the measured current compared with the fundamental component. Blocking is cancelled when an adjustable threshold value of the short-circuit current is reached, so that very high current faults are switched off instantaneously.
 - In the case of transformers within the protection zone, vector group adaptation and matching of different current transformer ratios is carried out within the unit. The interference zero current, which flows through the grounded winding, is eliminated from the differential current measurement. The 7SD610 thus behaves like a transformer differential relay whose ends, however, can be quite far apart.
 - A more sensitive protection for transformers within the protection zone is given by measurement of the star-point current on an grounded winding. Therefore the I_E current measurement input has to be used. If the sum of the phase currents of a winding is compared with the measured star-point current, a sensitive ground-current differential protection (REF) can be implemented. This function is substantially more sensitive than the differential protection during faults to ground in a winding, detecting fault currents as small as 10 % of the transformer rated current.

Characteristics of differential protection communication through the remote relay interfaces

The 7SD610 is ideally adapted for application in communication networks.

The data required for measurement of differential currents and numerous other variables are exchanged between the protection units in the form of synchronous serial telegrams employing the full duplex mode. The telegrams are secured using 32-bit check-sums so that transmission errors in a communication network are detected immediately. Moreover, each telegram carries a time stamp accurate to a microsecond, thus allowing measurement and monitoring of the continuous transmission delay times.

- Data communication is immune to electromagnetic interference, since fiber-optic cables are employed in the critical region, e.g. in the relay house or relay room.
- Monitoring of each individual incoming telegram and of overall communication between the units, no need of supplementary equipment. The check sum (correctness of the telegram contents), the address of the neighboring unit and the transmission delay time of the telegram are monitored.
- Unambiguous identification of each unit is ensured by assignment of a settable communication address within a differential protection topology. Only those units mutually known to each other can cooperate. Incorrect interconnection of the communication links results in blocking of the protection system.
- Detection of telegrams, which are reflected back to the transmitting unit within the communication network.
- Detection of path switching in a communication network. Automatic restraint of the protection function until measurement of the parameters of the new communication link has been completed.
- Continuous measurement of the transmission delay time to the remote line end. Taking into account the delay time in differential current measurement and compensation thereof, including monitoring of a settable maximum permissible delay time of 30 ms.
- Generation of alarm signals on disturbed communication links. Statistical values for the percentage availability of the communication links per minute and per hour are available as operational measured values.
- With a GPS high-precision 1-s pulse from a GPS receiver the relays can be synchronized with an absolute, exact time at each line end. In this way, the delay in the receive and transmit path can be measured exactly. With this optional feature the relay can be used in communication networks where this delay times are quite different.

Phase-selective intertrip and remote trip/indications

Normally the differential current is calculated for each line end nearly at the same time. This leads to fast and uniform tripping times. Under weak infeed conditions, especially when the differential function is combined with an overcurrent pickup, a phase-selective intertrip offers a tripping of both line ends.

- 7SD610 has 4 intertrip signals which are transmitted in high-speed mode (20 ms) to the other terminals. These intertrip signals can also be initiated and transmitted by an external relay via binary inputs. In cases where these signals are not employed for breaker intertripping, other alternative information can be rapidly transmitted to the remote end of the line.

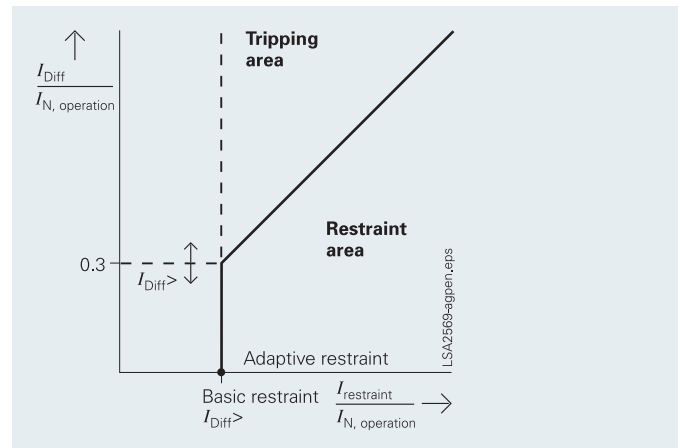


Fig. 7/14 Tripping characteristic

- In addition, four high-speed remote commands are available, which can be introduced either via a binary input or by means of an internal event and then rapidly communicated to the other end.
- Provided that the circuit-breaker auxiliary contacts are wired to binary inputs at the line ends, the switching status of the circuit-breakers is indicated and evaluated at the remote ends of the line. Otherwise the switching status is derived from the measured current.

Possible modes of operation of the differential protection section

Special modes of operation such as the "Commissioning mode" and "Test operation" are advantageous for commissioning and servicing the units.

- In general, an alarm indication is generated on interruption of the communication links and an attempt is made to re-establish the communication link. The units operate in the emergency mode, provided that these have been parameterized.
- The complete configuration can also be used in a testing mode. The local end is in an operating mode, which, for example, allows the pickup values to be tested. The current values received from the remote end of the line are set to zero, so as to achieve defined test conditions. The remote-end unit ignores the differential currents, which occur as a result of testing, and blocks differential protection and breaker intertripping. It may optionally operate in the backup protection mode.
- Differential protection is activated in the commissioning mode. However, test currents injected at one end of the line and which generate a differential current do not lead to output of a TRIP command by the differential protection or to breaker intertripping. All those indications that would actually occur in conjunction with a genuine short-circuit are generated and displayed. TRIP commands can be issued by the backup protection.

Line Differential Protection / 7SD61

Protection functions

Thermal overload protection (ANSI 49)

A built-in overload protection with a current and thermal alarm stage is provided for thermal protection of cables and transformers.

The trip time characteristics are exponential functions according to IEC 60255-8. The preload is considered in the trip times for overloads.

An adjustable alarm stage can initiate an alarm before tripping is initiated.

Overcurrent protection (ANSI 50, 50N, 51, 51N, 67, 67N)

The 7SD610 provides a three-stage overcurrent protection. Two definite-time stages and one inverse-time stage (IDMT) are available, separately for phase currents and for the ground current. Two operating modes (backup, emergency) are selectable. Two stages e.g. can run in backup mode, whereas the third stage is configured for emergency operation, e.g. during interruption of the protection communication and/or failure of the voltage in the VT secondary circuit. The secondary voltage failure can be detected by the integrated fuse failure monitor or via a binary input from a VT miniature circuit-breaker (VT m.c.b. trip).

The following ANSI/IEC inverse-time characteristics are available:

- Inverse
- Short inverse
- Long inverse
- Moderately inverse
- Very inverse
- Extremely inverse
- Definite inverse

If VTs are connected, separate stages with directional measurement are available, two definite-time and two inverse-time stages (each for phase and ground). Using the forward pickup indication as a signal to the remote end, a 100 % protection coverage of the line can be operated in parallel to the differential protection.

Instantaneous high-speed switch-onto-fault overcurrent protection (ANSI 50HS)

Instantaneous tripping is possible when energizing a faulty line. On large fault currents, the high-speed switch-onto-fault overcurrent stage can initiate very fast three-pole tripping.

Circuit-breaker closure onto a faulty line is also possible provided that the circuit-breaker auxiliary contacts of the remote end are connected and monitored. If an overcurrent arises on closing of the circuit-breaker at one end of a line (while the other end is energized) the measured current can only be due to a short-circuit. In this case, the energizing line end is tripped instantaneously.

In the case of circuit-breaker closure, the auto-reclosure is blocked at both ends of the line to prevent a further unsuccessful closure onto a short-circuit. If circuit-breaker intertripping to the remote end is activated, intertripping is also blocked.

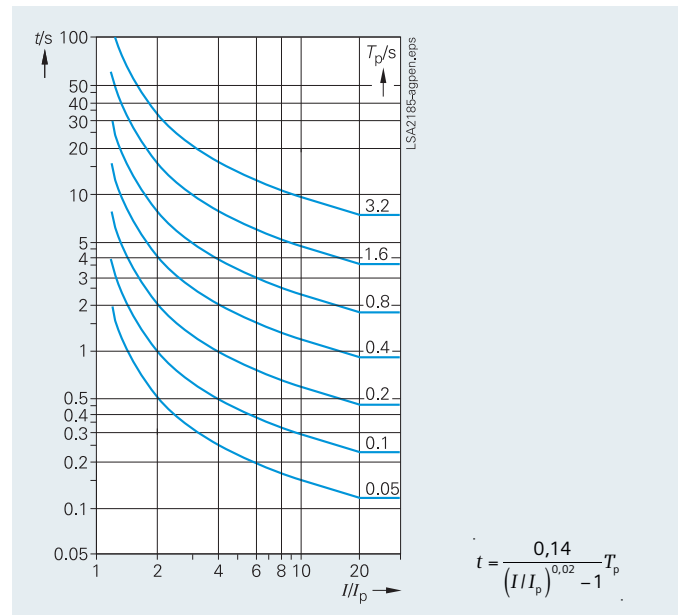


Fig. 7/15 Inverse

Auto-reclosure (ANSI 79)

The 7SD610 relay is equipped with an auto-reclose function (AR). The function includes several operating modes:

- 3-pole auto-reclosure for all types of faults; different dead times are available depending the type of fault
- 1-pole auto-reclosure for 1-phase faults, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and for 2-phase faults without ground, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase and 3-pole auto-reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and 2-phase faults without ground and 3-pole auto-reclosure for other faults
- Multiple-shot auto-reclosure
- Interaction with an external device for auto-reclosure via binary inputs and outputs
- Control of the integrated AR function by external protection
- Adaptive auto-reclosure. Only one line end is closed after the dead time. If the fault persists this line end is switched off. Otherwise the other line ends are closed via a command over the communication links. This avoids stress when heavy fault currents are fed from all line ends again.
- Interaction with an external synchro-check
- Monitoring of the circuit-breaker auxiliary contacts

In addition to the above-mentioned operating modes, several other operating principles can be employed by means of the integrated programmable logic (CFC).

Integration of auto-reclosure in the feeder protection allows evaluation of the line-side voltages. A number of voltage-dependent supplementary functions are thus available:

- **DLC**
By means of dead-line check, reclosure is effected only when the line is deenergized (prevention of asynchronous breaker closure).
- **ADT**
The adaptive dead time is employed only if auto-reclosure at the remote station was successful (reduction of stress on equipment).
- **RDT**
Reduced dead time is employed in conjunction with auto-reclosure where no tele-protection method is employed: When faults within the zone extension, but external to the protected line, are switched off for rapid auto-reclosure (RAR), the RDT function decides on the basis of measurement of the return voltage from the remote station which has not tripped whether or not to reduce the dead time.

Breaker failure protection (ANSI 50BF)

The 7SD610 relay incorporates a two-stage breaker failure protection to detect the failure of tripping command execution, for example, due to a defective circuit-breaker. The current detection logic is phase-segregated and can therefore also be used in single-pole tripping schemes. If the fault current is not interrupted after a settable time delay has expired, a retrip command or a busbar trip command is generated. The breaker failure protection can be initiated by all integrated protection functions as well as by external devices via binary input signals.

Overvoltage protection, undervoltage protection (ANSI 59, 27)

A voltage rise can occur on long lines that are operating at no-load or are only lightly loaded. The 7SD610 contains a number of overvoltage measuring elements. Each measuring element is of two-stage design. The following measuring elements are available:

- Phase-to-ground overvoltage
- Phase-to-phase overvoltage
- Zero-sequence overvoltage
- The zero-sequence voltage can be connected to the 4th voltage input or be derived from the phase voltages.
- Positive-sequence overvoltage of the local end or calculated for the remote end of the line (compounding).
- Negative-sequence overvoltage

Tripping by the overvoltage measuring elements can be effected either at the local circuit-breaker or at the remote station by means of a transmitted signal.

The 7SD610 is fitted, in addition, with three two-stage undervoltage measuring elements:

- Phase-to-ground undervoltage
- Phase-to-phase undervoltage
- Positive-sequence undervoltage

The undervoltage measuring elements can be blocked by means of a minimum current criterion and by means of binary inputs.

Frequency protection (ANSI 81O/U)

Frequency protection can be used for overfrequency and underfrequency protection. Unwanted frequency changes in the network can be detected and the load can be removed at a specified frequency setting. Frequency protection can be used over a wide frequency range (45 to 55, 55 to 65 Hz). There are four elements (selectable as overfrequency or underfrequency) and each element can be delayed separately.

Line Differential Protection / 7SD61

Protection functions

Monitoring and supervision functions

The 7SD610 relay provides comprehensive monitoring functions covering both hardware and software. Furthermore, the measured values are continuously checked for plausibility. Therefore the current and voltage transformers are also included in this monitoring system.

Current transformer / Monitoring functions

A broken wire between the CTs and relay inputs under load may lead to maloperation of a differential relay if the load current exceeds the differential setpoint. The 7SD610 provides fast broken wire supervision which immediately blocks all line ends if a broken wire condition is measured by a local relay. This avoids maloperation due to broken wire condition. Only the phase where the broken wire is detected is blocked. The other phases remain under differential operation.

Fuse failure monitoring

If any measured voltage is not present due to short-circuit or open circuit in the voltage transformer secondary circuit this can lead to a failure or a being missing measuring of the directional overcurrent protection. This secondary voltage interruption can be detected by means of the integrated fuse failure monitor. Immediate blocking of the directional steps of the overcurrent protection is started automatically.

Additional measurement supervision functions are

- Symmetry of voltages and currents
- Summation of currents and voltages

Trip circuit supervision (ANSI 74TC)

One or two binary inputs for each circuit-breaker pole can be used for monitoring the circuit-breaker trip coils including the connecting cables. An alarm signal is issued whenever the circuit is interrupted.

Lockout (ANSI 86)

All binary outputs can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only be issued after the lockout state is reset.

Local measured values

The measured values are calculated from the measured current and voltage signals along with the power factor ($\cos \varphi$), the frequency, the active and reactive power. Measured values are displayed as primary or secondary values or in percent of the specific line rated current and voltage. The relay uses a 20 bit high-resolution AD converter and the analog inputs are factory-calibrated, so a high accuracy is reached.

The following values are available for measured-value processing:

- Currents $3 \times I_{\text{Phase}}, 3I_0, I_E, I_E$ sensitive
- Voltages $3 \times V_{\text{Phase-Ground}}, 3 \times V_{\text{Phase-Phase}}, 3V_0, V_{\text{en}}$
- Symmetrical components I_1, I_2, V_1, V_2
- Real power P (Watt), reactive power
- Q (Var), apparent power S (VA)
- Power factor $\text{PF} (= \cos \varphi)$
- Frequency f
- Differential and restraint current per phase
- Availability of the data connection to the remote line ends per minute and per hour
- Regarding delay time measuring with the GPS-version the absolute time for transmit and receive path is displayed separately.

Limit value monitoring: Limit values are monitored by means of the CFC. Commands can be derived from these limit value indications.

Measured values at remote line ends

Every two seconds the currents and voltages are frozen at the same time at all line ends and transmitted via the communication link. At a local line end, currents and voltages are thus available with their amount and phases (angle) locally and remotely. This allows checking the whole configuration under load conditions. In addition, the differential and restraint currents are also displayed. Important communication measurements, such as delay time or faulty telegrams per minute/hour are also available as measurements. These measured values can be processed with the help of the CFC logic editor.

Commissioning

Special attention has been paid to commissioning. All binary inputs and outputs can be displayed and activated directly. This can simplify the wiring check significantly for the user. The operational and fault events and the fault records are clearly arranged.

Furthermore, all currents and optional voltages and phases are available via communication link at the local relay and are displayed in the relay, with DIGSI 4 or with the Web Monitor.

The operational and fault events and fault records from all line ends share a common time tagging which allows to compare events registered in the different line ends on a common time base.

WEB Monitor – Internet technology simplifies visualization

In addition to the universal DIGSI 4 operating program, the relay contains a WEB server that can be accessed via a telecommunication link using a browser (e.g. Internet Explorer). The advantage of this solution is to operate the unit with standard software tools and at the same time make use of the Intranet/Internet infrastructure. This program shows the protection topology and comprehensive measurements from local and remote line ends. Local and remote measurements are shown as phasors and the breaker positions of each line end are depicted. It is possible to check the correct connection of the current transformers or the correct vector group of a transformer.

Stability can be checked by using the operating characteristic as well as the calculated differential and restraint values in the browser windows.

Event log and trip log messages are also available. Remote control can be used, if the local front panel cannot be accessed.

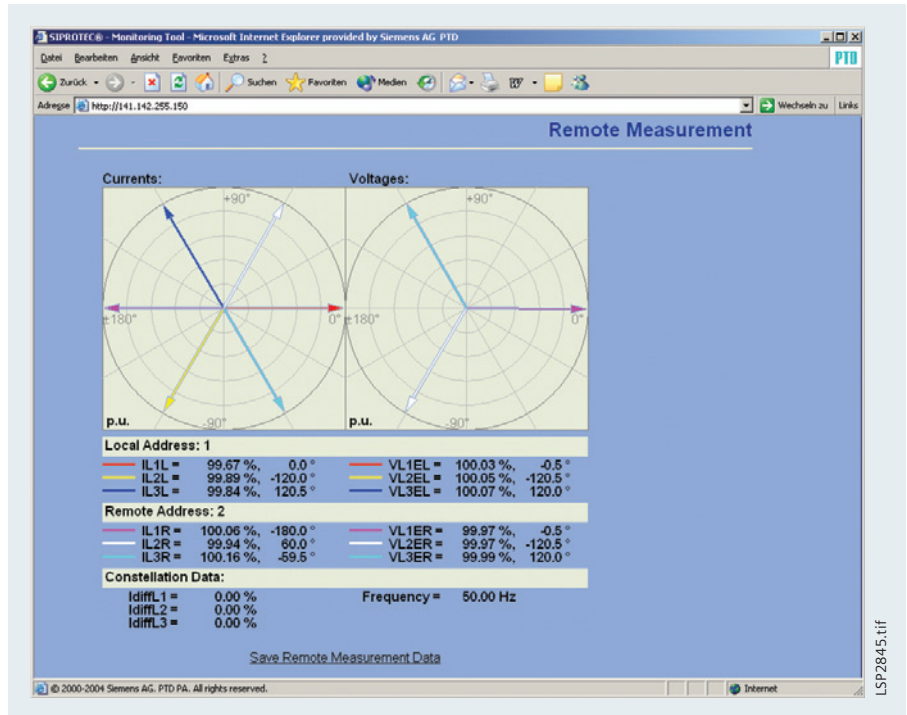


Fig. 7/16 Browser-aided commissioning: Phasor diagram

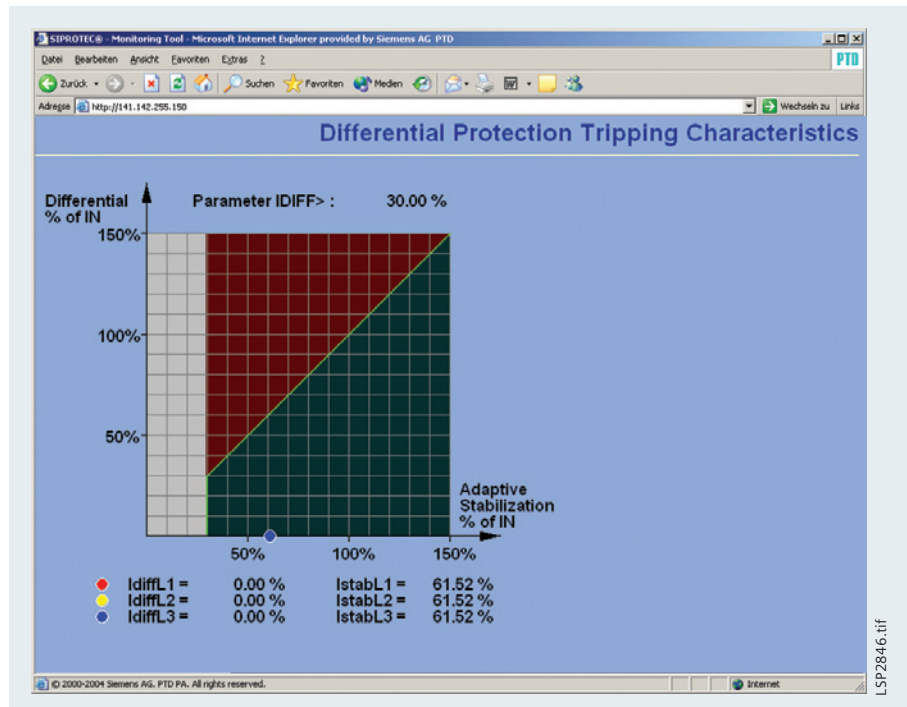


Fig. 7/17 Browser-aided commissioning: Differential protection tripping characteristic

Line Differential Protection / 7SD61

Functions

Functions

■ Control and automation functions

Control

In addition to the protection functions, the SIPROTEC 4 units also support all control and monitoring functions that are required for operating medium-voltage or high-voltage substations.

The main application is reliable control of switching and other processes.

The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated via binary inputs. Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a fault or intermediate circuit-breaker or auxiliary contact position.

The switchgear or circuit-breaker can be controlled via:

- integrated operator panel
- binary inputs
- substation control and protection system
- DIGSI 4

Command processing

All the functionality of command processing is offered. This includes the processing of single and double commands with or without feedback, sophisticated monitoring of the control hardware and software, checking of the external process, control actions using functions such as runtime monitoring and automatic command termination after output. Here are some typical applications:

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable bay interlocks
- Operating sequences combining several switching operations such as control of circuit-breakers, disconnectors and ground-ing switches
- Triggering of switching operations, indications or alarm by combination with existing information

Automation / user-defined logic

With integrated logic, the user can set, via a graphic interface (CFC), specific functions for the automation of switchgear or substation. Functions are activated via function keys, binary input or via communication interface.

Switching authority

Switching authority is determined according to parameters, communication or by key-operated switch (when available).

If a source is set to "LOCAL", only local switching operations are possible. The following sequence of switching authority is laid down: "LOCAL"; DIGSI PC program, "REMOTE"

Every switching operation and change of breaker position is kept in the status indication memory. The switch command source, switching device, cause (i.e. spontaneous change or command) and result of a switching operation are retained.

Assignment of feedback to command

The positions of the circuit-breaker or switching devices and transformer taps are acquired by feedback. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication change is a consequence of switching operation or whether it is a spontaneous change of state (intermediate position).

Chatter disable

The chatter disable feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

Filter time

All binary indications can be subjected to a filter time (indication suppression).

Indication filtering and delay

Indications can be filtered or delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time. In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

A further indication (or a command) can be derived from an existing indication. Group indications can also be formed. The volume of information to the system interface can thus be reduced and restricted to the most important signals.

Transmission lockout

A data transmission lockout can be activated, so as to prevent transfer of information to the control center during work on a circuit bay.

Test operation

During commissioning, all indications can be passed to an automatic control system for test purposes.

With respect to communication, particular emphasis has been placed on high flexibility, data security and use of customary standards in the field of energy automation. The concept of the communication modules allows interchangeability on the one hand, and, on the other hand, is open for future standards.

Local PC interface

The PC interface provided on the front panel on the unit allows the parameters, status and fault event data to be rapidly accessed by means of the DIGSI 4 operating program. Use of this program is particularly advantageous during testing and commissioning.

Rear-mounted interfaces

The service and system communication interfaces are located at the rear of the unit. In addition, the 7SD610 is provided with a protection interface. The interface complement is variable and retrofitting is possible without any difficulty. These interfaces ensure that the requirements for different communication interfaces (electrical and optical) and protocols can be met.

The interfaces are designed for the following applications:

Service/modem interface

By means of the RS485 interface, it is possible to efficiently operate a number of protection units centrally via DIGSI 4. Remote operation is possible on connection of a modem. This offers the advantage of rapid fault clarification, especially in the case of unmanned power plants.

In the case of the 7SD610, a PC with a standard browser can be connected to the service interface (refer to "Commissioning program").

System interface

This interface is used to carry out communication with a control or protection and control system and supports a variety of communication protocols and interface designs, depending on the module connected.

Commissioning aid via a standard Web browser

In the case of the 7SD610, a PC with a standard browser can be connected to the local PC interface or to the service interface (refer to "Commissioning program"). The relays include a small Web server and sends its HTML pages to the browser via an established dial-up network connection.

Retrofitting: Modules for every type of communication

Communication modules for retrofitting are available for the entire SIPROTEC 4 unit range. These ensure that, where different communication interfaces (electrical or optical) and protocols (IEC 61850 Ethernet, IEC 60870-5-103, PROFIBUS-DP, DNP 3.0, MODBUS, DIGSI, etc.) are required, such demands can be met.

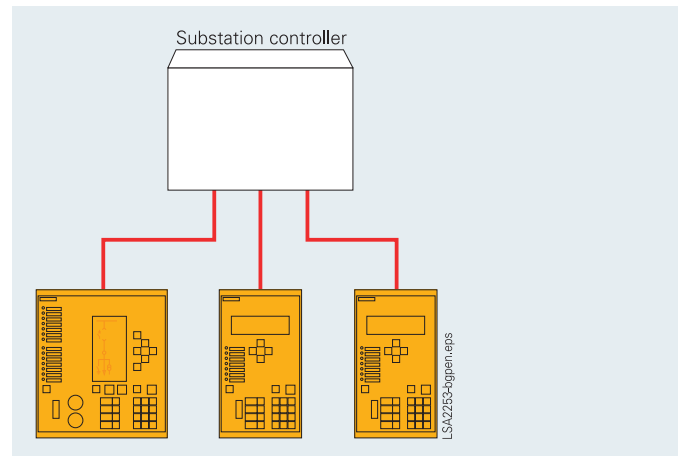


Fig. 7/18 IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

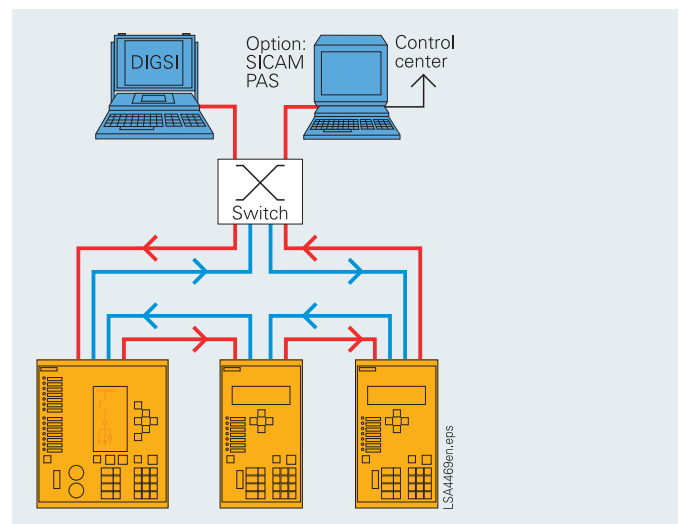


Fig. 7/19 Bus structure for station bus with Ethernet and IEC 61850

Safe bus architecture

- RS485 bus
With this data transmission via copper conductors, electromagnetic fault influences are largely eliminated by the use of twisted-pair conductor. Upon failure of a unit, the remaining system continues to operate without any disturbances.
- Fiber-optic double ring circuit
The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without disturbance.

It is generally impossible to communicate with a unit that has failed. If a unit were to fail, there is no effect on the communication with the rest of the system.

Line Differential Protection/7SD61

Communication

Communication

IEC 61850 Ethernet

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens was the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay ans system interlocking. Access to the units via the Ethernet bus is also possible with DIGSI.

IEC 60870-5-103

IEC 60870-5-103 is an internationally standardized protocol for the efficient communication in the protected area. IEC 60870-5-103 is supported by a number of protection device manufacturers and is used worldwide.

PROFIBUS-DP

PROFIBUS-DP is an industry-recognized standard for communications and is supported by a number of PLC and protection device manufacturers.

MODBUS RTU

MODBUS RTU is an industry-recognized standard for communications and is supported by a number of PLC and protection device manufacturers.

DNP 3.0

DNP 3.0 (Distributed Network Protocol Version 3) is a messaging-based communication protocol. The SIPROTEC 4 units are fully Level 1 and Level 2 compliant with DNP 3.0. DNP 3.0 is supported by a number of protection device manufacturers.

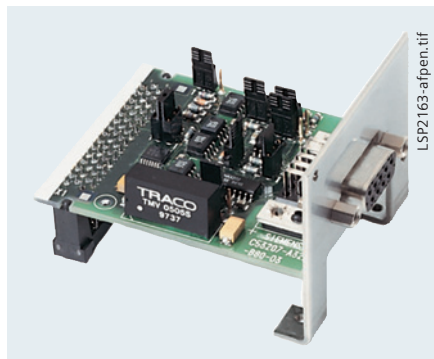


Fig. 7/20 RS232/RS485 electrical communication module

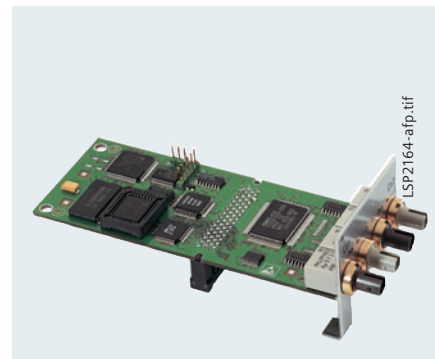


Fig. 7/21 PROFIBUS fiber-optic double ring communication module

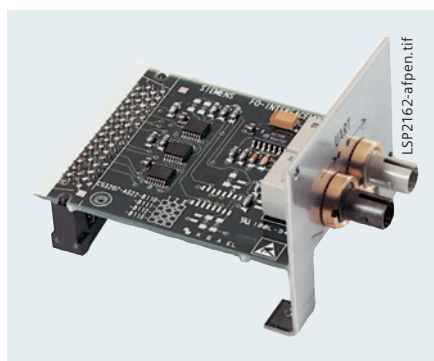


Fig. 7/22 820 nm fiber-optic communication module



Fig. 7/23 Fiber-optic Ethernet communication module for IEC 61850 with integrated Ethernet switch

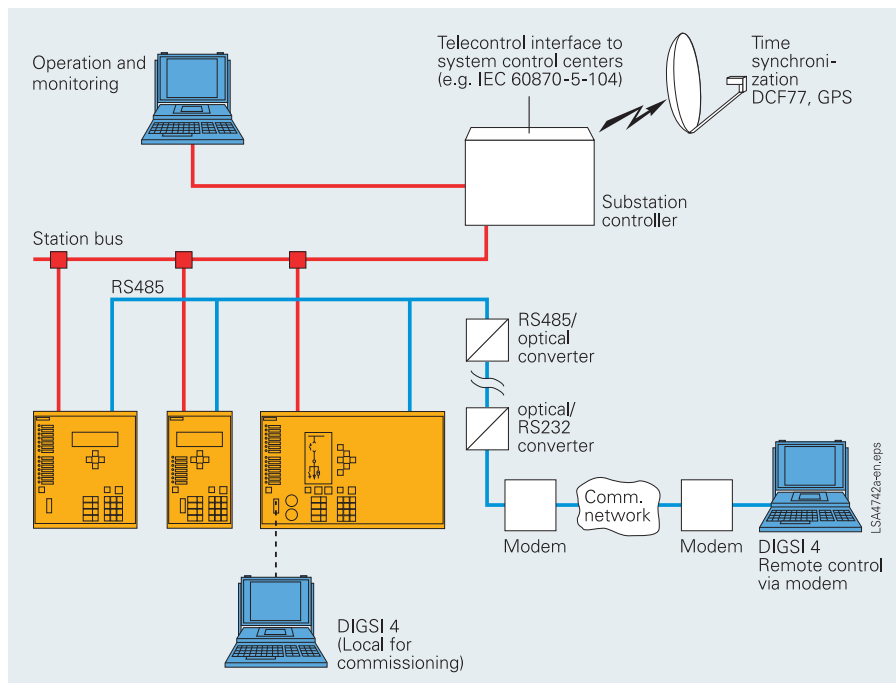


Fig. 7/24 System solution: Communications

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system.

Units featuring IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 7/18).

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 7/19).

Via modem and service interface, the protection engineer has access to the protection devices at all times. This permits remote maintenance and diagnosis (cyclic testing).

Parallel to this, local communication is possible, for example, during a major inspection.

Serial protection interface (R2R interface)

The 7SD610 provides one protection interface to cover two line end applications.

In addition to the differential protection function, other protection functions can use this interface to increase selectivity and sensitivity as well as covering advanced applications.

- Fast phase-selective teleprotection signaling using the directional stages of the overcurrent protection with POTT or PUTT schemes
- Two terminal line applications can be implemented without additional logic
- Inter-close command transfer with the auto-reclosure "Adaptive dead time" (ADT) mode
- 4 remote signals for fast transfer of binary signals
- Flexible utilization of the communication channels by means of the programmable CFC logic

The protection interfaces have different options to cover new and existing communication infrastructures.

- FO5¹⁾, OMA1²⁾ module:
820 nm fiber-optic interface with clock recovery/ST connectors for direct connection with multi-mode FO cable up to 1.5 km for the connection to a communication converter.
- FO6¹⁾, OMA2²⁾ module:
820 nm fiber-optic interface/ST connectors for direct connection up to 3.5 km with multi-mode FO cable.

New fiber-optic interfaces, series FO1x

FO17¹⁾:

For direct connection up to 24 km³⁾, 1300 nm, for mono-mode fiber 9/125 μm, LC-Duplex connector

FO18¹⁾:

For direct connection up to 60 km³⁾, 1300 nm, for mono-mode fiber 9/125 μm, LC-Duplex connector

FO19¹⁾:

For direct connection up to 100 km³⁾, 1550 nm, for mono-mode fiber 9/125 μm, LC-Duplex connector

FO30:

820 nm fiber-optic interface/ST connectors for direct connection up to 1.5 km and for connections to a IEEE C37.94 multiplexer interface.

The link to a multiplexed communication network is made by separate communication converters (7XV5662). These have a fiber-optic interface with 820 nm and 2 ST connectors to the protection relay. The link to the communication network is optionally an electrical X21/G703-64 kbit/s or G703-E1/T1 interface. Furthermore the IEEE C37.94 interface is supported by the FO30 module.

For operation via copper wire communication (pilot wires or twisted telephone pair), a modern communication converter for copper cables is available. This operates with both the two-wire and three-wire copper connections which were used by conventional differential protection systems before. The communication converter for copper cables is designed for 5 kV insulation voltage. An additional 20 kV isolation transformer can extend the field of applications of this technique into ranges with higher insulation voltage requirements. The connection via FO cable to the relay is interference-free. With SIPROTEC 4 and the communication converter for copper cables a digital follow-up technique is available for two-wire protection systems (up to 8 km) and all three-wire protection systems using existing copper communication links.

Different communication converters are listed under "Accessories".

Communication data:

- 32-bit CRC-check according to CCITT and ITU
- Each protection relay possesses a unique relay address
- Continuous communication link supervision: Individual faulty data telegrams do not constitute an immediate danger, if they occur only sporadically. The statistical availability, per minute and hour, of the serial protection interface can be displayed.
- Supported network interfaces X21/RS422 with 64 or 128 or 512 kbit/s; or G703-64 kbit/s and G703-E1 (2,048 kbit/s) or G703-T1 (1,554 kbit/s) or IEEE C37.94.
- Max. channel delay time 0.1 ms to 30 ms (in steps of 0.1 ms)
- Protocol HDLC

1) For flush-mounting housing.

2) For surface-mounting housing.

3) For surface-mounting housing the internal FO module OMA1 will be delivered together with an external repeater.

Line Differential Protection/7SD61

Communication

Communication possibilities between relays

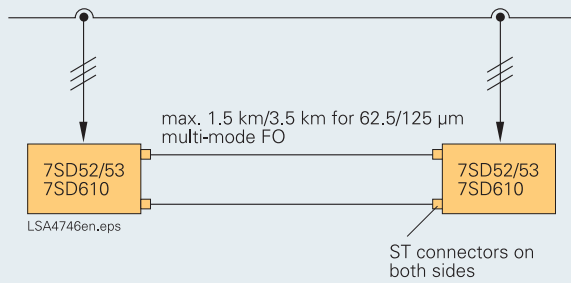


Fig. 7/25 Direct optical link up to 1.5 km/3.5 km, 820 nm

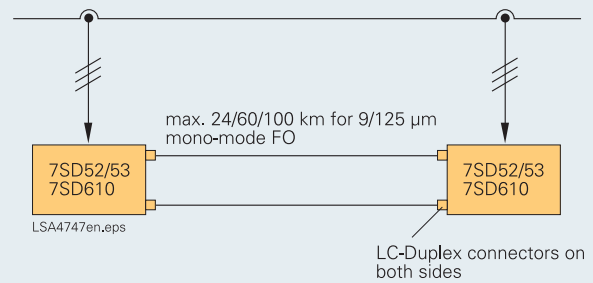


Fig. 7/26 Direct optical link up to 25/60 km with 1300 nm or up to 100 km with 1550 nm

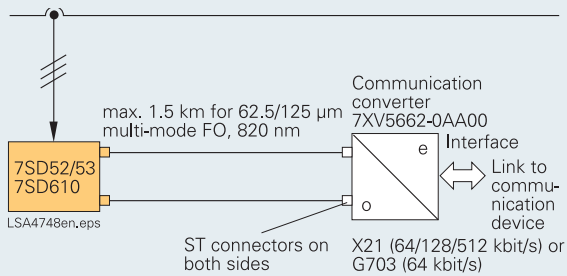


Fig. 7/27 Connection to a communication network CC-XG

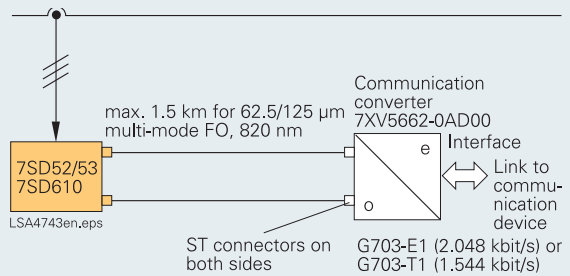


Fig. 7/28 Connection to a communication network CC-2M

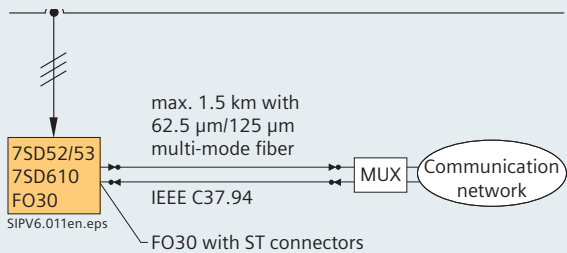


Fig. 7/29 Connection to a communication network via IEEE C37.94

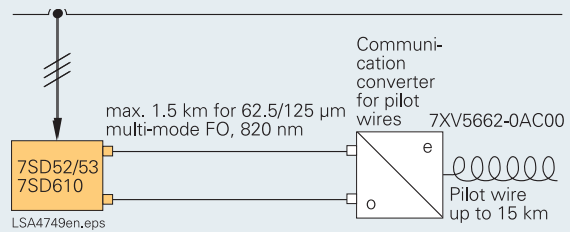


Fig. 7/30 Connection to a pilot wire

Typical connection

Connection of current and voltage transformers

A typical connection is to the phase CT. The residual current at the I_E input is formed by summation of the phase currents. This ensures optimum supervision functions for the current.

Optionally, voltages are measured by means of voltage transformers and are fed to the unit as a phase-to-ground voltage. The zero voltage is derived from the summation voltage by calculation performed in the unit.

As a matter of fact, the 7SD610 unit does not require any voltage transformers for operation of the differential protection.

Alternative current measurement

3 phase current transformers with neutral point in the line direction, I_4 connected to a current transformer in the neutral point of a grounded (earthed) transformer for restricted ground-fault protection (REF) or directional ground (earth)-fault protection.

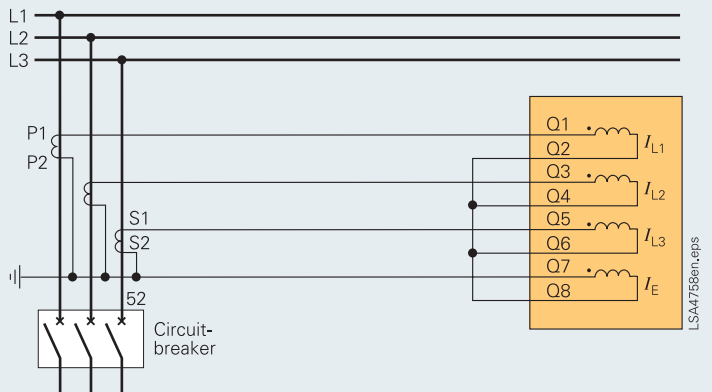


Fig. 7/31 Typical connection to current transformers

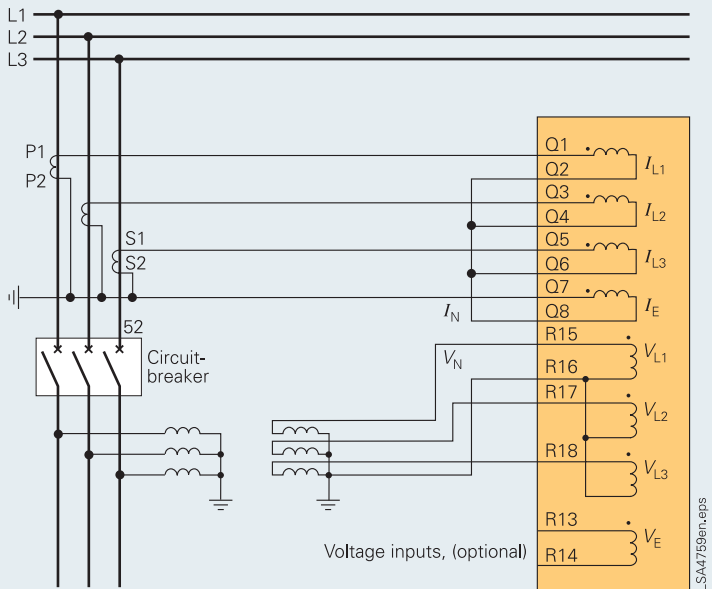


Fig. 7/32 Typical connection to current transformers with optional voltage inputs

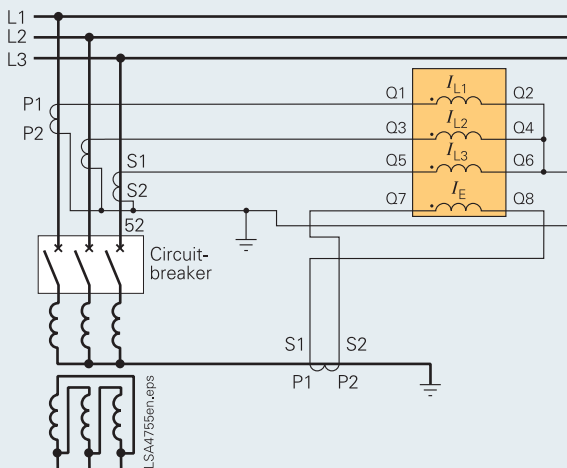


Fig. 7/33 Connection for transformer with restricted ground-fault protection (REF)

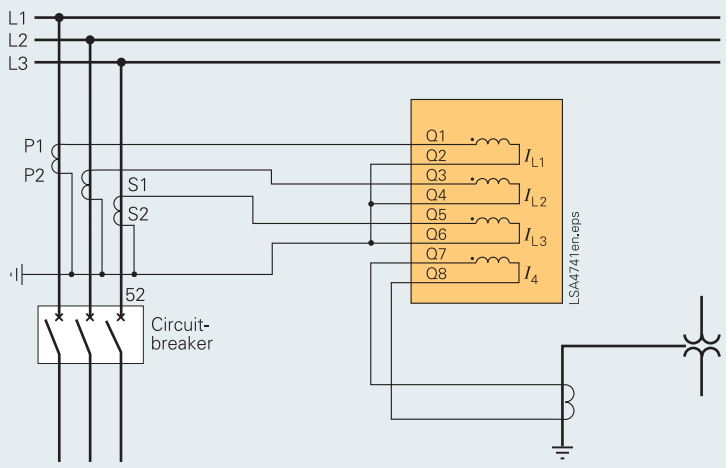


Fig. 7/34 Alternative connection of current transformers for measuring neutral current of a grounded (earthed) power transformer

Line Differential Protection / 7SD61

Technical data

General unit data	
<i>Analog inputs</i>	
Rated frequency	50 or 60 Hz (selectable)
Rated current I_N	1 or 5 A (selectable)
Rated voltage V_N	80 to 125 V (selectable)
Power consumption	
in CT circuits with $I_N = 1$ A	Approx. 0.05 VA
with $I_N = 5$ A	Approx. 0.3 VA
in VT circuits	Approx. 0.1 VA
Thermal overload capacity	I_N
in CT circuits (for $I_N = 5$ A)	100 A for 1 s 30 I_N for 10 s 4 I_N continuous
Dynamic (peak value)	250 I_N (half sine)
In VT circuits for highly sensitive ground-fault protection	
in VT circuits	300 A for 1 s 100 A for 10 s 15 A continuous 230 V per phase continuous
<i>Auxiliary voltage</i>	
Rated voltages	DC 24 to 48 V
Ranges are settable by means of jumpers	DC 60 to 125 V ¹⁾ DC 110 to 250 V ¹⁾ and AC 115 V (50/60 Hz) ¹⁾
Permissible tolerance	-20 % to +20 %
Superimposed AC voltage (peak-to-peak)	≤ 15 %
Power consumption	
Under normal operating conditions	Approx. 8 W
During pickup with all inputs and outputs activated	Approx. 18 W
Bridging time during failure of the auxiliary voltage	
$V_{aux} \geq 110$ V	≥ 50 ms
<i>Binary inputs</i>	
Number	7 (marshallable)
Rated voltage range	24 to 250 V, bipolar
Pickup threshold	17 or 73 V (selectable)
Functions are freely assignable	
Minimum pickup threshold	
Ranges are settable by means of jumpers for each binary input	DC 17 or 73 V, bipolar
Maximum permissible voltage	DC 300 V
Current consumption, energized	Approx. 1.8 mA
<i>Output relay</i>	
Command / indication relay	
Number	5 (marshallable) 1 alarm contact (not marshallable)
Switching capacity	1000 W/VA
Make	30 VA
Break	40 W
Break (with resistive load)	25 W
Break (with L/R ≤ 50 ms)	250 V
Switching voltage	30 A for 0.5 seconds
Permissible total current	5 A continuous

LEDs	
Number	
RUN (green)	1
ERROR (red)	1
LED (red), function can be assigned	7
<i>Unit design</i>	
Housing 7XP20	For dimensions refer to dimension drawings, part 14
Degree of protection acc. to EN 60529	
Surface-mounting housing	IP 51
Flush-mounting housing	
front	IP 51
rear	IP 50
for the terminals	IP 20 with terminal cover put on
Weight	
Flush-mounting housing	
1/3 x 19"	4 kg
Surface-mounting housing	
1/3 x 19"	6 kg
<i>Serial interfaces</i>	
<i>Operating interface 1 for DIGSI 4 or browser (front of unit)</i>	
Connection	Non-isolated, RS232, front panel, 9-pin subminiature connector (SUB-D)
Baud rate	4800 to 115200 baud, setting as supplied: 38400 baud; parity 8E1
<i>Time synchronization (rear of unit DCF77/IRIG-B signal format IRIG-B000)</i>	
Connection	Non-isolated, RS232, front panel, 9-pin subminiature connector (SUB-D)
Baud rate	4800 to 115200 baud, setting as supplied: 38400 baud; parity 8E1
<i>Service interface (op. interface 2) for DIGSI 4/modem/service/browser (rear of unit)</i>	
Isolated RS232/RS485	9-pin subminiature connector (SUB-D)
Dielectric test	500 V/50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m
<i>System interface (rear of unit)</i>	
Refer to ordering code	IEC 61850 Ethernet IEC 60870-5-103 PROFIBUS-DP DNP 3.0, MODBUS
Isolated RS232/RS485	9-pin subminiature connector (SUB-D)
Baud rate	4800 to 38400 baud
Dielectric test	500 V/50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m
For fiber-optic cable	ST connector
Optical wavelength	λ = 820 nm
Permissible attenuation	Max. 8 dB for 62.5/125 μm fiber
Distance (spanned)	Max. 1.5 km

System interface, continued	
PROFIBUS RS485	
Dielectric test	500 V/50 Hz
Baud rate	Max. 12 Mbaud
Distance	1 km at 93.75 kbd; 100 m at 12 Mbd
PROFIBUS fiber-optic ²⁾	
Only for flush-mounting housing	ST connector
For surface-mounting housing	Optical interface with OLM ²⁾
Baud rate	Max. 1.5 Mbaud
Optical wavelength	$\lambda = 820$ nm
Permissible attenuation	Max. 8 dB for 62.5/125 μ m fiber
Distance	500 kbit/s 1.6 km; 1500 kbit/s 530 m
Protection interface (R2R interface)	
FO5 ¹⁾ , OMA1 ²⁾ : Fiber-optic interface with clock recovery for direct connection up to 1.5 km or for connection to a comm. converter, 820 nm	For multi-mode fiber 62.5/125 μ m, ST connectors Permissible fiber attenuation: 8 dB
FO6 ¹⁾ , OMA2 ²⁾ : Fiber-optic interface for direct connection up to 3.5 km, 820 nm	For multi-mode fiber 62.5/125 μ m, ST connectors Permissible fiber attenuation: 16 dB
New fiber-optic interfaces, series FO1:	
FO30: Fiber-optic interface to support the IEEE C37.94 interface and for direct fiber – optic connection up to 1.5 km	For multi-mode fiber 62.5/125 μ m, ST connectors Permissible fiber attenuation: 8 dB
FO17 ¹⁾ : for direct connection up to 24 km ³⁾ , 1300 nm	For mono-mode fiber 9/125 μ m, LC-Duplex connector Permissible fiber attenuation: 13 dB
FO18 ¹⁾ : for direct connection up to 60 km ³⁾ , 1300 nm	For mono-mode fiber 9/125 μ m, LC-Duplex connector Permissible fiber attenuation: 29 dB
FO19 ¹⁾ : for direct connection up to 100 km ³⁾ , 1550 nm	For mono-mode fiber 9/125 μ m, LC-Duplex connector Permissible fiber attenuation: 29 dB
Relay communication equipment	
<i>External communication converter 7XV5662-OAA00 for communication networks X21/G703-64 kbit/s</i>	
External communication converter to interface between the relays, optical 820 nm interface and the X21/RS422/G703-64 kbit/s interface of a communication device	
X21/G703, RS422 selectable by jumpers. Baud rate selectable by jumpers	
Input: fiber-optic 820 nm with clock recovery	Max. 1.5 km with 62.5/125 μ m multi-mode FO cable to device side
Output: X21 (RS422) electrical interface on communication device	64/128/512 kbit (selectable by jumper) max. 800 m, 15-pin connector
G703-64 kbit/s electrical interface on communication device	64 kbit/s, max. 800 m, screw-type terminal
<i>External communication converter 7XV5662-OAD00 for communication networks with G703-E1 or G703-T1</i>	
External communication converter to interface between the relays, optical 820 nm interface and G703-E1 or G703-T1 interface of a communication network	
Inputs: 2 fiber-optic inputs 820 nm, 1 RS232 input	Max. 1.5 km with 62.5/125 μ m multi-mode 1 FO cable to device side
Output: G703.5	E1: 2,048 kbit/s
G703.6	T1: 1,554 kbit/s
Electrical interface on communication network	max. 800 m, screw-type terminal
<i>External communication converter 7XV5662-OAC00 for pilot wires</i>	
External communication converter to interface between relays, optical 820 nm interface and a pilot wire or twisted telephone pair.	
Typical distance	15 km
Fiber-optic 820 nm with clock recovery	Max. 1.5 km with 62.5/125 μ m multi-mode FO cable
Pilot wire	Screw-type terminal 5 kV isolated
Permissible time delay (duration of data transmission)	
Delay of telegrams due to transmission from one unit to the other. Delay is constantly measured and adjusted	Max. 30 ms per transmission path Permissible max. value can be selected
Electrical tests	
<i>Specification</i>	
Standards	EC 60255 (product standards) ANSI/IEEE C37.90.01.1/.2 UL 508 For further standards see "Individual functions"
<i>Insulation tests</i>	
Standards	IEC 60255-5
Voltage test (100 % test) All circuits except for auxiliary supply, binary inputs and communication interfaces	2.5 kV (r.m.s.), 50 / 60 Hz
Auxiliary voltage and binary inputs (100 % test)	DC 3.5 kV
RS485/RS232 rear side communication interfaces and time synchronization interface (100 % test)	500 V (r.m.s.), 50 / 60 Hz
Impulse voltage test (type test) All circuits except for communication interfaces and time synchronization interface, class III	5 kV (peak); 1.2/50 ms; 0.5 J 3 positive and 3 negative impulses at intervals of 5 s
EMC tests for noise immunity; type tests	
Standards	IEC 60255-6, IEC 60255-22 (product standards) (type tests) EN 50082-2 (generic standard) DIN 57435 part 303
High frequency test IEC 60255-22-1, class III and VDE 0435 part 303, class III	2.5 kV (peak); 1 MHz; $\tau = 15$ ms; 400 surges per s; test duration 2 s
Electrostatic discharge IEC 60255-22-2, class IV EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; $R_i = 330 \Omega$
Irradiation with RF field, non-modulated IEC 60255-22-3 (report), class III	10 V/m; 27 to 500 MHz
Irradiation with RF field, amplitude-modulated IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz
1) For flush-mounting housing.	
2) For surface-mounting housing.	
3) For surface-mounting housing the internal FO module OMA1 will be delivered together with an external repeater.	

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Technical data

Irradiation with RF field, pulse-modulated IEC 61000-4-3/ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transients, bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50 \Omega$; test duration 1 min
High-energy surge voltages (SURGE), IEC 61000-4-5 installation, class III	Impulse: 1.2/50 μ s
Auxiliary supply	Common (longitudinal) mode: 2 kV; 12 Ω ; 9 μ F Differential (transversal) mode: 1 kV; 2 Ω ; 18 μ F
Measurement inputs, binary inputs, binary output relays	Common (longitudinal) mode: 2 kV; 42 Ω ; 0.5 μ F Differential (transversal) mode: 1 kV; 42 Ω ; 0.5 μ F
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Magnetic field with power frequency IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak); 1 to 1.5 MHz damped wave; 50 surges per second, duration 2 s, $R_i = 150$ to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 impulses per second; both polarities; duration 2 s; $R_i = 80 \Omega$
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz
Damped oscillation IEC 60694, IEC 61000-4-12	2.5 kV (peak value); polarity alternating 100 kHz; 1 MHz; 10 and 50 MHz; $R_i = 200 \Omega$

EMC tests for interference emission; type tests

Standard	EN 50081-1 (generic standard)
Conducted interference voltage on lines, only auxiliary voltage IEC-CISPR 22	150 kHz to 30 MHz
Radio interference field strength IEC-CISPR 22	Limit class B 30 to 1000 MHz Limit class B

Mechanical dynamic tests

Vibration, shock stress and seismic vibration

During operation

Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 g acceleration frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 5 g, duration 11 ms, 3 shocks on each of the 3 axes in both directions
Seismic vibration IEC 60255-21-2, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis), 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis), 8 to 35 Hz: 1 g acceleration (horizontal axis), 8 to 35 Hz: 0.5 g acceleration (vertical axis), frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes

During transport

Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 g acceleration, Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 15 g, duration 11 ms, 3 shocks on each of the 3 axes in both directions
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Half-sinusoidal Acceleration 10 g, duration 16 ms, 1000 shocks on each of the 3 axes in both directions

Climatic stress test

Temperatures

Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C / -13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	-20 °C to +70 °C / -4 °F to +158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C / +131 °C)	-5 °C to +55 °C / +25 °F to +131 °F
- Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to +131 °F
- Limiting temperature during transport	-25 °C to +70 °C / -13 °F to +158 °F

Humidity

Permissible humidity stress; It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average ≤ 75 % relative humidity; on 56 days in the year up to 93 % relative humidity; moisture condensation during operation is not permitted
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Functions	
<i>Differential protection (ANSI 87L, 87T)</i>	
Sensitive differential current trip stage $I_{Diff>}$	
Setting range	
$I_{Diff>} I_N$ secondary 1 A	0.1 to 20 A (steps 0.01 A)
secondary 5 A	0.5 to 100 A
Tripping time	Typical 35 ms with FO cable
$I_{Diff>} > 2 \times I_{Diff>}$ (setting value)	
High current differential trip stage $I_{Diff>>}$	
Setting range	
$I_{Diff>>}$ secondary 1 A	0.8 to 100 A (steps 0.01 A)
secondary 5 A	4.0 to 50 A
Tripping time	Typical 16 ms with FO cable
$I_{Diff>>} > 2 \times I_{Diff>>}$ (setting value)	
<i>Vector group adaption with transformers in the differential zone</i>	
Adaption of connection symbol	0 to 11 (x 30°)(step 1)
Neutral point connection	Grounded (earthed) or not grounded (earthed)(for each winding)
<i>Inrush restraint</i>	
Restraint ratio	
2 nd harmonic I_{2fn}/I_{fn}	10 % to 45 % (step 1 %)
Max. current for restraint	1.1 A to 25 A ¹⁾ (step 0.1 A)
Crossblock function	Can be switched on and off
Max. operative time for crossblock	0 to 60 s (step 0.01 s) or deactivated (operating up to release)
$T_{oper\ crossblk}$	
<i>Backup / emergency overcurrent protection (ANSI 50N, 51N, 67, 67N)</i>	
Operating modes	Backup (always active) or emergency (e.g. loss of data connection)
Characteristic	2 definite-time stages / 1 inverse-time stage
<i>Definite-time stage (ANSI 50, 50N)</i>	
Phase current pickup $I_{ph>>}$	0.1 to 25 A _{(1A)}} / 0.5 to 125 A _{(5A)}} (step 0.01 A) or deactivated
Ground current pickup $3I_{0>>}$	0.05 to 25 A _{(1A)}} / 0.25 to 125 A _{(5A)}} (step 0.01 A) or deactivated
Phase current pickup $I_{ph>}$	0.1 to 25 A _{(1A)}} / 0.5 to 125 A _{(5A)}} (step 0.01 A)
Ground current pickup $3I_{0>}$	0.05 to 25 A _{(1A)}} / 0.25 to 125 A _{(5A)}} (step 0.01 A)
Phase current pickup $I_{ph>}$ with directional element	0.1 to 25 A _{(1A)}} / 0.5 to 125 A _{(5A)}}
Ground current pickup $3I_{0>}$ with directional element	0.05 to 25 A _{(1A)}} / 0.25 to 125 A _{(5A)}} (step 0.01 A)
Time delay	0 to 30 s (step 0.01 s) or deactivated
Tolerances	
Current pickup	≤ 3 % setting value or 1 % of I_N
Delay times	± 1 % setting value or 10 ms
Operating time	Approx. 25 ms
<i>Inverse-time stage (ANSI 51, 51N)</i>	
Phase current pickup I_p	0.1 to 4 A _{(1A)}} / 0.5 to 20 A _{(5A)}} (step 0.01 A)
Ground current pickup $3I_0$	0.05 to 4 A _{(1A)}} / 0.25 to 20 A _{(5A)}} (step 0.01 A)
Phase current pickup $I_p >$ with directional element	0.1 to 4 A _{(1A)}} / 0.5 to 20 A _{(5A)}} (step 0.01 A)
Ground current pickup $3I_0 >$ with directional element	0.05 to 25 A _{(1A)}} / 0.25 to 20 A _{(5A)}} (step 0.01 A)
<i>Tripping characteristics</i>	
Tripping time characteristics acc. to IEC 60255-3	Normal inverse; very inverse; extremely inverse; long time inverse
Tripping time characteristics acc. to ANSI/IEEE (not for DE region, see selection and ordering data 10th position)	Inverse; short inverse; long inverse; moderately inverse; very inverse; extremely inverse; definite inverse
Time multiplier for IEC characteristics T	$T_p = 0.05$ to 3 s (step 0.01 s) or deactivated
Time multiplier for ANSI characteristics D	$D_p = 0.5$ to 15 (step 0.01) or deactivated
Pickup threshold	Approx. 1.1 III_p (ANSI: $III_p = M$)
Reset threshold	Approx. 1.05 x III_p (ANSI: $III_p = M$)
Tolerances	
Operating time for $2 \leq III_p \leq 20$	≤ 5 % of setpoint ± 15 ms
<i>Instantaneous high-speed switch-onto-fault overcurrent protection (ANSI 50HS)</i>	
Operating mode	Active only with connected auxiliary contacts
Characteristic	2 independent stages
Pickup current $I_{>>>}$	0.1 to 15 A _{(1A)}} / 0.5 to 75 A _{(5A)}} (step 0.01 A) or deactivated
Pickup current $I_{>>>>}$	1 to 25 A _{(1A)}} / 5 to 125 A _{(5A)}} (step 0.01 A) or deactivated
Reset ratio	Approx. 0.95
Tolerances	
Current starting	≤ 3 % of setting value or 1 % I_N
<i>Auto-reclosure (ANSI 79)</i>	
Number of auto-reclosures	Up to 8
Operating modes with line voltage check	Only 1-pole; only 3-pole, 1 or 3-pole, adaptive AR Discrimination between successful and non-successful reclose attempts
Dead times $T_{1-ph}, T_{3-ph}, T_{Seq}$	0.01 to 1800 s (step 0.01 s) or deactivated
Action times	0.01 to 300 s (step 0.01 s) or deactivated
Reclaim times	0.5 to 300 s (step 0.01 s)
CLOSE command duration	0.01 to 30 s (steps 0.01 s)
Tolerances	
Time stages	1 % of setting value or 10 ms
Voltage limit values	≤ 3 % of setting value or 0.5 V

Line Differential Protection / 7SD61

Technical data

Breaker failure protection (ANSI 50BF)	
Number of stages	2
Pickup of current element	0.05 to 20 A _(1A) / 0.25 to 100 A _(5A) (step 0.01 A)
Time delays $T1_{1\text{phase}}, T1_{3\text{phase}}, T2$	0 to 30 s (steps 0.01 s) or deactivated
Additional functions	CB synchronism monitoring
Reset time	10 ms, typical
Tolerances	
Current limit value	≤ 3 % of setting value or 1 % I_N
Time stages	1 % of setting value or 10 ms
Voltage protection (ANSI 59, 27)	
Operating modes	Local tripping or only indication
Overvoltage protection	
Pickup values $V_{\text{PH-Gnd}} \gg, V_{\text{PH-Gnd}} >$ (phase-ground (earth) overvoltage)	1 to 170 V (step 0.1 V) or deactivated
Pickup values $V_{\text{PH-PH}} \gg, V_{\text{PH-PH}} >$ (phase-phase overvoltage)	2 to 220 V (step 0.1 V) or deactivated
Pickup values $3V_0 \gg, 3V_0 >$ ($3V_0$ can be measured via V4 transformers or calculated by the relay)(zero-sequence overvoltage)	1 to 220 V (step 0.1 V) or deactivated
Pickup values $V_1 \gg, V_1 >$ (positive-sequence overvoltage)	2 to 220 V (step 0.1 V) or deactivated
Measured voltage	Local positive-sequence voltage or calculated remote positive-sequence voltage (compounding)
Pickup values $V_2 \gg, V_2 >$ (negative-sequence overvoltage)	2 to 220 V (step 0.1 V) or deactivated
Reset ratio (settable)	0.5 to 0.98 (step 0.01)
Undervoltage protection	
Pickup values $V_{\text{PH-Gnd}} \ll, V_{\text{PH-Gnd}} <$ (phase-ground (earth) undervoltage)	1 to 100 V (step 0.1 V) or deactivated
Pickup values $V_{\text{PH-PH}} \ll, V_{\text{PH-PH}} <$ (phase-phase undervoltage)	1 to 175 V (step 0.1 V) or deactivated
Pickup values $V_1 \ll, V_1 <$ (positive-sequence undervoltage)	1 to 100 V (step 0.1 V) or deactivated
Blocking of undervoltage protection stages	Minimum current; binary input
Reset ratio	1.05
Time delays	
Time delay for all over- and undervoltage stages	0 to 100 s (steps 0.01 s) or deactivated
Command / pickup time	Approx. 40 ms
Tolerances	
Voltage limit values	≤ 3 % of setting value or 0.5 V
Time stages	1 % of setting value or 10 ms
Frequency protection (ANSI 81)	
Number of frequency elements	4
Setting range	45.5 to 54.5 Hz (in steps of 0.01) at $f_{\text{nom}} = 50$ Hz 55.5 to 64.5 Hz (in steps of 0.01) at $f_{\text{nom}} = 60$ Hz
Delay times	0 to 600 s or ∞ (in steps of 0.01 s)
Operating voltage range	6 to 230 V (phase-to-ground (earth))
Pickup times	Approx. 85 ms
Dropout times	Approx. 30 ms
Hysteresis	Approx. 20 mHz
Dropout condition	Voltage = 0 V and current = 0 A
Tolerances	
Frequency	12 m Hz for $V = 29$ to 230 V
Delay times	1 % of the setting value or 10 ms
Restricted ground-fault protection (ANSI 87N)	
Multiple availability	2 times (option)
Settings	
Differential current $I_{\text{REF}} > I_{\text{Nobj}}$	0.05 to 2.00 (steps 0.01)
Limit angle φ_{REF}	110 ° (fixed)
Time delay T_{REF}	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
The set times are pure delay times	
Operating times	
Pickup time (in ms) at frequency	50 Hz 60 Hz
At 1.5 · setting value $I_{\text{REF}} >$, approx.	35 30
At 2.5 · setting value $I_{\text{REF}} >$, approx.	33 29
Dropout time (in ms), approx.	26 23
Dropout ratio, approx.	0.7
Overcurrent-time protection for phase and residual currents	
Multiple availability	3 times (option)
Characteristics	
Definite-time stages (DT)	$I_{\text{Ph}} \gg, 3I_0 \gg, I_{\text{Ph}} >, 3I_0 >$
Inverse-time stages (IT)	$I_{\text{p}}, 3I_{0\text{p}}$ Inverse, very inverse, extremely inverse, long-time inverse
Acc. to IEC	
Acc. to ANSI	Inverse, moderately inverse, very inverse, extremely inverse, definite inverse, short inverse, long inverse
	Alternatively, user-specified trip and reset characteristics
Reset characteristics (IT)	Acc. to ANSI with disk emulation
Current stages	
High-current stages $I_{\text{Ph}} \gg$	0.10 to 35.00 A ¹⁾ (steps 0.01 A) or deactivated (stage ineffective)
$T_{\text{Iph}} \gg$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
$3I_0 \gg$	0.05 to 35.00 A ¹⁾ (steps 0.01 A) or deactivated (stage ineffective)
$T_{3I_0} \gg$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
Definite-time stages $I_{\text{Ph}} >$	0.10 to 35.00 A ¹⁾ (steps 0.01 A) or deactivated (stage ineffective)
T_{Iph}	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
$3I_0 >$	0.05 to 35.00 A ¹⁾ (steps 0.01 A) or deactivated (stage ineffective)
$T_{3I_0} >$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)

Inverse-time stages	I_P	0.10 to 4.00 A ¹⁾ (steps 0.01 A)
Acc. to IEC	T_{IP}	0.05 to 3.20 s (steps 0.01 s) or deactivated (no trip)
	$3I_{OP}$	0.05 to 4.00 A ¹⁾ (steps 0.01 A)
	T_{3IOP}	0.05 to 3.20 s (steps 0.01 s) or deactivated (no trip)
Inverse-time stages	I_P	0.10 to 4.00 A ¹⁾ (steps 0.01 A)
Acc. to ANSI	D_{IP}	0.50 to 15.00 s (steps 0.01 s) or deactivated (no trip)
	$3I_{OP}$	0.05 to 4.00 A ¹⁾ (steps 0.01 A)
	D_{3IOP}	0.50 to 15.00 s (steps 0.01 s) or deactivated (no trip)

Thermal overload protection (ANSI 49)

Setting range		
Factor k to IEC 60255.8		0.1 to 4 (steps 0.01)
Time constant τ		1 to 999.9 min (steps 0.1 min)
Thermal alarm stage $\Theta_{Alarm}/\Theta_{Trip}$		50 to 100 % referred to tripping temperature (steps 1 %)
Current-based alarm stage I_{Alarm}		0.1 to 4 A _{(1A) / 0.5 to 5 A_(5A) (steps 0.01 A)}
Calculating mode for overtemperature		Θ_{max} , Θ_{mean} , Θ with I_{max}
Pickup time characteristic		$t = \tau \ln \frac{I^2 - I_{pre}^2}{I^2 - (k I_N)^2}$
Reset ratio		Approx. 0.99
Θ/Θ_{Alarm}		Approx. 0.99
Θ/Θ_{Trip}		Approx. 0.99
III_{Alarm}		Class 10 % acc. to IEC 60255-8
Tolerances		

Additional functions

Operational measured values

Representation		Primary, secondary and percentage referred to rated value
Currents		$3 \times I_{Phase}$; $3I_0$; I_E ; I_1 ; I_2
Tolerances		
10 to 50 % I_N		Typical ≤ 1 % of 50 % I_N
50 to 200 % I_N		Typical ≤ 1 % of measured value
Voltages		$3 \times V_{Phase-Ground}$; $3 \times V_{Phase-Phase}$; $3V_0$, V_1 , V_2 , V_{en}
Tolerances		
10 to 50 % V_N		Typical ≤ 1 % of 50 % V_N
50 to 200 % V_N		Typical ≤ 1 % of measured value
Power with direction indication		P , Q , S
Tolerances		
P : for $ \cos \varphi = 0.7$ to 1 and V/V_N , $III_N = 50$ to 120 %		Typical ≤ 3 %
Q : for $ \sin \varphi = 0.7$ to 1 and V/V_N , $III_N = 50$ to 120 %		Typical ≤ 3 %
S : for V/V_N , $III_N = 50$ to 120 %		Typical ≤ 2 %
Frequency		f
Tolerance		≤ 20 mHz
Power factor		p.f. ($\cos \varphi$)
Tolerance for $ \cos \varphi = 0.7$ to 1		Typical ≤ 3 %
Remote measurements		$3 \times I_{Phase-Ground}$; $3I_0$, $3 \times V_{Phase-Ground}$; $3V_0$
Overload measured values		Θ/Θ_{Trip} L1; Θ/Θ_{Trip} L2; Θ/Θ_{Trip} L3; Θ/Θ_{Trip}

Fault record storage

Measured analog channels	$3 \times I_{Phase}$, $3I_0$, $3I_{Diff}$ $3 \times V_{Phase}$, $3V_0$, $3I_{Restraint}$
Max. number of available recordings	8, backed up by battery if auxiliary voltage supply fails
Sampling intervals	20 samplings per cycle
Total storage time	Approx. 10 s
Binary channels	Pickup and trip information; number and contents can be freely configured by the user

Further additional functions

Measured value supervision	Current sum Current symmetry Voltage sum Voltage symmetry Voltage phase sequence Fuse failure monitor
Indications	
Operational indications	Buffer size 200
System disturbance indication	Storage of signals of the last 8 faults, buffer size
Switching statistics	600 Number of breaking operations per CB pole Sum of breaking current per phase Breaking current of last trip operations Max. breaking current per phase
Circuit-breaker test	TRIP/CLOSE cycle, 3 phases TRIP/CLOSE cycle per phase
Dead time for CB TRIP / CLOSE cycle	0 to 30 s (steps 0.01 s)
Commissioning support	Operational measured values, CB test, status display of binary indication inputs, setting of output relays, generation of indications for testing serial interfaces, commissioning support via Web-browser, test mode, commissioning mode

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EG previous 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 2006/95/EG previous 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1.

The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".

Line Differential Protection / 7SD61

Selection and ordering data

Description	Order No.	Short code
7SD61 numerical line differential protection 87L SIPROTEC 4 for two-line ends, allows transformers in the protection zone	7SD610	
Current transformer		
$I_{ph} = 1 A^{1)}$, $I_e = 1 A^{1)}$	1	
$I_{ph} = 1 A^{1)}$, $I_e = 5 A^{1)}$	5	
Auxiliary voltage		
(Power supply, BI operating voltage) DC 24 to 48 V, trigger level binary input 19 V ³⁾	2	
DC 60 to 125 V ²⁾ , trigger level binary input 19 V ³⁾	4	
DC 110 to 250 V ²⁾ , AC 115 to 230 V, trigger level binary input 88 V ³⁾	5	
DC 110 to 250 V ²⁾ , AC 115 to 230 V, trigger level binary input 176 V ³⁾	6	
Housing, number of binary inputs/outputs		
Flush-mounting housing with screw-type terminals 1/2 19", 7 BI, 5 BO, 1 live-status contact	B	
Surface-mounting housing with screw-type terminals 1/2 19", 7 BI, 5 BO, 1 live-status contact	F	
Flush-mounting housing with plug-in terminals, 1/2 19", 7 BI, 5 BO, 1 live-status contact	K	
Region-specific default settings/function versions and language settings		
Region DE, German language (language changeable)	A	
Region world, English language (language changeable)	B	
Region US, US-English language (language changeable)	C	
Region world, French language (language changeable)	D	
Region world, Spanish language (language changeable)	E	
Region world, Italian language (language changeable)	F	
System interfaces, functions and hardware		
Without system interface	0	
IEC 60870-5-103 protocol, electric RS232	1	
IEC 60870-5-103 protocol, electric RS485	2	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	3	
Further protocols see supplement L	9	L 0
PROFIBUS DP slave, RS485		A
PROFIBUS DP slave, optical 820 nm, double ring, ST connector ⁴⁾		B
MODBUS, RS485		D
MODBUS, optical 820 nm, ST connector ⁴⁾		E
DNP 3.0, RS485		G
DNP 3.0, optical 820 nm, ST connector ⁴⁾		H
IEC 61850, 100 Mbit Ethernet electrical, double, RS45 connector (EN 100)		R
IEC 61850, 100 Mbit Ethernet, with integrated switch optical, double, LC connector ⁵⁾		S

see next page

L 0

BI = Binary input
BO = Binary output

- 1) Rated current 1/5 A can be selected by means of jumpers.
- 2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.
- 3) Setting of the BI thresholds can be made for each binary input via jumpers in 3 steps.

- 4) Not possible for surface mounting housing (Order No. pos. 9 = F). For the surface mounted version, please order a device with the appropriate electrical RS485 interface and an external FO-converter
- 5) Not possible for surface mounting housing (Order No. pos. 9 = F) please order the relay with electrical interface and use a separate fiber-optic switch

Line Differential Protection/7SD61

Selection and ordering data

Description				Order No.	Short code
7SD61 numerical line differential protection 87L SIPROTEC 4 (continued)				7SD610□-□□□□□□□□-□□□□□□□□-□□□□□□	
DIGSI/Modem interface (on rear of device) and protection interface 1				9	M□□
DIGSI/Modem interface (on rear of device)					1
DIGSI 4, electrical RS232					2
DIGSI 4, electrical RS485					
Protection data interface 1					
FO5: Optical 820 nm, 2 ST-plugs, line length up to 1.5 km via multimode FO cable for communication converter or direct FO connection ¹⁾					A
FO6: Optical 820 nm, 2 ST-plugs, line length up to 3.5 km via multimode FO cable for direct FO connection					B
FO17: Optical 1300 nm, LC-Duplex-plugs, line length up to 24 km ²⁾ via monomode FO cable for direct FO connection ²⁾					G
FO18: Optical 1300 nm, LC-Duplex-plugs, line length up to 60 km via monomode FO cable for direct FO connection ²⁾³⁾					H
FO19: Optical 1550 nm, LC-Duplex-plugs, line length up to 100 km via monomode FO cable for direct FO connection ²⁾⁴⁾					J
FO30: Optical 820 nm, 2 ST-plugs, line length up to 1.5 km via multimode FO cable for communication networks with IEEE C37.94 interface or direct FO connection ⁵⁾					S
Functions 1					
Trip mode 3-pole only without auto reclosure				0	
Trip mode 3-pole only with auto reclosure				1	
Trip mode 1- and 3-pole without auto reclosure				2	
Trip mode 1- and 3-pole with auto reclosure				3	
Back-up functions					
with emergency or back-up overcurrent protection					B
without with emergency or back-up overcurrent and breaker failure protection					C
with directional – emergency or back-up overcurrent protection					R
with directional – emergency or back-up overcurrent and breaker failure protection					S
Additional functions 1					
4 Remote commands/ 24 Remote indications	Transformer expansions	Voltage-/frequency protection	Restricted earth fault (low impedance)		A
		■			B
	■				E
	■	■			F
■					J
■		■			K
■	■				N
■	■	■			P
■			■		S
■	■	■	■		T
without external GPS synchronisation of differential protection					0
with external GPS synchronisation of differential protection					1

1) Communication converter 7XV5662, see Accessories.
 2) Device for surface-mounting housing (Order No. pos. 9 = F) will be delivered with external repeater 7XV5461-0Bx00.
 3) For distances less than 25 km a set of optical attenuators 7XV5107-0AA00 must be installed to avoid saturation of the receiver element.

4) For distances less than 50 km a set of optical attenuators 7XV5107-0AA00 must be installed to avoid saturation of the receiver element.
 5) Only available in flush-mounting housing (Order No. pos. 9 = B, K).

Line Differential Protection / 7SD61

Selection and ordering data




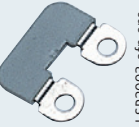

Accessories	Description	Order No.
	<p>Opto-electric communication converter CC-XG (connection to communication network)</p> <p>Converter to interface to X21 or RS422 or G703-64 kbit/s synchronous communication interfaces Connection via FO cable for 62.5 / 125 µm or 50 / 120 µm and 820 nm wavelength (multi-mode FO cable) with ST connector, max. distance 1.5 km Electrical connection via X21/RS422 or G703-64 kbit/s interface</p>	7XV5662-0AA00
	<p>Opto-electric communication converter CC-2M to G703-E1/-T1 communication networks with 2,048 / 1,554 kbit/s</p> <p>Converter to interface between optical 820 nm interface and G703-E1/-T1 interface of a communication network Connection via FO cable for 62.5/125 µm or 50/120 µm and 820 nm wavelength (multi-mode FO cable) with ST connector, max. distance 1.5 km Electrical connection via G703-E1/-T1 interface</p>	7XV5662-0AD00
	<p>Opto-electric communication converter (connection to pilot wire)</p> <p>Converter to interface to a pilot wire or twisted telephone pair (typical 15 km length) Connection via FO cable for 62.5/125 µm or 50/120 µm and 820 nm wavelength (multi-mode FO cable) with ST connector; max. distance 1.5 km, screw-type terminals to pilot wire</p>	7XV5662-0AC00
	<p>Additional interface modules</p> <p>Protection interface module, optical 820 nm, multi-mode FO cable, ST connector, 1.5 km</p>	C53207-A351-D651-1
	Protection interface module, optical 820 nm, multi-mode FO cable, ST connector, 3.5 km	C53207-A351-D652-1
	<p>Further modules</p> <p>Protection interface module, optical 1300 nm, mono-mode FO cable, LC-Duplex connector, 24 km</p>	C53207-A351-D655-1
	Protection interface module, optical 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	C53207-A351-D656-1
	Protection interface module, optical 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	C53207-A351-D657-1
	Protection interface module, optical 820 nm, multi-mode FO cable, ST connector, 1.5 km support of IEEE C37.94	C53207-A351-D658-1
	<p>Optical repeaters</p> <p>Serial repeater (2-channel), optical 1300 nm, mono-mode FO cable, LC-Duplex connector, 24 km</p>	7XV5461-0BG00
	Serial repeater (2-channel), optical 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	7XV5461-0BH00
	Serial repeater (2-channel), optical 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	7XV5461-0BJ00
	<p>Time synchronizing unit with GPS output</p> <p>GPS 1 sec pulse and time telegram IRIG B/DCF 77</p>	7XV5664-0AA00
	Isolation transformer (20 kV) for pilot wire communication	7XR9516
	<p>Voltage transformer miniature circuit-breaker</p> <p>Rated current 1.6 A; thermal overload release 1.6 A; overcurrent trip 6 A</p>	3RV1611-1AG14

Line Differential Protection/7SD61

Selection and ordering data

Accessories	Description	Order No.
	DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper) Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
	Professional Complete version: DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for control displays), DIGSI 4 Remote (remote operation)	7XS5402-0AA00
	SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows (Windows 2000/XP Professional). Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	7XS5410-0AA00
	Connecting cable (copper) Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	7XV5100-4
	Manual for 7SD61 V4.6 English	C53000-G1176-C145-4



Accessories	Description	Order No.	Size of package	Supplier	Fig.
 <p>Fig. 7/35 Mounting rail for 19" rack</p> <p>LSP2090-afp.eps LSP2289-afp.eps</p>	Connector	2-pin 3-pin	1 1	Siemens Siemens	7/36 7/37
 <p>Fig. 7/36 2-pin connector</p> <p>LSP2090-afp.eps</p>	Crimp connector	CI2 0.5 to 1 mm ²	4000 1	AMP ¹⁾ AMP ¹⁾	
 <p>Fig. 7/37 3-pin connector</p> <p>LSP2091-afp.eps</p>		CI2 0.5 to 2.5 mm ²	4000 1	AMP ¹⁾ AMP ¹⁾	
	Crimping tool	Type III+ 0.75 to 1.5 mm ²	4000 1	AMP ¹⁾ AMP ¹⁾	
		For type III+ and matching female	1	AMP ¹⁾	
		For CI2 and matching female	1	AMP ¹⁾ AMP ¹⁾	
 <p>Fig. 7/38 Short-circuit link for current contacts</p> <p>LSP2093-afp.eps</p>	19"-mounting rail	C73165-A63-D200-1	1	Siemens	7/35
	Short-circuit links	For current terminals	1	Siemens	7/38
		For other terminals	1	Siemens	7/39
 <p>Fig. 7/39 Short-circuit link for voltage contacts/indications contacts</p> <p>LSP2092-afp.eps</p>	Safety cover for terminals	large	1	Siemens	
		small	1	Siemens	

1) Your local Siemens representative can inform you on local suppliers.

Line Differential Protection/7SD61

Connection diagram

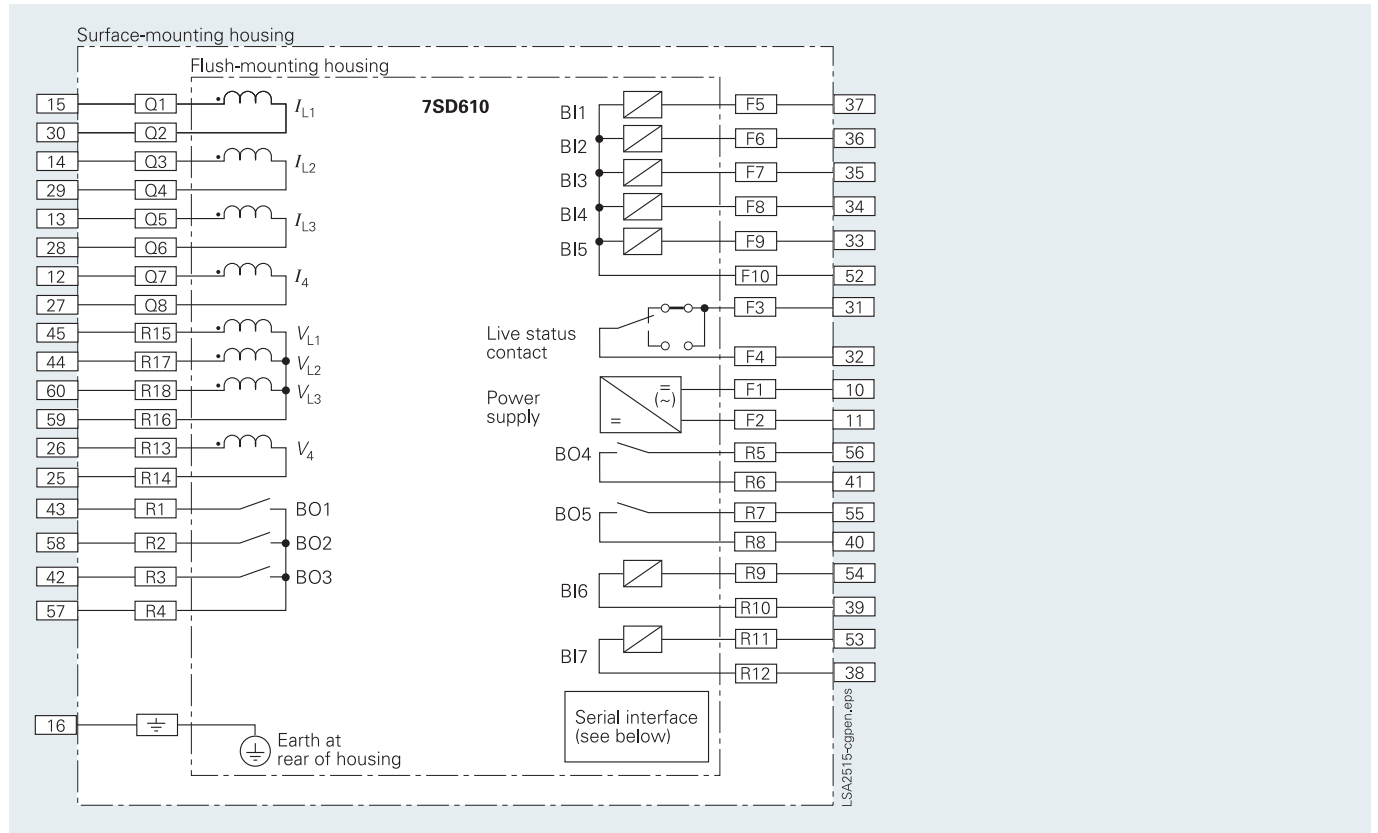


Fig. 7/40 Connection diagram

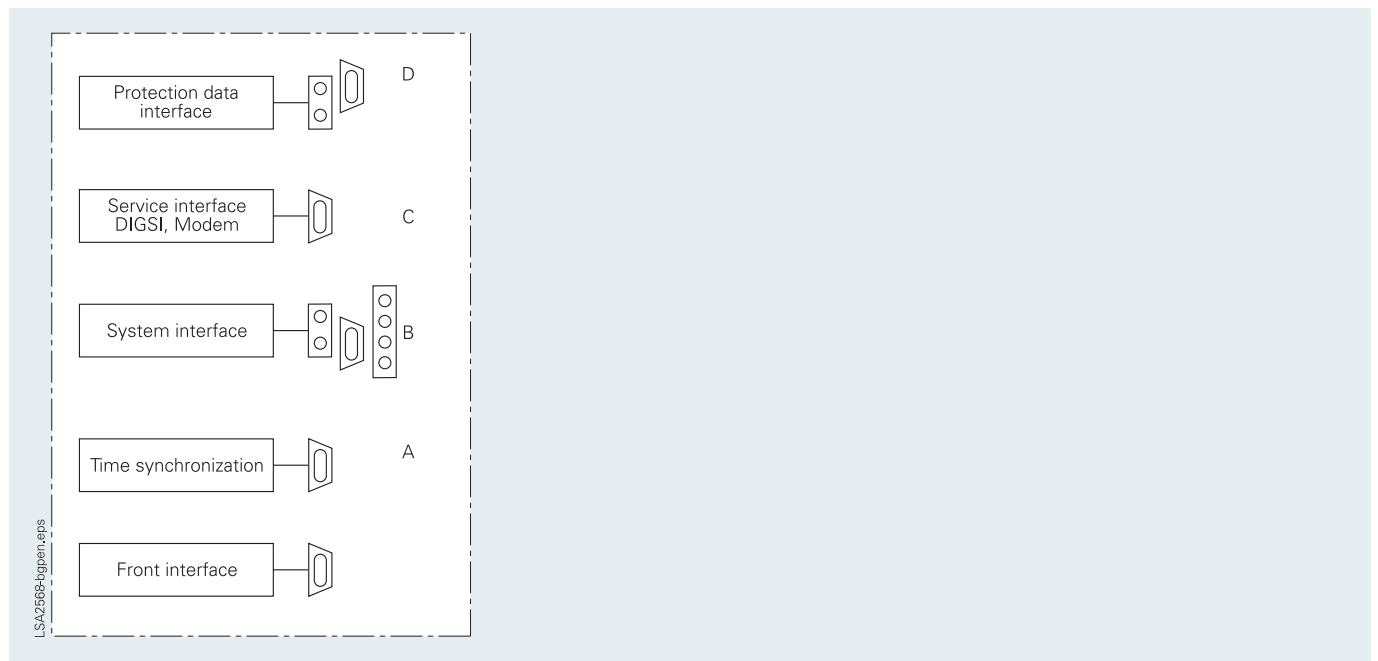


Fig. 6/41 Serial interfaces

Line Differential Protection/7SD52/53

SIPROTEC 4 7SD52/53 multi-end differential and distance protection in one relay



Fig. 7/42 SIPROTEC 4 7SD52/53 differential protection relay

Description

The 7SD52/53 relay provides full scheme differential protection and incorporates all functions usually required for the protection of power lines. It is designed for all power and distribution levels and protects lines with two up to six line ends. The relay is designed to provide high-speed and phase-selective fault clearance. The relay uses fiber-optic cables or digital communication networks to exchange telegrams and includes special features for the use in multiplexed communication networks. Also pilot wires connections can be used with an external converter. This contributes toward improved reliability and availability of the electrical power system.

The relay is suitable for single and three-phase tripping applications for two up to six line ends. Also, transformers and compensation coils within the differential protection zone are protected as are serial and parallel-compensated lines and cables. The relays may be employed with any type of system grounding.

The relay also provides a full-scheme and non-switched distance protection as an optional main 2 protection. Several teleprotection schemes ensure maximum selectivity and high-speed tripping time.

The units measure the delay time in the communication networks and adaptively match their measurements accordingly.

A special GPS-option allows the use of the relays in communication networks, where the delay time in the transmit and receive path may be quite different.

The 7SD52/53 has the following features:

- 2 full-scheme main protections in one unit (differential and distance protection)
- High-speed tripping 10 – 15 ms
- The serial protection interfaces (R2R interfaces) of the relays can flexibly be adapted to the requirements of all communication media available.
- If the communication method is changed, flexible retrofitting of communication modules to the existing configuration is possible.
- Tolerates loss of one data connection in a ring topology (routing in 120 ms). The differential protection scheme is fully available in a chain topology.
- Browser-based commissioning tool.

- Fault locator for one and two terminal measurement for high accuracy on long lines with high load and high fault resistance.
- Capacitive charge current compensation increases the sensitivity of the differential protection on cables and long lines.

Function overview

Protection functions

- Differential protection with phase-segregated measurement (87L, 87T)
- Restricted ground-fault protection (87N) if a transformer is within the protection zone
- Sensitive meas. stage f. high-resist. faults
- Non-switched distance protection with 7 measuring systems (21/21N)
- High resistance ground (earth)-fault protection for single and three-pole tripping (50N/51N/67N)
- Phase-selective intertripping (85)
- Ground-fault detection in isolated and resonant-grounded networks
- Tele (pilot) protection (85/21, 85/67N)
- Weak-infeed protection (27WI)
- Fault locator (FL)
- Power swing detection/tripping (68/68T)
- 3-stage overcurrent protection (50, 50N, 51, 51N)
- STUB bus protection (50 STUB)
- Switch-onto-fault protection (50HS)
- Over/undervoltage protection (59/27)
- Over/underfrequency protection (81O/U)
- Auto-reclosure (79), Synchro-check (25)
- Breaker failure protection (50BF)
- Overload protection (49)
- Lockout function (86)

Control functions

- Commands for control of CB and isolators

Monitoring functions

- Self-supervision of relay and protection data (R2R) communication
- Trip circuit supervision (74TC)
- Measured-value supervision
- Oscillographic fault recording
- Event logging/fault logging
- Switching statistics

Front design

- User-friendly local operation
- PC front port for relay setting
- Function keys and 14 LEDs f. local alarm

Communication interfaces

- 2 serial protection data (R2R) interfaces for ring and chain topology
- Front interface for connecting a PC
- System interface for connection to a control system via various protocols
 - IEC 61850 Ethernet
 - IEC 60870-5-103
 - PROFIBUS-FMS/-DP and DNP 3.0
- Rear-side service/modem interface
- Time synchronization via IRIG-B or DCF77 or system interface

Line Differential Protection / 7SD52/53

Application

ANSI	Protection functions	ANSI	Protection functions
87L	ΔI for lines / cables	85/67N	Teleprotection for earth(ground)-fault protection
87T	ΔI for lines / cables with transformers	50/50N/51/51N	Overcurrent protection
87N	Low impedance restricted ground-fault protection for transformers	50HS	Instantaneous high-current tripping (switch-onto-fault)
85	Phase-selective intertrip, remote trip	59/27	Oversvoltage/undersvoltage protection
86	Lockout function	81O/U	Over/underfrequency protection
21/21N	Distance protection	25	Synchro-check
FL	Fault locator	79	Single or three-pole auto-reclosure with new adaptive technology
68/68T	Power swing detection/tripping	49	Overload protection
85/21	Teleprotection for distance protection	50BF	Breaker-failure protection
27WI	Weak-infeed protection	74TC	Trip circuit supervision
50N/51N/67N	Directional earth(ground)-fault protection	50 STUB	STUB-bus overcurrent stage

7

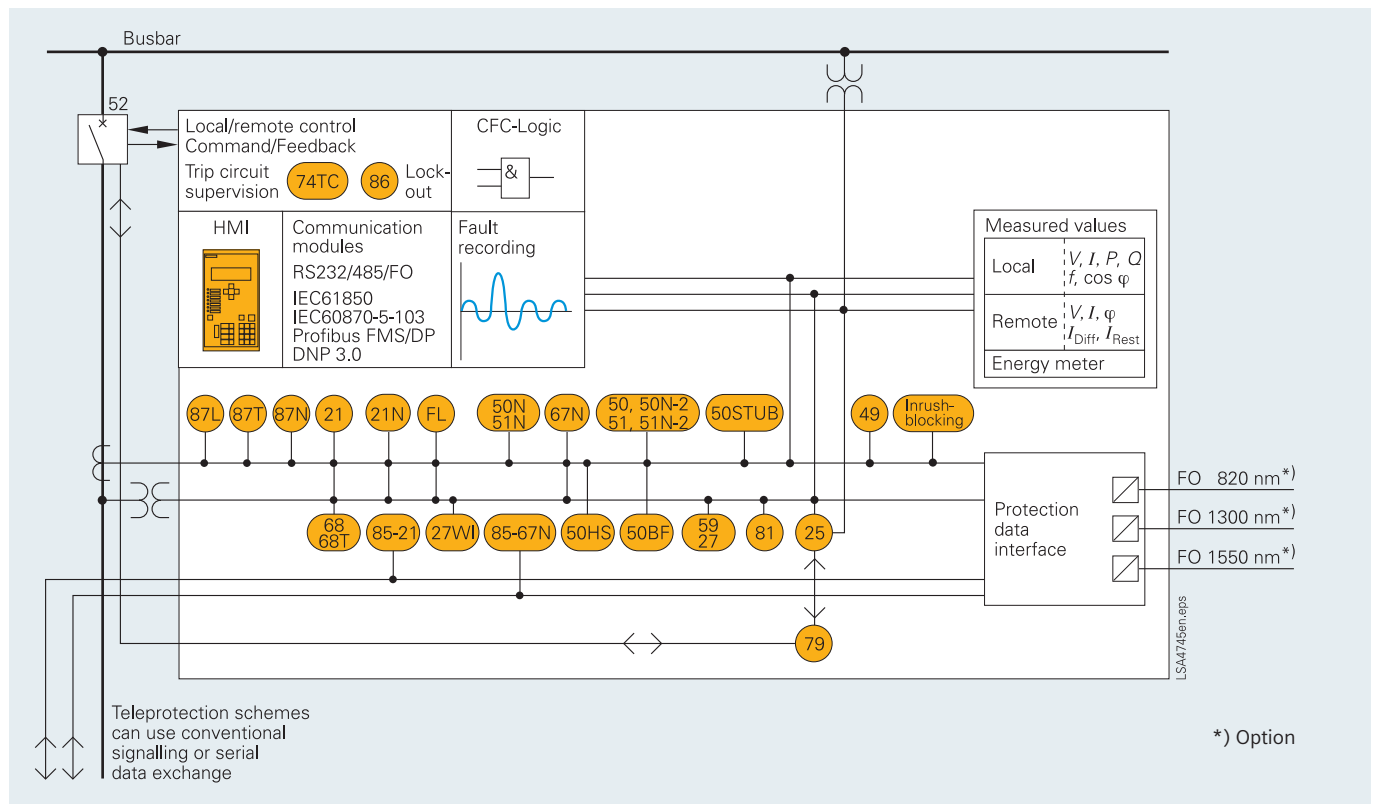


Fig. 7/43

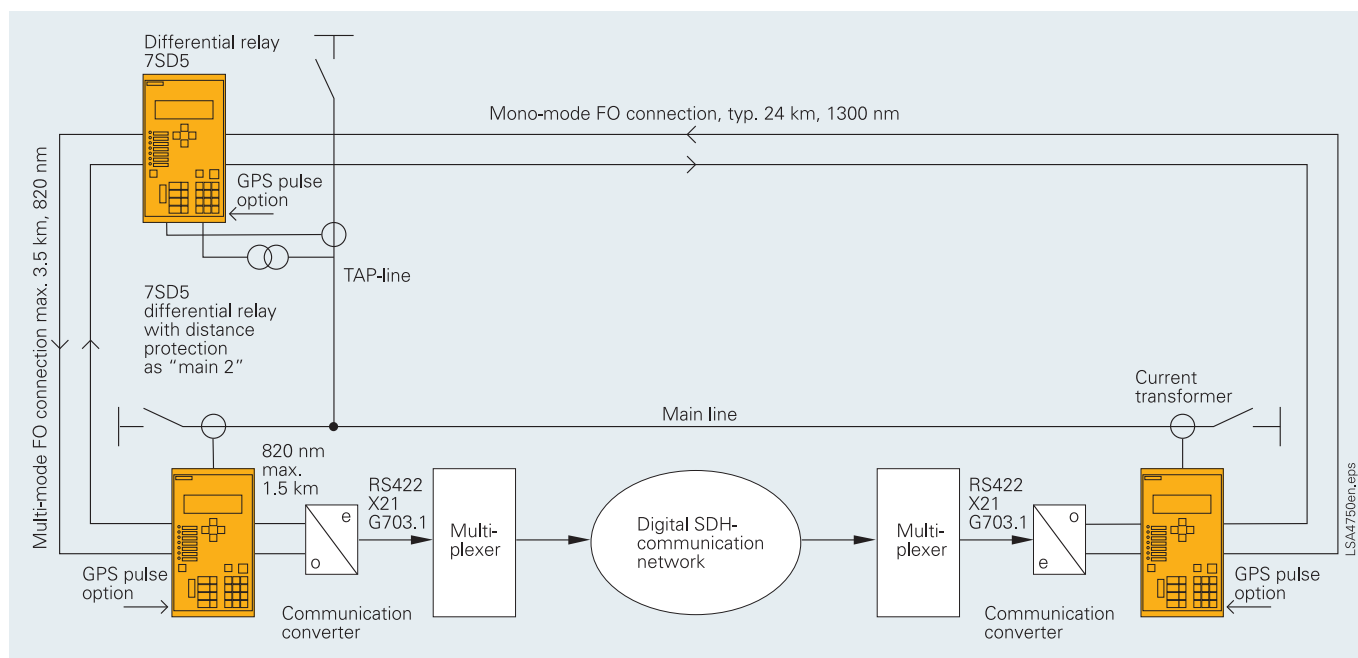


Fig. 7/44 Application for three line ends (Ring topology)

Typical applications

SIPROTEC 7SD52/53 is a full-scheme differential protection relay for two up to six line ends, incorporating all the additional functions for protection of overhead lines and cables at all voltage levels. Also transformers and compensation coils within the protection zone are protected. The 7SD52/53 is suitable for single-pole and three-pole tripping. The power system star point can be solid or impedance-grounded (earthed), resonant-grounded via Peterson coil or isolated. On the TAP-line, the 7SD52/53 differential relay is connected to current (CT) and optionally voltage (VT) transformers. For the differential functions, only CTs are necessary. By connecting the relay to VTs, the integrated "main 2" distance protection can be applied (full-scheme, nonswitched). Therefore, no separate distance protection relay is required.

The link to the other relays is made by multi-mode or mono-mode FO cables. There are 5 options available, which correspondingly cover:

- 820 nm, up to 1.5 km, multi-mode
- 820 nm, up to 3.5 km, multi-mode
- 1300 nm, up to 24 km, mono-mode
- 820 nm support of the IEEE C37.94 interface
- 1300 nm, up to 60 km, mono-mode
- 1550 nm, up to 100 km, mono-mode

Direct fiber-optic connection offers high-speed data exchange with 512 kbit/s and improves the speed for remote signaling.

At the main line two differential relays are connected to CTs. The communication is made via a multiplexed communication network.

The 7SD52/53 offers many features to reliably and safely handle data exchange via communication networks.

Depending on the bandwidth available in the communication system, 64, 128 or 512 kbits/s can be selected for the X21 (RS422) interface; the G703 interface with 64 kbit/s, and G703-E1 (2,048 kbit/s) or G703-T1 (1,554 kbit/s). Furthermore the 7SD610 supports the IEEE C37.94 interface with 1/2/4 and 8 timeslots.

The connection to the communication device is effected via cost-effective 820 nm interface with multi-mode FO cables. A communication converter converts the optical to electrical signals. This offers an interference-free and isolated connection between the relay and the communication device.

Cost-effective power system management

The SIPROTEC 4 units are numerical relays which also provide control and monitoring functions and therefore support the user in view of a cost-effective power system management. The security and reliability of power supply is increased as a result of minimizing the use of hardware.

The local operation has been designed according to ergonomic criteria. Large, easy-to-read backlit displays are provided.

The SIPROTEC 4 units have a uniform design and a degree of functionality which represents a benchmark-level of performance in protection and control. If the requirements for protection, control or interlocking change, it is possible in the majority of cases to implement such changes by means of parameterization using DIGSI 4 without having to change the hardware.

The use of powerful microcontrollers and the application of digital measured-value conditioning and processing largely suppresses the influence of higher-frequency transients, harmonics and DC components.

Line Differential Protection / 7SD52/53

Construction

Construction

Connection techniques and housing with many advantages

$\frac{1}{3}$, $\frac{1}{2}$, $\frac{2}{3}$, and $\frac{1}{1}$ -rack sizes:

These are the available housing widths of the 7SD52/53 relays, referred to a 19" module frame system. This means that previous models can always be replaced. The height is a uniform 245 mm for flush-mounting housings and 266 mm for surface-mounting housings for all housing widths. All cables can be connected with or without ring lugs. Plug-in terminals are available as an option. It is thus possible to employ prefabricated cable harnesses. In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located in a sloped case at the top and bottom of the housing.

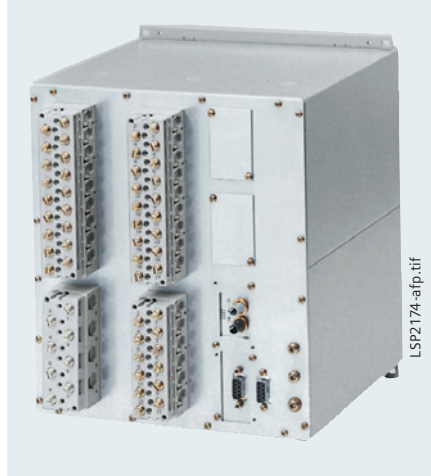


Fig. 7/45 Flush-mounting housing with screw-type terminals

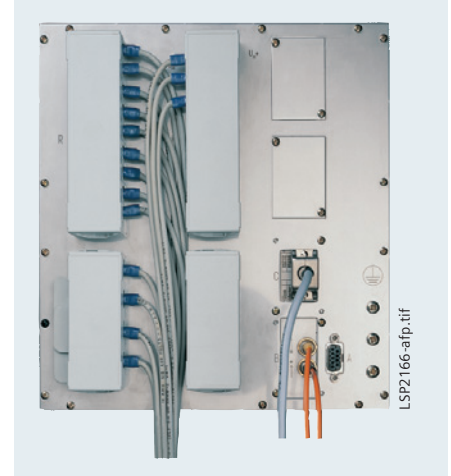


Fig. 7/46 Rear view with screw-type terminals and serial interfaces



Fig. 7/47 Surface-mounting housing with screw-type terminals



Fig. 7/48 Communication interfaces in a sloped case in a surfacemounting housing

Protection functions

Differential protection (ANSI 87L, 87T, 87N)

The differential protection function has the following features:

- It is possible to select the operating mode as "main" or as "main 1", if the back-up distance protection is activated as "main 2".
- Measurements are performed separately for each phase; thus the trip sensitivity is independent of the fault type.
- An adaptive, sensitive measurement method with high sensitivity for differential fault currents below the rated current offers the detection of highly resistive faults. This trip element uses special filters, which offers high security even with high level DC-components in the short-circuit current. The trip time of this stage is about 30 ms.
- A high-set differential trip stage which clears differential fault currents higher than the rated current within 10 – 15 ms offers fast tripping time and high-speed fault clearance time.
- When a long line or cable is switched on, transient charge currents load the line. To avoid a higher setting of the sensitive differential trip stage, this setpoint may be increased for a settable time. This offers greater sensitivity under normal load conditions.
- With the setting of the CT-errors the relay automatically calculates the restraint/stabilization current and adapts its permissible sensitivity according to the CT's data in the differential configuration, optimizing sensitivity.
- Different CT ratios at the line ends are handled inside the relay. The mismatch of 1 to 6 is allowed.
- The differential protection trip can be guarded with an overcurrent pickup. Thus differential current and overcurrent lead to a final trip decision.
- Easy to set tripping characteristic. Because the relay works adaptively, only the setpoint $I_{Diff>}$ (sensitive stage) and $I_{Diff>>}$ (high-set current differential stage) must be set according to the charge current of the line/cable.
- With an optional capacitive charge current compensation, the sensitivity can be increased to 40 % of the normal setting of $I_{Diff>}$. This function is recommended for long cables and long lines.
- Differential and restraint currents are monitored continuously during normal operation and are displayed as operational measurements.
- High stability during external faults even with different current transformers saturation level. For an external fault, only 5 ms saturation-free time are necessary to guarantee the stability of the differential configuration.
- With transformers or compensation coils in the protection zone, the sensitive trip stage can be blocked by an inrush detection function. It works with the second harmonic of the measured current which is compared with the fundamental component.
- With transformers in the protection zone, vector group adaptation and matching of different CT ratios are carried out in the relay. Additionally, the zero-sequence current flowing through an grounded neutral is eliminated from the differential measurement. The 7SD52/53 therefore works like a transformer differential relay, whereas the line ends may be far away.

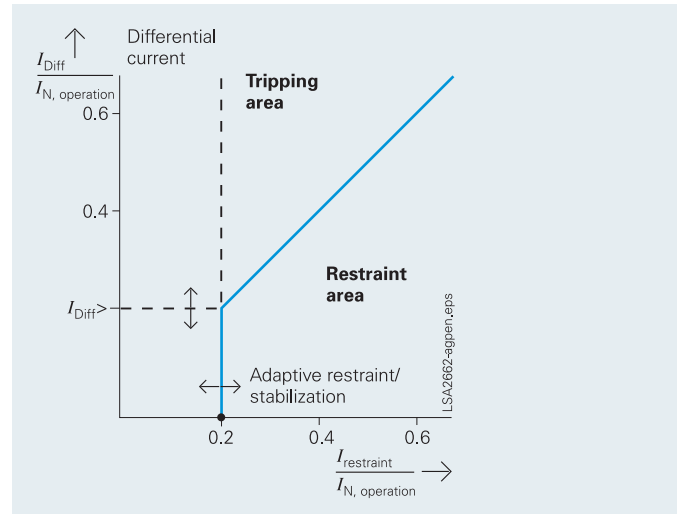


Fig. 7/49 Tripping characteristic

- A more sensitive protection for transformers within the protection zone is given by measurement of the star-point current on an grounded winding. Therefore the I_E current measuring input has to be used. If the sum of the phase currents of winding is compared with the measured star-point current, a sensitive ground-current differential protection (REF) can be implemented. This function is substantially more sensitive than the differential protection during faults to ground in a winding, detecting fault currents as small as 10 % of the transformer rated current.

Enhanced communication features for communication networks

The data required for the differential calculations are cyclically exchanged in full-duplex mode in form of synchronous, serial telegrams between the protection units. The telegrams are secured with CRC check sums, so that transmission errors in a communication network are immediately detected.

- Data communication is immune to electromagnetic interference because fiber-optic cables are employed in the critical region
- Supervision of each individual incoming telegram and of the entire communication path between the units without additional equipment.
- Unambiguous identification of each unit is ensured by assignment of a settable communication address within a differential protection topology. Only those units mutually known to each other can cooperate. Incorrect interconnection of the communication links results in blocking of the protection system.
- Detection of reflected telegrams in the communication system.
- Detection of delay time changes in communication networks.
- Measurement of the delay time to the remote line ends with dynamic compensation of the delay in the differential measurement. Supervision of the maximum permissible delay time is included.
- Generation of alarms on heavily disturbed communication links. Faulty telegram counters are available as operational measurement.

(continued on next page)

Line Differential Protection / 7SD52/53

Protection functions

- With a GPS high-precision 1-s pulse from a GPS receiver the relays can be synchronized with an absolute, exact time at each line end. In this way, the delay in the receive and transmit path can be measured exactly. With this optional feature the relay can be used in communication networks where this delay times are quite different.

Phase-selective intertrip and remote trip/indications

Normally the differential fault current is calculated for each line end nearly at the same time. This leads to fast and uniform tripping times. Under weak infeed conditions, especially when the differential function is combined with an overcurrent pickup a phase-selective intertrip offers a tripping of all line ends.

- 7SD52/53 has 4 intertrip signals which are transmitted in high-speed (< 20 ms) to the other line ends. These intertrip signals can also be initiated by an external relay via binary inputs and therefore be used to indicate, for example, a directional decision of the backup distance relay.
- In addition, 4 high-speed remote trip signals are available, which may be initiated by an external or internal event.
- 24 remote signals can be freely assigned to inputs and outputs at each line end and are circulating between the different devices.

Communication topologies / modes of operation

The differential relays may work in a ring or daisy chain line topology. Use of a test mode offer advantages under commissioning and service conditions.

- The system tolerates the loss of one data connection in a ring topology. The ring topology is rerouted within 20 ms forming then a chain topology, while the differential protection function is immediately reactivated.
- When the communication connections need to be reduced or when these are not available, the whole system is able to function without interruption as chain topology. At the line ends, only cost-effective 7SD52/53 relays with one protection interface are necessary for this application.

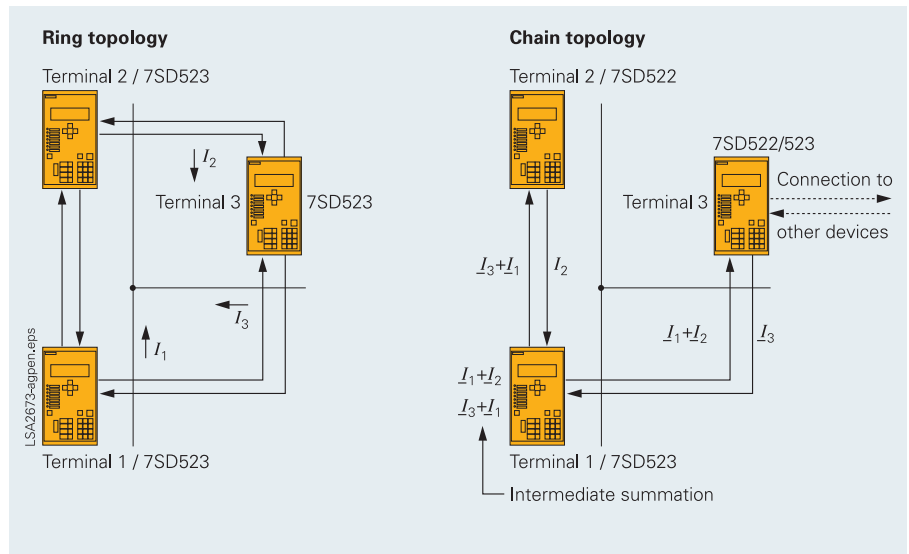


Fig. 7/50 Differential protection in ring or chain topology

- The two-end line is a special case, because when the main connection is interrupted, the communication switches over from a main path to a secondary path. This hot standby transmission function ensures a high availability of the system and protects differential protection against communication route failure on important lines.
- In a ring topology, one line end can be logged out from the differential protection topology for service or maintenance reasons by a signal via binary input. Checks for the breaker position and load current are made before this logout is initiated. In a chain topology, the relays at the end of the line can be logged out from the differential protection topology.
- The whole configuration can be set up into a test mode. All functions and indications are available except the breakers are not tripped. The local relay can be tested and no trip or intertrip reaction is effected by the other relays.

Distance protection (ANSI 21, 21N)

7SD52/53 provides a non-switched distance protection featuring all well-proven algorithms of 7SA522 and 7SA6. It is possible to select the operating mode "main" or "main 2", if the back-up differential is activated as "main 1". By parallel calculation and monitoring of all six impedance loops, a high degree of sensitivity and selectivity is achieved for all types of faults. The shortest tripping time is less than one cycle. All methods of neutral-point connection (resonant grounding, isolated, solid or low-resistance grounding) are reliably dealt with. Single and three-pole tripping is possible. Overhead lines can be equipped with or without series capacitor compensation.

Quadrilateral and mho characteristics

The 7SD52/53 relay provides quadrilateral as well as mho zone characteristics. Both characteristics can be used separately for phase and ground (earth) faults. Resistance ground (earth) faults can, for instance, be covered with the quadrilateral characteristic and phase faults with the mho characteristic.

Alternatively, the quadrilateral characteristic is available with 4 different pickup methods:

- Overcurrent pickup $I >$
- Voltage-dependent overcurrent pickup VII
- Voltage-dependent and phase angle-dependent overcurrent pickup $VIII\phi$
- Impedance pickup $Z <$

Load zone

In order to guarantee a reliable discrimination between load operation and short-circuit – especially on long high loaded lines – the relay is equipped with a selectable load encroachment characteristic. Impedances within this load encroachment characteristic prevent the distance zones from unwanted tripping.

Absolute phase-selectivity

The distance protection incorporates a well-proven highly sophisticated phase selection algorithm. The pickup of unfaulted loops is reliably eliminated to prevent the adverse influence of currents and voltages in the fault-free loops. This phase selection algorithm achieves single-pole tripping and correct distance measurement in a wide application range.

Parallel line compensation

The influence of wrong distance measurement due to parallel lines can be compensated by feeding the neutral current of the parallel line to the relay. Parallel line compensation can be used for distance protection as well as for fault locating.

7 distance zones

6 independent distance zones and one separate overreach zone are available. Each distance zone has dedicated time stages, partly separate for single-phase or multi-phase faults. Ground (earth) faults are detected by monitoring the neutral current $3I_0$ and the zero-sequence voltage $3V_0$.

The quadrilateral tripping characteristic permits separate setting of the reactance X and the resistance R . The resistance section R can be set separately for faults with and without ground involvement. This characteristic has therefore an optimal performance

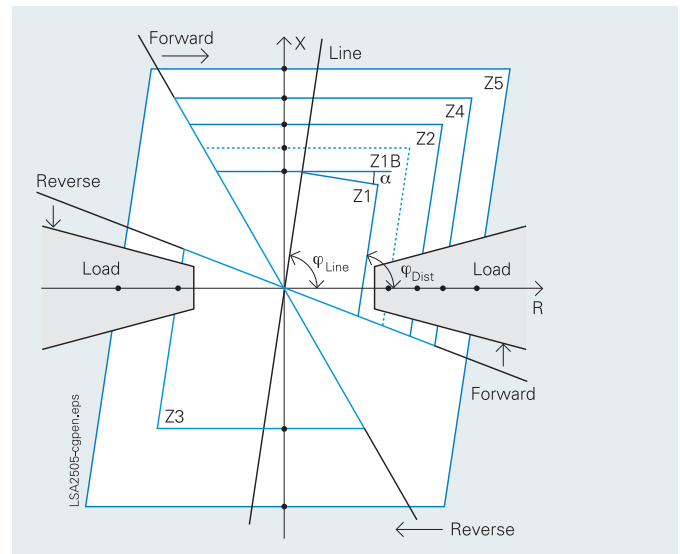


Fig. 7/51 Distance protection: quadrilateral characteristic

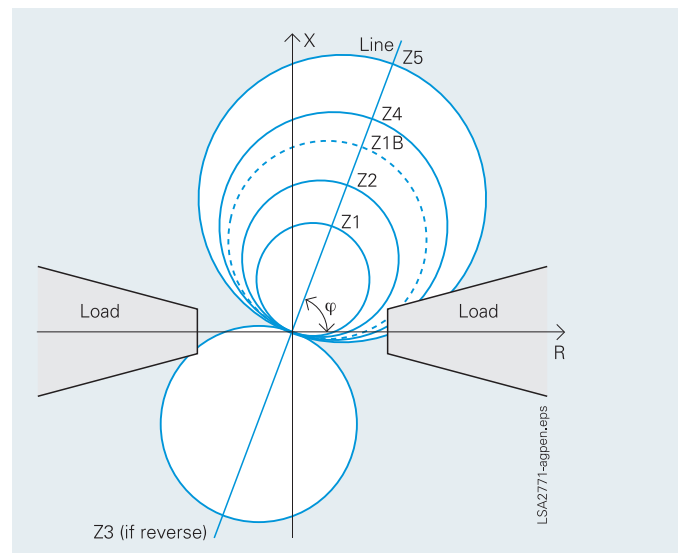


Fig. 7/52 Distance protection: mho characteristic

in case of faults with fault resistance. The distance zones can be set forward, reverse or non-directional. Sound phase polarization and voltage memory provides a dynamically unlimited directional sensitivity.

Mho

The mho tripping characteristic provides sound phase respectively memory polarization for all distance zones. The diagram shows characteristic without the expansion due to polarizing. During a forward fault the polarizing expands the mho circle towards the source so that the origin is included. This mho circle expansion guarantees safe and selective operation for all types of faults, even for close-in faults.

Line Differential Protection / 7SD52/53

Protection functions

Elimination of interference signals

Digital filters render the unit immune to interference signals contained in the measured values. In particular, the influence of DC components, capacitive voltage transformers and frequency changes is considerably reduced. A special measuring method is employed in order to assure protection selectivity during saturation of the current transformers.

Measuring voltage monitoring

Tripping of the distance protection is blocked automatically in the event of failure of the measuring voltage, thus preventing spurious tripping.

The measuring voltage is monitored by the integrated fuse failure monitor. Distance protection is blocked if either the fuse failure monitor or the auxiliary contact of the voltage transformer protection switch operates and, in this case, the EMERGENCY definite-time overcurrent protection can be activated.

Power swing detection (ANSI 68, 68T)

Dynamic transient reactions, for instance short-circuits, load fluctuations, auto-reclosures or switching operations can cause power swings in the transmission network. During power swings, large currents along with small voltages can cause unwanted tripping of distance protection relays. To avoid uncontrolled tripping of the distance protection and to achieve controlled tripping in the event of loss of synchronism, the 7SD52/53 relay is equipped with an efficient power swing detection function. Power swings can be detected under symmetrical load conditions as well as during single-pole auto-reclosures.

Tele (pilot) protection for distance protection (ANSI 85-21)

A teleprotection function is available for fast clearance of faults up to 100 % of the line length. The following operating modes may be selected:

- PUTT, permissive underreaching zone transfer trip
- POTT, permissive overreaching zone transfer trip
- UNBLOCKING
- BLOCKING
- Directional comparison pickup
- Pilot-wire comparison
- Reverse interlocking
- DUTT, direct underreaching zone transfer trip (together with Direct Transfer Trip function)

The carrier send and receive signals are available as binary inputs and outputs and can be freely assigned to each physical relay input or output. At least one channel is required for each direction.

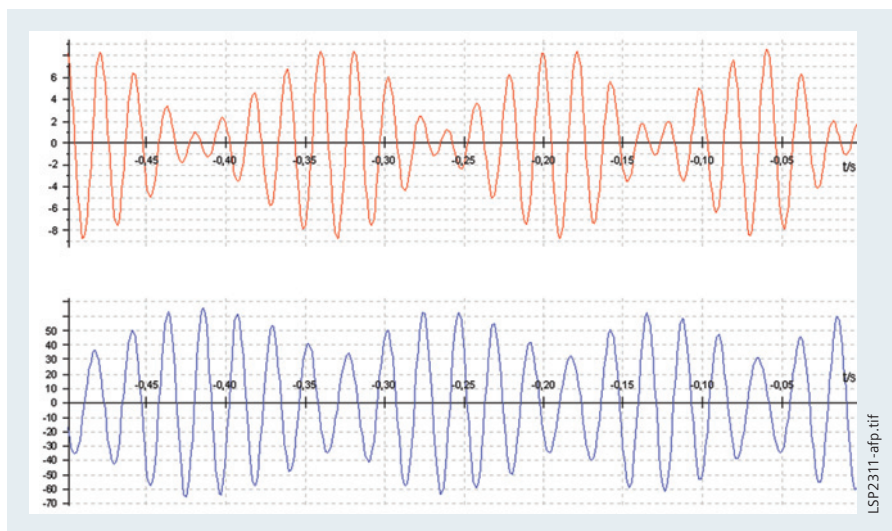


Fig. 7/53 Power swing current and voltage wave forms

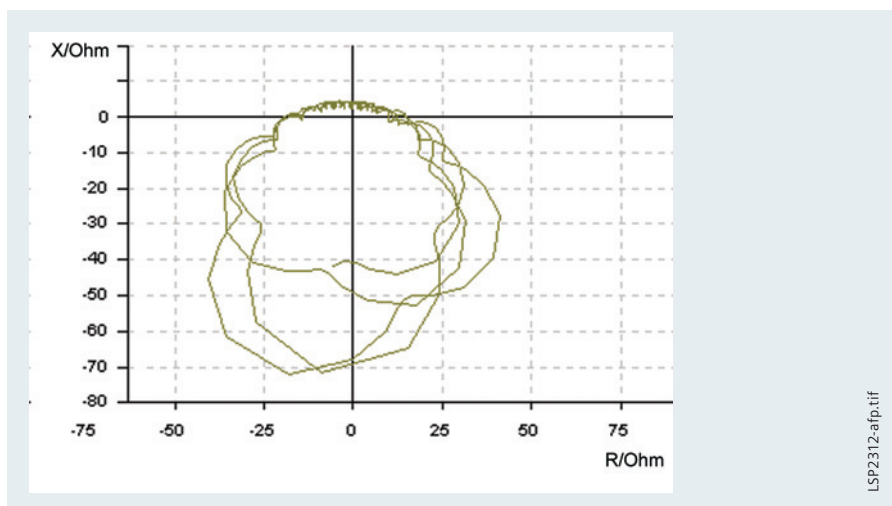


Fig. 7/54 Power swing circle diagram

Common transmission channels are power-line carrier, microwave radio and fiber-optic links. The serial protection interface can be used for direct connection to a digital communication network, fiber-optic or pilot-wire link as well.

7SD52/53 also permits the transfer of phase-selective signals. This feature is particularly advantageous as it ensures reliable single-pole tripping, if two single-pole faults occur on different lines. The transmission methods are suitable also for lines with three ends (three-terminal lines).

Phase-selective transmission is also possible with multi-end applications, if some user-specific linkages are implemented by way of the integrated CFC logic. During disturbances in the transmission receiver or on the transmission circuit, the teleprotection function can be blocked by a binary input signal without losing the zone selectivity. The control of the overreach zone Z1B (zone extension) can be switched over to the auto-reclosure function. A transient blocking function (Current reversal guard) is provided in order to suppress interference signals during tripping of parallel lines.

Direct transfer tripping

Under certain conditions on the power system it is necessary to execute remote tripping of the circuit-breaker. The 7SD52/53 relay is equipped with phase-selective "external trip inputs" that can be assigned to the received inter-trip signal for this purpose.

Weak-infeed protection: echo and/or trip (ANSI 27 WI)

To prevent delayed tripping of permissive schemes during weak or zero infeed situations, an echo function is provided. If no fault detector is picked up at the weak-infeed end of the line, the signal received here is returned as echo to allow accelerated tripping at the strong infeed end of the line. It is also possible to initiate tripping at the weak-infeed end. A phase-selective 1-pole or 3-pole trip is issued if a permissive trip signal (POTT or Unblocking) is received and if the phase-ground voltage drops correspondingly. As an option, the weak-infeed logic can be equipped according to a French specification.

Directional ground(earth)-fault protection for high-resistance faults (ANSI 50N, 51N, 67N)

In grounded (earthed) networks, it may happen that the distance protection sensitivity is not sufficient to detect high-resistance ground (earth) faults. The 7SD52/53 protection relay has therefore protection functions for faults of this nature.

The ground (earth)-fault overcurrent protection can be used with 3 definite-time stages and one inverse-time stage (IDMT). A 4th definite-time stage can be applied instead of the 1st inverse-time stage.

Inverse-time characteristics according to IEC 60255-3 and ANSI/IEEE are provided (see "Technical data"). An additional logarithmic inverse-time characteristic is also available.

The direction decision can be determined by the neutral current and the zero-sequence voltage or by the negative-sequence components V_2 and I_2 . In addition or as an alternative to the directional determination with zero-sequence voltage, the star-point current of a grounded (earthed) power transformer may also be used for polarization. Dual polarization applications can therefore be fulfilled.

Alternatively, the direction can be determined by evaluation of zero-sequence power. Each overcurrent stage can be set in forward or reverse direction or for both directions (non-directional). As an option the 7SD52/53 relay can be provided with a sensitive neutral (residual) current transformer. This feature provides a measuring range for the neutral (residual) current from 5 mA to 100 A with a nominal relay current of 1 A and from 5 mA to 500 A with a nominal relay current of 5 A. Thus the ground (earth)-fault overcurrent protection can be applied with extreme sensitivity.

The function is equipped with special digital filter algorithms, providing the elimination of higher harmonics. This feature is particularly important for low zero-sequence fault currents which usually have a high content of 3rd and 5th harmonics. Inrush stabilization and instantaneous switch-onto-fault trip can be activated separately for each stage as well.

Different operating modes can be selected. The ground(earth)-fault protection is suitable for three-phase and, optionally, for single-phase tripping by means of a sophisticated phase selector. It may be blocked during the dead time of single-pole auto-reclose cycles or during pickup of the distance protection.

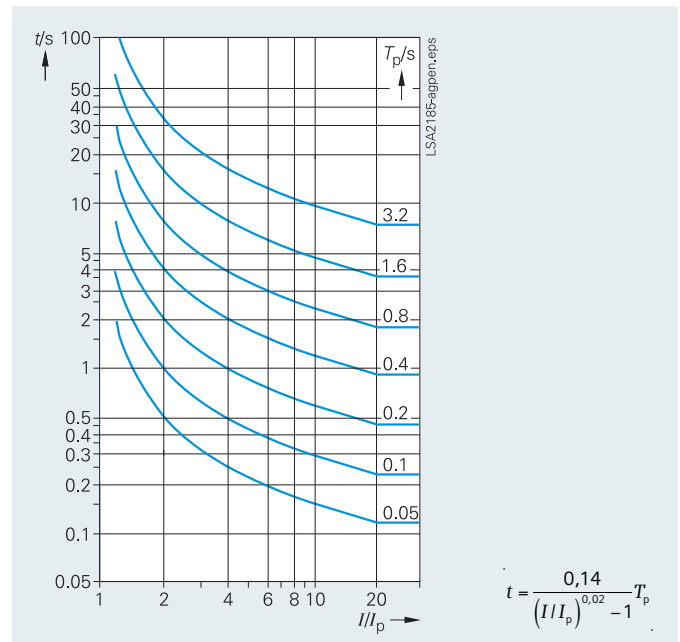


Fig. 7/55 Normal inverse

Tele (pilot) protection for directional ground(earth)-fault protection (ANSI 85-67N)

The directional ground(earth)-fault overcurrent protection can be combined with one of the following teleprotection schemes:

- Directional comparison
- BLOCKING
- UNBLOCKING

The transient blocking function (current reversal guard) is also provided in order to suppress interference signals during tripping of parallel lines.

The pilot functions for distance protection and for ground(earth)-fault protection can use the same signaling channel or two separate and redundant channels.

Overcurrent protection (ANSI 50, 50N, 51, 51N)

The 7SD52/53 provides a backup over-current protection. Two definite-time stages and one inverse-time stage (IDMTL) are available, separately for phase currents and for the neutral (residual) current. Two operating modes are selectable. The function can run in parallel to the differential protection and the distance protection or only during interruption of the protection communication and/or failure of the voltage in the VT secondary circuit (emergency operation). The secondary voltage failure can be detected by the integrated fuse failure monitor or via a binary input from a VT miniature circuit-breaker (VT m.c.b. trip).

The following inverse-time characteristics according to IEC 60255-3 and ANSI/IEEE are provided:

- Inverse
- Short inverse
- Long inverse
- Moderately inverse
- Very inverse
- Extremely inverse
- Definite inverse

Line Differential Protection / 7SD52/53

Protection functions

STUB bus overcurrent protection (ANSI 50(N)-STUB)

The STUB bus overcurrent protection is a separate definite-time overcurrent stage. It can be activated from a binary input signaling the line isolator (disconnect) is open. Settings are available for phase and ground (earth)-faults.

Instantaneous high-speed switch-onto-fault overcurrent protection (ANSI 50HS)

Instantaneous tripping is possible when energizing a faulty line. In the event of large fault currents, the high-speed switch-onto-fault overcurrent stage can initiate very fast 3-pole tripping.

With lower fault currents, instantaneous tripping after switch-onto-fault is also possible

- if the breaker positions at the line ends are monitored and connected to the relays. This breaker position monitor offers a high-speed trip during switch-onto-fault conditions.
- with the overreach distance zone Z1B or just with pickup in any zone.

The switch-onto-fault initiation can be detected via the binary input "manual close" or automatically via measurement.

Fault locator

The integrated fault locator calculates the fault impedance and the distance-to-fault. The result is displayed in ohms, miles, kilometers or in percent of the line length. Parallel line and load current compensation is also available.

As an option for a line with two ends, a fault locator function with measurement at both ends of the line is available. Thanks to this feature, accuracy of measurement on long lines under high load conditions and high fault resistances is considerably increased.

Overvoltage protection, undervoltage protection (ANSI 59, 27)

A voltage rise can occur on long lines that are operating at no-load or are only lightly loaded. The 7SD52/53 contains a number of overvoltage measuring elements. Each measuring element is of two-stage design. The following measuring elements are available:

- Phase-to-ground overvoltage
- Phase-to-phase overvoltage
- Zero-sequence overvoltage
The zero-sequence voltage can be connected to the 4th voltage input or be derived from the phase voltages.
- Positive-sequence overvoltage of the local end or calculated for the remote end of the line (compounding).
- Negative-sequence overvoltage

Tripping by the overvoltage measuring elements can be effected either at the local circuit-breaker or at the remote station by means of a transmitted signal.

The 7SD52/53 is fitted, in addition, with three two-stage undervoltage measuring elements:

- Phase-to-ground undervoltage
- Phase-to-phase undervoltage
- Positive-sequence undervoltage

The undervoltage measuring elements can be blocked by means of a minimum current criterion and by means of binary inputs.

Frequency protection (ANSI 81O/U)

Frequency protection can be used for overfrequency and underfrequency protection. Unwanted frequency changes in the network can be detected and the load can be removed at a specified frequency setting. Frequency protection can be used over a wide frequency range (45 to 55, 55 to 65 Hz). There are four elements (selectable as overfrequency or underfrequency) and each element can be delayed separately.

Breaker failure protection (ANSI 50BF)

The 7SD52/53 relay incorporates a two-stage breaker failure protection to detect the failure of tripping command execution, for example due to a defective circuit-breaker. The current detection logic is phase-segregated and can therefore also be used in single-pole tripping schemes. If the fault current is not interrupted after a settable time delay has expired, a retrip command or a busbar trip command is generated. The breaker failure protection can be initiated by all integrated protection functions as well as by external devices via binary input signals.

Auto-reclosure (ANSI 79)

The 7SD52/53 relay is equipped with an auto-reclose function (AR). The function includes several operating modes:

- 3-pole auto-reclosure for all types of faults; different dead times are available depending the type of fault
- 1-pole auto-reclosure for 1-phase faults, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and for 2-phase faults without ground, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase and 3-pole auto-reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and 2-phase faults without ground and 3-pole auto-reclosure for other faults
- Multiple-shot auto-reclosure
- Interaction with an external device for auto-reclosure via binary inputs and outputs
- Control of the integrated AR function by external protection
- Adaptive auto-reclosure. Only one line end is closed after the dead time. If the fault persists this line end is switched off. Otherwise the other line ends are closed via a command over the communication links. This avoids stress when heavy fault currents are fed from all line ends again.
- Interaction with the internal or an external synchro-check
- Monitoring of the circuit-breaker auxiliary contacts

In addition to the above-mentioned operating modes, several other operating principles can be employed by means of the integrated programmable logic (CFC).

Integration of auto-reclosure in the feeder protection allows evaluation of the line-side voltages. A number of voltage-dependent supplementary functions are thus available:

- DLC
By means of dead-line check, reclosure is effected only when the line is deenergized (prevention of asynchronous breaker closure).

- **ADT**
The adaptive dead time is employed only if auto-reclosure at the remote station was successful (reduction of stress on equipment).
- **RDT**
Reduced dead time is employed in conjunction with auto-reclosure where no tele-protection method is employed: When faults within the zone extension, but external to the protected line, are switched off for rapid auto-reclosure (RAR), the RDT function decides on the basis of measurement of the return voltage from the remote station which has not tripped whether or not to reduce the dead time.

Synchronism check (ANSI 25)

Where two network sections are switched in by control command or following a 3-pole auto-reclosure, it must be ensured that both network sections are mutually synchronous. For this purpose, a synchronism-check function is provided. After verification of the network synchronism the function releases the CLOSE command. Alternatively, reclosing can be enabled for different criteria, e.g., checking that the busbar or line is not carrying a voltage (dead line or dead bus).

Thermal overload protection (ANSI 49)

A built-in overload protection with a current and thermal alarm stage is provided for the thermal protection of cables and transformers. The trip time characteristics are exponential functions according to IEC 60255-8. The preload is thus considered in the trip times for overloads. An adjustable alarm stage can initiate an alarm before tripping is initiated.

Monitoring and supervision functions

The 7SD52/53 relay provides comprehensive monitoring functions covering both hardware and software. Furthermore, the measured values are continuously checked for plausibility. Therefore the current and voltage transformers are also included in this monitoring system.

Current transformer / Monitoring functions

A broken wire between the CTs and relay inputs under load may lead to maloperation of a differential relay if the load current exceeds the differential setpoint. The 7SD52/53 provides fast broken wire supervision which immediately blocks all line ends if a broken wire condition is measured by a local relay. This avoids mal-operation due to broken wire condition. Only the phase where the broken wire is detected is blocked. The other phases remain under differential operation.

Fuse failure monitoring

If any measured voltage is not present due to short-circuit or open circuit in the voltage transformer secondary circuit the distance protection would respond with an unwanted trip due to this loss of voltage. This secondary voltage interruption can be detected by means of the integrated fuse failure monitor. Immediate blocking of distance protection is provided for all types of secondary voltage failures.

Additional measurement supervision functions are

- Symmetry of voltages and currents
- Summation of currents and voltages

Trip circuit supervision (ANSI 74TC)

One or two binary inputs for each circuit-breaker pole can be used for monitoring the circuit-breaker trip coils including the connecting cables. An alarm signal is issued whenever the circuit is interrupted.

Lockout (ANSI 86)

All binary outputs can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only be issued after the lockout state is reset.

Local measured values

The measured values are calculated from the measured current and voltage signals along with the power factor ($\cos \varphi$), the frequency, the active and reactive power. Measured values are displayed as primary or secondary values or in percent of the specific line rated current and voltage. The relay uses a 20 bit high-resolution AD converter and the analog inputs are factory-calibrated, so a high accuracy is reached.

The following values are available for measured-value processing:

- Currents $3 \times I_{\text{Phase}}$, $3I_0$, I_E , I_E sensitive
- Voltages $3 \times V_{\text{Phase-Ground}}$, $3 \times V_{\text{Phase-Phase}}$, $3V_0$, V_{en} , V_{SYNC} , V_{COMP}
- Symmetrical components I_1 , I_2 , V_1 , V_2
- Real power P (Watt), reactive power Q (Var), apparent power S (VA)
- Power factor PF (= $\cos \varphi$)
- Frequency f
- Differential and restraint current per phase
- Load impedances with directional indication
 $3 \times R_{\text{Phase-Ground}}$, $X_{\text{Phase-Ground}}$
 $3 \times R_{\text{Phase-Phase}}$, $X_{\text{Phase-Phase}}$
- Long term mean values
 $3 \times I_{\text{Phase}}$; I_1 ; P ; $P+$; $P-$; Q ; $Q+$; $Q-$; S
- Minimum/maximum memory
 $3 \times I_{\text{Phase}}$; I_1 ; $3 \times V_{\text{Phase-Ground}}$
 $3 \times V_{\text{Phase-Phase}}$, $3V_0$; V_1 ; $P+$; $P-$; $Q+$; $Q-$; S ; f ;
power factor (+); power factor (-);
from mean values $3 \times I_{\text{Phase}}$; I_1 ; P ; Q ; S
- Energy meters W_{p+} ; W_{p-} ; W_{Q+} ; W_{Q-}
- Availability of the data connection to the remote line ends per minute and per hour Regarding delay time measuring with the GPS-version the absolute time for transmit and receive path is displayed separately.

Limit value monitoring: Limit values are monitored by means of the CFC. Commands can be derived from these limit value indications.

Line Differential Protection / 7SD52/53

Protection functions

Measured values at remote line ends

Every two seconds the currents and voltages are frozen at the same time at all line ends and transmitted via the communication link. At a local line end, currents and voltages are thus available with their amount and phases (angle) locally and remotely. This allows checking the whole configuration under load conditions. In addition, the differential and restraint currents are also displayed. Important communication measurements, such as delay time or faulty telegrams per minute/hour are also available as measurements. These measured values can be processed with the help of the CFC logic editor.

Commissioning

Special attention has been paid to commissioning. All binary inputs and outputs can be displayed and activated directly. This can simplify the wiring check significantly for the user. The operational and fault events and the fault records are clearly arranged.

Furthermore, all currents and optional voltages and phases are available via communication link at the local relay and are displayed in the relay, with DIGSI 4 or with the Web Monitor.

The operational and fault events and fault records from all line ends share a common time tagging which allows to compare events registered in the different line ends on a common time base.

WEB Monitor – Internet technology simplifies visualization

In addition to the universal DIGSI 4 operating program, the relay contains a WEB server that can be accessed via a telecommunication link using a browser (e.g. Internet Explorer). The advantage of this solution is to operate the unit with standard software tools and at the same time make use of the Intranet/Internet infrastructure. This program shows the protection topology and comprehensive measurements from local and remote line ends. Local and remote measurements are shown as phasors and the breaker positions of each line end are depicted. It is possible to check the correct connection of the current transformers or the correct vector group of a transformer.

Stability can be checked by using the operating characteristic as well as the calculated differential and restraint values in the browser windows.

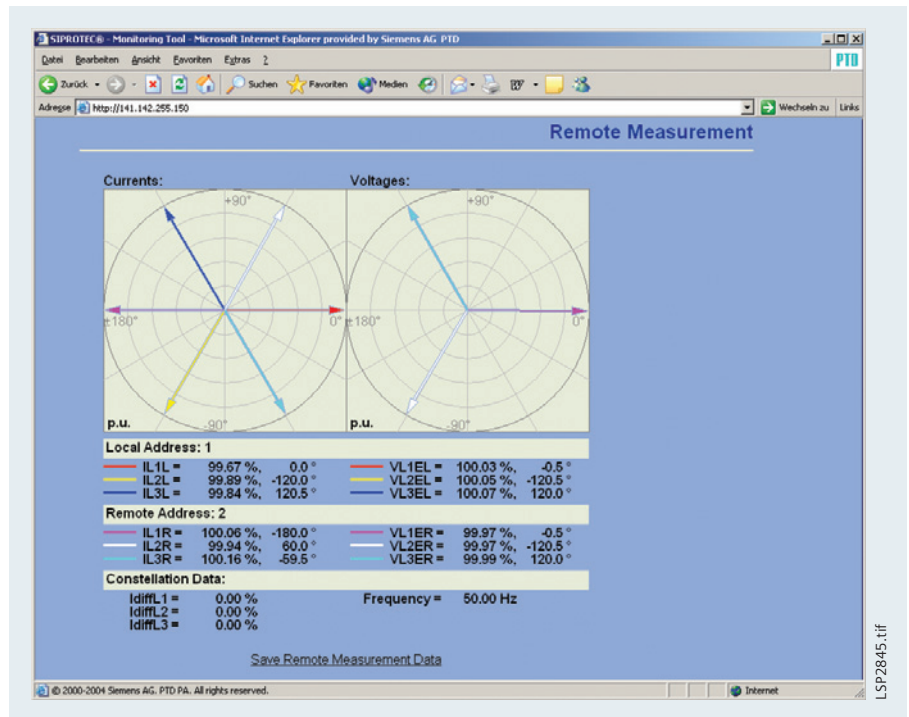


Fig. 7/56 Browser-aided commissioning: Phasor diagram

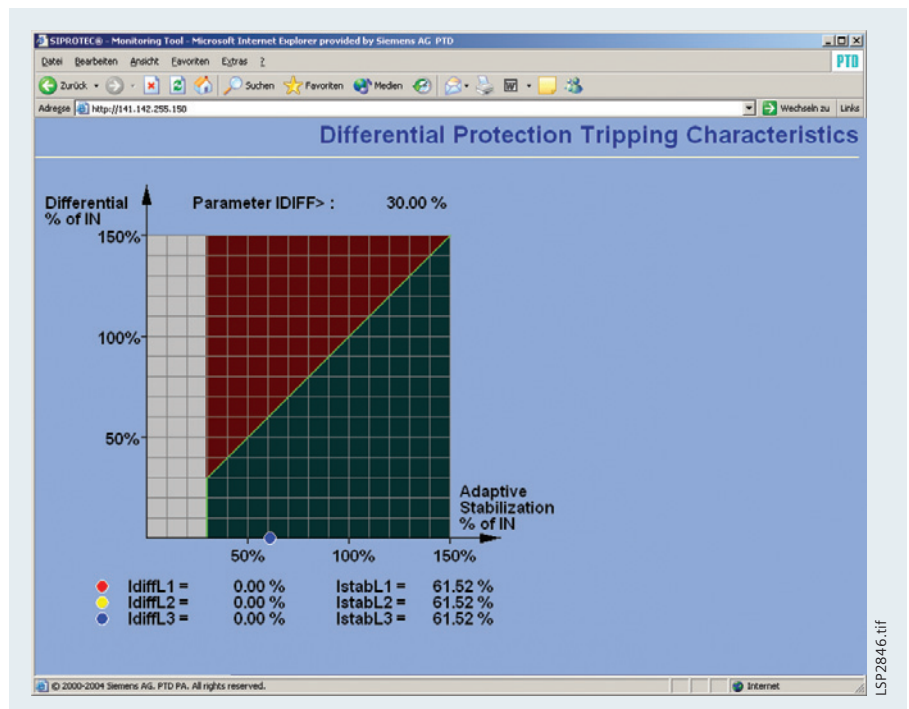


Fig. 7/57 Browser-aided commissioning: Differential protection tripping characteristic

If the distance protection is active, then the valid zone characteristic (quadrilateral/mho) is displayed.

Event log and trip log messages are also available. Remote control can be used, if the local front panel cannot be accessed.

■ Control and automation functions

Control

In addition to the protection functions, the SIPROTEC 4 units also support all control and monitoring functions that are required for operating medium-voltage or high-voltage substations.

The main application is reliable control of switching and other processes.

The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated via binary inputs. Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a fault or intermediate circuit-breaker or auxiliary contact position.

The switchgear or circuit-breaker can be controlled via:

- integrated operator panel
- binary inputs
- substation control and protection system
- DIGSI 4

Command processing

All the functionality of command processing is offered. This includes the processing of single and double commands with or without feedback, sophisticated monitoring of the control hardware and software, checking of the external process, control actions using functions such as runtime monitoring and automatic command termination after output. Here are some typical applications:

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable bay interlocks
- Operating sequences combining several switching operations such as control of circuit-breakers, disconnectors and grounding switches
- Triggering of switching operations, indications or alarm by combination with existing information

Automation/user-defined logic

With integrated logic, the user can set, via a graphic interface (CFC), specific functions for the automation of switchgear or substation. Functions are activated via function keys, binary input or via communication interface.

Switching authority

Switching authority is determined according to parameters, communication or by key-operated switch (when available).

If a source is set to "LOCAL", only local switching operations are possible. The following sequence of switching authority is laid down: "LOCAL"; DIGSI PC program, "REMOTE"

Every switching operation and change of breaker position is kept in the status indication memory. The switch command source, switching device, cause (i.e. spontaneous change or command) and result of a switching operation are retained.

Assignment of feedback to command

The positions of the circuit-breaker or switching devices and transformer taps are acquired by feedback. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication change is a consequence of switching operation or whether it is a spontaneous change of state (intermediate position).

Chatter disable

The chatter disable feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

Filter time

All binary indications can be subjected to a filter time (indication suppression).

Indication filtering and delay

Indications can be filtered or delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time. In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

A further indication (or a command) can be derived from an existing indication. Group indications can also be formed. The volume of information to the system interface can thus be reduced and restricted to the most important signals.

Transmission lockout

A data transmission lockout can be activated, so as to prevent transfer of information to the control center during work on a circuit bay.

Test operation

During commissioning, all indications can be passed to an automatic control system for test purposes.

Line Differential Protection / 7SD52/53

Communication

Communication

With respect to communication, particular emphasis has been placed on high levels of flexibility, data integrity and utilization of standards common in energy automation. The design of the communication modules permits interchangeability on the one hand, and on the other hand provides openness for future standards (for example, Industrial Ethernet).

Local PC interface

The PC interface accessible from the front of the unit permits quick access to all parameters and fault event data. Of particular advantage is the use of the DIGSI 4 operating program during commissioning.

Rear-mounted interfaces

Two communication modules located on the rear of the unit incorporate optional equipment complements and readily permit retrofitting. They assure the ability to comply with the requirements of different communication interfaces.

The interfaces make provision for the following applications:

- **Service /modem interface**
By means of the RS232/RS485 or optical interface, it is possible to efficiently operate a number of protection units centrally via DIGSI 4 or standard browser. Remote operation is possible on connection of a modem. This offers the advantage of rapid fault clarification, especially in the case of unmanned power plants. With the optical version, centralized operation can be implemented by means of a star coupler.
- **System interface**
This interface is used to carry out communication with a control or protection and control system and supports a variety of communication protocols and interface designs, depending on the module connected.

Commissioning aid via a standard Web browser

In the case of the 7SD52/53, a PC with a standard browser can be connected to the local PC interface or to the service interface (refer to "Commissioning program"). The relays include a small Web server that sends its HTML pages to the browser via an established dial-up network connection.

Retrofitting: Modules for every type of communication

Communication modules for retrofitting are available for the entire SIPROTEC 4 unit range. These ensure that, where different communication interfaces (electrical or optical) and protocols (IEC 61850 Ethernet, IEC 60870-5-103, PROFIBUS-FMS/DP, DNP 3.0, DIGSI, etc.) are required, such demands can be met.

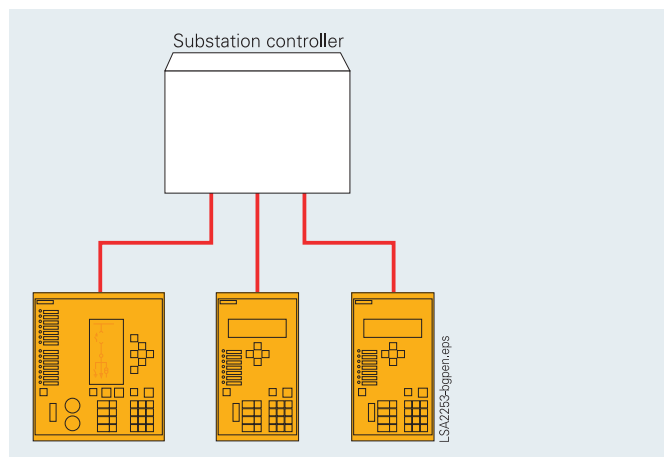


Fig. 7/58 IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

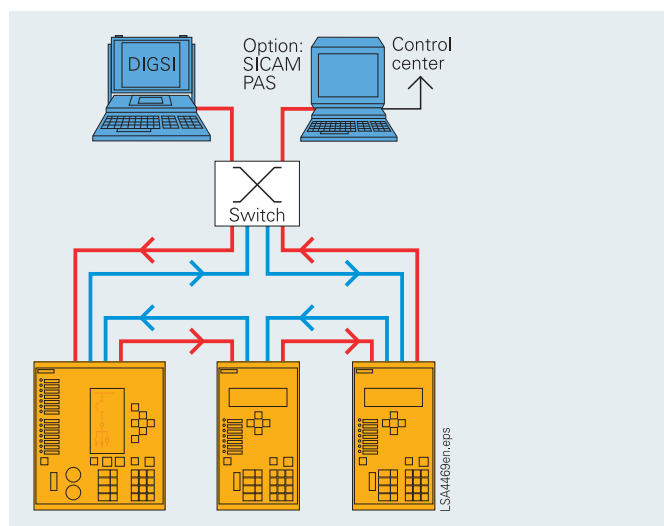


Fig. 7/59 Bus structure for station bus with Ethernet and IEC 61850

Safe bus architecture

- **RS485 bus**
With this data transmission via copper conductors electromagnetic fault influences are largely eliminated by the use of twisted-pair conductors. Upon failure of a unit, the remaining system continues to operate without any disturbances.
- **Fiber-optic double ring circuit**
The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without disturbance.

It is generally impossible to communicate with a unit that has failed. If a unit were to fail, there is no effect on the communication with the rest of the system.

IEC 61850 Ethernet

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens was the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus is also possible with DIGSI.

IEC 60870-5-103

IEC 60870-5-103 is an internationally standardized protocol for the efficient communication in the protected area. IEC 60870-5-103 is supported by a number of protection device manufacturers and is used worldwide.

PROFIBUS-DP

PROFIBUS-DP is an industry-recognized standard for communications and is supported by a number of PLC and protection device manufacturers.

DNP 3.0

DNP 3.0 (Distributed Network Protocol Version 3) is a messaging-based communication protocol. The SIPROTEC 4 units are fully Level 1 and Level 2 compliant with DNP 3.0. DNP 3.0 is supported by a number of protection device manufacturers.

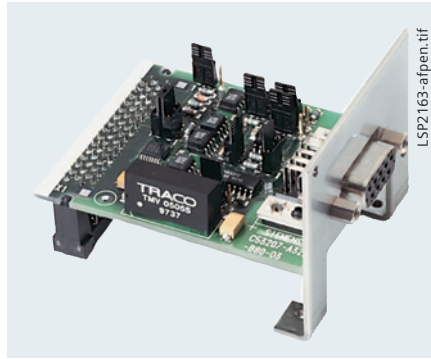


Fig. 7/60 RS232/RS485 electrical communication module

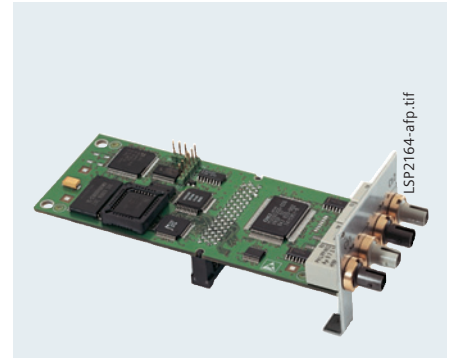


Fig. 7/61 PROFIBUS communication module, optical double-ring

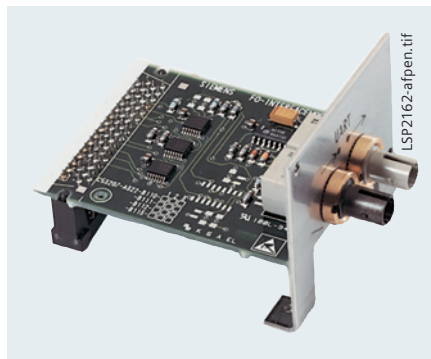


Fig. 7/62 820 nm fiber-optic communication module

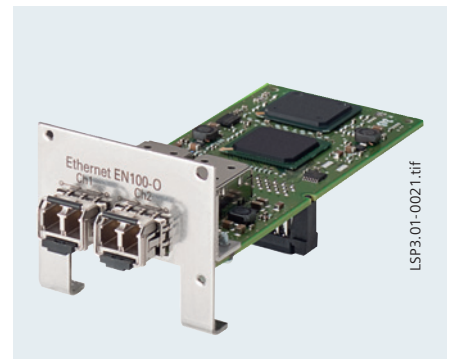


Fig. 7/63 Fiber-optic Ethernet communication module for IEC 61850 with integrated Ethernet switch

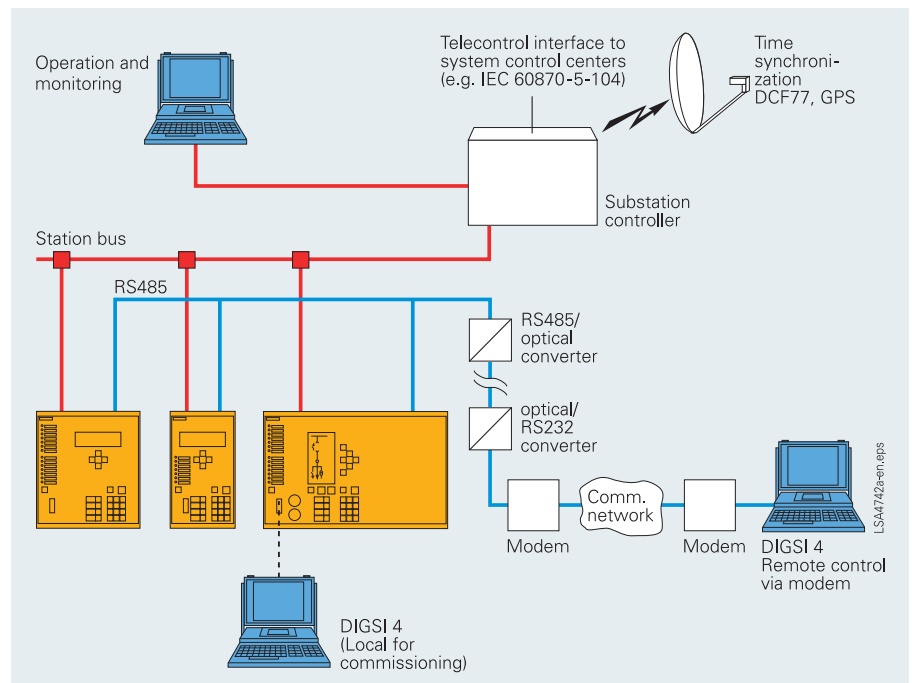


Fig. 7/64 System solution: Communications

Line Differential Protection / 7SD52/53

Communication

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system.

Units featuring IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 7/58).

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 7/59).

Via modem and service interface, the protection engineer has access to the protection devices at all times. This permits remote maintenance and diagnosis (cyclic testing).

Parallel to this, local communication is possible, for example, during a major inspection.

Serial protection interface (R2R interface)

As an option, the 7SD52/53 provides one or two protection interfaces to cover two up to six line end applications in ring or chain topology and hot standby communication between two line ends.

In addition to the differential protection function, other protection functions can use this interface to increase selectivity and sensitivity as well as covering advanced applications.

- Fast phase-selective teleprotection signaling for distance protection, optionally with POTT or PUTT schemes
- Two and three-terminal line applications can be implemented without additional logic
- Signaling for directional ground(earth)- fault protection – directional comparison for high-resistance faults in solidly grounded systems
- Echo function
- Interclose command transfer with the auto-reclosure "Adaptive dead time" (ADT) mode
- 28 remote signals for fast transfer of binary signals

Flexible utilization of the communication channels by means of the programmable CFC logic

The protection interfaces have different options to cover new and existing communication infrastructures.

- FO5¹⁾, OMA1²⁾ module:
820 nm fiber-optic interface with clock recovery/ST connectors for direct connection with multi-mode FO cable up to 1.5 km for the connection to a communication converter.

- FO6¹⁾, OMA2²⁾ module:
820 nm fiber-optic interface/ST connectors for direct connection up to 3.5 km with multi-mode FO cable.

New fiber-optic interfaces, series FO1x

- FO17¹⁾: For direct connection up to 24 km³⁾, 1300 nm, for mono-mode fiber 9/125 μm, LC-Duplex connector
- FO18¹⁾: For direct connection up to 60 km³⁾, 1300 nm, for mono-mode fiber 9/125 μm, LC-Duplex connector
- FO19¹⁾: For direct connection up to 100 km³⁾, 1550 nm, for mono-mode fiber 9/125 μm, LC-Duplex connector
- FO30: 820 nm fiber-optic interface/ST connectors for direct connection up to 1.5 km and for connections to a IEEE C37.94 multiplexer interface.

The link to a multiplexed communication network is made by separate communication converters (7XV5662). These have a fiber-optic interface with 820 nm and 2 ST connectors to the protection relay. The link to the communication network is optionally an electrical X21 or a G703/-E1/-T1 interface. Furthermore the IEEE C37.94 interface is supported by the FO30 module.

For operation via copper wire communication (pilot wires or twisted telephone pair), a modern communication converter for copper cables is available. This operates with both the two-wire and three-wire copper connections which were used by conventional differential protection systems before. The communication converter for copper cables is designed for 5 kV insulation voltage. An additional 20 kV isolation transformer can extend the field of applications of this technique into ranges with higher insulation voltage requirements. The connection via FO cable to the relay is interference-free. With SIPROTEC 4 and the communication converter for copper cables a digital follow-up technique is available for two-wire protection systems (typical 8 km) and all three-wire protection systems using existing copper communication links.

Different communication converters are listed under "Accessories".

Communication data:

- 32-bit CRC-check according to CCITT and ITU
- Each protection relay possesses a unique relay address
- Continuous communication link supervision: Individual faulty data telegrams do not constitute an immediate danger, if they occur only sporadically. The statistical availability, per minute and hour, of the serial protection interface can be displayed.
- Supported network interfaces X21/RS422 with 64 or 128 or 512 kbit/s; or G703-64 kbit/s and G703-E1 (2,048 kbit/s) or G703-T1 (1,554 kbit/s).
- Max. channel delay time 0.1 ms to 30 ms (in steps of 0.1 ms) or IEEE C37.94.
- Protocol HDLC

1) For flush-mounting housing.

2) For surface-mounting housing.

3) For surface-mounting housing the internal fiber-optic module (OMA1) will be delivered together with an external repeater.

Communication possibilities between relays

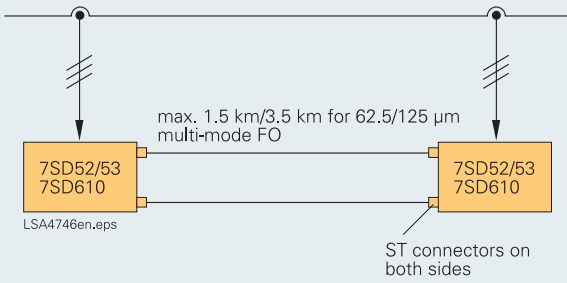


Fig. 7/65 Direct optical link up to 1.5 km/3.5 km, 820nm

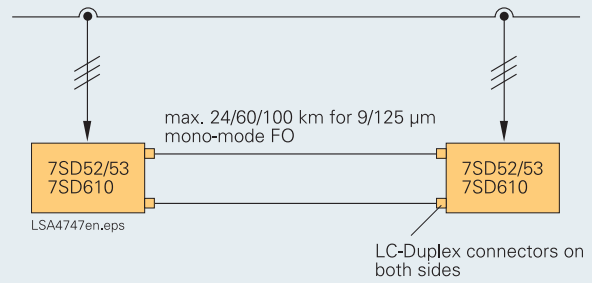


Fig. 7/66 Direct optical link up to 25/60 km with 1300 nm or up to 100 km with 1550 nm

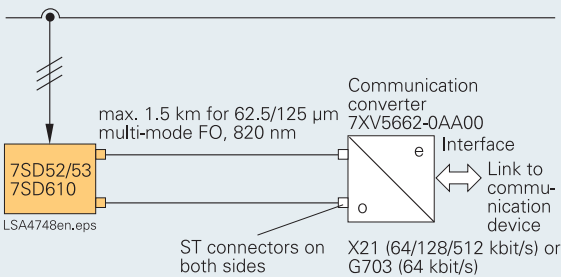


Fig. 7/67 Connection to a communication network CC-XG

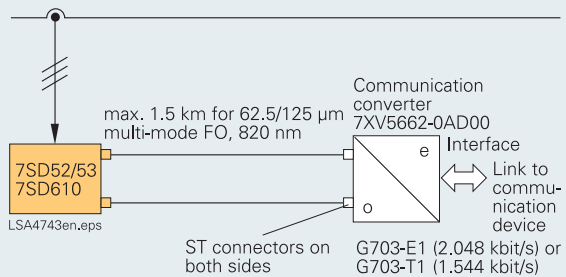


Fig. 7/69 Connection to a communication network CC-2M

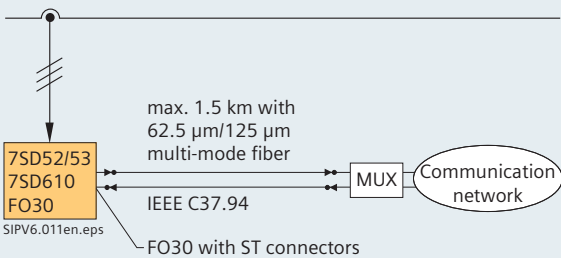


Fig. 7/68 Connection to a communication network via IEEE C37.94

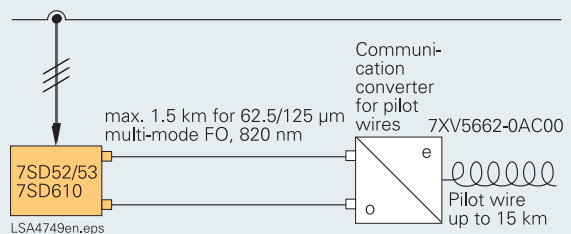


Fig. 7/70 Connection to a pilot wire

Line Differential Protection / 7SD52/53

Typical connection

Typical connection

Typical connection for current and voltage transformers

3 phase current transformers with neutral point in the line direction, I_4 connected as summation current transformer ($= 3I_0$): Holmgreen circuit

3 voltage transformers, without connection of the broken (open) delta winding on the line side; the $3V_0$ voltage is derived internally.

Note:

Voltage inputs are always available in the relay. But there is no need to connect it to voltage transformers for the differential protection function.

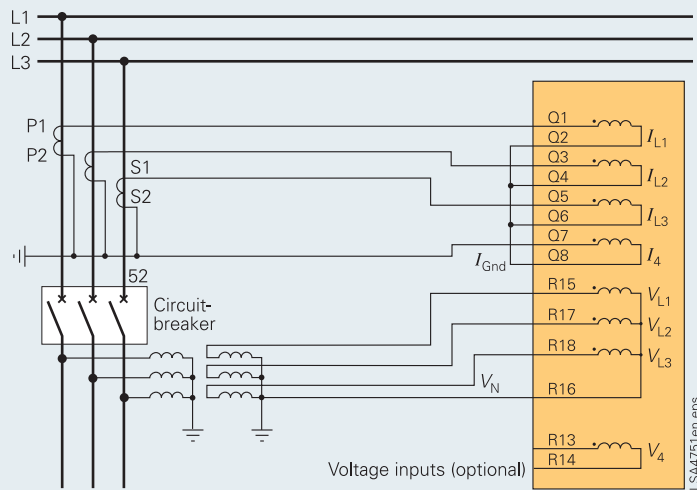


Fig. 7/71 Example of connection for current and voltage transformers

Alternative current measurement

The 3 phase current transformers are connected in the usual manner. The neutral point is in line direction. I_4 is connected to a separate neutral core-balance CT, thus permitting a high sensitive $3I_0$ measurement.

Note:

Terminal Q7 of the I_4 transformer must be connected to the terminal of the core-balance CT pointing in the same direction as the neutral point of the phase current transformers (in this case in line direction). The voltage connection is effected in accordance with Fig. 7/71, 7/76 or 7/77.

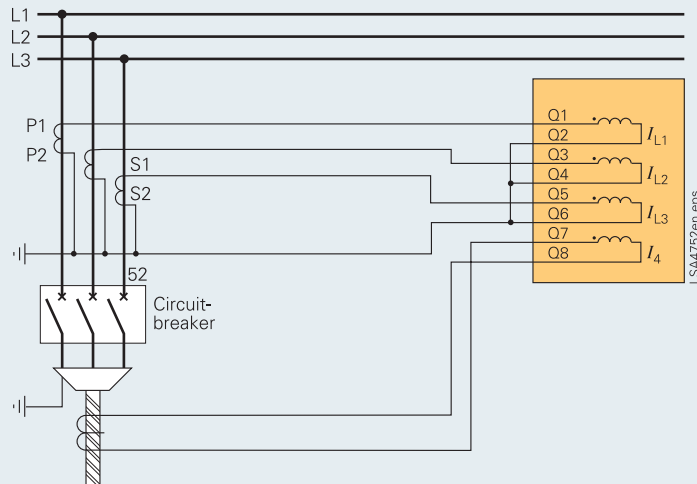


Fig. 7/72 Alternative connection of current transformers for sensitive ground(earth)-current measuring with core-balance current transformers

Alternative current connection

3 phase current transformers with neutral point in the line direction, I_4 connected to a current transformer in the neutral point of a grounded (earthed) transformer for directional ground(earth)-fault protection. The voltage connection is effected in accordance with Fig. 7/171, 7/176 or 7/177.

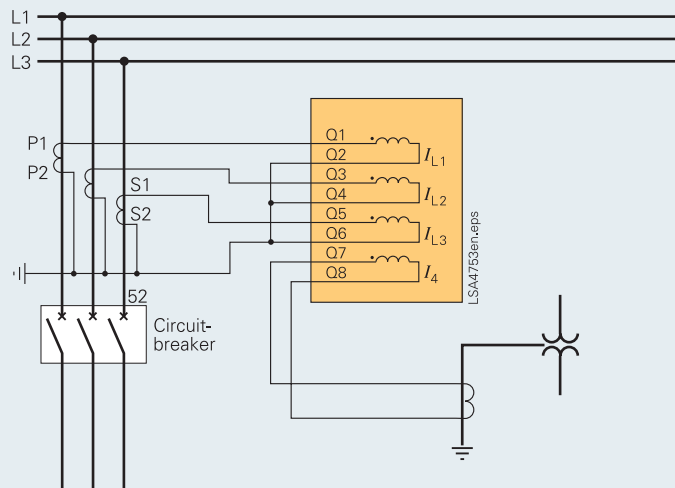


Fig. 7/73 Alternative connection of current transformers for measuring neutral current of a grounded (earthed) power transformer

Alternative current connection

3 phase current transformers with neutral point in the line direction, I_4 connected to the summation current of the parallel line for parallel line compensation on overhead lines. The voltage connection is effected in accordance with Fig. 7/171, 7/176 or 7/177.

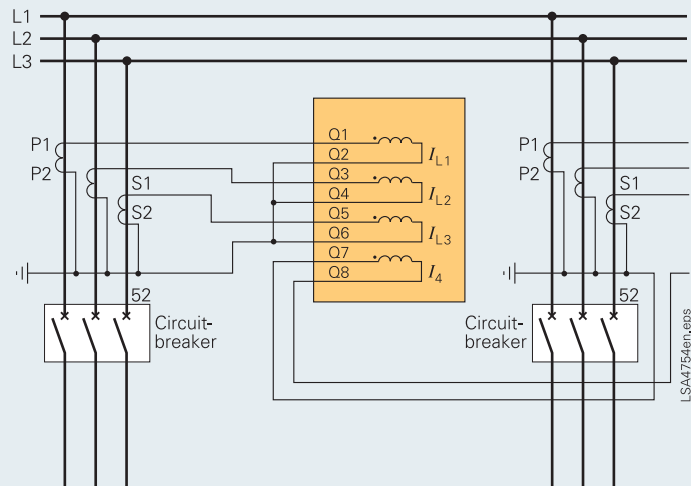


Fig. 7/74 Alternative connection of current transformers for measuring the ground (earth) current of a parallel line

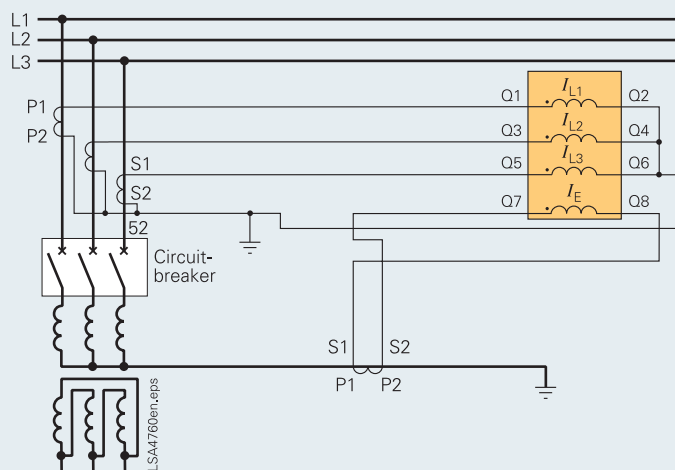


Fig. 7/75 Connection of current transformer with restricted ground-fault protection (REF)

Line Differential Protection / 7SD52/53

Typical connection

Alternative voltage connection

3 phase voltage transformers, V_4 connected to broken (open) delta winding (V_{en}) for additional summation voltage monitoring and ground(earth)-fault directional protection. The current connection is effected in accordance with Fig. 7/71, 7/72, 7/73 and 7/74.

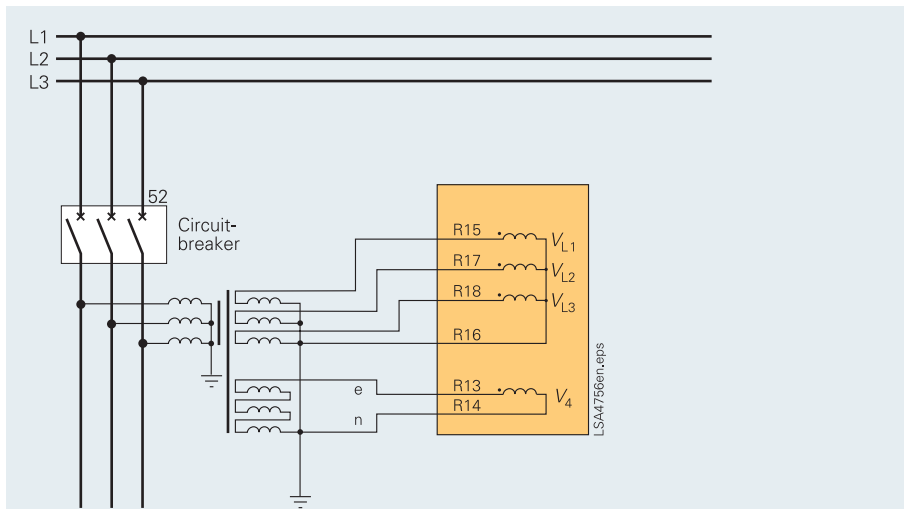


Fig. 6/76 Alternative connection of voltage transformers for measuring the displacement voltage (e-n voltage)

Alternative voltage connection

3 phase voltage transformers, V_4 connected to busbar voltage transformer for synchrocheck.

Note:

Any phase-to-phase or phase-to-ground (earth) voltage may be employed as the busbar voltage. Parameterization is carried out on the unit. The current connection is effected in accordance with Fig. 7/71, 7/72, 7/73 and 7/74.

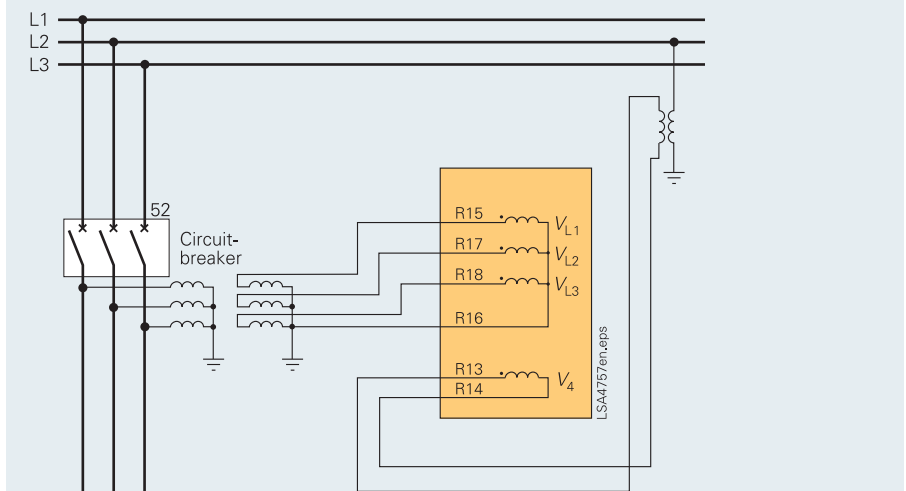


Fig. 6/77 Alternative connection of voltage transformers for measuring the busbar voltage

General unit data	
<i>Analog inputs</i>	
Rated frequency	50 or 60 Hz (selectable)
Rated current I_N	1 or 5 A (selectable, controlled by firmware)
Rated voltage	80 to 125 V (selectable)
Power consumption	
In CT circuits with $I_N = 1$ A	Approx. 0.05 VA
In CT circuits with $I_N = 5$ A	Approx. 0.30 VA
In VT circuits	Approx. 0.10 VA
Thermal overload capacity	
In CT circuits	500 A for 1 s 150 A for 10 s 4 x I_N continuous
In VT circuits	230 V, continuous per phase
Dynamic overload capacity	
In CT circuits	1250 A (half cycle)
In the CT circuit for high sensitive ground-fault protection (refer to ordering code)	
<i>Auxiliary voltage</i>	
Rated voltage	DC 24 to 48 V DC 60 to 125 V ¹⁾ DC 110 to 250 V ¹⁾ and AC 115 V with 50/60 Hz ¹⁾
Permissible tolerance	-20 % to +20 %
Max. superimposed AC voltage (peak-to-peak)	≤ 15 %
Power consumption	
During normal operation	Approx. 8 W
During pickup with all inputs and outputs activated	Approx. 18 W
Bridging time during auxiliary voltage failure V_{aux} AC/DC 110 V	≥ 50 ms
<i>Binary inputs</i>	
Quantity	8 or 16 or 24
Function can be assigned	
Minimum permissible voltage	DC 19 or 88 or 176 V, bipolar (3 operating ranges)
Range is selectable with jumpers for each binary input	
Maximum permissible voltage	DC 300 V
Current consumption, energized	Approx. 1.8 mA
<i>Output relays</i>	
Quantity	16 or 24 or 32
Function can be assigned	
Switching capacity	
Make	1000 W /VA
Break	30 VA
Break (for resistive load)	40 W
Break (for $\tau = L/R \leq 50$ ms)	25 VA
Switching voltage	250 V
Permissible current	30 A for 0.5 s 5 A continuous

1) Ranges are settable by means of jumpers.

<i>LEDs</i>	
	Quantity
RUN (green)	1
ERROR (red)	1
Indication (red), function can be assigned	14
<i>Unit design</i>	
Housing 7XP20 1/2 x 19" or 1/1 x 19"	See dimension drawings, part 14
Degree of protection acc. to EN 60529	
Surface-mounting housing	IP 51
Flush-mounting housing	
Rear	IP 50
Front	IP 51
For the terminals	IP 2x with cover cap
Weight	
Flush-mounting housing	
1/2 x 19"	6 kg
1/1 x 19"	10 kg
Surface-mounting housing	
1/2 x 19"	11 kg
1/1 x 19"	19 kg
<i>Serial interfaces</i>	
<i>Operating interface, front of unit for DIGSI 4</i>	
Connection	Front panel, non-isolated, RS232, 9-pin subminiature connector
Baud rate	4800 to 115200 baud
<i>Time synchronization (rear of unit)</i>	
<i>IRIG-B/DCF77/SCADA or 1 sec pulse from GPS (format IRIG-B000)</i>	
Connection	9-pin subminiature connector (SUB-D)
Voltage levels	5 or 12 or 24 V
Dielectric test	500 V/50 Hz
<i>Service interface (operating interface 2) for DIGSI 4 /modem / service</i>	
Isolated RS232/RS485	9-pin subminiature connector
Dielectric test	500 V/50 Hz
Distance for RS232	Max. 15 m
Distance for RS485, depends on the baud rate	Max. 1000 m
Fiber-optic	Integrated ST connector
Optical wavelength	$\lambda = 820$ nm
Permissible attenuation	Max. 8 dB for glass-fiber 62.5/125 μ m
Distance	Max. 1.5 km
<i>System interface</i>	
(refer to ordering code)	IEC 61850 Ethernet IEC 60870-5-103 PROFIBUS-FMS PROFIBUS-DP DNP 3.0
Isolated RS232/RS485	9-pin subminiature connector
Baud rate	4800 to 38400 baud
Dielectric test	500 V/50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m

Line Differential Protection / 7SD52/53

Technical data

System interface, continued		External communication converter 7XV5662-0AC00 for pilotwires	
PROFIBUS RS485		External communication converter to interface between relays, optical 820 nm interface and a pilot wire or twisted telephone pair.	
Dielectric test	500 V/50 Hz	Typical distance	15 km
Baud rate	Max. 12 Mbaud	Fiber-optic 820 nm with clock recovery	Max. 1.5 km with 62.5/125 μm multi-mode FO cable
Distance	1 km at 93.75 kB; 100 m at 12 MB	Pilot wire	Screw-type terminal 5 kV isolated
PROFIBUS fiber-optic ²⁾		Permissible time delay (duration of data transmission)	
Only for flush-mounting housing	ST connector	Delay of telegrams due to transmission for one unit to the other. Delay is constantly measured and adjusted	Max. 30 ms per transmission path
For surface-mounting housing	Optical interface with OLM ²⁾		Permissible max. value can be selected
Baud rate	Max. 1.5 Mbaud	Electrical tests	
Optical wavelength	λ = 820 nm	Specifications	
Permissible attenuation	Max. 8 dB for glass-fiber 62.5/125 μm	Standards	IEC 60255 (product standards) ANSI/IEEE C37.90.0/1.1.2 UL 508 For further standards see "Individual functions"
Distance	500 kB/s 1.6 km, 1500 kB/s 530 m	Insulation tests	
Protection interface (R2R interface)		Standards	IEC 60255-5
FO5 ¹⁾ , OMA1 ²⁾ : Fiber-optic interface with clock recovery for direct connection up to 1.5 km or for connection to a communication converter, 820 nm	For multi-mode fiber 62.5/125 μm, ST connectors Permissible fiber attenuation 8 dB	Voltage test (100 % test) All circuits except for auxiliary supply, binary inputs and communication interfaces	2.5 kV (r.m.s.), 50/60 Hz
FO6 ¹⁾ , OMA2 ²⁾ : Fiber-optic interface for direct connection up to 3.5 km, 820 nm	For multi-mode fiber 62.5/125 μm, ST connectors Permissible fiber attenuation 16 dB	Auxiliary voltage and binary inputs (100 % test)	DC 3.5 kV
New fiber-optic interfaces, series FO1x		RS485/RS232 rear side communication interfaces and time synchronization interface (100 % test)	500 V (r.m.s.), 50/60 Hz
FO17 ¹⁾ : for direct connection up to 24 km ³⁾ , 1300 nm	For mono-mode fiber 9/125 μm, LC-Duplex connector Permissible fiber attenuation 13 dB	Impulse voltage test (type test) All circuits except for communication interfaces and time synchronization interface, class III	5 kV (peak); 1.2/50 μs; 0.5 J 3 positive and 3 negative impulses at intervals of 5 s
FO18 ¹⁾ : for direct connection up to 60 km ³⁾ , 1300 nm	For mono-mode fiber 9/125 μm, LC-Duplex connector Permissible fiber attenuation 29 dB	EMC tests for noise immunity; type tests	
FO19 ¹⁾ : for direct connection up to 100 km ³⁾ , 1550 nm	For mono-mode fiber 9/125 μm, LC-Duplex connector Permissible fiber attenuation 29 dB	Standards	IEC 60255-6, IEC 60255-22 (product standards) (type tests) EN 50082-2 (generic standard) DIN 57435 part 303
Relay communication equipment		High frequency test IEC 60255-22-1, class III and VDE 0435 part 303, class III	2.5 kV (peak); 1 MHz; τ = 15 ms; 400 surges per s; test duration 2 s
External communication converter 7XV5662-0AA00 for communication networks X21/G703-64 kbit/s		Electrostatic discharge IEC 60255-22-2, class IV EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; R _i = 330 Ω
External communication converter to interface between the relays, optical 820 nm interface and the X21(RS422) G703-64 kbit/s interface of a communication device		Irradiation with RF field, non-modulated IEC 60255-22-3 (report), class III	10 V/m; 27 to 500 MHz
X21/G703, RS422 selectable by jumpers. Baud rate selectable by jumpers		Irradiation with RF field, amplitude-modulated IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz
Input: fiber-optic 820 nm with clock recovery	Max. 1.5 km with 62.5/125 μm multi-mode FO cable to device side	1) For flush-mounting housing.	
Output: X21 (RS422) electrical interface on communication device	64/128/512 kbit (selectable by jumper) max. 800 m, 15-pin connector	2) For surface-mounting housing.	
G703-64 kbit/s electrical interface on communication device	64 kbit/s, max. 800 m, screw-type terminal	3) For surface-mounting housing the internal FO module OMA1 will be delivered together with an external repeater.	
External communication converter 7XV5662-0AD00 for communication networks with G703-E1 or G703-T1			
External communication converter to interface between the relays, optical 820 nm interface and G703-E1 or G703-T1 interface of a communication network.			
Inputs: 2 fiber-optic inputs 820 nm, 1RS232 input	Max. 1.5 km with 62.5/125 μm multi-mode 1 FO cable to device side		
Output: G703.5	E1: 2,048 kbit/s		
G703.6	T1: 1,554 kbit/s		
Electrical interface on communication network	max. 800 m, screw-type terminal		

Irradiation with RF field, pulse-modulated IEC 61000-4-3/ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transients, bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50 \Omega$; test duration 1 min
High-energy surge voltages (SURGE) IEC 61000-4-5, installation class III Auxiliary supply	Common mode: 2 kV, 12 Ω , 9 μF Differential mode: 1 kV; 2 Ω , 18 μF
Measurements inputs, binary inputs, binary outputs	Common mode: 2 kV, 42 Ω , 0.5 μF Differential mode: 1 kV; 42 Ω , 0.5 μF
Line-conducted HF, amplitude-modulated, IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Magnetic field with power frequency IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous; 300 A/m for 3 s; 50 Hz; 0.5 mT; 50 MHz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak); 1 to 1.5 MHz Damped wave; 50 surges per second; Duration 2 s; $R_i = 150 \Omega$ to 200 Ω
Fast transient surge withstand capability, ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per second; both polarities; duration 2 s; $R_i = 80 \Omega$
Radiated electromagnetic interference, IEEE C37.90.2	35 V/m; 25 to 1000 MHz amplitude and pulse-modulated
Damped oscillations IEC 60894, IEC 61000-4-12	2.5 kV (peak value), polarity alternating 100 kHz 1, 10 and 50 MHz, $R_i = 200 \Omega$

EMC tests for interference emission; type tests	
Standard	EN 50081-* (generic standard)
Conducted interference voltage on lines, only auxiliary supply, IEC-CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC-CISPR 22	30 to 1000 MHz Limit class B

Mechanical dynamic tests	
<i>Vibration, shock stress and seismic vibration</i>	
<u>During operation</u>	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 g acceleration frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal acceleration 5 g, duration 11 ms, 3 shocks each in both directions of the 3 axes
Seismic vibration IEC 60255-21-2, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis), 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis), 8 to 35 Hz: 1 g acceleration (horizontal axis), 8 to 35 Hz: 0.5 g acceleration (vertical axis), frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
1) Ordering option with high-speed contacts required.	

During transport	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60255-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 g acceleration frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 15 g, duration 11 ms, 3 shocks each in both directions of the 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Half-sinusoidal Acceleration 10 g, duration 16 ms, 1000 shocks each in both directions of the 3 axes

Climatic stress tests	
<u>Temperatures</u>	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C / -13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	-20 °C to +70 °C / -4 °F to +158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C / +131 °F)	-5 °C to +55 °C / +25 °F to +131 °F
- Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to 131 °F
- Limiting temperature during transport	-25 °C to +70 °C / -13 °F to +158 °F
<u>Humidity</u>	
Permissible humidity stress It is recommended to arrange the units in such a way, that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Yearly average ≤ 75 % relative humidity; on 56 days in the year up to 93 % relative humidity; condensation is not permitted

Functions	
<u>Differential protection (ANSI 87L, 87T)</u>	
<u>Sensitive normal trip stage $I_{\text{Diff}}>$</u>	
Setting range of $I_{\text{Diff}}>$	secondary 1 A secondary 5 A
Tripping time (three line ends) $I_{\text{Diff}}> 2.5 \times I_{\text{Diff}}>$ (setting)	0.1 to 20 A (step 0.1) 0.5 to 100 A 50 Hz Min. 27 ms Typ. 29 ms 60 Hz Min. 24 ms Typ. 26 ms
<u>Delay time of $I_{\text{Diff}}>$ trip stage</u>	
Delay time	0 to 60 s (step 0.01 s)
<u>Capacitive current load compensation</u>	
Restraint ratio $I_{\text{C STAB}}/I_{\text{CN}}$	2 to 4 (steps 0.1)
<u>High-set fast trip stage $I_{\text{Diff}}>>$</u>	
Setting range $I_{\text{Diff}}>>$	secondary 1 A secondary 5 A
Tripping time (three line ends) $I_{\text{Diff}} \geq 2.5 \times I_{\text{Diff}}>>$ (setting)	0.8 to 100 A (step 0.1) 4 to 500 A (step 0.5) Min. 9 ms ¹⁾ Typ. 12 ms ¹⁾

Line Differential Protection / 7SD52/53

Technical data

Vector group adaptation with transformers in the differential zone		Ground(earth)-fault pickup	
Adaptation of connection symbol	0 to 11 (x 30 °) (step 1)	Neutral (residual) current $3I_0$ (Ground current)	0.05 to 4 A _(1A) / 0.25 to 20 A _(5A) (step 0.01 A)
Neutral point connection	Grounded (earthed) or not grounded (earthed) (for each winding)	Zero-sequence voltage $3V_0$ > for grounded networks for resonant-grounded networks	1 to 100 V (step 1 V) or deactivated 10 to 200 V (step 1 V)
Inrush restraint		Zero-sequence compensation	R_E/R_L and X_E/X_L
Restraint ratio 2 nd harmonic I_{2FN}/I_{FN}	10 % to 45 % (step 1 %)	Selectable input formats	k_0 and $\varphi(k_0)$
Max. current for restraint	1.1 A to 25 A ¹⁾ (step 0.1 A)	Separately selectable for zones	Z1 higher zones (Z1B, Z2 to Z5)
Crossblock function	Can be switched on and off		-0.33 to 7 (step 0.01)
Max. operative time for crossblock $T_{oper\ crossblk}$	0 to 60 s (step 0.01 s) or deactivated (operating up to release)	R_E/R_L and X_E/X_L	0 to 4 (step 0.001)
Distance protection (ANSI 21, 21N)		k_0	-135 to 135 ° (step 0.01 °)
Distance protection zones	6, 1 of which as controlled zone, all zones can be set forward or/and reverse	$\varphi(k_0)$	(refer to ordering code)
Time stages for tripping delay	6 for multi-phase faults 3 for single-phase faults	Parallel line mutual compensation R_M/R_L and X_M/X_L	0.00 to 8 (step 0.01)
Setting range	0 to 30 s or deactivated (steps 0.01 s)	Phase reference on double ground-faults in resonant-grounded/non-grounded network	Phase preference or no preference (selectable)
Characteristic	(refer to ordering code) quadrilateral and/or Mho (only impedance pickup)	Load encroachment	0.10 to 600 $\Omega_{(1A)}$ / 0.02 to 120 $\Omega_{(5A)}$ (step 0.001 Ω) or deactivated
Selectable separately for phase and ground (earth) faults		Minimum load resistance	20 to 60 ° (step 1 °)
Types of pickup	Overcurrent pickup ($I>$); Voltage-dependent overcurrent pickup ($V<I>$); Voltage-dependent and phase angle-dependent overcurrent pickup ($V<I>/\varphi>$); Impedance pickup ($Z<$)	Maximum load angle	With sound phase polarization and/or voltage memory
Types of tripping	Three-pole for all types of faults; Single-pole for single-phase faults / otherwise three-pole; Single-pole for single-phase faults and two-pole phase-to-phase faults / otherwise three-pole	Directional decision for all types of faults	Dynamically unlimited
Time range	0 to 30 s (step 0.01 s) or deactivated	Directional sensitivity	For sinusoidal quantities
Line angle φ_L	30 ° to 89 ° (step 1 °)	Tolerances	
Inclination angle for quadrilateral characteristic	30 ° to 90 ° (step 1 °)	Impedances (in conformity with DIN 57435, Part 303)	$\left \frac{\Delta X}{X} \right \leq 5\% \text{ for } 30^\circ \leq \varphi_{SC} \leq 90^\circ$
Quadrilateral reactance reach X	0.05 to 600 $\Omega_{(1A)}$ / 0.01 to 120 $\Omega_{(5A)}$ (step 0.001 Ω)		$\left \frac{\Delta R}{R} \right \leq 5\% \text{ for } 0^\circ \leq \varphi_{SC} \leq 60^\circ$
Quadrilateral resistance reach R for phase-to-phase faults and phase-to-ground(earth) faults	0.05 to 600 $\Omega_{(1A)}$ / 0.01 to 120 $\Omega_{(5A)}$ (step 0.001 Ω)		$\left \frac{\Delta Z}{Z} \right \leq 5\% \text{ for } -30^\circ \leq (\varphi_{SC} - \varphi_{line}) \leq +30^\circ$
Mho impedance reach Z_R	0.05 to 200 $\Omega_{(1A)}$ / 0.01 to 40 $\Omega_{(5A)}$ (step 0.01 Ω)	Response values (in conformity with DIN 57435, Part 303)	$\leq 5\%$ of setting value
Minimum phase current I	0.05 to 4 A _(1A) / 0.25 to 20 A _(5A) (step 0.01 A)	V and I	$\leq 3^\circ$
Overcurrent pickup $I>>$ (for $I>>$, $V<I>$, $V<I>/\varphi>$)	0.25 to 10 A _(1A) / 1.25 to 50 A _(5A) (step 0.01 A)	Angle (φ)	$\pm 1\%$ of set value or 10 ms
Minimum current pickup $I>$ (for $V<I>$, $V<I>/\varphi>$ and $Z<$)	0.05 to 4 A _(1A) / 0.25 to 20 A _(5A) (step 0.01 A)	Timer tolerance	
Minimum current pickup $I_\varphi>$ (for $V<I>$, $V<I>/\varphi>$)	0.1 to 8 A _(1A) / 0.5 to 40 A _(5A) (step 0.01 A)	Operating times	Approx. 17 ms at 50 Hz
Undervoltage pickup (for $V<I>$ and $V<I>/\varphi>$)		Minimum trip time with fast relays	Approx. 15 ms at 60 Hz
$V_{ph-e<}$	20 to 70 V (step 1 V)	Minimum trip time with high-speed relays	Approx. 10 ms at 60 Hz
$V_{ph-ph<}$	40 to 130 V (step 1 V)	Reset time	Approx. 30 ms
Load angle pickup (for $V<I>/\varphi>$)			
Load angle φ	30 ° to 80 °		
Load angle φ	90 ° to 120 °		

1) Secondary data for $I_N = 1$ A; with $I_N = 5$ A the values must be multiplied.

Power swing detection (ANSI 68, 68T)		Inverse-time stage (ANSI 51, 51N)	
Power swing detection principle	Measurement of the rate of impedance vector change and monitoring of the vector path	Phase current pickup	0.1 to 4 A ^(1A) / 0.5 to 20 A ^(5A) (step 0.01 A) or deactivated
Max. detectable power swing frequency	Approx. 7 Hz	Neutral (residual) current pickup	0.05 to 4 A ^(1A) / 0.25 to 20 A ^(5A) (step 0.01 A) or deactivated
Operating modes	Power swing blocking and/or power swing tripping (out-of-step tripping)	Characteristics	
Power swing blocking programs	All zones blocked Z1/Z1B blocked Z2 to Z5 blocked Z1, Z1B, Z2 blocked	Characteristics according to IEC 60255-3	Normal inverse Very inverse Extremely inverse Long time inverse
Detection of faults during power swing blocking	Reset of power swing blocking for all types of faults	Time multiplier	$T_p = 0.05$ to 3 s (step 0.01 s) or deactivated
Tele (pilot) protection for distance protection (ANSI 85-21)		Pickup threshold	Approx. $1.1 \times III_p$
Modes of operation	PUTT (Z1B acceleration); DUTT PUTT (acceleration with pickup); POTT; Directional comparison; Reverse interlocking Pilot-wire comparison; Unblocking; Blocking	Reset threshold	Approx. $1.05 \times III_p$
Additional functions	Echo function (refer to weak-infeed function) Transient blocking for schemes with measuring range extension	Tolerances Operating time for $2 \leq III_p \leq 20$	$\leq 5\%$ of setpoint ± 15 ms
Transmission and reception signals	Phase-selective signals available for maximum selectivity with single-pole tripping; signals for 2 and 3-end-lines	Characteristics according to ANSI/IEEE	Inverse Short inverse Long inverse Moderately inverse Very inverse Extremely inverse Definite inverse
Direct transfer trip (DTT)		Time dial	0.5 to 15 (step 0.01) or deactivated
Direct phase-selective tripping via binary input	Alternatively with or without auto-reclosure	Pickup threshold	Approx. $1.1 \times M$
Trip time delay	0 to 30 s (step 0.01 s) or deactivated	Reset threshold	Approx. $1.05 \times M$
Timer tolerance	$\pm 1\%$ of setting value or 10 ms	Tolerances Operating time for $2 \leq M \leq 20$	$\leq 5\%$ of setpoint ± 15 ms
Backup overcurrent protection (ANSI 50N, 51N)		Instantaneous high-speed switch-onto-fault overcurrent protection (ANSI 50HS)	
Operating modes	Active only with loss of data connection and voltage or always active	Operating mode	Active only after c.b. closing; instantaneous trip after pickup
Characteristics	3 definite-time stages / 1 inverse-time stage	Characteristic	2 definite-time stages
Definite-time stage (ANSI 50, 50N)		Pickup current $I_{>>>}$	0.1 to 15 A ^(1A) / 0.5 to 75 A ^(5A) (step 0.01 A) or deactivated
Pickup definite time stage 1, phase current	0.1 to 25 A ^(1A) / 0.5 to 125 A ^(5A) (step 0.01 A) or deactivated	Pickup current $I_{>>>>}$	1 to 25 A ^(1A) / 5 to 125 A ^(5A) (step 0.01 A) or deactivated
Pickup definite-time stage 1, neutral (residual) current	0.5 to 25 A ^(1A) / 0.25 to 125 A ^(5A) (step 0.01 A) or deactivated	Reset ratio	Approx. 0.95
Pickup definite-time stage 2, phase current	0.1 to 25 A ^(1A) / 0.5 to 125 A ^(5A) (step 0.01 A) or deactivated	Tolerances	$< 3\%$ of set value or 1% of I_N
Pickup definite-time stage 2, neutral (residual) current	0.05 to 25 A ^(1A) / 0.25 to 125 A ^(5A) (step 0.01 A) or deactivated	Directional ground (earth)-fault overcurrent protection for high-resistance faults in systems with grounded star point (ANSI 50N, 51N, 67N)	
Pickup definite-time stage 3, phase current	0.1 to 25 A ^(1A) / 0.5 to 125 A ^(5A) (step 0.01 A) or deactivated	Characteristic	3 definite-time stages / 1 inverse-time stage or 4 definite-time stages or definite-time stages / 1 $V_{0invers.}$ stage
Pickup definite-time stage 3, neutral (residual) current	0.05 to 25 A ^(1A) / 0.25 to 125 A ^(5A) (step 0.01 A) or deactivated	Phase selector	Permits 1-pole tripping for single-phase faults or 3-pole tripping for multi-phase faults
Time delay for definite-time stages	0 to 30 s, (step 0.01 s) or deactivated stages	Inrush restraint	Selectable for every stage
Tolerances		Instantaneous trip after switch-onto-fault	Selectable for every stage
Current pickup	$\leq 3\%$ of set value or 1% of I_N	Influence of harmonics	
Delay times	$\pm 1\%$ of set value or 10 ms	Stages 1 and 2 ($I_{>>>}$ and $I_{>>>>}$)	3 rd and higher harmonics are completely suppressed by digital filtering
Operating time	Approx. 25 ms	Stages 3 and 4 ($I_{>}$ and inverse 4 th stage)	2 nd and higher harmonics are completely suppressed by digital filtering

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Technical data

Definite-time stage (ANSI 50N)	
Pickup value $3I_{0>>>}$	0.5 to 25 A _(1A) / 2.5 to 125 A _(5A) (step 0.01 A)
Pickup value $3I_{0>>}$	0.2 to 25 A _(1A) / 1 to 125 A _(5A) (step 0.01 A)
Pickup value $3I_{0>}$	0.05 to 25 A _(1A) / 0.25 to 125 A _(5A) (step 0.01 A) Neutral (residual) current transformer with normal sensitivity (refer to ordering data, position 7); 0.003 to 25 A _(1A) / 0.015 to 125 A _(5A) (step 0.001 A) Neutral (residual) current transformer with high sensitivity (refer to ordering data, position 7)
Pickup value $3I_0$, 4 th stage	0.05 to 25 A _(1A) / 0.25 to 125 A _(5A) (step 0.01 A) Neutral (residual) current transformer with normal sensitivity (refer to ordering data, position 7); 0.003 to 25 A _(1A) / 0.015 to 125 A _(5A) (step 0.001 A) Neutral (residual) current transformer with high sensitivity (refer to ordering data, position 7)
Time delay for definite-time stages	0 to 30 s (step 0.01 s) or deactivated
Tolerances	
Current pickup	≤ 3 % of setting value or 1 % I_N
Delay times	1 % of setting value or 10 ms
Command / pickup times $3I_{0>>>}$ and $3I_{0>>}$	Approx. 30 ms
Command / pickup times $3I_{0>}$ and $3I_0$, 4 th stage	Approx. 40 ms
Inverse-time stage (ANSI 51N)	
Ground (earth)-current pickup $3I_{0p}$	0.05 to 4 A _(1A) / 0.25 to 20 A _(5A) (step 0.01 A) Neutral (residual) current transformer with normal sensitivity (refer to ordering data, position 7) 0.003 to 4 A _(1A) / 0.015 to 20 A _(5A) (step 0.001 A) Neutral (residual) current transformer with high sensitivity (refer to ordering data, position 7)
Tripping characteristics acc. to IEC 60255-3	Normal inverse; very inverse; extremely inverse; long inverse
ANSI/IEEE tripping characteristic (not for region DE, refer to ordering data, position 10)	Inverse; short inverse; long inverse; moderately inverse; very inverse; extremely inverse; definite inverse
Inverse logarithmic tripping characteristics (not for regions DE and US, refer to ordering data, position 10)	$t = T_{3I_{0p}max} - T_{3I_{0p}} \cdot \ln \frac{3I_0}{3I_{0p}}$
Pickup threshold	1.1 to 4.0 × II_p (step 0.1 s)
Time multiplier for IEC <i>T</i> characteristics	$T_p = 0.05$ to 3 s (step 0.01 s)
Time multiplier for ANSI <i>D</i> characteristics	$D_{I0p} = 0.5$ to 15 s (step 0.01 s)
Pickup threshold	Approx. 1.1 × II_p (ANSI: $II_p = M$)
Inverse logarithmic pickup threshold	1.1 to 4.0 × III_{0p} (step 0.1)
Reset threshold	Approx. 1.05 × III_0 (ANSI: $III_p = M$)
Tolerance	
Operating time for $2 \leq II_p \leq 20$	≤ 5 % of setpoint ± 15 ms
Zero-sequence voltage protection $V_{0inverse}$	
Tripping characteristic	$t = \frac{2s}{\frac{V_0}{4} - V_{0invmin}}$
Direction decision (ANSI 67N)	
Measured signals for direction decision	$3I_0$ and $3V_0$ or $3I_0$ and $3V_0$ and I_Y (star point current of a grounded power transformer) or $3I_2$ and $3V_2$ (negative-sequence system) or zero-sequence power S_T or automatic selection of zero-sequence or negative-sequence quantities dependent on the magnitude of the component voltages
Min. zero-sequence voltage $3V_0$	0.5 to 10 V (step 0.1 V)
Min. current I_Y (of grounded (earthed) transformers)	0.05 to 1 A _(1A) / 0.25 to 5 A _(5A) (step 0.01 A)
Min. negative-sequence voltage $3V_2$	0.5 to 10 V (step 0.1 V)
Min. negative-sequence current $3I_2$	0.05 to 1 A _(1A) / 0.25 to 5 A _(5A) (step 0.01 A)
Inrush current blocking, capable of being activated for each stage	
Component of the 2 nd harmonic	10 to 45 % of the fundamental (step 1 %)
Max. current, which cancels inrush current blocking	0.5 to 25 A _(1A) / 2.5 to 125 A _(5A) (step 0.01 A)
Tele (pilot) protection for directional ground(earth)-fault overcurrent protection (ANSI 85-67N)	
Operating modes	Directional comparison: Pickup Directional comparison: Blocking Directional comparison: Unblocking
Additional functions	Echo (see function "weak infeed"); transient blocking for schemes with parallel lines
Transmission and reception signals	Phase-selective signals available for maximum selectivity with single-pole tripping; signals for 2 and 3-end-lines
Weak-infeed protection with undervoltage (ANSI 27WI)	
Operating modes with carrier (signal) reception	Echo Echo and trip with undervoltage
Undervoltage phase – ground (earth)	2 to 70 V (step 1 V)
Time delay	0.00 to 30 s (step 0.01 s)
Echo impulse	0.00 to 30 s (step 0.01 s)
Tolerances	
Voltage threshold	≤ 5 % of set value or 0.5 V
Timer	± 1 % of set value or 10 ms
Fault locator	
Output of the distance to fault	X, R (secondary) in Ω X, R (primary) in Ω Distance in kilometers or in % of line length
Start of calculation	With trip, with reset of pickup, with binary input
Reactance per unit length	0.005 to 6.5 $\Omega/km_{(1A)}$ / 0.001 to 1.3 $\Omega/km_{(5A)}$ (step 0.0001 Ω/km)
Tolerance	For sinusoidal quantities ≤ 2.5 % line length for $30^\circ \leq \varphi_{SC} \leq 90^\circ$ and $V_{SC}/V_{nom} > 0.1$

Voltage protection (ANSI 59, 27)	
Operating modes	Local tripping or only indication
Overvoltage protection	
Pickup values $V_{PH-Gnd}>>$, $V_{PH-Gnd}>$ (phase-ground (earth) overvoltage)	1 to 170 V (step 0.1 V) or deactivated
Pickup values $V_{PH-PH}>>$, $V_{PH-PH}>$ (phase-phase overvoltage)	2 to 220 V (step 0.1 V) or deactivated
Pickup values $3V_0>>$, $3V_0>$ ($3V_0$ can be measured via V4 transformers or calculated by the relay) (zero-sequence overvoltage)	1 to 220 V (step 0.1 V) or deactivated
Pickup values $V_1>>$, $V_1>$ (positive-sequence overvoltage)	2 to 220 V (step 0.1 V) or deactivated
Measured voltage	Local positive-sequence voltage or calculated remote positive-sequence voltage (compounding)
Pickup values $V_2>>$, $V_2>$ (negative-sequence overvoltage)	2 to 220 V (step 0.1 V) or deactivated
Reset ratio (settable)	0.5 to 0.98 (step 0.01)
Undervoltage protection	
Pickup values $V_{PH-Gnd}<<$, $V_{PH-Gnd}<$ (phase-ground (earth) undervoltage)	1 to 100 V (step 0.1 V) or deactivated
Pickup values $V_{PH-PH}<<$, $V_{PH-PH}<$ (phase-phase undervoltage)	1 to 175 V (step 0.1 V) or deactivated
Pickup values $V_1<<$, $V_1<$ (positive-sequence undervoltage)	1 to 100 V (step 0.1 V) or deactivated
Blocking of undervoltage protection stages	Minimum current; binary input
Reset ratio	1.05
Time delays	
Time delay for all over- and undervoltage stages	0 to 100 s (steps 0.01 s) or deactivated
Command / pickup time	Approx. 30 ms
Tolerances	
Voltage limit values	≤ 3 % of setting value or 0.5 V
Time stages	1 % of setting value or 10 ms
Frequency protection (ANSI 81)	
Number of frequency elements	4
Setting range	45.5 to 54.5 Hz (in steps of 0.01) at $f_{nom} = 50$ Hz 55.5 to 64.5 Hz (in steps of 0.01) at $f_{nom} = 60$ Hz
Delay times	0 to 600 s or ∞ (in steps of 0.01 s)
Operating voltage range	6 to 230 V (phase-to-ground (earth))
Pickup times	Approx. 80 ms
Dropout times	Approx. 80 ms
Hysteresis	Approx. 20 mHz
Dropout condition	Voltage = 0 V and current = 0 A
Tolerances	
Frequency	12 m Hz for V = 29 to 230 V
Delay times	1 % of the setting value or 10 ms

Breaker failure protection (ANSI 50BF)	
Number of stages	2
Pickup of current element	0.05 to 20 $A_{(1A)}$ / 0.25 to 100 $A_{(5A)}$ (step 0.01 A)
Time delays $T1_{1phase}$, $T1_{3phase}$, $T2$	0 to 30 s (steps 0.01 s) or deactivated
Additional functions	End-fault protection
Reset time	CB pole discrepancy monitoring Approx. 15 ms, typical; 25 ms max.
Tolerances	
Current limit value	≤ 5 % of setting value or 1 % I_{nom}
Time stages	1 % of setting value or 10 ms
Auto-reclosure (ANSI 79)	
Number of auto-reclosures	Up to 8
Operating mode	Only 1-pole; only 3-pole, 1 or 3-pole
Operating modes with line voltage check	DLC – dead-line check ADT – adaptive dead time RDT – reduced dead time
Dead times $T1_{-ph}$, $T3_{-ph}$, T_{Seq}	0 to 1800 s (step 0.01 s) or deactivated
Action times	0.01 to 300 s (step 0.01 s) or deactivated
Reclaim times	0.5 to 300 s (step 0.01 s)
Start-signal monitoring time	0.01 to 300 s (step 0.01 s)
Additional functions	Synchro-check request 3-phase intertripping InterCLOSE command to the remote end Check of CB ready state Blocking with manual CLOSE
Voltage limit values for DLC, ADT, RDT	
Healthy line voltage	30 to 90 V (step 1 V)
Dead line	2 to 70 V (step 1 V)
Tolerances	
Time stages	1 % of setting value or 10 ms
Voltage limit values	≤ 3 % of setting value or 0.5 V
Synchro-check (ANSI 25)	
Initiate options	Auto-reclosure; Manual CLOSE control Control commands
Operating modes with auto-reclosure	Synchro-check Line dead/busbar live Line live/busbar dead Line and busbar dead Bypassing
For manual closure and control commands	As for auto-reclosure
Permissible voltage difference	1 to 60 V (step 0.1 V)
Permissible frequency difference	0.03 to 2 Hz (step 0.01 Hz)
Permissible angle difference	2 to 80 ° (step 1 °)
Max. duration of synchronization	0.01 to 600 s (step 0.01 s) or deactivated
Release delay with synchronous networks	0 to 30 s (step 0.01 s)
Tolerances	
Time stages	1 % of setting value or 10 ms
Voltage limit values	≤ 2 % of setting value or 2 V

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Technical data

Restricted ground-fault protection (ANSI 87N)		
Multiple availability	2 times (option)	
Settings		
Differential current I_{REF}/I_{Nobj}	0.05 to 2.00	(steps 0.01)
Limit angle φ_{REF}	110 ° (fixed)	
Time delay T_{REF}	0.00 to 60.00 s	(steps 0.01 s) or deactivated (no trip)
The set times are pure delay times		
Operating times		
Pickup time (in ms) at frequency	50 Hz	60 Hz
At 1.5 · setting value $I_{REF}>$, approx.	30	25
At 2.5 · setting value $I_{REF}>$, approx.	28	24
Dropout time (in ms), approx.	26	23
Dropout ratio, approx.	0.7	
Overcurrent-time protection for phase and residual currents		
Multiple availability	3 times (option)	
Characteristics		
Definite-time stages (DT)	$I_{Ph} >>$, $3I_0 >>$, $I_{Ph} >$, $3I_0 >$	
Inverse-time stages (IT)	I_P , $3I_{OP}$ Inverse, very inverse, extremely inverse, long-time inverse	
Acc. to IEC		
Acc. to ANSI	Inverse, moderately inverse, very inverse, extremely inverse, definite inverse, short inverse, long inverse Alternatively, user-specified trip and reset characteristics	
Reset characteristics (IT)	Acc. to ANSI with disk emulation	
Current stages		
High-current stages $I_{Ph} >>$	0.10 to 35.00 A ¹⁾ (steps 0.01 A) or deactivated (stage ineffective)	
$T_{I_{Ph} >>}$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)	
$3I_0 >>$	0.05 to 35.00 A ¹⁾ (steps 0.01 A) or deactivated (stage ineffective)	
$T_{3I_0 >>}$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)	
Definite-time stages $I_{Ph} >$	0.10 to 35.00 A ¹⁾ (steps 0.01 A) or deactivated (stage ineffective)	
$T_{I_{Ph} >}$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)	
$3I_0 >$	0.05 to 35.00 A ¹⁾ (steps 0.01 A) or deactivated (stage ineffective)	
$T_{3I_0 >}$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)	
Inverse-time stages I_P	0.10 to 4.00 A ¹⁾ (steps 0.01 A)	
Acc. to IEC	T_{I_P} 0.05 to 3.20 s (steps 0.01 s) or deactivated (no trip)	
$3I_{OP}$	0.05 to 4.00 A ¹⁾ (steps 0.01 A)	
$T_{3I_{OP}}$	0.05 to 3.20 s (steps 0.01 s) or deactivated (no trip)	
Inverse-time stages I_P	0.10 to 4.00 A ¹⁾ (steps 0.01 A)	
Acc. to ANSI	D_{I_P} 0.50 to 15.00 s (steps 0.01 s) or deactivated (no trip)	
$3I_{OP}$	0.05 to 4.00 A ¹⁾ (steps 0.01 A)	
D_{3I_0}	0.50 to 15.00 s (steps 0.01 s) or deactivated (no trip)	

Thermal overload protection (ANSI 49)	
Setting ranges	
Factor k acc. to IEC 60255-8	1 to 4 (steps 0.01)
Time constant τ	1 to 999.9 min (steps 0.1 min)
Temperature alarm stage $\Theta_{alarm}/\Theta_{trip}$	50 to 100 % in relation to the trip temperature
Current alarm stage I_{alarm}	
Secondary 1 A	0.1 to 4 A (step 0.1)
Secondary 5 A	0.5 to 20 A (step 0.1)
Trip time characteristic	$t = \tau \ln \frac{I^2 - I_{pre}^2}{I^2 - (k \cdot I_N)^2}$
Reset ratios	
Θ/Θ_{alarm}	Approx. 0.99
Θ/Θ_{trip}	Approx. 0.99
III_{alarm}	Approx. 0.99
Tolerances	Class 10 % acc. to IEC
Trip circuit supervision (ANSI 74TC)	
Number of supervisable trip circuits	Up to 3
Number of required binary inputs per trip circuit	1 or 2
Indication relay	1 to 30 s (step 1 s)

Additional functions	
Operational measured values	
Representation	Primary, secondary and percentage referred to rated value
Currents	$3 \times I_{Phase}$; $3I_0$; I_{Gnd} sensitive; I_1 ; I_2 ; I_Y ; $3I_{OPAR}$ $3 \times I_{Diff}$, $3 \times I_{Stab}$
Tolerances	≤ 0.5 % of indicated measured value or 0.5 % I_{nom}
Voltages	$3 \times V_{Phase-Ground}$; $3 \times V_{Phase-Phase}$; $3V_0$, V_1 , V_2 , V_{SYNC} , V_{enr} , V_{COMP}
Tolerances	≤ 0.5 % of indicated measured value or 0.5 % V_{nom}
Power with direction indication	P , Q , S
Tolerances	
P : for $ \cos \varphi = 0.7$ to 1 and V/V_{nom} , $III_{nom} = 50$ to 120 %	Typical ≤ 1 %
Q : for $ \sin \varphi = 0.7$ to 1 and V/V_{nom} , $III_{nom} = 50$ to 120 %	Typical ≤ 1 %
S : for V/V_{nom} , $III_{nom} = 50$ to 120 %	Typical ≤ 1 %
Frequency	f
Tolerance	≤ 20 mHz
Power factor	PF ($\cos \varphi$)
Tolerance for $ \cos \varphi = 0.7$ to 1	Typical ≤ 3 %
Load impedances with directional indication	$3 \times R_{Phase-Ground}$, $X_{Phase-Ground}$ $3 \times R_{Phase-Phase}$, $X_{Phase-Phase}$
Overload measured values	Θ/Θ_{Trip} L1; Θ/Θ_{Trip} L2; Θ/Θ_{Trip} L3; Θ/Θ_{Trip}
Long-term mean values	
Interval for derivation of mean value	15 min / 1 min; 15 min / 3 min; 15 min / 15 min
Synchronization instant	Every $\frac{1}{4}$ hour; every $\frac{1}{2}$ hour; every hour
Values	$3 \times I_{Phase}$; I_1 ; P ; $P+$; $P-$; Q ; $Q+$; $Q-$; S

Minimum/maximum memory	
Indication	Measured values with date and time
Resetting	Cyclically Via binary input Via the keyboard Via serial interface
Values	
Min./max. of measured values	$3 \times I_{\text{Phase}}; I_1; 3 \times V_{\text{Phase-Ground}};$ $3 \times V_{\text{Phase-to-phase}}; 3V_0; V_1;$ $P+; P-; Q+; Q-; S; f;$ power factor (+); power factor (-)
Min./max. of mean values	$3 \times I_{\text{Phase}}; I_1; P; Q; S$
Energy meters	
Four-quadrant meters	$W_{P+}; W_{P-}; W_{Q+}; W_{Q-}$
Tolerance for $ \cos \varphi > 0.7$ and $V > 50 \% V_{\text{nom}}$ and $I > 50 \% I_{\text{nom}}$	5 %
Oscillographic fault recording	
Analog channels	$3 \times I_{\text{Phase}}, 3I_0, 3I_{\text{OPAR}}, 3I_0$ Gnd sensitive, $3 \times I_{\text{Diff}}, 3 \times I_{\text{Stab}}$ $3 \times V_{\text{Phase}}, 3V_0, V_{\text{SYNC}}, V_{\text{en}}, V_x$
Max. number of available recordings	8, backed-up by battery if auxiliary voltage supply fails
Sampling intervals	20 samplings per cycle
Total storage time	Approx. 15 s
Binary channels	Pickup and trip information; number and contents can be freely configured by the user
Max. number of displayed binary channels	40
Control	
Number of switching units	Depends on the number of binary / indication inputs and indication / command outputs
Control commands	Single command / double command 1, 1 plus 1 common or 2 pole
Feed back	CLOSE, TRIP, intermediate position
Interlocking	Freely configurable
Local control	Control via menu, function keys
Remote control	Control protection, DIGSI, pilot wires

Further additional functions	
Measurement supervision	Current sum Current symmetry Voltage sum Voltage symmetry Voltage phase sequence Fuse failure monitor
Annunciations Event logging Fault logging	Buffer size 200 Storage of signals of the last 8 faults, buffer size 800
Switching statistics	Number of breaking operations per c.b. pole Sum of breaking current per phase Breaking current of last trip operation Max. breaking current per phase
Circuit-breaker test	TRIP/CLOSE cycle 3-phase TRIP/CLOSE cycle per phase
Setting range Dead time for CB TRIP/CLOSE cycle	0.00 to 30 s (step 0.01 s) 0.00 to 30 s (step 0.01 s)
Commissioning support	Operational measured values Circuit-breaker test Read binary test Initiate binary inputs Set binary outputs Set serial interface outputs Lockout of a device Test mode of the differential protection topology

CE conformity	
<p>This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EG previous 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 2006/95/EG previous 73/23/EEC).</p>	
<p>This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).</p>	
<p>Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1.</p>	
<p>The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.</p>	
<p>This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".</p>	

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Selection and ordering data

Description								Order No.	Short code
7SD5 combined multi-end line differential protection with distance protection								7SD5	□□□□□□□□□□□□□□□□
Device type¹⁾									
Two-terminal differential relay with 4-line display								2	2
Two-terminal differential relay with graphical display								3	2
Multi-terminal differential relay with 4-line display								2	3
Multi-terminal differential relay with graphical display								3	3
Measurement input									
$I_{ph} = 1 \text{ A}^2$, $I_e = 1 \text{ A}^2$								1	
$I_{ph} = 1 \text{ A}^2$, $I_e = \text{high}$ (min. = 0.005 A)								2	
$I_{ph} = 5 \text{ A}^2$, $I_e = 5 \text{ A}^2$								5	
$I_{ph} = 5 \text{ A}^2$, $I_e = \text{sensitive}$ (min. = 0.005 A)								6	
Auxiliary voltage (Power supply, BI trigger level)									
24 to 48 V DC, trigger level binary input 19 V ⁴⁾								2	
60 to 125 V DC ³⁾ , trigger level binary input 19 V ⁴⁾								4	
110 to 250 V DC ³⁾ , 115 V AC, trigger level binary input 88 V ⁴⁾								5	
220 to 250 V DC ³⁾ , 115 V AC, trigger level binary input 176 V ⁴⁾								6	
Binary/ indication inputs	Signal/ command outputs incl. live status contact	Fast relay ⁵⁾	High- speed trip output ⁶⁾	Housing width referred to 19"	Flush- mounting housing/ screw-type terminals	Flush- mounting housing/ plug-in terminals	Surface- mounting housing/ screw-type terminals		
8	4	12	–	½	■				A
8	4	12	–	½			■		E
8	4	12	–	½		■			J
16	12	12	–	½	■				C
16	12	12	–	½			■		G
16	12	12	–	½		■			L
16	4	15	5	½	■				N
16	4	15	5	½			■		Q
16	4	15	5	½		■			S
24	20	12	–	½	■				D
24	20	12	–	½			■		H
24	20	12	–	½		■			M
24	12	15	5	½	■				P
24	12	15	5	½			■		R
24	12	15	5	½		■			T
24	4	18	10	½	■				W
Region-specific default/language settings and function versions									
Region GE, German language (can be changed)									A
Region world, English language (can be changed)									B
Region US, US-English language (can be changed)									C
Region world, French language (can be changed)									D
Region world, Spanish language (can be changed)									E
Region world, Italian language (can be changed)									F

see next page

7

- 1) Redundant prot. data interface for Hot-Standby-service is possible with a two terminal differential relay (second prot. data interface is needed)
- 2) Rated current 1/5 A can be selected by the means of jumpers.
- 3) Transition between three auxiliary voltage ranges can be selected by means of jumpers.

- 4) The binary input thresholds are selectable in three steps by means of jumpers.
- 5) Fast relays are identified in the terminal diagram. The time advantage compared to signal/command outputs is approx. 3 ms, mainly for protection commands
- 6) High-speed trip outputs are identified in the in the terminal diagram. The time advantage compared to fast relays is approx. 5 ms

Line Differential Protection/7SD52/53

Selection and ordering data

Description	Order No.	Short code
7SD5 combined multi-end line differential protection with distance protection	7SD52□□-□□□□□-□□□□□□□□□□	
System interfaces		
No system interface	0	
IEC protocol, electrical RS232	1	
IEC protocol, electrical RS485	2	
IEC protocol, optical 820 nm, ST-plug	3	
PROFIBUS FMS Slave, electrical RS485	4	
PROFIBUS FMS Slave, optical 820 nm, twin-ring, ST-plug	6	
Further protocols see supplement L	9	L 0 □
PROFIBUS DP slave, RS485		A
PROFIBUS DP slave, optical 820 nm, double ring, ST connector ¹⁾		B
DNP 3.0, RS485 G		G
DNP 3.0, optical 820 nm, ST connector ¹⁾		H
IEC 61850, 100 Mbit Ethernet, electrical, double, RS45 connector (EN100)		R
IEC 61850, 100 Mbit Ethernet, with integrated switch, optical, double, LC-connector (EN100) ²⁾		S
DIGSI/Modem interface (on rear of device) and protection interface 1		
See additional indication M	9	M□□
DIGSI/Modem interface (on rear of device)		
Without DIGSI-interface on rear		0
DIGSI 4, electric RS232		1
DIGSI 4, electric RS485		2
DIGSI 4, optical 820 nm, ST plug		3
Protection data interface 1		
FO5: Optical 820 nm, 2 ST-plugs, line length up to 1.5 km via multimode FO cable for communication converter or direct FO connection ³⁾		A
FO6: Optical 820 nm, 2 ST-plugs, line length up to 3.5 km via multimode FO cable for direct FO connection		B
FO17: Optical 1300 nm, LC-Duplex-plugs, line length up to 24 km via monomode FO cable for direct FO connection ⁴⁾		G
FO18: Optical 1300 nm, LC-Duplex-plugs, line length up to 60 km via monomode FO cable for direct FO connection ^{4) 5)}		H
FO19: Optical 1550 nm, LC-Duplex-plugs, line length up to 100 km via monomode FO cable for direct FO connection ^{4) 6)}		J
FO30: Optical 820 nm, 2 ST-plugs, line length up to 1.5 km via multimode FO cable for communication networks with IEEE C37.94 interface or direct FO connection ⁷⁾		S

see next page

7

- 1) Not possible for surface mounting housing (Order No. pos. 9 = E/G/H/Q/R). For the surface mounted version, please order a device with the appropriate electrical RS485 interface and an external FO-converter
- 2) Not possible for surface mounting housing (Order No. pos. 9 = E/G/H/Q/R) please order the relay with electrical interface and use a separate fiber-optic switch.
- 3) Communication converter 7XV5662, see Accessories.
- 4) Device for surface mounting housing (Order No. pos. 9 = E/G/H/Q/R) will be delivered with external repeater 7XV5461-0Bx00.

- 5) For distances less than 25 km a set of optical attenuators 7XV5107-0AA00 must be installed to avoid saturation of the receiver element
- 6) For distances less than 50 km a set of optical attenuators 7XV5107-0AA00 must be installed to avoid saturation of the receiver element
- 7) Only available in flush-mounting housing (Order No. pos. 9 ≠ E/G/H/Q/R).

Line Differential Protection / 7SD52/53

Selection and ordering data

Description			Order No.	Short code
7SD5 combined multi-end line differential protection with distance protection			7SD52	□□-□□□□-□□□□-□□□□
Functions 1 / Protection interface 2				
Trip mode	Auto-reclosure (ANSI 79)	Synchro-check (ANSI 25)		
3-pole	without	without	0	↑ see next page
3-pole	with	without	1	
1-/3-pole	without	without	2	
1-/3-pole	with	without	3	
3-pole	without	with	4	
3-pole	with	with	5	
1-/3-pole	without	with	6	
1-/3-pole	with	with	7	
Functions 1 and Protection interface 2 ⁶⁾			9	N □□
Functions 1				
Trip mode	Auto-reclosure (ANSI 79)	Synchro-check (ANSI 25)		
3-pole	without	without	0	↑
3-pole	with	without	1	
1-/3-pole	without	without	2	
1-/3-pole	with	without	3	
3-pole	without	with	4	
3-pole	with	with	5	
1-/3-pole	without	with	6	
1-/3-pole	with	with	7	
Protection interface 2				
FO5: Optical 820 nm, 2 ST-plugs, line length up to 1.5 km via multimode FO cable for communication converter or direct FO connection ¹⁾				A
FO6: Optical 820 nm, 2 ST-plugs, line length up to 3.5 km via multimode FO cable for direct FO connection				B
FO17: Optical 1300 nm, LC-Duplex-plugs, line length up to 24 km via monomode FO cable for direct FO connection ²⁾				G
FO18: Optical 1300 nm, LC-Duplex-plugs, line length up to 60 km via monomode FO cable for direct FO connection ^{2) 3)}				H
FO19: Optical 1550 nm, LC-Duplex-plugs, line length up to 100 km via monomode FO cable for direct FO connection ^{2) 4)}				J
FO30: Optical 820 nm, 2 ST-plugs, line length up to 1.5 km via multimode FO cable for communication networks with IEEE C37.94 interface or direct FO connection ⁵⁾				S

1) Communication converter 7XV5662, see Accessories.

2) Device for surface mounting housing (Order No. pos. 9 = E/G/H/Q/R) will be delivered with external repeater 7XV5461-0Bx00.

3) For distances less than 25 km a set of optical attenuators 7XV5107-0AA00 must be installed to avoid saturation of the receiver element.

4) For distances less than 50 km a set of optical attenuators 7XV5107-0AA00 must be installed to avoid saturation of the receiver element.

5) Only available in flush-mounting housing (Order No. pos. 9 ≠ E/G/H/Q/R).

6) In a two terminal differential relay the protection interface 2 can be used as redundant protection interface (Hot Standby).

Line Differential Protection/7SD52/53

Selection and ordering data

Description					Order No.	Short code
7SD5 combined multi-end line differential protection with distance protection					7SD52□□-□□□□□-□□□□-□□□	
Functions						
Time overcurrent protection/ Breaker failure protection (ANSI 50, 50N, 51, 51N, 50BF)	Ground fault protection (ANSI 67N)	Distance protection (Pickup $Z<$, polygon, MHO, parallel line comp.) Power swing detection (ANSI 21, 21N, 68, 68T)	Distance protection ($I_{pick-up} >$, $-VI\phi$, $-Z<$), polygon, parallel line comp. ²⁾ , power swing det. (ANSI 21, 21N, 68, 68T)	Ground fault detection for isolated/ compensated networks ¹⁾		
with	without	without	without	without		C
with	without	without	with	without		D
with	without	with	without	without		E
with	with	without	without	without		F
with	with	without	with	without		G
with	with	with	without	without		H
with	without	without	without	with		J
with	without	without	with	with		K
with	with	without	without	with		L
with	with	without	with	with		M
Additional functions 1						
4 Remote commands/ 24 Remote indications	Transformer expansions	Fault locator	Voltage protection, frequency protection (ANSI 27, 50)	Restricted ground fault low impedance (ANSI 87N) ²⁾		
with	without	1-side measuring	without	without		J
with	without	1-side measuring	with	without		K
with	without	2-side measuring	without	without		L
with	without	2-side measuring	with	without		M
with	with	1-side measuring	without	without		N
with	with	1-side measuring	with	without		P
with	with	2-side measuring	without	without		Q
with	with	2-side measuring	with	without		R
with	with	1-side measuring	without	with		S
with	with	1-side measuring	with	with		T
with	with	2-side measuring	without	with		U
with	with	2-side measuring	with	with		V
Additional functions 2						
Measured values, extended, Min/Max values	External GPS synchronization	Capacitive current load compensation				
without	without	without				0
without	with	without				1
with	without	without				2
with	with	without				3
without	without	with				4
without	with	with				5
with	without	with				6
with	with	with				7

1) Only available with Order No. Pos. 7 = 2 or 6

2) Only available with Order No. Pos. 7 = 1 or 5

Line Differential Protection / 7SD52/53

Selection and ordering data

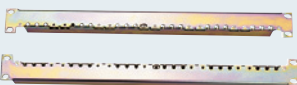


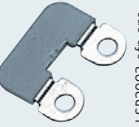

Accessories	Description	Order No.
	<p>Opto-electric communication converter CC-XG (connection to communication network)</p> <p>Converter to interface to X21 or RS422 or G703-64 kbit/s synchronous communication interfaces Connection via FO cable for 62.5/125 µm or 50/120 µm and 820 nm wavelength (multi-mode FO cable) with ST connector, max. distance 1.5 km Electrical connection via X21/RS422 or G703-64 kbit/s interface</p>	7XV5662-0AA00
	<p>Opto-electric communication converter CC-2M to G703-E1 / -T1 communication networks with 2,048/1,554 kbit/s</p> <p>Converter to interface between optical 820 nm interface and G703-E1 /-T1 interface of a communication network Connection via FO cable for 62.5/125 µm or 50/120 µm and 820 nm wavelength (multi-mode FO cable) with ST connector, max. distance 1.5 km Electrical connection via G703-E1/-T1 interface</p>	7XV5662-0AD00
	<p>Opto-electric communication converter (connection to pilot wire)</p> <p>Converter to interface to a pilot wire or twisted telephone pair (typical 15 km length) Connection via FO cable for 62.5/125 µm or 50/120 µm and 820 nm wavelength (multi-mode FO cable) with ST connector; max. distance 1.5 km, screw-type terminals to pilot wire</p>	7XV5662-0AC00
	<p>Additional interface modules</p> <p>Protection interface mod. opt. 820 nm, multi-mode FO cable, ST connector, 1.5 km</p>	C53207-A351-D651-1
	Protection interface mod. opt. 820 nm, multi-mode FO cable, ST connector, 3.5 km	C53207-A351-D652-1
	<p>Further modules</p> <p>Protection interface mod. opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 24 km</p>	C53207-A351-D655-1
	Protection interface mod. opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	C53207-A351-D656-1
	Protection interface mod. opt. 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	C53207-A351-D657-1
	<p>Optical repeaters</p> <p>Serial repeater (2-channel), opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 24 km</p>	7XV5461-0BG00
	Serial repeater (2-channel), opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	7XV5461-0BH00
	Serial repeater (2-channel), opt. 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	7XV5461-0BJ00
	<p>Time synchronizing unit with GPS output</p> <p>GPS 1 sec pulse and time telegram IRIG B/DCF 77</p>	7XV5664-0AA00
	Isolation transformer (20 kV) for pilot wire communication	7XR9516
	<p>Voltage transformer miniature circuit-breaker</p> <p>Rated current 1.6 A; thermal overload release 1.6 A; overcurrent trip 6 A</p>	3RV1611-1AG14

Line Differential Protection/7SD52/53

Selection and ordering data

Accessories	Description	Order No.
	DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper) Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
	Professional Complete version: DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
	SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows (Windows 2000 or XP Professional). Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	7XS5410-0AA00
	Connecting cable Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	7XV5100-4
	Manual for 7SD522/523 V4.6 English	C53000-G1176-C169



	Description	Order No.	Size of package	Supplier	Fig.
 Fig. 7/78 Mounting rail for 19" rack LSP2289-afp.eps	Connector 2-pin	C73334-A1-C35-1	1	Siemens	7/79
	Connector 3-pin	C73334-A1-C36-1	1	Siemens	7/80
 Fig. 7/79 2-pin connector LSP2090-afp.eps	Crimp connector	CI2 0.5 to 1 mm ²	0-827039-1	4000	AMP ¹⁾
		CI2 0.5 to 2.5 mm ²	0-827040-1	1	AMP ¹⁾
		Type III+ 0.75 to 1.5 mm ²	0-163083-7	4000	AMP ¹⁾
			0-163084-2	1	AMP ¹⁾
 Fig. 7/80 3-pin connector LSP2091-afp.eps	Crimping tool	For type III+ and matching female	0-539635-1	1	AMP ¹⁾
		For CI2 and matching female	0-539668-2	1	AMP ¹⁾
 Fig. 7/81 Short-circuit link for current contacts LSP2093-afp.eps	19"-mounting rail	For current terminals	C73165-A63-D200-1	1	Siemens
		For other terminals	C73334-A1-C33-1	1	Siemens
 Fig. 7/82 Short-circuit link for voltage contacts/indications contacts LSP2092-afp.eps	Short-circuit links	For current terminals	C73334-A1-C34-1	1	Siemens
		For other terminals	C73334-A1-C31-1	1	Siemens
	Safety cover for terminals	large	C73334-A1-C31-1	1	Siemens
		small	C73334-A1-C32-1	1	Siemens

1) Your local Siemens representative can inform you on local suppliers.

Line Differential Protection / 7SD52/53

Connection diagram

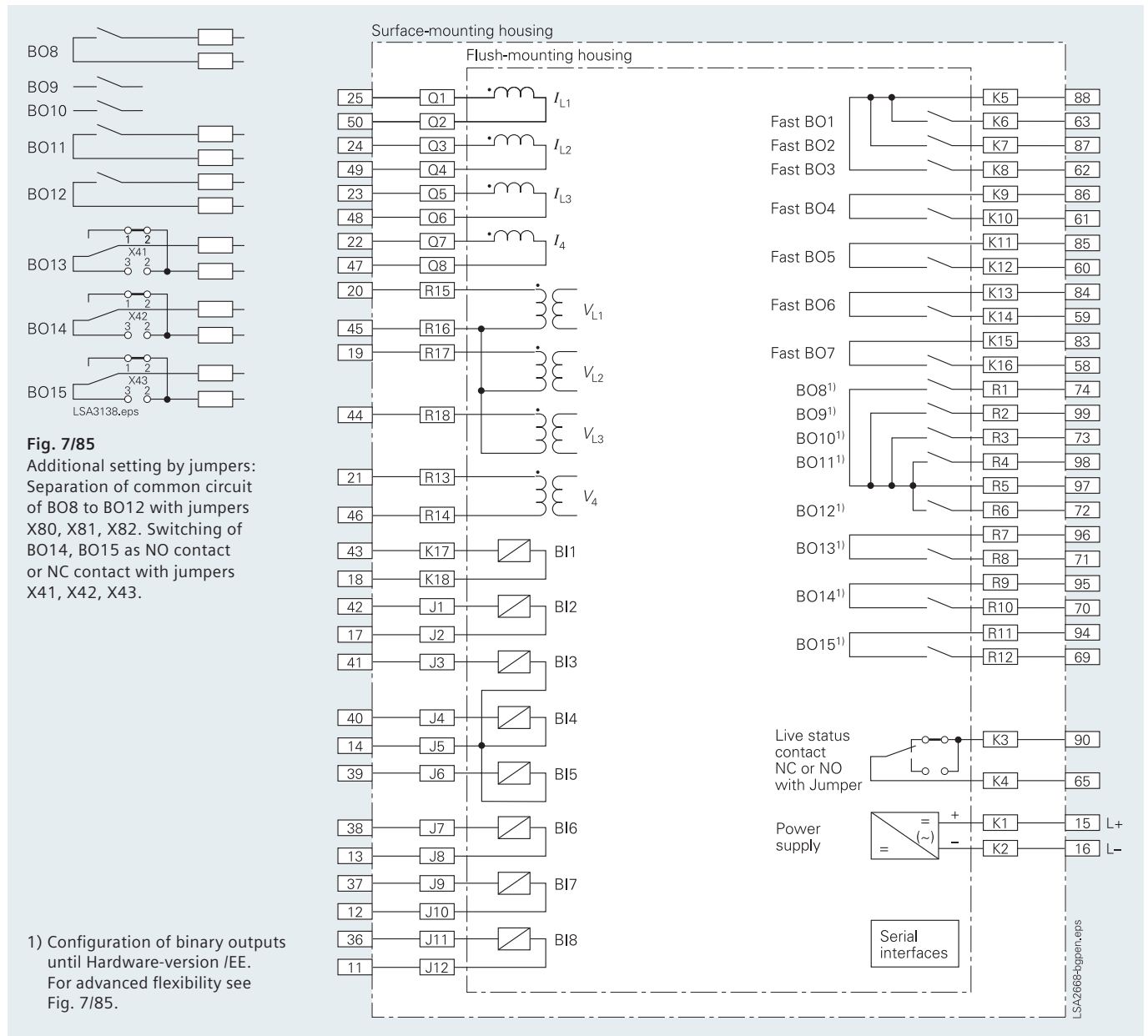


Fig. 7/83 Basic version in housing 1/2 x 19" with 8 binary inputs and 16 binary outputs

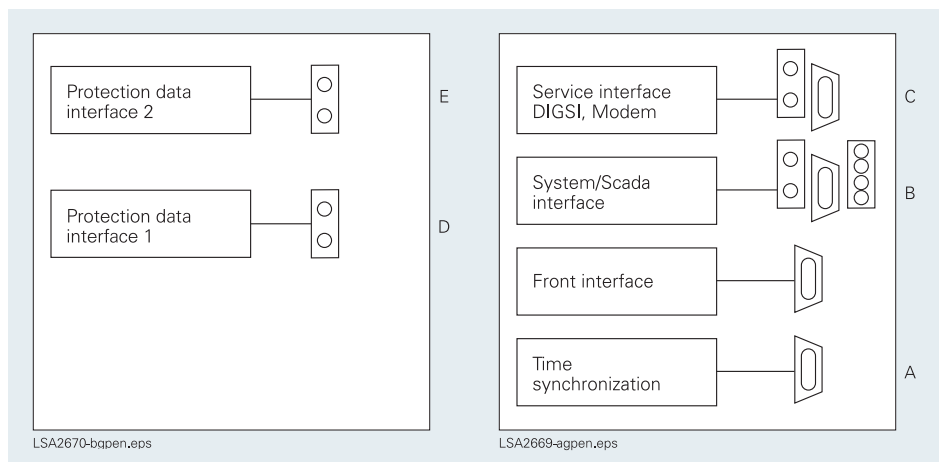
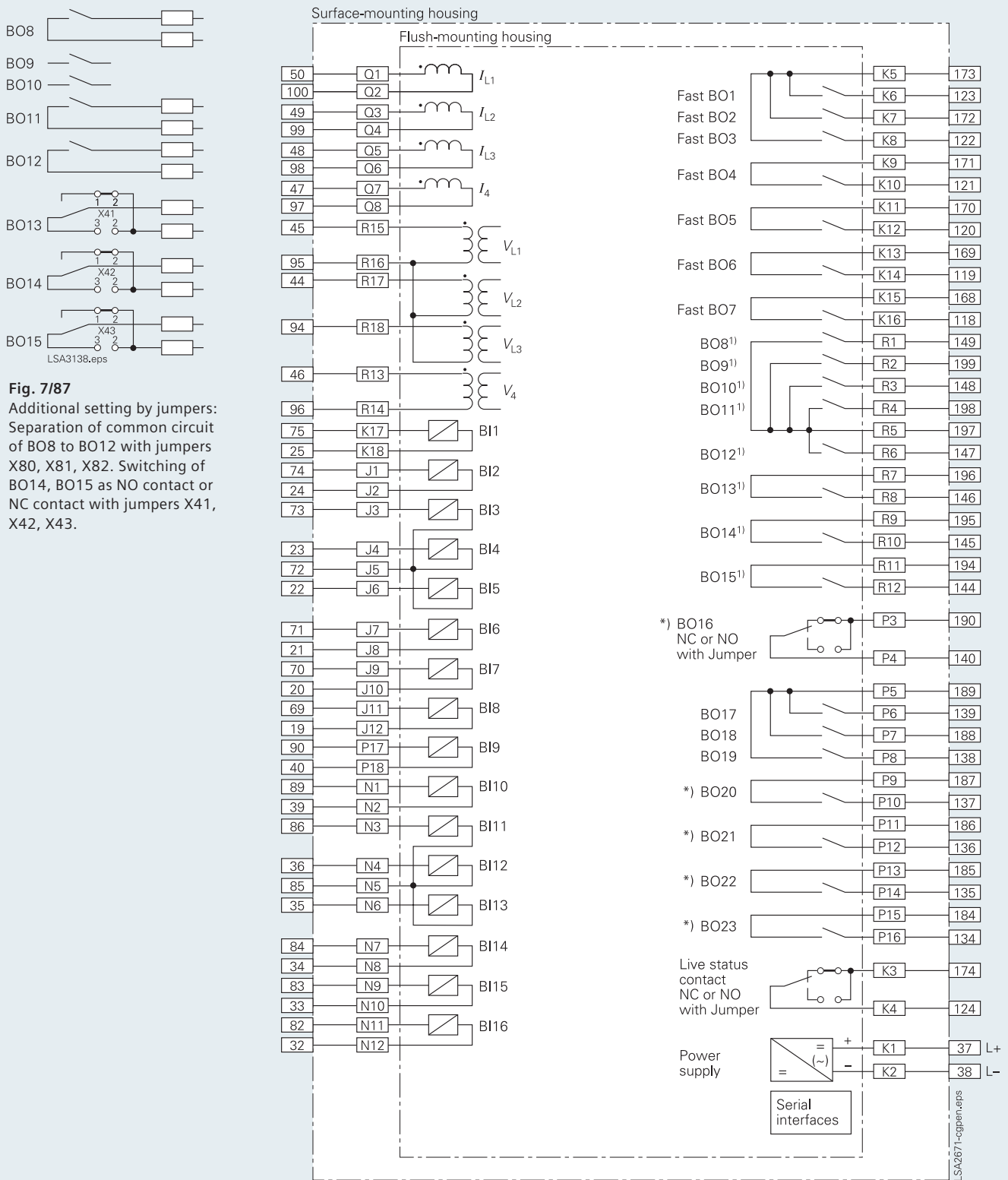


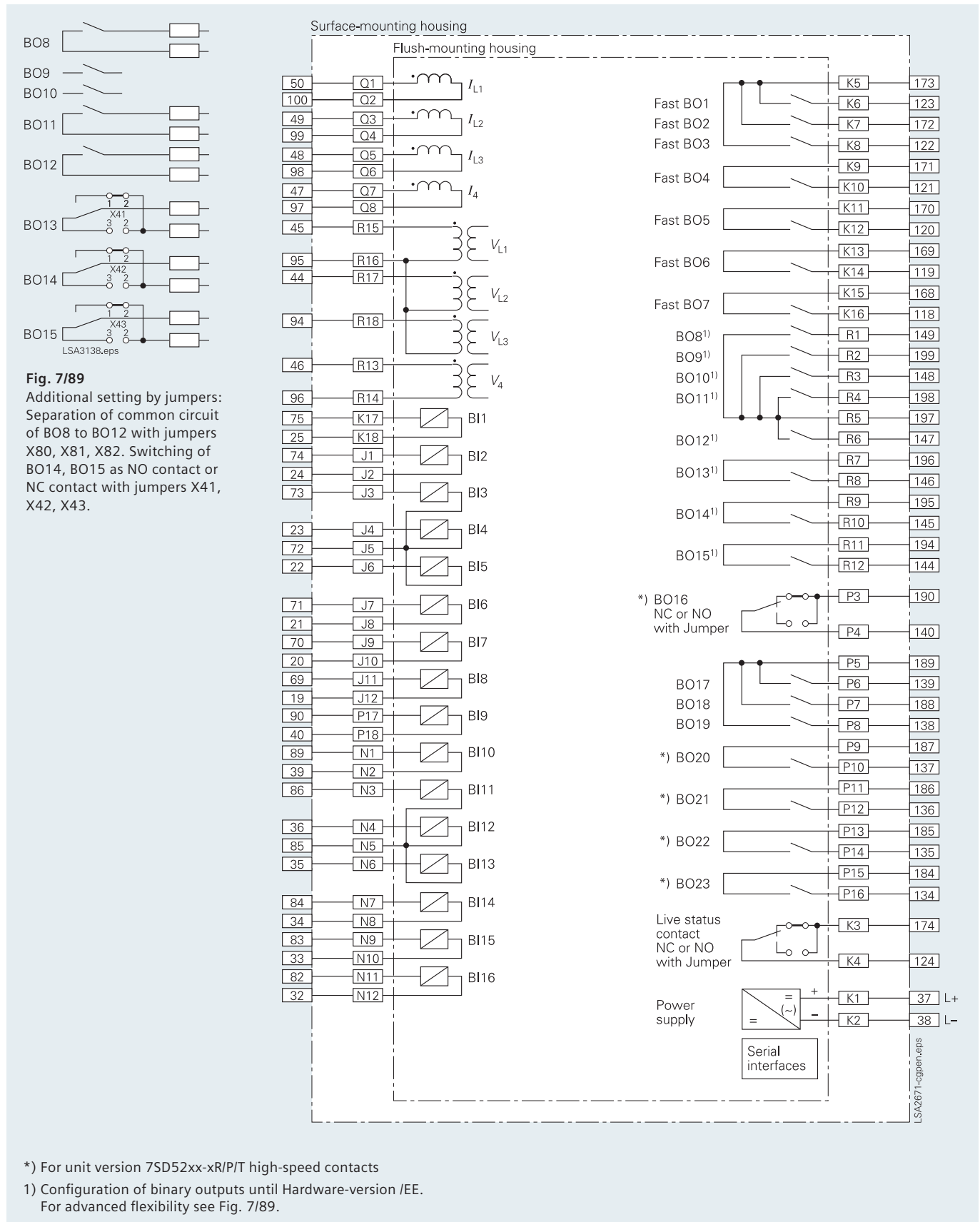
Fig. 7/84 Serial interfaces



*) For unit version 7SD52xx-xN/S/Q high-speed contacts
1) Configuration of binary outputs until Hardware-version /EE.
For advanced flexibility see Fig. 7/87.

Line Differential Protection / 7SD52/53

Connection diagram



Transformer Differential Protection

SIPROTEC 4 7UT6 differential protection relay
for transformers, generators, motors and busbars



Transformer Differential Protection/7UT6

SIPROTEC 4 7UT6 differential protection relay for transformers, generators, motors and busbars



Fig. 8/1 SIPROTEC 4 7UT6 differential protection relay for transformers, generators, motors and busbar

Description

The SIPROTEC 7UT6 differential protection relays are used for fast and selective fault clearing of short-circuits in transformers of all voltage levels and also in rotating electric machines like motors and generators, for short lines and busbars.

The protection relay can be parameterized for use with three-phase and single-phase transformers.

The specific application can be chosen by parameterization. In this way an optimal adaptation of the relay to the protected object can be achieved.

In addition to the differential function, a backup overcurrent protection for 1 winding/star point is integrated in the relay. Optionally, a low or high-impedance restricted ground-fault protection, a negative-sequence protection and a breaker failure protection can be used. 7UT613 and 7UT633 feature 4 voltage inputs. With this option an overvoltage and undervoltage protection is available as well as frequency protection, reverse / forward power protection, fuse failure monitor and overexcitation protection. With external temperature monitoring boxes (thermo-boxes) temperatures can be measured and monitored in the relay. Therefore, complete thermal monitoring of a transformer is possible, e.g. hot-spot calculation of the oil temperature.

7UT613 and 7UT63x only feature full coverage of applications without external relays by the option of multiple protection functions e.g. overcurrent protection is available for each winding or measurement location of a transformer. Other functions are available twice: ground-fault differential protection, breaker failure protection and overload protection. Furthermore, up to 12 user-defined (flexible) protection functions may be activated by the customer with the choice of measured voltages, currents, power and frequency as input variables.

The relays provide easy-to-use local control and automation functions. The integrated programmable logic (CFC) allows the users to implement their own functions, e.g. for the automation of switchgear (interlocking). User-defined messages can be generated as well. The flexible communication interfaces are open for modem communication architectures with control system.

Function overview

- Differential protection for 2- up to 5-winding transformers (3-/1-phase)
- Differential protection for motors and generators
- Differential protection for short 2 up to 5 terminal lines
- Differential protection for busbars up to 12 feeders (phase-segregated or with summation CT)

Protection functions

- Differential protection with phase-segregated measurement
- Sensitive measuring for low-fault currents
- Fast tripping for high-fault currents
- Restraint against inrush of transformer
- Phase /ground overcurrent protection
- Overload protection with or without temperature measurement
- Negative-sequence protection
- Breaker failure protection
- Low/high-impedance restricted ground fault (REF)
- Voltage protection functions (7UT613/633)

Control functions

- Commands for control of circuit-breakers and isolators
- 7UT63x: Graphic display shows position of switching elements, local/remote switching by key-operated switch
- Control via keyboard, binary inputs, DIGSI 4 or SCADA system
- User-defined logic with CFC

Monitoring functions

- Self-supervision of the relay
- Trip circuit supervision
- Oscillographic fault recording
- Permanent differential and restraint current measurement, extensive scope of operational values

Communication interfaces

- PC front port for setting with DIGSI 4
- System interface
IEC 61850 Ethernet
IEC 60870-5-103 protocol,
PROFIBUS-FMS/-DP,
MODBUS or DNP 3.0
- Service interface for DIGSI 4 (modem)/ temperature monitoring (thermo-box)
- Time synchronization via IRIG-B/DCF 77

Transformer Differential Protection / 7UT6

Application

Application

The numerical protection relays 7UT6 are primarily applied as differential protection on

- transformers
 - 7UT612: 2 windings
 - 7UT613/633: 2 up to 3 windings
 - 7UT635: 2 up to 5 windings,
- generators
- motors
- short line sections
- small busbars
- parallel and series reactors.

The user selects the type of object that is to be protected by setting during configuration of the relay. Subsequently, only those parameters that are relevant for this particular protected object need to be set. This concept, whereby only those parameters relevant to a particular protected object need to be set, substantially contributed to a simplification of the setting procedure. Only a few parameters must be set. Therefore the new 7UT6 relays also make use of and extend this concept. Apart from the protected plant objects defined in the 7UT6, a further differential protection function allows the protection of

- single busbars with up to 12 feeders.

The well-proven differential measuring algorithm of the 7UT51 relay is also used in the new relays, so that a similar response with regard to short-circuit detection, tripping time saturation detection and inrush restraint is achieved.

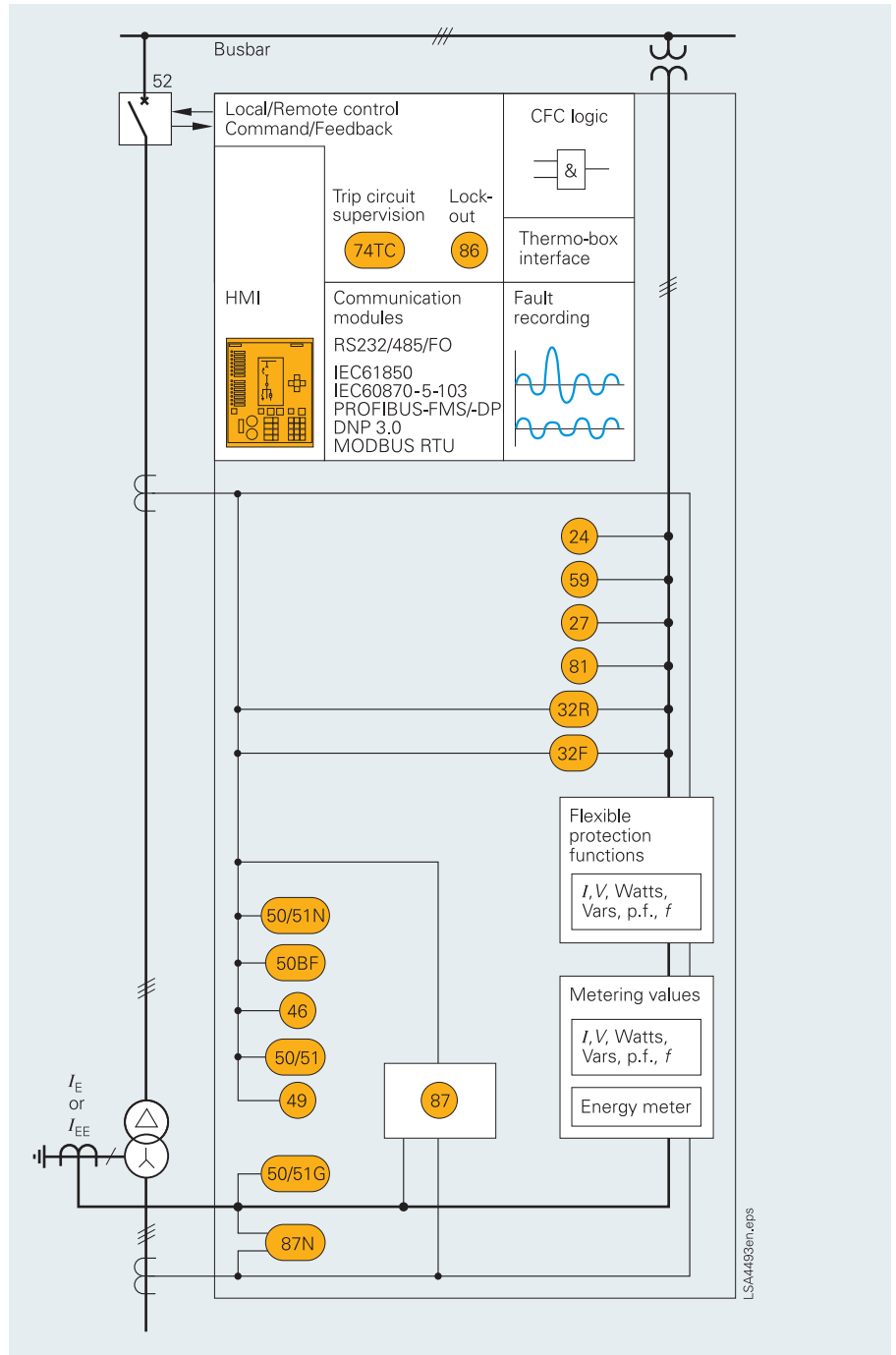


Fig. 8/2 Function diagram

Application										
Protection functions	ANSI No.				Three-phase transformer	Single-phase transformer	Auto-transformer	Generator/Motor	Busbar, 3-phase	Busbar, 1-phase
		7UT612	7UT613/33	7UT635						
Differential protection	87T/G/M/L	1	1	1	■	■	■	■	■	■
Ground-fault differential protection	87 N	1	2	2	■	■	■*)	■	–	–
Overcurrent-time protection, phases	50/51	1	3	3	■	■	■	■	■	–
Overcurrent-time protection $3I_0$	50/51N	1	3	3	■	–	■	■	■	–
Overcurrent-time protection, ground	50/51G	1	2	2	■	■	■	■	■	■
Overcurrent-time protection, single-phase		1	1	1	■	■	■	■	■	■
Negative-sequence protection	46	1	1	1	■	–	■	■	■	–
Overload protection IEC 60255-8	49	1	2	2	■	■	■	■	■	–
Overload protection IEC 60354	49	1	2	2	■	■	■	■	■	–
Overexcitation protection *) V/Hz	24	–	1	–	■	■	■	■	■	■
Overvoltage protection *) V>	59	–	1	–	■	■	■	■	–	–
Undervoltage protection *) V<	27	–	1	–	■	■	■	■	–	–
Frequency protection *) f>, f<	81	–	1	–	■	■	■	■	–	–
Reverse power protection *) -P	32R	–	1	–	■	■	■	■	–	–
Forward power protection*) P>, P<	32F	–	1	–	■	■	■	■	–	–
Fuse failure protection	60FL	–	1	–	■	■	■	■	–	–
Breaker failure protection	50 BF	1	2	2	■	■	■	■	■	–
External temperature monitoring (thermo-box)	38	■	■	■	■	■	■	■	■	■
Lockout	86	■	■	■	■	■	■	■	■	■
Measured-value supervision		■	■	■	■	■	■	■	■	■
Trip circuit supervision	74 TC	■	■	■	■	■	■	■	■	■
Direct coupling 1		■	■	■	■	■	■	■	■	■
Direct coupling 2		■	■	■	■	■	■	■	■	■
Operational measured values		■	■	■	■	■	■	■	■	■
Flexible protection functions	27, 32, 47, 50, 55, 59, 81	–	12	12	■	■	■	■	■	■

■ Function applicable
 – Function not applicable in this application
 *) Only 7UT613/63x

Construction

The 7UT6 is available in three housing widths referred to a 19" module frame system. The height is 243 mm.

- 1/3 (7UT612),
- 1/2 (7UT613),
- 1/1 (7UT633/635) of 19"

All cables can be connected with or without cable ring lugs. Plug-in terminals are available as an option, it is thus possible to employ prefabricated cable harnesses. In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located on the same sides of the housing. For dimensions please refer to the dimension drawings (part 14).



Fig. 8/3 Rear view flush-mountig housing

Transformer Differential Protection / 7UT6

Protection functions

Protection functions

Differential protection for transformers (ANSI 87T)

When the 7UT6 is employed as fast and selective short-circuit protection for transformers the following properties apply:

- Tripping characteristic according to Fig. 8/4 with normal sensitive $I_{DIFF>}$ and high-set trip stage $I_{DIFF>>}$
- Vector group and ratio adaptation
- Depending on the treatment of the transformer neutral point, zero-sequence current conditioning can be set with or without consideration of the neutral current. With the 7UT6, the star-point current at the star-point CT can be measured and considered in the vector group treatment, which increases sensitivity by one third for single-phase faults.
- Fast clearance of heavy internal transformer faults with high-set differential element $I_{DIFF>>}$.
- Restrain of inrush current with 2nd harmonic. Cross-block function that can be limited in time or switched off.
- Restrain against overfluxing with a choice of 3rd or 5th harmonic stabilization is only active up to a settable value for the fundamental component of the differential current.
- Additional restrain for an external fault with current transformer saturation (patented CT-saturation detector from 7UT51).
- Insensitivity to DC current and current transformer errors due to the freely programmable tripping characteristic and fundamental filtering.
- The differential protection function can be blocked externally by means of a binary input.

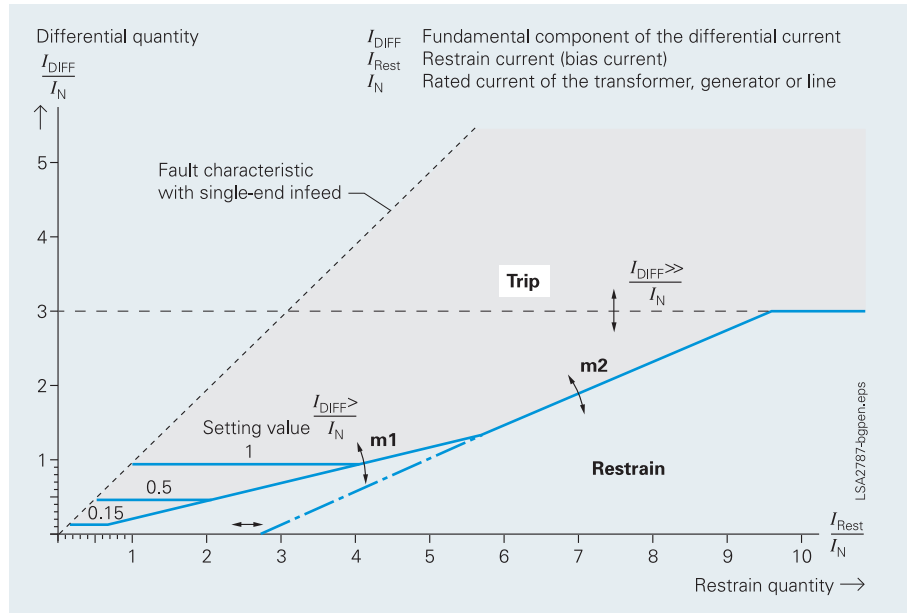


Fig. 8/4 Tripping characteristic with preset transformer parameters for three-phase faults

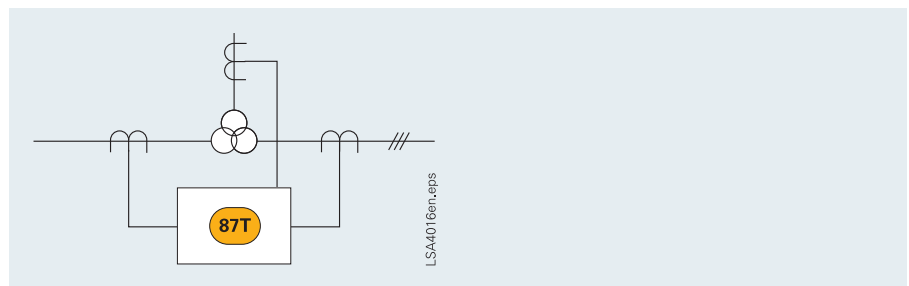


Fig. 8/5 3-winding transformers (1 or 3-phase)

Sensitive protection by measurement of star-point current (see Fig. 8/6) (ANSI 87N/87GD)

Apart from the current inputs for detection of the phase currents on the sides of the protected object, the 7UT6 also contains normal sensitivity I_E and high sensitivity I_{EE} current measuring inputs. Measurement of the star-point current of an grounded winding via the normal sensitivity measuring input, and consideration of this current by the differential protection, increases the sensitivity during internal single-phase faults by 33 %. If the sum of the phase currents of a winding is compared with the star-point current measured with the normal sensitivity input I_E , a sensitive ground current differential protection can be implemented (REF).

This function is substantially more sensitive than the differential protection during faults to ground in a winding, detecting fault currents as small as 10 % of the transformer rated current.

Furthermore, this relay contains a high-impedance differential protection input. The sum of the phase currents is compared with the star-point current. A voltage-dependent resistor (varistor) is applied in shunt (see Fig. 8/6). Via the sensitive current measuring input I_{EE} , the voltage across the varistor is measured; in the milli-amp range via the external resistor. The varistor and the resistor are mounted externally. An ground fault results in a voltage across the varistor that is larger than the voltage resulting from normal current transformer errors. A prerequisite is the application of accurate current transformers of the class 5P (TPY) which exhibit a small measuring error in the operational and overcurrent range. These current transformers may not be the same as used for the differential protection, as the varistor may cause rapid saturation of this current transformers.

Both high-impedance and low-impedance REF are each available twice (option) for transformers with two grounded windings. Thus separate REF relays are not required.

Differential protection for single-phase busbars (see Fig. 8/7) (ANSI 87L)

The short-circuit protection is characterized by the large number of current measuring inputs. The scope of busbar protection ranges from a few bays e.g. in conjunction with one and a half circuit-breaker applications, to large stations having up to more than 50 feeders. In particular in smaller stations, the busbar protection arrangements are too expensive. With the 7UT6 relays the current inputs may also be used to achieve a cost-effective busbar protection system for up to 12 feeders (Fig. 8/7). This busbar protection functions as a phase-selective protection with 1 or 5 A current transformers, whereby the protected phase is connected. All three phases can therefore be protected by applying three relays. Furthermore a single-phase protection can be implemented by connecting the three-phase currents via a summation transformer. The summation transformer connection has a rated current of 100 mA.

The selectivity of the protection can be improved by monitoring the current magnitude in all feeders, and only releasing the differential protection trip command when the overcurrent condition is also met. The security measures to prevent maloperation resulting from failures in the current transformer secondary circuits can be improved in this manner. This overcurrent release may also be used to implement a breaker failure protection. Should the release signal not reset within a settable time, this indicates that a breaker failure condition is present, as the short-circuit was not switched off by the bay circuit-breaker.

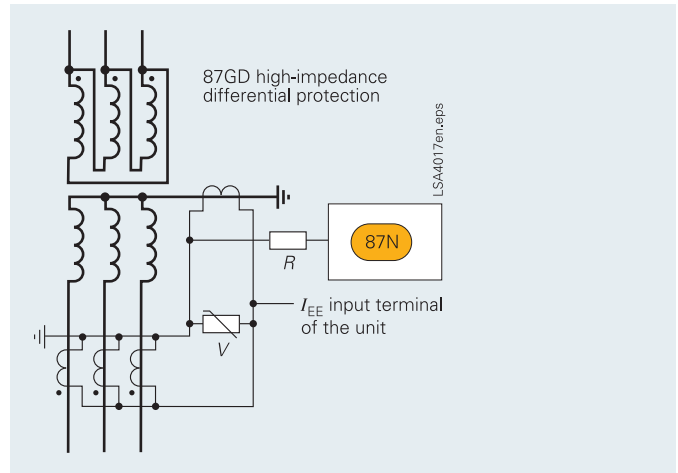


Fig. 8/6 High-impedance differential protection

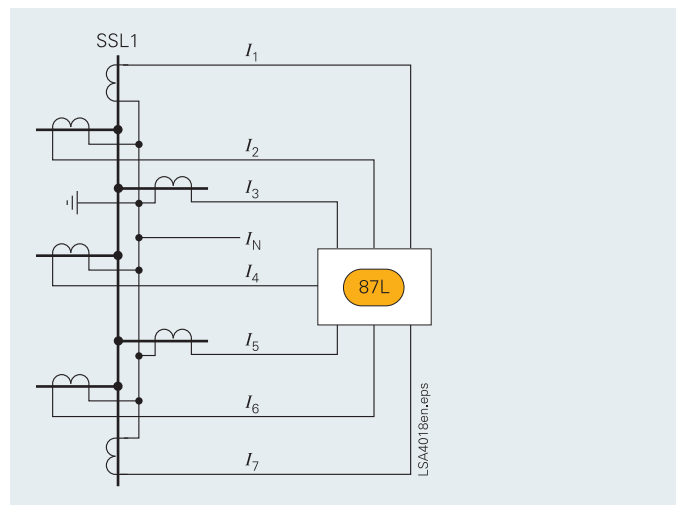


Fig. 8/7 Simple busbar protection with phase-selective configuration
7UT612: 7 feeders; 7UT613/633: 9 feeders;
7UT635: 12 feeders

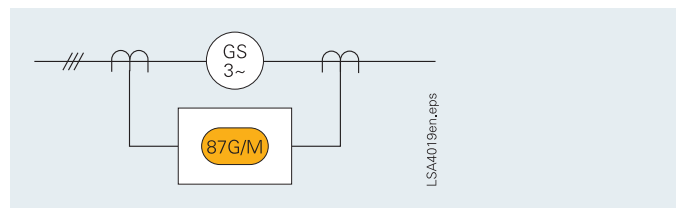


Fig. 8/8 Generator/motor differential protection

After expiry of the time delay the circuit-breakers of the infeeds to the busbar may be tripped.

Differential protection for generators and motors (see Fig. 8/8) (ANSI 87G/M)

Equal conditions apply for generators, motors and series reactors. The protected zone is limited by the sets of current transformers at each side of the protected object.

Transformer Differential Protection / 7UT6

Protection functions

■ Backup protection functions

Overcurrent-time protection (ANSI 50, 50N, 51, 51N)

Backup protection on the transformer is achieved with a two-stage overcurrent protection for the phase currents and $3I_0$ for the calculated neutral current. This function may be configured for one of the sides or measurement locations of the protected object. The high-set stage is implemented as a definite-time stage, whereas the normal stage may have a definite-time or inverse-time characteristic. Optionally, IEC or ANSI characteristics may be selected for the inverse stage. The overcurrent protection $3I_0$ uses the calculated zero-sequence current of the configured side or measurement location.
Multiple availability: 3 times (option)

Overcurrent-time protection for ground (ANSI 50/51G)

The 7UT6 feature a separate 2-stage overcurrent-time protection for the ground. As an option, an inverse-time characteristic according to IEC or ANSI is available. In this way, it is possible to protect e.g. a resistor in the transformer star point against thermal overload, in the event of a single-phase short-circuit not being cleared within the time permitted by the thermal rating.
Multiple availability: 3 times (option)

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

Furthermore a negative-sequence protection may be defined for one of the sides or measurement locations. This provides sensitive overcurrent protection in the event of asymmetrical faults in the transformer. The set pickup threshold may be smaller than the rated current.

Breaker failure protection (ANSI 50BF)

If a faulted portion of the electrical circuit is not disconnected upon issuing of a trip command, another command can be initiated using the breaker failure protection which operates the circuit-breaker, e.g., of an upstream (higher-level) protection relay.
Multiple availability: 2 times (option)

Overexcitation protection Volt/Hertz (ANSI 24) (7UT613/633 only)

The overexcitation protection serves for detection of an unpermissible high induction (proportional to V/f) in generators or transformers, which leads to a thermal overloading. This may occur when starting up, shutting down under full load, with weak systems or under isolated operation. The inverse characteristic can be set via seven points derived from the manufacturer data.
In addition, a definite-time alarm stage and an instantaneous stage can be used.

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal occurs whenever the circuit is interrupted.

Lockout (ANSI 86)

All binary outputs (alarm or trip relays) can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only occur after the lockout state is reset.

External trip coupling

For recording and processing of external trip information via binary inputs. They are provided for information from the Buchholz relay or specific commands and act like a protective function. Each input initiates a fault event and can be individually delayed by a timer.

Undervoltage protection (ANSI 27) (7UT613/633 only)

The undervoltage protection evaluates the positive-sequence components of the voltages and compares them with the threshold values. There are two stages available.

The undervoltage function is used for asynchronous motors and pumped-storage stations and prevents the voltage-related instability of such machines.
The function can also be used for monitoring purposes.

Overvoltage protection (ANSI 59) (7UT613/633 only)

This protection prevents insulation faults that result when the voltage is too high.

Either the maximum line-to-line voltages or the phase-to-ground voltages (for low-voltage generators) can be evaluated. The measuring results of the line-to-line voltages are independent of the neutral point displacement caused by ground faults.
This function is implemented in two stages.

Frequency protection (ANSI 81) (7UT613/633 only)

The frequency protection prevents impermissible stress of the equipment (e.g. turbine) in case of under or overfrequency. It also serves as a monitoring and control element.

The function has four stages; the stages can be implemented either as underfrequency or overfrequency protection. Each stage can be delayed separately.

Even in the event of voltage distortion, the frequency measuring algorithm reliably identifies the fundamental waves and determines the frequency extremely precisely. Frequency measurement can be blocked by using an undervoltage stage.

Reverse-power protection (ANSI 32R) (7UT613/633 only)

The reverse-power protection monitors the direction of active power flow and picks up when the mechanical energy fails. This function can be used for operational shutdown (sequential tripping) of the generator but also prevents damage to the steam turbines. The reverse power is calculated from the positive-sequence systems of current and voltage. Asymmetrical power system faults therefore do not cause reduced measuring accuracy. The position of the emergency trip valve is injected as binary information and is used to switch between two trip command delays. When applied for motor protection, the sign (\pm) of the active power can be reversed via parameters.

Forward-power protection (ANSI 32F) (7UT613/633 only)

Monitoring of the active power produced by a generator can be useful for starting up and shutting down generators. One stage monitors exceeding of a limit value, while another stage monitors falling below another limit value. The power is calculated using the positive-sequence component of current and voltage. The function can be used to shut down idling motors.

Flexible protection functions (7UT613/63x only)

For customer-specific solutions up to 12 flexible protection functions are available and can be parameterized. Voltages, currents, power and frequency from all measurement locations can be chosen as inputs. Each protection function has a settable threshold, delay time, blocking input and can be configured as a 1-phase or 3-phase unit.

Monitoring functions

The relay comprises high-performance monitoring for the hardware and software.

The measuring circuits, analog-digital conversion, power supply voltages, battery, memories and software sequence (watch-dog) are all monitored.

The fuse failure function detects failure of the measuring voltage due to short-circuit or open circuit of the wiring or VT and avoids overfunction of the undervoltage elements in the protection functions. (7UT613/633 only)

Thermal monitoring of transformers

The importance of reducing the costs of transmitting and distributing energy by optimizing the system load has resulted in the increased importance of monitoring the thermal condition of transformers. This monitoring is one of the tasks of the monitoring systems, designed for medium and large transformers. Overload protection based on a simple thermal model, and using only the measured current for evaluation, has been integrated in differential protection systems for a number of years.



Fig. 8/9 Temperature measurement and monitoring with external thermo-boxes

The ability of the 7UT6 to monitor the thermal condition can be improved by serial connection of a temperature monitoring box (also called thermo-box or RTD-box) (Fig. 8/9). The temperature of up to 12 measuring points (connection of 2 boxes) can be registered. The type of sensor (Pt100, Ni100, Ni120) can be selected individually for each measuring point. Two alarm stages are derived for each measuring point when the corresponding set threshold is exceeded.

Alternatively to the conventional overload protection, the relay can also provide a hot-spot calculation according to IEC 60345. The hot-spot calculation is carried out separately for each leg of the transformer and takes the different cooling modes of the transformer into consideration.

The oil temperature must be registered via the thermo-box for the implementation of this function. An alarm warning stage and final alarm stage is issued when the maximum hot-spot temperature of the three legs exceeds the threshold value.

For each transformer leg a relative rate of ageing, based on the ageing at 98 °C is indicated as a measured value. This value can be used to determine the thermal condition and the current thermal reserve of each transformer leg. Based on this rate of ageing, a remaining thermal reserve is indicated in % for the hottest spot before the alarm warning and final alarm stage is reached.

Transformer Differential Protection / 7UT6

Protection functions

Measured values

The operational measured values and statistic value registering in the 7UT6, apart from the registration of phase currents and voltages (7UT613/633 only) as primary and secondary values, comprises the following:

- Currents 3-phase $I_{L1}, I_{L2}, I_{L3}, I_1, I_2, 3I_0$ for each side and measurement location
- Currents 1-phase I_1 to I_{12} for each feeder and further inputs I_{x1} to I_{x4}
- Voltages 3-phase $V_{L1}, V_{L2}, V_{L3}, V_{L1L2}, V_{L2L3}, V_{L3L1}, V_1, V_2, V_0$ and 1-phase V_{EN}, V_4
- Phase angles of all 3-phase / 1-phase currents and voltages
- Power Watts, Vars, $VA/P, Q, S$ (P, Q : total and phase selective)
- Power factor ($\cos \phi$),
- Frequency
- Energy + kWh, + kVarh, forward and reverse power flow
- Min./max. and mean values of $V_{PH-PH}, V_{PHE}, V_E, V_0, V_1, V_2, I_{PH}, I_1, I_2, 3I_0, I_{DIFF}, I_{RESTRAINT}, S, P, Q, \cos \phi, f$
- Operating hours counter
- Registration of the interrupted currents and counter for protection trip commands
- Mean operating temperature of overload function
- Measured temperatures of external thermo-boxes
- Differential and restraint currents of differential protection and REF

Metered values

For internal metering, the unit can calculate an energy metered value from the measured current and voltage values.

The 7UT6 relays may be integrated into monitoring systems by means of the diverse communication options available in the relays. An example for this is the connection to the SITRAM transformer monitoring system with PROFIBUS-DP interface.

Commissioning and operating aids

Commissioning could hardly be easier and is fully supported by DIGSI 4. The status of the binary inputs can be read individually and the state of the binary outputs can be set individually. The operation of switching elements (circuit-breakers, disconnect devices) can be checked using the switching functions of the bay controller. The analog measured values are represented as wide-ranging operational measured values. To prevent transmission of information to the control center during maintenance, the bay controller communications can be disabled to prevent unnecessary data from being transmitted. During commissioning, all indications with test marking for test purposes can be connected to a control and protection system.

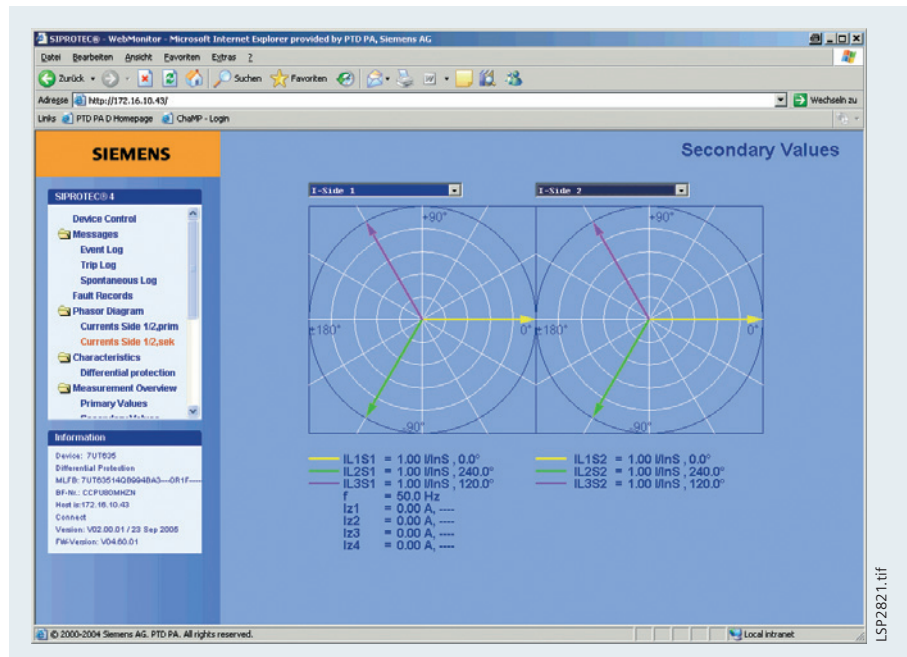


Fig. 8/10 Commissioning via a standard Web browser: Phasor diagram

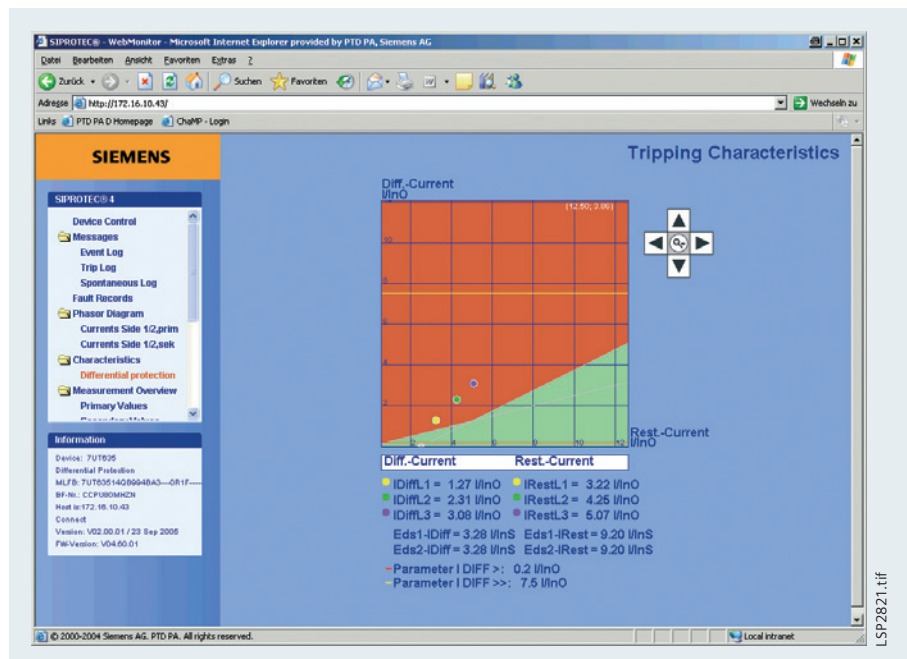


Fig. 8/11 Commissioning via a standard Web browser: Operating characteristic

All measured currents and voltages (7UT613/633 only) of the transformer can be indicated as primary or secondary values. The differential protection bases its pickup thresholds on the rated currents of the transformer. The referred differential and stabilising (restraint) currents are available as measured values per phase.

If a thermo-box is connected, registered temperature values may also be displayed. To check the connection of the relay to the primary current and voltage transformers, a commissioning measurement is provided.

This measurement function works with only 5 to 10 % of the transformer rated current and indicates the current and the angle between the currents and voltages (if voltages applied). Termination errors between the primary current transformers and input transformers of the relay are easily detected in this manner.

The operating state of the protection may therefore be checked online at any time. The fault records of the relay contain the phase and ground currents as well as the calculated differential and restraint currents. The fault records of the 7UT613/633 relays also contain voltages.

Browser-based commissioning aid

The 7UT6 provides a commissioning and test program which runs under a standard internet browser and is therefore independent of the configuration software provided by the manufacturer.

For example, the correct vector group of the transformer may be checked. These values may be displayed graphically as vector diagrams.

The stability check in the operating characteristic is available as well as event log and trip log messages. Remote control can be used if the local front panel cannot be accessed.

■ Control and automation functions

Control

In addition to the protection functions, the SIPROTEC 4 units also support all control and monitoring functions that are required for operating medium-voltage or high-voltage substations.

The main application is reliable control of switching and other processes.

The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated via binary inputs. Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a fault or intermediate circuit-breaker or auxiliary contact position.

The switchgear or circuit-breaker can be controlled via:

- integrated operator panel
- binary inputs
- substation control and protection system
- DIGSI 4

Command processing

All the functionality of command processing is offered. This includes the processing of single and double commands with or without feedback, sophisticated monitoring of the control hardware and software, checking of the external process, control actions using functions such as runtime monitoring and automatic command termination after output. Here are some typical applications:

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable bay interlocks
- Operating sequences combining several switching operations such as control of circuit-breakers, disconnectors and grounding switches
- Triggering of switching operations, indications or alarm by combination with existing information

Automation/user-defined logic

With integrated logic, the user can set, via a graphic interface (CFC), specific functions for the automation of switchgear or substation. Functions are activated via function keys, binary input or via communication interface.

Switching authority

Switching authority is determined according to parameters, communication or by key-operated switch (when available).

If a source is set to "LOCAL", only local switching operations are possible. The following sequence of switching authority is laid down: "LOCAL"; DIGSI PC program, "REMOTE"

Every switching operation and change of breaker position is kept in the status indication memory. The switch command source, switching device, cause (i.e. spontaneous change or command) and result of a switching operation are retained.

Assignment of feedback to command

The positions of the circuit-breaker or switching devices and transformer taps are acquired by feedback. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication change is a consequence of switching operation or whether it is a spontaneous change of state (intermediate position).

Chatter disable

The chatter disable feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

Filter time

All binary indications can be subjected to a filter time (indication suppression).

Indication filtering and delay

Indications can be filtered or delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time. In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

A further indication (or a command) can be derived from an existing indication. Group indications can also be formed. The volume of information to the system interface can thus be reduced and restricted to the most important signals.

Transmission lockout

A data transmission lockout can be activated, so as to prevent transfer of information to the control center during work on a circuit bay.

Test operation

During commissioning, all indications can be passed to an automatic control system for test purposes.

Transformer Differential Protection / 7UT6

Communication

Communication

With respect to communication, particular emphasis has been placed on high levels of flexibility, data integrity and utilization of standards common in energy automation. The design of the communication modules permits interchangeability on the one hand, and on the other hand provides openness for future standards (for example, Industrial Ethernet).

Local PC interface

The PC interface accessible from the front of the unit permits quick access to all parameters and fault event data. Of particular advantage is the use of the DIGSI 4 operating program during commissioning.

Rear-mounted interfaces

Two communication modules located on the rear of the unit incorporate optional equipment complements and readily permit retrofitting. They assure the ability to comply with the requirements of different communication interfaces.

The interfaces make provision for the following applications:

- Service interface (Port C/Port D)
In the RS485 version, several protection units can be centrally operated with DIGSI 4. On connection of a modem, remote control is possible. Via this interface communication with thermo-boxes is executed.
- System interface (Port B)
This interface is used to carry out communication with a control or protection and control system and supports a variety of communication protocols and interface designs, depending on the module connected.

Commissioning aid via a standard Web browser

In the case of the 7UT6, a PC with a standard browser can be connected to the local PC interface or to the service interface (refer to "Commissioning program"). The relays include a small Web server and send their HTML-pages to the browser via an established dial-up network connection.

Retrofitting: Modules for every type of communication

Communication modules for retrofitting are available for the entire SIPROTEC 4 unit range. These ensure that, where different communication interfaces (electrical or optical) and protocols (IEC 61850 Ethernet, IEC 60870-5-103, PROFIBUS-FMS/-DP, MODBUS RTU, DNP 3.0, DIGSI, etc.) are required, such demands can be met.

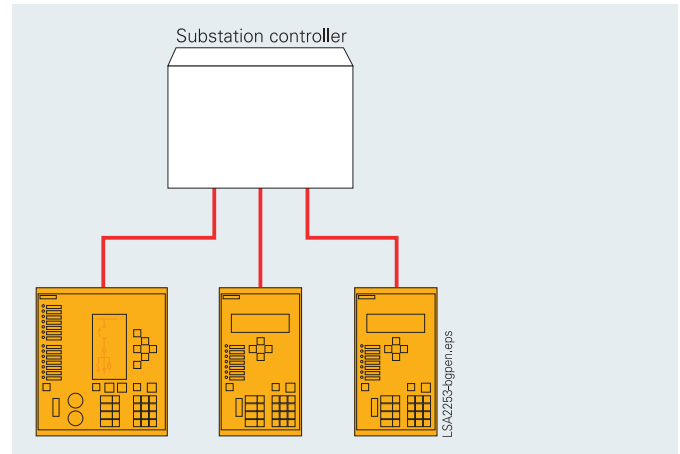


Fig. 8/12 IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

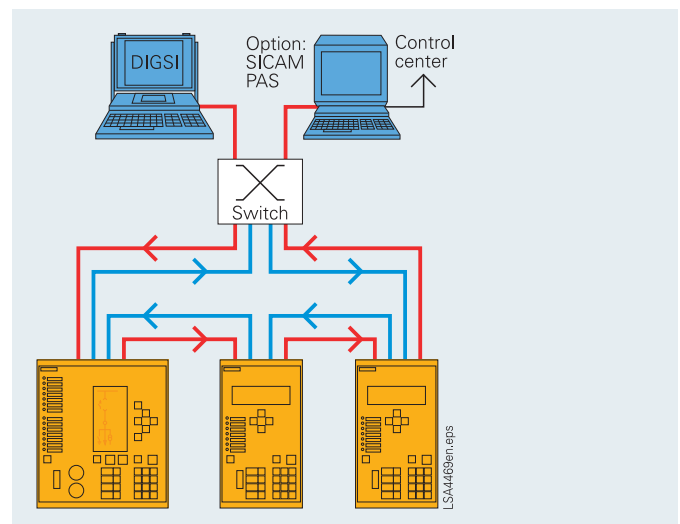


Fig. 8/13 Bus structure for station bus with Ethernet und IEC 61850, fiber-optic ring

Safe bus architecture

- RS485 bus
With this data transmission via copper conductors electromagnetic fault influences are largely eliminated by the use of twisted-pair conductor. Upon failure of a unit, the remaining system continues to operate without any disturbances.
- Fiber-optic double ring circuit
The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without disturbance.

It is generally impossible to communicate with a unit that has failed. If a unit were to fail, there is no effect on the communication with the rest of the system.

IEC 61850 Ethernet

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens was the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus is also possible with DIGSI.

IEC 60870-5-103

IEC 60870-5-103 is an internationally standardized protocol for the efficient communication in the protected area. IEC 60870-5-103 is supported by a number of protection device manufacturers and is used worldwide.

PROFIBUS-DP

PROFIBUS-DP is an industry-recognized standard for communications and is supported by a number of PLC and protection device manufacturers.

MODBUS RTU

MODBUS RTU is an industry-recognized standard for communications and is supported by a number of PLC and protection device manufacturers.

DNP 3.0

DNP 3.0 (Distributed Network Protocol Version 3) is a messaging-based communication protocol. The SIPROTEC 4 units are fully Level 1 and Level 2 compliant with DNP 3.0. DNP 3.0 is supported by a number of protection device manufacturers.

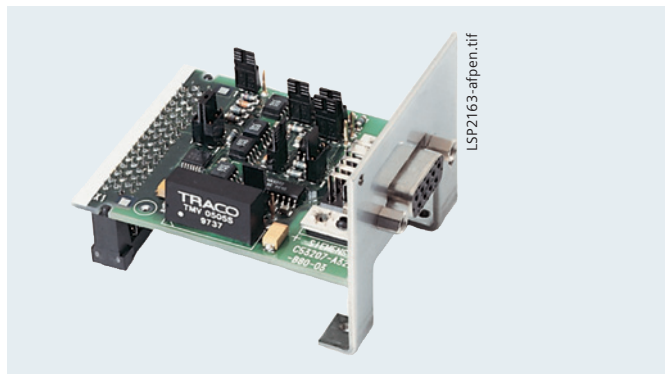


Fig. 8/14 RS232/RS485 electrical communication module

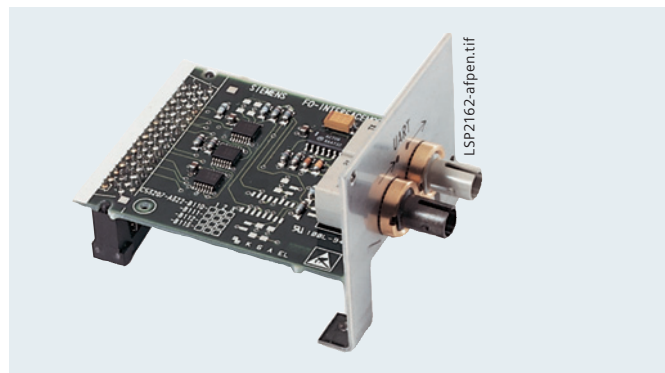


Fig. 8/15 820 nm fiber-optic communication module

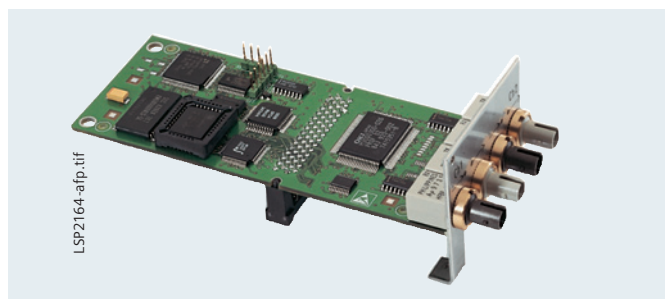


Fig. 8/16 PROFIBUS communication module, optical double-ring



Fig. 8/17 Optical Ethernet communication module for IEC 61850 with integrated Ethernet switch

Transformer Differential Protection / 7UT6

Communication

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system.

Units featuring IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 8/12).

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 8/13).

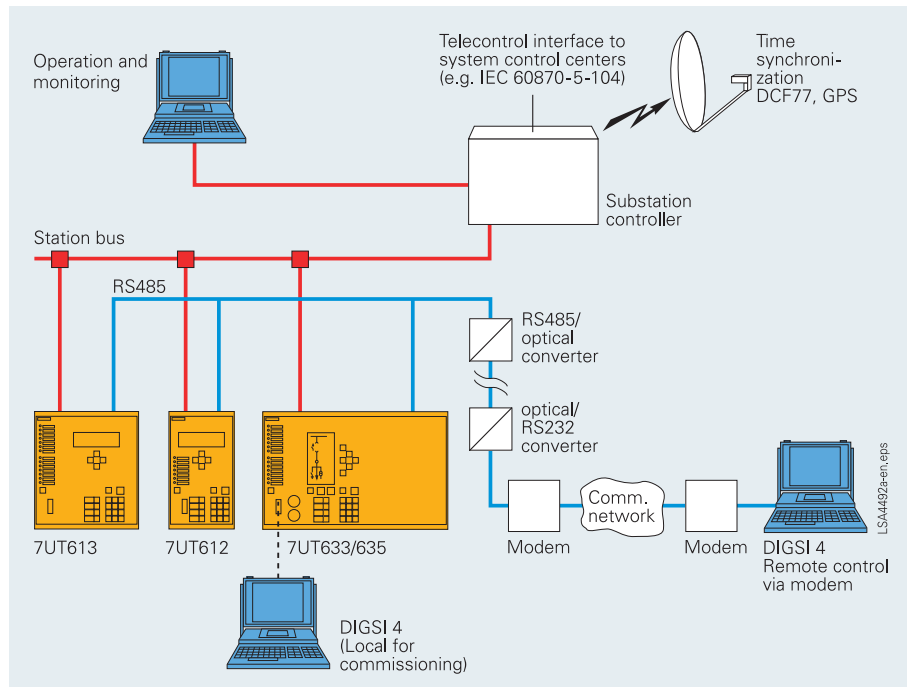


Fig. 8/18 System solution: Communications

Typical connections

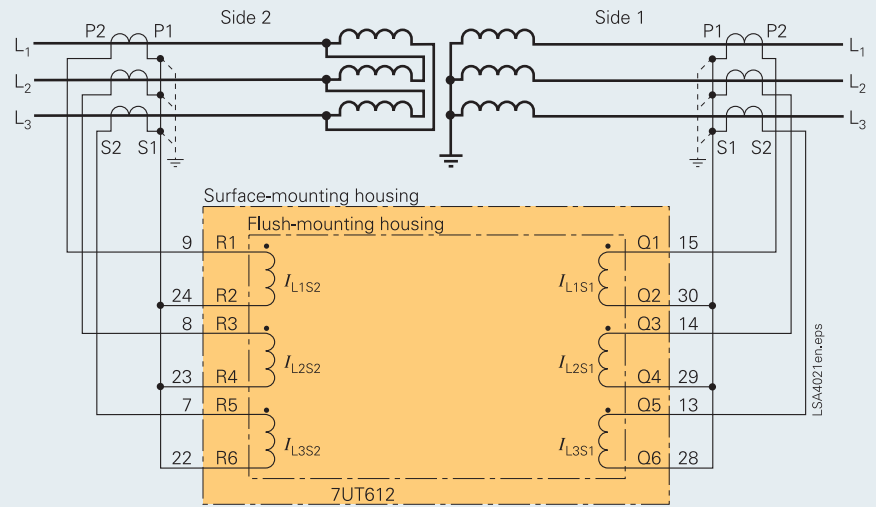


Fig. 8/19 Standard connection to a transformer without neutral current measurement

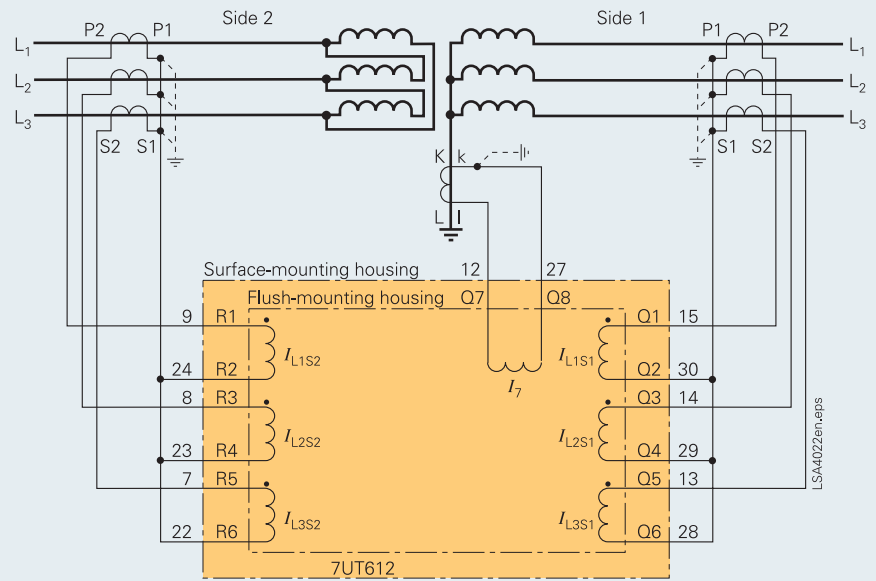


Fig. 8/20 Connection to a transformer with neutral current measurement

Transformer Differential Protection / 7UT6

Typical connections

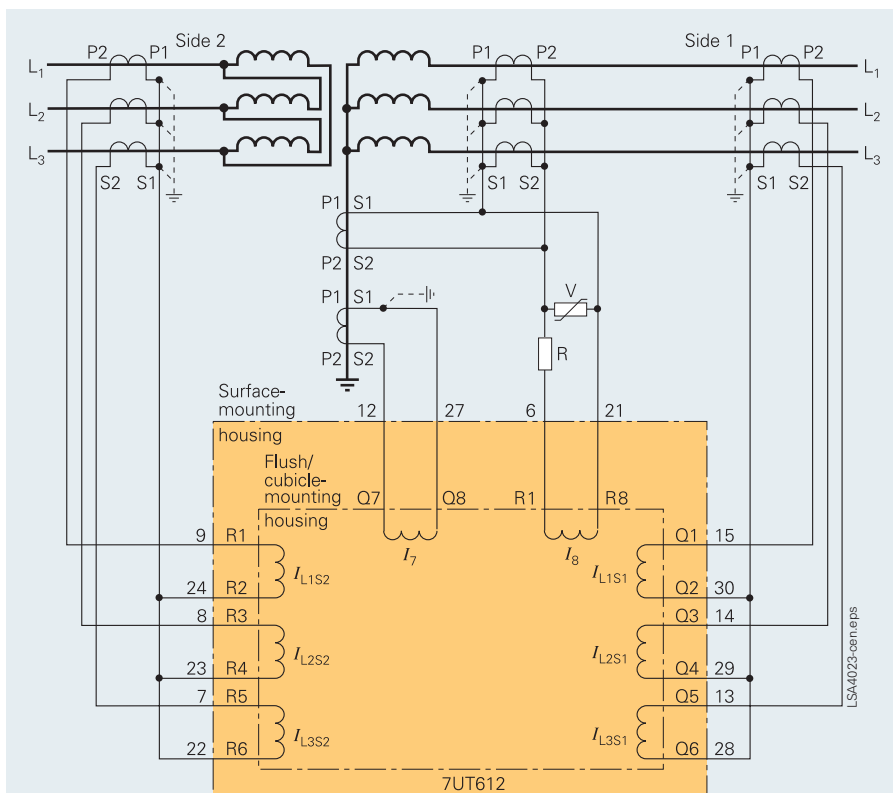


Fig. 8/21 Connection of transformer differential protection with high impedance REF (I_8) and neutral current measurement at I_7

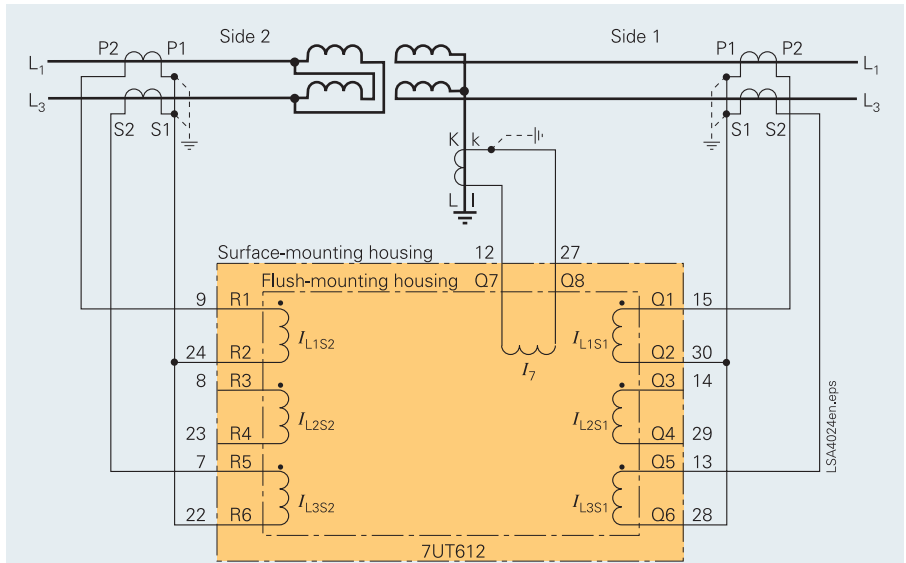


Fig. 8/22 Connection example to a single-phase power transformer with current transformer between starpoint and grounding point

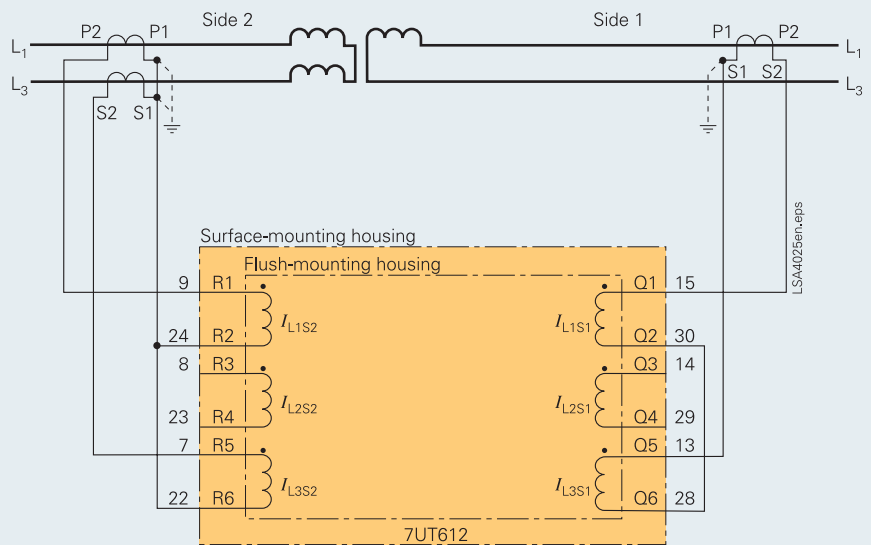


Fig. 8/23 Connection example to a single-phase power transformer with only one current transformer (right side)

Transformer Differential Protection / 7UT6

Typical connections

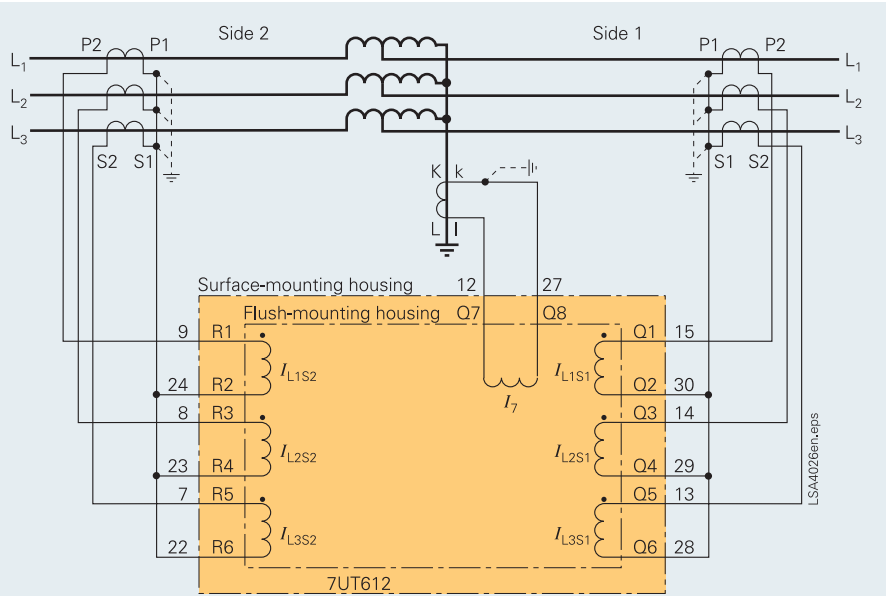


Fig. 8/24 Connection to a three-phase auto-transformer with current transformer between starpoint and grounding point

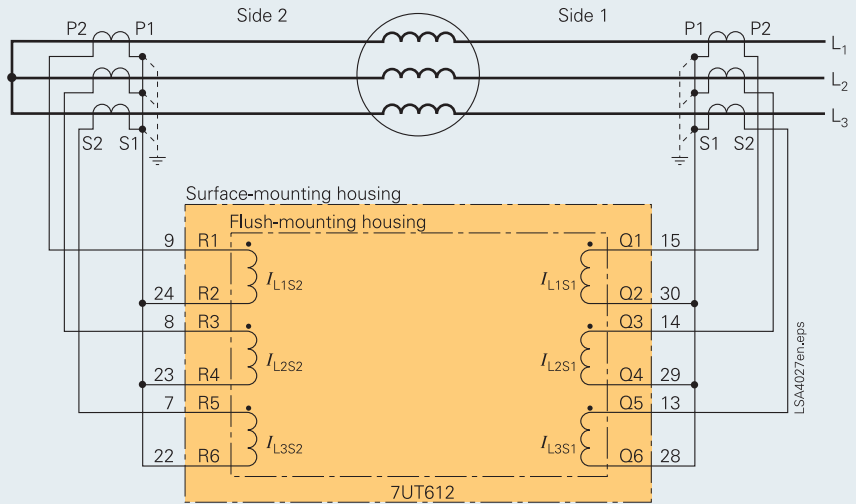


Fig. 8/25 Generator or motor protection

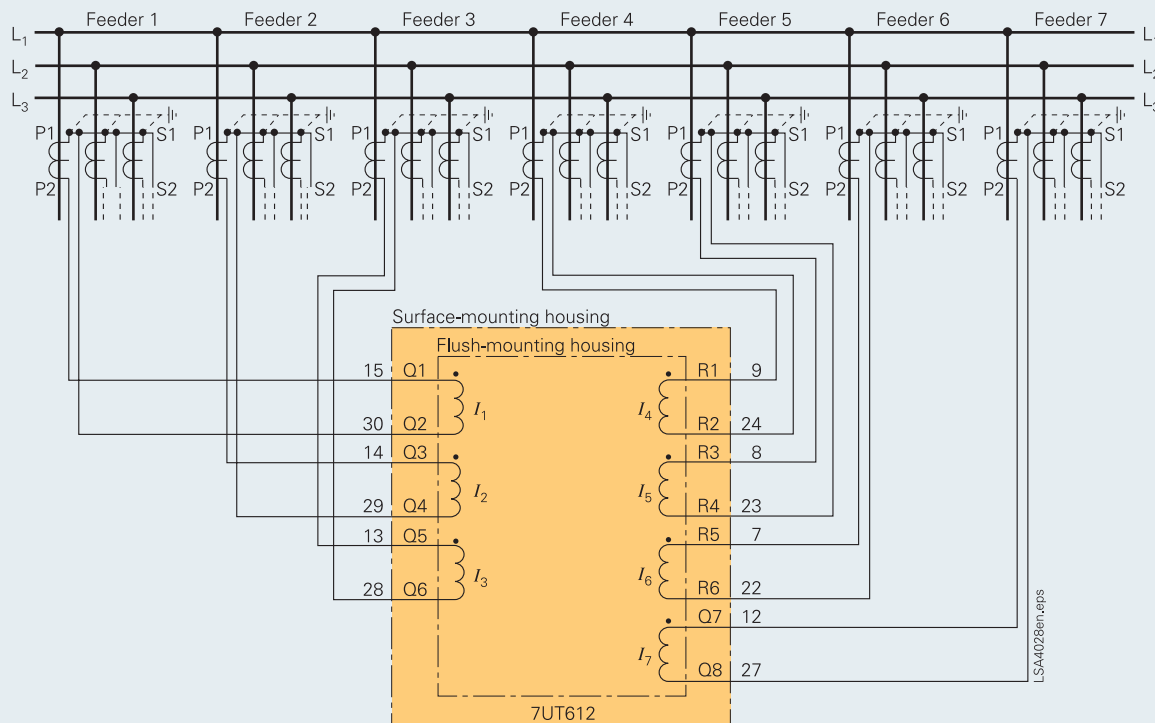


Fig. 8/26 Connection 7UT612 as single-phase busbar protection for 7 feeders, illustrated for phase L1

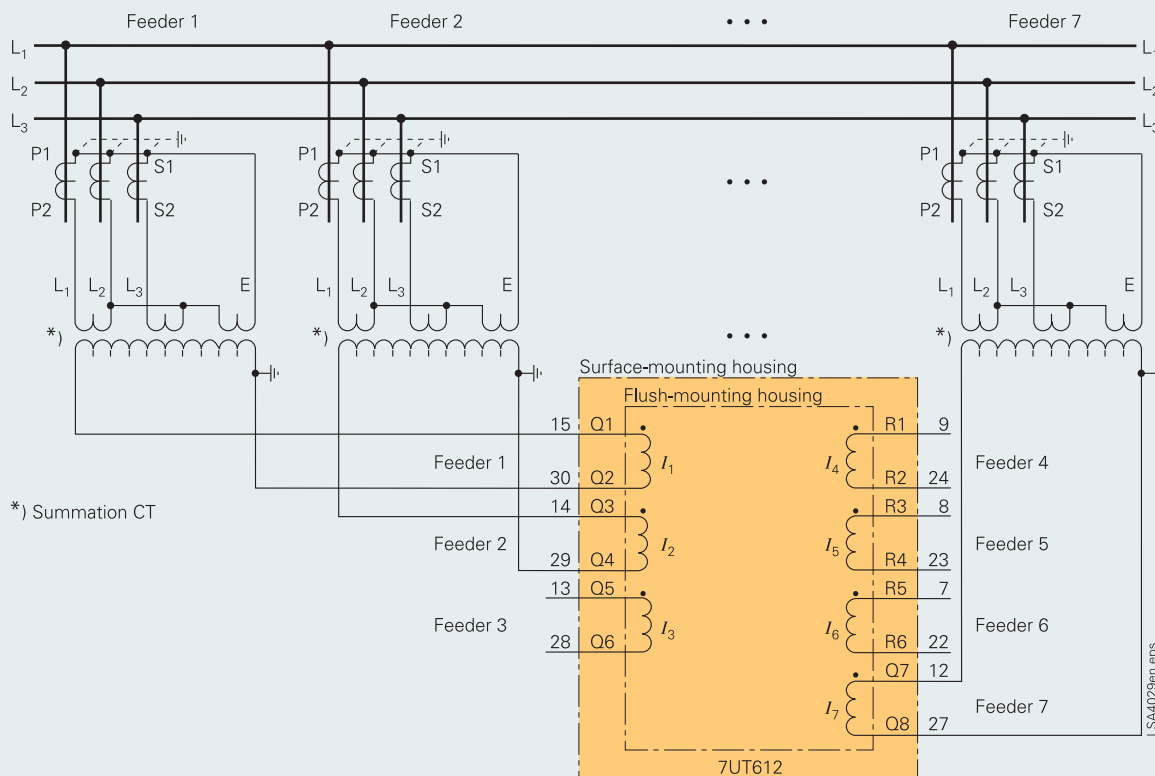


Fig. 8/27 Connection 7UT612 as busbar protection for feeders, connected via external summation current transformers (SCT) – partial illustration for feeders 1, 2 and 7

Transformer Differential Protection / 7UT6

Typical connections

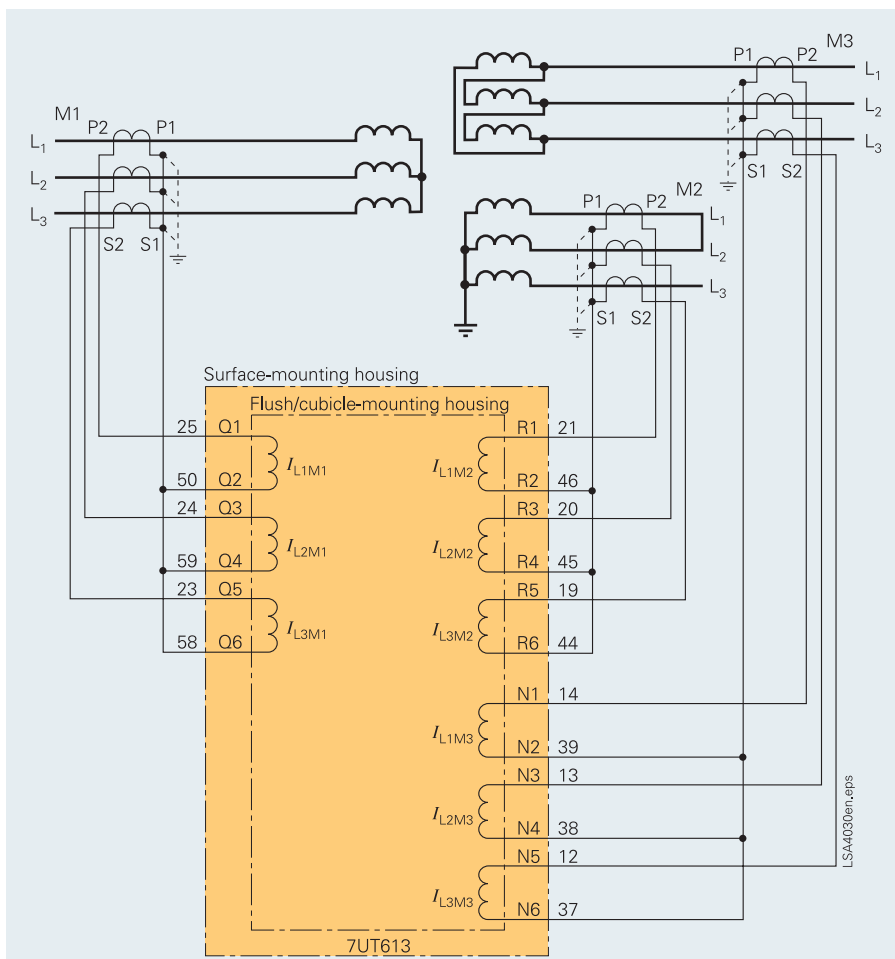


Fig. 8/28 Connection example 7UT613 for a three-winding power transformer

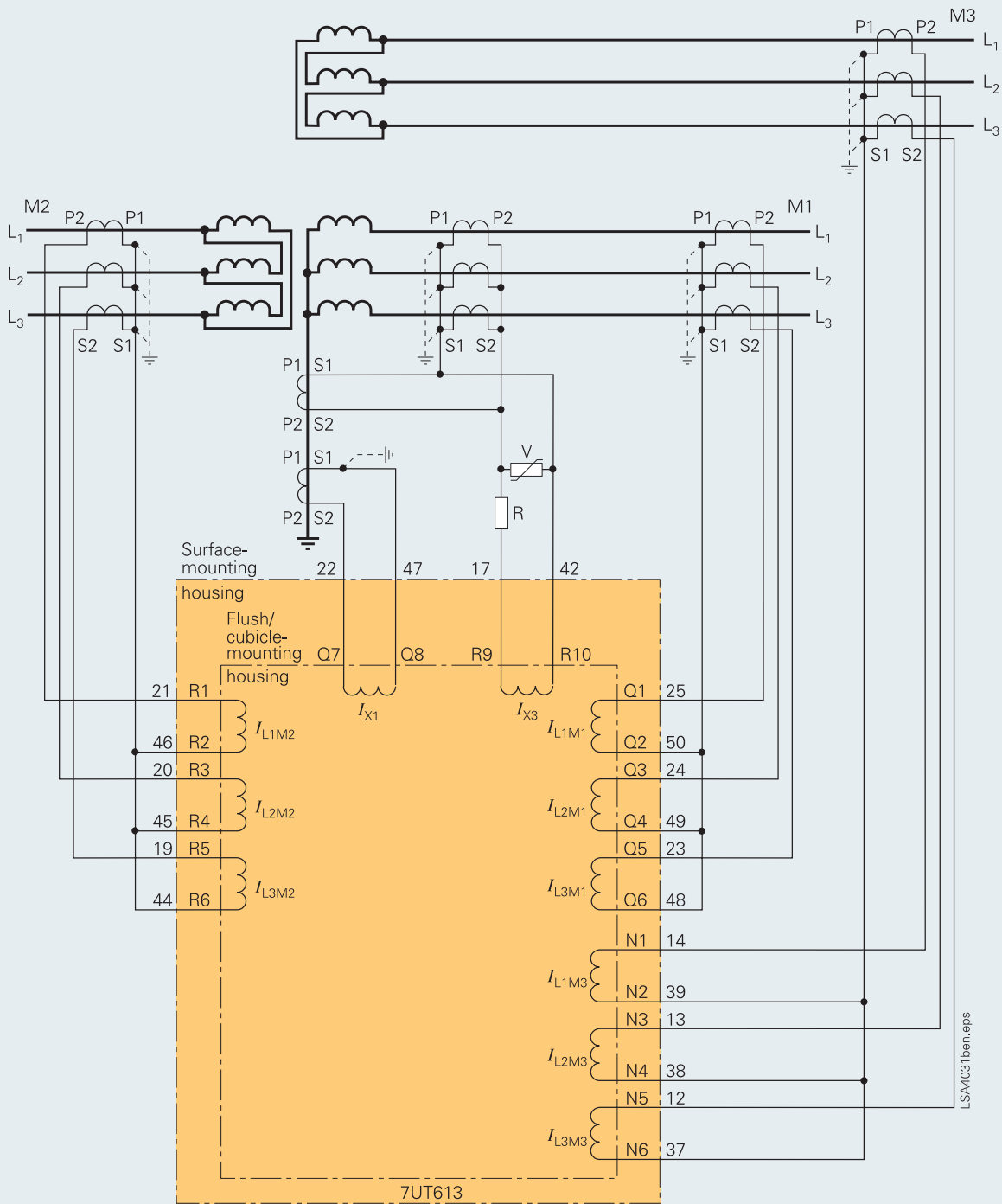


Fig. 8/29 Connection example 7UT613 for a three-winding power transformer with current transformers between starpoint and grounding point, additional connection for high-impedance protection; I_{X3} connected as high-sensitivity input

Transformer Differential Protection / 7UT6

Typical connections

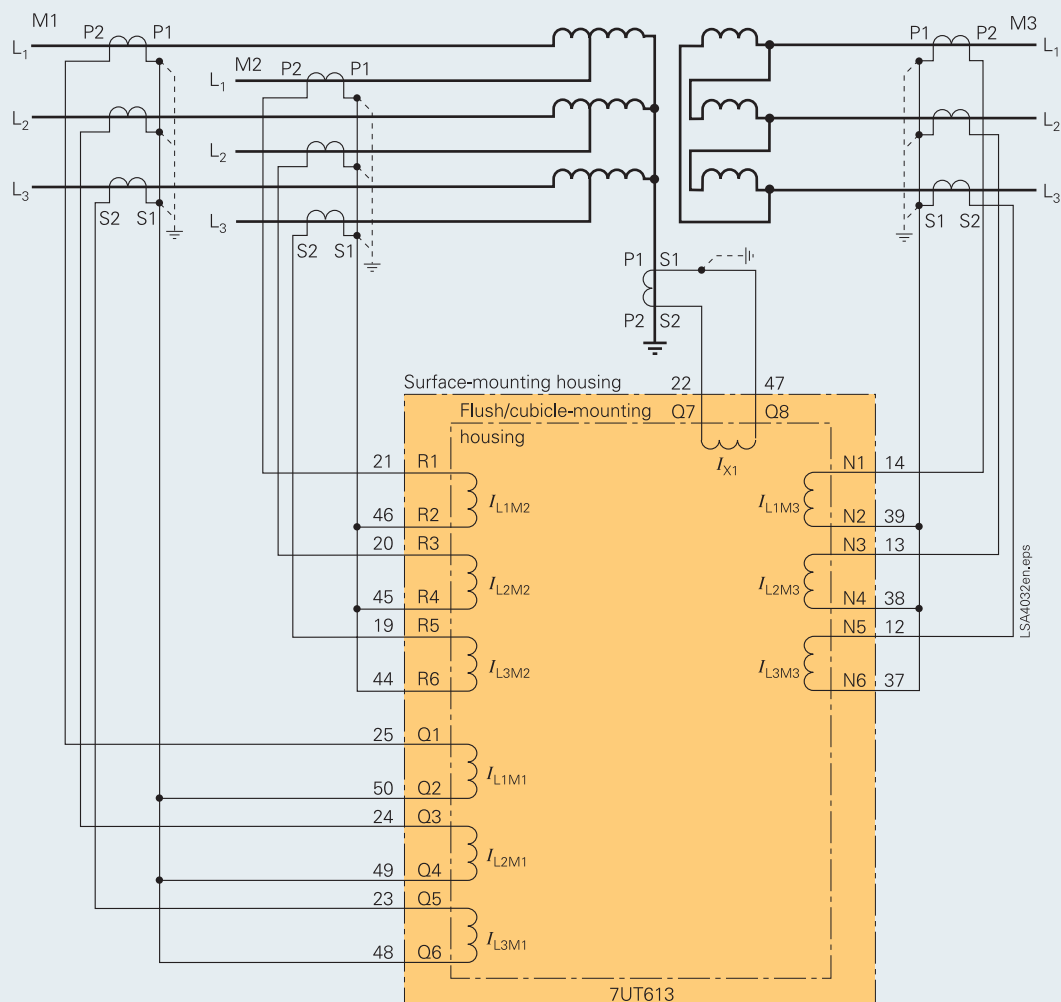


Fig. 8/30 Connection example 7UT613 for a three-phase auto-transformer with three-winding and current transformer between starpoint and grounding point

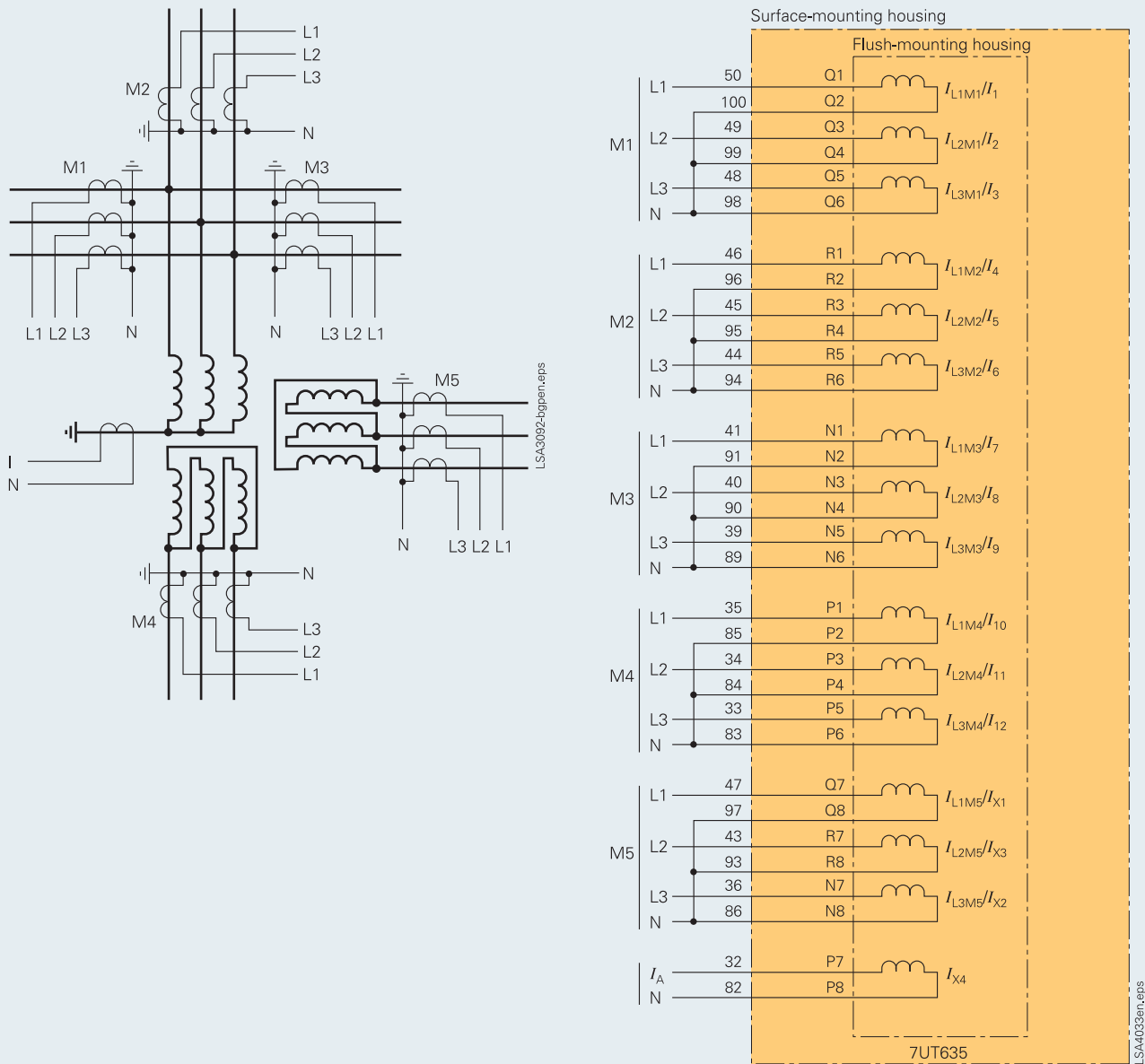


Fig. 8/31 Connection example 7UT635 for a three-winding power transformer with 5 measurement locations (3-phase) and neutral current measurement

Transformer Differential Protection / 7UT6

Typical connections

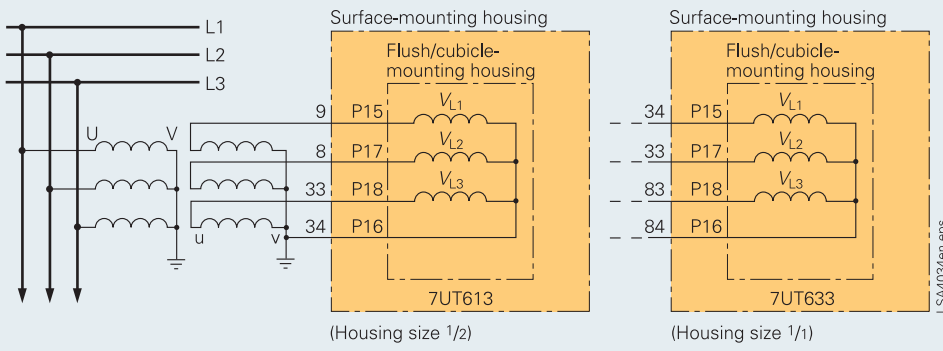


Fig. 8/32 Voltage transformer connection to 3 star-connected voltage transformers (7UT613 and 7UT633 only)

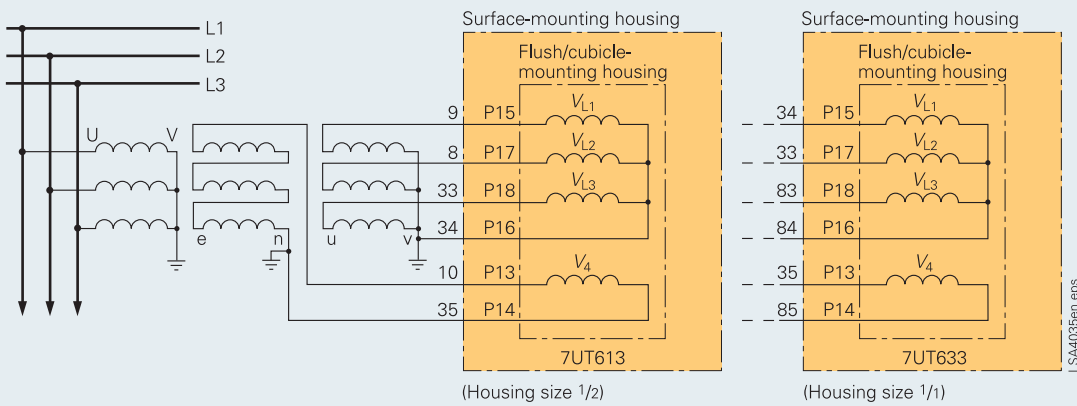


Fig. 8/33 Voltage transformer connection to 3 star-connected voltage transformers with additional delta winding (e-n-winding) (7UT613 and 7UT633 only)

Transformer Differential Protection/7UT6

Technical data

General unit data				
<i>Analog inputs</i>				
Rated frequency	50 or 60 Hz (selectable)			
Rated current	0.1 or 1 or 5 A (selectable by jumper, 0.1 A)			
Power consumption	7UT			
In CT circuits	612	613	633	635
with $I_N = 1$ A; in VA approx.	0.02	0.05	0.05	0.05
with $I_N = 5$ A; in VA approx.	0.2	0.3	0.3	0.3
with $I_N = 0.1$ A; in VA approx.	0.001	0.001	0.001	0.001
sensitive input; in VA approx.	0.05	0.05	0.05	0.05
Overload capacity	I_N			
In CT circuits	100 I_N for 1 s 30 I_N for 10 s 4 I_N continuous			
Thermal (r.m.s.)	250 I_N (half cycle)			
Dynamic (peak value)	250 I_N (half cycle)			
In CT circuits for highly sensitive input I_{EE}	300 A for 1 s 100 A for 10 s 15 A continuous 750 A (half cycle)			
Thermal	300 A for 1 s 100 A for 10 s 15 A continuous 750 A (half cycle)			
Dynamic	300 A for 1 s 100 A for 10 s 15 A continuous 750 A (half cycle)			
Rated voltage (7UT613/633 only)	80 to 125 V			
Power consumption per phase at 100 V	≤ 0.1 VA			
Overload capacity	230 V continuous			
Thermal (r.m.s.)	230 V continuous			
<i>Auxiliary voltage</i>				
Rated voltage	DC 24 to 48 V DC 60 to 125 V DC 110 to 250 V and AC 115 V (50/60 Hz), AC 230 V			
Permissible tolerance	-20 to +20 %			
Superimposed AC voltage (peak-to-peak)	≤ 15 %			
Power consumption (DC/AC)	7UT			
	612	613	633	635
Quiescent; in W approx.	5	6/12	6/12	6/12
Energized; in W approx. depending on design	7	12/19	20/28	20/28
Bridging time during failure of the auxiliary voltage $V_{aux} \geq 110$ V	≥ 50 ms			
<i>Binary inputs</i>				
Functions are freely assignable	7UT			
Quantity marshallable	612	613	633	635
	3	5	21	29
Rated voltage range	24 to 250 V, bipolar			
Minimum pickup threshold	DC 19 or 88 V (bipolar)			
Ranges are settable by means of jumpers for each binary input	DC 19 or 88 V (bipolar)			
Maximum permissible voltage	DC 300 V			
Current consumption, energized	Approx. 1.8 mA			
<i>Output relay</i>				
Command / indication / alarm relay	7UT			
Quantity each with 1 NO contact (marshallable)	612	613	633	635
1 alarm contact, with 1 NO or NC contact (not marshallable)	4	8	24	24

Switching capacity	1000 W / VA			
Make	30 VA			
Break	40 W			
Break (with resistive load)	25 W			
Break (with L/R w 50 ms)	250 V			
Switching voltage	30 A for 0.5 seconds 5 A continuous			
Permissible total current	30 A for 0.5 seconds 5 A continuous			
Operating time, approx.	NO contact 8 ms NO/NC contact (selectable) 8 ms Fast NO contact 5 ms High-speed*) NO trip outputs < 1 ms			
<i>LEDs</i>				
Quantity	7UT			
	612	613	633	635
RUN (green)	1	1	1	1
ERROR (red)	1	1	1	1
LED (red), function can be assigned	7	14	14	14
<i>Unit design</i>				
Housing 7XP20	For dimensions please refer to dimension drawings part 14			
Degree of protection acc. to IEC 60529	For the device in surface-mounting housing IP 51 in flush-mounting housing IP 51 front IP 50 rear IP 50			
For personal safety	IP 2x with closed protection cover			
Housing	7UT			
	612	613	633	635
Size, referred to 19" frame	1/3	1/2	1/1	1/1
Weight, in kg	Flush-mounting housing 5.1 8.7 13.8 14.5 Surface-mounting housing 9.6 13.5 22.0 22.7			

Serial interfaces	
<i>Operating interface 1 for DIGSI 4 or browser</i>	
Connection	Front side, non-isolated, RS232, 9-pin subminiature connector (SUB-D)
Transmission rate in kbaud	7UT612: 4.8 to 38.4 kbaud
Setting as supplied:	7UT613/633/635: 4.8 to 115 kbaud
38.4 kbaud, parity 8E1	
Distance, max.	15 m
<i>Time synchronization DCF77 / IRIG-B signal / IRIG-B000</i>	
Connection	Rear side, 9-pin subminiature connector (SUB-D) (terminals with surface-mounting housing)
Voltage levels	5, 12 or 24 V (optional)
<i>Service interface (operating interface 2) for DIGSI 4 /modem / service</i>	
Isolated RS232/RS485/FO	9-pin subminiature connector (SUB-D)
Dielectric test	500 V / 50 Hz
Distance for RS232	Max. 15 m / 49.2 ft
Distance for RS485	Max. 1000 m / 3300 ft
Distance for FO	1.5 km (1 mile)
*) With high-speed contacts all operating times are reduced by 4.5 ms.	

Transformer Differential Protection / 7UT6

Technical data

System interface		Electrical tests	
IEC 61850		Specifications	
Ethernet, electrical (EN 100) for IEC 61850 and DIGSI		Standards	IEC 60255 (Product standards) ANSI/IEEE C37.90.01.1/.2 UL 508
Connection for flush-mounting case	Rear panel, mounting location "B", two RJ45 connector, 100 Mbit acc. to IEEE802.3	Insulation tests	
Connection for surface-mounting case	At bottom part of the housing	Standards	EC 60255-5 and 60870-2-1
Test voltage	500 V; 50 Hz	Voltage test (100 % test)	2.5 kV (r.m.s.), 50 Hz / 60 Hz
Transmission Speed	100 Mb/s	All circuits except for auxiliary supply, binary inputs and communication interfaces	
Distance	20 m/66 ft	Auxiliary voltage and binary inputs (100 % test)	DC 3.5 kV
Ethernet, optical (EN 100) for IEC 61850 and DIGSI		RS485/RS232 rear side communication interfaces and time synchronization interface (100 % test)	500 V (r.m.s.), 50 Hz / 60 Hz
Connection for flush-mounting case	Rear panel, mounting location "B", LC connector receiver/transmitter	Impulse voltage test (type test)	5 kV (peak); 1.2/50 ms; 0.5 J 3 positive and 3 negative impulses at intervals of 5 s
Connection for surface-mounting case	Not available	All circuits except for communication interfaces and time synchronization interface, class III	
Optical wavelength	$\lambda = 1350$ nm	EMC tests for interference immunity	
Transmission Speed	100 Mb/s	Standards	IEC 60255-6, 60255-22 (product standards) EN 6100-6-2 (generic standard) DIN 57435 / Part 303
Laser class 1 acc. to EN 60825-1/-2	glass fiber 50/125 μ m or glass fiber 62/125 μ m	High frequency test	IEC 60255-22-1, class III and DIN 57435 / Part 303, class III 2.5 kV (peak); 1 MHz; $\tau = 15$ ms; 400 surges per s; test duration 2 s; $R_i = 200 \Omega$
Permissible path attenuation	Max. 5 dB for glass fiber 62.5/125 μ m	Electrostatic discharge	
Distance	Max. 800 m/0.5 mile	IEC 60255-22-2 class IV EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; $R_i = 330 \Omega$
IEC 60870-5-103		Irradiation with RF field, frequency sweep, IEC 60255-22-3, IEC 61000-4-3 class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz
Isolated RS232/RS485/FO	9-pin subminiature connector (SUB-D)	Irradiation with RF field, amplitude-modulated, single frequencies, IEC 60255-22-3, IEC 61000-4-3, class III	10 V/m; 80, 160, 450, 900 MHz; 80 % AM; duration > 10 s
Baud rate	4800 to 19200 baud	Irradiation with RF field, pulse-modulated, single frequencies, IEC 60255-22-3, IEC 61000-4-3/ ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 % PM
Dielectric test	500 V/50 Hz	Fast transients interference, bursts	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50 \Omega$; test duration 1 min
Distance for RS232	Max. 15 m	IEC 60255-22-4 and IEC 61000-4-4, class IV	Impulse: 1.2/50 ms
Distance for RS485	Max. 1000 m	High-energy surge voltages (SURGE), IEC 61000-4-5, installation class III	Common (longitudinal) mode: 2kV; 12 Ω , 9 μ F Differential (transversal) mode: 1kV; 2 Ω , 18 μ F
For fiber-optic cable		Auxiliary supply	
Connector type	ST connector	Common (longitude) mode: 2kV; 42 Ω , 0.5 μ F Differential (transversal) mode: 1kV; 42 Ω , 0.5 μ F	
Optical wavelength	$\lambda = 820$ nm	Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Permissible attenuation	Max. 8 dB, for glass-fiber 62.5/125 μ m		
Distance	Max. 1.5 km		
PROFIBUS RS485 (-FMS/-DP)			
Connector type	9-pin subminiature connector (SUB-D)		
Baud rate	Max. 1.5 Mbaud		
Dielectric test	500 V / 50 Hz		
Distance	Max. 1000 m (3300 ft) at w 93.75 kbaud		
PROFIBUS fiber optic (-FMS/-DP)			
Only for flush-mounting housing	ST connector		
For surface-mounting housing	Optical interface with OLM ¹⁾		
Baud rate	Max. 1.5 Mbaud		
Optical wavelength	$\lambda = 820$ nm		
Permissible attenuation	Max. 8 dB, for glass-fiber 62.5/125 μ m		
Distance	500 kbaud 1.6 km (0.99 miles) 1500 kbaud 530 m (0.33 miles)		
DNP 3.0 RS485 / MODBUS RS485			
Connector type	9-pin subminiatur connector (SUB-D)		
Baud rate	Max. 19200 baud		
Dielectric test	500 V / 50 Hz		
Distance	Max. 1000 m (3300 ft)		
DNP 3.0 Optical/MODBUS FO			
Connector type	ST connector		
Optical wavelength	$\lambda = 820$ nm		
Permissible attenuation	Max. 8 dB, for glass-fiber 62.5/125 μ m		
Distance	1.5 km (1 mile)		

1) Conversion with external OLM
For fiber-optic interface please complete Order No. at 11th position with **4** (FMS RS485) or **9** (DP RS485) and Order code **LOA** and additionally order: For single ring: SIEMENS OLM 6GK1502-3AB10
For double ring: SIEMENS OLM 6GK1502-4AB10

Electrical tests (cont'd)	
<i>EMC tests for interference immunity (cont'd)</i>	
Magnetic field with power frequency IEC 61000-4-8, IEC 60255-6 class IV	30 A/m continuous; 300 A/m for 3 s; 50 Hz, 0.5 mT; 50 Hz
Oscillatory surge withstand capability, ANSI/IEEE C37.90.1	2.5 kV (peak); 1 MHz; $\tau = 15 \mu\text{s}$; Damped wave; 400 surges per second; duration 2 s; $R_i = 200 \Omega$
Fast transient surge withstand capability, ANSI/IEEE C37.90.1	4 kV; 5/50 ns; 5 kHz; burst 15 ms; repetition rate 300 ms; both polarities; duration 1 min.; $R_i = 80 \Omega$
Damped oscillations IEC 60894, IEC 61000-4-12	2.5 kV (peak value), polarity alternating 100 kHz, 1 MHz, 10 MHz and 50 MHz, $R_i = 200 \Omega$
<i>EMC tests for interference emission (type test)</i>	
Standard	EN 50081-* (generic standard)
Conducted interference, only auxiliary supply IEC-CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC-CISPR 22	30 to 1000 MHz Limit class B

Mechanical stress tests	
<i>Vibration, shock stress and seismic vibration</i>	
<u>During operation</u>	
Standards	IEC 60255-21 and IEC 60068
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: $\pm 0.075 \text{ mm}$ amplitude; 60 to 150 Hz: 1 g acceleration frequency sweep 1 octave/min. 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal acceleration 5 g, duration 11 ms, 3 shocks each in both directions of the 3 axes
Seismic vibration IEC 60255-21-2, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: $\pm 3.5 \text{ mm}$ amplitude (horizontal axis) 1 to 8 Hz: $\pm 1.5 \text{ mm}$ amplitude (vertical axis) 8 to 35 Hz: 1 g acceleration (horizontal axis) 8 to 35 Hz: 0.5 g acceleration (vertical axis) frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
<u>During transport</u>	
Standards	IEC 60255-21 and IEC 60068
Vibration IEC 60255-21-1, class 2 IEC 60255-2-6	Sinusoidal 5 to 8 Hz: $\pm 7.5 \text{ mm}$ amplitude; 8 to 150 Hz: 2 g acceleration frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal acceleration 15 g, duration 11 ms, 3 shocks each in both directions of the 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Half-sinusoidal acceleration 10 g, duration 16 ms, 1000 shocks on each of the 3 axes in both directions

Climatic stress tests	
<i>Temperatures</i>	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C / -13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	-20 °C to +70 °C / -4 °F to +158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C / +131 °F)	-5 °C to +55 °C / +25 °F to +131 °F
– Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to +131 °F
– Limiting temperature during-transport	-25 °C to +70 °C / -13 °F to +158 °F
<i>Humidity</i>	
Permissible humidity stress It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Yearly average $\leq 75 \%$ relative humidity; on 56 days in the year up to 93 % relative humidity; ondensation not permitted

CE conformity	
This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EG previous 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 2006/95/EG previous 73/23/EEC).	
This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).	
Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1.	
This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".	

Transformer Differential Protection / 7UT6

Technical data

Functions			
<i>Differential protection</i>			
<i>General</i>			
<i>Pickup values</i>			
Differential current $I_{DIFF} > I_{Nobj}$	0.05 to 2.00	(steps 0.01)	
High-current stage $I_{DIFF} \gg I_{Nobj}$	0.5 to 35.0	(steps 0.1) or deactivated (stage ineffective)	
Pickup on switch-on (factor of $I_{DIFF} >$)	1.0 to 2.0	(steps 0.1)	
Add-on stabilization on external fault ($I_{STAB} >$ set value) I_{add-on} / I_{Nobj} action time	2.00 to 15.00	(steps 0.01) 2 to 250 cycles (steps 1 cycle) or deactivated (effective until dropout)	
Tolerances (at preset parameters) $I_{DIFF} >$ stage and characteristic $I_{DIFF} \gg$ stage	5 % of set value	5 % of set value	
<i>Time delays</i>			
Delay of $I_{DIFF} >$ stage $T_{I-DIFF} >$	0.00 to 60.00 s	(steps 0.01 s) or deactivated (no trip)	
Delay of $I_{DIFF} \gg$ stage $T_{I-DIFF} \gg$	0.00 to 60.00 s	(steps 0.01 s) or deactivated (no trip)	
Time tolerance	1 % of set value or 10 ms		
The set times are pure delay times			
<i>Transformers</i>			
<i>Harmonic stabilization</i>			
Inrush restraint ratio (2 nd harmonic) I_{2fn} / I_{fn}	10 to 80 %	(steps 1 %)	
Stabilization ratio further (n-th) harmonic (optional 3 rd or 5 th) I_{nfn} / I_{fn}	10 to 80 %	(steps 1 %)	
Crossblock function max. action time for crossblock	Can be activated / deactivated 2 to 1000 AC cycles (steps 1 cycle) or 0 (crossblock deactivated) or deactivated (active until dropout)		
<i>Operating times</i>			
Pickup time/dropout time with single-side infeed			
Pickup time (in ms) at frequency	50 Hz	60 Hz	
<u>7UT 612</u>			
$I_{DIFF} >$, min.	38	35	
$I_{DIFF} \gg$, min.	19	17	
Dropout time (in ms), approx.	35	30	
<u>7UT 613/63x</u>			
$I_{DIFF} >$, min.	30	27	
$I_{DIFF} \gg$, min.	11	11	
Dropout time (in ms), approx.	54	46	
Dropout ratio, approx.	0.7		
<i>Current matching for transformers</i>			
Vector group adaptation	0 to 11 (x 30 °) (steps 1)		
Star-point conditioning	Grounded or non-grounded (for each winding)		

<i>Generators, motors, reactors</i>			
<i>Operating times</i>			
Pickup time/dropout time with single-side infeed			
Pickup time (in ms) at frequency	50 Hz	60 Hz	
<u>7UT 612</u>			
$I_{DIFF} >$, min.	38	35	
$I_{DIFF} \gg$, min.	19	17	
Dropout time (in ms), approx.	35	30	
<u>7UT 613/63x</u>			
$I_{DIFF} >$, min.	30	27	
$I_{DIFF} \gg$, min.	11	11	
Dropout time (in ms), approx.	54	46	
Dropout ratio, approx.	0.7		
<i>Busbars, short lines</i>			
<i>Differential current monitor</i>			
Steady-state differential current monitoring $I_{DIFF\ mon} / I_{Nobj}$	0.15 to 0.80	(steps 0.01)	
Delay of blocking with differential current monitoring $T_{DIFF\ mon}$	1 to 10 s	(steps 1 s)	
<i>Feeder current guard</i>			
Trip release I_{guard} / I_{Nobj} by feeder current guard	0.20 to 2.00	(steps 0.01) or 0 (always released)	
<i>Operating times</i>			
Pickup time/dropout time with single-side infeed			
Pickup time (in ms) at frequency	50 Hz	60 Hz	
<u>7UT 612</u>			
$I_{DIFF} >$, min.	25	25	
$I_{DIFF} \gg$, min.	19	17	
Dropout time (in ms), approx.	30	30	
<u>7UT 613/63x</u>			
$I_{DIFF} >$, min.	11	11	
$I_{DIFF} \gg$, min.	11	11	
Dropout time (in ms), approx.	54	46	
Dropout ratio, approx.	0.7		

Restricted ground-fault protection		
Multiple availability	2 times (option)	
Settings		
Differential current $I_{REF} > I_{Nobj}$	0.05 to 2.00	(steps 0.01)
Limit angle φ_{REF}	110° (fixed)	
Time delay T_{REF}	0.00 to 60.00 s	(steps 0.01 s) or deactivated (no trip)
Operating times		
Pickup time (in ms) at frequency	0 Hz	60 Hz
<u>7UT 612</u>		
At 1.5 · setting value $I_{REF} >$, approx.	40	38
At 2.5 · setting value $I_{REF} >$, approx.	37	32
Dropout time (in ms), approx.	40	40
<u>7UT 613/63x</u>		
At 1.5 · setting value $I_{REF} >$, approx.	35	30
At 2.5 · setting value $I_{REF} >$, approx.	33	29
Dropout time (in ms), approx.	26	23
Dropout ratio, approx.	0.7	
Overcurrent-time protection for phase and residual currents		
Multiple availability	3 times (option)	
Characteristics		
Definite-time stages (DT)	$I_{Ph} \gg, 3I_0 \gg, I_{Ph} >, 3I_0 >$	
Inverse-time stages (IT)	$I_P, 3I_{OP}$	
Acc. to IEC	Inverse, very inverse, extremely inverse, long-time inverse	
Acc. to ANSI	Inverse, moderately inverse, very inverse, extremely inverse, definite inverse, short inverse, long inverse	
Reset characteristics (IT)	Alternatively, user-specified trip and reset characteristics	
Reset characteristics (IT)	Acc. to ANSI with disk emulation	
Current stages		
High-current stages $I_{Ph} \gg$	0.10 to 35.00 A ¹⁾ (steps 0.01 A) or deactivated (stage ineffective)	
$T_{I_{Ph}} \gg$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)	
$3I_0 \gg$	0.05 to 35.00 A ¹⁾ (steps 0.01 A) or deactivated (stage ineffective)	
$T_{3I_0} \gg$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)	
Definite-time stages $I_{Ph} >$	0.10 to 35.00 A ¹⁾ (steps 0.01 A) or deactivated (stage ineffective)	
$T_{I_{Ph}} >$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)	
$3I_0 >$	0.05 to 35.00 A ¹⁾ (steps 0.01 A) or deactivated (stage ineffective)	
$T_{3I_0} >$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)	
Inverse-time stages I_P	0.10 to 4.00 A ¹⁾ (steps 0.01 A)	
Acc. to IEC T_{I_P}	0.05 to 3.20 s (steps 0.01 s) or deactivated (no trip)	
$3I_{OP}$	0.05 to 4.00 A ¹⁾ (steps 0.01 A)	
$T_{3I_{OP}}$	0.05 to 3.20 s (steps 0.01 s) or deactivated (no trip)	
Inverse-time stages I_P	0.10 to 4.00 A ¹⁾ (steps 0.01 A)	
Acc. to ANSI D_{I_P}	0.50 to 15.00 s (steps 0.01 s) or deactivated (no trip)	
$3I_{OP}$	0.05 to 4.00 A ¹⁾ (steps 0.01 A)	
$D_{3I_{OP}}$	0.50 to 15.00 s (steps 0.01 s) or deactivated (no trip)	

Current stages (cont'd)		
Tolerances		
Definite time	Currents	3 % of set value or 1 % of rated current
	Times	1 % of set value or 10 ms
Inverse time	Currents	Pickup at $1.05 \leq III_P \leq 1.15$; or $1.05 \leq III_{IOP} \leq 1.15$
Acc. to IEC	Times	5 % ± 15 ms at $f_N = 50/60$ Hz for $2 \leq III_P \leq 20$ and $T_{I_P}/s \geq 1$; or $2 \leq III_{IOP} \leq 20$ and $T_{3I_{OP}}/s \geq 1$
Acc. to ANSI	Times	5 % ± 15 ms at $f_N = 50/60$ Hz for $2 \leq III_P \leq 20$ and $D_{I_P}/s \geq 1$; or $2 \leq III_{IOP} \leq 20$ and $D_{3I_{OP}}/s \geq 1$
The set definite times are pure delay times.		
Operating times of the definite-time stages		
Pickup time/dropout time phase current stages		
Pickup time (in ms) at frequency	50 Hz	60 Hz
<u>7UT612</u>		
Without inrush restraint, min.	20	18
With inrush restraint, min.	40	35
Dropout time (in ms), approx.	30	30
<u>7UT613/6x</u>		
Without inrush restraint, min.	11	11
With inrush restraint, min.	33	29
Dropout time (in ms), approx.	35	35
Pickup time/dropout time residual current stages		
Pickup time (in ms) at frequency	50 Hz	60 Hz
<u>7UT612</u>		
Without inrush restraint, min.	40	35
With inrush restraint, min.	40	35
Dropout time (in ms), approx.	30	30
<u>7UT613/6x</u>		
Without inrush restraint, min.	21	19
With inrush restraint, min.	31	29
Dropout time (in ms), approx.	45	43
Dropout ratios		
Current stages	Approx. 0.95 for $III_N \leq 0.5$	
Inrush blocking		
Inrush blocking ratio (2 nd harmonic) I_{2fN}/I_{fN}	10 to 45 % (steps 1 %)	
Lower operation limit	$I > 0.2 A^{1)}$	
Max. current for blocking	0.30 to 25.00 A ¹⁾ (steps 0.01 A)	
Crossblock function between phases	Can be activated/deactivated	
max. action time for crossblock	0.00 to 180 s (steps 0.01 A)	
1) Secondary values based on $I_N = 1 A$; for $I_N = 5 A$ they must be multiplied by 5.		

Transformer Differential Protection / 7UT6

Technical data

Overcurrent-time protection for ground current		
Multiple availability	3 times (option)	
Characteristics		
Definite-time stages (DT)	$I_E \gg, I_E >$	
Inverse-time stages (IT)	I_{EP}	
Acc. to IEC	Inverse, very inverse, extremely inverse, long-time inverse	
Acc. to ANSI	Inverse, moderately inverse, very inverse, extremely inverse, definite inverse, short inverse, long inverse	
	Alternatively, user-specified trip and reset characteristics	
Reset characteristics (IT)	Acc. to ANSI with disk emulation	
Current stages		
High-current stage	$I_E \gg$	0.05 to 35.00 A ¹⁾ (steps 0.01 A) or deactivated (stage ineffective)
	$T_{IE} \gg$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
Definite-time stage	$I_E >$	0.05 to 35.00 A ¹⁾ (steps 0.01 A) or deactivated (stage ineffective)
	$T_{IE} >$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
Inverse-time stages	I_{EP}	0.05 to 4.00 A ¹⁾ (steps 0.01 A)
Acc. to IEC	T_{IEP}	0.05 to 3.20 s (steps 0.01 s) or deactivated (no trip)
Inverse-time stages	I_{EP}	0.05 to 4.00 A ¹⁾ (steps 0.01 A)
Acc. to ANSI	D_{IEP}	0.50 to 15.00 s (steps 0.01 s) or deactivated (no trip)
Tolerances		
Definite time	Currents	3 % of set value or 1 % of rated current
	Times	1 % of set value or 10 ms
Inverse time	Currents	Pickup at $1.05 \leq III_{EP} \leq 1.15$
Acc. to IEC	Times	5 % ± 15 ms at $f_N = 50/60$ Hz for $2 \leq III_{EP} \leq 20$ and $T_{IEP/s} \geq 1$
Acc. to ANSI	Times	5 % ± 15 ms at $f_N = 50/60$ Hz for $2 \leq III_{EP} \leq 20$ and $D_{IEP/s} \geq 1$
The set definite times are pure delay times.		
Operating times of the definite-time stages		
Pickup time / dropout time	50 Hz	60 Hz
Pickup time (in ms) at frequency		
<u>7UT612</u>		
Without inrush restraint, min.	20	18
With inrush restraint, min.	40	35
Dropout time (in ms), approx.	30	30
<u>7UT613/63x</u>		
Without inrush restraint, min.	11	11
With inrush restraint, min.	33	29
Dropout time (in ms), approx.	35	35
Dropout ratios		
Current stages	Approx. 0.95 for $III_N \geq 0.5$	
Inrush blocking		
Inrush blocking ratio (2 nd harmonic) I_{2N}/I_{fN}	10 to 45 %	(steps 1 %)
Lower operation limit	$I > 0.2$ A ¹⁾	
Max. current for blocking	0.30 to 25.00 A ¹⁾	steps 0.01 A)
1) Secondary values based on $I_N = 1$ A; for $I_N = 5$ A they must be multiplied by 5.		

Dynamic cold-load pickup for overcurrent-time protection		
Time control		
Start criterion	Binary input from circuit-breaker auxiliary contact or current criterion (of the assigned side)	
CB open time	$T_{CB\ open}$	0 to 21600 s (= 6 h) (steps 1 s)
Active time	$T_{Active\ time}$	1 to 21600 s (= 6 h) (steps 1 s)
Accelerated dropout time	$T_{Stop\ time}$	1 to 600 s (= 10 min) (steps 1 s) or deactivated (no accelerated dropout)
Setting ranges and changeover values		
Dynamic parameters of current pickup and delay times or time multipliers	Setting ranges and steps are the same as for the functions to be influenced	
Single-phase overcurrent-time protection		
Current stages		
High-current stage	$I \gg$	0.05 to 35.00 A ¹⁾ (steps 0.01 A) or deactivated (stage ineffective)
	$T_T \gg$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
Definite-time stage	$I >$	0.05 to 35.00 A ¹⁾ (steps 0.01 A) or deactivated (stage ineffective)
	$T_I >$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
Tolerances	Currents	3 % of set value or 1 % of rated current at $I_N = 1$ A or 5 A; 5 % of set value or 3 % of rated current at $I_N = 0.1$ A
	Times	1 % of set value or 10 ms
Operating times		
Pickup time (in ms) at frequency	50 Hz	60 Hz
<u>7UT612</u>		
Minimum	20	18
Dropout time (in ms), approx.	30	27
<u>7UT613/63x</u>		
Minimum	14	13
Dropout time (in ms), approx.	25	22
Dropout ratios		
Current stages	Approx. 0.95 for $III_N \geq 0.5$	
2) Secondary values for high-sensitivity current input I_B , independent of rated current.		

Unbalanced load protection (Negative-sequence protection)		
Characteristics		
Definite-time stages (DT)	$I_2 \gg, I_2 >$	
Inverse-time stages (IT) Acc. to IEC	I_{2P} Inverse, very inverse, extremely inverse	
Acc. to ANSI	Inverse, moderately inverse, very inverse, extremely inverse	
Reset characteristics (IT)	Acc. to ANSI with disk emulation	
Operating range	0.1 to 4 A ¹⁾	
Current stages		
High-current stage	$I_2 \gg$ $T_{I2} \gg$	0.10 to 3.00 A ¹⁾ (steps 0.01 A) 0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
Definite-time stage	$I_2 >$ $T_{I2} >$	0.10 to 3.00 A ¹⁾ (steps 0.01 A) 0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
Inverse-time stages Acc. to IEC	I_{2P} T_{I2P}	0.10 to 2.00 A ¹⁾ (steps 0.01 A) 0.05 to 3.20 s (steps 0.01 s) or deactivated (no trip)
Inverse-time stages Acc. to ANSI	I_{2P} D_{I2P}	0.10 to 2.00 A ¹⁾ (steps 0.01 A) 0.50 to 15.00 s (steps 0.01 s) or deactivated (no trip)
Tolerances		
Definite-time	Currents	3 % of set value or 1 % of rated current
	Times	1 % of set value or 10 ms
Inverse time Acc. to IEC	Currents	Pickup at $1.05 \leq III_{EP} \leq 1.15$
	Times	5 % ± 15 ms at $f_N = 50/60$ Hz for $2 \leq III_{EP} \leq 20$ and $T_{IEP/s} \geq 1$
Acc. to ANSI	Times	5 % ± 15 ms at $f_N = 50/60$ Hz for $2 \leq III_{EP} \leq 20$ and $D_{IEP/s} \geq 1$
The set definite times are pure delay times.		
Operating times of the definite-time stages		
Pickup time/dropout time		
Pickup time (in ms) at frequency	50 Hz	60 Hz
7UT612		
Minimum	50	45
Dropout time (in ms), approx.	30	30
7UT613/63x		
Minimum	41	34
Dropout time (in ms), approx.	23	20
Dropout ratios		
Current stages	Approx. 0.95 for $I_2/I_N \geq 0.5$	
Thermal overload protection		
Overload protection using a thermal replica		
Multiple availability	2 times (option)	
Setting ranges		
Factor k acc. IEC 60255-8	0.10 to 4.00 (steps 0.01)	
Time constant τ	1.0 to 999.9 min (steps 0.1 min)	
Cooling down factor at motor stand-still (for motors) K τ -factor	1.0 to 10.0 (steps 0.1)	
Thermal alarm stage $\Theta_{alarm}/\Theta_{trip}$	50 to 100 % referred to trip temperature rise (steps 1 %)	
Current-based alarm stage I_{alarm}	0.10 to 4.00 A ¹⁾ (steps 0.01 A)	
Start-up recognition (for motors) $I_{start-up}$	0.60 to 10.00 A ¹⁾ (steps 0.01 A) or deactivated (no start-up recognition)	
Emergency start run-on time (for motors) T_{run-on}	10 to 15000 s (steps 1 s)	

Overload protection using a thermal replica (continued)		
Tripping characteristics		
Tripping characteristic for $II(k \cdot I_N) \leq 8$	$t = \tau \cdot I_N \frac{\left(\frac{I}{k \cdot I_N}\right)^2 - \left(\frac{I_{pre}}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1}$	
	t Tripping time τ Heating-up time constant I Actual load current I_{pre} Preload current k Setting factor IEC 60255-8 I_N Rated current of the protected object	
Dropout ratios		
Θ/Θ_{trip}	Dropout at Θ_{alarm}	
Θ/Θ_{alarm}	Approx. 0.99	
II_{alarm}	Approx. 0.97	
Tolerances		
(with one 3-phase measuring location)		
Referring to $k \cdot I_N$	3 % or 10 mA ¹⁾ ; class 3 % acc. IEC 60255-8	
Referring to tripping time	3 % or 1 s at $f_N = 50/60$ Hz for $II(k \cdot I_N) > 1.25$	
Frequency influence referring to $k \cdot I_N$		
In the range $0.9 \leq f/f_N \leq 1.1$	1 % at $f_N = 50/60$ Hz	
Hot-spot calculation and determination of the ageing rate		
Thermo-box (temperature monitoring box)		
Number of measuring points	From 1 thermo-box (up to 6 temperature sensors) or from 2 thermo-boxes (up to 12 temperature sensors)	
For hot spot calculation <i>one</i> temperature sensor must be connected.		
Cooling		
Cooling method	ON (oil natural) OF (oil forced) OD (oil directed)	
Oil exponent Y	1.6 to 2.0 (steps 0.1)	
Hot spot to top-oil gradient H_{gr}	22 to 29 (steps 1)	
Annunciation thresholds		
Warning temperature hot spot	98 to 140 °C (steps 1 °C) 208 to 284 °F (steps 1 °F)	
Alarm temperature hot spot	98 to 140 °C (steps 1 °C) 208 to 284 °F (steps 1 °F)	
Warning ageing rate	0.125 to 128.000 (steps 0.001)	
Alarm ageing rate	0.125 to 128.000 (steps 0.001)	
1) Secondary values based on $I_N = 1$ A; for $I_N = 5$ A they must be multiplied by 5.		

Transformer Differential Protection / 7UT6

Technical data

Thermo-boxes for overload protection	
Thermo-boxes (connectable)	1 or 2
Number of temperature sensors per thermo-box	Max. 6
Measuring type	Pt 100 Ω or Ni 100 Ω or Ni 120 Ω
Annunciation thresholds	
For each measuring point:	
Warning temperature (stage 1)	-50 to 250 °C (steps 1 °C) -58 to 482 °F (steps 1 °F) or deactivated (no warning)
Alarm temperature (stage 2)	-50 to 250 °C (steps 1 °C) -58 to 482 °F (steps 1 °F) or deactivated (no alarm)
Breaker failure protection	
Multiple availability	2 times (option)
Setting ranges	
Current flow monitoring	0.04 to 1.00 A ¹⁾ (steps 0.01 A) for the respective side
Dropoff to pickup ratio	Approx. 0.9 for $I \geq 0.25 A^1$
Pickup tolerance	5 % of set value or 0.01 A ¹⁾
Breaker status monitoring	Binary input for CB auxiliary contact
Starting conditions	
For breaker failure protection	Internal trip External trip (via binary input)
Times	
Pickup time	Approx. 2 ms (7UT613/63x) and approx. 3 ms (7UT612) with measured quantities present; Approx. 20 ms after switch-on of measured quantities, $f_N = 50/60$ Hz
Reset time (incl. output relay), approx.	50 Hz 60 Hz
7UT612	30 ms 30 ms
7UT613/63x	25 ms 25 ms
Delay times for all stages	0.00 to 60.00 s; deactivated (steps 0.01 s)
Time tolerance	1 % of setting value or 10 ms
Overexcitation protection (Volt /Hertz) (7UT613 / 633 only)	
Setting ranges	
Pickup threshold alarm stage	1 to 1.2 (steps 0.01)
Pickup threshold $V/f >>$ -stage	1 to 1.4 (steps 0.01)
Time delays T	0 to 60 s (steps 0.01 s) or deactivated
Characteristic values of V/f and assigned times t (V/f)	1.05/1.1/1.15/1.2/1.25/1.3/1.35/1.4
Cooling down time $T_{cooling}$	0 to 20000 s (steps 1 s)
Times (in ms) (alarm and $V/f >>$ -stage)	50 Hz 60 Hz
Pickup times at 1.1 of set value, approx.	36 31
Drop-off times, approx.	28 23
Drop-off ratio (alarm, trip)	0.95
Tolerances	
V/f -Pickup	3 % of set value
Time delays T	1 % or 10 ms
Thermal characteristic (time)	5 % rated to V/f or 600 ms
1) Secondary values based on $I_N = 1$ A; for $I_N = 5$ A they must be multiplied by 5.	
Undervoltage protection (definite-time and inverse-time function) (ANSI 27)	
Setting range	
Undervoltage pickup $V<$, $V<<$, $V_{p<}$ (positive sequence as phase-to-phase values)	10 to 125 V (steps 0.1 V)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Time multiplier T_M	0.1 to 5 s (steps 0.01 s)
Times	
Pickup time $V<$, $V<<$	Approx. 50 ms
Drop-off time $V<$, $V<<$	Approx. 50 ms
Drop-off ratio $V<$, $V<<$, $V_{p<}$	1.01 or 0.5 V
Tolerances	
Voltage limit values	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms
Inverse-time characteristic	1 % of measured value of voltage
Overvoltage protection (ANSI 59)	
Setting ranges	
Overvoltage pickup $V>$, $V>>$ (maximum phase-to-phase voltage or phase-to-ground-voltage)	30 to 170 V (steps 0.1 V)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup times $V>$, $V>>$	Approx. 50 ms
Drop-off times $V>$, $V>>$	Approx. 50 ms
Drop-off ratio $V>$, $V>>$	0.9 to 0.99 (steps 0.01)
Tolerances	
Voltage limit value	1 % of set value 0.5 V
Time delays T	1 % or 10 ms
Frequency protection (ANSI 81)	
Setting ranges	
Steps; selectable $f>$, $f<$	4
Pickup values $f>$, $f<$	40 to 65 Hz (steps 0.01 Hz)
Time delays T	3 stages 0 to 100 s, 1 stage up to 600 s
Undervoltage blocking $V_1<$	(steps 0.01 s) 10 to 125 V (steps 0.1 V)
Times	
Pickup times $f>$, $f<$	Approx. 100 ms
Drop-off times $f>$, $f<$	Approx. 100 ms
Drop-off difference Δf	Approx. 20 mHz
Drop-off ratio $V_1<$	Approx. 1.05
Tolerances	
Frequency	10 mHz (at $V > 0.5 V_N$)
Undervoltage blocking	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms
Reverse-power protection (ANSI 32R)	
Setting ranges	
Reverse power $P_{Rev.>}/S_N$	- 0.5 to - 30 % (steps 0.01 %)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off time	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off ratio $P_{Rev.>}$	Approx. 0.6
Tolerances	
Reverse power $P_{Rev.>}$	0.25 % $S_N \pm 3$ % set value
Time delays T	1 % or 10 ms

Forward-power protection (ANSI 32F)	
Setting ranges	
Forward power $P_{\text{Forw.}} < /S_N$	0.5 to 120 % (steps 0.1 %)
Forward power $P_{\text{Forw.}} > /S_N$	1 to 120 % (steps 0.1 %)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time (accurate measuring)	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Pickup time (fast measuring)	Approx. 60 ms (50 Hz); Approx. 50 ms (60 Hz)
Drop-off time (accurate measuring)	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off time (fast measuring)	Approx. 60 ms (50 Hz); Approx. 50 ms (60 Hz)
Drop-off ratio $P_{\text{Forw.}} <$	1.1 or 0.5 % of S_N
Drop-off ratio $P_{\text{Forw.}} >$	Approx. 0.9 or - 0.5 % of S_N
Tolerances	
Active power $P_{\text{Forw.}} <, P_{\text{Forw.}} >$	0.25 % $S_N \pm 3$ % of set value at $Q < 0.5 S_N$ at accurate measuring 0.5 % $S_N \pm 3$ % of set value at $Q < 0.5 S_N$ at fast measuring
Time delays T	1 % or 10 ms
External trip commands	
Binary inputs	
Number of binary inputs for direct tripping	2
Operating time	Approx. 12.5 ms min. Approx. 25 ms typical
Dropout time	Approx. 25 ms
Delay time	0.00 to 60.00 s (steps 0.01 s)
Expiration tolerance	1 % of set value or 10 ms
The set definite times are pure delay times.	
Transformer annunciations	
External annunciations	Buchholz warning Buchholz tank Buchholz tripping
Measured quantities supervision	
Current symmetry (for each measurement location)	$ I_{\text{min}} / I_{\text{max}} < \text{BAL. FAKT. } I$ if $I_{\text{max}} / I_N > \text{BAL. } I \text{ LIMIT} / I_N$ BAL. FAKT. I 0.10 to 0.90 (steps 0.01) BAL. $I \text{ LIMIT}$ 0.10 to 1.00 A ¹⁾ (steps 0.01 A)
Voltage symmetry (if voltages applied)	$ V_{\text{min}} / V_{\text{max}} < \text{BAL. FAKT.}$ if $ V_{\text{max}} > \text{BALANCE V-LIMIT}$
Voltage sum (if voltages applied)	$ \underline{V}_{L1} + \underline{V}_{L2} + \underline{V}_{L3} - \text{kV} \cdot \underline{V}_{\text{EN}} > 25 \text{ V}$
Current phase sequence	\underline{I}_{L1} before \underline{I}_{L2} before \underline{I}_{L3} (clockwise) or \underline{I}_{L1} before \underline{I}_{L3} before \underline{I}_{L2} (counter-clockwise) if $ \underline{I}_{L1} , \underline{I}_{L2} , \underline{I}_{L3} > 0.5 I_N$
Voltage phase sequence (if voltages applied)	\underline{V}_{L1} before \underline{V}_{L2} before \underline{V}_{L3} (clockwise) or \underline{V}_{L1} before \underline{V}_{L3} before \underline{V}_{L2} (counter-clock) if $ \underline{V}_{L1} , \underline{V}_{L2} , \underline{V}_{L3} > 40 \text{ V}/\sqrt{3}$
Broken wire	Unexpected instantaneous current value and current interruption or missing zero crossing
Fuse failure monitor	
	detects failure of the measured voltage

Trip circuit supervision	
Trip circuits	
Number of supervised trip circuits	1
Operation of each trip circuit	With 1 binary input or with 2 binary inputs
Flexible protection functions (ANSI 27, 32, 47, 50, 55, 59, 81)	
N°. of selectable stages	12
Operating modes / measuring quantities	Measurement location or side selectable
3-phase	$I, I_1, I_2, 3I_0, V, V_1, V_2, V_0, P, Q, \cos \varphi$
1-phase	$I, I_E, I_{E \text{ sens.}}, V, P, Q, \cos \varphi$
Without fixed phase relation	f , binary input
Pickup when	Exceeding or falling below threshold value
Setting ranges	
Current $I, I_1, I_2, 3I_0, I_E$	0.05 to 35 A (steps of 0.01 A)
Sens. ground curr. $I_{E \text{ sens.}}$	0.001 to 1.5 A (steps of 0.001 A)
Voltages V, V_1, V_2, V_0	1 to 170 V (steps of 0.1 V)
Displacement voltage V_E	1 to 200 V (steps of 0.1 V)
Power P, Q	1.6 to 3000 W (steps of 0.1 W)
Power P, Q (side)	0.01 to 17 $P/S_N, Q/S_N$, (steps of 0.01)
Power factor ($\cos \varphi$)	- 0.99 to + 0.99 (steps of 0.01)
Frequency $f_N = 50/60 \text{ Hz}$	10 to 66 Hz (steps of 0.01 Hz)
Pickup delay time	0 to 60 s (steps of 0.01 s)
Trip delay time	0 to 3600 s (steps of 0.01 s)
Dropout delay time	0 to 60 s (steps of 0.01 s)
Times	On request (see Manual)
Dropout times	On request (see Manual)
Tolerances	On request (see Manual)

Additional functions			
Operational measured values			
– Operational measured values of currents, 3-phase for each side and measurement location	$I_{L1}; I_{L2}; I_{L3}$	in A primary and secondary and % of I_N	
Tolerance at $I_N = 1$ or 5 A		1 % of measured value or 1 % of I_N	
Tolerance at $I_N = 0.1$ A		2 % of measured value or 2 % of I_N	
– Operational measured values of currents, 3-phase for each side and measurement location	$3I_0; I_1; I_2$	in A primary and secondary and % of I_N	
Tolerance		2 % of measured value or 2 % of I_N	
– Operational measured values of currents			
1-phase for each measurement location		in A primary and secondary and % of I_N	
Tolerance at $I_N = 1$ or 5 A		1 % of measured value or 1 % of I_N	
Tolerance at $I_N = 0.1$ A		2 % of measured value or 2 % of I_N	
For high-sensitivity inputs		in A primary and secondary	
Tolerance		1 % of measured value or 2 mA	
	Feeder	Further	High-sensitivity
7UT612	I_1 to I_7	I_7 to I_8	I_8
7UT613	I_1 to I_9	I_{X1} to I_{X3}	I_{X3}
7UT633	I_1 to I_9	I_{X1} to I_{X3}	I_{X3}
7UT635	I_1 to I_{12}	I_{X1} to I_{X4}	I_{X3}, I_{X4}
– Phase angles of currents, 3-phase for each measurement location			$\varphi (I_{L1}); \varphi (I_{L2}); \varphi (I_{L3})$ in °, referred to $\varphi (I_{L1})$
Tolerance			1 ° at rated current

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Technical data

Operational measured values (cont'd)																					
– Phase angles of currents, 7UT612 7UT613 7UT633 7UT635 1-phase for each measurement location Tolerance	$\varphi (I_1)$ to $\varphi (I_8)$ $\varphi (I_1)$ to $\varphi (I_9)$, $\varphi (I_{x1})$ to $\varphi (I_{x3})$ $\varphi (I_1)$ to $\varphi (I_9)$, $\varphi (I_{x1})$ to $\varphi (I_{x4})$ $\varphi (I_1)$ to $\varphi (I_{12})$, $\varphi (I_{x1})$ to $\varphi (I_{x4})$ in °, referred to $\varphi (I_1)$ 1° at rated current																				
– Operational measured values of voltages (7UT613/633 only) 3-phase (if voltage applied) Tolerance Tolerance 1-phase (if voltage applied) Tolerance	in kV primary and V secondary and % of V_N V_{L1-E} , V_{L2-E} , V_{L3-E} , V_{L1-L2} , V_{L2-L3} , V_{L3-L1} , 0.2 % of measured value or + 0.2 V V_1 , V_2 , V_0 , 0.4 % of measured value or + 0.4 V V_{EN} or V_4 0.2 % of measured value or + 0.2 V																				
– Phase angles of voltages (7UT613/633 only, if voltages applied) Tolerance	$\varphi (V_{L1-E})$, $\varphi (V_{L2-E})$, $\varphi (V_{L3-E})$, $\varphi (V_4)$, $\varphi (V_{EN})$ 1° at rated voltage																				
– Operational measured values of frequency Range Tolerance	f in Hz and % of f_N 10 to 75 Hz 1 % within range $f_N \pm 10\%$ and $I \geq I_N$																				
– Operational measured values of power	<table border="1"> <thead> <tr> <th></th> <th>S</th> <th>P</th> <th>Q</th> </tr> </thead> <tbody> <tr> <td>7UT612</td> <td>x</td> <td>–</td> <td>–</td> </tr> <tr> <td>7UT613</td> <td>x</td> <td>x</td> <td>x</td> </tr> <tr> <td>7UT633</td> <td>x</td> <td>x</td> <td>x</td> </tr> <tr> <td>7UT635</td> <td>x</td> <td>–</td> <td>–</td> </tr> </tbody> </table>		S	P	Q	7UT612	x	–	–	7UT613	x	x	x	7UT633	x	x	x	7UT635	x	–	–
	S	P	Q																		
7UT612	x	–	–																		
7UT613	x	x	x																		
7UT633	x	x	x																		
7UT635	x	–	–																		
S (apparent power)	Applied or rated voltage																				
P (active power)	Only if voltage applied, 7UT613/633 only																				
Q (reactive power)	Only if voltage applied, 7UT613/633 only, in kVA; MVA; GVA primary																				
– Operational measured value of power factor	$\cos \varphi$ (p.f.) Only if voltage applied, 7UT613/633 only																				
– Overexcitation Tolerance	V/f Only if voltage applied, 7UT613/633 only 2 % of measured value																				
– Operational measured values for thermal value	Θ_{L1} ; Θ_{L2} ; Θ_{L3} ; Θ_{res} , referred to tripping temperature rise Θ_{trip}																				
– Operational measured values (Overload protection acc. to IEC 60354)	$\Theta_{thermo-box1}$ to $\Theta_{thermo-box12}$ in °C or °F relative aging rate, load reserve																				
– Measured values of differential protection Tolerance (with preset values)	$I_{DIFF L1}$; $I_{DIFF L2}$; $I_{DIFF L3}$; $I_{REST L1}$; $I_{REST L2}$; $I_{REST L3}$ in % of operational rated current 2 % of measured value or 2 % of I_N (50/60 Hz) 3 % of measured value or 3 % of I_N (16.7 Hz)																				
– Measured values of restricted ground-fault protection Tolerance (with preset values)	$I_{DIFF REF}$; $I_{REST REF}$ in % of operational rated current 2 % of measured value or 2 % of I_N (50/60 Hz) 3 % of measured value or 3 % of I_N (16.7 Hz)																				
Max. / Min. / Mean report																					
Report of measured values	With date and time from all sides and measurement locations																				

Reset, automatic	Time of day adjustable (in minutes, 0 to 1439 min) Time frame and starting time adjustable (in days, 1 to 365 days, and ∞)
Reset, manual	Using binary input, using keypad, via communication
Min./max./mean values for current	I_{L1} , I_{L2} , I_{L3} , I_1 (positive-sequence component) I_2 (negative-sequence component), $3I_0$, $I_{DIFF L1}$, $I_{DIFF L2}$, $I_{DIFF L3}$, $I_{RESTR.L1}$, $I_{RESTR.L2}$, $I_{RESTR.L3}$
Min./max./mean values for voltages	V_{L1-E} , V_{L2-E} , V_{L3-E} V_1 (positive-sequence component) V_2 (negative-sequence component) V_0 , V_E , V_{L1-L2} , V_{L2-L3} , V_{L3-L1}
Min./max./mean values for power	S, P, Q, $\cos \varphi$, frequency
Min./max. for mean values	see above
Fault event log	
Storage of the messages of the last 8 faults	With a total of max. 200 messages
Fault recording	
Number of stored fault records	Max. 8
Storage period (start with pickup or trip)	Max. 5 s for each fault, Approx. 5 s in total
	7UT
	612 613 633 635
Sampling rate at $f_N = 50$ Hz	600 Hz 800 Hz 800 Hz 800 Hz
Sampling rate at $f_N = 60$ Hz	720 Hz 960 Hz 960 Hz 960 Hz
Switching statistics	
Number of trip events caused by 7UT6	
Total of interrupted currents caused by 7UT6	Segregated for each pole, each side and each measurement location
Operating hours Criterion	Up to 7 decimal digits Excess of current threshold
Real-time clock and buffer battery	
Resolution for operational messages	1 ms
Resolution for fault messages	1 ms
Buffer battery	3 V/1 Ah, type CR ½ AA Self-discharging time approx. 10 year
Time synchronization	
Operating modes:	
Internal IEC 60870-5-103	Internal via RTC External via system interface (IEC 60870-5-103)
Time signal IRIG B	External via IRIG B
Time signal DCF77	External, via time signal DCF77
Time signal synchro-box	External, via synchro-box
Pulse via binary input	External with pulse via binary input
Indication of conformity	
This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/ 108/EC) and concerning electrical equipment for use within specified voltage limits (Low-voltage Directive 2006/95/EC).	
This conformity has been established by means of tests conducted by Siemens AG in accordance of the Council Directive in agreement with the generic standards EN 61000-6-2 and EN 61000-6-4 for the EMC directives, and with the standard EN 60255-5 for the low-voltage directive.	
The product is conforming to the international standards of the series IEC 60255 and the German regulation of DIN 57435 part 303 (VDE 0435 part 303).	

Transformer Differential Protection/7UT6

Selection and ordering data

Description	Order No.	Order code
7UT612 differential protection relay for transformers, generators, motors and busbars Housing 1/3 x 19"; 3 BI, 4 BO, 1 live status contact, 7 I, I _{EE} ¹⁾	7UT612	A 0
Rated current		
I _N = 1 A	1	
I _N = 5 A	5	
Rated auxiliary voltage (power supply, binary inputs)		
DC 24 to 48 V, binary input threshold 19 V ²⁾	2	
DC 60 to 125 V ³⁾ , binary input threshold 19 V ²⁾	4	
DC 110 to 250 V, AC 115/230 V, binary input threshold 88 V ²⁾	5	
Unit design		
For panel surface mounting, two-tier terminals on top and bottom	B	
For panel flush mounting, plug-in terminals (2/3-pole AMP connector)	D	
For panel flush mounting, screw-type terminals, (direct wiring/ring lugs)	E	
Region-specific default settings/function and language settings		
Region DE, 50/60 Hz, IEC/ANSI, language German; selectable	A	
Region World, 50/60 Hz, IEC/ANSI, language English (GB); selectable	B	
Region US, 60/50 Hz, ANSI/IEC, language English (US); selectable	C	
Region World, 50/60 Hz, IEC/ANSI, language Spanish; selectable	E	
System interface (Port B) on rear		
No system interface	0	
IEC 60870-5-103 protocol, electrical RS232	1	
IEC 60870-5-103 protocol, electrical RS485	2	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	3	
PROFIBUS-FMS Slave, electrical RS485	4	
PROFIBUS-FMS Slave, optical, single loop, ST connector ⁴⁾	5	
PROFIBUS-FMS Slave, optical, double loop, ST connector ⁴⁾	6	
PROFIBUS-DP Slave, electrical RS485	9	L O A
PROFIBUS-DP Slave, optical 820 nm, double loop, ST connector ⁴⁾	9	L O B
MODBUS, electrical RS485	9	L O D
MODBUS, optical 820 nm, ST connector ⁴⁾	9	L O E
DNP 3.0, electrical RS485	9	L O G
DNP 3.0, optical 820 nm, ST connector ⁴⁾	9	L O H
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector (EN 100)	9	L O R
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector (EN 100) ⁵⁾	9	L O S

see next page

- 1) Sensitivity selectable normal/high.
- 2) The binary input thresholds are selectable in two stages by means of jumpers.
- 3) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

- 4) With surface-mounting housing: only RS485 interface available.
- 5) If position 9 = "B" (surface-mounting housing), please order relay with electrical Ethernet interface and use a separate FO switch.

Transformer Differential Protection / 7UT6

Selection and ordering data

Description	Order No.	Order code
7UT612 differential protection relay for transformers, generators, motors and busbars	7UT612□-□□□□□-□□	A 0
DIGSI 4 / browser / modem interface (Port C) on rear / temperature monitoring box connection		
No DIGSI 4 port		0
DIGSI 4 / browser, electrical RS232		1
DIGSI 4 / browser or temperature monitoring box ¹⁾ , electrical RS485		2
DIGSI 4 / browser or temperature monitoring box ¹⁾ , 820 nm fiber optic, ST connector		3
Functions		
Measured values / monitoring functions		
Basic measured values		1
Basic measured values, transformer monitoring functions (connection to thermo-box / hot spot acc. to IEC, overload factor)		4
Differential protection + basic functions		
Differential protection for transformer, generator, motor, busbar (87)		
Overload protection for one winding (49), Lockout (86)		
Overcurrent-time protection (50/51): $I>$, $I>>$, I_P (inrush stabilization)		
Overcurrent-time protection (50N/51N): $3I_{D>}$, $3I_{D>>}$, $3I_{OP}$ (inrush stabilization)		
Overcurrent-time protection ground (50G/51G): $I_{E>}$, $I_{E>>}$, I_{EP} (inrush stabilization)		A
Differential protection + basic functions + additional functions		
Restricted ground fault protection, low impedance (87N)		
Restricted ground fault protection, high impedance (87N without resistor and varistor), O/C 1-phase		
Trip circuit supervision (74TC), breaker failure protection (50BF), unbalanced load protection (46)		B

1) External temperature monitoring box required.

Transformer Differential Protection/7UT6

Selection and ordering data

Description	Order No.	Order code
7UT613 differential protection relay for transformers, generators, motors and busbars Housing ½ x19"; 5 BI, 8 BO, 1 live status contact, 11 I, I _{EE} ¹⁾	7UT613	
Rated current		
I _N = 1 A	1	
I _N = 5 A	5	see next page
Rated auxiliary voltage (power supply, binary inputs)		
DC 24 to 48 V, binary input threshold 19 V ²⁾	2	
DC 60 to 125 V ³⁾ , binary input threshold 19 V ²⁾	4	
DC 110 to 250 V ¹⁾ , AC 115/230 V, binary input threshold 88 V ²⁾	5	
DC 110 to 250 V ¹⁾ , AC 115/230 V, binary input threshold 176 V ²⁾	6	
Unit design		
Surface-mounting housing with two-tier terminals	B	
Flush-mounting housing with plug-in terminals	D	
Flush-mounting housing with screw-type terminals	E	
Region-specific default settings/language settings		
Region DE, 50/60 Hz, IEC/ANSI, language German; selectable	A	
Region World, 50/60 Hz, IEC/ANSI, language English (GB); selectable	B	
Region US, 60/50 Hz, ANSI/IEC, language English (US); selectable	C	
Region World, 50/60 Hz, IEC/ANSI, language French; selectable	D	
Region World, 50/60 Hz, IEC/ANSI, language Spanish; selectable	E	
System interface (Port B) on rear		
No system interface	0	
IEC 60870-5-103 protocol, electrical RS232	1	
IEC 60870-5-103 protocol, electrical RS485	2	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	3	
PROFIBUS-FMS Slave, electrical RS485	4	
PROFIBUS-FMS Slave, optical, single ring, ST connector ⁴⁾	5	
PROFIBUS-FMS Slave, optical, double ring, ST connector ⁴⁾	6	
PROFIBUS-DP Slave, electrical RS485	9	L O A
PROFIBUS-DP Slave, optical 820 nm, double ring, ST connector ⁴⁾	9	L O B
MODBUS, electrical RS485	9	L O D
MODBUS, optical 820 nm, ST connector ⁴⁾	9	L O E
DNP 3.0, electrical RS485	9	L O G
DNP 3.0, optical 820 nm, ST connector ⁴⁾	9	L O H
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector (EN 100)	9	L O R
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector (EN 100) ⁵⁾	9	L O S

- 1) Sensitivity selectable normal/high.
- 2) The binary input thresholds are selectable in two stages by means of jumpers.
- 3) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

- 4) With surface-mounting housing: only RS485 interface available.
- 5) If position 9 = "B" (surface-mounting housing), please order relay with electrical Ethernet interface and use a separate FO switch.

Transformer Differential Protection / 7UT6

Selection and ordering data

Description	Order No.	Order code
7UT613 differential protection relay for transformers, generators, motors and busbars	7UT613 □-□□□□□-□□□□□-□□□□□	
Port C and Port D		
Port C: DIGSI 4 / modem, electrical RS232; Port D: empty		1
Port C: DIGSI 4 / modem/thermo-box, electrical RS485; Port D: empty		2
Port C and Port D installed		9
		M □ □
Port C (service interface)		
DIGSI 4 / modem, electrical RS232		1
DIGSI 4 / modem/thermo-box, electrical RS485		2
Port D (additional interface)		
Thermo-box, optical 820 nm, ST connector		A
Thermo-box, electrical RS485		F
Measured values/monitoring functions		
Basic measured values		1
Extended measured values, min./max. values, mean values		2
Extended measured values, min./max., mean values, transformer monitoring functions (connection to thermo-box/hot spot, overload factor)		4
Differential protection + basic functions		
Differential protection for transformer, generator, motor, busbar (87)		
Overload protection according to IEC for one side (49)		
Lock out (86)		
Overcurrent-time protection phases (50/51): $I>$, $I>>$, I_P (inrush stabilization)		
Overcurrent-time protection $3I_0$ (50N/51N): $3I_{0>}$, $3I_{0>>}$, $3I_{0P}$ (inrush stabilization)		
Overcurrent-time protection ground (50G/51G): $I_{E>}$, $I_{E>>}$, I_{EP} (inrush stabilization)		A
Differential protection + basic functions + additional current functions		
Restricted ground-fault protection, low impedance (87N)		
Restricted ground-fault protection, high impedance (87N without resistor and varistor), O/C 1-phase		
Trip circuit supervision (74TC)		
Unbalanced load protection (46)		
Breaker failure protection (50BF)		
High-sensitivity overcurrent-time protection/tank leakage protection (64), O/C 1-phase		B
Additional voltage functions		
Without voltage functions		A
With overexcitation protection and voltage/power/energy/measurement		B
With overexcitation protection and voltage/power/energy measurement		
+ Over/undervoltage protection (59/27)		
+ Frequency protection (81)		
+ Directional power protection (32R/F)		
+ Fuse failure monitor (60FL)		C
Additional functions (general)		
Without		0
Multiple protection functions (50, 51, 50N/G, 87N, 50BF, 49) ¹⁾		1
Flexible protection functions		2
Multiple + flexible protection functions		3

1) Available if selected on position 14.




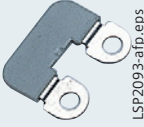

Transformer Differential Protection/7UT6

Selection and ordering data

Accessories	Description	Order No.
	DIGSI 4 Software for configuration and operation of Siemens protection relays running under MS Windows (Windows 2000/XP Professional Edition), device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper) Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
	Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
	Professional + IEC 61850 DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	7XS5403-0AA00
	IEC 61850 System configurator Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM	7XS5460-0AA00
	SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format) running under MS Windows 2000/XP Professional Edition. Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	7XS5410-0AA00
	Connecting cable Cable between PC/notebook (9-pin connector) and protection relay (9-pin connector) (contained in DIGSI 4, but can be ordered additionally) Cable between thermo-box and relay - length 5 m / 16.4 ft - length 25 m / 82 ft - length 50 m / 164 ft	7XV5100-4 7XV5103-7AA05 7XV5103-7AA25 7XV5103-7AA50
	Voltage transformer miniature circuit-breaker Rated current 1.6 A; thermal overload release 1.6 A; overcurrent trip 6 A	3RV1611-1AG14
	Temperature monitoring box with 6 thermal inputs For SIPROTEC units With 6 temperature sensors and RS485 interface	AC/DC 24 to 60 V AC/DC 90 to 240 V 7XV5662-2AD10 7XV5662-5AD10
	Manual for 7UT6x English V4.6 German V4.6 Turkey V4.6	C53000-G1176-C230-2 C53000-G1100-C230-3 C53000-G115A-C230-1
	Manual for 7UT612 English	C53000-G1176-C148-1
	Manual for 7UT6 English V4.0 English V4.6	C53000-G1176-C160-1 C53000-G1176-C160-2

Transformer Differential Protection / 7UT6

Selection and ordering data

Accessories	Description	Order No.	Size of package	Supplier	Fig.
 <p>Fig. 8/34 Mounting rail for 19" rack</p>	Connector	2-pin 3-pin	1 1	Siemens Siemens	8/35 8/36
	Crimp connector	CI2 0.5 to 1 mm ²	0-827039-1 0-827396-1	4000 1	AMP ¹⁾ AMP ¹⁾
CI2 0.5 to 2.5 mm ²		0-827040-1 0-827397-1	4000 1	AMP ¹⁾ AMP ¹⁾	
 <p>Fig. 8/35 2-pin connector</p>	Crimping tool	Type III+ 0.75 to 1.5 mm ²	0-163083-7 0-163084-2	4000 1	AMP ¹⁾ AMP ¹⁾
		For type III+ and matching female For CI2 and matching female	0-539635-1 0-539668-2 0-734372-1 1-734387-1	1 1 1 1	AMP ¹⁾ AMP ¹⁾ AMP ¹⁾ AMP ¹⁾
 <p>Fig. 8/36 3-pin connector</p>	19"-mounting rail	C73165-A63-D200-1	1	Siemens	8/34
 <p>Fig. 8/37 Short-circuit link for current contacts</p>	Short-circuit links	For current terminals	C73334-A1-C33-1	1	Siemens
		For other terminals	C73334-A1-C34-1	1	Siemens
 <p>Fig. 8/38 Short-circuit link for voltage contacts/indications contacts</p>	Safety cover for terminals	large	C73334-A1-C31-1	1	Siemens
		small	C73334-A1-C32-1	1	Siemens

1) Your local Siemens representative can inform you on local suppliers.

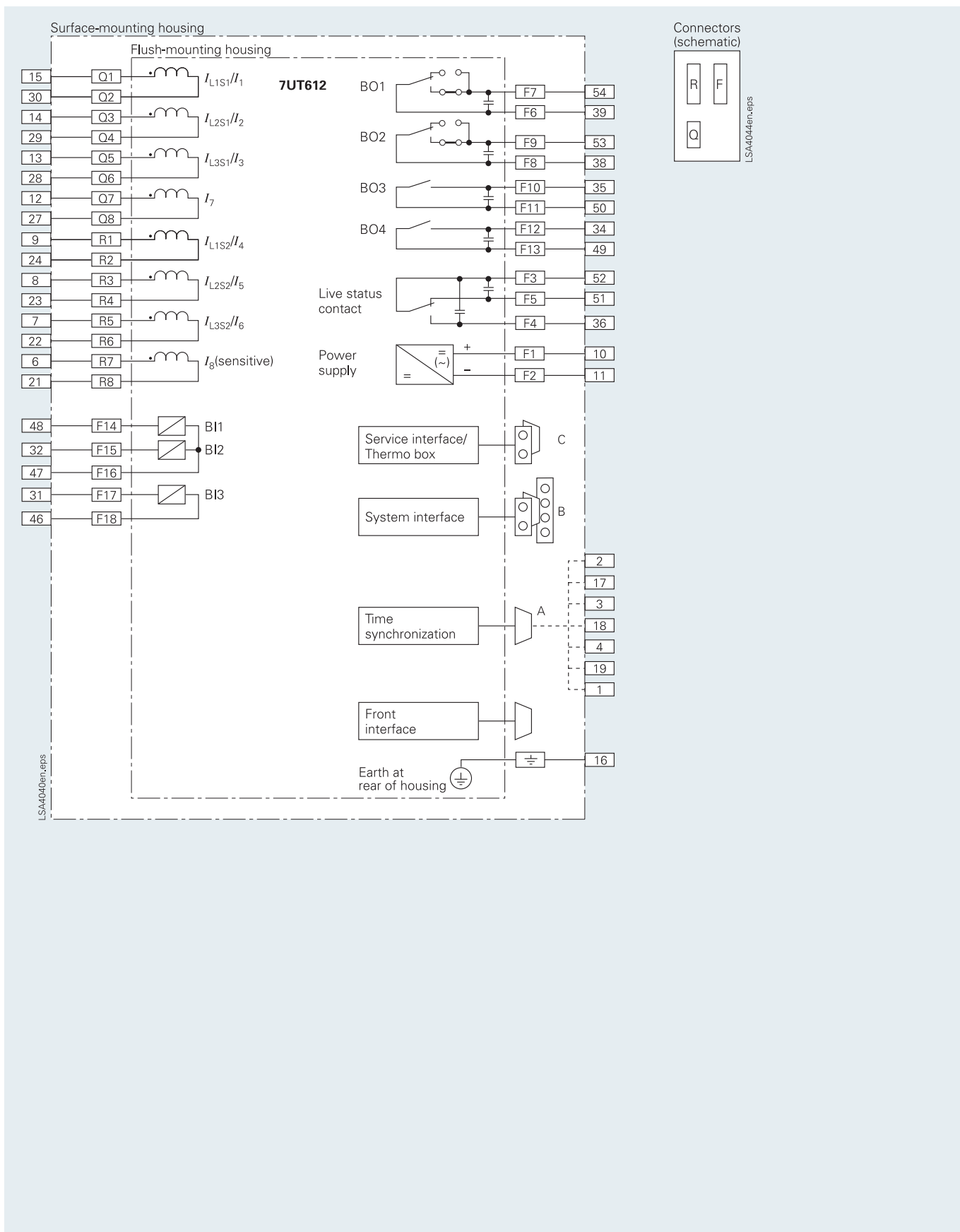


Fig. 8/39 Connection diagram

Transformer Differential Protection / 7UT6

Connection diagram

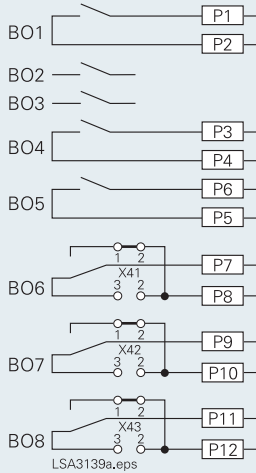
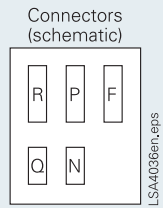
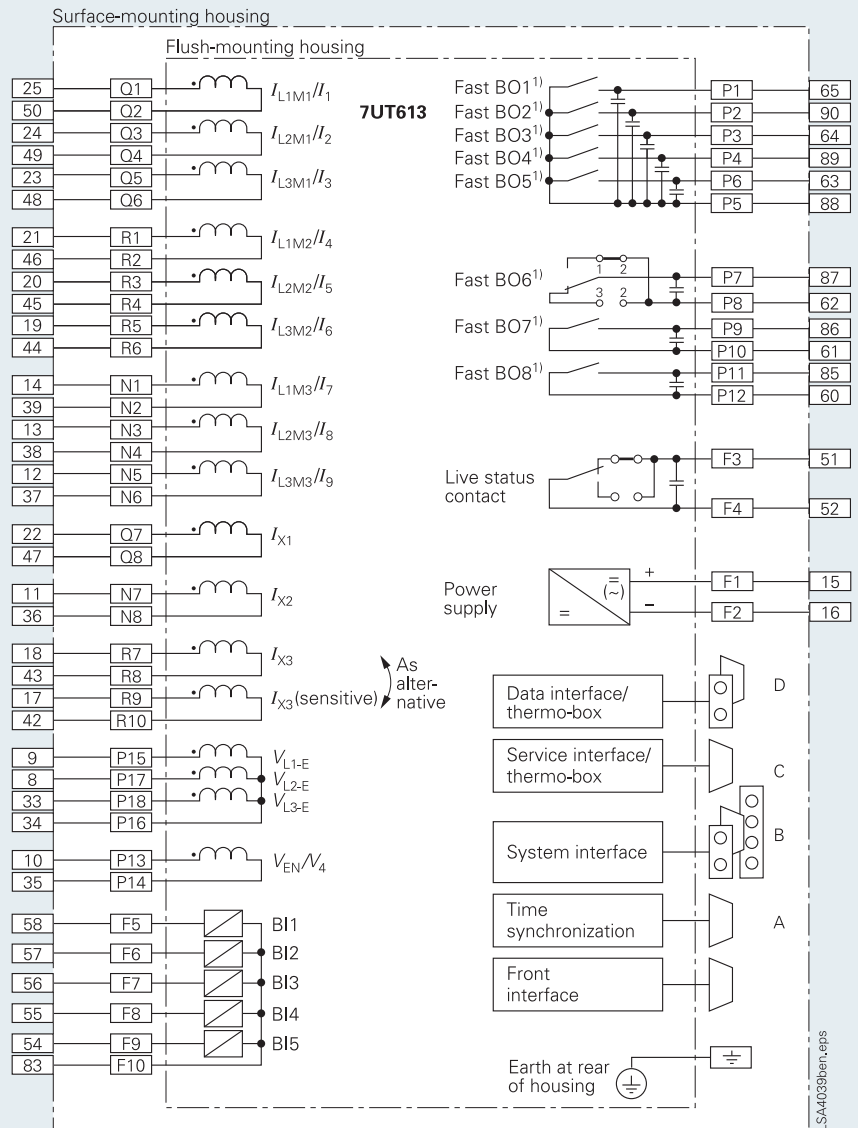


Fig. 8/40a
Additional setting by jumpers:
Separation of common circuit of fast BO1 to BO5 with jumpers X80, X81, X82. Switching of fast BO7, BO8 as NO contact or NC contact with jumpers X41, X42, X43.



1) Configuration of binary outputs up to hardware-version .../CC
For advanced flexibility see Fig. 8/40a.

Fig. 8/40 Connection diagram 7UT613

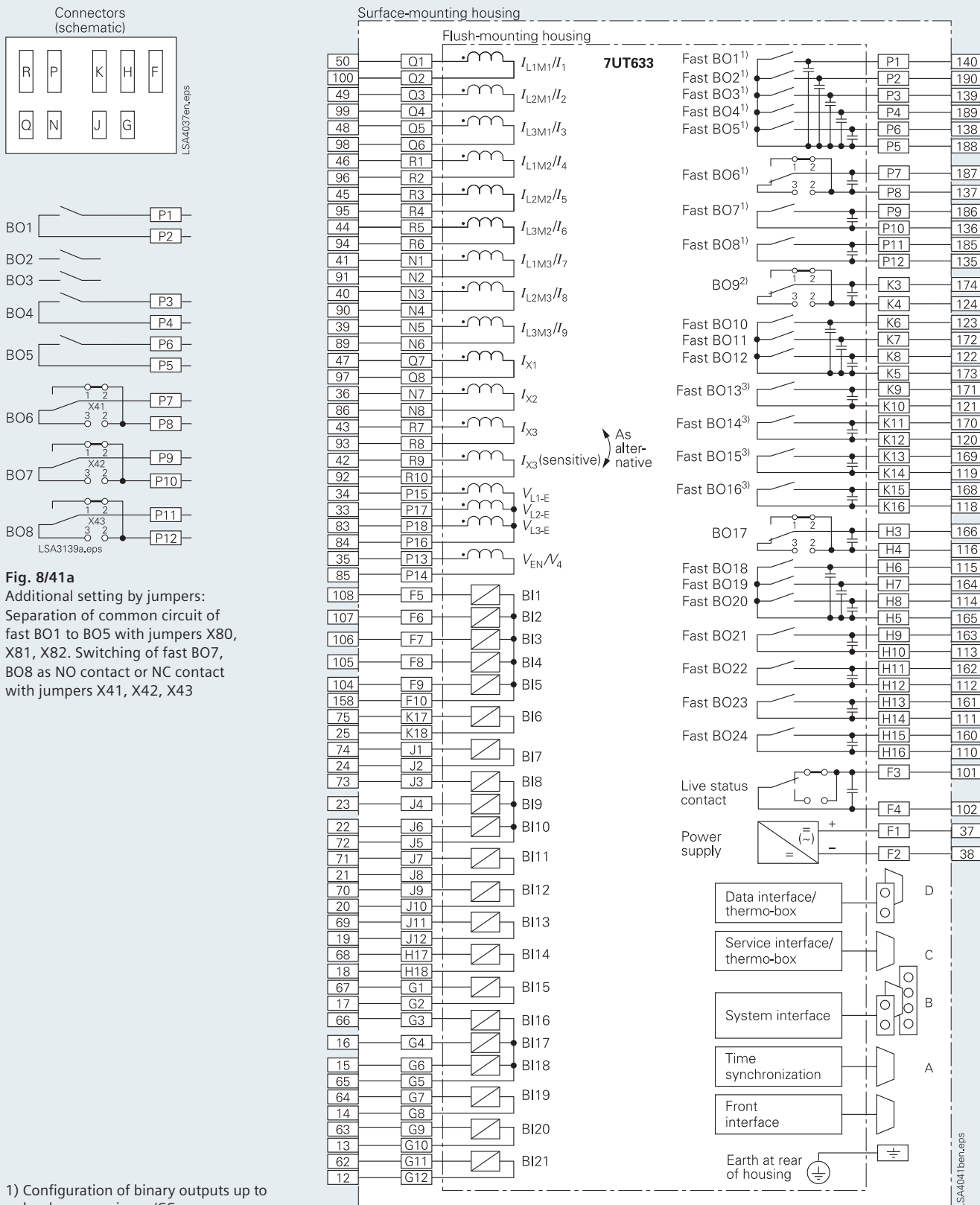


Fig. 8/41 Connection diagram 7UT63

Transformer Differential Protection / 7UT6

Connection diagram

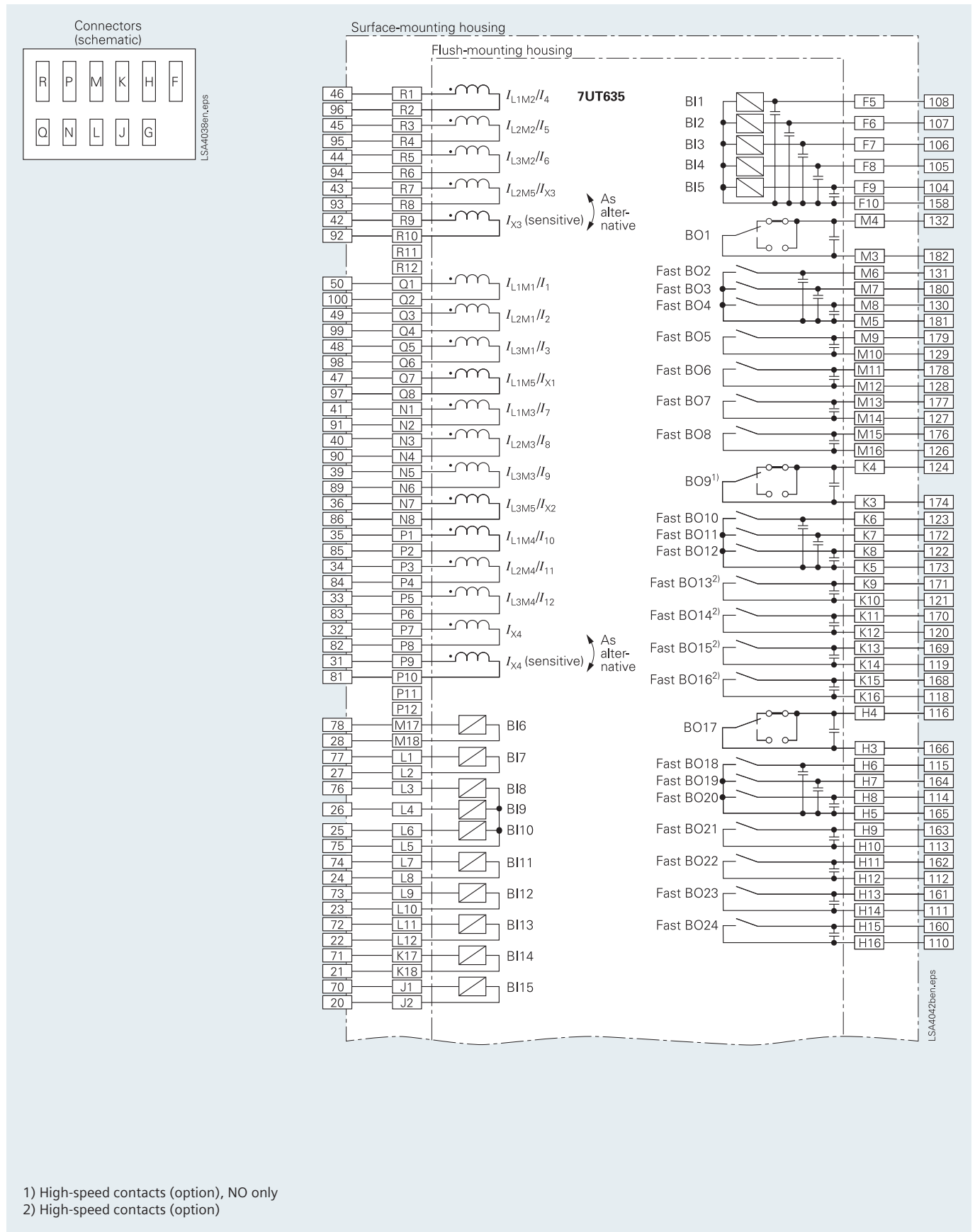


Fig. 8/42 Connection diagram 7UT635 part 1; continued on following page

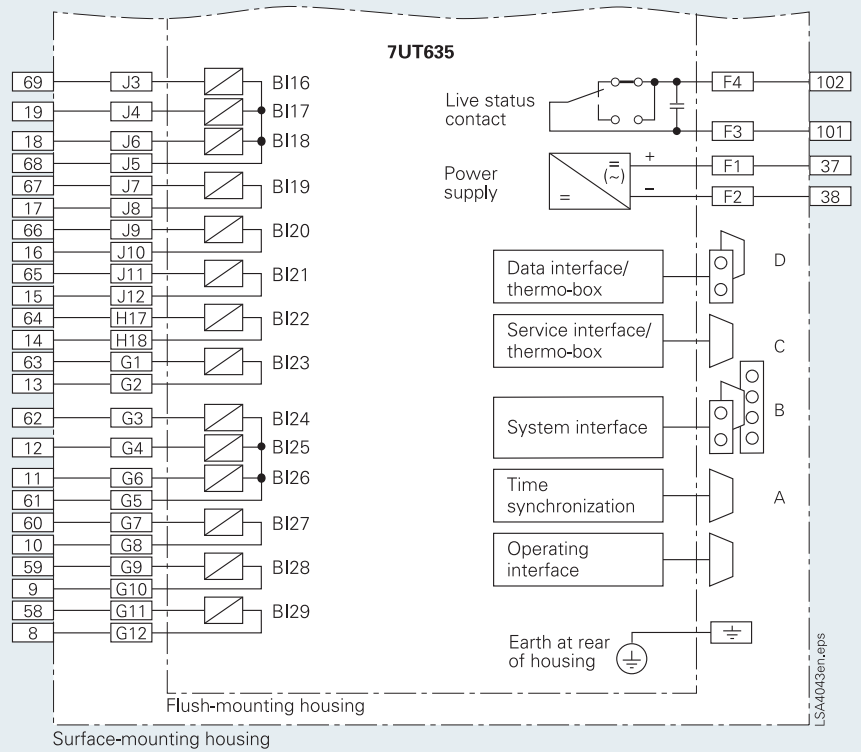


Fig. 8/43 Connection diagram 7UT635 part 2

Busbar Differential Protection

Page

SIPROTEC 7SS60 centralized numerical busbar protection 9/3

SIPROTEC 4 7SS52 distributed numerical busbar
and breaker failure protection 9/19





Fig. 9/1 7SS601 measuring system

Description

The SIPROTEC 7SS60 system is an inexpensive numerical differential current protection for busbars in a centralized configuration.

It is suitable for all voltage levels and can be adapted to a large variety of busbar configurations with an unlimited number of feeders. The components are designed for single busbars, 1½-breaker configurations and double busbars with or without couplers.

Different primary CT ratios can be matched by using appropriate windings of the input current transformers.

The use of matching transformers allows phase-selective measurement. Single-phase measurement can be achieved by using summation current transformers.

Function overview

Features

- Optimized for single busbar and 1½ circuit-breaker configurations
- Suitable for double busbars with or without couplers
- Separate check zone possible
- Short trip times
- Unlimited number of feeders
- Matching of different primary CT ratios
- Differential current principle
- Low-impedance measuring method
- Numerical measured-value processing
- Suitable for all voltage levels
- Low demands on CTs thanks to additional restraint
- Measured-value acquisition via summation current transformer or phase-selective matching transformers
- Maintained TRIP command (lockout function)
- Centralized, compact design
- Combinative with separate breaker failure protection

Monitoring functions

- Primary current transformers including supply leads
- Operational measured values: Differential and restraint current
- Self-supervision of the relay
- 30 event logs
- 8 fault logs
- 8 oscillographic fault records

Communication interface

- RS485 interface for local and remote operation with DIGSI

Hardware

- Concept of modular components
- Reduced number of module types
- Auxiliary voltage DC 48 V to DC 250 V
- 7SS601 measuring system in 1/6 19-inch housing 7XP20
- Peripheral components in 1/2 19-inch housing 7XP20

Front design

- Display for operation and measured values
- 6 LEDs for local indication

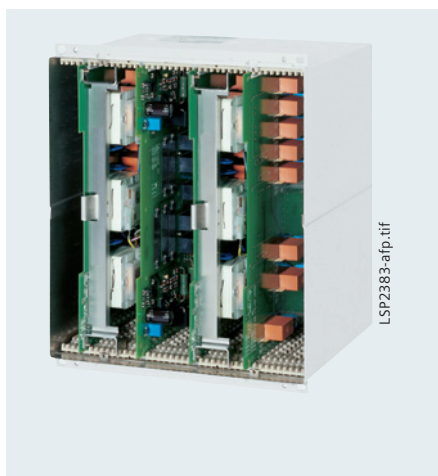


Fig. 9/3 Housing for peripheral modules (front cover removed)

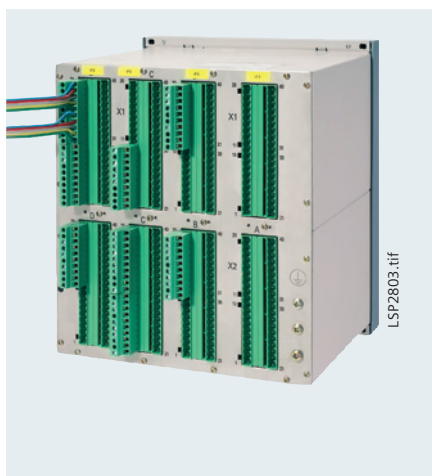


Fig. 9/4 Rear view

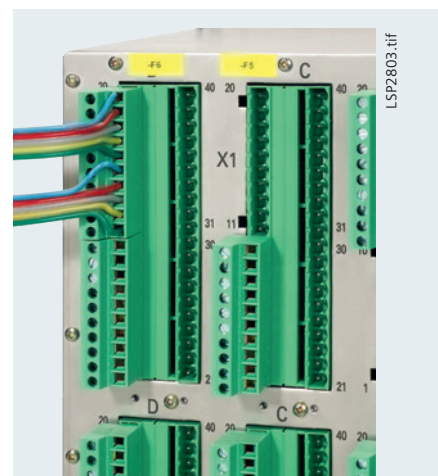


Fig. 9/5 Rear view detail

Construction

Design

The 7SS60 compactly-built protection system contains all components for:

- Measured-value acquisition and evaluation
- Operation and LC display
- Annunciation and command output
- Input and evaluation of binary signals
- Data transmission via the RS485 interface with bus capability
- Auxiliary voltage supply

The 7SS60 system comprises the following components:

- 7SS601 measuring system and the peripheral modules
- 7TM70 restraint/command output module
- 7TR71 isolator replica/preference module
- 7TS72 command output module

The number of modules required is determined by the substation configuration and the measuring principle used (summation current transformers or phase-selective measurement). The 7SS601 measuring system is accommodated in a separate housing (1/6 19-inch 7XP20) that is suited for panel flush mounting or cubicle mounting. The 7XP2040 peripheral module housing has a width of 1/2 19 inches and can hold up to four peripheral modules.

It is suited for panel flush mounting or cubicle mounting and has plug-on connectors fitted at the rear. The primary current transformers are connected to summation current transformers of type 4AM5120-3DA/4DA or to matching transformers of type 4AM5120-1DA/2DA. With a rated current of 1 or 5 A, the current output at these transformers is 100 mA. This output current is fed onto the 7SS601 measuring system (for differential current formation) and onto the 7TM70 restraint units (for restraint current formation). The summated restraint current is fed onto the 7SS601 measuring system as well.

Functions

Functions of the components

- The 7SS601 measuring system comprises:
 - One measuring input for acquisition and processing of the differential and the restraint current
 - 3 binary inputs for acquisition of information, e.g. a blocking condition
 - 2 command relays for activation of other, feeder-specific command relays on the 7TM70 and 7TS72 peripheral modules.

In circuits with summation current transformer, one 7SS601 measuring system is required per protected zone. For phase-selective measurement, one 7SS601 measuring system is required per phase and protected zone.

- 7TM70 restraint/command output module
This module contains 5 current transformers with rectifiers for the formation of the restraint current. It has also 5 command relays with 2 NO contacts each for output of a direct TRIP command to the circuit-breakers.
- 7TR71 isolator replica/preference module
This module enables the two bus isolators to be detected in a double busbar. The feeder current is assigned to the corresponding measuring system on the basis of the detected isolator position. The module is also designed for an additional function. In the case of a double busbar system, for example, where both bus isolators of a feeder are closed at a time, no selective protection of the two busbars is possible. During this state, one of the two measuring systems is given priority. The module 7TR71 appropriately assigns feeder currents to the corresponding measuring system 7SS601. The module also contains an auxiliary relay with two changeover contacts.
- 7TS72 command output module
The 7TM70 contains 5 trip relays with 2 NO contacts each. If more trip contacts are needed, the 7TS72 module can be used, providing 8 relays with 2 NO contacts each.

Busbar Differential Protection / 7SS60

Protection functions

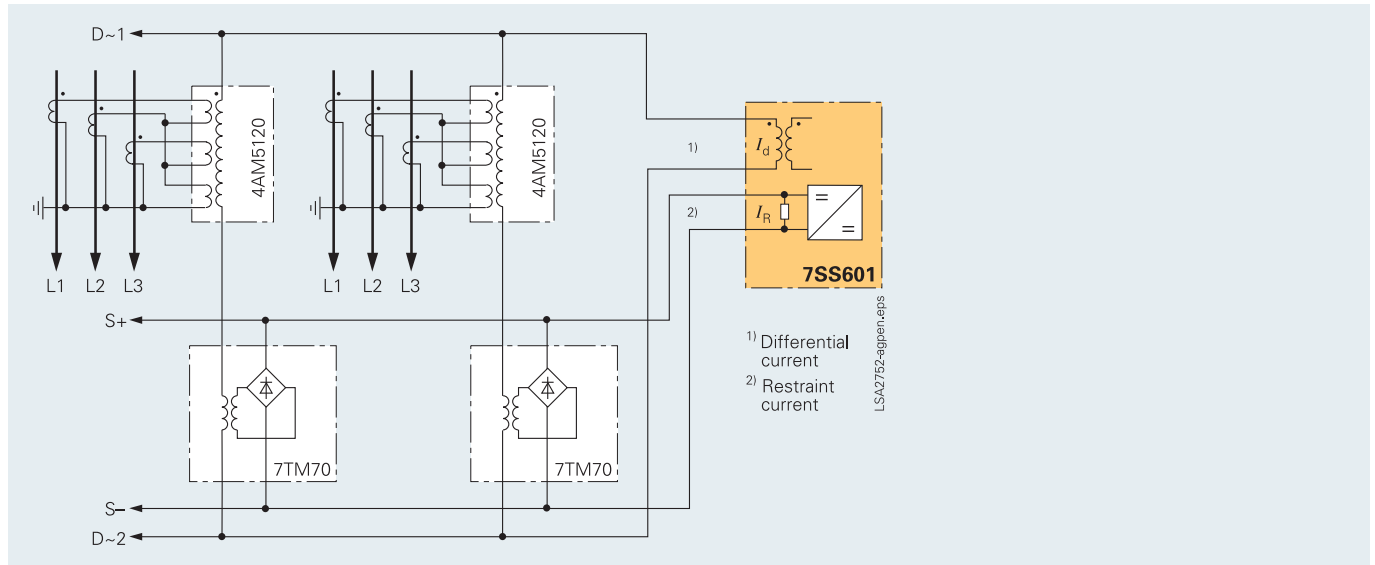


Fig. 9/6 Block diagram: Acquisition of measured values

Protection functions

Measuring principles

The feeder currents can be measured and processed according to different principles.

• Summation current transformer principle

In the summation current transformer variant, the three secondary currents of the primary CTs are fed onto the three primary windings of the summation current transformers with a winding ratio of $n_1:n_2:n_3 = 2:1:3$. According to the expected fault currents two different circuits for connecting the summation current transformer are possible. For power systems with low-resistance or solid grounding of the starpoint, the 1-phase ground-faults are sufficiently high to use the circuit with normal sensitivity (see Fig. 9/7). An increased sensitivity for ground-faults can be achieved by use of a circuit according to Fig. 9/8. With a symmetrical, three-phase current of $1 \times I_N$, the secondary current of the summation current transformers is 100 mA.

Different primary CT transformation ratios can usually be compensated directly by appropriate selection of the summation CT primary windings. Where the circuit conditions do not allow this, additional matching transformers, such as the 4AM5272-3AA, should be used, preferably in the form of autotransformers (see Fig. 9/9: Protection with summation current transformer and matching transformers). The autotransformer circuit reduces the total burden for the primary CTs.

• Phase-selective measurement

In this variant, each phase current is measured separately. To do so, each of the secondary currents of the primary transformers is fed onto a matching transformer. This transformer allows, if its primary windings are selected accordingly, to generate a normalized current from a variety of different primary CT transformation ratios (see Fig. 9/10: Phase-selective measurement). With a primary current of $1 \times I_N$, the secondary current of the matching transformers is 100 mA.

Function principle of the differential protection

The main function of the 7SS60 protection system is a busbar protection that operates with the differential current measuring principle. Its algorithm relies on Kirchhoff's current law, which states that in fault-free condition the vectorial sum I_d of all currents flowing into an independent busbar section must be zero. Some slight deviations from this law may be caused by current transformer error, inaccuracies in the matching of the transformation ratios and measuring inaccuracies. Further errors, which may be due to e.g. transformer saturation in case of high-current external short-circuits, are counteracted by a load-dependent supplementary restraint.

The restraint current I_R is derived from the load condition. This restraint current is formed as the summated magnitudes of all currents. The differential and the restraint current are fed into the 7SS601 measuring system (see Fig. 9/6: Block diagram). With double busbars or sectionalized busbars, one measuring system 7SS601 (summation CT), respectively 3 measuring systems (phase-selective measurement) will be used for each selective section. The module 7TS71 (isolator replica/preference) appropriately assigns feeder currents to the corresponding measuring system 7SS601.

Typical connections

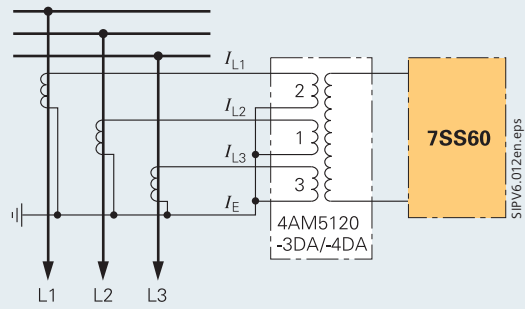


Fig. 9/7 Protection with summation current transformer (L1-L2-L3 circuit)

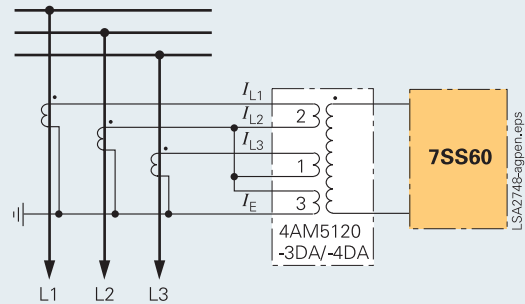


Fig. 9/8 Protection with summation current transformer (L1-L3-N circuit)

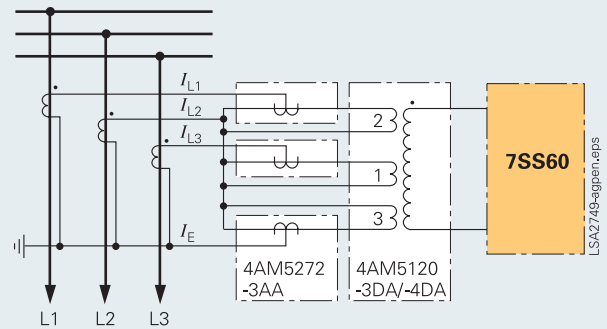


Fig. 9/9 Protection with summation current transformer and matching transformers

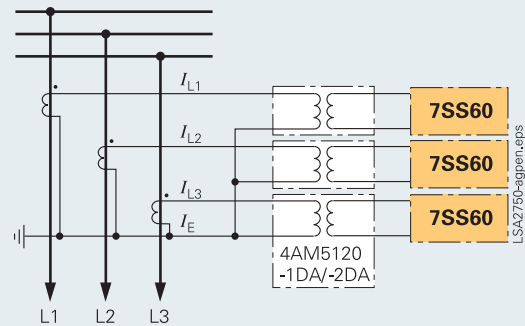


Fig. 9/10 Phase-selective measurement

Busbar Differential Protection / 7SS60

Protection functions

Pickup characteristic of the differential protection

The characteristic can be set in the parameters for $I_d >$ (pickup value) and for the k factor which considers the linear and non-linear current transformer errors. Differential currents above the set characteristic lead to tripping.

Current transformer monitoring

An independent sensitive differential current monitoring with its parameter $I_{d\text{ thr}}$ detects faults (short-circuits, open circuit) of current transformers and their wiring even with load currents. The affected measuring system is blocked and an alarm is given. By this, the stability of the busbar protection is ensured in case of external faults.

Trip command lockout (with manual reset)

Following a trip of the differential protection, the TRIP command can be kept (sealed-in). The circuit-breakers are not reclosed until the operator has obtained information on the fault; the command must be manually reset by pressing a key or by a binary input.

The logical state of the TRIP command is buffered against a loss of the auxiliary power supply, so that it is still present on restoration of the auxiliary voltage supply.

Test and commissioning aids

The protection system provides user support for testing and commissioning. It has a wide range of integrated aids that can be activated from the keypad or from a PC using the DIGSI program. For some tests a codeword must be entered.

The following test aids are available:

- Display of operational measured values
- Interrogation of status of binary inputs and LED indicators
- Blocking of the TRIP function during testing

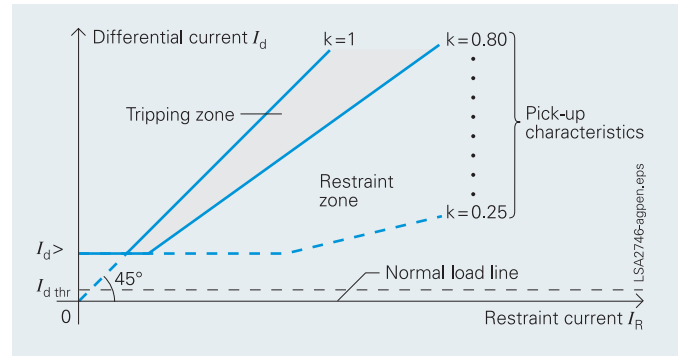


Fig. 9/11 Tripping characteristic

Communication

Serial data transmission

The device is equipped with an RS485 interface. The interface has bus capability and allows a maximum of 32 units to be connected via a serial two-wire interface. A PC can be connected to the interface via an RS232 to RS485 converter, so that configuration, setting and evaluation can be performed comfortably via the PC using the DIGSI operating program. The PC can also be used to read out the fault record that is generated by the device when a fault occurs.

With RS485 to 820 nm optical converters, which are available as accessories (7XV5650, 7XV5651), an interference-free, isolated connection to a control center or a DIGSI-based remote control unit is possible; this allows to design low-cost stations concepts that permit e.g. remote diagnosis.

Comfortable setting

The parameter settings are made in a menu-guided procedure from the integrated operator panel and the LC display. It is, however, more comfortable to use a PC for this purpose, together with the standard DIGSI operating program.

Fault recording

If a fault leads to a trip, a fault record is generated, in which the differential and the restraint current are recorded with a sampling frequency of 2 kHz. In addition, signals are stored as binary traces, which represent internal device states or binary input states. Up to eight fault records can be stored. When a ninth fault occurs, the oldest record is overwritten. A total storage capacity of 7 s is available. The most recent 2.5 s are buffered against power failure.

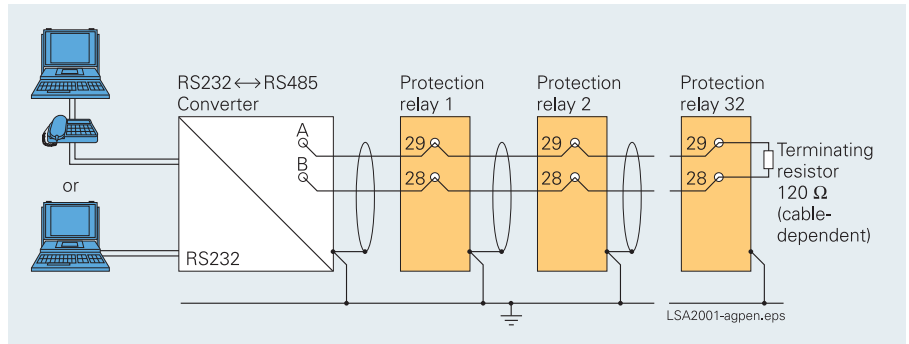


Fig. 9/12 Communication scheme

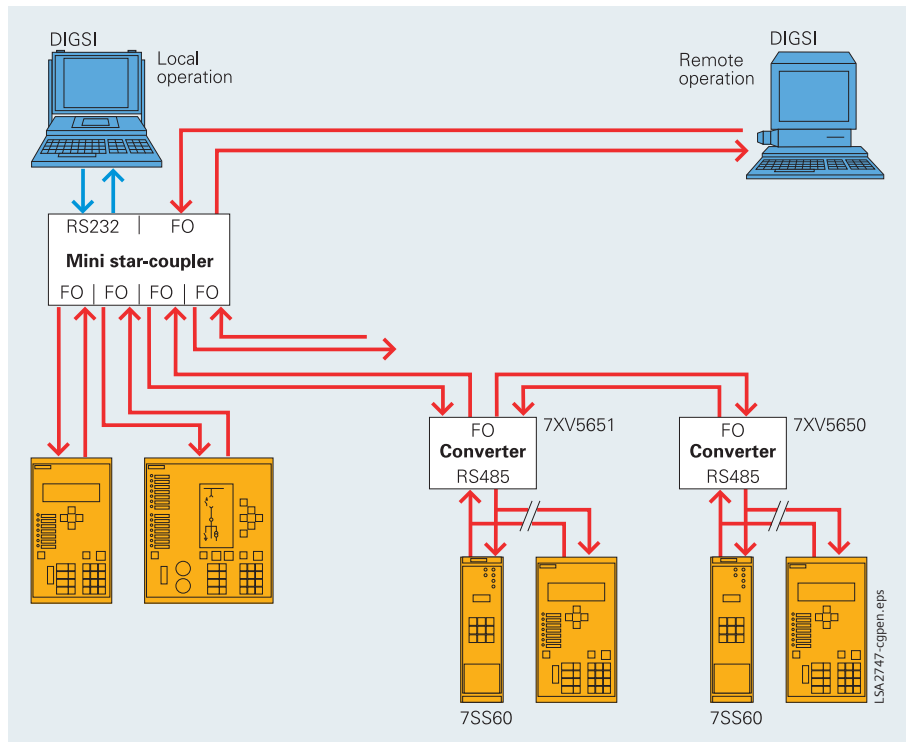


Fig. 9/13 Communication scheme

Busbar Differential Protection / 7SS60

Technical data

7SS60 measuring system		Command contacts	
Measuring input I_d		Number of relays	1 (2 NO contacts) 1 (1 NO contact)
Rated current	100 mA	Switching capacity	
Rated frequency	50/60 Hz settable, 16.7 Hz	Make	1000 W/VA
Dynamic overload capacity (pulse current)	$250 \times I_N$ one half cycle	Break	30 W/VA
Thermal overload capacity (r.m.s.) (where external summation or matching current transformers are used, their limit data must be observed)	$100 \times I_N$ for ≤ 1 s $30 \times I_N$ for ≤ 10 s $4 \times I_N$ continuous	Switching voltage	AC/DC 250 V
Isolating voltage	2.5 kV (r.m.s.)	Permissible current	
Measuring range for operational measured values	0 to 240 %	Continuous	5 A
Measuring dynamics	$100 \times I_N$ without offset $50 \times I_N$ with full offset	0.5 s	30 A
Measuring input I_R		Signal contacts	
Rated current	1.9 mA	Number of relays	3 (2 marshallable)
Dynamic overload capability (pulse current)	$250 \times I_N$ for 10 ms	Contacts	2 changeover contacts and 1 NO contact (can be changed to NC by jumper)
Thermal overload capability (r.m.s.) (where external summation or matching current transformers are used, their limit data must be observed)	$100 \times I_N$ for ≤ 1 s $30 \times I_N$ for ≤ 10 s $4 \times I_N$ continuous	Switching capacity	
Isolating voltage	2.5 kV (r.m.s.)	Make	1000 W/VA
Measuring dynamics	0 to $200 \times I_N$	Break	30 W/VA
Auxiliary voltage		Switching voltage	AC/DC 250 V
Via integrated DC/DC converter	DC 24/48 V (DC 19 to 58 V)	Permissible current	
Rated auxiliary voltage V_{aux} (permissible voltage)	DC 60/110/125 V (DC 48 to 150 V) DC 220/250 V (DC 176 to 300 V) AC 115 V (AC 92 to 133 V)	Continuous	5 A
Superimposed AC voltage (peak-to-peak)	≤ 15 % of rated voltage	0.5 s	30 A
Power consumption	Quiescent Approx. 3 W Energized Approx. 5 W	Serial interface	
Bridging time during failure / short-circuit of auxiliary voltage	≥ 50 ms at $V_{aux} \geq DC 100$ V ≥ 20 ms at $V_{aux} \geq DC 48$ V	Standard	Isolated RS485
Binary inputs		Test voltage	DC 3.5 kV
Number	3 (marshallable)	Connection	Data cable at housing terminals, 2 data lines For connection of a personal computer or similar Cables must be shielded, and shields must be grounded. As delivered 9600 baud min. 1200 baud, max. 19200 baud
Operating voltage range	DC 24 to 250 V	Unit design	
Current consumption when energized	Approx. 2.5 mA Independent of operating voltage	Housing 7XP20	1/6 19"
Pickup threshold	Can be changed by setting jumpers	Dimensions	See part 14
Rated aux. voltage DC 48/60 V		Weight	Approx. 4.0 kg
V_{pickup}	$\geq DC 17$ V	Degree of protection according to IEC 60529-1	
$V_{drop-off}$	< DC 8 V	For the unit	IP 51
Rated aux. voltage DC 110/125/220/250 V		For operator protection	IP 2X
V_{pickup}	$\geq DC 74$ V		
$V_{drop-off}$	< DC 45 V		
Max. voltage	DC 300 V		

Busbar Differential Protection / 7SS60

Technical data

Functions	
<i>Differential current protection</i>	
Setting ranges for pickup threshold	
Differential current $I_{d>}$	0.20 to 2.50 I_{NO}
Restraint factor	0.25 to 0.80
Tolerance of pickup value	
Differential current $I_{d>}$	± 5 % of setpoint
Minimum duration of trip command	0.01 to 32.00 s (in steps of 0.01 s)
Time delay of trip	0.00 to 10.00 s (in steps of 0.01 s)
Times	
Minimum tripping time 50/60 Hz ¹⁾	10 ms
Typical tripping time 50/60 Hz ¹⁾	12 ms (rapid measurement) 40 ms (repeated measurement)
Minimum tripping time 16.7 Hz ¹⁾	12 ms
Typical tripping time 16.7 Hz ¹⁾	14 ms (rapid measurement) 40 ms (repeated measurement)
Reset time ²⁾	28 ms at 50 Hz 26 ms at 60 Hz 70 ms at 16.7 Hz
Differential current supervision	
Pickup threshold	0.10 to 1.00 I_{NO}
<i>Lockout function</i>	
Lockout seal-in of trip command	Until reset
Reset	By binary input and/or local operator panel
<i>Additional functions</i>	
Operational measured values	
Operating currents	I_d, I_R
Measuring range	0 to 240 % I_{NO}
Tolerance	5 % of rated value
Fault logging	Buffered storage of the annunciations of the last 8 faults
Time stamping	
Resolution for operational annunciation	1 ms
Resolution for fault annunciation	1 ms
Fault recording (max. 8 fault)	Buffered against voltage failure (last 2.5 s)
Recording time (from fault detection)	Max. 7.1 s total Pre-trigger and post-fault time can be set
Max. length per record	0.2 to 5.0 s (in steps of 0.01 s)
Pre-trigger time	0.05 to 1.5 s (in steps of 0.01 s)
Post-fault time	0.01 to 1.5 s (in steps of 0.01 s)
Sampling frequency	2 kHz
<i>Peripheral modules</i>	
<i>7TM700 restraint/command output module</i>	
<i>Measuring input I_R</i>	
Number of restraint units	5
Rated current	100 mA
Rated frequency	16.7, 50, 60 Hz
Dynamic overload capacity (pulse current)	250 x I_N one half cycle
Thermal overload capacity (r.m.s.) (where external summation or matching current transformers are used, their limit data must be observed)	100 x I_N for ≤ 1 s 30 x I_N for ≤ 10 s 4 x I_N continuous

<i>Auxiliary voltage (7TM700)</i>	
Rated auxiliary voltage V_{aux} (permitted voltage range)	DC 48/60 V (DC 38 to 72 V) DC 110/125 V (DC 88 to 150 V) DC 220/250 V (DC 176 to 300 V) Settable As delivered: DC 220/250 V
<i>Command contacts (7TM700)</i>	
Number of relays	5
Contacts per relay	2 NO contacts
For short-term operation < 10 s ³⁾	
Pickup time	Approx. 7 ms
Switching capacity	
Make	1000 W/VA
Break	30 W/VA
Switching voltage	AC/DC 250 V
Permissible currents	
Continuous	5 A
0.5 s	30 A
Weight	Approx. 2.0 kg
<i>7TR710 isolator replica/preferential treatment module</i>	
NOTE: The module 7TR710 can be used to implement 2 different functions: isolator replica or preferential treatment	
<i>Isolator replica</i>	
Number of feeders (single busbar and double busbar)	1
Number of isolators per feeder	2
<i>Preferential treatment</i>	
Number of preferential treatment circuits	2
Number of contacts per preferential treatment	3 changeover contacts
Switching time	< 20 ms
Number of auxiliary relays	1
Contacts of auxiliary relay	2 changeover contacts
<i>Auxiliary voltage</i>	
Rated auxiliary voltage V_{aux} (permissible voltage range)	DC 48/60 V (DC 38 to 72 V) DC 110/125 V (DC 88 to 150 V) DC 220/250 V (DC 176 to 300 V) Depending on the design
<i>Relay contacts</i>	
Switching capacity	
Make	1000 W/VA
Break	30 W/VA
Switching voltage	AC/DC 250 V
Permissible current	
Continuous	5 A
0.5 s	10 A
Weight	Approx. 0.6 kg
1) Each additional intermediate relay increases the tripping time by 7 ms.	
2) Each additional intermediate relay increases the reset time by 8 ms.	
3) Limited by the continuous power dissipation of the device.	

Busbar Differential Protection / 7SS60

Technical data

Peripheral modules (cont'd)		Connectors with screw-type terminals	
7TS720 command output module			
Auxiliary voltage			
Rated auxiliary voltage V_{aux} (permissible voltage range)	48/60 V (DC 38 to 72 V) 110/125 V (DC 88 to 150 V) 220/250 V (DC 176 to 300 V) Settable As delivered: DC 220/250 V	Type	COMBICON system of PHOENIX CONTACT Front-MSTB 2.5/10-ST-5.08
Command contacts		For conductor cross-sections of	0.2 to 2.5 mm ² (rigid and flexible) AWG 24 to 12 0.25 to 2.5 mm ² (with end sleeve)
Number of relays	8	Multiple conductor connection (2 conductors of same cross-section)	0.2 to 1.0 mm ² (rigid) 0.2 to 1.5 mm ² (flexible) 0.25 to 1.0 mm ² (flexible with end sleeve, without plastic collar) 0.5 to 1.5 mm ² (flexible with TWIN end sleeve with plastic collar)
Contacts per relay	2 NO contacts	Stripping length	7 mm
For short term operation < 10 s ¹⁾		Recommended tightening torque	0.5 to 0.6 Nm
Pickup time	Approx. 7 ms	Unit design	
Switching capacity		Housing 7XP204	½ 19"
Make	1000 W/VA	Dimensions	See part 14
Break	30 W/VA	Weight	Approx. 3.5 kg
Switching voltage	AC/DC 250 V	Degree of protection according to IEC 60529-1 For the device	IP 51 (front panel) IP 20 (rear)
Permissible current		For the operator protection	IP 2X (if all connectors and blanking plates are fitted)
Continuous	5 A		
0.5 s	30 A		
Weight	Approx. 0.5 kg		
7SS601 measuring system			
Current connections (terminals 1 to 6)			
Screw-type terminals (ring-type cable lug)	For bolts of 6 mm		
Max. outside diameter	13 mm		
Type	e.g. PDIG of AMP		
For conductor cross-sections of	2.7 to 6.6 mm ² AWG 12 to 10		
In parallel double leaf-spring-crimp contact for conductor cross-sections of	2.5 to 4.0 mm ² AWG 13 to 11		
Max. tightening torque	3.5 Nm		
Control connections (terminals 7 to 31)			
Screw-type terminals (ring-type cable lug)	For 4 mm bolts		
Max. outside diameter	9 mm		
Type	e.g. PDIG of AMP		
For conductor cross-sections of	1.0 to 2.6 mm ² AWG 17 to 13		
In parallel double leaf-spring-crimp contact for conductor cross-sections of	0.5 to 2.5 mm ² AWG 20 to 13		
Max. tightening torque	1.8 Nm		
		Matching transformers	
		4AM5120-1DA00-0AN2	
		For connection to current transformers with a rated current I_N of	1 A
		Rated frequency f_N	45-60 Hz
		Winding	A-B B-C D-E E-F G-H H-J Y-Z
		Number of turns	1 2 4 8 16 32 500
		Max. current, continuous A	6.8 6.8 6.8 6.8 6.8 6.8 0.85
		Max. voltage V	0.4 0.8 1.6 3.2 6.4 12.8 200
		Max. burden VA	1.0
		4AM5120-2DA00-0AN2	
		For connection to current transformers with a rated current I_N of	A
		Rated frequency f_N	45-60 Hz
		Winding	A-B B-C D-E E-F Y-Z
		Number of turns	1 2 4 8 500
		Max. current, continuous A	26 26 26 26 0.85
		Max. voltage V	0.4 0.8 1.6 3.2 200
		Max. burden VA	1.2
1) Limited by the continuous power dissipation of the device.			

Summation current matching transformers									
4AM5120-3DA00-0AN2									
For connection to current transformers with a rated current I_N of	1 A								
Rated frequency f_N	45-60 Hz								
Winding	A-B	C-D	E-F	G-H	J-K	L-M	N-O	Y-Z	
Number of turns	3	6	9	18	24	36	90	500	
Max. current, continuous	A	4	4	4	4	4	2	0.85	
Max. voltage	V	1.2	2.4	3.6	7.2	9.6	14.4	36	200
Max. burden	VA	1.8							
4AM5120-4DA00-0AN2									
For connection to current transformers with a rated current I_N of	5 A								
Rated frequency f_N	45-60 Hz								
Winding	A-B	C-D	E-F	G-H	J-K	L-M	N-O	Y-Z	
Number of turns	1	2	3	4	6	8	12	500	
Max. current, continuous	A	17.5	17.5	17.5	17.5	17.5	8.0	0.85	
Max. voltage	V	0.4	0.8	1.2	1.6	2.4	3.2	4.8	200
Max. burden	VA	2.5							

Matching transformer									
4AM5272-3AA00-0AN2									
Multi-tap auxiliary current transformer to match different c.t. ratios									
Rated frequency f_N	45-60 Hz								
Winding	A-B	C-D	E-F	G-H	J-K	L-M	N-O	P-Q	
Number of turns	1	2	7	16	1	2	7	16	
Max. current, continuous	A	6	6	6	1.2	6	6	6	1.2
Max. voltage	V	4	8	28	64	4	8	28	64
resistance	Ω	0.018	0.035	0.11	1.05	0.018	0.035	0.11	1.05

Electrical tests	
<i>Specifications</i>	
Standards: IEC 60255-5; ANSI/IEEE C37.90.0	
<i>Insulation tests</i>	
High voltage test (routine test), measuring input I_d and relay outputs	2.5 kV (r.m.s.); 50 Hz
High voltage test (routine test), auxiliary voltage input and RS485 interface, binary inputs and measuring input I_R	DC 3.5 kV
Impulse voltage test (type test), all circuits, class III	5 kV (peak); 1.2/50 μ s; 0.5 J; 3 positive and 3 negative impulses in intervals of 5 s

EMC tests for interference immunity; type tests	
Standard	IEC 60255-6, IEC 60255-22 (international product standards) EM 50 Ω 082-2 (technical generic standard) DIN VDE 57435 part 303 (German product standard for protection devices)
High-frequency test IEC 60255-22-1, DIN 57435 part 303; class III	2.5 kV (peak); 1 MHz; $t = 15$ ms; 400 surges per s; test duration 2 s
Electrostatic discharge IEC 60255-22-2; IEC 61000-4-2; class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; $R_i = 330 \Omega$
Irradiation with RF field, non-modulated IEC 60255-22-3 (report); class III	10 V/m; 27 to 500 MHz
Irradiation with RF field, amplitude-modulated IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz
Irradiation with RF field, pulse-modulated IEC 61000-4-3/ENV 50204; class III	10 V/m; 900 MHz; repetition frequency 200 Hz; ED 50 %
Fast transient disturbance /bursts IEC 60255-22-4; IEC 61000-4-4; class III	4 kHz; 5/50 ns; 5 kHz, burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50 \Omega$; test duration 1 min
High-energy surge voltages (SURGE), IEC 61000-4-5, installation, class III	Auxiliary voltage: Longitudinal test: 2 kV; 12 Ω ; 9 μ F Transversal test: 1 kV; 2 Ω ; 18 μ F Measuring inputs, binary inputs and relay outputs: Longitudinal test: 2 kV; 42 Ω ; 0.5 μ F Transversal test: 1 kV; 42 Ω ; 0.5 μ F
Line-conducted HF, amplitude-modulated IEC 61000-4-6; class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Magnetic field with power frequency IEC 61000-4-8; class IV IEC 60255-6	30 A/m; continuous; 300 A/m for 3 s; 50 Hz; 0.5 mT
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak); 1 to 1.5 MHz; damped wave; 50 surges per s; duration 2 s; $R_i = 150$ to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per s; both polarities; duration 2 s; $R_i = 80 \Omega$
Radiated electromagnetic interference ANS/IEEE C37.90.2	35 V/m; 25 to 1000 MHz
Damped oscillations IEC 61000-4-12 IEC 60694	2.5 kV (peak, alternating polarity); 100 kHz; 1, 10 and 50 MHz; damped wave; $R_i = 50 \Omega$
<i>EMC tests for interference emission; type test</i>	
Standard	EN 50081-* (technical generic standard)
Conducted interference voltage on lines only auxiliary voltage, EN 55022, DIN VDE 0878 part 22, IEC CISPR 22	150 kHz to 30 MHz, limit value, class B
Radio interference field strength EN 55011; DIN VDE 0875 part 11, IEC CISPR 11	30 to 1000 MHz, limit value, class A

Busbar Differential Protection / 7SS60

Technical data

Mechanical stress tests		CE conformity
<i>Vibration, shock stress and seismic vibration</i>		<p>This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EG previous 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 2006/95/EG previous 73/23/EEC).</p> <p>This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).</p> <p>The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.</p> <p>This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".</p>
<u>During operation</u>		
Standards	IEC 60255-21-1 IEC 60068-2	
Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 10 to 60 Hz, ± 0.075 mm amplitude 60 to 150 Hz; 1 g acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes	
Shock IEC 60255-21-2, class I IEC 60068-2-27	Half-sinusoidal Acceleration 5 g; duration 11 ms 3 shocks in each direction of the 3 orthogonal axes	
Seismic vibration IEC 60255-21-3, class I IEC 60068-3-3 Horizontal axis	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude 8 to 35 Hz: 1 g acceleration	
Vertical axis	1 to 8 Hz: ± 1.5 mm amplitude 8 to 35 Hz: 0.5 g acceleration Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes	
<u>During transport</u>		
Standards	IEC 60255-21 IEC 60068-2	
Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude 8 to 150 Hz: 2 g acceleration sweep rate 1 octave/min 20 cycles in 3 orthogonal axes	
Shock IEC 60255-21-2, class I IEC 60068-2-27	Half-sinusoidal Acceleration 15 g; duration 11 ms 3 shocks in each direction of the 3 orthogonal axes	
Continuous shock IEC 60255-21-2, class I IEC 60068-2-29	Half-sinusoidal Acceleration 10 g; duration 16 ms 1000 shocks in each direction of the 3 orthogonal axes	
Climatic stress test		
<i>Temperatures</i>		
Standards	IEC 60255-6	
Permissible ambient temperatures		
– In service	-20 to +45/55 °C	
– During storage	-25 to +55 °C	
– During transport	-25 to +70 °C	
Storage and transport with standard works packing		
<i>Humidity</i>		
Standards	IEC 60068-2-3	
Permissible humidity It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average 75 % relative humidity; on 30 days in the year up to 95 % relative humidity; condensation not permissible!	

Busbar Differential Protection / 7SS60

Selection and ordering data

Description	Order No.
Centralized numerical busbar protection 7SS60, measuring system 50, 60, 16.7 Hz	7SS601-□-□□A□0-0AA0
Rated current/frequency	
100 mA; 50/60 Hz AC	0
100 mA; 16.7 Hz AC	6
Rated auxiliary voltage	
24 to 48 V DC	2
60 to 125 V DC	4
220 to 250 V DC	5
Unit design	
Housing 7XP20 ½ 19-inch, for panel flush mounting or cubicle mounting	E
Measuring system	
Standard	0
Stabilizing/command output module	
5 stabilizing CTs, 5 relays with 2 NO contacts 48/60 V DC, 110/125 V DC, 220/250 V DC settable	7TM7000-0AA00-0AA0
Isolator replica/preference module	
	7TR7100-□AA00-0AA0
48 to 60 V DC	3
110 to 125 V DC	4
220 to 250 V DC	5
Command output module	
8 relays with 2 NO contacts 48/60 V DC, 110/125 V DC, 220/250 V DC settable	7TS7200-0AA00-0AA0
Housing ½19-inch for peripheral modules 7SS60	
For panel flush mounting or cubicle mounting	7XP2041-2MA00-0AA0

Busbar Differential Protection / 7SS60

Selection and ordering data

Accessories	Description	Order No.
	Copper interconnecting cable PC (9-pole socket) and converter/protection relay	7XV5100-2
	Connector adapter 9 pin female / 25 pinmale	7XV5100-8H
	RS232 - RS485 converter With power supply unit for AC 230 V With power supply unit for AC 110 V	7XV5700-0AA00 7XV5700-1AA00
	Converter Full duplex fiber-optic cable ↔ RS485 Auxiliary voltage: DC 24 V to DC 250 V, DC 110/230 V Line converter ST connector Cascada converter ST connector	7XV5650-0BA00 7XV5651-0BA00
	Connector for peripheral modules, as spare part	W73078-B9005-A710
	Extraction tool for connector	W73078-Z9005-A710
	Test adapter	7XV6010-0AA00
	Angle bracket (set)	C73165-A63-D200-1
	Summation current matching transformer 1 A, 50/60 Hz 5 A, 50/60 Hz	4AM5120-3DA00-0AN2 4AM5120-4DA00-0AN2
	Matching transformer 1 A, 50/60 Hz 5 A, 50/60 Hz 1 A, 5 A, 50/60 Hz	4AM5120-1DA00-0AN2 4AM5120-2DA00-0AN2 4AM5272-3AA00-0AN2
	Manual 7SS60 English	E50417-G1176-C132-A3

Connection diagrams

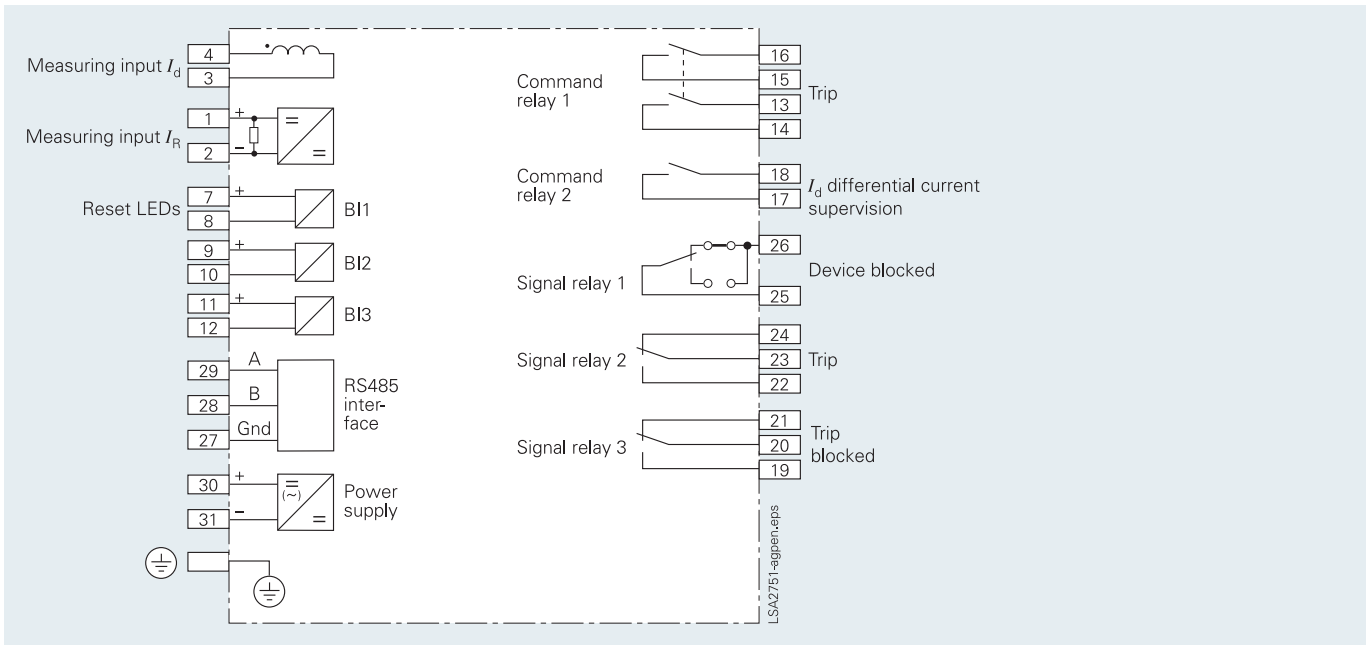


Fig. 9/14 Connection diagram for 7SS601

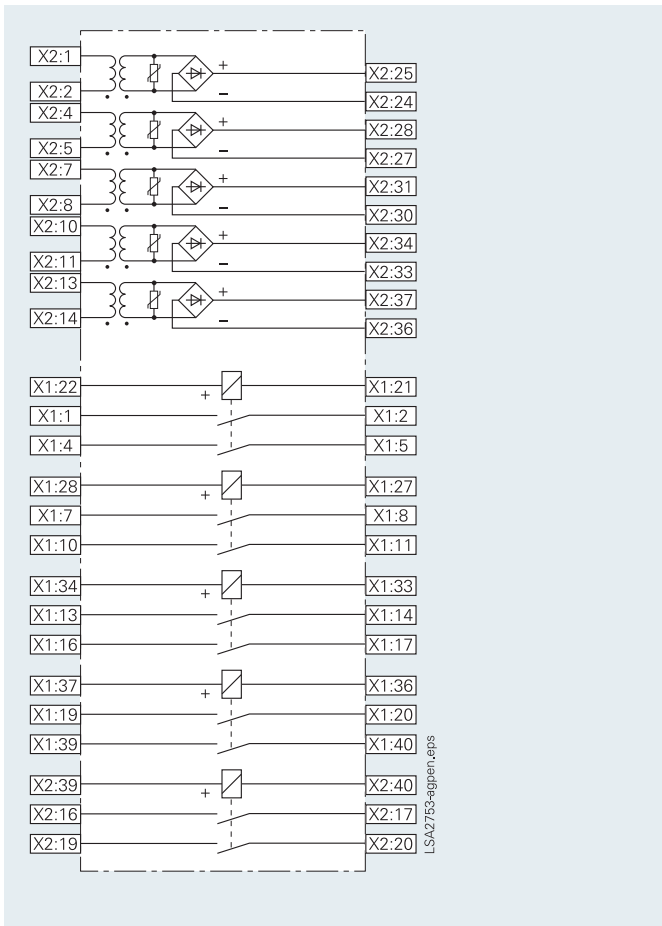


Fig. 9/15 Connection diagram for 7TM700

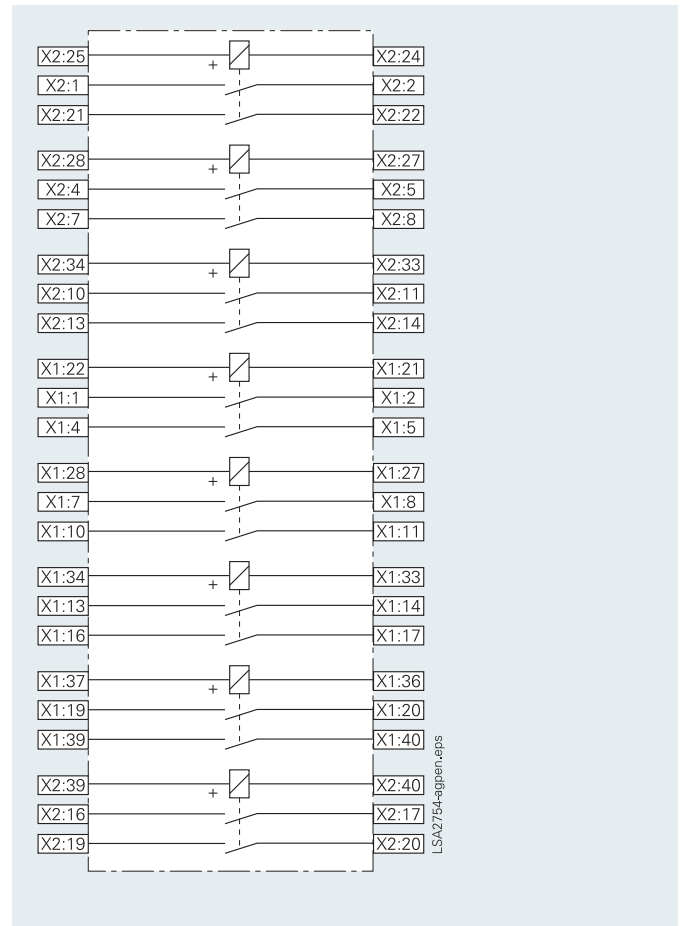


Fig. 9/16 Connection diagram for 7TS720

Busbar Differential Protection / 7SS60

Connection diagram

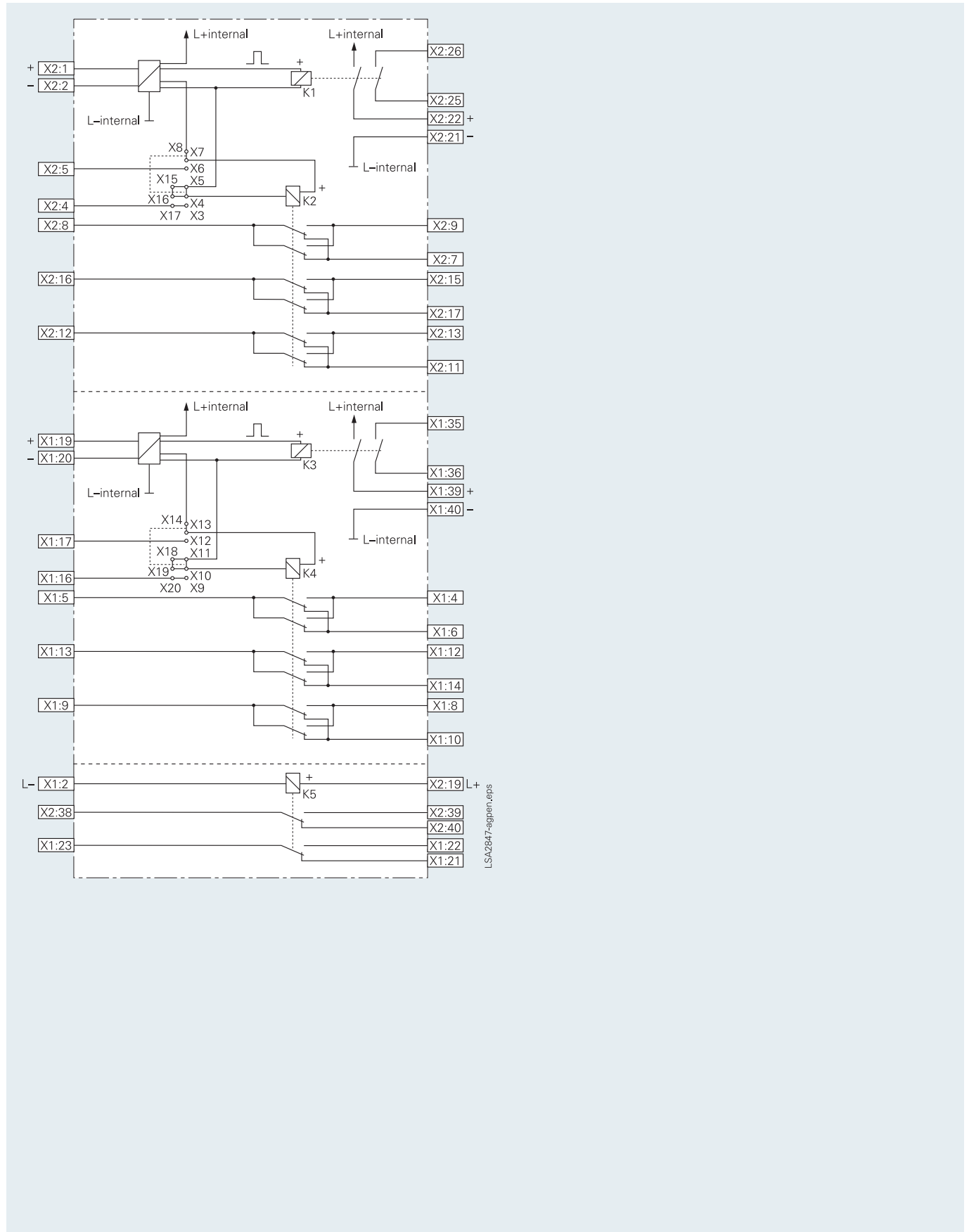


Fig. 9/17 Block diagram of 7TR710

Busbar Differential Protection / 7SS52

SIPROTEC 4 7SS52 distributed numerical busbar and breaker failure protection



Function overview

Busbar protection functions

- Busbar differential protection
- Selective zone tripping
- Very short tripping time (<15 ms)
- Extreme stability against external fault, short saturation-free time (≥ 2 ms)
- Phase-segregated measuring systems
- Integrated check zone
- 48 bays can be configured
- 12 busbar sections can be protected
- Bay-selective intertripping

Breaker failure protection functions

- Breaker failure protection (single-phase with/without current)
- 5 operation modes, selectable per bay
- Separate parameterization possible for busbar and line faults
- Independently settable delay times for all operation modes

Fig. 9/18 SIPROTEC 4 7SS52 busbar protection system

Description

The SIPROTEC 7SS52 numerical protection is a selective, reliable and fast protection for busbar faults and breaker failure in medium, high and extra-high voltage substations with various possible busbar configurations.

The protection is suitable for all switchgear types with iron-core or linearized current transformers. The short tripping time is especially advantageous for applications with high fault levels or where fast fault clearance is required for power system stability.

The modular hardware allows the protection to be optimally matched to the busbar configuration. The decentralized arrangement allows the cabling costs in the substation to be drastically reduced. The 7SS52 busbar protection caters for single, double or triple busbar systems with or without and quadruple busbar systems without transfer bus with up to: 48 bays,

16 bus couplers, and 24 sectionalizing disconnectors and 12 busbar sections.

- 2-stage operation bay trip repeat/trip busbar
- Intertrip facility (via teleprotection interface)
- "Low-current" mode using the circuit-breaker auxiliary contacts

Additional protection functions

- End-fault protection with intertrip or bus zone trip
- Backup overcurrent protection per bay unit (definite-time or inverse-time)
- Independent breaker failure protection per bay unit

Features

- Distributed or centralized installation
- Easy expansion capability
- Integrated commissioning aids
- Centralized user-friendly configuration / parameterization with DIGSI
- Universal hardware

Communication interfaces

- FO interface
 - IEC 60870-5-103 protocol
- Electrical interface
 - IEC 61850 protocol with EN 100 module (firmware V4.6)

Busbar Differential Protection / 7SS52

Application

Application

The 7SS52 distributed numerical busbar and breaker failure protection system is a selective, reliable and fast protection for busbar faults and breaker failure in medium, high and extra-high voltage substations with various possible busbar configurations. The protection is suitable for all switchgear types with iron-core or linearized current transformers. The short tripping time is especially advantageous for applications with high fault levels or where fast fault clearance is required for power system stability.

The modular hardware design allows the protection system to be optimally matched to the busbar configuration.

The distributed arrangement allows the cabling costs between bay and substation to be drastically reduced. The 7SS52 busbar protection caters for single, double, triple and quadruple busbar systems with or without transfer bus with up to:

- 48 bays
- 16 bus couplers
- 24 sectionalizing disconnectors
- 12 busbar sections

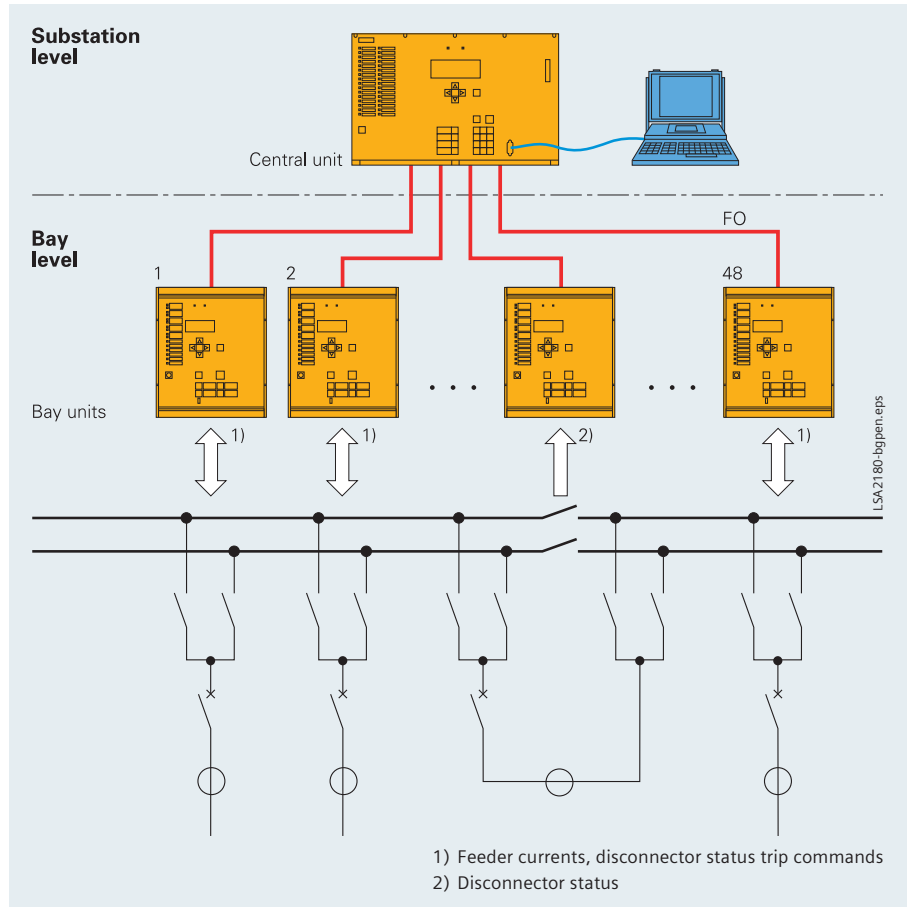


Fig. 9/19 Distributed system structure

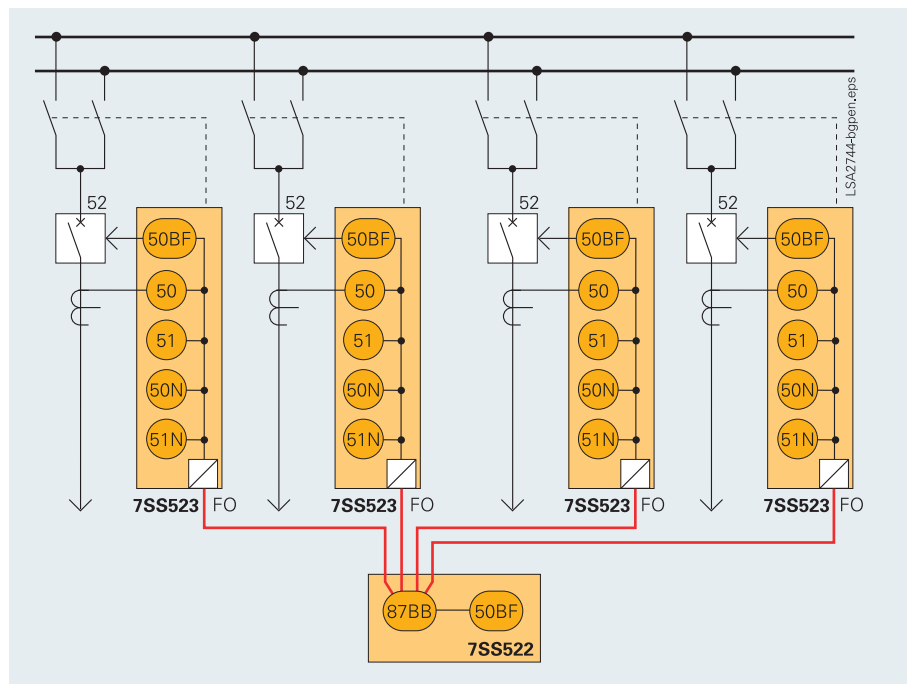


Fig. 9/20 Protection functions of the central unit and the bay units

Construction

The distributed bay units measure the 3 phase currents in each bay. The rated input current is 1 or 5 A and therefore eliminates the need for interposing current transformers. The disconnecter status, breaker failure protection triggering, bay out-of-service and other bay status information is derived via marshallable binary inputs in the bay units. The complete information exchange is conveyed to the central unit via a fiber-optic interface. The bay unit also has an interface on the front side for connection to a PC for operation and diagnosis. The trip and intertrip commands are issued via trip contacts in the bay units. The 7XP20 standard housing is available in a flush or surface mounting version (7SS523).

The central unit is connected to the bay units via fiber-optic communication links. The connection is built up in a star configuration. The central unit also contains serial ports for system configuration via PC or communication with a substation control system, an integrated LC Display with keypad and marshallable binary inputs, LEDs and alarm relays. The central unit is available in a 19" SIPAC module rack version for either cubicle or wall mounting.

Because of its modular hardware design, it is easy to adapt the central unit to the substation or to expand it with further modules each being connected with up to 8 bay units.

Each bay unit and the central unit has its own internal power supply.



Fig. 9/21 7SS522 central unit – front view of SIPAC subrack version



Fig. 9/22 7SS522 central unit – rear view



Fig. 9/23 7SS523 bay unit – front view of panel/flush/cubicle mounting unit



Fig. 9/24 7SS525 bay unit – front view of panel/flush/cubicle mounting unit

Busbar Differential Protection / 7SS52

Protection functions

Protection functions

Busbar protection

The main function of the 7SS52 is busbar protection, and has the following characteristics:

- Evaluation of differential currents, with stabilization by through-currents based on the proven performance of the Siemens busbar protection 7SS1 and 7SS50/51, currently in service worldwide
- Selective busbar protection for busbars with up to 12 busbar sections and 48 bays
- Integrated “check zone” (evaluation of all busbar section currents without use of the disconnector replica)
- Very short tripping time (15 ms typical)
- Selective detection of short-circuits, also for faults on the transfer bus, with transfer trip to the remote end.
- Detection and clearance of faults between the current transformer and the circuit-breaker via current measurement and selective unbalancing.
- Tripping only when all three fault detection modules recognize a busbar fault (2 measurement processors and check zone processor)
- No special CT requirements (stability is guaranteed, even when the CTs saturate after 2 ms)
- Selective output tripping relays per feeder in bay units.

Mode of operation

The 7SS52 protection relay offers complete numerical measured-value processing from sampling to digital conversion of the measured variables through to the circuit-breaker tripping decision. The bay units dispose of sufficient powerful contacts to directly trip the circuit-breaker.

For each busbar section and for all three phases, two independent processors execute the protection algorithm on alternate data samples. Based on the proven performance of the 7SS1 and 7SS50/51, this method of measurement ensures highest stability even in case of high short-circuit currents and CT saturation.

In addition, an disconnector status independent check-zone measurement is executed on a further processor thus increasing the protection against unwanted operation. All three processors must reach a trip decision independently before the trip command is released.

The disconnector status is monitored using normally open and normally closed contacts to enable plausibility checks for both status and transition time. The contact monitoring voltage is also supervised.

In case of an auxiliary voltage failure in the bay, the latest disconnector status is stored and a bay-selective indication of the failure is issued.

The assignment of the feeder currents to the corresponding busbar systems is controlled by software via the disconnector replica. The disconnector replica is applied for both busbar protection and breaker failure protection.

The integrated breaker failure protection function provides phase-segregated two-stage operation (bay-specific trip repeat, trip bus section). Alternatively, an external breaker failure protection relay can issue its trip commands via the disconnector replica in the 7SS52.

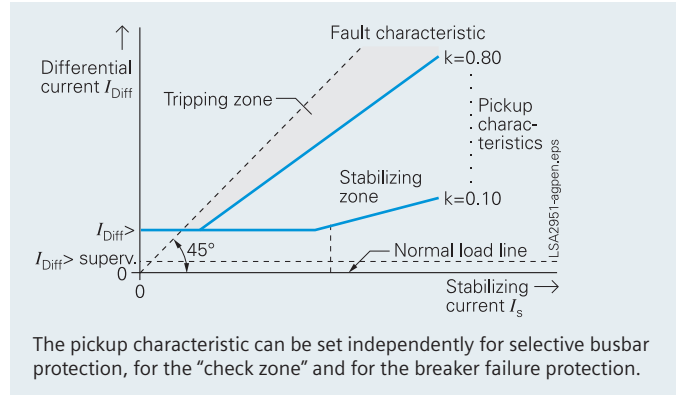


Fig. 9/25 Standard characteristic

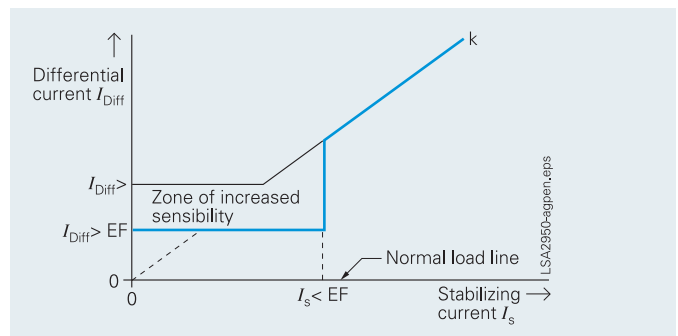


Fig. 9/26 Ground-fault characteristic

Breaker failure protection

The 7SS52 protection includes an integrated breaker failure protection with the following features:

- Five breaker failure protection modes that are selectable:
 1. Following the issue of a trip signal from a feeder protection, the busbar protection monitors the drop-off of the trip signal. If the feeder current is not interrupted before a set time delay the polarity of the feeder current is reversed, which results in a differential current in the corresponding section of the bus protection. For this function, a separate parameter set is used.
 2. Following a trip signal from a feeder protection, a trip signal will be output after a settable time delay from the 7SS52 protection to the corresponding feeder circuit-breaker. If this second trip signal is also unsuccessful, the unbalancing procedure according to mode 1) as described above will take place.
 3. With external stand-alone breaker failure protection, the disconnector replica of the 7SS52 may be used to selectively trip the busbar section with the faulty circuit-breaker.
 4. Following a trip signal from the feeder protection, the 7SS52 monitors the drop-off of the trip signal. If, after a settable time, the current does not fall below a settable limiting value, busbar-selective feeder trip commands are issued with the help of the disconnector replica within the 7SS52.
 5. Following a trip signal from a feeder protection, a trip signal will be output after a settable time delay from the 7SS52 protection to the corresponding feeder circuit-breaker. If this second trip signal is also unsuccessful, the tripping as described under 4) will take place.

- For single-pole or multi-pole starting, delay times are available.
- Breaker failure detection following a busbar fault by comparison of the measured current with a set value.
- For all modes of breaker failure protection, a transfer trip command output contact is provided for each feeder to initiate remote tripping.

Sensitive tripping characteristic

In some applications, e.g. within resistive grounded networks, single-phase short-circuit currents are limited to rated current values. In order to provide a busbar protection for these cases, an independent characteristic is available. This characteristic presents separate parameters for the pickup threshold, as well as for a limitation of efficiency. The activation of the characteristic takes place by means of a binary input in the central unit, e.g. by recognizing a displacement voltage.

End-fault protection

The location of the current transformer normally limits the measuring range of the busbar protection. When the circuit-breaker is open, the area located between the current transformer and the circuit-breaker can be optimally protected by means of the end-fault protection. In the event of a fault, depending on the mounting position of the current transformer, instantaneous and selective tripping of the busbar section or intertripping of the circuit-breaker at the opposite end occurs.

Backup protection

As an option, a two-stage backup protection, independent of the busbar protection is included in every bay unit. This backup protection is completed by means of a breaker failure protection. The parametrization and operation can be carried out in the central unit or locally in each bay unit with the DIGSI operating program.

Disconnecter replica

The disconnector replica is used for both the busbar protection and the breaker failure protection.

The following features characterize the disconnector replica function:

- Includes up to 48 bays and 12 busbar sections
- Integrated bi-stable disconnector status characteristic (status stored on loss of auxiliary power).
- Disconnecter transition time monitoring.

- By the assignment "NOT open = closed", the disconnector is taken to be CLOSED during the transition time. Accurate matching of the disconnector auxiliary contacts with the main contact is not required.
- Menu-guided graphic configuration with DIGSI operating program.
- LEDs in the bay modules indicate the actual status of the busbar disconnector.
- Dynamic visualization of the substation with DIGSI on the central unit.

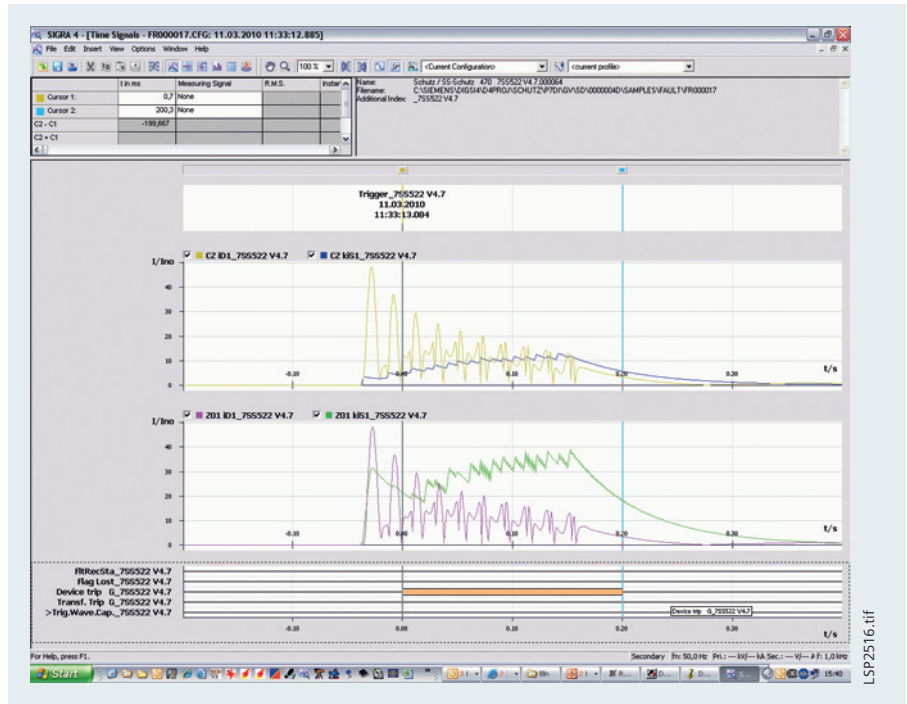


Fig. 9/27 Fault record

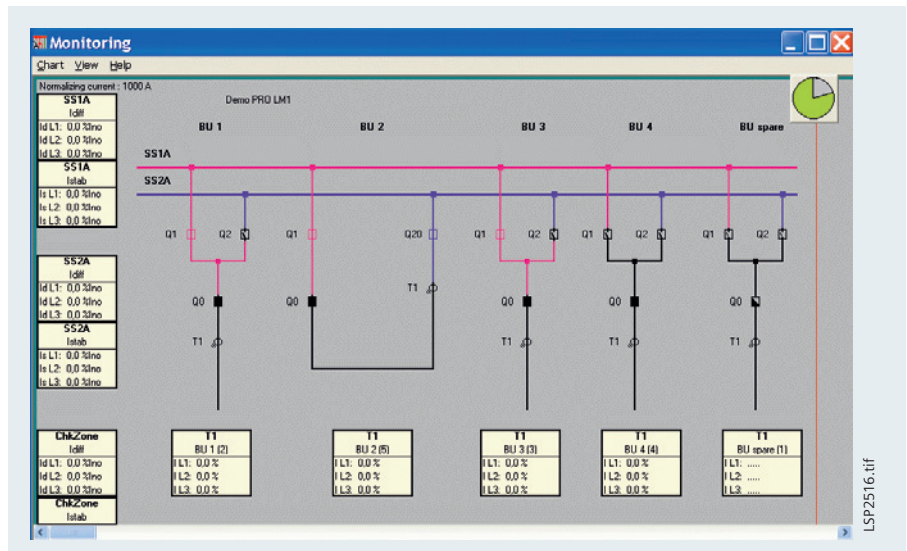


Fig. 9/28 DIGSI plant monitoring

Busbar Differential Protection / 7SS52

Protection functions

Tripping command/reset

The tripping output processing for the 7SS52 protection has the following features:

- Bay-selective tripping by bay units
- Settings provided for overcurrent release of the tripping command (to enable selective tripping of infeeding circuits only)
- Settable minimum time for the trip command.
- Current-dependent reset of the tripping command.

Disturbance recording

The digitized measured values from the phase currents and the differential and stabilizing currents of the busbar sections and check zone are stored following a trip decision by the 7SS52 or following an external initiation via a binary input. Pre-trigger and post-fault times with regard of the trip command can be set. Up to 8 fault recordings are stored in the 7SS52. The fault records may be input to a PC connected to the central unit, using the menu-guided DIGSI operating program. Then, the SIGRA graphics program makes it possible to easily analyze the fault recordings.

Marshallable tripping relays, binary inputs, alarm relays and LEDs

The bay units are equipped with marshallable command relays for direct circuit-breaker tripping. For each bay there are 9 (7SS523) or 8 (7SS525) duty contacts available.

For user-specific output and indication of events, 16 alarm relays and 32 LEDs in the central unit are freely marshallable.

Several individual alarms may be grouped together.

The central unit has marshallable binary inputs with:

- Reset of LED display
- Time synchronization
- Blocking of protection functions

The bay units have marshallable binary inputs:

- Disconnecter status closed/open
- Phase-segregated start of circuit-breaker failure protection
- Release of circuit-breaker failure protection
- Release of TRIP command
- Circuit-breaker auxiliary contacts
- Bay out of service
- Test of circuit-breaker tripping

Measurement and monitoring functions

In the 7SS52 protection relay, a variety of measurement and monitoring functions is provided for commissioning and maintenance. These functions include:

- Measurement and display of the phase currents of the feeders in the central unit and bay units.
- Measurement and display (on the integrated LCD or PC) of the differential and stabilizing currents of all measuring systems in the central unit and the bay units.
- Monitoring of busbar-selective and phase-segregated differential currents with busbar-selective blocking/alarming
- Monitoring of the differential currents of the check zone with alarming/blocking

- Phase-segregated trip test including control of feeder circuit-breaker (by central or bay unit)
- Removal of a bay from the busbar measurement processing during feeder service and maintenance via central or bay units (bay out of service)
- Blocking of breaker failure protection or tripping command for testing purposes.
- Disconnecter replica freezing (maintenance) with alarm indication ("Disconnecter switching prohibition").
- Cyclic tests of measured-value acquisition and processing and trip circuit tests including coils of the command relays.

Event recording

The 7SS52 protection provides complete data for analysis of protection performance following a trip or any other abnormal condition and for monitoring the state of the relay during normal service.

Up to 200 operational events and 80 fault annunciations with a resolution of one millisecond may be stored in two independent buffers:

- Operational indications
This group includes plant/substation operation events, for example disconnecter switching, disconnecter status discrepancies (transition time limit exceeded, loss of auxiliary voltage, etc.) or event/alarm indications
- Tripping following a busbar short-circuit fault or circuit-breaker failure.

Settings

A PC can be connected to the operator interface located at the front panel or the rear of the central unit. An operating program is available for convenient and clear setting, fault recording and evaluation as well as for commissioning. All settings of the busbar or breaker failure protection, as well as settings of additional functions such as backup protection, need only be parameterized at the central unit. Settings at the bay units are not necessary.

With the help of the integrated keypad and display on the central unit, all setting parameters may be read out.

Keypad, display (7SS523) and the front side interface of the bay units serve for commissioning, display of operational values and diagnosis.

All parameters are written into nonvolatile memories to ensure that they are retained even during loss of auxiliary voltage.

Configuration, visualization

The configuration of the 7SS52 is effected by means of a graphics-orientated editor included in the DIGSI operation program. For frequently used bay types, a symbol library is available. Enhancements can be easily effected anytime.

A graphical configuration visualizes the states of the disconnecter position, the circuit-breaker and measuring values.

Self-monitoring

Hardware and software are continuously monitored and any irregularity is immediately detected and alarmed. The self-monitoring feature improves both the reliability and the availability of the 7SS52. The following quantities are monitored:

- The current transformer circuits
- The analog-to-digital conversion

- All internal supply voltages
- The program memory
- The program running times by a watch dog function
- The disconnecter status
- The three channel tripping circuit

Maximum lifetime and reliability

The hardware of the 7SS52 units is guaranteed by more than 20 years of experience in numerical protection design at Siemens. The number of components employed is reduced through use of a powerful microprocessor in conjunction with highly-integrated components, thus enhancing the reliability. The experience gained by Siemens in production of over 1 million numerical protection units has been incorporated in the software design. The most modern manufacturing methods together with effective quality control ensure high reliability and a long service life.

Battery monitoring

The internal battery is used to back-up the clock and memory for storage of switching statistics, status and fault indications and fault recording, in the event of a power supply failure. The processor checks its capacity at regular intervals. If the capacity of the battery is found to be declining, an alarm is generated. Routine replacement is therefore not necessary. All setting parameters are stored in the Flash-EPROM, and therefore not lost if the power supply or the battery fails.

Functions for testing and commissioning

The 7SS52 offers auxiliary functions for commissioning. The physical status of all binary inputs and output relays of the central unit can be displayed and directly altered to facilitate testing.

All measured values can be clearly depicted by means of DIGSI and simultaneously displayed in different windows as primary or percentage values.

The 7SS52 units are provided with a circuit-breaker test function. Single-pole and three-pole TRIP commands can be issued.

Data transmission lockout

Data transmission lockout can be activated, so as to prevent transfer of information to the control center during work on a circuit bay.

Test mode

During commissioning, a test mode can be selected; all indications then have a test mode suffix for transmission to the control system.

Communication

Serial communication

With respect to communication, particular emphasis is placed on the customer requirements in energy automation:

- Every data item is time-stamped at the source, i.e. where it originates.
- Already during the process of communication, information is assigned to the cause thereof (e.g. assignment of the indication "circuit-breaker TRIP" to the corresponding command).
- The communication system automatically handles the transfer of large data blocks (e.g. fault recordings or parameter data files). The user has access to these features without any additional programming effort.

Local and remote communication

The 7SS52 central unit provides several serial communication interfaces for various tasks:

- Front interface for connecting a PC
- Rear-side service interface (always provided) for connection to a PC, either directly or via a modem
- System interface for connecting to a control system via IEC 60870-5-103 protocol.
- System interface (EN 100 module) for connecting to a control system via IEC 61850 protocol
- Time synchronization via IRIG-B / DCF / system interface

Serial front interface (central unit and bay units)

There is a serial RS232 interface on the front of all the units. All of the unit's functions can be set on a PC by means of the DIGSI 4 protection operation program. Commissioning tools and fault analysis are also built into the program and are available through this interface.

Rear-mounted interfaces (central unit only)

A number of communication modules suitable for various applications can be fitted in the rear of the flush-mounting housing. The interface modules support the following applications:

- Service interface
The service interface was conceived for remote access to a number of protection units via DIGSI. It can be an electrical RS232/RS85 or an optical interface.
- RS485 bus
With this data transmission via copper conductors, electromagnetic fault influences are largely eliminated by the use of twisted-pair conductors. Upon failure of a unit, the remaining system continues to operate without any problem.

System interface

Communication with a central control system takes place through this interface. Radial or ring type station bus topologies can be configured depending on the chosen interface. Furthermore, the units can exchange data through this interface via Ethernet and IEC 61850 protocol and can also be operated by DIGSI.

Busbar Differential Protection / 7SS52

Communication

IEC 61850 protocol (retrofittable)

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. By means of this protocol, information can also be exchanged directly between protection units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus will also be possible with DIGSI.

IEC 60870-5-103 protocol

The IEC 60870-5-103 protocol is an international standard for the transmission of protective data and fault recordings. All messages from the unit and also control commands can be transferred by means of published, Siemens-specific extensions to the protocol.

Time synchronization

The battery-backed clock of the 7SS52 central unit can be synchronized via:

- DCF 77 signal via time synchronization receiver
- IRIG-B satellite signal via time synchronization receiver
- Minute-pulse via binary input
- System interface by the substation control, e.g. SICAM

Date and time with milliseconds resolution is assigned to every indication. The synchronization of the 7SS52 bay units is automatically effected with the central unit.

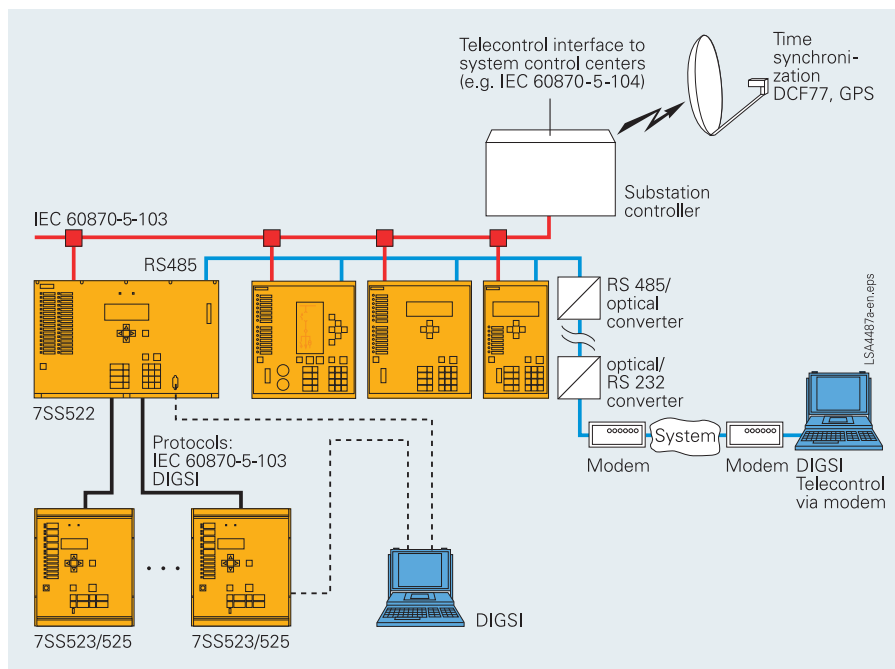


Fig. 9/29 Communication structure with DIGSI and IEC 60870-5-103

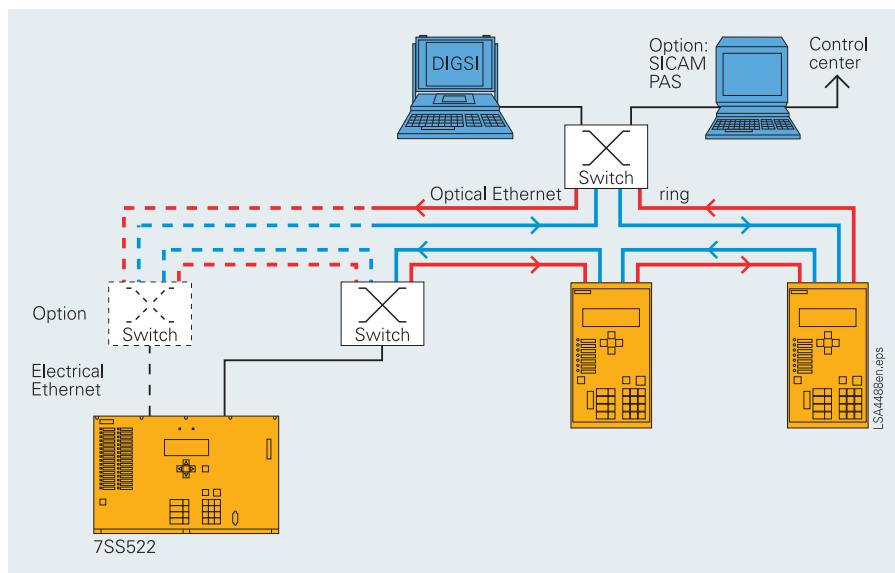


Fig. 9/30 Communication structure for station bus with Ethernet and IEC 61850, FO ring

General unit data			
<i>Input circuits</i>			
Rated current I_N		1 or 5 A	
Rated frequency f_N		50/60 Hz	
Thermal overload capability in current path	Continuous 10 s 1 s	4 x I_N 10 x I_N 100 x I_N	
Dynamic overload capability		250 x I_N	
Burden of current inputs	At $I_N = 1$ A At $I_N = 5$ A	< 0.1 VA < 0.2 VA	
<i>Auxiliary voltage</i>			
Rated auxiliary voltage V_{aux}	Central unit	DC 48/60, 110/125, 220/250 V	
Rated auxiliary voltage V_{aux}	Bay unit	DC 48, 60 to 250 V	
Permissible tolerance V_{aux}		-20 to +20 %	
Maximum ripple		≤ 15 %	
Power consumption		Configuration dependent	
Central unit	Quiescent Energized	30 to 50 W 35 to 65 W	
Bay unit		7SS523	7SS525
	Quiescent Energized	12 W 16 W	10 W 14 W
Max. bridging time during loss of voltage supply		> 50 ms at $V_{aux} \geq 60$ V	
<i>Binary inputs</i>			
		7SS523	7SS525
Number of binary inputs	Bay unit Central unit	20 12	10
Voltage range		DC 24 to 250 V	
Current consumption		Approx. 1.5 mA/input	
<i>Alarm/event contacts</i>			
Central unit			
Number of relays	Marshallable Fixed	16 (each 1 NO contact) 1 (2 NC contacts)	
Switching capacity	Make/Break	20 W/VA	
Switching voltage		AC/DC 250 V	
Permissible current		1 A	
Bay unit		7SS523	7SS525
Number of relays	Marshallable Fixed	1 (1 NO contact) 1 (2 NC contacts)	1 (1 NO contact) 1 (1 NC contacts)
Switching capacity	Make/Break	20 W/VA	
Switching voltage	AC/DC 250 V	AC/DC 250 V	
Permissible current	1 A	1 A	
<i>Command contacts</i>			
Number of relays (bay unit)		7SS523	7SS525
		4 (each 2 NO contacts) 1 (1 NO contact)	3 (each 2 NO contacts) 2 (1 NO contact)
Switching capacity	Make Break	1000 W/VA 30 W/VA	
Switching voltage		AC/DC 250 V	
Permissible current	Continuous 0.5 s	5 A 30 A	

LEDs		
Central unit		
Operation indication	Green	1
Device failure	Red	1
Marshallable	Red	32
Bay unit		
Operation indication	Green	1
Device failure	Red	1
Indications	Green Red	5 (7SS523)/- (7SS525) 11 (7SS523)/1 (7SS525)
<i>Control, displays</i>		
Central unit		
LC Display		4 lines x 20 characters
Membrane keyboard		24 keys
Bay unit (7SS523)		
LC Display		4 lines x 16 characters
Membrane keyboard		12 keys
<i>Serial interfaces</i>		
<i>Central unit</i>		
<i>PC interface (front)</i>		
Connection, electrical		SUB-D, 9-pin (subminiature ISO 2110)
Baud rate		1200 to 115000 baud
<i>System interface IEC 60870-5-103 (rear)</i>		
Connection, optical electrical		ST connectors SUB-D, 9-pin (subminiature ISO 2110)
Baud rate		1200 to 115000 baud
<i>System interface IEC 61850 (rear)</i>		
Connection, electrical with EN 100 module		RJ45 connector
Baud rate		up to 100 Mbaud
<i>Service interface (rear)</i>		
Connection, optical electrical		ST connectors SUB-D, 9-pin (subminiature ISO 2110)
Baud rate		1200 to 115000 baud
<i>Bay unit</i>		
<i>PC interface (front)</i>		
Connection, electrical		SUB-D, 9-pin (subminiature ISO 2110)
Baud rate		1200 to 19200 baud
<i>Central/bay unit</i>		
<i>Interface for high-speed data communication</i>		
Connection		ST connectors
Fiber-optic cable		Glass fiber 62.5/125 μ m
Optical wavelength		820 nm
Permissible cable attenuation		Max. 8 dB
Transmission distance		Max. 1.5 km

Busbar Differential Protection / 7SS52

Technical data

Unit design (degree of protection according to EN 60529)		
Central unit		
Cubicle	IP 54	
Housing for wall mounting	IP 55	
SIPAC subrack	IP 20	
Bay unit	7SS523	7SS525
Housing	IP 51	IP 20
Terminals	IP 21	
Weight at max. configuration		
Central unit		
SIPAC subrack	14.3 kg	
Surface-mounting housing	43.0 kg	
Bay unit	7SS523	7SS525
Flush mounting	8.1 kg	5.5 kg
Surface mounting	11.8 kg	

Electrical tests	
Specification	
Standards	IEC 60255-5, DIN 57435 part 303
High-voltage test (routine test), except DC voltage supply input	2 kV (r.m.s.), 50 Hz
High-voltage test (routine test), only DC voltage supply input	DC 2.8 kV
Impulse voltage test (type test), all circuits, class III	5 kV (peak), 1.2/50 µs, 0.5 J, 3 positive and 3 negative impulses at intervals of 5 s

EMC tests for interference immunity; type test	
Standards	IEC 60255-6, IEC 60255-22 (international product standard), EN 50082-2 (European generic standard for industrial environment), VDE 0435 part 303 (German product standard)
High-frequency test with 1 MHz interference IEC 60255-2-1, class III and VDE 0435 part 303, class III	2.5 kV (peak), 1 MHz, $\tau = 15 \mu\text{s}$, 400 surges/s, duration 2 s
Electrostatic discharge IEC 60255-22-2, class IV and IEC 61000-4-2, class IV	8 kV contact discharge, 15 kV air discharge, both polarities, 150 pF, $R_i = 330 \Omega$
Irradiation with radio-frequency field, non-modulated IEC 60255-22-3, class III	10 V/m, 27 to 500 MHz
Irradiation with radio-frequency field, amplitude-modulated IEC 61000-4-3, class III	10 V/m, 80 to 1000 MHz, AM 80 %, 1 kHz
Irradiation with radio-frequency field, pulse-modulated ENV 50204, class III	10 V/m, 900 MHz, repetition rate 200 Hz, duty cycle 50 %
Fast transients interference/bursts IEC 60255-22-4, class IV; IEC 61000-4-4, class IV; IEC 60801-4	4 kV, 5/50 ns, 5 kHz, burst length = 15 ms, repetition rate 300 ms, both polarities, $R_i = 50 \Omega$, duration 1 min
Line-conducted disturbances induced by radio-frequency fields, amplitude-modulated IEC 61000-4-6, class III	10 V, 150 kHz to 80 MHz, AM 80 %, 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous, 300 A/m for 3 s, 50 Hz 0.5 mT; 50 Hz

EMC tests for interference emission; type test	
Standard	EN 50081-2 (European generic standard for industrial environment)
Conducted interference voltage, auxiliary voltage CISPR 11, EN 55011 and VDE 0875 part 11	150 kHz to 30 MHz, limit class B
Radio interference field strength CISPR 11, EN 55011 and VDE 0875 part 11	30 to 1000 MHz, limit class B

Mechanical stress tests	
Specification	
Standards	IEC 60255-21-1, IEC 6068-2
Permissible mechanical stress	
During service	10 to 60 Hz, 0.035 mm amplitude 60 to 500 Hz, 0.5 g acceleration
During transport	5 to 8 Hz, 7.5 mm amplitude 8 to 500 Hz, 2 g acceleration

Climatic stress tests	
Temperatures	
Standard	IEC 60255-6
Permissible ambient temperature	
– In service	–10 °C to +55 °C (bay unit) – 5 °C to +55 °C (central unit)
– For storage	–25 °C to +70 °C
– During transport	–25 °C to +70 °C
– During start-up	–10 °C to +55 °C (bay unit) 0 °C to +55 °C (central unit)

Humidity	
Standards	IEC 60068-2-3
It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average 75 % relative humidity; on 56 days a year up to 93 % relative humidity; condensation not permissible!

Busbar configuration	
Quadruple or triple busbar with transfer busbar;	
Number of bays	48
Number of bus sections	12
Number of bus couplers	16
Number of sectionalizers	24
Number of coupler bus sections	12

Busbar protection	
Tripping characteristics	
Setting ranges	
Overcurrent $II_{NO}^{1)}$	0.2 to 4 (in steps of 0.01)
Stabilizing factor k for busbar-selective protection	0.1 to 0.8 (in steps of 0.01)
Stabilizing factor k for check zone	0 to 0.8 (in steps of 0.01)
Tripping time	
Typical trip time	15 ms
Differential current monitoring	
Setting ranges	
Current limit $III_{NO}^{1)}$	0.05 to 0.8 (in steps of 0.01)
Time delay	1 to 10 s (in steps of 1 s)

1) I_{NO} = highest c.t. ratio.

Breaker failure protection	
Tripping	
Setting ranges	
Overcurrent III_N	0.05 to 2 (in steps of 0.01)
Stabilizing factor k	0 to 0.8 (in steps of 0.01)
Time delay for unbalancing $I > \text{query}$	0.05 to 10 s (in steps of 0.01 s)
Time delay for TRIP repeat	0.00 to 10 s (in steps of 0.01 s)
Modes of operation	
Individually selectable per feeder:	
$I > \text{query}$	
TRIP repeat (1/3-phase) with $I > \text{query}$	
Unbalancing (1-stage BF)	
Unbalancing with TRIP repeat (1/3-phase, 2-stage BF)	
TRIP by external BF protection (tripping via disconnecter replica of busbar protection)	
Plus for each mode (except for TRIP by external BF): low-current mode	
Plus for modes with TRIP repeat: pulse mode	
Breaker failure protection for busbar short-circuit	
Setting value	
Overcurrent III_N	0.05 to 2 (in steps of 0.01)
Time delay	0.05 to 10.00 s (in steps of 0.01 s)
General data of the protection system	
Min. time of TRIP commands	
Setting range	
Current threshold for command reset III_N	0.02 to 1 s (in steps of 0.01 s)
	0.05 to 2 (in steps of 0.10)
Overcurrent release of TRIP commands	
Setting range	0 to 25 (in steps of 0.01)
Disconnecter transition time	
Setting range	1 to 180 s (in steps of 0.01 s)
Overcurrent protection in the bay unit	
Characteristics	Definite-time or inverse-time overcurrent protection
Setting ranges	
High-set stage; $I \gg$ (phase) III_N	0.05 to 25.00 (in steps of 0.01)
High-set stage; $I_E \gg$ (ground) III_N	0.05 to 25.00 (in steps of 0.01)
Trip time delays; $T_1 \gg, T_{IE} \gg$	0.00 to 60.00 s or ∞
Definite-time overcurrent protection	
Overcurrent stage; $I >$ (phase) III_N	0.05 to 25.00 (in steps of 0.01)
Overcurrent stage; $I_E >$ (ground) III_N	0.05 to 25.00 (in steps of 0.01)
Trip time delays; $T_1 >, T_{IE} >$	0.00 to 60.00 s or ∞
Inverse-time overcurrent protection	
Inverse time O/C stage; I_p (phase) III_N	0.10 to 4.00 (in steps of 0.01)
Inverse time O/C stage; I_E (ground) III_N	0.10 to 4.00 (in steps of 0.01)
Trip time delays; T_{1p}, T_{IE}	0.00 to 10.00 s or ∞
Characteristics	Inverse (IEC 60255-3 type A) Very inverse (IEC 60255-3 type B) Extremely inverse (IEC 60255-3 type C)

Additional functions	
Self-diagnosis	
Current monitoring per feeder	
Auxiliary voltage monitoring	
Cyclic test	
Check of the data transmission between central unit and bay units	
Memory tests	
Operational measured values: Central unit	
Feeder currents	$I_{L1}; I_{L2}; I_{L3}$ in A primary and in % I_N
Range	0 to 1000 % I_N
Tolerance	typically 2 % of measured value
Differential and restraint (stabilizing) currents of all bus sections (separate for ZPS-BSZ1 and ZPS-BSZ2)	$I_{dL1}; I_{dL2}; I_{dL3}$ $I_{sL1}; I_{sL2}; I_{sL3}$ in % I_N
Range	0 to 1000 % I_N
Operational measured values: Bay unit	
Feeder currents	$I_{L1}; I_{L2}; I_{L3}; I_E$ in A primary and in % I_N
Range	0 to 6 000 % I_N
Tolerance	typically 2 % of measured value
Differential and restraint (stabilizing) currents	$I_{dL1}; I_{dL2}; I_{dL3}$ $I_{sL1}; I_{sL2}; I_{sL3}$
Range	0 to 6 000 % I_N
Frequency	f in Hz ($I > 0.1 I_N$)
Range	$f_N \pm 5$ Hz
Tolerance	0.1 Hz
Event recording: Central unit	
Storage of the last 200 operational events and 80 fault events	
Event recording: Bay unit	
Storage of the last 50 operational events and 100 fault events	
Fault recording: Central unit	
Resolution	1 ms at 50 Hz; 0.83 ms at 60 Hz
Storage time (from busbar TRIP or external initiation by binary input)	- 500 to + 500 ms at 50 Hz - 416 to + 416 ms at 60 Hz (up to 8 fault records)
Fault recording: Bay unit	
Resolution	1 ms at 50 Hz; 0.83 ms at 60 Hz
Storage time (from busbar TRIP or external initiation by binary input)	- 500 to + 500 ms at 50 Hz - 416 to + 416 ms at 60 Hz (up to 8 fault records)
CE conformity	
This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EG previous 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 2006/95/EG previous 73/23/EEC).	
This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).	
The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.	
This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".	

Busbar Differential Protection / 7SS52

Selection and ordering data

Description	Order No.	Order code
7SS522 distributed busbar/breaker failure protection	7SS52	0- - - - - A 0 - - - -
Central unit		
Central unit 50/60 Hz	2	
Rated auxiliary voltage		
48, 60 V DC	3	
110, 125 V DC	4	
220, 250 V DC	5	
Unit design		
In subrack ES902C	A	
Regional presettings/regional functions and languages		
Region DE, language German (language can be selected)	A	
Region World, language English (UK) (language can be selected)	B	
Region US, language English (US) (language can be selected)	C	
Region FR, language French (language can be selected)	D	
Region World, language Spanish (language can be selected)	E	
Region World, language Italian (language can be selected)	F	
Region World, language Russian (language can be selected)	G	
System interface		
Without	0	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	3	
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector	9	L O R
Service interface (on rear of relay)		
DIGSI 4 / modem, electrical RS232	1	
DIGSI 4 / modem, electrical RS485	2	
DIGSI 4 / modem, optical 820 nm, ST connector	3	
Additional functions		
without 1	1	
with cross stabilisation	2	
Equipped for		
8 bays	A	
16 bays	B	
24 bays	C	
32 bays	D	
40 bays	E	
48 bays	F	
7SS523 distributed busbar / breaker failure protection	7SS52	- - - - A 0 1 - - A A 1
Bay unit, frequency, housing, binary inputs and outputs		
Bay unit, 50/60 Hz, housing ½ x 19", 20 BI, 6 BO, 2 live status contacts	3	
Rated current		
1 A	1	
5 A	5	
Rated auxiliary voltage		
48 V DC	2	
60 to 250 V DC	5	
Unit design		
7XP2040-2 for flush mounting or cubicle mounting	C	
7XP2040-1 for surface mounting	D	
7XP2040-2 for flush mounting without glass cover	E	
Additional functions		
Without additional functions	0	
With overcurrent-time protection	1	

Busbar Differential Protection/7SS52

Selection and ordering data

Description	Order No.
7SS523 distributed busbar/breaker failure protection Bay unit, frequency 50/60 Hz; Housing 1/3 x 19"; 10 BI, 6 BO, 1 live status contact	7SS525□-□□A 01-□AA 1
Rated current	
1 A	1
5 A	5
Rated auxiliary voltage at converter	
DC 48 to 250 V	5
Unit design	
7XP2040-2 for panel flush mounting or cubicle mounting without glass cover	F
Additional functions	
Without additional functions	0
With overcurrent-time protection	1

Accessories	Description	Order No.
	DIGSI 4 Software for configuration and operation of Siemens protection relays running under MS Windows (version Windows 2000/XP Professional Edition) device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper) Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
	Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
	Professional + IEC 61850 DIGSI 4 Basis and additionally SIGRA (fault record analysis), CDC Editor (logic editor), Display Editor (editor for default and control displays), and DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	7XS5403-0AA00
	IEC 61850 System configurator Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM	7XS5460-0AA00
	SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000/XP Professional Edition. Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM (contained in DIGSI 4, but can be ordered additionally)	7XS5410-0AA00
	Connection cable Cable between PC/notebook (9-pin connector) and protection relay (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	7XV5100-4
	Manual 7SS52 V4.7/V3.3 English	C53000-G1176-C182-5

Busbar Differential Protection / 7SS52

Connection diagram

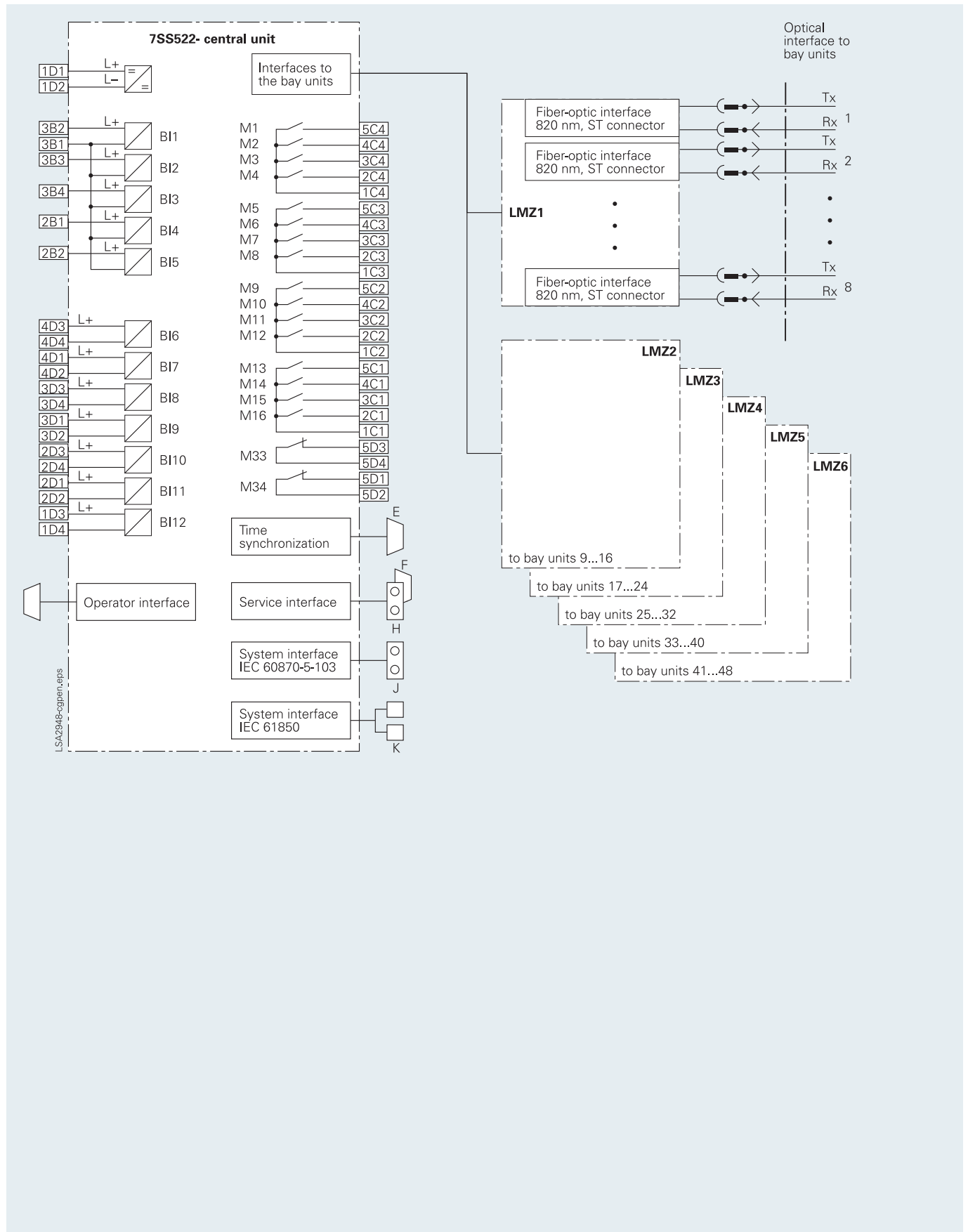


Fig. 9/31 Connection diagram 7SS52

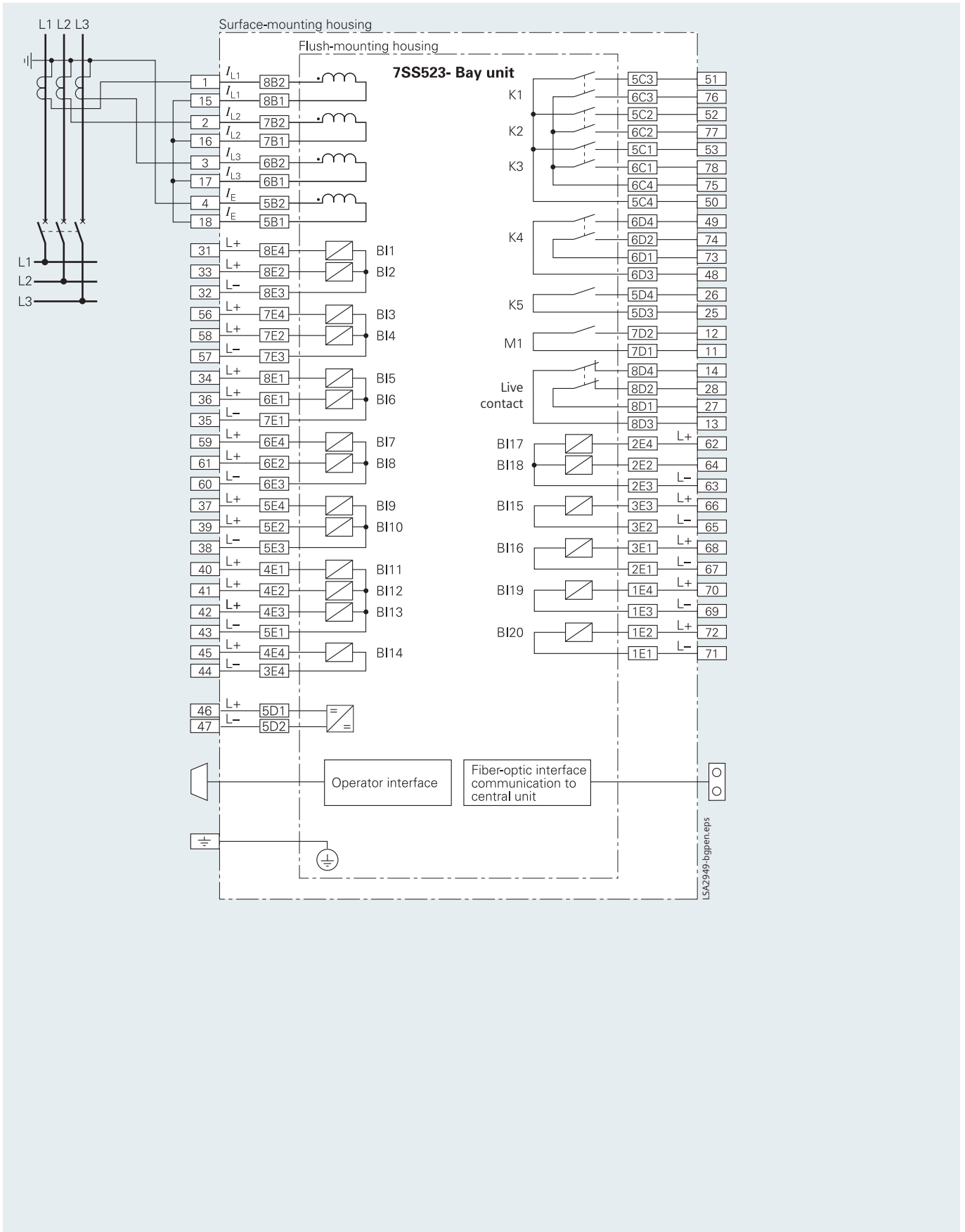


Fig. 9/32 Connection diagram 7SS523

Busbar Differential Protection / 7SS52

Connection diagram

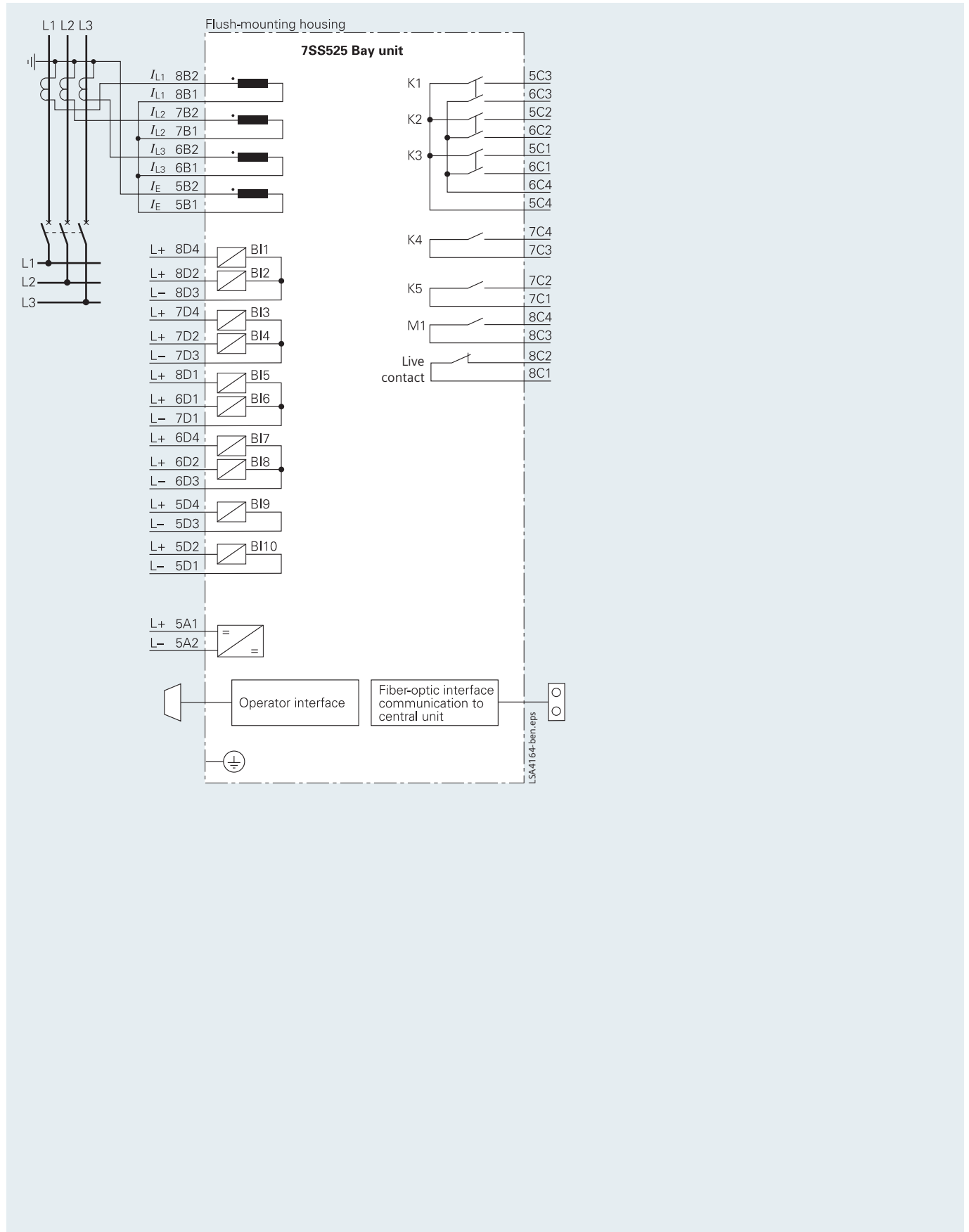


Fig. 9/33 Connection diagram 7SS525

Relays for Various Protection Applications

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SIPROTEC 4 7VK61 breaker management relay	10/3
SIPROTEC 7SV600 numerical circuit-breaker failure protection relay	10/21
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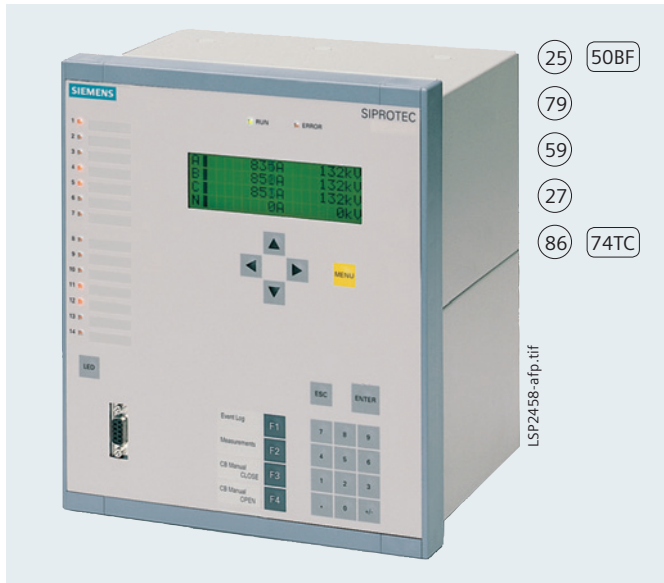


Fig. 10/1 SIPROTEC 4 7VK61 breaker management relay

Description

The SIPROTEC 4 breaker management relay 7VK61 is a highly flexible auto-reclosure, synchro-check and circuit-breaker failure protection unit.

This unit is used for the single and three-pole auto-reclosure of a circuit-breaker, after this circuit-breaker has tripped due to a fault. The synchro-check function ensures that the two circuits being reconnected by closing the circuit-breaker are within a defined safe operating state before the CLOSE command is issued.

The 7VK61 is also applicable as circuit-breaker failure protection. A breaker failure occurs when the circuit-breaker fails to correctly open and clear the fault after single or three-pole trip commands have been issued by the protection. It is then necessary to trip the relevant busbar zone (section) to ensure fault clearance. Together with the above-mentioned protection functions, the following additional functions of the 7VK61 can be applied: end-fault protection, pole-discrepancy protection, overvoltage protection and undervoltage protection. As a member of the numerical SIPROTEC 4 relay family, it also provides control and monitoring functions and therefore supports the user with regard to a cost-effective power system management.

Function overview

Protection functions

- Single and/or three-pole auto-reclosure
- Synchro-check with live/dead line/bus measurement
- Closing under asynchronous conditions (consideration of CB operating time)
- Circuit-breaker failure protection with two stages (single and three-pole with/without current)
- End-fault protection
- Pole-discrepancy protection
- Overvoltage/undervoltage protection

Control function

- Commands for control of CB and isolators

Monitoring functions

- Operational measured values
- Self-supervision of the relay
- Event buffer and fault protocols
- Oscillographic fault recording
- Monitoring of CB auxiliary contacts
- Switching statistics

Features

- All functions can be used separately
- Initiation/start by phase-segregated or 3-pole trip commands
- Auto-reclosure for max. 8 reclose cycles
- Evolving/sequential trip recognition
- Auto-reclosure with ADT, DLC, RDT
- Synchro-check with ΔV , $\Delta \varphi$, Δf measurement
- Breaker failure protection with highly secure 2-out-of-4 current check detectors
- Breaker failure protection with short reset time and negligible overshoot time

Communication interfaces

- Front interface for connecting a PC
- System interface for connecting to a control system via various protocols
 - IEC 61850 Ethernet
 - IEC 60870-5-103 protocol
 - PROFIBUS-FMS/-DP
 - DNP 3.0
- Rear-side service/modem interface
- Time synchronization via
 - IRIG-B or DCF77 or system interface

Relays for Various Protection Applications/7VK61

Application

Application

The 7VK61 provides highly flexible breaker management. It applies to single-breaker, ring-bus, and 1½ breaker installations. The auto-reclosure, synchronism-check, breaker failure protection and voltage protection functions can be used separately or combined. Therefore the current and voltage transformer connection can be selected according to the required application.

The auto-reclosure function closes the circuit-breaker after this circuit-breaker has tripped due to a fault. The check-synchronism function ensures that the two circuits being reconnected by closing the circuit-breaker are within a defined safe operating state before the CLOSE command is issued.

The numerical 7VK61 relay provides rapid backup fault clearance in case the circuit-breaker nearest to the fault fails to respond to a TRIP command. It is suitable for power systems of all voltage levels with single and/or three-pole circuit-breaker operation. The initiation signal can be issued from any protection or supervision equipment. Information from the circuit-breaker auxiliary contact is only required for the breaker failure protection during faults which produce little or no fault current flow, for instance due to a trip from the power transformer Buchholz protection.

Cost-effective power system management

The SIPROTEC 4 units are numerical relays which also provide control and monitoring functions and therefore support the user with regard to a cost-effective power system management. The security and reliability of the power supply is increased as a result of minimizing the use of hardware.

The local operation has been designed according to ergonomic criteria. Large, easy-to-read backlit displays are provided.

The SIPROTEC 4 units have a uniform design and a degree of functionality which represents a benchmark-level of performance in protection and control.

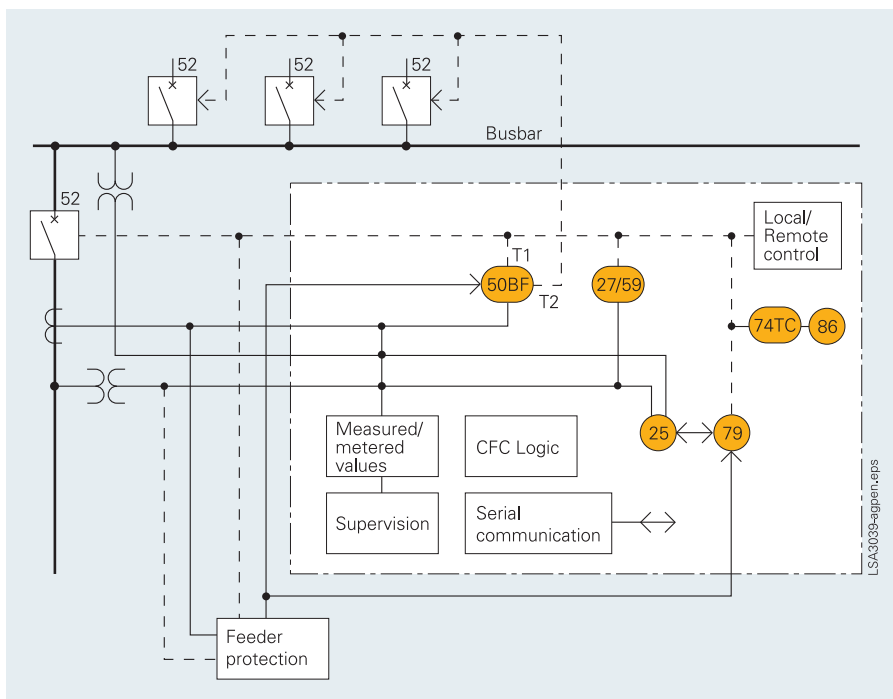


Fig. 10/2 Application and function diagram

If the requirements for protection, control and interlocking change, it is possible in the majority of cases to implement such changes by means of parameterization using DIGSI 4 without having to change the hardware.

The use of powerful microcontrollers and the application of digital measured-value conditioning and processing largely suppresses the influence of higher-frequency transients, harmonics and DC components.

ANSI	Protection functions
50BF	Breaker-failure protection
59/27	Overtoltage/undervoltage protection
25	Synchro-check
79	Auto-reclosure
74TC	Trip circuit supervision
86	Lockout (CLOSE command interlocking)

Construction

Connection technique and housing with many advantages

1/3 and 1/2-rack sizes are available as housing widths of the SIPROTEC 4 7VK61 relays, referred to a 19" modular frame system. This means that previous models can always be replaced. The height is a uniform 255 mm for flush-mounting housings and 266 mm for surface-mounting housings for all housing widths. All cables can be connected with or without ring lugs.

In the case of surface mounting on a panel, the connection terminals are located above and below the housing in the form of screw-type terminals. The communication interfaces are located in a sloped case at the top and bottom of the housing.



Fig. 10/3 Flush-mounting housing with screw-type terminals

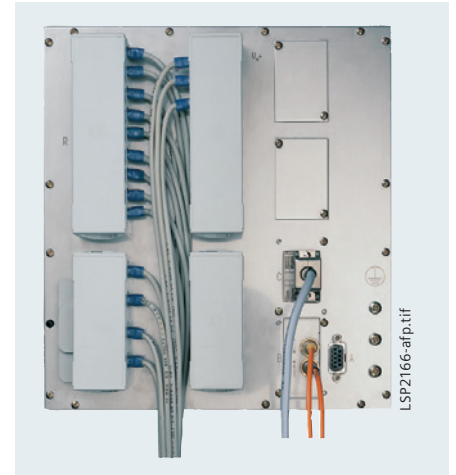


Fig. 10/4 Rear view of flush-mounting housing with covered connection terminals and wirings



Fig. 10/5 Surface-mounting housing with screw-type terminals, example 7SA63



Fig. 10/6 Communication interfaces in a sloped case in a surface-mounting housing

Relays for Various Protection Applications/7VK61

Protection functions

Protection functions

Auto-reclosure (ANSI 79)

The 7VK61 relay is equipped with an auto-reclose function (AR). Usually the auto-reclosure interacts with the feeder protection via binary inputs and outputs.

The function includes several operating modes:

- 3-pole auto-reclosure for all types of faults; different dead times are available depending on the type of fault
- 1-pole auto-reclosure for 1-phase faults, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase and 3-pole auto-reclosing for multi-phase faults
- Multiple-shot auto-reclosure
- Interaction with the internal or an external synchro-check
- Monitoring of the circuit-breaker auxiliary contacts.

In addition to the above-mentioned operating modes, several other operating principles can be employed by means of the integrated programmable logic (CFC).

The 7VK61 allows the line-side voltages to be evaluated. A number of voltage-dependent supplementary functions are thus available:

- ADT
The adaptive dead time is employed only if auto-reclosure at the remote station was successful (reduction of stress on equipment).
- DLC
By means of dead-line check, reclosure is effected only when the line is deenergized (prevention of asynchronous breaker closure in case that the synchronism check can not be used).
- RDT
Reduced dead time is employed in conjunction with auto-reclosure where no teleprotection method is employed: when faults within the zone extension of a distance feeder protection but external to the protected line, are switched off for rapid auto-reclosure (RAR), the RDT function decides on the basis of measurement of the return voltage from the remote station which has not tripped, that the fault has been cleared by the protection on the faulted downstream feeder and that reclosure with reduced dead time may take place.

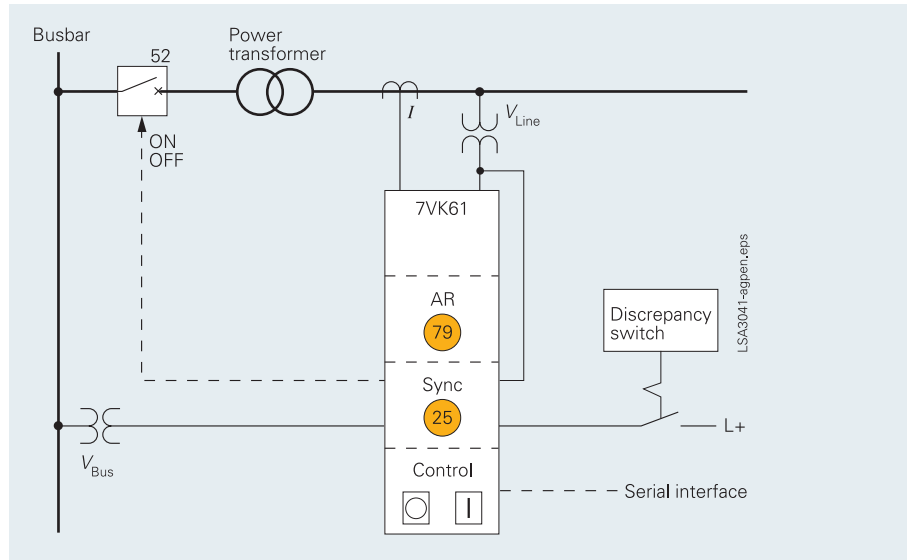


Fig. 10/7 Auto-reclosure and synchro-check with voltage measurement across a power transformer

Synchro-check (ANSI 25)

Where two network sections are switched in by control command or following a 3-pole auto-reclosure, it must be ensured that both network sections are mutually synchronous. For this purpose, a synchronism-check function is provided. After verification of the network synchronism, the function releases the CLOSE command. Consideration of the duration of the CB operating time before issuing the CLOSE command (especially important under asynchronous conditions and when several circuit-breakers with different operating times are to be operated by one single relay).

In addition, reclosing can be enabled for different criteria, e.g., when the busbar or line are not carrying a voltage (dead line or dead bus).

Breaker failure protection (ANSI 50BF)

The 7VK61 relay incorporates a two-stage circuit-breaker failure protection to detect failures of tripping command execution, for example due to a defective circuit-breaker. The current detection logic is phase-segregated and can therefore also be used in single-pole tripping schemes.

If the fault current is not interrupted after a settable time delay has expired, a retrip command or the busbar trip command will be generated. The breaker failure protection will usually be initiated by external feeder protection relays via binary input signals. Trip signals from the internal auto-reclosure logic or from the voltage protection can start the breaker failure protection as well.

Overvoltage protection, undervoltage protection (ANSI 59, 27)

The 7VK61 contains a number of overvoltage measuring elements. Each measuring element is of two-stage design. The following measuring elements are available:

- Phase-to-ground overvoltage
- Phase-to-phase overvoltage
- Zero-sequence overvoltage
The zero-sequence voltage can be connected to the 4th voltage input (not in conjunction with syncho-check) or be derived from the phase voltages.
- Negative-sequence overvoltage

Tripping by the overvoltage measuring elements can be effected either at the local circuit-breaker or at the remote station by means of a transmitted signal.

The 7VK61 is fitted, in addition, with three two-stage undervoltage measuring elements:

- Phase-to-ground undervoltage
- Phase-to-phase undervoltage
- Positive-sequence undervoltage

The undervoltage measuring elements can be blocked by means of a minimum current criterion and by means of binary inputs.

End-fault protection

When the circuit-breaker is open, the area located between the current transformer and the circuit-breaker can be optimally protected by means of the end-fault protection. In the event of a fault, an independently settable time delay is started after a valid initiation has been received and the circuit-breaker auxiliary contacts indicate an open circuit-breaker position, with current still flowing (see Fig. 10/8). Depending on the mounting position of the current transformer, instantaneous tripping of the busbar section or intertripping of the circuit-breaker at the opposite end occurs.

Pole-discrepancy protection

This function ensures that any one or two poles of a circuit-breaker do not remain open for longer than an independently settable time (i.e. unsymmetrical conditions). This time stage is initiated when current (above the set value) is flowing in any 1 or 2 phases, but not in all 3 phases. Additionally, the circuit-breaker auxiliary contacts (if connected) are interrogated and must show the same condition as the current measurement. Should this time delay expire, then a three-pole trip command is issued. This function is normally used when single-pole auto-reclosing is applied.



Fig. 10/8 End-fault between circuit-breaker and current transformer

Trip circuit supervision (ANSI 74TC)

One or two binary inputs for each circuit-breaker pole can be used for monitoring the circuit-breaker trip coils including the connecting cables. An alarm signal is issued whenever the circuit is interrupted. The trip circuit supervision function requires one or two independent potential-free binary inputs per trip circuit. To make existing (non potential-free) binary inputs potential-free, external optocoupler modules can be applied.

Lockout (ANSI 86)

Under certain operating conditions, it is advisable to block CLOSE commands after a final TRIP command of the relay has been issued. Only a manual 'Reset' command unblocks the CLOSE command. The 7VK61 is equipped with such an interlocking logic.

Monitoring functions

The 7VK61 relay provides comprehensive monitoring functions covering both hardware and software. Furthermore, the measured values are continuously checked for plausibility. Therefore the current and voltage transformers are also included in this monitoring system.

- If all voltages are connected, the relay will detect secondary voltage interruptions by means of the integrated fuse failure monitor. Immediate alarm and blocking of the synchronism check and dead line check is provided for all types of secondary voltage failures. Additional measurement supervision functions are
- Symmetry of voltages and currents (in case of appropriate transformer connection)
 - Broken-conductor supervision (if current transformers are connected)
 - Summation of currents and voltages (in case of appropriate transformer connection)
 - Phase-sequence supervision (if three voltage transformers are connected)

Communication

Communication

With respect to communication, particular emphasis is placed on the customer requirements in energy automation:

- Every data item is time-stamped at the source, i.e. where it originates.
- Already during the process of communication, information is assigned to the cause thereof (e.g. assignment of the indication "circuit-breaker TRIP" to the corresponding command).
- The communication system automatically handles the transfer of large data blocks (e.g. fault recordings or parameter data files). The user has access to these features without any additional programming effort.
- For the safe execution of a control command the corresponding data telegram is initially acknowledged by the unit which will execute the command. After the release and execution of the command a feedback signal is generated. At every stage of the control command execution particular conditions are checked. If these are not satisfied, command execution may be terminated in a controlled manner.

The units offer a high degree of flexibility by supporting different standards for connection to industrial and power automation systems. By means of the communication modules, on which the protocols run, exchange and retrofit is possible. Therefore, the units will also in future allow for optimal adaptation to changing communication infrastructure such as the application of Ethernet networks (which will also be used increasingly in the power supply sector in the years to come).

Local PC interface

The serial RS232 PC interface accessible from the front of the unit permits quick access to all parameters and fault event data. The use of the DIGSI 4 operating program is particularly advantageous during commissioning.

Service/modem interface

7VK61 units are always fitted with a rear-side hardwired service interface, optionally as RS232 or RS485. In addition to the front-side operator interface, a PC can be connected here either directly or via a modem.

Time synchronization interface

The time synchronization interface is a standard feature in all units. The supported formats are IRIG-B and DCF77.

Reliable bus architecture

- RS485 bus
With this data transmission via copper conductors, electromagnetic fault influences are largely eliminated by the use of twisted-pair conductors. Upon failure of a unit, the remaining system continues to operate without any problem.
- Fiber-optic double ring circuit
The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without disturbance. It is usually impossible to communicate with a unit that has failed. Should a unit fail, there is no effect on the communication with the rest of the system.

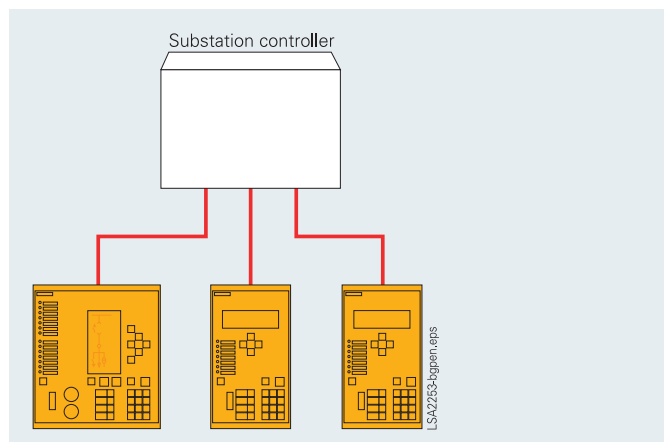


Fig. 10/9 IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

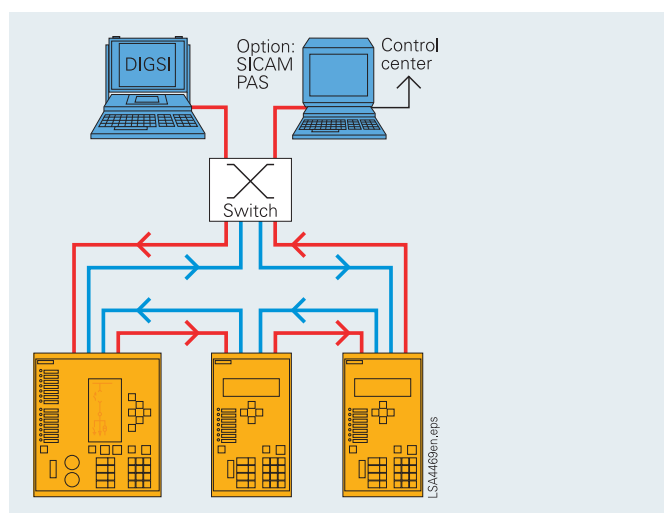


Fig. 10/10 Bus structure for station bus with Ethernet and IEC 61850 with fiber-optic ring

Retrofitting: Modules for every type of communication

Communication modules for retrofitting are available for the entire SIPROTEC 4 unit range. These ensure that, where different communication protocols (IEC 61850, IEC 60870-5-103, PROFIBUS, DNP, etc.) are required, such demands can be met. For fiber-optic communication, no external converter is required for SIPROTEC 4.

IEC 61850 protocol

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens was the first manufacturer to support this Standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus is also possible with DIGSI.

IEC 60870-5-103 protocol

IEC 60870-5-103 is an internationally standardized protocol for efficient communication with protection relays. IEC 60870-5-103 is supported by a number of protection device manufacturers and is used worldwide. Supplements for the control function are defined in the manufacturer-specific part of this standard.

PROFIBUS-DP

PROFIBUS-DP is an industrial communications standard and is supported by a number of PLC and protection device manufacturers.

DNP 3.0

DNP 3.0 (Distributed Network Protocol, Version 3) is an internationally recognized protection and bay unit communication protocol. SIPROTEC 4 units are Level 1 and Level 2 compatible.

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system. Units equipped with IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or connected in star by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 10/14).

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus.

With IEC 61850, however, the units can also be used in other manufacturers' systems. Units with an IEC 60870-5-103 interface are connected with PAS via the Ethernet station bus by means of serial/Ethernet converters. DIGSI can also be used via the same station bus.

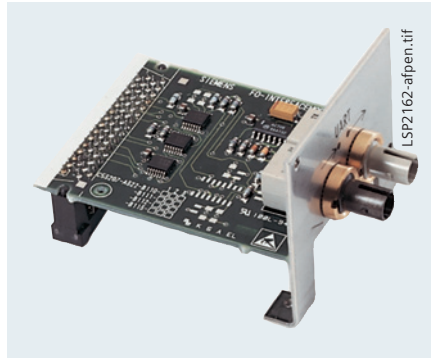


Fig. 10/11 820 nm fiber-optic communication module

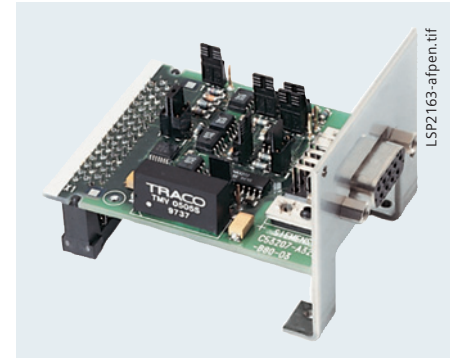


Fig. 10/12 RS232/RS485 electrical communication module

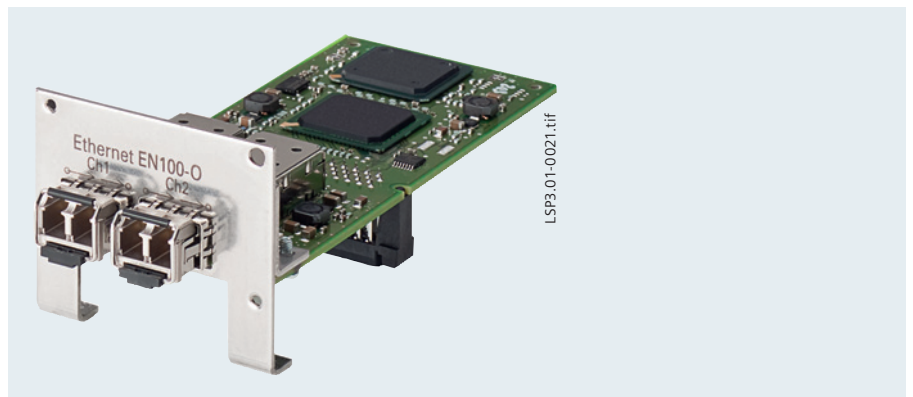


Fig. 10/13 Fiber-optic Ethernet communication module for IEC 61850 with integrated Ethernet switch

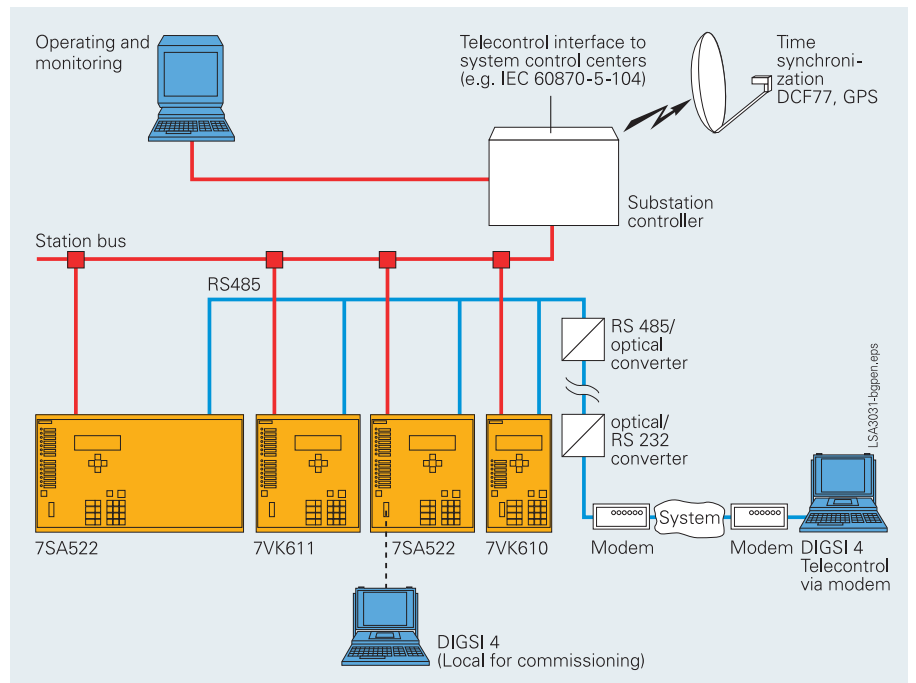


Fig. 10/14 Communication

Relays for Various Protection Applications/7VK61

Typical connection

Typical connection

Connection for current and voltage transformers

With the transformer connection as shown in Fig. 10/15, it is possible to use the complete scope of functions of 7VK61, i.e. breaker failure protection, synchronism-check with 3-phase dead line check (with or without auto-reclosure), complete measured value monitoring, voltage protection, and the complete range of operational measured values.

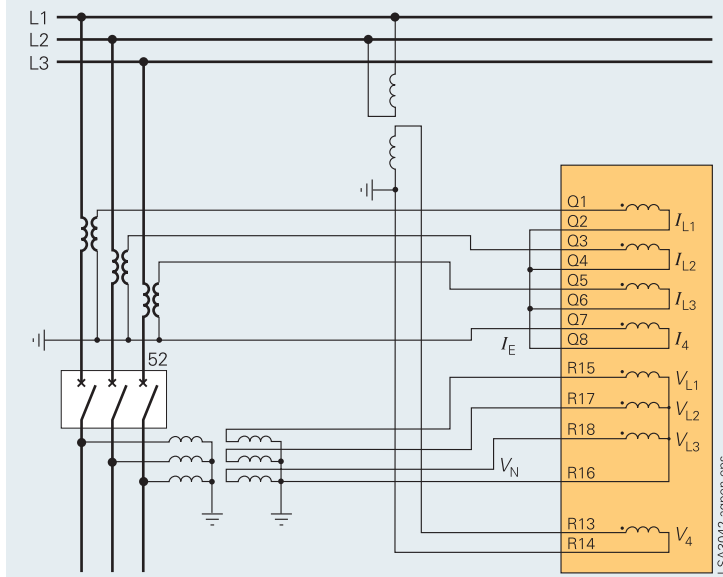


Fig. 10/15 Complete connection of all current and voltage transformers

Alternative: Connection for current transformers only

The connection for current transformers only provides breaker failure protection and current operational measured values.

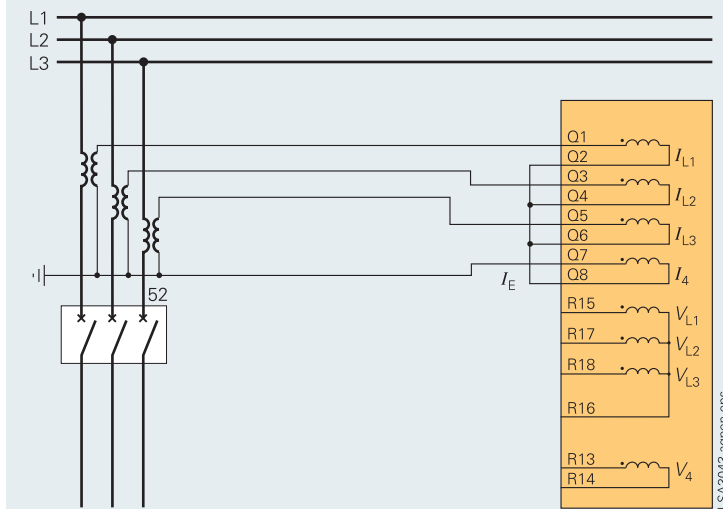


Fig. 10/16 Typical current transformer connection for breaker failure protection

Alternative: Connection for two voltage transformers

In case of a connection for two voltage transformers, synchro-check and two operational measured voltages, and additionally synchro-check measured values are applicable. Dead line check is performed for the connected line voltage only.

Note: Please connect the two voltages always to the terminals R15/R16 and R13/R14 with the appropriate polarity. The setting address 106 "Voltage transformer" must then be set to "single-phase". The terminals R17 and R18 must not be connected.

The connection of the voltage V_{L1-L2} as shown in Fig. 10/17 is just an example: any other of the shown combinations is possible for synchronization.

The two voltage transformer connection can also be combined with the current transformer connection according to Fig. 10/16.

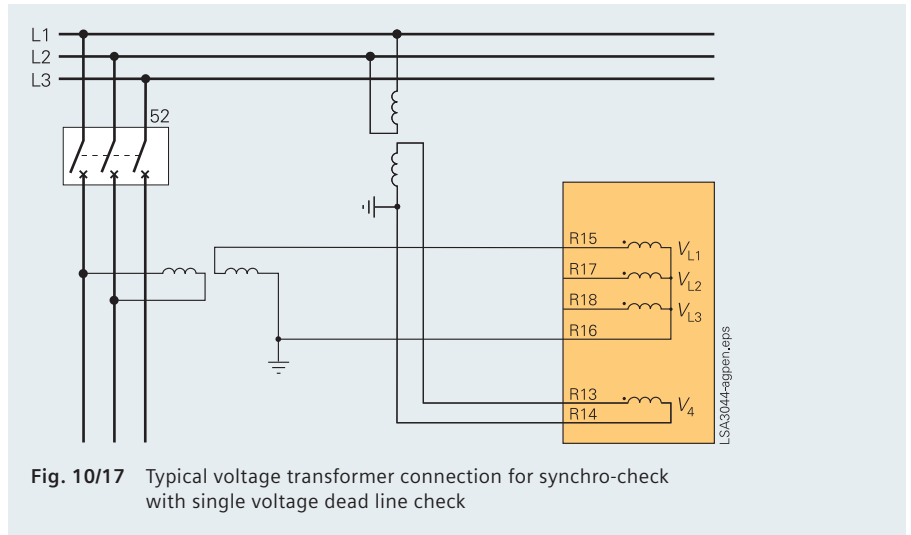


Fig. 10/17 Typical voltage transformer connection for synchro-check with single voltage dead line check

Relays for Various Protection Applications/7VK61

Technical data

General unit data		Output contacts	
Analog inputs		"Unit ready" contact (live status contact)	
Rated frequency	50 or 60 Hz (selectable)	Command/indication relay	1 NC/NO contact ¹⁾
Rated current I_{nom}	1 or 5 A (selectable)	Quantity	5 NO contacts, 14 NO contacts, 4 NC/NO contacts ¹⁾
Rated voltage V_{nom}	80 to 125 V (selectable)	7VK610	
Power consumption		7VK611	
With $I_{nom} = 1$ A	Approx. 0.05 VA	NO/NC contact	
With $I_{nom} = 5$ A	Approx. 0.30 VA	Switching capacity	
Voltage inputs	≤ 0.10 VA	Make	1000 W/VA
Overload capacity of current circuit		Break, contacts	30 VA
Thermal (r.m.s.)	500 A for 1 s 150 A for 10 s 20 A continuous 1250 A (half cycle)	Break, contacts (for resistive load)	40 W
Dynamic (peak value)		Break, contacts (for $\tau = L/R \leq 50$ ms)	25 VA
Thermal overload capacity of voltage circuit	230 V continuous	Switching voltage	250 V
Auxiliary voltage		Permissible total current	30 A for 0.5 seconds 5 A continuous
Rated voltages	DC 24, 48 V DC 60, 125 V DC 110, 250 V and AC 115, 230 V (50/60 Hz)	Operating time, approx.	
Permissible tolerance	-20 % to +20 %	NO contact	8 ms
Superimposed AC voltage (peak-to-peak)	≤ 15 %	NO/NC contact (selectable)	8 ms
Power consumption		Fast NO contact	5 ms
Quiescent	Approx. 5 W	LEDs	
Energized	Approx. 8 W to 14 W, depending on design	Quantity	
Bridging time during failure of the auxiliary voltage		RUN (green)	1
For $V_{aux} = 48$ V and $V_{aux} \geq 110$ V	≥ 50 ms	ERROR (red)	1
For $V_{aux} = 24$ V and $V_{aux} = 60$ V	≥ 20 ms	LED (red), function can be assigned	
Binary inputs		7VK610	7
Quantity		7VK611	14
7VK610	7	Unit design	
7VK611	20	Housing	7XP20
Rated voltage range	24 to 250 V, bipolar	Dimensions	Refer to part 14 for dimension drawings
Pickup threshold	DC 19 or 88 V or 176 V, bipolar	Degree of protection acc. to EN 60529	
Functions are freely assignable		Surface-mounting housing	IP 51
Minimum pickup voltage	DC 19 or 88 V or 176 V, bipolar (3 operating ranges)	Flush-mounting housing	
Ranges are settable by means of jumpers for each binary input		Front	IP 51
Maximum permissible voltage	DC 300 V	Rear	IP 50
Current consumption, energized	Approx. 1.8 mA	For the terminals	IP 20 with terminal cover put on
Input impulse suppression	220 nF coupling capacitance at 220 V with a recovery time >60 ms	Weight	
		Flush-mounting housing	
		$\frac{1}{3} \times 19''$	5 kg
		$\frac{1}{2} \times 19''$	6 kg
		Surface-mounting housing	
		$\frac{1}{3} \times 19''$	9.5 kg
		$\frac{1}{2} \times 19''$	11 kg

1) Can be set via jumpers.

Serial interfaces		Electrical tests	
<i>Operating interface, front of unit for DIGSI 4</i>		<i>Specifications</i>	
Connection	Non-isolated, RS232, 9-pin subminiature connector (SUB-D)	Standards	IEC 60255 (product standards) IEEE C37.90.01.1/2 VDE 0435 For further standards see "Individual tests"
Baud rate	4800 to 115200 baud setting as supplied: 38400 baud; parity 8E1	<i>Insulation tests</i>	
<i>Time synchronization DCF77/IRIG-B signal (Format IRIG-B000)</i>		Standards	IEC 60255-5 and 60870-2-1
Connection	9-pin subminiature connector (SUB-D) (terminal with surface-mounting housing)	Voltage test (100 % test) All circuits except for auxiliary supply, binary inputs, communication and time synchronization interfaces	2.5 kV (r.m.s.), 50 Hz
Voltage levels	5 V, 12 V or 24 V (optional)	Auxiliary voltage and binary inputs (100 % test)	DC 3.5 kV
<i>Service/modem interface for DIGSI4/modem/service</i>		RS485/RS232 rear side communication interfaces and time synchronization interface (100 % test)	500 V (r.m.s.), 50 Hz
Isolated RS232/RS485	9-pin subminiature connector (SUB-D)	Impulse voltage test (type test) All circuits except for communication interfaces and time synchronization interface, class III	5 kV (peak); 1.2/50 µs; 0.5 J, 3 positive and 3 negative impulses in intervals of 5 s
Dielectric test	500 V / 50 Hz	<i>EMC tests for noise immunity; type tests</i>	
Distance for RS232	Max. 15 m	Standards	IEC 60255-6; IEC 60255-22 (product standard) EN 61000-6-2 (generic standard), VDE 0435 Part 301, DIN VDE 0435-110
Distance for RS485	Max. 1000 m	High-frequency test IEC 60255-22-1 class III and VDE 0435 Part 303, class III	2.5 kV (peak); 1 MHz; τ = 15 µs; 400 surges per s; test duration 2 s; R _i = 200 Ω
<i>System interface</i>		Electrostatic discharge IEC 60255-22-2 class IV and EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; R _i = 330 Ω
Isolated RS232/RS485	9-pin subminiature connector (SUB-D)	Irradiation with HF field, IEC 60255-22-3 class III IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz 10 V/m; 1.4 to 2 GHz; 80 % AM; 1 kHz
Baud rate	4800 to 38400 baud	Irradiation with HF field, IEC 60255-22-31, IEC 61000-4-3 Amplitude-modulated	Class III, 10 V/m 80; 160; 450; 900 MHz; 80 % AM 1 kHz; duration >10 s 900 MHz, 50 % PM, repetition frequency 200 Hz
Dielectric test	500 V / 50 Hz	Pulse-modulated	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R _i = 50 Ω; test duration 1 min
Distance for RS232	Max. 15 m	Fast transient disturbance/bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	
Distance for RS485	Max. 1000 m		
PROFIBUS RS485	9-pin subminiature connector (SUB-D)		
Dielectric test	500 V / 50 Hz		
Baud rate	Max. 12 Mbaud		
Distance	1000 m at 93.75 kbaud; 100 m at 12 Mbaud		
PROFIBUS fiber-optic	ST connector		
Only for flush-mounting housing	Optical interface with OLM ¹⁾		
For surface-mounting housing	Max. 1.5 Mbaud		
Baud rate	λ = 820 nm		
Optical wavelength	Max. 8 dB for glass-fiber 62.5/125 µm		
Permissible attenuation	500 kB/s 1.6 km		
Distance	1500 kB/s 530 m		

1) Conversion with external OLM
Fiber-optic interface please complete order number at 11th position with **4** (FMS RS485) or **9** and Order Code **LOA** (DP RS485) or **9** and Order Code **LOG** (DNP 3.0) and additionally a suitable external repeater.

Relays for Various Protection Applications/7VK61

Technical data

EMC tests for noise immunity; type tests (continued)		Seismic vibration	Sinusoidal
High-energy surge voltages (SURGE), IEC 61000-4-5 installation class III Auxiliary supply	Impulse: 1.2/50 μ s Common (longitudinal) mode: 2 kV; 12 Ω ; 9 μ F Differential (transversal) mode: 1 kV; 2 Ω ; 18 μ F	IEC 60255-21-3, class 1 IEC 60068-3-3	1 to 8 Hz: \pm 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: \pm 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 g acceleration (horizontal axis) 8 to 35 Hz: 0.5 g acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
Measurement inputs, binary inputs, binary output relays	Common (longitudinal) mode: 2 kV; 42 Ω ; 0.5 μ F Differential (transversal) mode: 1 kV; 42 Ω ; 0.5 μ F	<u>During transport</u>	
Line-conducted HF, amplitude-modulated, IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz	Standards	IEC 60255-21 and IEC 60068-2
Magnetic field with power frequency IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz	Vibration	Sinusoidal 5 to 8 Hz: \pm 7.5 mm amplitude; 8 to 150 Hz: 2 g acceleration, frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Oscillatory surge withstand capability, IEEE C37.90.1	2.5 kV (peak); 1 MHz; τ = 50 μ s; 400 surges per second, duration 2 s, R_i = 200 Ω	Shock	Semi-sinusoidal Acceleration 15 g, duration 11 ms, 3 shocks on each of the 3 axes in both directions
Fast transient surge withstand capability, IEEE C37.90.1	4 kV; 5/50 ns; 5 kHz burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω ; duration 1 min	IEC 60255-21-2, class 1 IEC 60068-2-27	
Radiated electromagnetic interference IEEE C37.90.2	35 V/m; 25 to 1000 MHz,	Continuous shock	Semi-sinusoidal Acceleration 10 g, duration 16 ms, 1000 shocks on each of the 3 axes in both directions
Damped oscillation IEC 60694, IEC 61000-4-12	2.5 kV (peak value); polarity alternating 100 kHz; 1 MHz; 10 and 50 MHz; R_i = 200 Ω		
EMC tests for interference emission; type tests		Climatic stress tests	
Standard	EN 61000-6-3 (generic standard)	Standard	IEC 60255-6
Conducted interference voltage on lines, only auxiliary voltage IEC-CISPR 22	150 kHz to 30 MHz Limit class B	<u>Temperatures</u>	
Radio interference field strength IEC-CISPR 22	30 to 1000 MHz Limit class B	Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C / -13 °F to +185 °F
Harmonic currents on the network lead at AC 230 V, IEC 61000-3-2	Class A limits are observed	Temporarily permissible operating temperature, tested for 96 h (Legibility of display may be impaired above +55 °C / +131 °F)	-20 °C to +70 °C / -4 °F to +158 °F
Voltage fluctuations and flicker on the network incoming feeder at AC 230 V, IEC 61000-3-3	Limits are observed	Recommended permanent operating temperature acc. to IEC 60255-6	-5 °C to +55 °C / +23 °F to +131 °F
		– Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to 131 °F
		– Limiting temperature during transport	-25 °C to +70 °C / -13 °F to +158 °F
Mechanical stress test		Humidity	
<u>Vibration, shock stress and seismic vibration</u>		Permissible humidity stress:	Annual average on \leq 75 % relative humidity; on 56 days per year up to 93 % relative humidity; condensation is not permitted.
<u>During operation</u>		It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	
Standards	IEC 60255-21 and IEC 60068-2		
Vibration	Sinusoidal 10 to 60 Hz: \pm 0.075 mm amplitude; 60 to 150 Hz: 1 g acceleration, frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes		
IEC 60255-21-1, class 2 IEC 60068-2-6			
Shock	Half-sinusoidal Acceleration 5 g, duration 11 ms, 3 shocks on each of the 3 axes in both directions		
IEC 60255-21-2, class 1 IEC 60068-2-27			

Functions	
Auto-reclosure (ANSI 79)	
Number of auto-reclosures	Up to 8
Operating mode	Only 1-pole; only 3-pole, 1- or 3-pole
Operating modes with line voltage check	DLC – dead-line check ADT – adaptive dead time RDT – reduced dead time
Dead times T_{1-ph} , T_{3-ph} , T_{Seq}	0 to 1800 s (step 0.01 s) or deactivated
Action times	0.01 to 300 s (step 0.01 s) or deactivated
Reclaim times	0.5 to 300 s (step 0.01 s)
Start-signal monitoring time	0.01 to 300 s (steps 0.01 s)
Additional functions	Synchro-check request 3-phase intertripping InterCLOSE command to the remote end Check of CB ready state Blocking with manual CLOSE
Voltage limit values for DLC, ADT, RDT	
Healthy line voltage V_{PH-E}	30 to 90 V (steps 1 V)
Dead line voltage V_{PH-E}	2 to 70 V (steps 1 V)
Tolerances	
Time stages	1 % of setting value or 10 ms
Voltage limit values	≤ 3 % of setting value or 1 V
Synchro-check (ANSI 25)	
Initiate options	Auto-reclosure; Manual CLOSE control Control commands
Operating modes	Synchro-check
With auto-reclosure	Line dead/busbar live Line live/busbar dead Line and busbar dead Bypassing
For manual closure and control commands	As for auto-reclosure
Permissible voltage difference	1 to 60 V (step 0.1 V)
Permissible frequency difference	0.03 to 2 Hz (step 0.01 Hz)
Permissible angle difference	2 to 80 ° (step 1°)
Max. duration of synchronization	0.01 to 600 s (steps 0.01 s) or deactivated
Release delay with synchronous networks	0 to 30 s (steps 0.01 s)
Minimum measuring time	Approx. 80 ms
Tolerances	
Time stages	1 % of setting value or 10 ms
Voltage limit values	≤ 2 % of setting value or 1 V
Breaker failure protection (ANSI 50BF)	
Number of stages	2
Pickup of current element	0.05 to 20 A (I_{1A}) / 0.25 to 100 A (I_{5A}) (step 0.01 A)
Time delays $T_{1\text{phase}}$, $T_{3\text{phase}}$, T_2	0 to 30 s (steps 0.01 s) or deactivated
Dropout (overshoot) time, internal	≤ 15 ms, typical; 25 ms, max.
End-fault protection	For fault between open CB and CT, with intertrip to the remote line end
Pole discrepancy supervision	
Monitoring time	Initiation if not all CB poles are closed or open 0 to 30 s (steps 0.01 s) or deactivated
Tolerances	
Current limit value	≤ 5 % of setting value or 1 % I_{nom}
Time stages	1 % of setting value or 10 ms
Voltage protection (ANSI 59, 27)	
Operating modes	Local tripping and/or carrier trip for remote end
Overvoltage protection	
Pickup values $V_{PH-E}>>$, $V_{PH-E}>$ (phase-ground overvoltage)	1 to 170 V (step 0.1 V)
Pickup values $V_{PH-PH}>>$, $V_{PH-PH}>$ (phase-phase overvoltage)	2 to 220 V (step 0.1 V)
Pickup values $3V_0>>$, $3V_0>$ ($3V_0$ can be measured via V4 transformers or calculated by the relay) (zero-sequence overvoltage)	1 to 220 V (step 0.1 V)
Pickup values $V_1>>$, $V_1>$ (positive-sequence overvoltage)	2 to 220 V (step 0.1 V)
Pickup values $V_2>>$, $V_2>$ (negative-sequence overvoltage)	2 to 220 V (step 0.1 V)
Reset ratio (settable)	0.5 to 0.98 (step 0.01)
Undervoltage protection	
Pickup values $V_{PH-E}<<$, $V_{PH-E}<$ (phase-ground undervoltage)	1 to 100 V (step 0.1 V)
Pickup values $V_{PH-PH}<<$, $V_{PH-PH}<$ (phase-phase undervoltage)	1 to 170 V (step 0.1 V)
Pickup values $V_1<<$, $V_1<$ (positive-sequence undervoltage)	1 to 100 V (step 0.1 V)
Blocking of undervoltage protection stages	Minimum current; binary input
Reset ratio (settable)	1.01 to 1.20 (step 0.01)
Time delays	
Time delay for all stages	0 to 100 s (step 0.01 s) or deactivated
Command / pickup time	Approx. 34 ms at $f_{nom} = 50$ Hz Approx. 30 ms at $f_{nom} = 60$ Hz
Tolerances	
Voltage limit values	≤ 3 % of setting value or 1 V
Time stages	1 % of setting value or 10 ms
Trip circuit supervision (ANSI 74TC)	
Number of supervisable trip circuits	Up to 3
Number of required binary inputs per trip circuit	1 or 2
Indication relay	1 to 30 s (steps 1 s)

Relays for Various Protection Applications/7VK61


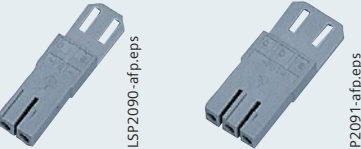
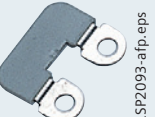

Technical data

Additional functions		Further additional functions	
<i>Operational measured values</i>			
Representation	Primary, secondary and percentage referred to rated value	Measured value supervision	Current sum Current symmetry Voltage sum Voltage symmetry Phase sequence Fuse failure monitor
Currents	$3 \times I_{\text{Phase}}; 3I_0; I_1; I_2$	Indications	Power direction Buffer size 200
Tolerances	Typ. 0.3 % of indicated measured value or 0.5 % I_{nom}	Operational indications	Storage of indications of the last 8 faults, buffer size 600
Voltages	$3 \times V_{\text{Phase-Ground}}; 3 \times V_{\text{Phase-Phase}}; 3V_0, V_1, V_2, V_{\text{SYNC}}, V_{\text{En}}$	System disturbance indication	
Tolerances	Typ. 0.25 % of indicated measured value or 0.01 % V_{nom}	Switching statistics	Number of breaking operations per CB pole Sum of breaking current per phase Breaking current of last trip operation Max. breaking current per phase
Power with direction indication	P, Q, S	Circuit-breaker test	TRIP/CLOSE cycle, 3 phases TRIP/CLOSE per phase
Tolerances		Dead time for CB TRIP / CLOSE cycle	0 to 30 s (steps 0.01 s)
P: for $ \cos \varphi = 0.7$ to 1 and $V/V_{\text{nom}}, III_{\text{nom}} = 50$ to 120 %	Typical $\leq 1\%$	Commissioning support	Operational measured values, CB test, status display of binary inputs, setting of output relays, generation of indications for testing serial interfaces
Q: for $ \sin \varphi = 0.7$ to 1 and $V/V_{\text{nom}}, III_{\text{nom}} = 50$ to 120 %	Typical $\leq 1\%$	Phase rotation adjustment	Clockwise or anti-clockwise
S: for $V/V_{\text{nom}}, III_{\text{nom}} = 50$ to 120 %	Typical $\leq 1\%$		
Frequency	f		
Tolerance	≤ 10 mHz		
Power factor	PF		
Tolerance for $ \cos \varphi = 0.7$ to 1	Typical ≤ 0.02		
<i>Energy meters</i>			
Four-quadrant meters	$W_{P+}; W_{P-}; W_{Q+}; W_{Q-}$		
Tolerance			
for $ \cos \varphi > 0.7$ and $V > 50\% V_{\text{nom}}$ and $I > 50\% I_{\text{nom}}$	5 %		
<i>Oscillographic fault recording</i>			
Analog channels	$3 \times I_{\text{Phase}}, 3I_0$ $3 \times V_{\text{Phase}}, 3V_0, V_{\text{SYNC}}, V_{\text{En}}$		
Max. number of available recordings	8, backed-up by battery if auxiliary voltage supply fails		
Sampling intervals	20 samplings per cycle		
Total storage time	> 15 s		
Binary channels	Pickup and trip information; number and contents can be freely configured by the user		
Max. number of displayed binary channels	40		
<i>Control</i>			
Number of switching units	Depends on the number of binary / indication inputs and indication / command outputs		
Control commands	Single command / double command 1, 1 plus 1 common or 2 pole		
Feed back	CLOSE, TRIP, intermediate position		
Interlocking	Freely configurable		
Local control	Control via menu, function keys, control keys (if available)		
Remote control	Control protection, DIGSI, pilot wires		
		CE conformity	
		This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EG previous 89/336/EEC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2006/95/EG previous 73/23/EEC).	
		This conformity is proved by tests conducted by Siemens AG in accordance with Article 10 of the Council Directive in agreement with the generic standards EN 61000-6-2 and EN 61000-6-4 for the EMC directive and with the standard EN 60255-6 for the low-voltage directive.	
		This device is designed and produced for industrial use.	
		The product conforms with the international standard of the series IEC 60255 and the German standard VDE 0435.	

Relays for Various Protection Applications/7VK61

Selection and ordering data

Accessories	Description	Order No.
	DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper) Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
	Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
	SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000/XP Professional Edition Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	7XS5410-0AA00
	Connecting cable (copper) Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	7XV5100-4
	Voltage transformer miniature circuit-breaker Rated current 1.6 A; thermal overload release 1.6 A; overcurrent trip 6 A	3RV1611-1AG14
	Manual for 7VK61 For the latest version please visit	www.siemens.com/siprotec

Accessories	Description	Order No.	Size of package	Supplier	Fig.
 <p>Fig. 10/18 Mounting rail for 19" rack</p>	Connector	2-pin 3-pin	1 1	Siemens Siemens	10/19 10/20
	 <p>Fig. 10/19 2-pin connector</p> <p>Fig. 10/20 3-pin connector</p>	Crimp connector	CI2 0.5 to 1 mm ²	4000 1	AMP ¹⁾ AMP ¹⁾
CI2 0.5 to 2.5 mm ²			4000 1	AMP ¹⁾ AMP ¹⁾	
Type III+ 0.75 to 1.5 mm ²			4000 1	AMP ¹⁾ AMP ¹⁾	
For type III+ and matching female for CI2 and matching female			1 1	AMP ¹⁾ AMP ¹⁾	
 <p>Fig. 10/21 Short-circuit link for current contacts</p>	19"-mounting rail		1	Siemens	10/18
	 <p>Fig. 10/22 Short-circuit link for voltage contacts/indications contacts</p>	Short-circuit links	For current terminals For other terminals	1 1	Siemens Siemens
		Safety cover for terminals	large small	1 1	Siemens Siemens

1) Your local Siemens representative can inform you on local suppliers.

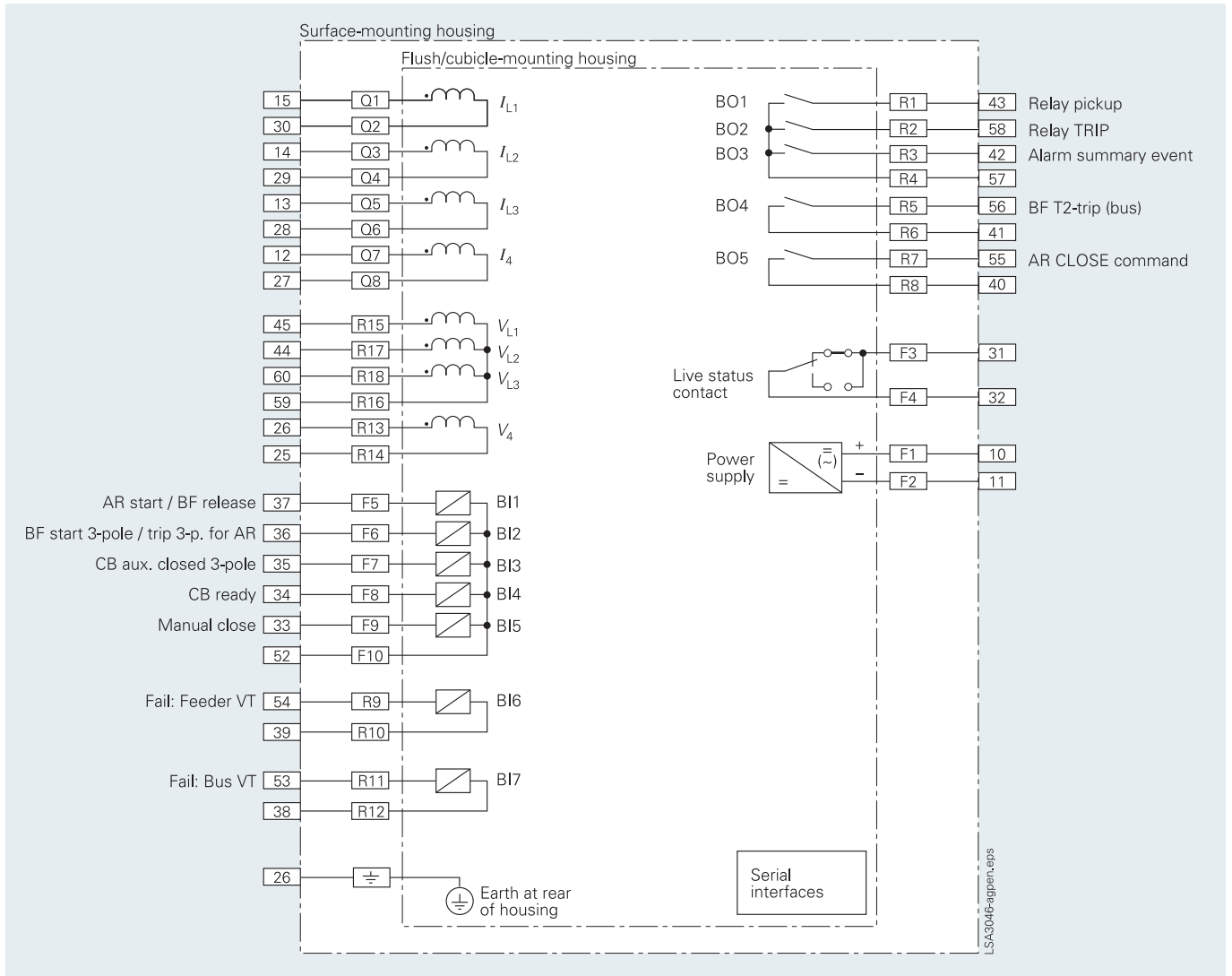


Fig. 10/23 Connection diagram 7VK610, 1/3 x 19" housing

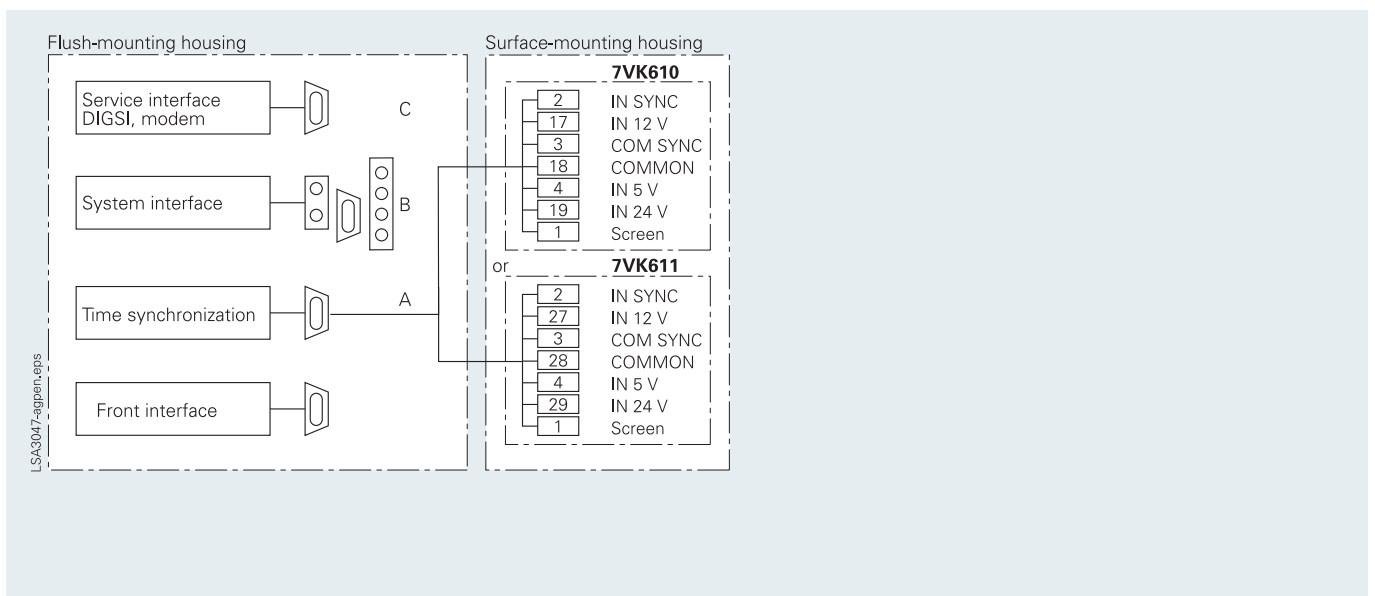


Fig. 10/24 Serial interfaces

Relays for Various Protection Applications/7VK61

Connection diagrams

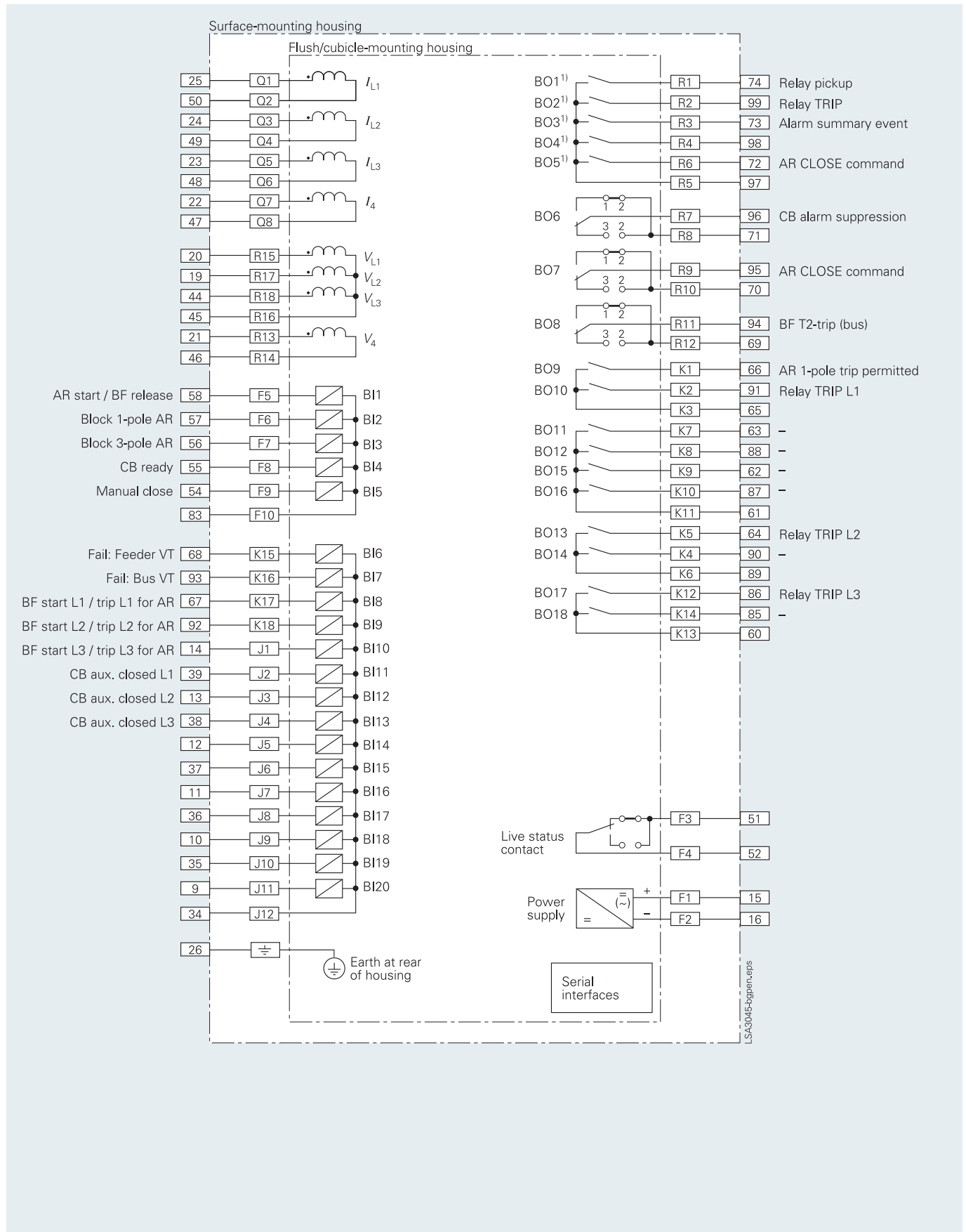


Fig. 10/25 Connection diagram 7VK611, 1/2 x 19" housing



Fig. 10/26 SIPROTEC 7SV600 numerical circuit-breaker failure protection relay

Description

The SIPROTEC 7SV600 is a numerical relay used for circuit-breaker failure protection. A failure occurs when the circuit-breaker fails to correctly open and clear the fault after single or three-pole trip commands have been issued by the protection unit. It is then necessary to trip the relevant busbar zone (section) to ensure fault clearance.

Generally, the monitoring of the current is sufficient as the criterion for the indication that the circuit-breaker has successfully cleared the fault ("current condition"). However, under certain fault conditions (e.g. overvoltage), little or no current may flow, making the measurement of current unreliable for indication of the circuit-breaker status ("no current condition"). The 7SV600 operates correctly for both these conditions. The relay is suitable for use at all voltage levels and in all applications. The current transformers can either be of the closed iron core or linear type. The relay can be incorporated in conventional switchgear systems and modem substation control systems e.g. SICAM.

Function overview

Protection functions

- Circuit-breaker failure protection (single or three-pole with/without current)
- Independently settable delay times for operation with and without current
- Single or two-stage time delay of the busbar trip command
- Re-trip (cross trip) stage (1st stage of the 2-stage operation)
- Intertrip facility (via teleprotection interface)
- End-fault protection with intertrip
- "No current" control using the circuit-breaker auxiliary contacts

Features

- Highly sensitive current detection
- 2-out-of-4 check of the current detectors
- Short reset time, negligible overshoot time
- Can be initiated by phase-segregated or common-phase trip commands
- End-fault protection
- Assignable output relays, LEDs and binary inputs

Monitoring functions

- Monitoring of circuit-breaker auxiliary contacts
- Operational current measured values
- Self-supervision of the relay
- Event buffer
- Fault protocols
- Oscillographic fault recording

Communication interfaces

- 1 x RS485 interface
 - IEC 60870-5-103 protocol
 - DIGSI

Hardware

- Digital inputs:
 - 3 binary inputs
- Digital outputs:
 - 4 output relays

Front design

- Display for operation and measured values
- 6 LEDs for local alarm

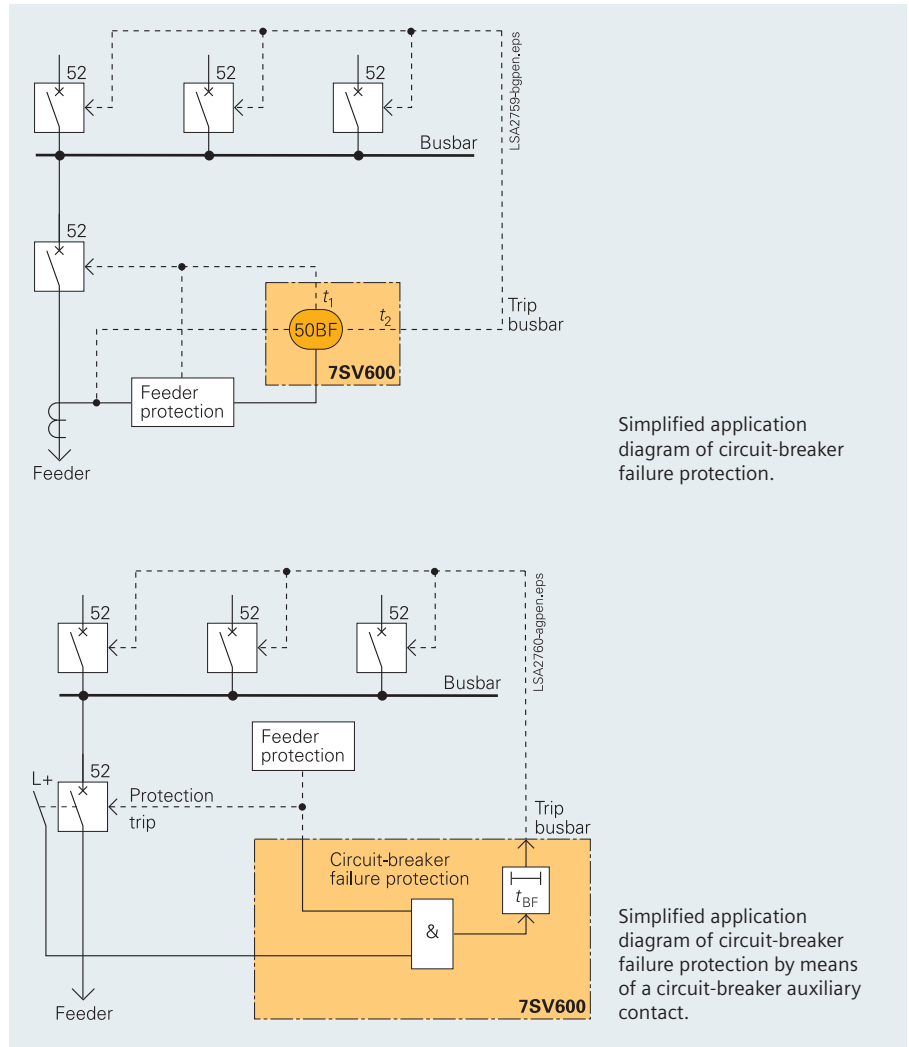
Relays for Various Protection Applications/7SV600

Application

Application

The numerical circuit-breaker failure protection relay 7SV600 provides rapid backup fault clearance instruction to the associated circuit-breakers in case the circuit-breaker nearest to the fault fails to respond.

It is suitable for power systems of all voltage levels. The initiation signal can be derived from any protection or supervision equipment or, in case of manual opening, from the control discrepancy switch of the breaker. Information from the circuit-breaker auxiliary contact is required for the breaker failure protection to function during faults which produce little or no current flow (possible only with common-phase initiation).



Simplified application diagram of circuit-breaker failure protection.

Simplified application diagram of circuit-breaker failure protection by means of a circuit-breaker auxiliary contact.

Fig. 10/27 Typical applications

Construction

The relay contains all the components needed for

- Acquisition and evaluation of measured values
- Operation and display
- Output of signals and trip commands
- Input and evaluation of binary signals
- SCADA interface (RS485)
- Power supply

The rated CT currents applied to the SIPROTEC 7SV600 can be 1 or 5 A. This is selectable via a jumper inside the relay.

Three different housings are available. The flush-mounting versions have terminals accessible from the rear. The surface-mounting version has terminals accessible from the front.

Protection functions

The breaker failure protection can operate single-stage or two-stage. When used as single-stage protection, the bus trip command is given to the adjacent circuit-breakers if the protected feeder breaker fails. When used as two-stage protection, the first stage can be used to repeat the trip command to the relevant feeder breaker, normally on a different trip coil, if the initial trip command from the feeder protection is not successful. The second stage will result in a bus trip to the adjacent breakers, if the command of the first stage is not successful.

The bus trip command from the breaker failure protection can be routed to all circuit-breakers linked to the same busbar (section) as the breaker that failed. It can also be transmitted to the remote end by means of a suitable communication link (e.g. PLC, radio wave, or optical fiber).

The isolator replica which is necessary in case of multiple busbar sections is not part of the 7SV600 relay.

The current level is monitored in each of the three phases against a set threshold. In addition, the zero-sequence component or the negative-sequence component of the phase currents derived by symmetrical component analysis is monitored. This ensures high security against malfunction by use of a 2-out-of-4 check of the current detectors.

The version with phase-segregated initiation enables reliable breaker failure detection even during single-pole auto-reclose cycles, provided the phase-segregated trip signals of the feeder protection are connected to the 7SV600.

If the protected circuit-breaker is not operational (e.g. air pressure failure or spring not charged), instantaneous bus trip of the adjacent circuit-breakers can be achieved following a feeder protection trip, provided the relay is informed via binary input of the breaker status (possible only for common-phase initiation).



Fig. 10/28 Rear view of surface-mounting housing

An end-fault protection function is integrated in the 7SV600 relay. An end fault is a short-circuit located between the circuit-breaker and the current transformer set of the feeder. For this fault, current flow is detected, although the auxiliary contacts of the breaker indicate open breaker poles.

A command signal is generated which can be transmitted to the remote-end breaker (possible only for common-phase initiation).

Special measures are taken to prevent malfunction of the relay. Besides the mentioned 2-out-of-4 check of the current detection elements, the trip signals of the feeder protection can be connected in a redundant manner, so that they can be checked for plausibility (possible only for common-phase initiation).

Continuous monitoring of the measured values permits rapid annunciation of any fault in the instrument transformer circuits. Continuous plausibility monitoring of the internal measured value processing circuits and monitoring of the auxiliary voltages to ensure that they remain within tolerance are obviously inherent features.

Relays for Various Protection Applications/7SV600

Serial data transmission, connection diagrams

Serial data transmission

A PC can be connected to ease setup of the relay using the Windows-based program DIGSI which runs under MS-Windows.

It can also be used to evaluate up to 8 oscillographic fault records, 8 fault logs and the operational event buffer. As an option, a system interface is available.

The SIPROTEC 7SV600 transmits a subset of data via IEC 60870-5-103 protocol:

- General fault detection of the device
- General trip of the device
- Current in phase L2 [%] =
- Breaker failure trip T1 (local trip)
- Breaker failure trip T2 (busbar trip)
- Circuit-breaker defective: Trip
- Trip by end-fault protection
- Trip by monitoring current symmetry
- Breaker failure protection is active

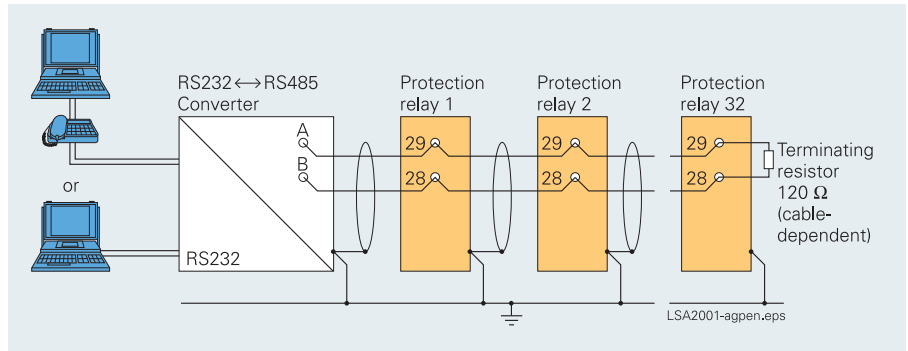


Fig. 10/29 Wiring communication RS485
For convenient wiring of the RS485 bus, use bus cable system 7XV5103
(see part 13 of this catalog)

Connection diagrams

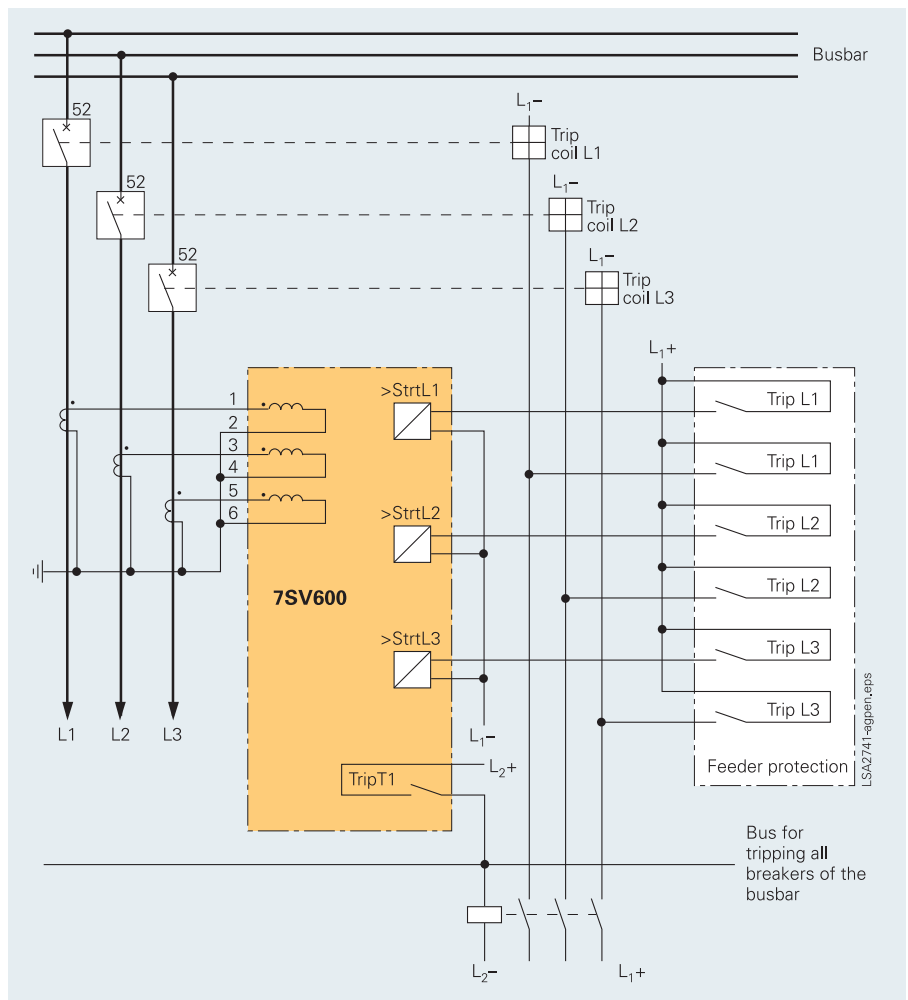


Fig. 10/30
Connection example for single-stage breaker failure protection with phase-segregated initiation

10

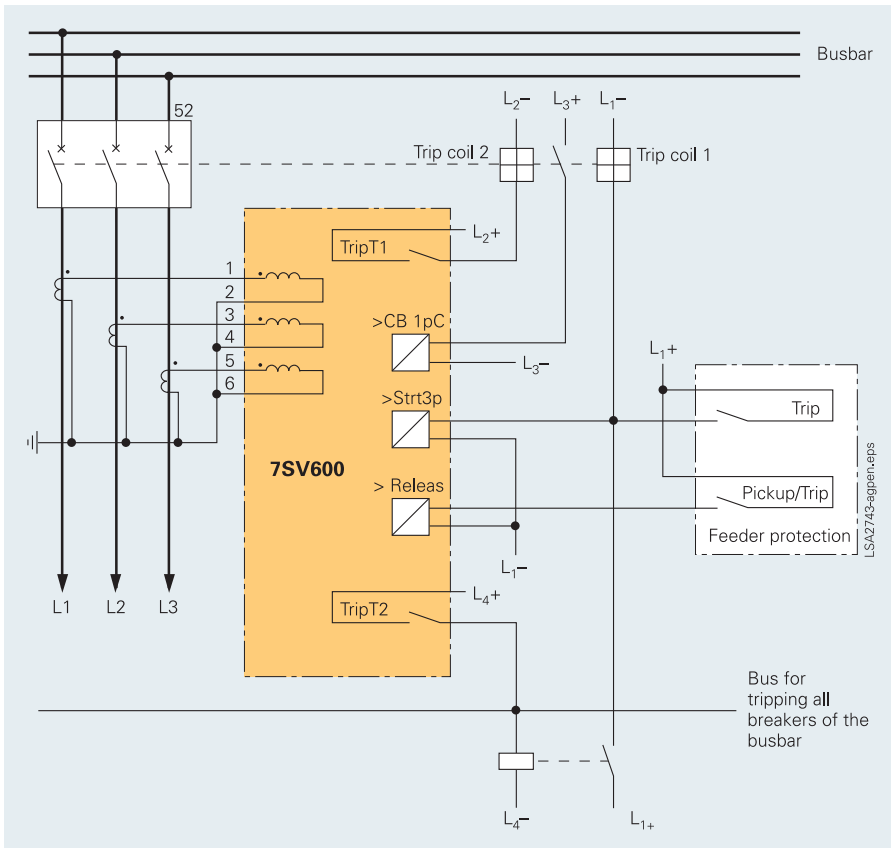


Fig. 10/31
Connection example for 2-stage breaker failure protection, common-phase initiation, CB interrogation

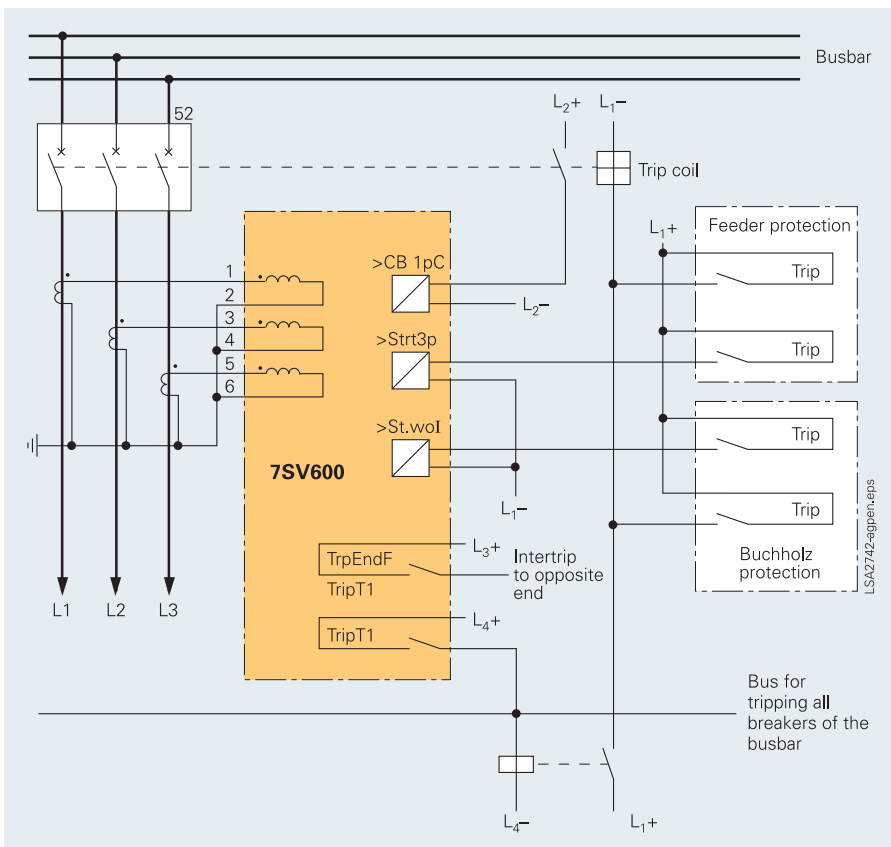


Fig. 10/32
Connection example for single-stage breaker failure protection with common-phase initiation and Buchholz protection, CB interrogation is imperative; additional intertrip signal to the opposite line end in case of breaker failure or end fault

Relays for Various Protection Applications/7SV600

Technical data

General unit data		Binary inputs	
<i>Measuring circuits</i>		<i>Unit design</i>	
Rated current I_N	1 to 5 A	Number	3 (can be marshalled)
Rated frequency f_N can be parameterized	50 or 60 Hz (selectable)	Rated operating voltage	DC 24 to 250 V
Power consumption of current inputs		Current consumption	Approx. 2.5 mA, independent of operating voltage
At $I_N = 1$ A	< 0.1 VA	Pick-up threshold	selectable by plug-in jumpers
At $I_N = 5$ A	< 0.2 VA	Rated aux. voltage DC 24/48/60 V	$V_{pick-up} \geq DC 17$ V
Overload capability current path, Thermal (r.m.s.)	100 x I_N for ≤ 1 s 30 x I_N for ≤ 10 s 4 x I_N continuous	Rated aux. voltage DC 110/125/220/250 V	$V_{drop-off} < DC 8$ V $V_{pick-up} \geq DC 74$ V $V_{drop-off} < DC 45$ V
Dynamic (pulse current)	250 x I_N one half cycle		
<i>Auxiliary voltage</i>			
Power supply via integrated DC/DC converter			
Rated auxiliary voltage V_{Aux} DC	DC 24 / 48 V DC 60 / 110 / 125 V DC 220 / 250 V	Weight	
Permissible variations	DC 19 to 58 V DC 48 to 150 V DC 176 to 300 V	In housing for surface mounting	Approx. 4.5 kg
Superimposed AC voltage	≤ 12 % at rated voltage	In housing for flush mounting	Approx. 4.0 kg
Peak-to-peak	≤ 6 % at limits of admissible voltage	Degree of protection acc. to EN 60529	
Power consumption		Housing	IP 51
Quiescent	Approx. 2 W	Terminals	IP 21
Energized	Approx. 4 W	<i>Serial interface</i>	
Bridging time during failure/short-circuit of auxiliary voltage	≥ 50 ms at $V_{rated} \geq DC 110$ V ≥ 20 ms at $V_{rated} \geq DC 24$ V	Isolated	
Rated auxiliary voltage V_{Aux}	AC 115 V, 50/60 Hz AC 230 V, 50/60 Hz	Standard	RS485
Permissible variations	AC 92 to 133 V AC 184 to 265 V	Test voltage	DC 2.8 kV
<i>Heavy duty (command) contacts</i>		Connection	Data cable on terminals, two data wires, one frame reference, for connection of a personal computer or similar; core pairs with shield, shield must be grounded; communication possible via modem
Command (trip) relays, number	2 (can be marshalled)	Baud rate	As delivered 9600 baud min. 1200 baud; max. 19200 baud
Contacts per relays	2 NO	<i>Electrical tests</i>	
Switching capacity		<i>Specifications</i>	
Make	1000 W/VA	Standards	IEC 60255-5; ANSI/IEEE C37.90.0
Break	30 W/VA	<i>Insulation tests</i>	
Switching voltage	250 V	High voltage test (routine test) except DC voltage supply input and RS485	2 kV (r.m.s.); 50 Hz
Permissible current	5 A continuous 30 A for 0.5 s	High voltage test (routine test) only DC voltage supply input and RS485	DC 2.8 kV
<i>Signal contacts</i>		High voltage test (type test) Between open contacts of trip relays	1.5 kV (r.m.s.), 50 Hz
Signal/alarm relays	2 (can be marshalled)	Between open contacts of alarm relays	1 kV (r.m.s.), 50 Hz
Contact per relays	1 CO	Impulse voltage test (type test) all circuits, class III	5 kV (peak); 1.2/50 μ s; 0.5 J; 3 positive and 3 negative impulses at intervals of 5 s
Switching capacity			
Make	1000 W/VA		
Break	30 W/VA		
Switching voltage	250 V		
Permissible current	5 A		

EMC tests for noise immunity; type tests	
Standards: IEC 60255-6, IEC 60255-22 (product standards); EN 50082-2 (generic standard) VDE 0435, part 303	
High frequency IEC 60255-22-1, class III	2.5 kV (peak); 1 MHz; $\tau = 15 \mu\text{s}$; 400 shots/s; duration 2 s
Electrostatic discharge IEC 60255-22-2, class III and IEC 61000-4-2, class III	4 kV/6 kV contact discharge; 8 kV air discharge; both polarities; 150 pF; $R_i = 330 \Omega$
Irradiation with radio-frequency field, non-modulated; IEC 60255-22-3 (report), class III	10 V/m; 27 to 500 MHz
Irradiation with radio-frequency field, amplitude-modulated; IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz
Irradiation with radio-frequency field, pulse-modulated; IEC 61000-4-3/ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transients/bursts IEC 60255-22-4 and IEC 61000-4-4, class III	2 kV; 5/50 ns; 5 kHz; burst length 15 ms; repetition rate 300 ms; both polarities; $R_i = 50 \Omega$; duration 1 min
Line-conducted HF, amplitude- modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Magnetic field with power frequency IEC 61000-4-8, class IV IEC 60255-6	30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1 (common mode)	2.5 to 3 kV (peak); 1 to 1.5 MHz, decaying oscillation; 50 surges per s; duration 2 s; $R_i = 150 \Omega$ to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1 (common mode)	4 to 5 kV; 10/150 ns; 50 surges per s; both polarities; duration 2 s; $R_i = 80 \Omega$
Radiated electromagnetic interference ANSI/IEEE C37.90.2	10 to 20 V/m; 25 to 1000 MHz; amplitude and pulse modulated
High frequency test document 17C (SEC) 102	2.5 kV (peak, alternating polarity); 100 kHz, 1 MHz, 10 and 50 MHz, decaying oscillation; $R_i = 50 \Omega$

EMC tests for interference emission; type tests	
Standard	EN 50081-* (generic standard)
Conducted interference voltage, aux. voltage CISPR 22, EN 55022	150 to 30 MHz Limit class B
Radio interference field strength CISPR 11, EN 55011	30 to 1000 MHz Limit class A

Mechanical stress tests	
Vibration, shock stress and seismic vibration	
During operation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class I IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.035 mm amplitude; 60 to 150 Hz: 0.5 g acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I	Half-sine Acceleration 5 g, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
Seismic vibration IEC 60255-21-3, class I IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 g acceleration (horizontal axis) 8 to 35 Hz: 0.5 g acceleration (vertical axis) Sweep rate 1 octave/min 1 cycle in 3 orthogonal axes
During transportation	
Standard	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 g acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I IEC 60068-2-27	Half-sine Acceleration 15 g, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
Continuous shock IEC 60255-21-2, class I IEC 60068-2-29	Half-sine Acceleration 10 g, duration 16 ms, 1000 shocks in each direction of 3 orthogonal axes

Relays for Various Protection Applications/7SV600

Technical data

Climatic stress tests	
<i>Temperatures</i>	
Permissible temperature during service	-20 °C to +70 °C (> 55 °C decreased display contrast)
Recommended temperature during service	-5 °C to +55 °C
Permissible temperature during storage	-25 °C to +55 °C
Permissible temperature during transport	-25 °C to +70 °C
Storage and transport with standard works packaging!	
<i>Humidity</i>	
Permissible humidity	Mean value per year ≤ 75 % relative humidity; on 30 days per year 95 % relative humidity; condensation not permissible!
We recommend that all units are installed such that they are not subjected to direct sunlight, nor to large temperature fluctuations which may give rise to condensation.	

Service conditions	
<p>The relay is designed for use in industrial environment, for installation in standard relay rooms and compartments so that with proper installation electromagnetic compatibility (EMC) is ensured. The following should also be heeded:</p> <ul style="list-style-type: none"> All contactors and relays which operate in the same cubicle or on the same relay panel as the digital protection equipment should, as a rule, be fitted with suitable spike quenching elements. All external connection leads in substations from 100 kV upwards should be shielded with a shield capable of carrying power currents and grounded at both sides. No special measures are normally necessary for substations of lower voltages. 	<ul style="list-style-type: none"> The shield of the RS485 cable must be grounded. It is not permissible to withdraw or insert individual modules under voltage. In the withdrawn condition, some components are electrostatically endangered; during handling the standards for electrostatically endangered components must be observed. The modules are not endangered when plugged in. <p>WARNING! The relay is not designed for use in residential, commercial or light-industrial environment as defined in EN 50081.</p>

Functions	
<i>Breaker supervision</i>	
Current detection	
Setting range	0.05 x I _N to 4.00 x I _N (steps 0.01 x I _N)
Drop-off ratio	Approx. 0.9
Tolerance	0.01 x I _N or 5 % of set value
Initiation conditions	
Depending on ordered version	Phase-segregated initiation (single-pole trip from feeder protection) or common-phase initiation (three-pole trip from feeder protection) and common-phase initiation (three-pole trip from non-short-circuit protection)
Times	
Pickup time	Approx. 15 ms with measured quantities present Approx. 25 ms after switch-on of measured quantities
Drop-off time with sinusoidal measured quantities	≤ 10 ms
Drop-off time maximum	≤ 25 ms
Delay times for all time stages	0.00 s to 32.00 s (steps 0.01 ms) or deactivated
Delay time tolerance	1 % of set value or 10 ms
The set times are pure delay times.	

Additional functions	
<i>Operational value measurements</i>	
Operational current values	I _{L1} ; I _{L2} ; I _{L3}
Measurement range	0 % to 240 % I _N
Tolerance	3 % of rated value or of measured value
<i>Steady-state measured value supervision</i>	
Current unbalance	I _{max} /I _{min} > symmetry factor as long as I > I _{limit}
<i>Fault event data storage</i>	
Storage of annunciations of the last eight faults with max. 30 messages each	
<i>Time assignment</i>	
Resolution for operational annunciations	1 s
Resolution for fault event annunciations	1 ms
Max. time deviation	0.01 %
<i>Data storage for fault recording (max. 8 fault events)</i>	
Total storage time (fault detection or trip command = 0 ms)	Max. 5 s, selectable pre-trigger and post-fault time
Max. storage period per fault event T _{max}	0.30 to 5.00 s (steps 0.01 s)
Pre-trigger time T _{pre}	0.05 to 0.50 s (steps 0.01 s)
Post-fault time T _{post}	0.05 to 0.50 s (steps 0.01 s)
Sampling rate	1 instantaneous value per ms at 50 Hz 1 instantaneous value per 0.83 ms at 60 Hz

Relays for Various Protection Applications/7SV600

Selection and ordering data

Description	Order No.
7SV600 numerical circuit-breaker failure protection relay	7SV600 □ - □ □ □ AA0 - □ DA0
Rated current; rated frequency	
1 A; 50/60 Hz	1
5 A; 50/60 Hz	5
Rated auxiliary voltage	
DC 24, 48 V	2
DC 60, 110, 125 V	4
DC 220, 250 V / AC 115 V, 50/60 Hz	5
AC 230 V, 50/60 Hz	6
Unit design	
For panel surface mounting with terminals on both sides	B
For panel surface mounting with terminals at top and bottom	D
For panel flush mounting / cubicle mounting	E
Options	
For common-phase initiation	0
For common-phase initiation or phase-segregated initiation	1

Accessories	Description	Order No.
	DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows (version Windows 2000/XP Professional Edition) device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper)	7XS5400-0AA00
	Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5402-0AA00
	Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	
	RS232 (V.24) ↔ RS485 converter *	7XV5700 - □ □ □ 00
	Plug-in auxiliary power supply unit AC 220 V/50 Hz	0
	Plug-in auxiliary power supply unit AC 110 V/60 Hz	1
	With RS485 connecting cable for 7SJ6, 7RW6, 7SD6, 7SV6 A	A
	With RS485 connecting cable with 9-pin connector for SIMEAS Q	B
	With RS485 connecting cable with plug connector for SIMEAS T	C
	Without RS232 connecting cable	A
	With RS232 connecting cable 7XV5100-2 for PC/notebook, 9-pin connector (female)	B
	With RS232 adapter, 25-pin connector (male) to 9-pin connector (female) for connection to notebook/PC	C
	Converter full-duplex fiber-optic cable ↔ RS485 With power supply DC 24 – 250 V and AC 110/230 V	7XV5650-0BA00
	Manual for 7SV600 For the latest version please visit	www.siemens.com/siprotec
	*) RS485 bus system up to 115 kbaud RS485 bus cable and adaptor 7XV5103-□AA□□; see part 13.	

Relays for Various Protection Applications/7SV600

Connection diagram

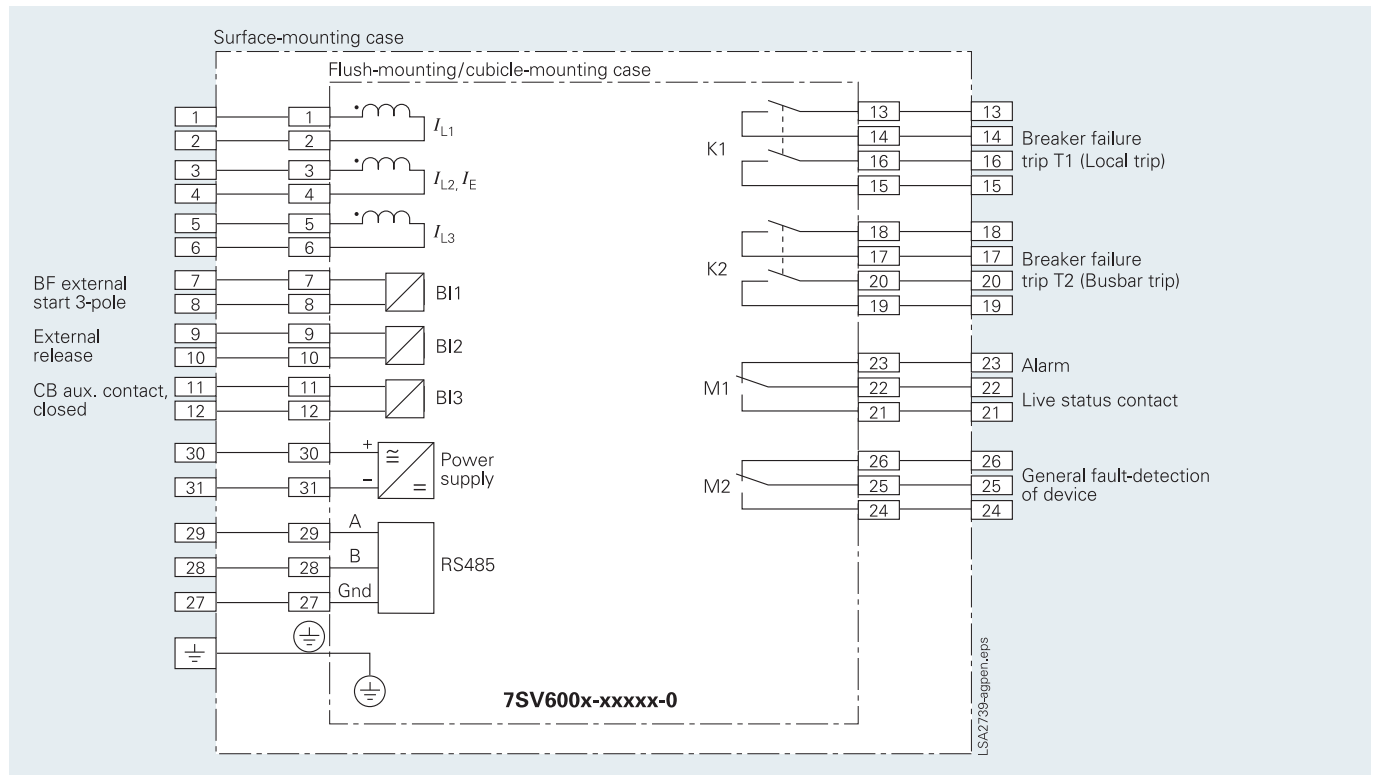


Fig. 10/33 General connection diagram of 7SV600 with presettings for common-phase initiation

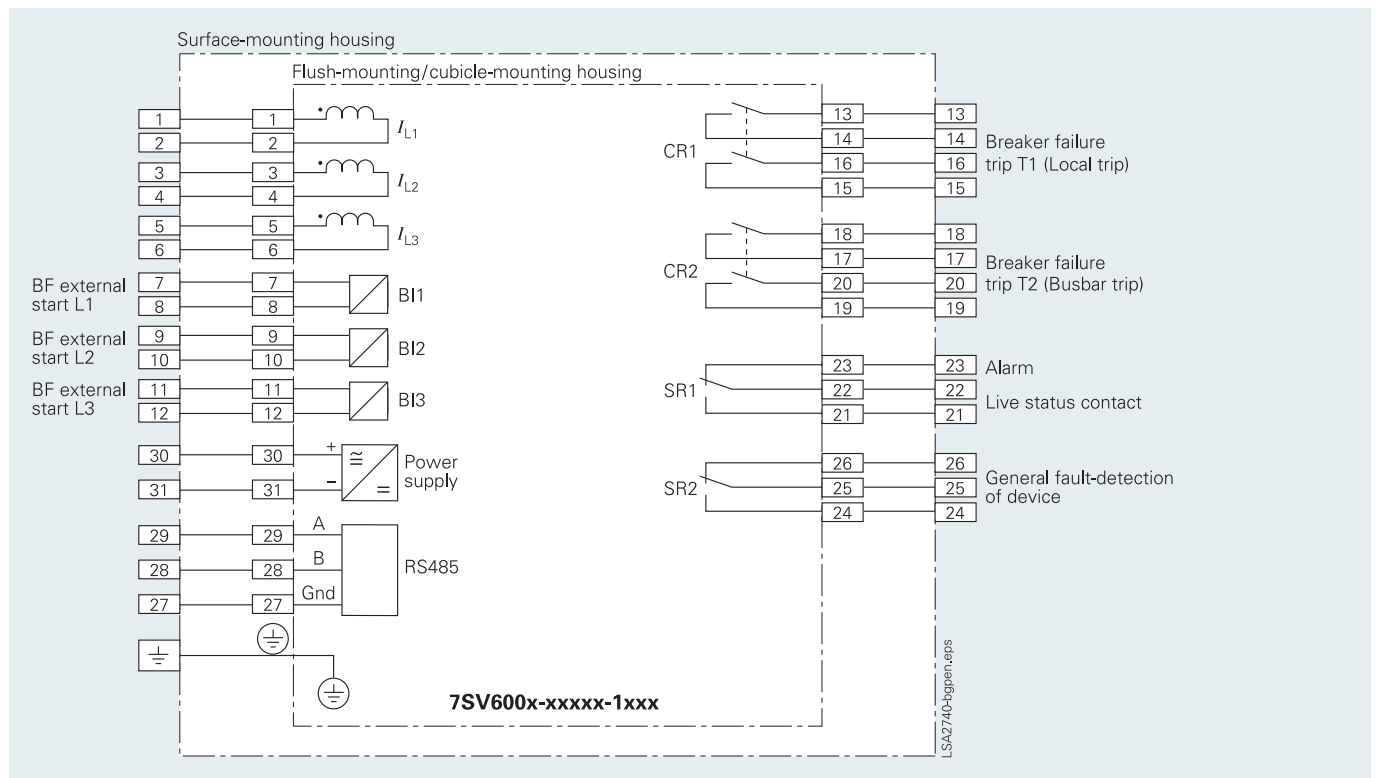


Fig. 10/34 General connection diagram of 7SV600 with presettings for phase-segregated initiation

10



Fig. 10/35 SIPROTEC 7SN60 transient ground-fault relay

Description

The highly sensitive 7SN60 transient ground-fault relay determines the direction of transient and continuous ground faults in systems with isolated neutral, in systems with high-impedance resistive grounding and in compensated systems. Continuous ground faults are indicated with a delay, either in conjunction with a transient ground fault and subsequently persisting displacement voltage, or with just the displacement voltage present.

Function overview

Protection functions

- Units for panel surface mounting or flush mounting in 7XP20 housing, with terminals on the side or terminals on the top/bottom
- Both fault directions indicated by LEDs and signaled by relays
- High pickup sensitivity due to separate detection and evaluation of total current and displacement voltage
- 1 A and 5 A rated current selectable for current transformer matching
- 16 selectable pickup thresholds for detection of transients in the current path, even with higher steady-state total currents of 10 to 300 mA
- Fixed pickup threshold of 5 V for detection of transients in the voltage path, even in the case of higher steady-state displacement voltages
- 4 selectable pickup thresholds for evaluation of the displacement voltage of 10 to 50 V
- Optional suppression of switching operations by evaluation of the displacement voltage after a switching-induced transient has occurred
- Wide-range power supply for connection to AC 110/230 V systems, DC 60 to 250 V station batteries or DC 100 V voltage transformers without switchover or DC 24 to 60 V
- Binary inputs for remote reset and blocking with extremely wide input voltage range of DC 24 to 250 V
- Automatic reset of direction indications and signals after 3 or 10 s (selectable)
- Automatic reset in case of intermittent ground faults only after the last ground-fault, i.e. the correct indication and signal of the first ground fault is preserved
- Detection of the displacement voltage and ground-fault indication/signal, independent of a transient fault detection
- Signaling and indication of a continuous ground fault possible only in the forward direction
- Fault indication if sensitivity is set too high

Relays for Various Protection Applications/7SN60

Construction, protection functions



Fig. 10/36 Rear view

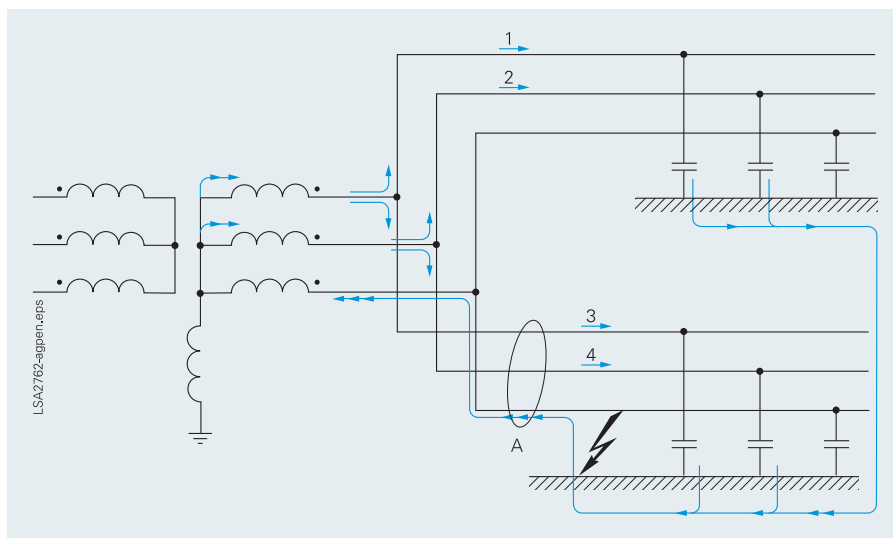


Fig. 10/37 Fault currents in the system

Construction

The relay contains all the components needed for

- Acquisition and evaluation of measured values
- Operation and display
- Output of signals and trip commands
- Power supply

The rated CT currents applied to the SIPROTEC 7SN60 can be 1 or 5 A. This is selectable via a jumper inside the relay.

Three different housings are available.

The flush-mounting/cubicle-mounting housings have terminals accessible from the rear. The surface-mounting housing has terminals either on the side or on the top and bottom.

Protection functions

Ground-fault directional determination

The highly sensitive 7SN60 transient ground-fault relay determines the direction of transient and continuous ground faults in systems with isolated neutral, in systems with high-impedance resistive grounding and in compensated systems.

Continuous ground faults are indicated with a delay, either in conjunction with a transient ground fault and subsequently persisting displacement voltage, or with just the displacement voltage present.

In the event of an ground fault, the neutral-point voltage to ground can be as high as the full-phase voltage.

The phase-to-ground capacitances of the non-ground-faulted phases are charged via the transformer inductance.

This charging process is bound up with a strong current surge (starting oscillation).

The amplitude of this current surge depends on the expands of the system and on the contact resistance values at the ground-fault location.

This current flows via the phase-to-ground capacitances of the unaffected lines to ground, enters the ground-faulted phase via the ground-fault location and flows back from there to the feeding transformer.

Thus the direction of the ground-fault induced current surge is identical to that of the short-circuit current at the same location.

At measuring point A, as a result of the transformer summation circuit, the ground current of the faulted line is not included in the measurement, as this current portion flows through the summation transformer of the relevant Holmgreen circuit and back, thereby canceling itself out.

It is the total of the capacitive ground currents from the non-faulted system which has an effect. In the diagram they are summated on the upper line. The capacitive currents of the non-faulted lines 1, 3 and 2, 4 accumulate vectorially, which explains why only three arrows instead of four are shown at the measuring point A.

With a transient ground fault, the equalizing current forming a damped oscillation of 100 to more than 1000 Hz decays after only a few periods.

The displacement voltage V_{EM} thereupon also returns to zero. In grounded systems this takes place after a number of periods (decay of the Petersen coil - ground capacitance oscillation circuit); in non-grounded systems this occurs after a very short time.

In the case of a continuous ground fault, the equalizing current in the non-grounded system changes into the mostly capacitive continuous ground current or, in compensated systems, into the relatively low residual active current.

For the directional determination, the direction of the first transient of neutral current and displacement voltage is considered.

The relay indicates the direction of the transient ground fault by LEDs (red = forward direction, yellow = reverse direction) and the relevant signaling relay pickups.

Continuous ground faults are indicated after a settable time by an LED on the relay and signaled by a signaling relay.

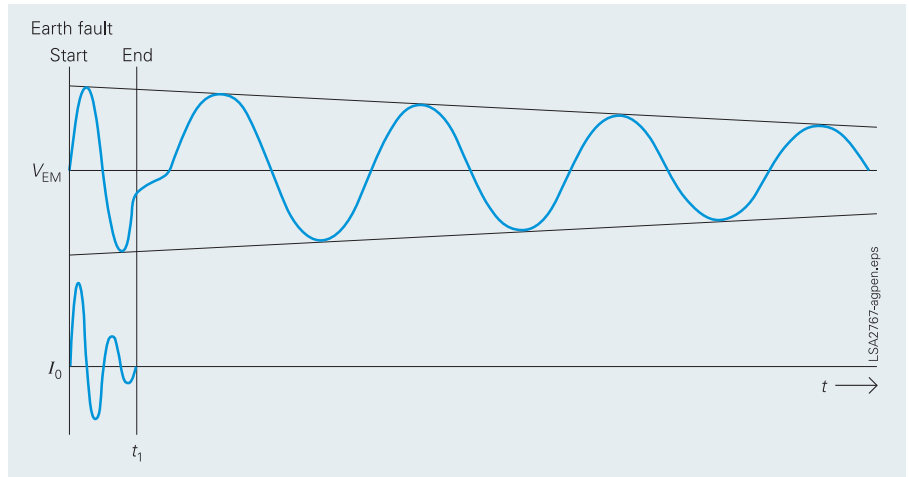


Fig. 10/38 Neutral current and displacement voltage

Detection of the fault location

If the system is of radial configuration, the red lamp immediately indicates the faulted line.

If one of the lines consists of several sections, the fault is upstream of the last red lamp.

The transient ground-fault relay can also be used without restrictions in any type of meshed systems. Transient ground-fault relays distributed at suitable points throughout the system allow detection of the ground-fault location from the directional indications.

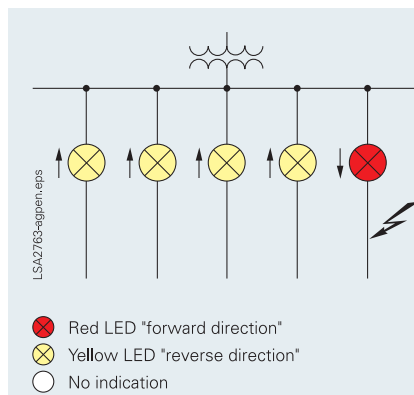


Fig. 10/39 Radial system

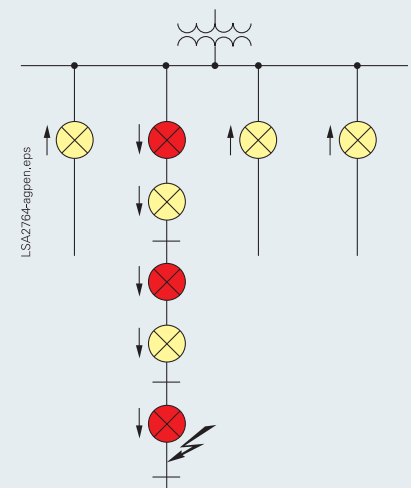


Fig. 10/40 Radial system

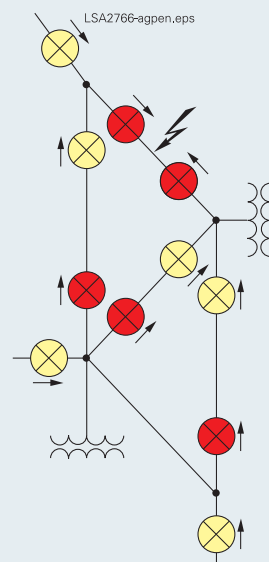


Fig. 10/41 Meshed system

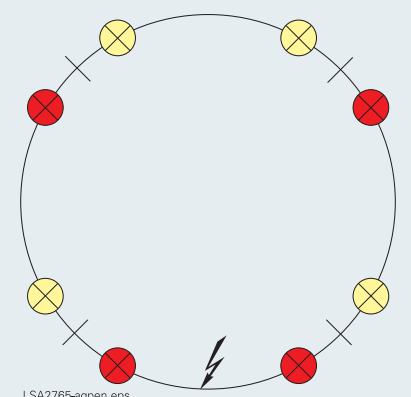


Fig. 10/42 Ring system

Relays for Various Protection Applications/7SN60

Typical connection

Typical connection

Connection of the current and voltage transformers

Figures 10/43 and 10/44 show the connection of the current and voltage transformer set in Holmgreen circuit.

In Fig. 10/43, the star point at the line-side of the CT must be connected to terminal 1 while the star point at the busbar side of the CTs must be connected to terminal 2.

The three phase voltages V_{L1} , V_{L2} and V_{L3} are connected to terminals 7, 8, 9 respectively. The grounded star point of the voltage transformer is connected to terminal 10.

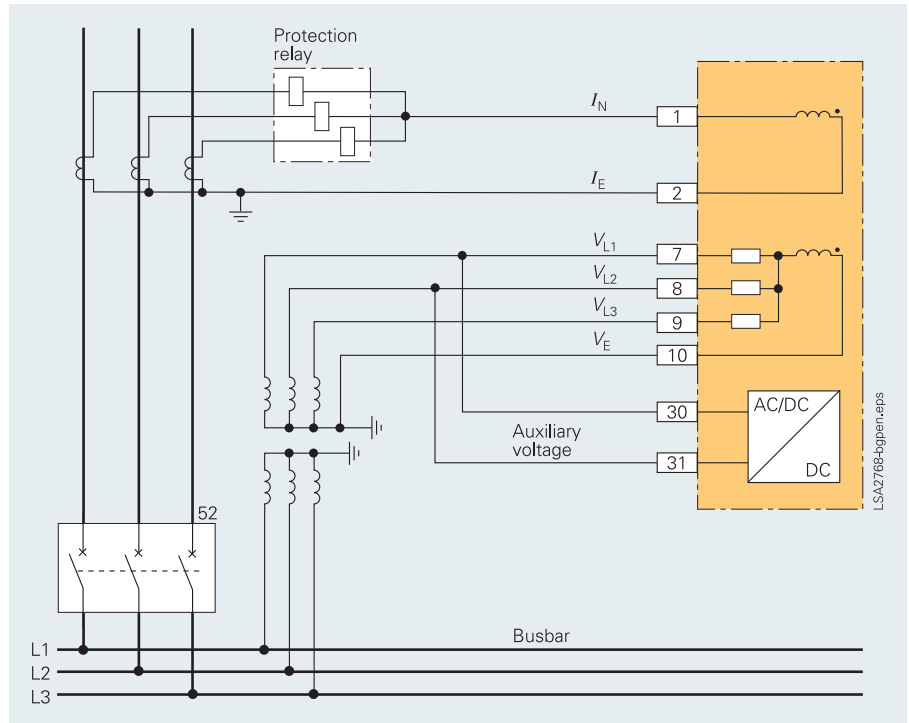


Fig. 10/43 Connection of transformers and auxiliary power supply for panel flush-mounting housing and panel surface-mounting housing (terminals on the side)

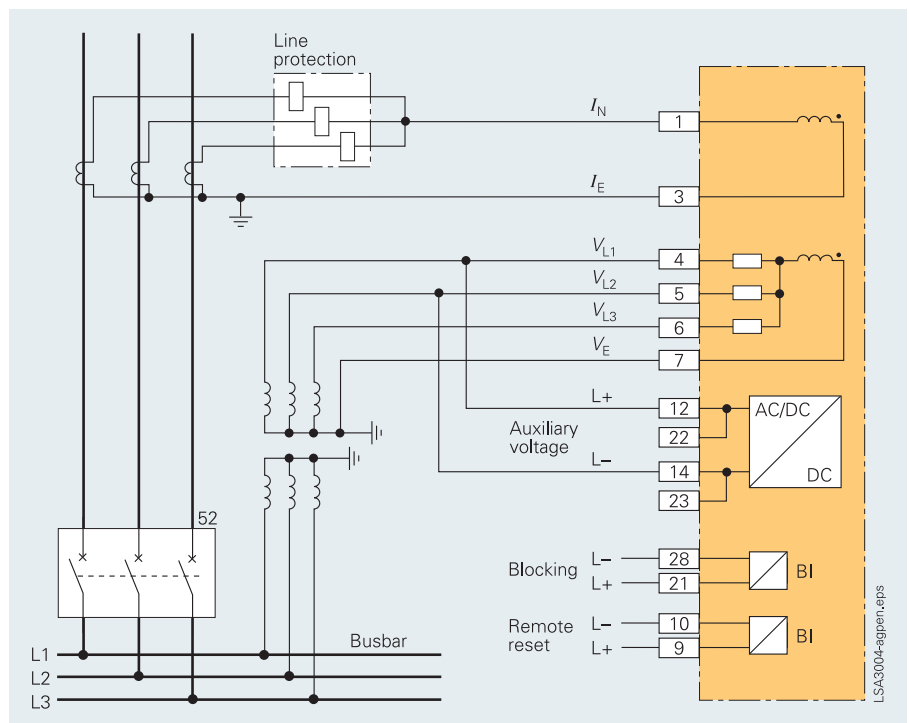


Fig. 10/44 Connection of transformers and auxiliary power supply for panel surface-mounting housing (terminals on the top/bottom)

General unit data	
<i>Measuring circuit</i>	
Rated current I_0	1 or 5 A
Input impedance Z at 50 Hz and I_N	< 0.05 Ω
Rated voltage V_N	AC 100/110 V
Rated frequency f_N	50 Hz (16.7 Hz)
Thermal rating	
- In voltage path, continuous	AC 140 V
- In current path, continuous	4 x I_N
10 s	30 x I_N
1 s (at 1 A)	100 x I_N
1 s (at 5)	300 A
<i>Auxiliary voltage</i>	
Rated auxiliary voltage V_{aux}	DC 60 – 250 V and AC 100 – 230 V without switchover
Power consumption at	Quiescent Energized
DC 60 V	3.1 W 4.5 W
DC 110 V	3.0 W 4.5 W
DC 220 V	3.6 W 4.6 W
DC 250 V	3.7 W 4.8 W
AC 100 V	2.9 VA 4.2 VA
AC 110 V	3.0 VA 4.2 VA
AC 230 V	4.6 VA 5.8 VA
<i>Binary inputs</i>	
Input voltage for blocking and remote reset input	DC 24 – 250 V
Pickup thresholds for	
- Blocking X30 pin 1-2, remote reset X31 pin 1-2	Approx. 19 V
- Blocking X30 pin 2-3, remote reset X31 pin 2-3	Approx. 75 V
<i>Signaling relays</i>	
Number of relays, forward or reverse direction	2 NO contacts
Number of relays, continuous ground-fault signal	1 NO contact
Number of relays, alarm	1 NC contact
Switching capacity Make (all relays)	1000 W/VA
Switching capacity Break (all relays)	30 W/VA
Switching voltage	AC/DC 250 V
Permissible switching current	
Continuous	5 A
0.5 s	30 A
<i>Unit design</i>	
Housing, dimensions	SIPROTEC housing of 1/6 width Refer to part 14 for dimension drawings
For flush mounting, terminals at the top/bottom	6 current / 25 voltage terminals
For panel surface mounting, terminals on the side	6 current / 25 voltage terminals
Weight	Approx. 4 kg
<i>Standards</i>	
DIN VDE 0435, Part 303 and IEC 60255-5	

Relays for Various Protection Applications/7SN60

Selection and ordering data, connection diagram

Description	Order No.
7SN60 transient ground-fault protection relay	7SN6000 - □ □ A00
In SIPROTEC housing 1/6 width Rated frequency 50 Hz	
Rated auxiliary voltage	
DC 60 – 250 V and AC 100 – 230 V without switchover	0
DC 24 – 48 V	1
For panel surface mounting with terminals on the side	B
For panel surface mounting with terminals at top/bottom part	D
For panel flush mounting or cubicle mounting	E

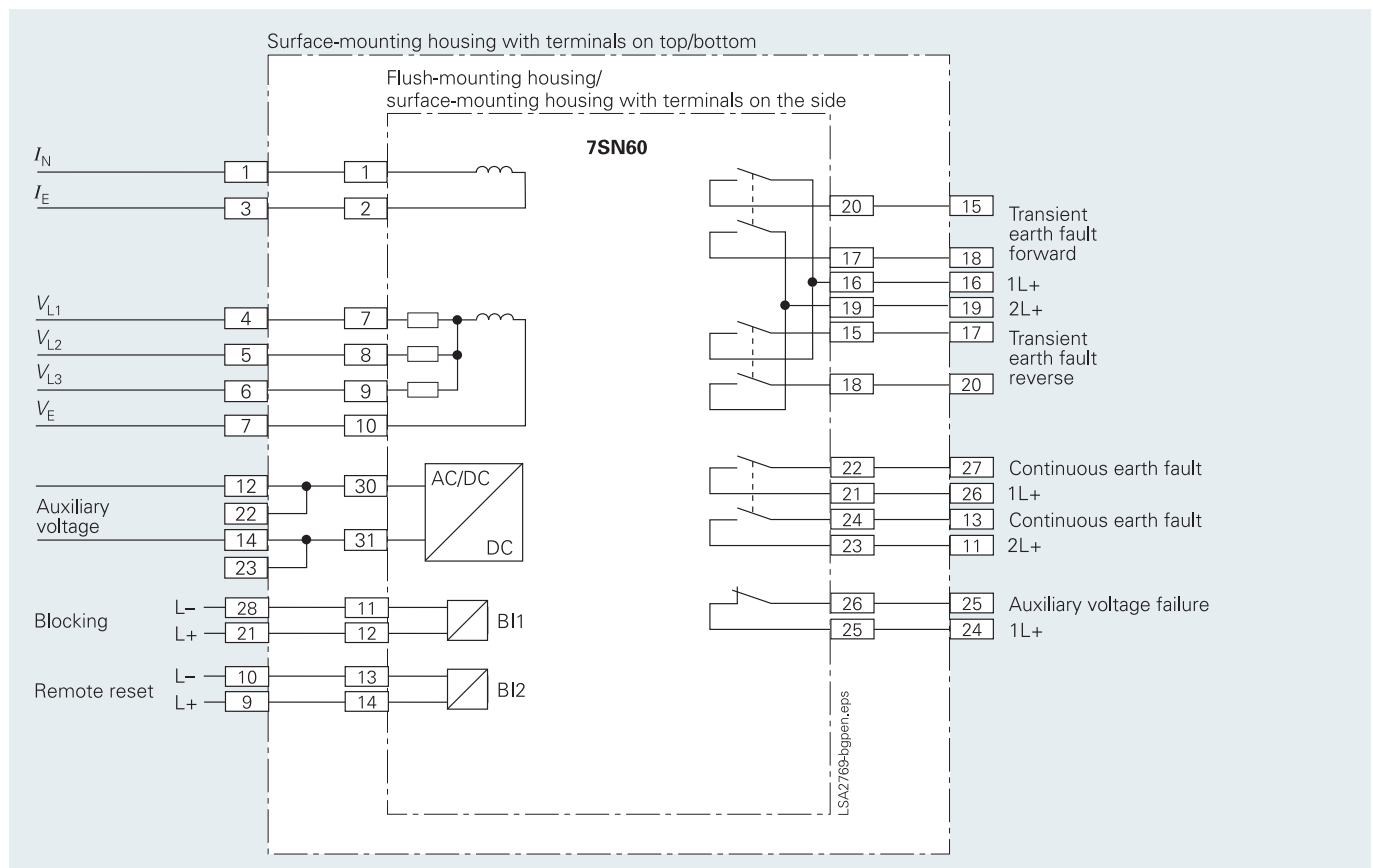


Fig. 10/45 Connection diagram

10

Generator Protection

	Page
SIPROTEC 4 7UM61 multifunction generator and motor protection relay	11/3
SIPROTEC 4 7UM62 multifunction generator, motor and transformer protection relay	11/33
SIPROTEC 7UW50 tripping matrix	11/69
SIPROTEC 7RW600 numerical voltage, frequency and overexcitation protection relay	11/71
SIPROTEC 7VE6 multifunction paralleling device	11/81
SIPROTEC 7VU683 high speed busbar transfer	11/103





Fig. 11/1 SIPROTEC 4 7UM61 multifunction generator and motor protection relay

Description

The SIPROTEC 4 7UM61 protection relays can do more than just protect. They also offer numerous additional functions. Be it ground faults, short-circuits, overloads, overvoltage, overfrequency or underfrequency, protection relays assure continued operation of power stations. The SIPROTEC 4 7UM61 protection relay is a compact unit which has been specially developed and designed for the protection of small and medium-sized generators. They integrate all the necessary protection functions and are particularly suited for the protection of:

- Hydro and pumped-storage generators
- Co-generation stations
- Private power stations using regenerative energy sources such as wind or biogases
- Diesel generator stations
- Gas-turbine power stations
- Industrial power stations
- Conventional steam power stations.

The device can also be used for protecting synchronous and asynchronous motors.

The integrated programmable logic functions (continuous function chart CFC) offer the user high flexibility so that adjustments can easily be made to the varying power station requirements, on the basis of special system conditions.

The flexible communication interfaces are open for modern communication architectures with the control system.

Function overview

Basic version

- Stator ground-fault protection
- Sensitive ground-fault protection
- Stator overload protection
- Overcurrent-time protection (either definite-time or inverse-time)
- Definite-time overcurrent-time protection, directional
- Undervoltage and overvoltage protection
- Underfrequency and overfrequency protection
- Reverse power protection
- Overexcitation protection
- External trip coupling

Standard version

Scope of basic version plus:

- Forward-power protection
- Underexcitation protection
- Negative-sequence protection
- Breaker failure protection

Full version

Scope of standard version plus:

- Inadvertent energization protection
- 100 %-stator ground-fault protection with 3rd harmonic
- Impedance protection

Asynchronous motor

Scope of standard version plus

- Motor starting time supervision
- Restart inhibit (without underexcitation protection)

Monitoring functions

- Trip circuit supervision
- Fuse failure monitor
- Operational measured values V, I, f, \dots
- Every metering value W_p, W_q
- Time metering of operation hours
- Self-supervision of relay
- 8 oscillographic fault records

Communication interfaces

- System interface
 - IEC 60870-5-103 protocol
 - PROFIBUS-DP
 - MODBUS RTU
 - DNP 3.0

Generator Protection/7UM61

Application

Application

The 7UM6 protection relays of the SIPROTEC 4 family are compact multifunction units which have been developed for small to medium-sized power generation plants. They incorporate all the necessary protective functions and are especially suitable for the protection of:

- Hydro and pumped-storage generators
- Co-generation stations
- Private power stations using regenerative energy sources such as wind or biogases
- Power generation with diesel generators
- Gas turbine power stations
- Industrial power stations
- Conventional steam power stations.

They can also be employed for protection of motors and transformers.

The numerous other additional functions assist the user in ensuring cost-effective system management and reliable power supply. Measured values display current operating conditions. Stored status indications and fault recording provide assistance in fault diagnosis not only in the event of a disturbance in generator operation.

Combination of the units makes it possible to implement effective redundancy concepts.

Protection functions

Numerous protection functions are necessary for reliable protection of electrical machines. Their extent and combination are determined by a variety of factors, such as machine size, mode of operation, plant configuration, availability requirements, experience and design philosophy.

This results in multifunctionality, which is implemented in outstanding fashion by numerical technology.

In order to satisfy differing requirements, the combination of functions is scalable (see Table 11/1). Selection is facilitated by division into groups.

Protection functions	Abbreviation	ANSI No.	Generator			
			Basic	Standard	Full	Motor async.
Stator ground-fault protection non-directional, directional	$V_0 >, 3I_0 >$ $\backslash (V_0, 3I_0)$	59N, 64G, 67G	■	■	■	■
Sensitive ground-fault protection (also rotor ground-fault protection)	$I_{EE} >$	50/51GN (64R)	■	■	■	■
Stator overload protection	$I^2 t$	49	■	■	■	■
Definite-time overcurrent protection with undervoltage seal-in	$I > + V <$	51	■	■	■	■
Definite-time overcurrent protection, directional	$I >>, \text{Direc.}$	50/51/67	■	■	■	■
Inverse-time overcurrent protection	$t = f(I) + V <$	51V	■	■	■	■
Overvoltage protection	$V >$	59	■	■	■	■
Undervoltage protection	$V <$	27	■	■	■	■
Frequency protection	$f <, f >$	81	■	■	■	■
Reverse-power protection	$-P$	32R	■	■	■	■
Overexcitation protection (Volt/Hertz)	V/f	24	■	■	■	■
Fuse failure monitor	$V_2 / V_1, I_1 / I_2$	60FL	■	■	■	■
External trip coupling (7UM611/612)	Incoup.		2/4	2/4	2/4	2/4
Trip circuit supervision (7UM612)	T.C.S.	74TC	■	■	■	■
Forward-power protection	$P >, P <$	32F	■	■	■	■
Underexcitation protection	$1/x_d$	40		■	■	
Negative-sequence protection	$I_2 >, t = f(I_2)$	46		■	■	■
Breaker failure protection	$I_{\min} >$	50BF		■	■	■
Inadvertent energization protection	$I >, V <$	50/27			■	
100 %-stator-ground-fault protection with 3rd harmonics	$V_0 (3^{\text{rd}} \text{ harm})$	59TN 27TN (3 rd harm)			■	
Impedance protection with ($I > + V <$)-pickup	$Z <$	21			■	
Motor starting time supervision	$I_{\text{an}}^2 t$	48			■	■
Restart inhibit for motors	$I^2 t$	49 Rotor			■	■
External temperature monitoring through serial interface	ϑ (Thermo-box)	38	■	■	■	■
Rate-of-frequency-change protection ¹⁾	$df/dt >$	81R	■	■	■	■
Vector jump supervision (voltage) ¹⁾	$\Delta\varphi >$		■	■	■	■

1) Available as an option (please refer to Order No., position 15).

Table 11/1 Scope of functions of the 7UM61

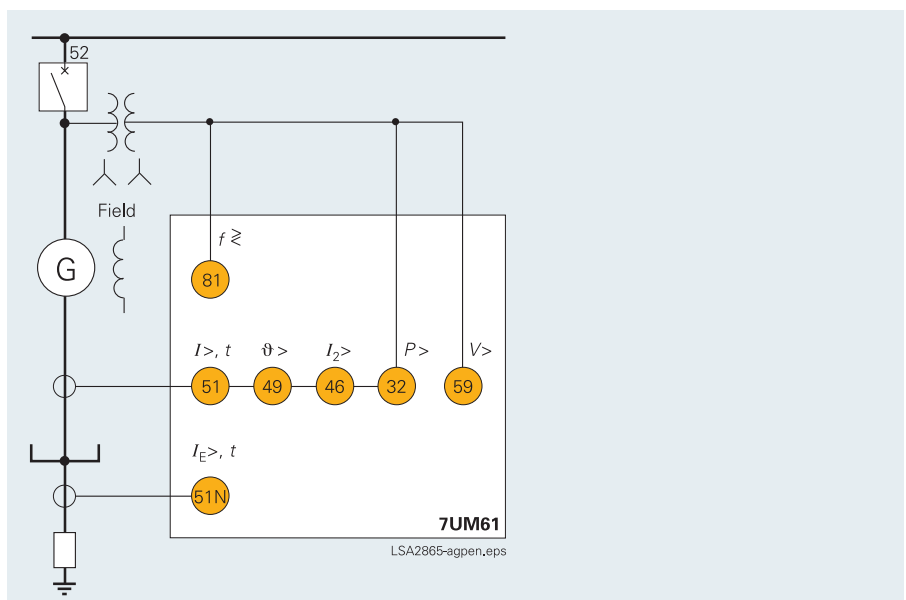


Fig. 11/2 Overview

Generator Basic

One application is concentrated on small generators or as backup protection for larger generators. The function mix is also an effective addition to transformer differential protection with parallel-connected transformers. The functions are also suitable for system disconnection.

Generator Standard

This function mix is recommended for generator outputs exceeding 1 MVA. It is also suitable for protection of synchronous motors. Another application is as backup protection for the larger block units.

Generator Full

Here, all protection functions are available and are recommended from generator outputs exceeding 5 MVA. Backup protection for the larger block units is also a recommended application.

Asynchronous motor

This protection function mix is recommended for motors up to 1 – 2 MW. It offers a wide frequency operating range from 11 Hz to 69 Hz. When an infeed is switched, the protection adapts to the changed voltage and frequency.

Construction

The SIPROTEC 4 units have a uniform design and a degree of functionality which represents a whole new quality in protection and control. Local operation has been designed according to ergonomic criteria. Large, easy-to-read displays were a major design aim. The DIGSI 4 operating program considerably simplifies planning and engineering and reduces commissioning times.

The 7UM611 is configured in $\frac{1}{3}$ 19 inch, and the 7UM612 in $\frac{1}{2}$ 19 inch width. This means that the units of previous models can be replaced. The height throughout all housing width increments is 243 mm.

All wires are connected directly or by means of ring-type cable lugs.

Alternatively, versions with plug-in terminals are also available. These permit the use of prefabricated cable harnesses.

In the case of panel surface mounting, the connecting terminals are in the form of screw-type terminals at top and bottom. The communication interfaces are also arranged on the same sides.

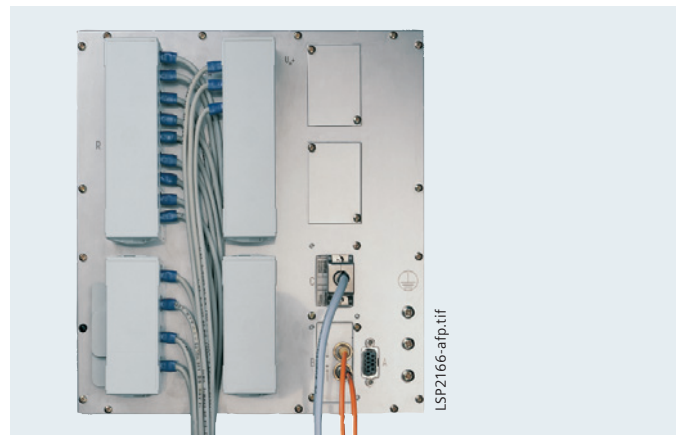


Fig. 11/3 Rear view with wiring terminal safety cover and serial interface

Protection functions

Protection functions

Definite-time overcurrent protection $I>$, $I>>$ (ANSI 50, 51, 67)

This protection function comprises the short-circuit protection for the generator and also the backup protection for upstream devices such as transformers or power system protection.

An undervoltage stage at $I>$ maintains the pickup when, during the fault, the current falls below the threshold. In the event of a voltage drop on the generator terminals, the static excitation system can no longer be sufficiently supplied. This is one reason for the decrease of the short-circuit current.

The $I>>$ stage can be implemented as high-set instantaneous trip stage. With the integrated directional function it can be applied for generators without star point CT (see Figure 11/4).

Inverse-time overcurrent protection (ANSI 51V)

This function also comprises short-circuit and backup protection and is used for power system protection with current-dependent protection devices.

IEC and ANSI characteristics can be selected (Table 11/2).

The current function can be controlled by evaluating the generator terminal voltage.

The "controlled" version releases the sensitive set current stage.

With the "restraint" version, the pickup value of the current is lowered linearly with decreasing voltage.

The fuse failure monitor prevents unwanted operation.

Stator overload protection (ANSI 49)

The task of the overload protection is to protect the stator windings of generators and motors from high, continuous overload currents. All load variations are evaluated by the mathematical model used. The thermal effect of the r.m.s. current value forms the basis of the calculation. This conforms to IEC 60255-8. In dependency of the current the cooling time constant is automatically extended. If the ambient temperature or the temperature of the coolant are injected via PROFIBUS-DP, the model automatically adapts to the ambient conditions; otherwise a constant ambient temperature is assumed.

Negative-sequence protection (ANSI 46)

Asymmetrical current loads in the three phases of a generator cause a temperature rise in the rotor because of the negative sequence field produced.

This protection detects an asymmetrical load in three-phase generators. It functions on the basis of symmetrical components and evaluates the negative sequence of the phase currents. The thermal processes are taken into account in the algorithm and form the inverse characteristic. In addition, the negative sequence is evaluated by an independent stage (alarm and trip) which is supplemented by a time-delay element (see Fig. 11/5).

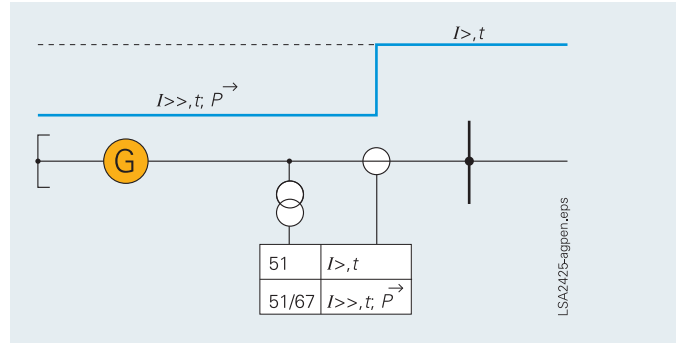


Fig. 11/4 Protection with current transformer on terminal side

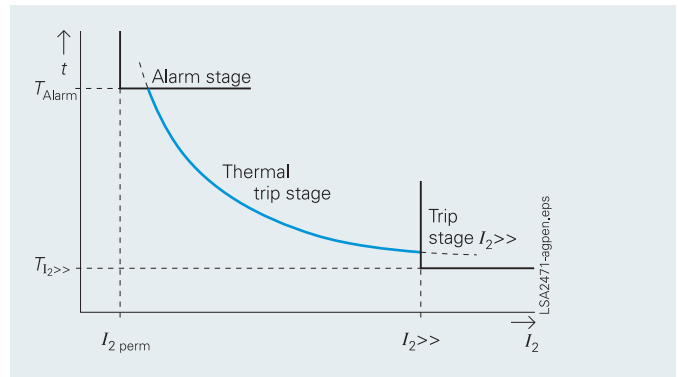


Fig. 11/5 Characteristic of negative-sequence protection

Available inverse-time characteristics		
Characteristics acc. to	ANSI/IEEE	IEC 60255-3
Inverse	•	•
Moderately inverse	•	
Very inverse	•	•
Extremely inverse	•	•
Definite inverse	•	

Table 11/2

Underexcitation protection (ANSI 40) (Loss-of-field protection)

Derived from the generator terminal voltage and current, the complex admittance is calculated and corresponds to the generator diagram scaled in per unit. This protection prevents damage due to loss of synchronism resulting from underexcitation. The protection function provides three characteristics for monitoring static and dynamic stability. In the event of exciter failure, fast response of the protection can be ensured via binary input. This input releases a timer with a short time delay.

The straight-line characteristics allow the protection of the generator diagram to be optimally adapted (see Fig. 11/6). The per-unit-presentation of the diagram allows the setting values to be directly read out.

The positive-sequence systems of current and voltage are used to calculate the admittance. This ensures that the protection always operates correctly even with asymmetrical network conditions.

If the voltage deviates from the rated voltage, the admittance calculation has the advantage that the characteristics move in the same direction as the generator diagram.

Reverse-power protection (ANSI 32R)

The reverse-power protection monitors the direction of active power flow and picks up when the mechanical energy fails because then the drive power is taken from the network. This function can be used for operational shut-down (sequential tripping) of the generator but also prevents damage to the steam turbines. The reverse power is calculated from the positive-sequence systems of current and voltage. Asymmetrical network faults therefore do not cause reduced measuring accuracy. The position of the emergency trip valve is injected as binary information and is used to switch between two trip command delays. When applied for motor protection, the sign (\pm) of the active power can be reversed via parameters.

Forward-power protection (ANSI 32F)

Monitoring of the active power produced by a generator can be useful for starting up and shutting down generators. One stage monitors threshold beyond one limit value while another stage monitors threshold below another limit value. The power is calculated using the positive-sequence component of current and voltage.

Impedance protection (ANSI 21)

This fast short-circuit protection protects the generator, the generator transformer and is a backup protection for the power system. This protection has two settable impedance stages; in addition, the first stage can be switched over via binary input. With the circuit-breaker in "open" position (see Fig. 11/7) the impedance measuring range can be extended. The overcurrent pickup element with under-voltage seal-in ensures a reliable pickup and the loop selection logic a reliable detection of the faulty loop. With this logic it is possible to perform a correct measurement via the unit transformer.

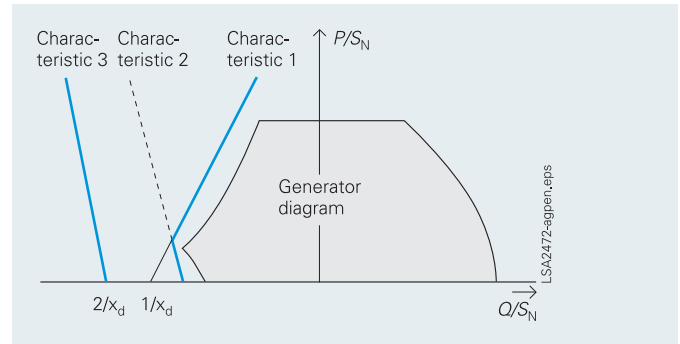


Fig. 11/6 Characteristic of underexcitation protection

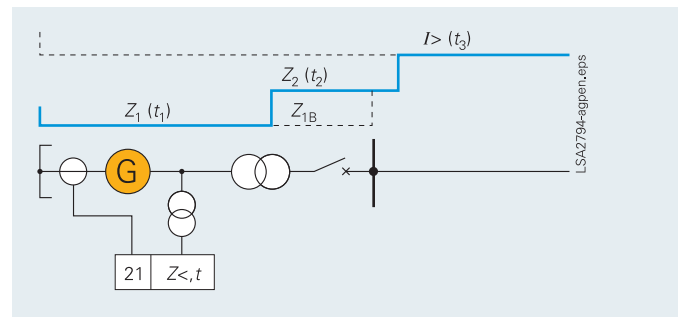


Fig. 11/7 Grading of impedance protection

Undervoltage protection (ANSI 27)

The undervoltage protection evaluates the positive-sequence components of the voltages and compares them with the threshold values. There are two stages available.

The undervoltage function is used for asynchronous motors and pumped-storage stations and prevents the voltage-related instability of such machines.

The function can also be used for monitoring purposes.

Overvoltage protection (ANSI 59)

This protection prevents insulation faults that result when the voltage is too high.

Either the maximum line-to-line voltages or the phase-to-ground voltages (for low-voltage generators) can be evaluated. The measuring results of the line-to-line voltages are independent of the neutral point displacement caused by ground-faults. This function is implemented in two stages.

Protection functions

Frequency protection (ANSI 81)

The frequency protection prevents impermissible stress of the equipment (e.g. turbine) in case of under or overfrequency. It also serves as a monitoring and control element.

The function has four stages; the stages can be implemented either as under-frequency or overfrequency protection. Each stage can be delayed separately.

Even in the event of voltage distortion, the frequency measuring algorithm reliably identifies the fundamental waves and determines the frequency extremely precisely. Frequency measurement can be blocked by using an undervoltage stage.

Overexcitation protection Volt/Hertz (ANSI 24)

The overexcitation protection serves for detection of an unpermissible high induction (proportional to V/f) in generators or transformers, which leads to thermal overloading. This may occur when starting up, shutting down under full load, with weak systems or under isolated operation. The inverse characteristic can be set via seven points derived from the manufacturer data.

In addition, a definite-time alarm stage and an instantaneous stage can be used.

For calculation of the V/f ratio, frequency and also the highest of the three line-to-line voltages are used. The frequency range that can be monitored comprises 11 to 69 Hz.

Stator ground-fault protection, non-directional, directional (ANSI 59N, 64G, 67G)

Ground faults manifest themselves in generators that are operated in isolation by the occurrence of a displacement voltage. In case of unit connections, the displacement voltage is an adequate, selective criterion for protection.

For the selective ground-fault detection, the direction of the flowing ground current has to be evaluated too, if there is a direct connection between generator and busbar.

The protection relay measures the displacement voltage at a VT located at the transformer star point or at the broken delta-winding of a VT. As an option, it is also possible to calculate the zero-sequence voltage from the phase-to-ground voltages. Depending on the load resistor selection, 90 to 95 % of the stator winding of a generator can be protected.

A sensitive current input is available for ground-current measurement. This input should be connected to a core-balance current transformer. The fault direction is deduced from the displacement voltage and ground current. The directional characteristic (straight line) can be easily adapted to the system conditions. Effective protection for direct connection of a generator to a busbar can therefore be established. During start-up, it is possible to switch over from the directional to the displacement voltage measurement via an externally injected signal.

Depending on the protection setting, various ground-fault protection concepts can be implemented with this function (see Figs. 11/17 to 11/21).

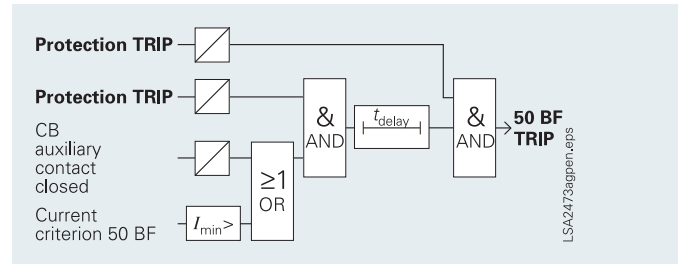


Fig. 11/8 Logic diagram of breaker failure protection

Sensitive ground-fault protection (ANSI 50/51GN, 64R)

The sensitive ground-current input can also be used as separate ground-fault protection. It is of two-stage form. Secondary ground currents of 2 mA or higher can be reliably handled.

Alternatively, this input is also suitable as rotor ground-fault protection. A voltage with rated frequency (50 or 60 Hz) is connected in the rotor circuit via the interface unit 7XR61. If a higher ground current is flowing, a rotor ground fault has occurred. Measuring-circuit monitoring is provided for this application (see Figure 11/20).

100 % stator ground-fault protection with 3rd harmonic (ANSI 59TN, 27TN (3rd H.))

Owing to the design, the generator produces a 3rd harmonic that forms a zero system. It is verifiable by the protection on a broken delta winding or on the neutral transformer. The magnitude of the voltage amplitude depends on the generator and its operation.

In the event of a ground fault in the vicinity of the neutral point, there is a voltage displacement in the 3rd harmonic (dropping in the neutral point and rising at the terminals).

Depending on the connection, the protection must be set in either undervoltage or overvoltage form. It can also be delayed. So as to avoid overfunction, the active power and the positive-sequence voltage act as enabling criteria.

The final protection setting can be made only by way of a primary test with the generator.

Breaker failure protection (ANSI 50BF)

In the event of scheduled downtimes or a fault in the generator, the generator can remain on line if the circuit-breaker is defective and could suffer substantial damage.

Breaker failure protection evaluates a minimum current and the circuit-breaker auxiliary contact. It can be started by internal protective tripping or externally via binary input. Two-channel activation avoids overfunction (see Figure 11/8).

Inadvertent energization protection (ANSI 50, 27)

This protection has the function of limiting the damage of the generator in the event of an unintentional switch-on of the circuit-breaker, whether the generator is standing still or rotating without being excited or synchronized. If the power system voltage is connected, the generator starts as an asynchronous machine with a large slip and this leads to excessively high currents in the rotor.

A logic circuit consisting of sensitive current measurement for each phase, measured value detector, time control and blocking as of a minimum voltage, leads to an instantaneous trip command. If the fuse failure monitor responds, this function is ineffective.

Starting time supervision (motor protection only) (ANSI 48)

Starting time supervision protects the motor against long unwanted start-ups, which might occur as a result of excessive load torque or excessive voltage drops within the motor, or if the rotor is locked.

The tripping time is dependent on the square of the start-up current and the set start-up time (Inverse Characteristic). It adapts itself to the start-up with reduced voltage. The tripping time is determined in accordance with the following formula:

$$t_{\text{Trip}} = \left(\frac{I_{\text{start}}}{I_{\text{rms}}} \right)^2 \cdot t_{\text{start max}}$$

t_{Trip} Tripping time

I_{start} Permissible start-up current

$t_{\text{start max}}$ Permissible start-up time

I_{rms} Measured r.m.s. current value

Calculation is not started until the current I_{rms} is higher than an adjustable response value (e.g. $2 I_{\text{N, MOTOR}}$).

If the permissible locked-rotor time is less than the permissible start-up time (motors with a thermally critical rotor), a binary signal is set to detect a locked rotor by means of a tachometer generator. This binary signal releases the set locked-rotor time, and tripping occurs after it has elapsed.

Restart inhibit for motors (ANSI 66, 49Rotor)

When cold or at operating temperature, motors may only be connected a certain number of times in succession. The start-up current causes heat development in the rotor which is monitored by the restart inhibit function.

Contrary to classical counting methods, in the restart inhibit function the heat and cooling phenomena in the rotor are simulated by a thermal replica. The rotor temperature is determined on the basis of the stator currents. Restart inhibit permits restart of the motor only if the rotor has enough thermal reserve for a completely new start. Fig. 11/9 illustrates the thermal profile for a permissible triple start out of the cold state. If the thermal reserve is too low, the restart inhibit function issues a blocking

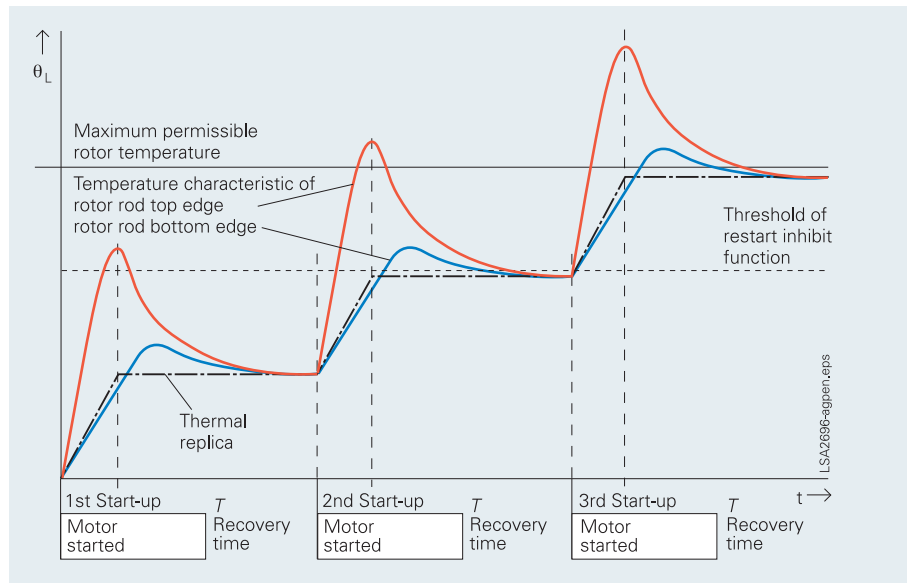


Fig. 11/9 Temperature characteristic at rotor and thermal replica of the rotor (multiple start-ups)

signal with which the motor starting circuit can be blocked. The blockage is cancelled again after cooling down and the thermal value has dropped below the pickup threshold.

As the fan provides no forced cooling when the motor is off, it cools down more slowly. Depending on the operating state, the protection function controls the cooling time constant. A value below a minimum current is an effective changeover criterion.

System disconnection

Take the case of in-plant generators feeding directly into a system. The incoming line is generally the legal entity boundary between the system owner and the in-plant generator. If the incoming line fails as the result of auto-reclosure, for instance, a voltage or frequency deviation may occur depending on the power balance at the feeding generator. Asynchronous conditions may arise in the event of connection, which may lead to damage on the generator or the gearing between the generator and the turbine. Besides the classic criteria such as voltage and frequency, the following two criteria are also applied (vector jump, rate-of-frequency-change protection).

Rate-of-frequency-change protection (ANSI 81)

The frequency difference is determined on the basis of the calculated frequency over a time interval. It corresponds to the momentary rate-of-frequency change. The function is designed so that it reacts to both positive and negative rate-of-frequency changes. Exceeding of the permissible rate-of-frequency change is monitored constantly. Release of the relevant direction depends on whether the actual frequency is above or below the rated frequency. In total, four stages are available, and can be used optionally.

Generator Protection/7UM61

Protection functions

Vector jump

Monitoring the phase angle in the voltage is a criterion for identifying an interrupted infeed. If the incoming line should fail, the abrupt current discontinuity leads to a phase angle jump in the voltage. This is measured by means of a delta process. The command for opening the generator or coupler circuit-breaker is issued if the set threshold is exceeded.

External trip coupling

For recording and processing of external trip information, there are 2 (for 7UM611) or 4 (for 7UM612) binary inputs. They are provided for information from the Buchholz relay or generator-specific commands and act like a protective function. Each input initiates a fault event and can be individually delayed by a timer.

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal occurs whenever the circuit is interrupted.

Phase rotation reversal

If the relay is used in a pumped-storage power plant, matching to the prevailing rotary field is possible via a binary input (generator/motor operation via phase rotation reversal).

2 pre-definable parameter groups

In the protection, the setting values can be stored in two data sets. In addition to the standard parameter group, the second group is provided for certain operating conditions (pumped-storage power stations). It can be activated via binary input, local control or DIGSI 4.

Lockout (ANSI 86)

All binary outputs (alarm or trip relays) can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only occur after the lockout state is reset.

Fuse failure and other monitoring

The relay comprises high-performance monitoring for the hardware and software.

The measuring circuits, analog-digital conversion, power supply voltages, memories and software sequence (watch-dog) are all monitored.

The fuse failure function detects failure of the measuring voltage due to short-circuit or open circuit of the wiring or VT and avoids overfunction of the undervoltage elements in the protection functions.

The positive and negative-sequence system (voltage and current) are evaluated.

Filter time

All binary inputs can be subjected to a filter time (indication suppression).

Communication

With respect to communication, particular emphasis has been placed on high levels of flexibility, data integrity and utilization of standards common in energy automation. The design of the communication modules permits interchangeability on the one hand, and on the other hand provides openness for future standards (for example, Industrial Ethernet).

Local PC interface

The PC interface accessible from the front of the unit permits quick access to all parameters and fault event data. The use of the DIGSI 4 operating program during commissioning is particularly advantageous.

Rear-mounted interfaces

Two communication modules on the rear of the unit incorporate optional equipment complements and permit retrofitting. They assure the ability to comply with the requirements of different communication interfaces (electrical or optical) and protocols (IEC 60870, PROFIBUS, DIGSI).

The interfaces make provision for the following applications:

Service interface

In the RS485 version, several protection units can be centrally operated with DIGSI 4. By using a modem, remote control is possible. This provides advantages in fault clearance, in particular in unmanned substations.

System interface

This is used to communicate with a control or protection and control system and supports, depending on the module connected, a variety of communication protocols and interface designs.

IEC 60870-5-103

IEC 60870-5-103 is an internationally standardized protocol for communication with protection relays.

IEC 60870-5-103 is supported by a number of protection unit manufacturers and is used worldwide.

The generator protection functions are stored in the manufacturer-specific, published part of the protocol.

PROFIBUS-DP

PROFIBUS is an internationally standardized communication protocol (EN 50170). PROFIBUS is supported internationally by several hundred manufacturers and has to date been used in more than 1,000,000 applications all over the world.

With the PROFIBUS-DP, the protection can be directly connected to a SIMATIC S5/S7. The transferred data are fault data, measured values and information from or to the logic (CFC).

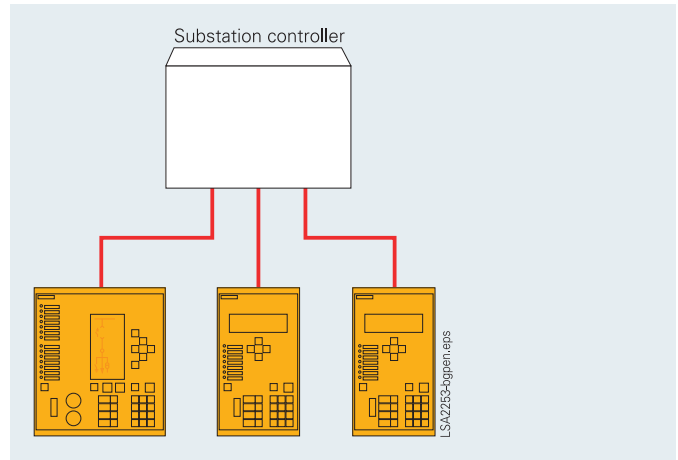


Fig. 11/10 IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

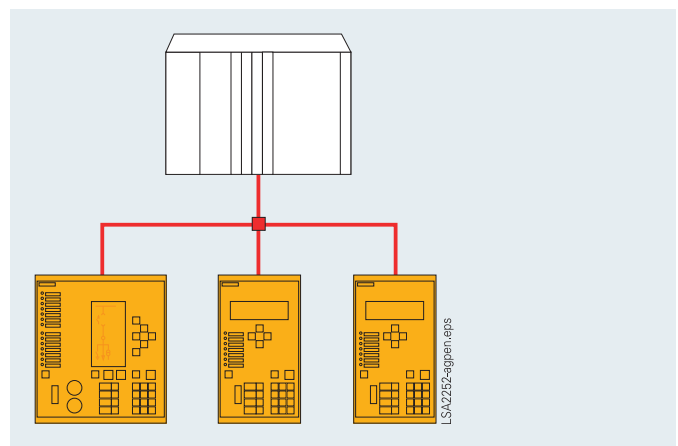


Fig. 11/11 PROFIBUS: RS485 copper conductors

MODBUS RTU

MODBUS is also a widely utilized communication standard and is used in numerous automation solutions.

DNP 3.0

DNP 3.0 (Distributed Network Protocol version 3) is a messaging-based communication protocol. The SIPROTEC 4 units are fully Level 1 and Level 2 compliant with DNP 3.0. DNP 3.0 is supported by a number of protection device manufacturers.

Safe bus architecture

- RS485 bus
With this data transmission via copper conductors, electromagnetic interference influences are largely eliminated by the use of twisted-pair conductor. Upon failure of a unit, the remaining system continues to operate without any faults.
- Fiber-optic double ring circuit
The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without disturbance.

Generator Protection/7UM61

Communication

System solution

SIPROTEC 4 is tailor-made for use in SIMATIC-based automation systems.

Via the PROFIBUS-DP, indications (pickup and tripping) and all relevant operational measured values are transmitted from the protection unit.

Via modem and service interface, the protection engineer has access to the protection devices at all times. This permits remote maintenance and diagnosis.

Parallel to this, local communication is possible, for example, during a major inspection.

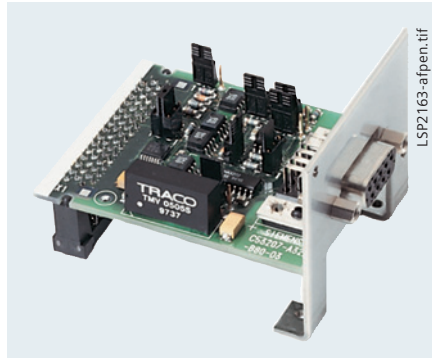


Fig. 11/12 RS232/RS485
Electrical communication module

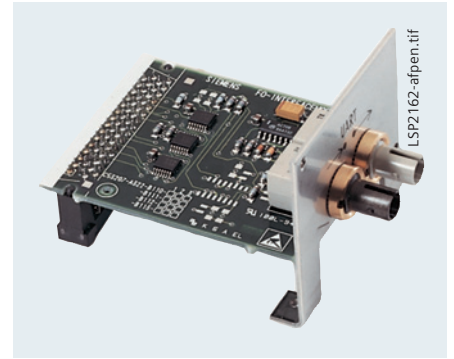


Fig. 11/13 820 nm fiber-optic communication module

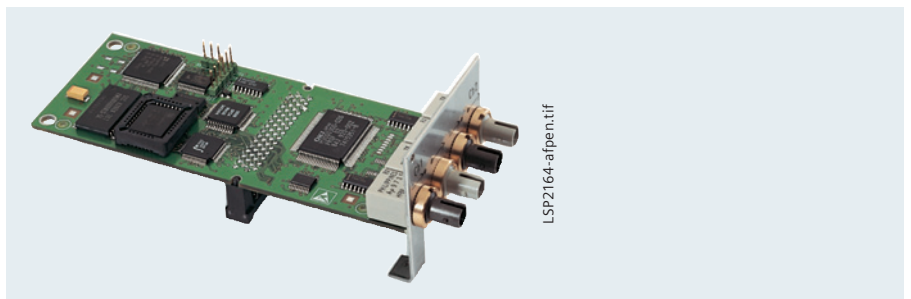


Fig. 11/14 PROFIBUS communication module, optical, double-ring

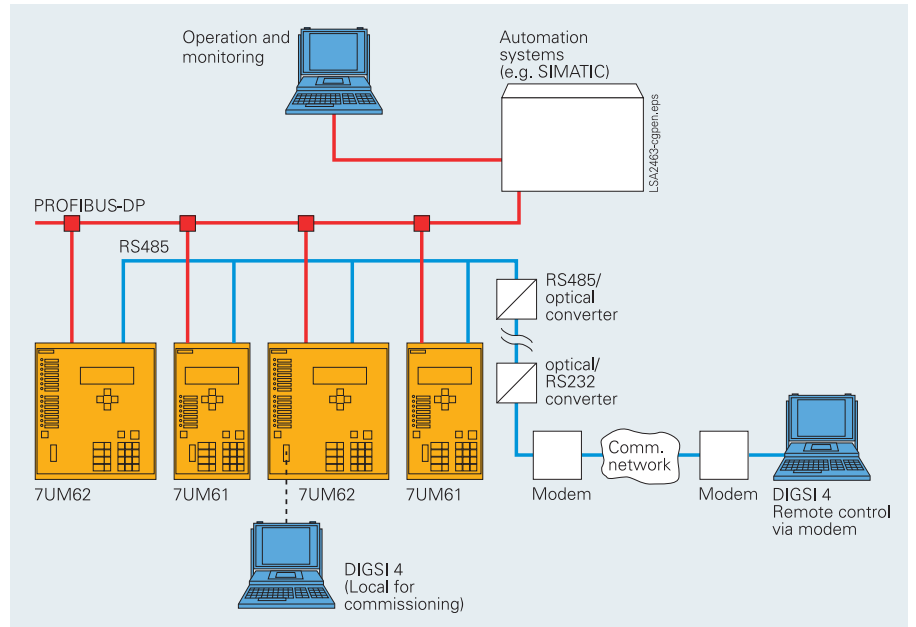


Fig. 11/15 System solution: Communication

Typical connections

Direct generator – busbar connection

Fig. 11/16 illustrates the recommended standard connection if several generators supply one busbar. Phase-to-ground faults are disconnected by employing the directional ground-fault criterion. The ground-fault current is driven through the cables of the system. If this is not sufficient, a grounding transformer connected to the busbar supplies the necessary current (maximum approximately 10 A) and permits a protection range of up to 90 %. The ground-fault current should be detected by means of core-balance current transformers in order to achieve the necessary sensitivity. The displacement voltage can be used as ground-fault criterion during starting operations until synchronization is achieved.

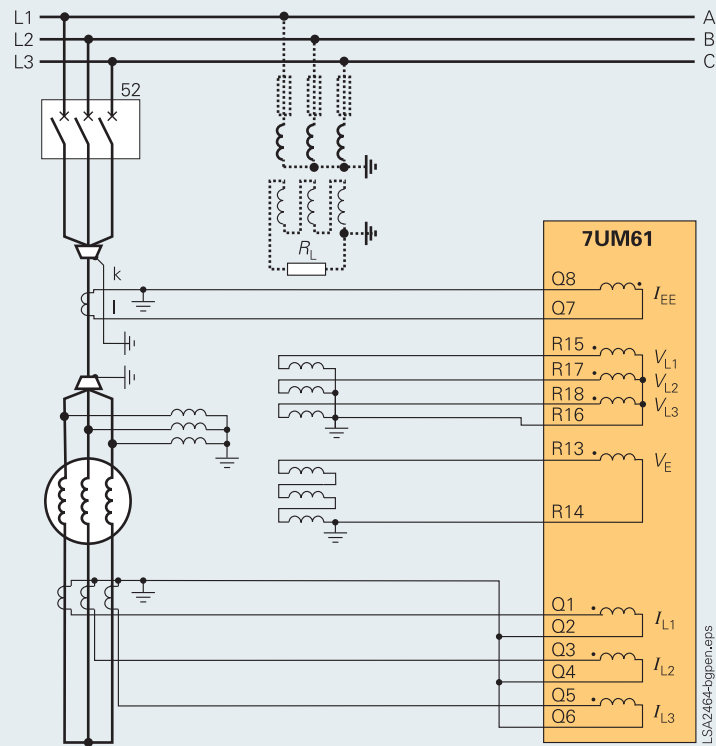


Fig. 11/16

Direct generator – busbar connection with low-resistance grounding

If the generator neutral point has low-resistance grounding, the connection illustrated in Fig. 11/17 is recommended. In the case of several generators, the resistance must be connected to only one generator, in order to prevent circulating currents (3rd harmonic).

For selective ground-fault detection, the ground-current input should be looped into the common return conductor of the two current transformer sets (differential connection). The current transformers must be grounded at only one point. The displacement voltage V_E is utilized as an additional enabling criterion.

Balanced current transformers are desirable with this form of connection. In the case of higher generator power (for example, I_N approximately 2000 A), current transformers with a secondary rated current of 5 A are recommended.

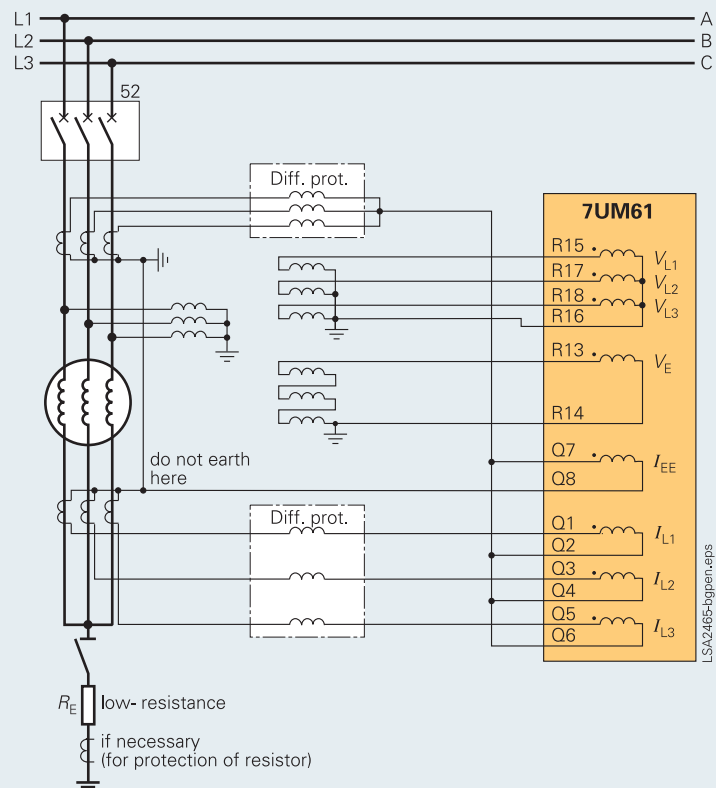


Fig. 11/17

Generator Protection/7UM61

Typical connections

Direct generator – busbar connection with high-resistance generator neutral grounding

With this system configuration, selective ground-fault detection is implemented on the basis of the lower fault currents through the differential connection of core-balance current transformers (see Figure 11/18). Secondary-side grounding must be effected at only one core-balance current transformer. The displacement voltage is to be utilized additionally as enable criterion.

The load resistor takes the form either of primary or of secondary resistor with neutral transformer. In the case of several generators connected to the busbar, again only one generator will be grounded via the resistor.

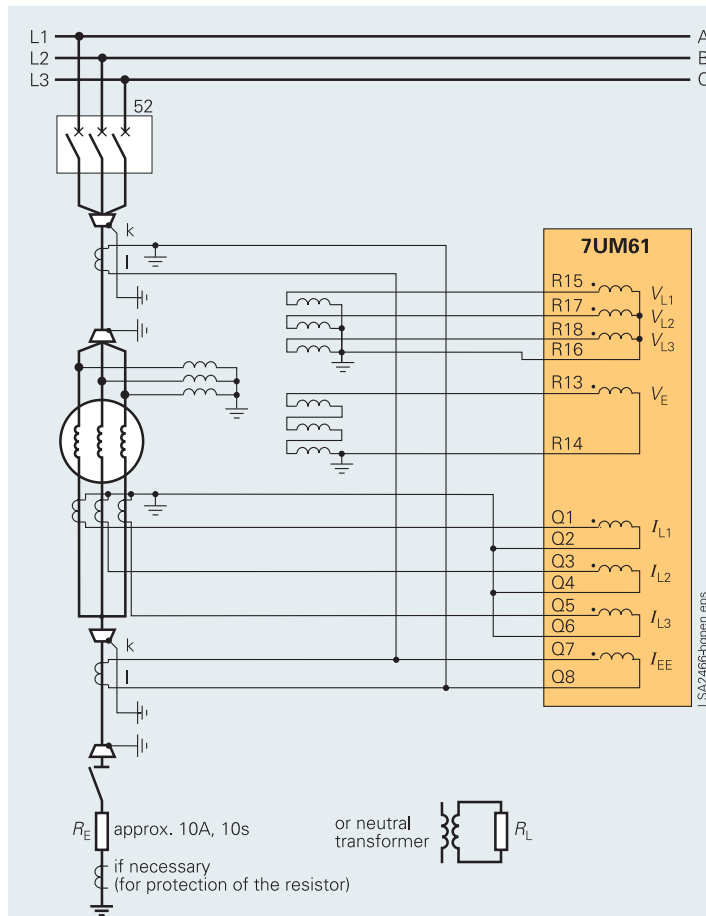


Fig. 11/18

Unit connection with isolated star point

This configuration of unit connection is a variant to be recommended (see Figure 11/19). Ground-fault detection is effected by means of the displacement voltage. In order to prevent unwanted operation in the event of ground faults in the system, a load resistor must be provided at the broken delta winding. Depending on the plant (or substation), a voltage transformer with a high power (VA) may in fact be sufficient. If not, an grounding transformer should be employed. The available measuring winding can be used for the purpose of voltage measurement.

Rotor ground-fault protection can be implemented with the unassigned ground-fault current input. The 7XR61 coupling unit must be used for this purpose.

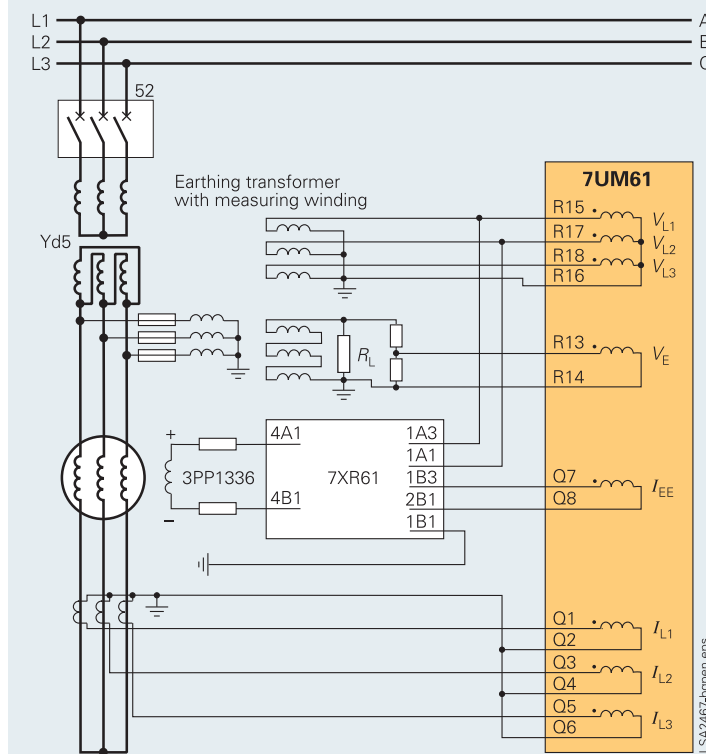


Fig. 11/19

11

Unit connection with neutral transformer

With this system configuration, disturbance voltage reduction and damping in the event of ground faults in the generator area are effected by a load resistor connected to generator neutral point. The maximum ground-fault current is limited to approximately 10 A. Configuration can take the form of a primary or secondary resistor with neutral transformer. In order to avoid low secondary resistance, the transformation ratio of the neutral transformer should be low. The higher secondary voltage can be reduced by means of a voltage divider.

Electrically, the circuit is identical to the configuration in Figure 11/19.

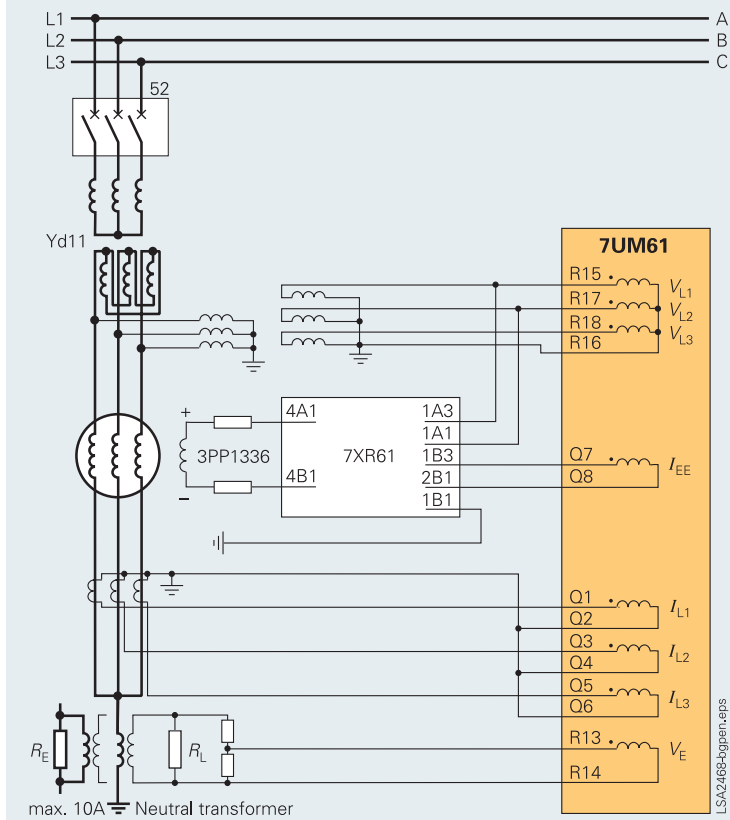


Fig. 11/20

Connection with low-voltage generators

As is generally known, the low-voltage system is solidly grounded, so that the generator neutral point is connected to ground (see Figure 11/21). With this configuration, there is the risk that, as a result of the 3rd harmonics forming a zero phase-sequence system, circulating currents will flow via the N-conductor. This must be limited by the generator or system configuration (reactor).

Otherwise, connection corresponds to the customary standard. In the case of residual current transformer design, it has to be ensured that the thermal current limit (1 s) of the I_{EE} input is restricted to 300 A.

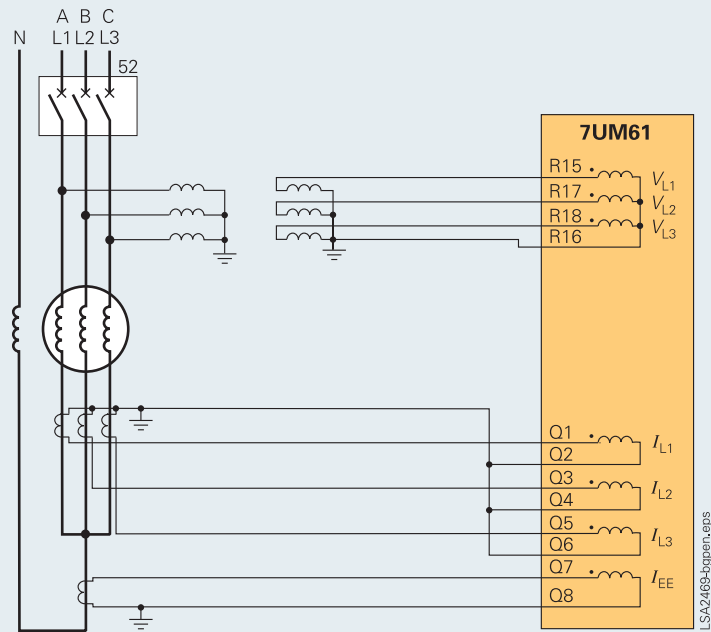


Fig. 11/21

Generator Protection/7UM61

Typical connections

Connection of an asynchronous motor

The figure shows the standard connection of motors of medium capacity (500 kW to <(1-2) MW). In addition to the short-circuit protection, an ground-fault protection (V_E ; I_E inputs) is available.

As the busbar voltage is being monitored, starting of the motor is prevented if the voltage is too low or – in case of failure of infeed – the motor circuit-breaker is opened. Here, the wide range of frequency is advantageous. For the detection of temperatures, 2 thermo-boxes (temperature monitoring boxes) can be connected via a serial interface.

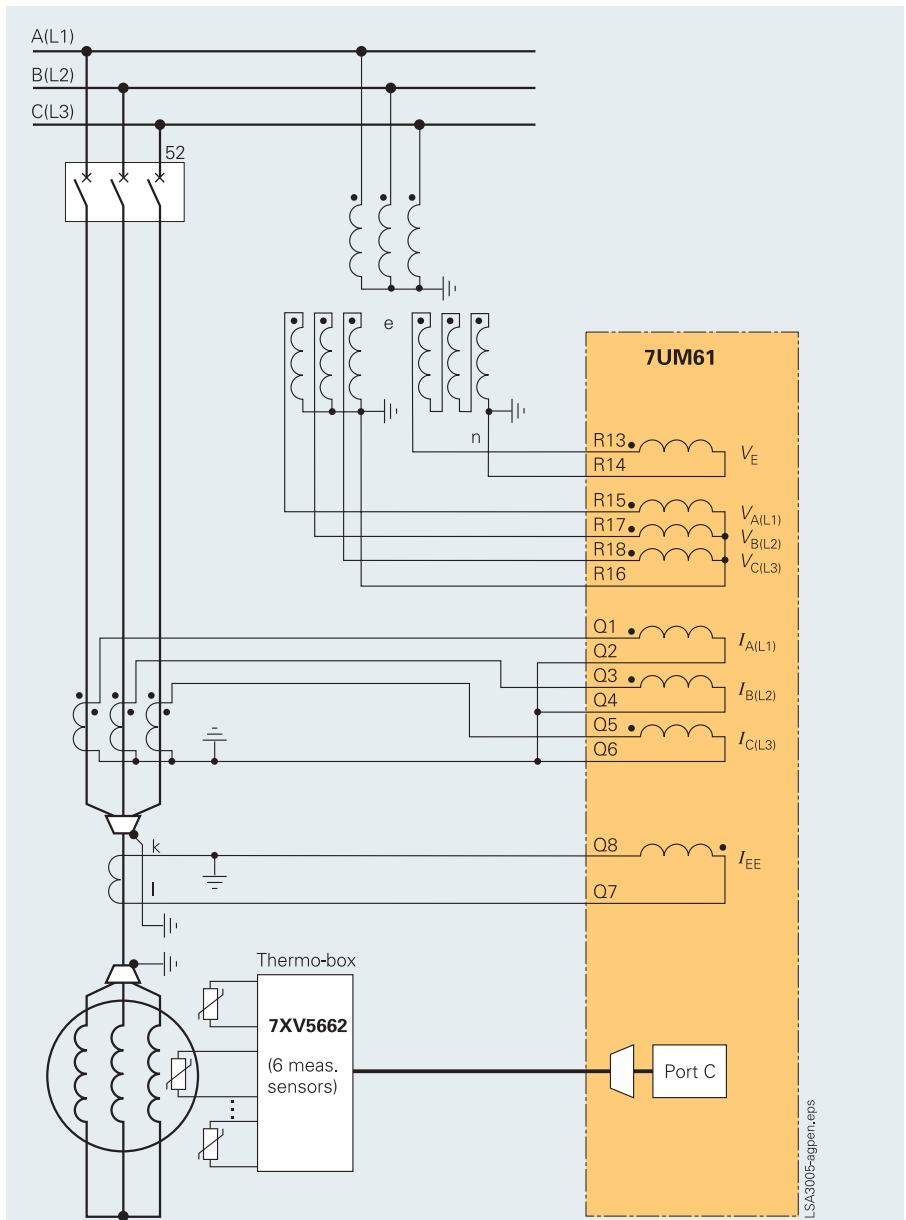


Fig. 11/22

LSA3005-egpen.eps

Voltage transformer in open delta connection (V-connection)

Protection can also be implemented on voltage transformers in open delta connection. Figure 11/23 shows the connection involved. If necessary, the operational measured values for the phase-to-ground voltages can be slightly asymmetrical. If this is disturbing, the neutral point (R16) can be connected to ground via a capacitor.

In the case of open delta connection, it is not possible to calculate the displacement voltage from the secondary voltages. It must be passed to the protection relay along a different path (for example, voltage transformer at the generator neutral point or from the grounding transformer).

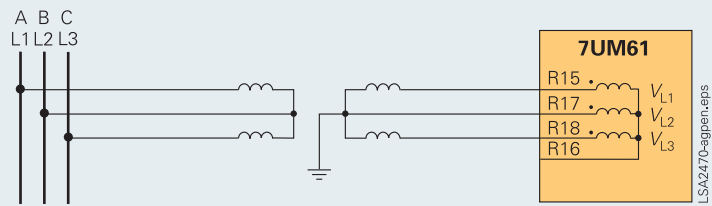


Fig. 11/23

Connection with two current transformers

This configuration is to be found in older systems with insulated or high-resistance star point. This connection is illustrated in Fig. 11/24. In the protection unit, the secondary currents are represented correctly and, in addition, the positive and the negative-sequence system are correctly calculated. Limits of application occur in the case of low-resistance and solid grounding.

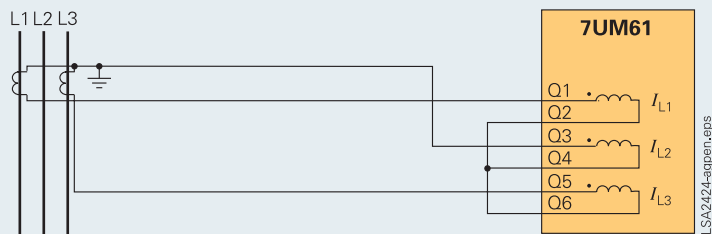


Fig. 11/24

Generator Protection/7UM61

Technical data

Hardware		Output relays	
Analog inputs		LEDs	
Rated frequency	50 or 60 Hz	Number	
Rated current I_N	1 or 5 A	7UM611	12 (1 NO, 1 optional as NC, via jumper)
Ground current, sensitive $I_{E_{max}}$	1.6 A	7UM612	20 (1 NO, 2 optional as NC, via jumper)
Rated voltage V_N	100 to 125 V	Switching capacity	
Power consumption		Make	1000 W/VA
With $I_N = 1$ A	Approx. 0.05 VA	Break	30 VA
With $I_N = 5$ A	Approx. 0.3 VA	Break (for resistive load)	40 W
For sensitive ground current	Approx. 0.05 VA	Break (for L/R \leq 50 ms)	25 VA
Voltage inputs (with 100 V)	Approx. 0.3 VA	Switching voltage	250 V
Capability in CT circuits		Permissible current	5 A continuous 30 A for 0.5 seconds
Thermal (r.m.s. values)	100 I_N for 1 s 30 I_N for 10 s 4 I_N continuous 250 I_N (one half cycle)		
Dynamic (peak)	300 A for 1 s 100 A for 10 s 15 A continuous 750 A (one half cycle)		
Ground current, sensitive			
Dynamic (peak)	750 A (one half cycle)		
Capability in voltage paths	230 V continuous		
Auxiliary voltage		Unit design	
Rated auxiliary voltage	DC 24 to 48 V DC 60 to 125 V DC 110 to 250 V and AC 115 V/230 V with 50/60 Hz	7XP20 housing	For dimensions see dimension drawings, part 14
Permitted tolerance	-20 to +20 %	Degree of protection acc. to EN 60529	
Superimposed (peak-to-peak)	\leq 15 %	For surface-mounting housing	IP 51
Power consumption		For flush-mounting housing	
During normal operation		Front	IP 51
7UM611	Approx. 4 W	Rear	IP 50
7UM612	Approx. 4.5 W	For the terminals	IP 2x with terminal cover put on
During pickup with all inputs and outputs activated		Weight	
7UM611	Approx. 9.5 W	Flush-mounting housing	
7UM612	Approx. 12.5 W	7UM611 (1/3 x 19")	Approx. 5.5 kg
Bridging time during auxiliary voltage failure		7UM612 (1/2 x 19")	Approx. 7 kg
at $V_{aux} = 48$ V and $V_{aux} \geq 110$ V	\geq 50 ms	Surface-mounting housing	
at $V_{aux} = 24$ V and $V_{aux} = 60$ V	\geq 20 ms	7UM611 (1/3 x 19")	Approx. 7.5 kg
		7UM612 (1/2 x 19")	Approx. 12 kg
Binary inputs			
Number			
7UM611	7		
7UM612	15		
3 pickup thresholds	DC 10 to 19 V or DC 44 to 88 V		
Range is selectable with jumpers	88 to 176 V DC ¹⁾		
Maximum permissible voltage	DC 300 V		
Current consumption, energized	Approx. 1.8 mA		
1) Not valid for the CPU board.			

Serial interfaces		Electrical tests	
<i>Operating interface for DIGSI 4</i>		<i>Specifications</i>	
Connection	Non-isolated, RS232, front panel; 9-pin subminiature connector	Standards	IEC 60255 (product standards) ANSI/IEEE C37.90.01.1/2 UL 508 DIN 57435, part 303 For further standards see below.
Baud rate	4800 to 115200 baud	<i>Insulation tests</i>	
<i>Time synchronization IRIG-B/DCF 77 signal (Format IRIG-B000)</i>		Standards	IEC 60255-5
Connection	9-pin subminiature connector, terminal with surface-mounting housing	Voltage test (100 % test) All circuits except for auxiliary supply, binary inputs communication and time synchronization interfaces	2.5 kV (r.m.s.), 50/60 Hz
Voltage levels	Selectable 5 V or 12 V or 24 V	Voltage test (100 % test) Auxiliary voltage and binary inputs	DC 3.5 kV
<i>Service/modem interface for DIGSI 4/modem/service</i>		Voltage test (100 % test) RS485/RS232 rear side communication interfaces and time synchronization interface	500 V (r.m.s. value), 50/60 Hz
Isolated RS232/RS485	9-pin subminiature connector	Impulse voltage test (type test) All circuits except for communication interfaces and time synchronization interface, class III	5 kV (peak); 1.2/50 µs; 0.5 J; 3 positive and 3 negative impulses at intervals of 5 s
Test voltage	500 V / 50 Hz	<i>EMC tests for noise immunity; type test</i>	
Distance for RS232	Max. 15 m	Standards	IEC 60255-6, IEC 60255-22 (product standards) EN 50082-2 (generic standard) DIN 57435 part 303
Distance for RS485	Max. 1000 m	High frequency test IEC 60255-22-1, class III and VDE 0435 part 303, class III	2.5 kV (peak value), 1 MHz; τ = 15 ms, 400 pulses per s; duration 2 s
Fiber-optic cable	Integrated ST-connector	Electrostatic discharge IEC 60255-22-2, class IV EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; R _i = 330 Ω
Optical wavelength	λ = 820 nm	Irradiation with RF field, non-modulated IEC 60255-22-3 (report), class III	10 V/m; 27 to 500 MHz
Permissible path attenuation	Max. 8 dB for glass-fiber 62.5/125 µm Max. 1.5 km	Irradiation with RF field, amplitude-modulated IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz
Bridgeable distance		Irradiation with RF field, pulse-modulated, IEC 61000-4-3/ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %
<i>System interface IEC 60870-5-103 protocol, PROFIBUS-DP, MODBUS RTU</i>		Fast transient interference bursts IEC 60255-22-4, IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R _i = 50 Ω; test duration 1 min
Isolated RS232/RS485	9-pin subminiature connector		
Baud rate	4800 to 115200 baud		
Test voltage	500 V / 50 Hz		
Distance for RS232	Max. 15 m		
Distance for RS485	Max. 1000 m		
PROFIBUS RS485			
Test voltage	500 V / 50 Hz		
Baud rate	Max. 12 Mbaud		
Distance	1000 m at 93.75 kBaud; 100 m at 12 Mbaud		
PROFIBUS fiber-optic			
Only for flush-mounting housing	ST connector		
For surface-mounting housing	Optical interface with OLM ¹⁾		
Baud rate	Max. 1.5 Mbaud		
Optical wavelength	λ = 820 nm		
Permissible path attenuation	Max. 8 dB for glass-fiber 62.5/125 µm 1.6 km (500 kB/s) 530 m (1500 kB/s)		
Distance			

1) Conversion with external OLM
For fiber-optic interface please complete order number at 11th position with **4** (FMS RS485) or **9** and Order code **LOA** (DP RS485) and additionally order:
For single ring: SIEMENS OLM 6GK1502-3AB10
For double ring: SIEMENS OLM 6GK1502-4AB10

Generator Protection/7UM61

Technical data

EMC tests for noise immunity; type tests		Mechanical stress tests	
High-energy surge voltages (SURGE), IEC 61000-4-5 Installation, class III Auxiliary supply		Impulse: 1.2/50 µs	
Measurement inputs, binary inputs and relay outputs		Common (longitudinal) mode: 2 kV; 12 Ω, 9 µF Differential (transversal) mode: 1 kV; 2 Ω, 18 µF	
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III		Common (longitudinal) mode: 2 kV; 42 Ω, 0.5 µF Differential (transversal) mode: 1 kV; 42 Ω, 0.5 µF	
Magnetic field with power frequency IEC 61000-4-8, class IV; IEC 60255-6		10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz	
Oscillatory surge withstand capability ANSI/IEEE C37.90.1		30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz	
Fast transient surge withstand capability ANSI/IEEE C37.90.1		2.5 to 3 kV (peak); 1 to 1.5 MHz damped wave; 50 surges per second; Duration 2 s; $R_i = 150$ to 200 Ω	
Radiated electromagnetic interference ANSI/IEEE C37.90.2		4 to 5 kV; 10/150 ns; 50 surges per second; both polarities; Duration 2 s ; $R_i = 80$ Ω	
Damped oscillations IEC 60894, IEC 61000-4-12		35 V/m; 25 to 1000 MHz	
Standard		EN 50 081-* (technical generic standard)	
Conducted interference voltage on lines only auxiliary supply IEC-CISPR 22		150 kHz to 30 MHz Limit class B	
Interference field strength IEC-CISPR 22		30 to 1000 MHz Limit class B	
		Vibration, shock stress and seismic vibration	
		<u>During operation</u>	
		Standards	IEC 60255-21 and IEC 60068
		Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 g acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
		Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 5 g, duration 11 ms, 3 shocks each in both directions of the 3 axes
		Seismic vibration IEC 60255-21-2, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 g acceleration (horizontal axis) 8 to 35 Hz: 0.5 g acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
		<u>During transport</u>	
		Standards	IEC 60255-21 and IEC 60068-2
		Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ±7.5 mm amplitude; 8 to 150 Hz: 2 g acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
		Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 15 g, duration 11 ms, 3 shocks each in both directions 3 axes
		Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Half-sinusoidal Acceleration 10 g, duration 16 ms, 1000 shocks in both directions of the 3 axes

Climatic stress tests	
<i>Temperatures</i>	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C / -13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	-20 °C to +70 °C / -4 °F to +158 °F
Recommended permanent operating temperature acc. to IEC 60255-6	-5 °C to +55 °C / +25 °F to +131 °F
- Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to +131 °F
- Limiting temperature during transport	-25 °C to +70 °C / -13 °F to +158 °F
<i>Humidity</i>	
Permissible humidity stress It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation	Annual average $\leq 75\%$ relative humidity; on 56 days a year up to 93 % relative humidity; condensation is not permitted

Functions	
<i>General</i>	
Frequency range	11 to 69 Hz
<i>Definite-time overcurrent protection, directional (ANSI 50, 51, 67)</i>	
<i>Setting ranges</i>	
Overcurrent $I>$, $I>>$	0.1 to 8 A (steps 0.01 A); 5 times at $I_N = 5$ A
Time delay T	0 to 60 s (steps 0.01 s) or indefinite
Undervoltage seal-in $V<$	10 to 125 V (steps 0.1 V)
Seal-in time of $V<$	0.1 to 60 s (steps 0.01 s)
Angle of the directional element (at $I>$)	-90 ° to +90 ° (steps 1 °)
<i>Times</i>	
Pickup time $I>$, $I>>$	
At 2 times of set value	Approx. 35 ms
At 10 times of set value	Approx. 25 ms
Drop-off time $I>$, $I>>$	Approx. 50 ms
Drop-off ratio	$I>$: 0.95; $I>>$: 0.9 to 0.99 (steps 0.01)
Drop-off ratio $V<$	Approx. 1.05
<i>Tolerances</i>	
Current pickup (starting) $I>$, $I>>$	1 % of set value or 10/50 mA
Undervoltage seal-in $V<$	1 % of set value or 0.5 V
Angle of the directional element	1 °
Time delays	1 % or 10 ms

Inverse-time overcurrent protection (ANSI 51V)	
<i>Setting ranges</i>	
Pickup overcurrent I_P	0.1 to 4 A (steps 0.01 A); 5 times at $I_N = 5$ A
Time multiplier IEC-characteristics T	0.05 to 3.2 s (steps 0.01 s) or indefinite
Time multiplier ANSI-characteristics D	0.5 to 15 (steps 0.01) or indefinite
Undervoltage release $V<$	10 to 125 V (steps 0.1 V)
<i>Trip characteristics</i>	
IEC	Normal inverse; very inverse; extremely inverse
ANSI	Inverse; moderately inverse; very inverse; extremely inverse; definite inverse
Pickup threshold	Approx. 1.1 I_P
Drop-off threshold	Approx. 1.05 I_P for $I_P/I_N \geq 0.3$
<i>Tolerances</i>	
Pickup threshold I_P	1 % of set value 10/50 mA
Pickup threshold $V<$	1 % of set value or 0.5 V
Time for $2 \leq III_P \leq 20$	5 % of nominal value + 1 % current tolerance or 40 ms

Stator overload protection, thermal (ANSI 49)	
<i>Setting ranges</i>	
Factor k according to IEC 60255-8	0.5 to 2.5 (steps 0.01)
Time constant	30 to 32000 s (steps 1 s)
Time delay factor at standstill	1 to 10 (steps 0.01)
Alarm overtemperature $\Theta_{Alarm}/\Theta_{Trip}$	70 to 100 % related to the trip temperature (steps 1 %)
Overcurrent alarm stage I_{Alarm}	0.1 to 4 A (steps 0.01 A); 5 times at $I_N = 5$ A
Temperature at I_N	40 to 200 °C (steps 1 °C) or 104 to 392 °F (steps 1 °F)
Scaling temperature of cooling medium	40 to 300 °C (steps 1 °C) or 104 to 572 °F (steps 1 °F)
Reset time at emergency start	20 to 150000 s (steps 1 s)
<i>Drop-off ratio</i>	
Θ/Θ_{Trip}	Drop-off with Θ_{Alarm}
Θ/Θ_{Alarm}	Approx. 0.99
III_{Alarm}	Approx. 0.95
<i>Tolerances</i>	
Regarding $k \times I_P$	2 % or 10/50 mA; class 2 % according to IEC 60255-8
Regarding trip time	3 % or 1 s; class 3 % according to IEC 60255-8 for $II(k I_N) > 1.25$

Generator Protection/7UM61

Technical data

Negative-sequence protection (ANSI 46)	
Setting ranges	
Permissible negative sequence I_2 perm. $/I_N$	3 to 30 % (steps 1 %)
Definite time trip stage $I_2 \gg /I_N$	10 to 100 % (steps 1 %)
Time delays $T_{Alarm}; T_{I_2 \gg}$	0 to 60 s (steps 0.01 s) or indefinite
Negative-sequence factor k	2 to 40 s (steps 0.1 s)
Cooling down time $T_{Cooling}$	0 to 50000 s (steps 1 s)
Times	
Pickup time (definite stage)	Approx. 50 ms
Drop-off time (definite stage)	Approx. 50 ms
Drop-off ratios I_2 perm.; $I_2 \gg$	Approx. 0.95
Drop-off ratio thermal stage	Drop-off at fall below of I_2 perm.
Tolerances	
Pickup values I_2 perm.; $I_2 \gg$	3 % of set value or 0.3 % negative sequence
Time delays	1 % or 10 ms
Thermal characteristic	5 % of nominal value +1 % current tolerance or 600 ms
Time for $2 \leq I_2 / I_2$ perm. ≤ 20	
Underexcitation protection (ANSI 40)	
Setting ranges	
Conductance thresholds 1/xd characteristic (3 characteristics)	0.25 to 3.0 (steps 0.01)
Inclination angle $\alpha_1, \alpha_2, \alpha_3$	50 to 120 ° (steps 1 °)
Time delay T	0 to 50 s (steps 0.01 s) or indefinite
Times	
Stator criterion 1/xd characteristic; α	Approx. 60 ms
Undervoltage blocking	Approx. 50 ms
Drop-off ratio	
Stator criterion 1/xd characteristic; α	Approx. 0.95
Undervoltage blocking	Approx. 1.1
Tolerances	
Stator criterion 1/xd characteristic	3 % of set value
Stator criterion α	1 ° electrical
Undervoltage blocking	1 % or 0.5 V
Time delays T	1 % or 10 ms
Reverse-power protection (ANSI 32R)	
Setting ranges	
Reverse power $P_{Rev.} > /S_N$	-0.5 to -30 % (steps 0.01 %)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off time	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off ratio $P_{Rev.} >$	Approx. 0.6
Tolerances	
Reverse power $P_{Rev.} >$	0.25 % $S_N \pm 3$ % set value
Time delays T	1 % or 10 ms
Forward-power protection (ANSI 32F)	
Setting ranges	
Forward power $P_{Forw.} < /S_N$	0.5 to 120 % (steps 0.1 %)
Forward power $P_{Forw.} > /S_N$	1 to 120 % (steps 0.1 %)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time (accurate measuring)	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Pickup time (fast measuring)	Approx. 60 ms (50 Hz); Approx. 50 ms (60 Hz)
Drop-off time (accurate measuring)	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off time (fast measuring)	Approx. 60 ms (50 Hz); Approx. 50 ms (60 Hz)
Drop-off ratio $P_{Forw.} <$	1.1 or 0.5 % of S_N
Drop-off ratio $P_{Forw.} >$	Approx. 0.9 or -0.5 % of S_N
Tolerances	
Active power $P_{Forw.} <, P_{Forw.} >$	0.25 % $S_N \pm 3$ % of set value at $Q < 0.5 S_N$ at accurate measuring 0.5 % $S_N \pm 3$ % of set value at $Q < 0.5 S_N$ at fast measuring
Time delays T	1 % or 10 ms
Impedance protection (ANSI 21)	
Setting ranges	
Overcurrent pickup $I >$	0.1 to 4 A (steps 0.01 A); 5 times at $I_N = 5A$
Undervoltage seal-in $V <$	10 to 125 V (steps 0.1V)
Impedance Z1 (related to $I_N = 1 A$)	0.05 to 130 Ω (steps 0.01 Ω)
Impedance Z1B (related to $I_N = 1 A$)	0.05 to 65 Ω (steps 0.01 Ω)
Impedance Z2 (related to $I_N = 1 A$)	0.05 to 65 Ω (steps 0.01 Ω)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Shortest tripping time	Approx. 40 ms
Drop-off time	Approx. 50 ms
Drop-off ratio	
Overcurrent pickup $I >$	Approx. 0.95
Undervoltage seal-in $V <$	Approx. 1.05
Tolerances	
Overcurrent pickup $I >$	1 % of set value. 10/50 mA
Undervoltage seal-in $V <$	1 % of set value. or 0.5 V
Impedance measuring Z1, Z2	$ \Delta Z/Z \leq 5$ % for $30^\circ \leq \varphi_K \leq 90^\circ$
Time delays T	1 % or 10 ms
Undervoltage protection (ANSI 27)	
Setting range	
Undervoltage pickup $V <, V <<$ (positive sequence as phase-to-phase values)	10 to 125 V (steps 0.1 V)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time $V <, V <<$	Approx. 50 ms
Drop-off time $V <, V <<$	Approx. 50 ms
Drop-off ratio $V <, V <<$	1.01 to 1.1 (steps 0.01)
Tolerances	
Voltage limit values	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms

Overvoltage protection (ANSI 59)	
Setting ranges	
Overvoltage pickup $V_{>}$, $V_{>>}$ (maximum phase-to-phase voltage or phase-to-ground-voltage)	30 to 170 V (steps 0.1 V)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Time	
Pickup times $V_{>}$, $V_{>>}$	Approx. 50 ms
Drop-off times $V_{>}$, $V_{>>}$	Approx. 50 ms
Drop-off ratio $V_{>}$, $V_{>>}$	0.9 to 0.99 (steps 0.01)
Tolerances	
Voltage limit value	1 % of set value 0.5 V
Time delays T	1 % or 10 ms
Frequency protection (ANSI 81)	
Setting ranges	
Steps; selectable $f_{>}$, $f_{<}$	4
Pickup values $f_{>}$, $f_{<}$	40 to 65 Hz (steps 0.01 Hz)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Undervoltage blocking $V_{1<}$	10 to 125 V (steps 0.1 V)
Times	
Pickup times $f_{>}$, $f_{<}$	Approx. 100 ms
Drop-off times $f_{>}$, $f_{<}$	Approx. 100 ms
Drop-off difference Δf	Approx. 20 mHz
Drop-off ratio $V_{1<}$	Approx. 1.05
Tolerances	
Frequency	10 mHz (at $V_{>} > 0.5 V_N$)
Undervoltage blocking	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms
Overexcitation protection (Volt/Hertz) (ANSI 24)	
Setting ranges	
Pickup threshold alarm stage	1 to 1.2 (steps 0.01)
Pickup threshold $V/f_{>>}$ -stage	1 to 1.4 (steps 0.01)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Characteristic values of V/f and assigned times $t(V/f)$	1.1/1.15/1.2/1.25/1.3/1.35/1.4
Cooling down time $T_{cooling}$	0 to 20000 s (steps 1 s)
Times (Alarm and $V/f_{>>}$ -stage)	
Pickup times at 1.1 of set value	Approx. 60 ms
Drop-off times	Approx. 60 ms
Drop-off ratio (alarm, trip)	0.95
Tolerances	
V/f -pickup	3 % of set value
Time delays T	1 % or 10 ms
Thermal characteristic (time)	5 % rated to V/f or 600 ms
90 % stator ground-fault protection, non-directional, directional (ANSI 59N, 64G, 67G)	
Setting ranges	
Displacement voltage $V_0 >$	5 to 125 V (steps 0.1 V)
Ground current $3I_0 >$	2 to 1000 mA (steps 1 mA)
Angle of direction element	0 to 360 ° (steps 1 °)
Time delays T	0 to 60 s (steps 0,01 s) or indefinite
Times	
Pickup times $V_0 >$, $3I_0 >$	Approx. 50 ms
Drop-off times $V_0 >$ / $3I_0 >$	Approx. 50 ms
Drop-off ratio $V_0 >$, $3I_0 >$	0.7
Drop-off difference angle	10 ° directed to power system
Tolerances	
Displacement voltage	1 % of set value or 0.5 V
Ground current	1 % of set value or 0.5 mA
Time delays T	1 % or 10 ms
Sensitive ground-fault protection (ANSI 50/51GN, 64R)	
Setting ranges	
Ground current pickup $I_{EE >}$, $I_{EE >>}$	2 to 1000 mA (steps 1 mA)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Measuring circuit supervision $I_{EE <}$	1.5 to 50 mA (steps 0.1 mA)
Times	
Pickup times	Approx. 50 ms
Drop-off times	Approx. 50 ms
Measuring circuit supervision	Approx. 50 ms
Drop-off ratio $I_{EE >}$, $I_{EE >>}$	0.95 or 1 mA
Drop-off ratio measuring circuit supervision $I_{EE <}$	Approx. 1.1 or 1 mA
Tolerances	
Ground current pickup	1 % of set value or 0.5 mA
Time delays T	1 % or 10 ms
100 % stator ground-fault protection with 3 rd harmonics (ANSI 59TN, 27TN (3 rd H.))	
Setting ranges	
Displacement voltage V_0 (3 rd harm.) $>$, V_0 (3 rd harm.) $<$	0.2 to 40 V (steps 0.1 V)
Time delay T	0 to 60 s (steps 0.01 s) or indefinite
Active-power release	10 to 100 % (steps 1 %) or indefinite
Positive-sequence voltage release	50 to 125 V (steps 0.1 V) or indefinite
Times	
Pickup time	Approx. 80 ms
Drop-off time	Approx. 80 ms
Drop-off ratio	
Undervoltage stage V_0 (3 rd harm.) $<$	Approx. 1.4
Overvoltage stage V_0 (3 rd harm.) $>$	Approx. 0.6
Active-power release	Approx. 0.9
Positive-sequence voltage release	Approx. 0.95
Tolerances	
Displacement voltage	3 % of set value or 0.1 V
Time delay T	1 % or 10 ms

Generator Protection/7UM61

Technical data

Breaker failure protection (ANSI 50BF)		Restart inhibit for motors (ANSI 66, 49 Rotor)	
Setting ranges		Setting ranges	
Current thresholds $I_{>BF}$	0.04 to 1 A (steps 0.01 A)	Motor starting current $I_{Start\ max} / I_N$	3.0 to 10.0 (steps 0.01)
Time delay BF-T	0.06 to 60 s (steps 0.01 s) or indefinite	Permissible starting time $T_{Start\ max}$	3.0 to 120.0 s (steps 0.1 s)
Time		Rotor temperature equalization time $T_{Equali.}$	0 to 60.0 min (steps 0,1 min)
Pickup time	Approx. 50 ms	Minimum restart inhibit time $T_{Restart, min}$	0.2 to 120.0 min (steps 0.1 min)
Drop-off time	Approx. 50 ms	Permissible number of warm starts n_W	1 to 4
Tolerances		Difference between warm and cold starts $n_K - n_W$	1 to 2
Current threshold $I_{>BF} / I_N$	1 % of set value or 10/50 mA	Extensions of time constants (running and stop)	1.0 to 100.0
Time delay T	1 % or 10 ms	Tolerances	
Inadvertent energizing protection (ANSI 50, 27)		Time delays T	1 % or 0.1 ms
Setting ranges		Rate-of-frequency-change protection (ANSI 81R)	
Current pickup $I_{>>>}$	0.1 to 20 A (steps 0.1 A); 5 times at $I_N = 5$ A	Setting ranges	
Voltage release $V_{1<}$	10 to 125 V (steps 1 V)	Steps, selectable +d/dt >; -d/dt	4
Time delay	0 to 60 s (steps 0.01 s) or indefinite	Pickup value d/dt	0.2 to 10 Hz/s (steps 0.1 Hz/s);
Drop-off time	0 to 60 s (steps 0.01 s) or indefinite	Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times		Undervoltage blocking $V_{1<}$	10 to 125 V (steps 0.1 V)
Reaction time	Approx. 25 ms	Times	
Drop-off time	Approx. 35 ms	Pickup times d/dt	Approx. 200 ms
Drop-off ratio $I_{>>>}$	Approx. 0.8	Drop-off times d/dt	Approx. 200 ms
Drop-off ratio $V_{1<}$	Approx. 1.05	Drop-off ratio d/dt	Approx. 0.95 or 0.1 Hz/s
Tolerances		Drop-off ratio V<	Approx. 1.05
Current pickup	5 % of set value or 20/100 mA	Tolerances	
Undervoltage seal-in $V_{1<}$	1 % of set value or 0.5 V	Rate-of-frequency change	Approx. 0.1 Hz/s at $V > 0.5 V_N$
Time delay T	1 % or 10 ms	Undervoltage blocking	1 % of set value or 0.5 V
External trip coupling		Time delays T	1 % or 10 ms
Number of external trip couplings	2 for 7UM611 4 for 7UM612	Vector jump supervision (voltage)	
Trip circuit supervision (ANSI 74TC)		Setting ranges	
Number of supervised trip circuits (only 7UM612)	1	Stage $\Delta\varphi$	0.5 ° to 15 ° (steps 0.1 °)
Starting time supervision for motors (ANSI 48)		Time delay T	0 to 60 s (steps 0.01 s) or indefinite
Setting ranges		Undervoltage blocking $V_{1<}$	10 to 125 V (steps 0.1 V)
Motor starting current $I_{Start\ max} / I_N$	1.0 to 16 (steps 0.01)	Tolerances	
Starting current pickup $I_{Start, pickup} / I_N$	0.6 to 10 (steps 0.01)	Vector jump	0.3 ° at $V > 0.5 V_N$
Permissible starting time $T_{Start\ max}$	1.0 to 180 s (steps 0.1 s)	Undervoltage blocking	1 % of set value or 0.5 V
Permissible locked rotor time $T_{Blocking}$	0.5 to 120 s (steps 0.1 s) or indefinite	Time delay T	1 % or 10 ms
Times	Depending on the settings	Incoupling of temperature via serial interface (thermo-box) (ANSI 38)	
Drop-off ratio	Approx. 0.95	Number of measuring sensors	6 or 12
Tolerances		Temperature thresholds	40 to 250 °C or 100 to 480 °F (steps 1 °C or 1 °F)
Current threshold	1 % of set value, or 1 % of I_N	Sensor types	Pt100; Ni 100, Ni 120
Time delays T	5 % or 30 ms		

Operational measured values	
Description	Primary; secondary or per unit (%)
Currents	$I_{L1}; I_{L2}; I_{L3}; I_{EE}; I_1; I_2$
Tolerance	0.2 % of measured values or $\pm 10 \text{ mA} \pm 1 \text{ digit}$
Voltages	$V_{L1}; V_{L2}; V_{L3}; V_E; V_{L12}; V_{L23}; V_{L31}; V_1; V_2$
Tolerance	0.2 % of measured values or $\pm 0.2 \text{ V} \pm 1 \text{ digit}$
Impedance	R, X
Tolerance	1 %
Power	$S; P; Q$
Tolerance	1 % of measured values or $\pm 0.25 \% S_N$
Phase angle	φ
Tolerance	$< 0.1^\circ$
Power factor	$\cos \varphi$ (p.f.)
Tolerance	$1 \% \pm 1 \text{ digit}$
Frequency	f
Tolerance	10 mHz at ($V > 0.5 V_N$; 40 Hz $< f < 65 \text{ Hz}$)
Overexcitation	V/f ;
Tolerance	1 %
Thermal measurement	$\Theta_{L1}; \Theta_{L2}, \Theta_{L3}, \Theta_{I2}, \Theta_{V/f}$,
Tolerance	5 %
Min./max. memory	
Memory	Measured values with date and time
Reset manual	Via binary input Via key pad Via communication
Values	
Positive sequence voltage	V_1
Positive sequence current	I_1
Active power	P
Reactive power	Q
Frequency	f
Displacement voltage (3 rd harmonics)	$V_{E(3^{\text{rd}} \text{ harm.})}$
Energy metering	
Meter of 4 quadrants	$W_{P+}; W_{P-}; W_{Q+}; W_{Q-}$
Tolerance	1 %
Fault records	
Number of fault records	Max. 8 fault records
Instantaneous values	Max. 5 s
Storage time	Depending on the actual frequency
Sampling interval	(e. g. 1.25 ms at 50 Hz; 1.04 ms at 60 Hz)
Channels	$V_{L1}, V_{L2}, V_{L3}, V_E; i_{L1}, i_{L2}, i_{L3}, i_{EE}$
R.m.s. values	
Storage period	Max. 80 s
Sampling interval	Fixed (20 ms at 50 Hz; 16.67 ms at 60 Hz)
Channels	$V_1, V_E, I_1, I_2, I_{EE}, P, Q, \varphi, f-f_n$

Additional functions	
Fault event logging	Storage of events of the last 8 faults Puffer length max. 600 indications Time solution 1 ms
Operational indications	Max. 200 indications Time solution 1 ms
Elapsed-hour meter	Up to 6 decimal digits (criterion: current threshold)
Switching statistics	Number of breaker operation Phase-summed tripping current

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EEC previous 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 2006/95/EEC previous 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".

Generator Protection/7UM61

Selection and ordering data

Description	Order No.	Order code
7UM61 multifunction generator and motor protection relay	7UM61	0
Housing, binary inputs and outputs		
Housing 1/3 19", 7 BI, 11 BO, 1 live status contact	1	
Housing 1/2 19", 15 BI, 19 BO, 1 live status contact	2	
Current transformer I_N		
1 A ¹⁾	1	
5 A ¹⁾	5	
Rated auxiliary voltage (power supply, indication voltage)		
DC 24 to 48 V, threshold binary input 19 V ³⁾	2	
DC 60 to 125 V ²⁾ , threshold binary input 19 V ³⁾	4	
DC 110 to 220 V ²⁾ , AC 115 to 230 V, threshold binary input 88 V ³⁾	5	
Unit version		
For panel surface-mounting, 2 tier screw-type terminals top/bottom	B	
For panel flush-mounting, plug-in terminals (2-/3- pin connector)	D	
Flush-mounting housing, screw-type terminal (direct connection, ring-type cable lugs)	E	
Region-specific default setting/function and language settings		
Region DE, 50 Hz, IEC characteristics, language: German, (language can be selected)	A	
Region World, 50/60 Hz, IEC/ANSI characteristics, language: English (UK), (language can be selected)	B	
Region US, 60 Hz, ANSI characteristics, language: English (US), (language can be selected)	C	
System interface (rear of units)		
No system interface	0	
IEC 60870-5-103 protocol, electrical RS232	1	
IEC 60870-5-103 protocol, electrical RS485	2	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	3	
PROFIBUS-DP slave, electrical RS485	9	L O A
PROFIBUS-DP slave, optical 820 nm, double ring, ST connector*	9	L O B
MODBUS, electrical RS485	9	L O D
MODBUS, optical 820 nm, ST connector*	9	L O E
DNP 3.0, electrical RS485	9	L O G
DNP 3.0, optical 820 nm, ST connector*	9	L O H
DIGSI 4/modem interface (rear of unit)		
No interface	0	
DIGSI 4, electrical RS232	1	
DIGSI 4, temperature monitoring box, electrical RS485	2	
DIGSI 4, temperature monitoring box, optical 820 nm, ST connector	3	
Measuring functions		
Without	0	
Min./max. values, energy metering	3	
Functions⁴⁾		
Generator Basic		A
Generator Standard		B
Generator Full		C
Motor, asynchronous		F
Additional functions⁴⁾		
Without A		A
Network decoupling (df/dt and vector jump)		E

- 1) Rated current can be selected by means of jumpers.
- 2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.
- 3) The binary input thresholds can be selected in stages by means of jumpers.




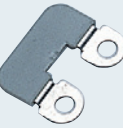

4) For more detailed information on the functions see Table 11/1 on page 11/4.

* Not with position 9 = B; if 9 = "B", please order 7UM61 unit with RS485 port and separate fiber-optic converters.

Accessories	Description	Order No.
	DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper) Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
	Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
	SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000/XP Professional Edition Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	7XS5410-0AA00
	Connecting cable Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	7XV5100-4
	Coupling device for rotor ground-fault protection	7XR6100-0CA00
	Series resistor for rotor ground-fault protection (group: 013002)	Short code 3PP1336-0DZ K2Y
	Resistor for stator ground-fault protection (voltage divider, 5 : 1) (group 013001)	3PP1336-1CZ K2Y
	Temperature monitoring box (thermo-box)	
	AC/DC 24 to 60 V	7XV5662-2AD10
	AC/DC 90 to 240 V	7XV5662-5AD10
	Manual for 7UM61	
	English	C53000-G1176-C127-2

Generator Protection/7UM61

Selection and ordering data

Accessories	Description	Order No.	Size of package	Supplier	Fig.
 <p>Fig. 11/25 Mounting rail for 19" rack</p> <p>LSP2289-afp.eps</p>	Connector	2-pin 3-pin	1 1	Siemens Siemens	11/26 11/27
	 <p>Fig. 11/26 2-pin connector</p> <p>LSP2090-afp.eps</p>	 <p>Fig. 11/27 3-pin connector</p> <p>LSP2091-afp.eps</p>	Crimp connector	CI2 0.5 to 1 mm ² CI2 0.5 to 2.5 mm ² Type III+ 0.75 to 1.5 mm ²	4000 1 4000 1 4000 1
Crimping tool			For type III+ and matching female For CI2 and matching female	1 1	AMP ¹⁾ AMP ¹⁾
 <p>Fig. 11/28 Short-circuit link for current contacts</p> <p>LSP2093-afp.eps</p>	19"-mounting rail	C73165-A63-D200-1	1	Siemens	11/25
 <p>Fig. 11/29 Short-circuit link for voltage contacts/indications contacts</p> <p>LSP2092-afp.eps</p>	Short-circuit links	For current terminals For other terminals	1 1	Siemens Siemens	11/28 11/29
	Safety cover for terminals	large small	C73334-A1-C31-1 C73334-A1-C32-1	1 1	Siemens Siemens

1) Your local Siemens representative can inform you on local suppliers.

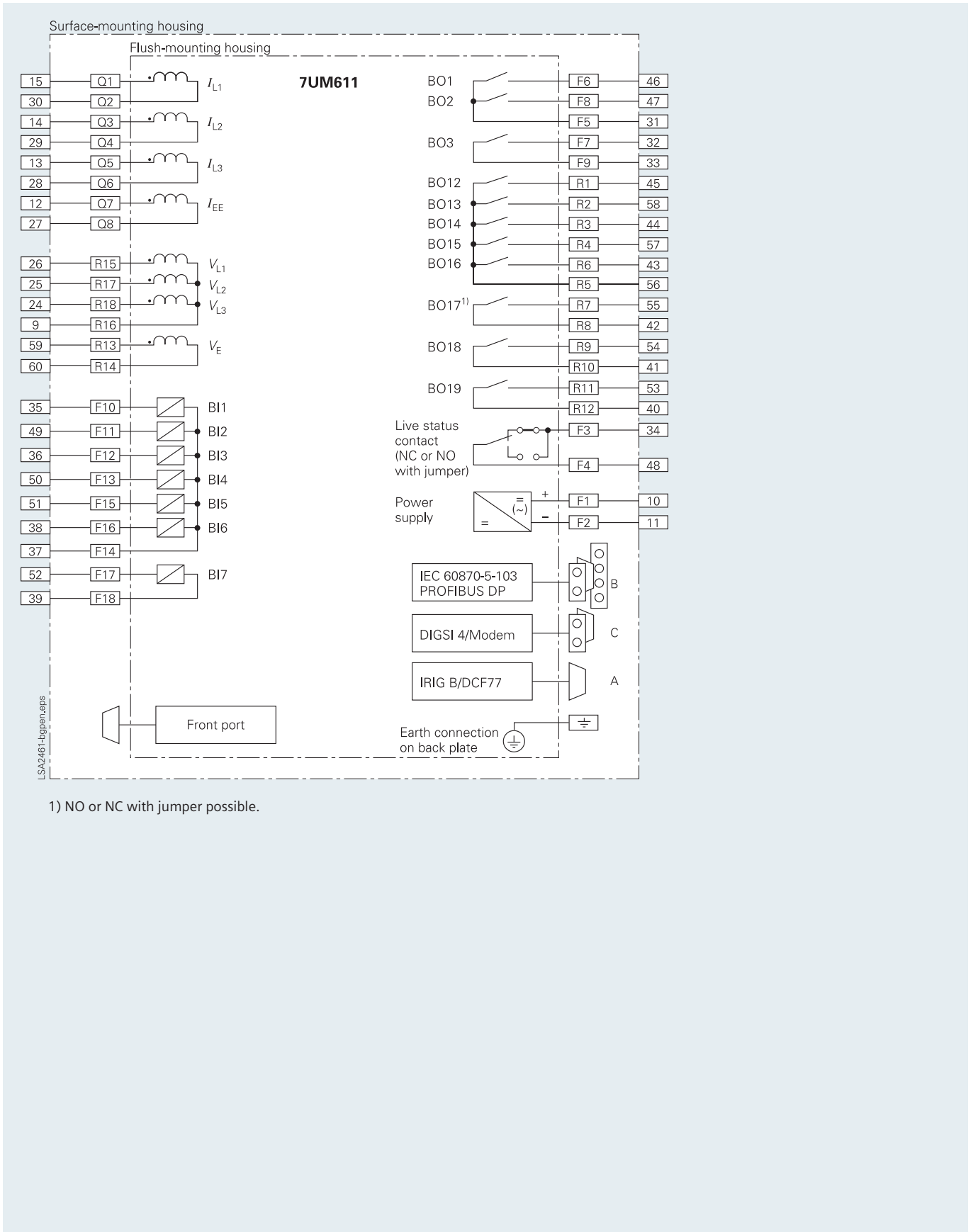


Fig. 11/30 7UM61 connection diagram (IEC standard)

Generator Protection/7UM61

Connection diagram, IEC

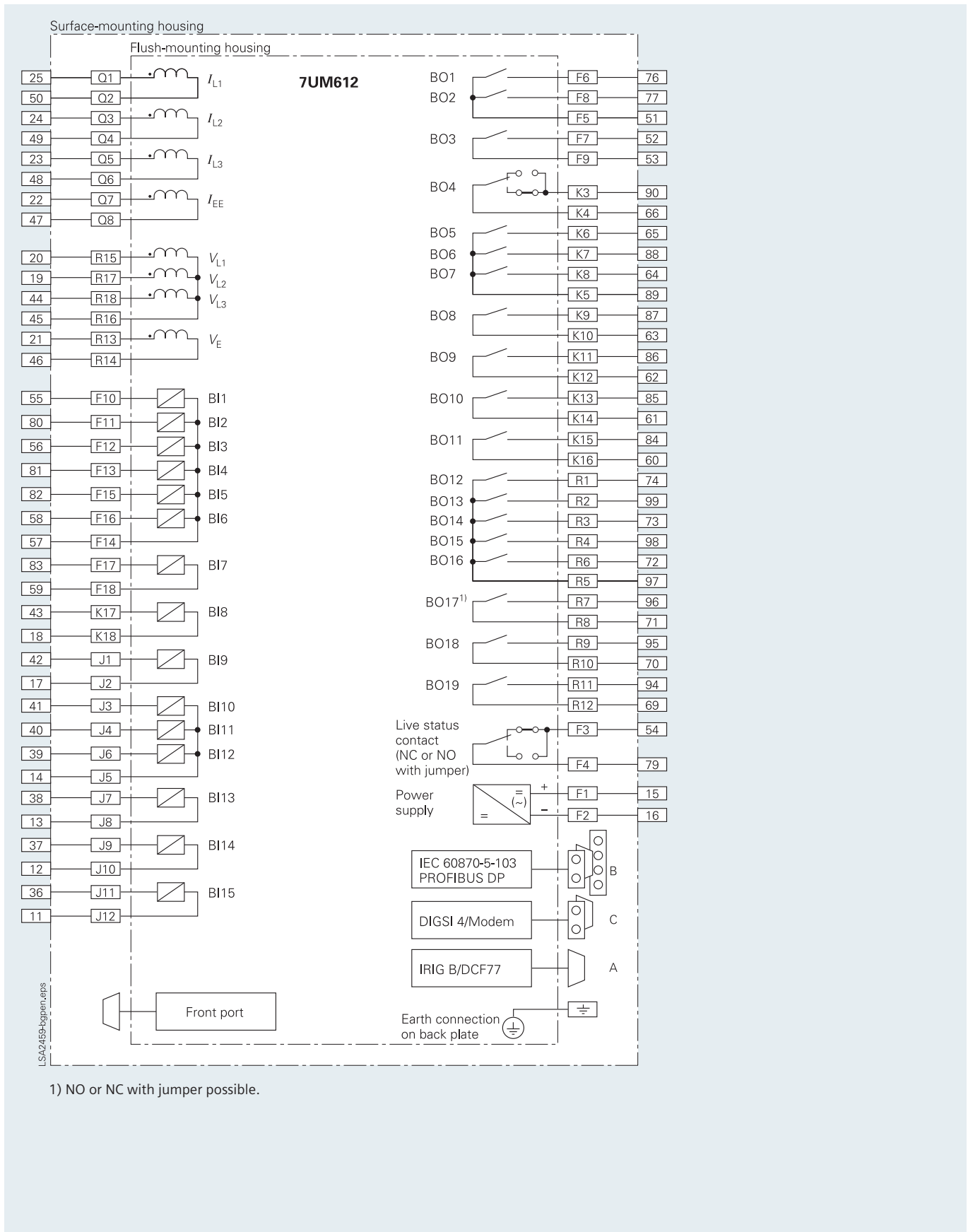
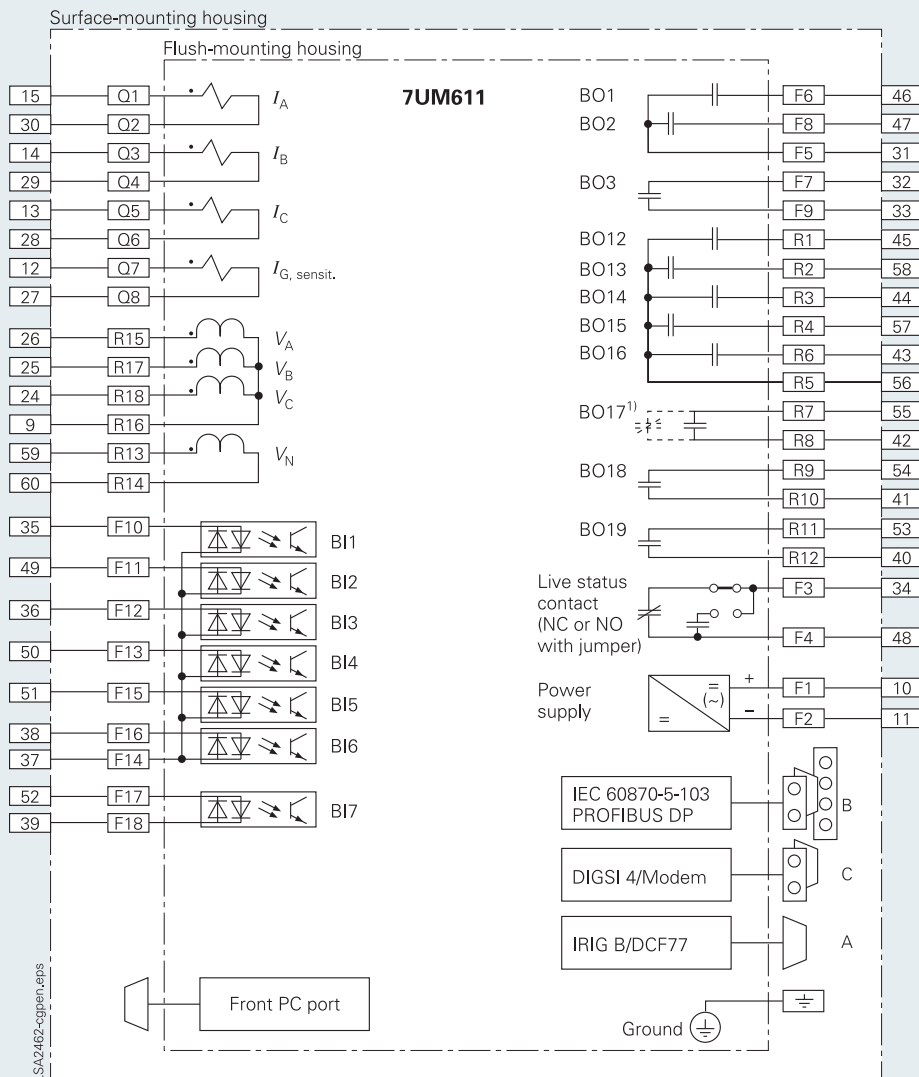


Fig. 11/31 7UM612 connection diagram (IEC standard)



1) NO or NC with jumper possible.

Fig. 11/32 7UM611 connection diagram (ANSI standard)

Generator Protection/7UM61

Connection diagram, ANSI

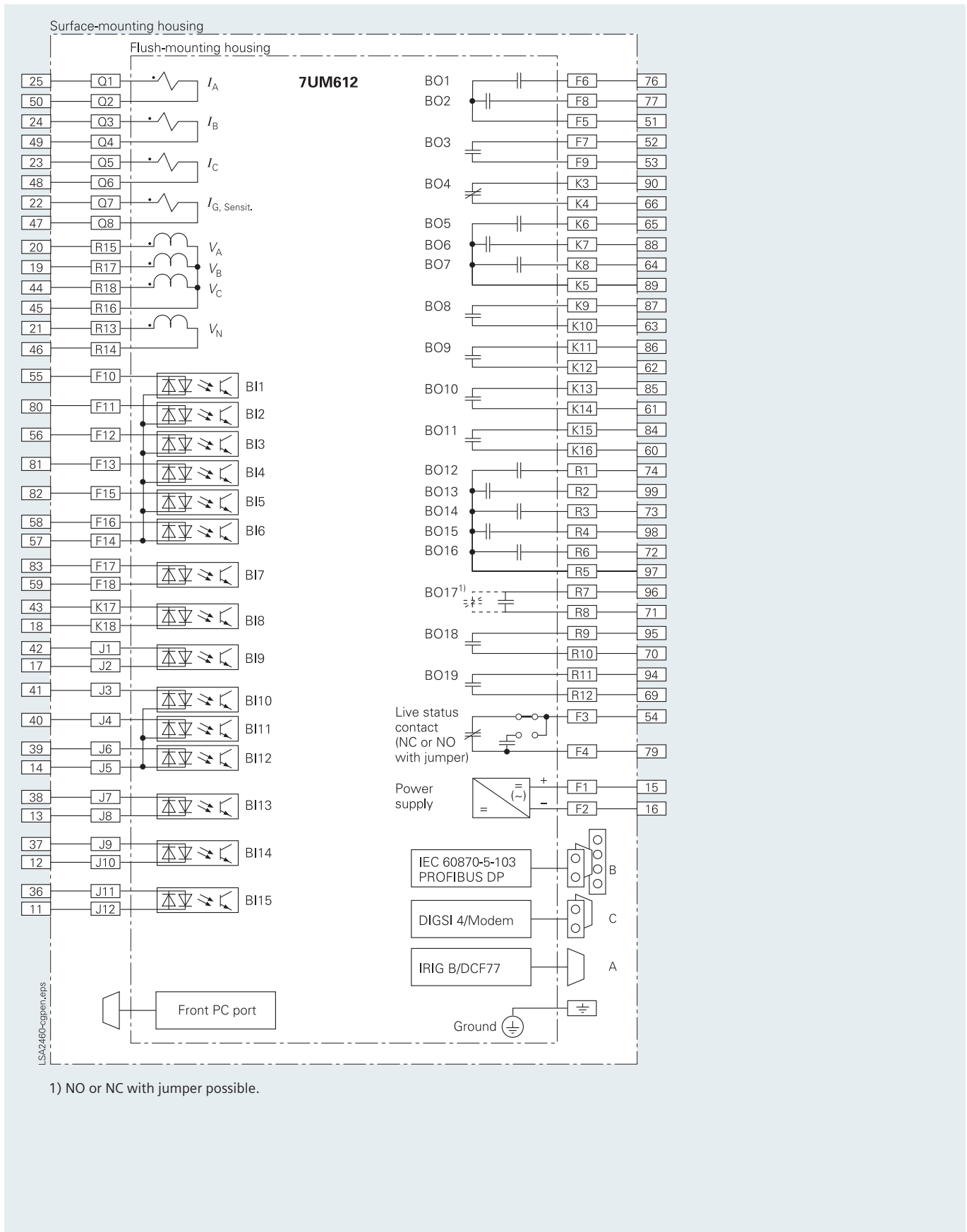


Fig. 11/33 7UM612 connection diagram (ANSI standard)

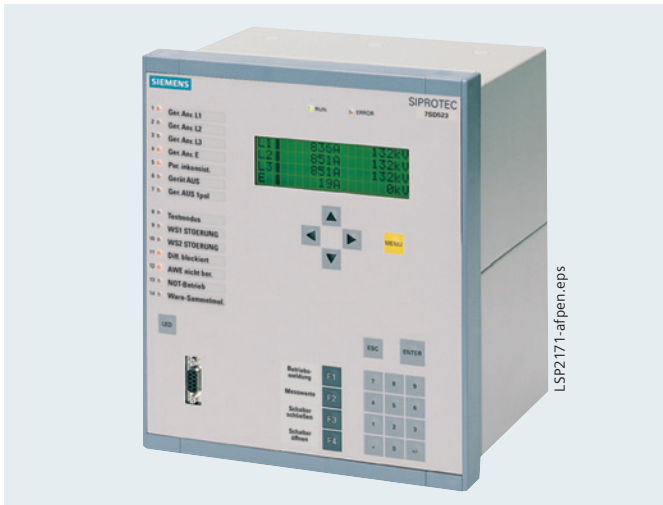


Fig. 11/34 SIPROTEC 4 7UM62 multifunction protection relay for generators, motors and transformers

Description

The SIPROTEC 4 7UM62 protection relays can do more than just protect. They also offer numerous additional functions. Be it ground faults, short-circuits, overloads, overvoltage, overfrequency or underfrequency asynchronous conditions, protection relays assure continued operation of power stations. The SIPROTEC 4 7UM62 protection relay is a compact unit which has been specially developed and designed for the protection of small, medium-sized and large generators. They integrate all the necessary protection functions and are particularly suited for the protection of:

- Hydro and pumped-storage generators
- Co-generation stations
- Private power stations using regenerative energy sources such as wind or biogases
- Diesel generator stations
- Gas-turbine power stations
- Industrial power stations
- Conventional steam power stations.

The SIPROTEC 4 7UM62 includes all necessary protection functions for large synchronous and asynchronous motors and for transformers.

The integrated programmable logic functions (continuous function chart CFC) offer the user high flexibility so that adjustments can easily be made to the varying power station requirements on the basis of special system conditions.

The flexible communication interfaces are open for modern communication architectures with the control system.

The following basic functions are available for all versions:

Current differential protection for generators, motors and transformers, stator ground-fault protection, sensitive ground-fault protection, stator overload protection, overcurrent-time protection (either definite time or inverse time), definite-time overcurrent protection with directionality, undervoltage and overvoltage protection, underfrequency and overfrequency protection, overexcitation and underexcitation protection, external trip coupling, forward-power and reverse-power protection, negative-sequence protection, breaker failure protection, rotor ground-faults protection (f_n , R -measuring), motor starting time supervision and restart inhibit for motors.

Function overview

Standard version

Scope of basic version plus:

- Inadvertent energization protection
- 100 %-stator ground-fault protection with 3rd harmonic
- Impedance protection

Full version

Scope of standard version plus:

- DC voltage protection
- Overcurrent protection during start-ups
- Ground-current differential protection
- Out-of-step protection

Additional version

Available for each version:

- Sensitive rotor ground-fault protection (1–3 Hz method)
- Stator ground-fault protection with 20 Hz voltage
- Rate-of-frequency-change protection
- Vector jump supervision

Monitoring function

- Trip circuit supervision
- Fuse failure monitor
- Operational measured values V , I , f , ...
- Energy metering values W_p , W_q
- Time metering of operating hours
- Self-supervision of relay
- 8 oscillographic fault records

Communication interfaces

- System interface
 - IEC 61850 protocol
 - IEC 60870-5-103 protocol
 - PROFIBUS-DP
 - MODBUS RTU
 - DNP 3.0

Hardware

- Analog inputs
- 8 current transformers
- 4 voltage transformers
- 7/15 binary inputs
- 12/20 output relays

Front design

- User-friendly local operation
- 7/14 LEDs for local alarm
- Function keys
- Graphic display with 7UM623

Generator Protection/7UM62

Application, construction

Application

The 7UM6 protection relays of the SIPROTEC 4 family are compact multifunction units which have been developed for small to medium-sized power generation plants. They incorporate all the necessary protective functions and are especially suitable for the protection of:

- Hydro and pumped-storage generators
- Co-generation stations
- Private power stations using regenerative energy sources such as wind or biogases
- Power generation with diesel generators
- Gas turbine power stations
- Industrial power stations
- Conventional steam power stations.

They can also be employed for protection of motors and transformers.

The numerous other additional functions assist the user in ensuring cost-effective system management and reliable power supply. Measured values display current operating conditions. Stored status indications and fault recording provide assistance in fault diagnosis not only in the event of a disturbance in generator operation.

Combination of the units makes it possible to implement effective redundancy concepts.

Protection functions

Numerous protection functions are necessary for reliable protection of electrical machines. Their extent and combination are determined by a variety of factors, such as machine size, mode of operation, plant configuration, availability requirements, experience and design philosophy.

This results in multifunctionality, which is implemented in outstanding fashion by numerical technology.

In order to satisfy differing requirements, the combination of functions is scalable (see Table 11/3). Selection is facilitated by division into five groups.

Generator Basic

One application concentrates on small and medium generators for which differential protection is required. The function mix is also suitable as backup protection. Protection of synchronous motors is a further application.

Generator Standard

In the case of medium-size generators (10 to 100 MVA) in a unit connection, this scope of functions offers all necessary protection functions. Besides inadvertent energization protection, it also includes powerful backup protection for the transformer or the power system. The scope of protection is also suitable for units in the second protection group.

Generator Full

Here, all protection functions are available and the main application focuses on large block units (more than 100 MVA). The function mix includes all necessary protection functions for the

generator as well as backup protection for the block transformer including the power system. Additional functions such as protection during start-up for generators with starting converters are also included. The scope of functions can be used for the second protection group, and functions that are not used, can be masked out.

Asynchronous motor

Besides differential protection, this function package includes all protection functions needed to protect large asynchronous motors (more than 1 MVA). Stator and bearing temperatures are measured by a separate thermo-box and are transmitted serially to the protection unit for evaluation.

Transformer

This scope of functions not only includes differential and overcurrent protection, but also a number of protection functions that permit monitoring of voltage and frequency stress, for instance. The reverse-power protection can be used for energy recovery monitoring of parallel-connected transformers.

Construction

The SIPROTEC 4 units have a uniform design and a degree of functionality which represents a whole new quality in protection and control.

Local operation has been designed according to ergonomic criteria. Large, easy-to-read displays were a major design aim. The 7UM623 is equipped with a graphic display thus providing and depicting more information especially in industrial applications. The DIGSI 4 operating program considerably simplifies planning and engineering and reduces commissioning times.

The 7UM621 and 7UM623 are configured in 1/2 19 inches width. This means that the units of previous models can be replaced. The height throughout all housing width increments is 243 mm.

All wires are connected directly or by means of ring-type cable lugs. Alternatively, versions with plug-in terminals are also available. These permit the use of prefabricated cable harnesses.

In the case of panel surface mounting, the connecting terminals are in the form of screw-type terminals at top and bottom. The communication interfaces are also arranged on the same sides.

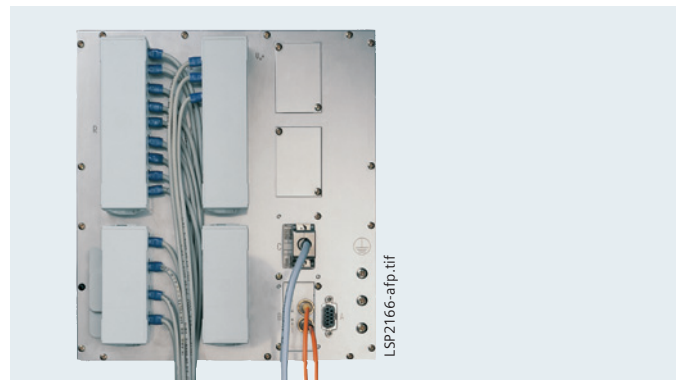


Fig. 11/35 Rear view with wiring terminal safety cover and serial interface

Protection functions

Protection functions	Abbreviation	ANSI No.	Generator Basic	Generator Standard	Generator Full	Motor Asynchronous	Transformer
Current differential protection	ΔI	87G/87T/87M	■	■	■	■	■
Stator ground-fault protection non-directional, directional	$V_0 >, 3I_0 >$ $\backslash(V_0, 3I_0)$	59N, 64G 67G	■	■	■	■	■
Sensitive ground-fault protection (also rotor ground-fault protection)	$I_{EE} >$	50/51GN (64R)	■	■	■	■	■
Sensitive ground-fault prot. B (e.g. shaft current prot.)	$I_{EE-B} > I_{EE-B} <$	51GN	■	■	■	■	■
Stator overload protection	$I^2 t$	49	■	■	■	■	■
Definite-time overcurrent prot. with undervolt. seal-in	$I > + V <$	51	■	■	■	■	■
Definite-time overcurrent protection, directional	$I >>, \text{Direc.}$	50/51/67	■	■	■	■	■
Inverse-time overcurrent protection	$t = f(I) + V <$	51V	■	■	■	■	■
Overvoltage protection	$V >$	59	■	■	■	■	■
Undervoltage protection	$V <, t = f(V)$	27	■	■	■	■	■
Frequency protection	$f <, f >$	81	■	■	■	■	■
Reverse-power protection	$-P$	32R	■	■	■	■	■
Overexcitation protection (Volt/Hertz)	V/f	24	■	■	■	■	■
Fuse failure monitor	$V_2/V_1, I_2/I_1$	60FL	■	■	■	■	■
External trip coupling	Incoup.		4	4	4	4	4
Trip circuit supervision	T.C.S.	74TC	■	■	■	■	■
Forward-power protection	$P >, P <$	32F	■	■	■	■	■
Underexcitation protection (loss-of-field protection)	$1/x_d$	40	■	■	■		
Negative-sequence protection	$I_2 >, t = f(I_2)$	46	■	■	■	■	
Breaker failure protection	$I_{\min} >$	50BF	■	■	■	■	■
Motor starting time supervision	$I_{\text{start}}^2 t$	48	■	■	■	■	
Restart inhibit for motors	$I^2 t$	66, 49 Rotor	■	■	■	■	
Rotor ground-fault protection (f_n , R-measuring)	$R <$	64R (f_n)	■	■	■		
Inadvertent energization protection	$I >, V <$	50/27		■	■		
100 % stator ground-fault protection with 3 rd harmonics	V_0 (3 rd harm.)	59TN, 27TN 3 rd h		■	■		
Impedance protection with ($I > + V <$) pickup	$Z <$	21		■	■		
Interturn protection	$U_{\text{Interturn}} >$	59N(IT)		■	■		
DC voltage / DC current time protection	$V_{\text{dc}} >$ $I_{\text{dc}} >$	59N (DC) 51N (DC)			■		
Overcurrent protection during startup (for gas turbines)	$I >$	51			■		
Ground-current differential protection	ΔI_e	87GN/TN	■ ¹⁾	■ ¹⁾	■	■ ¹⁾	■ ¹⁾
Out-of-step protection	$\Delta Z/\Delta t$	78			■		
Rotor ground-fault protection (1 – 3 Hz square wave voltage)	$R_{\text{REF}} <$	64R (1 – 3 Hz)	■ ¹⁾	■ ¹⁾	■ ¹⁾		
100 % stator ground-fault protection with 20 Hz voltage	$R_{\text{SEF}} <$	64G (100 %)	■ ¹⁾	■ ¹⁾	■ ¹⁾		
Rate-of-frequency-change protection	$df/dt >$	81R	■ ¹⁾	■ ¹⁾	■ ¹⁾	■ ¹⁾	■ ¹⁾
Vector jump supervision (voltage)	$\Delta \varphi >$		■ ¹⁾	■ ¹⁾	■ ¹⁾	■ ¹⁾	■ ¹⁾
Threshold supervision			■	■	■	■	■
Supervision of phase rotation	A, B, C	47	■	■	■	■	■
Undercurrent via CFC	$I <$	37	■	■	■	■	■
External temperature monitoring via serial interface	θ (Thermo-box)	38	■	■	■	■	■

1) Optional for all function groups.

Table 11/3 Scope of functions of the 7UM62

Protection functions

Current differential protection (ANSI 87G, 87M, 87T)

This function provides undelayed short-circuit protection for generators, motors and transformers, and is based on the current differential protection principle (Kirchhoff's current law).

The differential and restraint (stabilization) current are calculated on the basis of the phase currents. Optimized digital filters reliably attenuate disturbances such as aperiodic component and harmonics. The high resolution of measured quantities permits recording of low differential currents (10 % of I_N) and thus a very high sensitivity.

An adjustable restraint characteristic permits optimum adaptation to the conditions of the protected object. Software is used to correct the possible mismatch of the current transformers and the phase angle rotation through the transformer (vector group). Thanks to harmonic analysis of the differential current, inrush (second harmonic) and overexcitation (fifth harmonic) are reliably detected, and unwanted operation of the differential protection is prevented. The current of internal short-circuits is reliably measured by a fast measuring stage ($I_{Diff} \gg$), which operates with two mutually complementary measuring processes. An external short-circuit with transformer saturation is picked up by a saturation detector with time and status monitoring. It becomes active when the differential current (I_{Diff}) moves out of the add-on restraint area.

If a motor is connected, this is detected by monitoring the restraint current and the restraint characteristic is briefly raised. This prevents false tripping in the event of unequal current transmission by the current transformers.

Figure 11/36 shows the restraint characteristic and various areas.

Ground-current differential protection (ANSI 87GN, 87TN)

The ground-current differential protection permits high sensitivity to single-pole faults. The zero currents are compared. On the one hand, the zero-sequence current is calculated on the basis of the phase currents and on the other hand, the ground current is measured directly at the star-point current transformer.

The differential and restraint quantity is generated and fitted into the restraint characteristic (see Fig. 11/37).

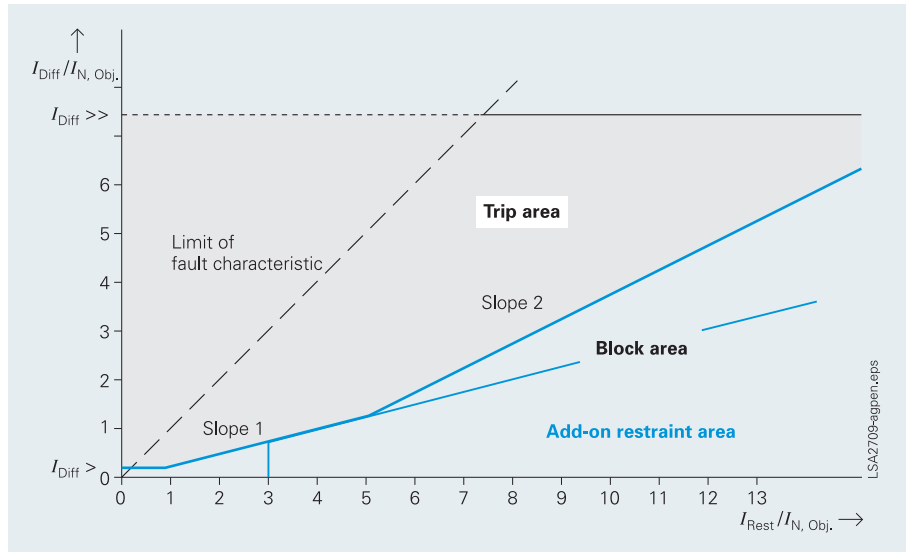


Fig. 11/36 Restraint characteristic of current differential protection

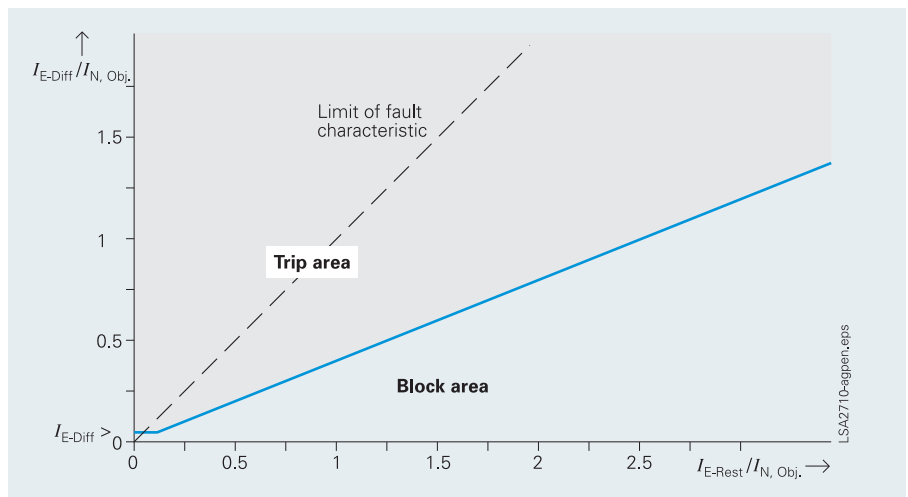


Fig. 11/37 Restraint characteristic of ground-current differential protection

DC components in particular are suppressed by means of specially dimensioned filters. A number of monitoring processes avoid unwanted operation in the event of external short-circuits. In the case of a sensitive setting, multiple measurement ensures the necessary reliability.

However, attention must be drawn to the fact that the sensitivity limits are determined by the current transformers.

The protection function is only used on generators when the neutral point is grounded with a low impedance. In the case of transformers, it is connected on the neutral side. Low impedance or solid grounding is also required.

Definite-time overcurrent protection $I>$, $I>>$ (ANSI 50, 51, 67)

This protection function comprises the short-circuit protection for the generator and also the backup protection for upstream devices such as transformers or power system protection.

An undervoltage stage at $I>$ maintains the pickup when, during the fault, the current drops below the threshold. In the event of a voltage drop on the generator terminals, the static excitation system can no longer be sufficiently supplied. This is one reason for the decrease of the short-circuit current.

The $I>>$ stage can be implemented as high-set instantaneous trip stage. With the integrated directional function it can be used as backup protection on the transformer high-voltage side. With the information of the directional element, impedance protection can be controlled via the CFC.

Inverse-time overcurrent protection (ANSI 51V)

This function also comprises short-circuit and backup protection and is used for power system protection with current-dependent protection devices.

IEC and ANSI characteristics can be selected (Table 11/4).

The current function can be controlled by evaluating the generator terminal voltage.

The "controlled" version releases the sensitive set current stage.

With the "restraint" version, the pickup value of the current is lowered linearly with decreasing voltage.

The fuse failure monitor prevents unwanted operation.

Stator overload protection (ANSI 49)

The task of the overload protection is to protect the stator windings of generators and motors from high, continuous overload currents. All load variations are evaluated by a mathematical model. The thermal effect of the r.m.s. current value forms the basis of the calculation. This conforms to IEC 60255-8.

In dependency of the current, the cooling time constant is automatically extended. If the ambient temperature or the temperature of the coolant are injected via a transducer (TD2) or PROFIBUS-DP, the model automatically adapts to the ambient conditions; otherwise a constant ambient temperature is assumed.

Negative-sequence protection (ANSI 46)

Asymmetrical current loads in the three phases of a generator cause a temperature rise in the rotor because of the negative-sequence field produced.

This protection detects an asymmetrical load in three-phase generators. It functions on the basis of symmetrical components and evaluates the negative sequence of the phase currents. The thermal processes are taken into account in the algorithm and form the inverse characteristic. In addition, the negative sequence is evaluated by an independent stage (alarm and trip) which is supplemented by a time-delay element (see Fig. 11/38). In the case of motors, the protection function is also used to monitor a phase failure.

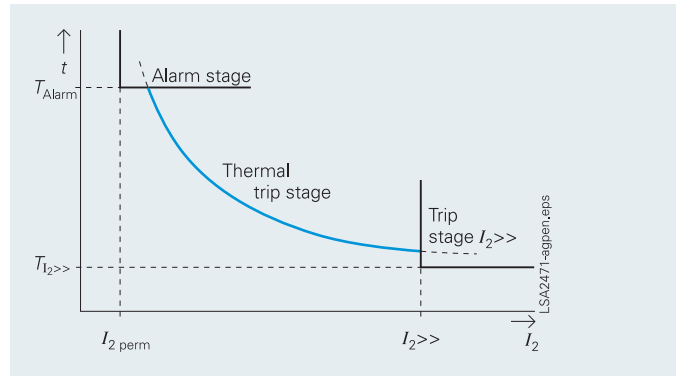


Fig. 11/38 Characteristic of negative-sequence protection

Available inverse-time characteristics		
Characteristics	ANSI	IEC 60255-3
Inverse	•	•
Moderately inverse	•	
Very inverse	•	•
Extremely inverse	•	•
Definite inverse	•	

Table 11/4

Underexcitation protection (Loss-of-field protection) (ANSI 40)

Derived from the generator terminal voltage and current, the complex admittance is calculated and corresponds to the generator diagram scaled in per unit. This protection prevents damage due to loss of synchronism resulting from underexcitation. The protection function provides three characteristics for monitoring static and dynamic stability. Via a transducer, the excitation voltage (see Figure 11/52) can be injected and, in the event of failure, a swift reaction of the protection function can be achieved by timer changeover.

The straight-line characteristics allow the protection to be optimally adapted to the generator diagram (see Figure 11/39). The per-unit-presentation of the diagram allows the setting values to be directly read out.

The positive-sequence systems of current and voltage are used to calculate the admittance. This ensures that the protection always operates correctly even with asymmetrical network conditions.

If the voltage deviates from the rated voltage, the admittance calculation has the advantage that the characteristics move in the same direction as the generator diagram.

Protection functions

Reverse-power protection (ANSI 32R)

The reverse-power protection monitors the direction of active power flow and picks up when the mechanical energy fails. This function can be used for operational shut-down (sequential tripping) of the generator but also prevents damage to the steam turbines. The reverse power is calculated from the positive-sequence systems of current and voltage. Asymmetrical power system faults therefore do not cause reduced measuring accuracy. The position of the emergency trip valve is injected as binary information and is used to switch between two trip command delays. When applied for motor protection, the sign (\pm) of the active power can be reversed via parameters.

Forward-power protection (ANSI 32F)

Monitoring of the active power produced by a generator can be useful for starting up and shutting down generators. One stage monitors exceeding of a limit value, while another stage monitors falling below another limit value. The power is calculated using the positive-sequence component of current and voltage. The function can be used to shut down idling motors.

Impedance protection (ANSI 21)

This fast short-circuit protection protects the generator and the unit transformer and is a backup protection for the power system. This protection has two settable impedance stages; in addition, the first stage can be switched over via binary input. With the circuit-breaker in the "open" position the impedance measuring range can be extended (see Figure 11/40).

The overcurrent pickup element with undervoltage seal-in ensures a reliable pickup and the loop selection logic ensures a reliable detection of the faulty loop. With this logic it is possible to perform correct measurement via the unit transformer.

Undervoltage protection (ANSI 27)

The undervoltage protection evaluates the positive-sequence components of the voltages and compares them with the threshold values. There are two stages available.

The undervoltage function is used for asynchronous motors and pumped-storage stations and prevents the voltage-related instability of such machines.

The function can also be used for monitoring purposes.

Overvoltage protection (ANSI 59)

This protection prevents insulation faults that result when the voltage is too high.

Either the maximum line-to-line voltages or the phase-to-ground voltages (for low-voltage generators) can be evaluated. The measuring results of the line-to-line voltages are independent of the neutral point displacement caused by ground faults. This function is implemented in two stages.

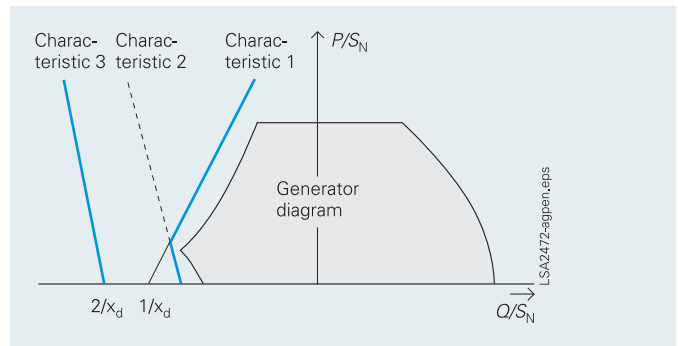


Fig. 11/39 Characteristic of underexcitation protection

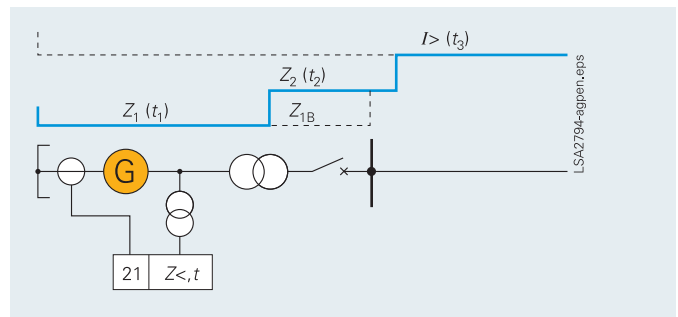


Fig. 11/40 Grading of impedance protection

Frequency protection (ANSI 81)

The frequency protection prevents impermissible stress of the equipment (e.g. turbine) in case of under or overfrequency. It also serves as a monitoring and control element.

The function has four stages; the stages can be implemented either as underfrequency or overfrequency protection. Each stage can be delayed separately.

Even in the event of voltage distortion, the frequency measuring algorithm reliably identifies the fundamental waves and determines the frequency extremely precisely. Frequency measurement can be blocked by using an undervoltage stage.

Overexcitation protection Volt/Hertz (ANSI 24)

The overexcitation protection serves for detection of an unpermissible high induction (proportional to V/f) in generators or transformers, which leads to thermal overloading. This may occur when starting up, shutting down under full load, with weak systems or under isolated operation. The inverse characteristic can be set via eight points derived from the manufacturer data.

In addition, a definite-time alarm stage and an instantaneous stage can be used. For calculation of the V/f ratio, frequency and also the highest of the three line-to-line voltages are used. The frequency range that can be monitored comprises 11 to 69 Hz.

90 % stator ground-fault protection, non-directional, directional (ANSI 59N, 64G, 67G)

Ground faults manifest themselves in generators that are operated in isolation by the occurrence of a displacement voltage. In case of unit connections, the displacement voltage is an adequate, selective criterion for protection.

For the selective ground-fault detection, the direction of the flowing ground current has to be evaluated too, if there is a direct connection between generator and busbar.

The protection relay measures the displacement voltage at a VT located at the transformer star point or at the broken delta winding of a VT. As an option, it is also possible to calculate the zero-sequence voltage from the phase-to-ground voltages.

Depending on the load resistor selection, 90 to 95 % of the stator winding of a generator can be protected.

A sensitive current input is available for ground-current measurement. This input should be connected to a core-balance current transformer. The fault direction is deduced from the displacement voltage and ground current. The directional characteristic (straight line) can be easily adapted to the system conditions. Effective protection for direct connection of a generator to a busbar can therefore be established. During startup, it is possible to switch over from the directional to the displacement voltage measurement via an externally injected signal.

Depending on the protection setting, various ground-fault protection concepts can be implemented with this function (see Figures 11/51 to 11/54).

Sensitive ground-fault protection (ANSI 50/51GN, 64R)

The sensitive ground-current input can also be used as separate ground-fault protection. It is of two-stage form. Secondary ground currents of 2 mA or higher can be reliably handled.

Alternatively, this input is also suitable as rotor ground-fault protection. A voltage with rated frequency (50 or 60 Hz) is connected in the rotor circuit via the interface unit 7XR61. If a higher ground current is flowing, a rotor ground fault has occurred. Measuring circuit monitoring is provided for this application (see Figure 11/56).

100 % stator ground-fault protection with 3rd harmonic (ANSI 59TN, 27TN (3rd H.))

Owing to the creative design, the generator produces a 3rd harmonic that forms a zero phase-sequence system. It is verifiable by the protection on a broken delta winding or on the neutral transformer. The magnitude of the voltage amplitude depends on the generator and its operation.

In the event of an ground fault in the vicinity of the neutral point, there is a change in the amplitude of the 3rd harmonic voltage (dropping in the neutral point and rising at the terminals).

Depending on the connection the protection must be set either as undervoltage or overvoltage protection. It can also be delayed. So as to avoid overfunction, the active power and the positive-sequence voltage act as enabling criteria.

The picked-up threshold of the voltage stage is restrained by the active power. This increases sensitivity at low load.

The final protection setting can be made only by way of a primary test with the generator.

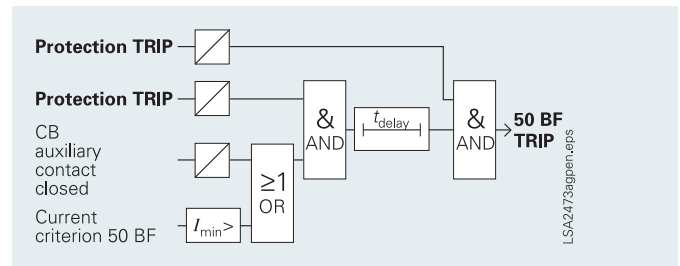


Fig. 11/41 Logic diagram of breaker failure protection

Breaker failure protection (ANSI 50BF)

In the event of scheduled downtimes or a fault in the generator, the generator can remain on line if the circuit-breaker is defective and could suffer substantial damage.

Breaker failure protection evaluates a minimum current and the circuit-breaker auxiliary contact. It can be started by internal protective tripping or externally via binary input. Two-channel activation avoids overfunction (see Figure 11/41).

Inadvertent energization protection (ANSI 50, 27)

This protection has the function of limiting the damage of the generator in the event of an unintentional switch-on of the circuit-breaker, whether the generator is standing still or rotating without being excited or synchronized. If the power system voltage is connected, the generator starts as an asynchronous machine with a large slip and this leads to excessively high currents in the rotor.

A logic circuit consisting of sensitive current measurement for each phase, measured value detector, time control and blocking as of a minimum voltage, leads to an instantaneous trip command. If the fuse failure monitor responds, this function is ineffective.

Rotor ground-fault protection (ANSI 64R)

This protection function can be realized in three ways with the 7UM62. The simplest form is the method of rotor-current measurement (see sensitive ground-current measurement).

Resistance measurement at system-frequency voltage

The second form is rotor ground resistance measurement with voltage at system frequency (see Fig. 11/56). This protection measures the voltage injected and the flowing rotor ground current. Taking into account the complex impedance from the coupling device (7XR61), the rotor ground resistance is calculated by way of a mathematical model. By means of this method, the disturbing influence of the rotor ground capacitance is eliminated, and sensitivity is increased. Fault resistance values up to 30 kΩ can be measured if the excitation voltage is without disturbances. Thus, a two-stage protection function, which features a warning and a tripping stage, can be realized. An additionally implemented undercurrent stage monitors the rotor circuit for open circuit and issues an alarm.

Protection functions

Resistance measurement with a square wave voltage of 1 to 3 Hz

A higher sensitivity is required for larger generators. On the one hand, the disturbing influence of the rotor ground capacitance must be eliminated more effectively and, on the other hand, the noise ratio with respect to the harmonics (e.g. sixth harmonic) of the excitation equipment must be increased. Injecting a low-frequency square wave voltage into the rotor circuit has proven itself excellently here (see Figure 11/57).

The square wave voltage injected through the controlling unit 7XT71 leads to permanent recharging of the rotor ground capacitance. By way of a shunt in the controlling unit, the flowing ground current is measured and is injected into the protection unit (measurement input). In the absence of a fault ($R_E \approx \infty$), the rotor ground current after charging of the ground capacitance is close to zero. In the event of an ground fault, the fault resistance including the coupling resistance (7XR6004), and also the injecting voltage, defines the stationary current. The current square wave voltage and the frequency are measured via the second input (control input). Fault resistance values up to 80 kΩ can be measured by this measurement principle. The rotor ground circuit is monitored for discontinuities by evaluation of the current during the polarity reversals.

100% stator ground-fault protection with 20 Hz injection (ANSI 64 G (100%))

Injecting a 20 Hz voltage to detect ground faults even at the neutral point of generators has proven to be a safe and reliable method. Contrary to the third harmonic criterion (see page 11/8), it is independent of the generator's characteristics and the mode of operation. Measurement is also possible during system standstill (Fig. 11/56).

This protection function is designed so as to detect both ground faults in the entire generator (genuine 100 %) and all electrically connected system components.

The protection unit measures the injected 20 Hz voltage and the flowing 20 Hz current. The disturbing variables, for example stator ground capacitance, are eliminated by way of a mathematical model, and the ohmic fault resistance is determined.

On the one hand, this ensures high sensitivity and, on the other hand, it permits use of generators with large ground capacitance values, e.g. large hydroelectric generators. Phase-angle errors through the grounding or neutral transformer are measured during commissioning and are corrected in the algorithm.

The protection function has a warning and tripping stage. The measurement circuit is also monitored and failure of the 20 Hz generator is measured.

Independent of ground resistance calculation, the protection function additionally evaluates the amount of the r.m.s. current value.

Starting time supervision (motor protection only) (ANSI 48)

Starting time supervision protects the motor against long unwanted start-ups, which might occur as a result of excessive load torque or excessive voltage drops within the motor, or if the rotor is locked.

The tripping time is dependent on the square of the start-up current and the set start-up time (Inverse Characteristic). It adapts itself to the start-up with reduced voltage. The tripping time is determined in accordance with the following formula:

$$t_{\text{Trip}} = \left(\frac{I_{\text{start}}}{I_{\text{rms}}} \right)^2 \cdot t_{\text{start max}}$$

t_{Trip}	Tripping time
I_{start}	Permissible start-up current
$t_{\text{start max}}$	Permissible start-up time
I_{rms}	Measured r.m.s. current value

Calculation is not started until the current I_{rms} is higher than an adjustable response value (e.g. $2 I_{N, \text{MOTOR}}$).

If the permissible locked-rotor time is less than the permissible start-up time (motors with a thermally critical rotor), a binary signal is set to detect a locked rotor by means of a tachometer generator. This binary signal releases the set locked-rotor time, and tripping occurs after it has elapsed.

DC voltage time protection/DC current time protection (ANSI 59N (DC) 51N (DC))

Hydroelectric generators or gas turbines are started by way of frequency starting converters. An ground fault in the intermediate circuit of the frequency starting converter causes DC voltage displacement and thus a direct current. As the neutral or grounding transformers have a lower ohmic resistance than the voltage transformers, the largest part of the direct current flows through them, thus posing a risk of destruction from thermal overloading.

As shown in Fig. 11/55, the direct current is measured by means of a shunt transformer (measuring transducer) connected directly to the shunt. Voltages or currents are fed to the 7UM62 depending on the version of the measuring transducer. The measurement algorithm filters out the DC component and takes the threshold value decision. The protection function is active as from 0 Hz.

If the measuring transducer transmits a voltage for protection, the connection must be interference-free and must be kept short.

The implemented function can also be used for special applications. Thus, the r.m.s. value can be evaluated for the quantity applied at the input over a wide frequency range.

Overcurrent protection during start-up (ANSI 51)

Gas turbines are started by means of frequency starting converters. Overcurrent protection during start-up measures short-circuits in the lower frequency level (as from about 5 Hz) and is designed as independent overcurrent-time protection. The pickup value is set below the rated current. The function is only active during start-up. If frequencies are higher than 10 Hz, sampling frequency correction takes effect and the further short-circuit protection functions are active.

Out-of-step protection (ANSI 78)

This protection function serves to measure power swings in the system. If generators feed to a system short-circuit for too long, low frequency transient phenomena (active power swings) between the system and the generator may occur after fault clearing. If the center of power swing is in the area of the block unit, the "active power surges" lead to unpermissible mechanical stressing of the generator and the turbine.

As the currents and voltages are symmetrical, the positive-sequence impedance is calculated on the basis of their positive-sequence components and the impedance trajectory is evaluated. Symmetry is also monitored by evaluation of the

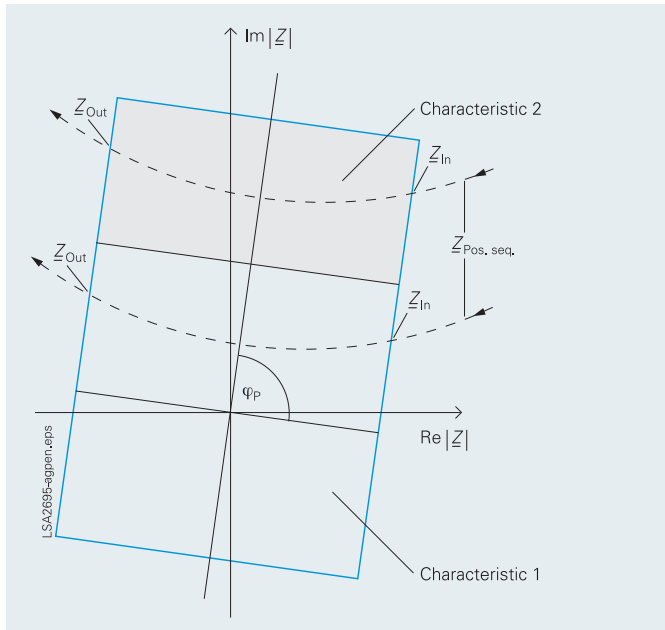


Fig. 11/42 Ranges of the characteristic and possible oscillation profiles

negative-phase-sequence current. Two characteristics in the R/X diagram describe the active range (generator, unit transformer or power system) of the out-of-step protection. The associated counters are incremented depending on the range of the characteristic in which the impedance vector enters or departs. Tripping occurs when the set counter value is reached.

The counters are automatically reset if power swing no longer occurs after a set time. By means of an adjustable pulse, every power swing can be signaled. Expansion of the characteristic in the R direction defines the power swing angle that can be measured. An angle of 120 ° is practicable. The characteristic can be tilted over an adjustable angle to adapt to the conditions prevailing when several parallel generators feed into the system.

Inverse undervoltage protection (ANSI 27)

Motors tend to fall out of step when their torque is less than the breakdown torque. This, in turn, depends on the voltage. On the one hand, it is desirable to keep the motors connected to the system for as long as possible while, on the other hand, the torque should not fall below the breakdown level. This protection task is realized by inverse undervoltage protection. The inverse characteristic is started if the voltage is less than the pickup threshold V_p . The tripping time is inversely proportional to the voltage dip (see equation). The protection function uses the positive-sequence voltage, for the protection decision.

$$t_{\text{TRIP}} = \frac{I}{I - \frac{V}{V_p}} \cdot T_M$$

t_{TRIP}	Tripping time
V	Voltage
V_p	Pickup value
T_M	Time multiplier

System disconnection

Take the case of in-plant generators feeding directly into a system. The incoming line is generally the legal entity boundary

between the system owner and the in-plant generator. If the incoming line fails as the result of auto-reclosure, for instance, a voltage or frequency deviation may occur depending on the power balance at the feeding generator. Asynchronous conditions may arise in the event of connection, which may lead to damage on the generator or the gearing between the generator and the turbine. Besides the classic criteria such as voltage and frequency, the following two criteria are also applied: vector jump, rate-of-frequency-change protection.

Rate-of-frequency-change protection (ANSI 81)

The frequency difference is determined on the basis of the calculated frequency over a time interval. It corresponds to the momentary rate-of-frequency change. The function is designed so that it reacts to both positive and negative rate-of-frequency changes. Exceeding of the permissible rate-of-frequency change is monitored constantly. Release of the relevant direction depends on whether the actual frequency is above or below the rated frequency. In total, four stages are available, and can be used optionally.

Vector jump

Monitoring the phase angle in the voltage is a criterion for identifying an interrupted infeed. If the incoming line should fail, the abrupt current discontinuity leads to a phase angle jump in the voltage. This is measured by means of a delta process. The command for opening the generator or coupler circuit-breaker is issued if the set threshold is exceeded.

Restart inhibit for motors (ANSI 66, 49Rotor)

When cold or at operating temperature, motors may only be connected a certain number of times in succession. The start-up current causes heat development in the rotor which is monitored by the restart inhibit function.

Contrary to classical counting methods, in the restart inhibit function the heat and cooling phenomena in the rotor are simulated by a thermal replica. The rotor temperature is determined on the basis of the stator currents. Restart inhibit permits restart of the motor only if the rotor has enough thermal reserve for a completely new start. Fig. 11/43 illustrates the thermal profile for a permissible triple start out of the cold state. If the thermal reserve is too low, the restart inhibit function issues a blocking signal with which the motor starting circuit can be blocked. The blockage is canceled again after cooling down and the thermal value has dropped below the pickup threshold.

As the fan provides no forced cooling when the motor is off, it cools down more slowly. Depending on the operating state, the protection function controls the cooling time constant. A value below a minimum current is an effective changeover criterion.

Sensitive ground-fault protection B (ANSI 51 GN)

The I_{EE-B} sensitive ground-fault protection feature of 7UM62 provides greater flexibility and can be used for the following applications:

- Any kind of ground-fault current supervision to detect ground faults (fundamental and 3rd harmonics)
- Protection against load resistances
- Shaft current protection in order to detect shaft currents of the generator shaft and prevent that bearings take damage.

The sensitive ground-current protection I_{EE-B} uses either the hardware input I_{EE1} or I_{EE2} . These inputs are designed in a way that

Protection functions

allows them to cut off currents greater than 1.6 A (thermal limit, see technical data). This has to be considered for the applications or for the selection of the current transformers.

The shaft current protection function is of particular interest in conjunction with hydroelectric generators. Due to their construction, the hydroelectric generators have relatively long shafts. A number of factors such as friction, magnetic fields of the generators and others can build up a voltage across the shaft which then acts as voltage source (electromotive force-emf). This induced voltage of approx. 10 to 30 V is dependent on the load, the system and the machine.

If the oil film covering a bearing is too thin, breakdown can occur. Due to the low resistance (shaft, bearing and grounding), high currents may flow that destroy the bearing. Past experience has shown that currents greater than 1 A are critical for the bearings. As different bearings can be affected, the current entering the shaft is detected by means of a special transformer (folding transformer).

Interturn protection (ANSI 59N (IT))

The interturn fault protection detects faults between turns within a generator winding (phase). This situation may involve relatively high circulating currents that flow in the short-circuited turns and damage the winding and the stator. The protection function is characterized by a high sensitivity.

The displacement voltage is measured at the open delta winding by means of 3 two-phase isolated voltage transformers. So as to be insensitive towards ground faults, the isolated voltage transformer star point has to be connected to the generator star point by means of a high-voltage cable. The voltage transformer star point must not be grounded since this implies that the generator star point, too, would be grounded with the consequence that each fault would lead to a single-pole ground fault.

In the event of an interturn fault, the voltage in the affected phase will be reduced causing a displacement voltage that is detected at the broken delta winding. The sensitivity is limited rather by the winding asymmetries than by the protection unit.

An FIR filter determines the fundamental component of the voltage based on the scanned displacement voltage. Selecting an appropriate window function has the effect that the sensitivity towards higher-frequency oscillations is improved and the disturbing influence of the third harmonic is eliminated while achieving the required measurement sensitivity.

External trip coupling

For recording and processing of external trip information, there are 4 binary inputs. They are provided for information from the Buchholz relay or generator-specific commands and act like a protection function. Each input initiates a fault event and can be individually delayed by a timer.

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal occurs whenever the circuit is interrupted.

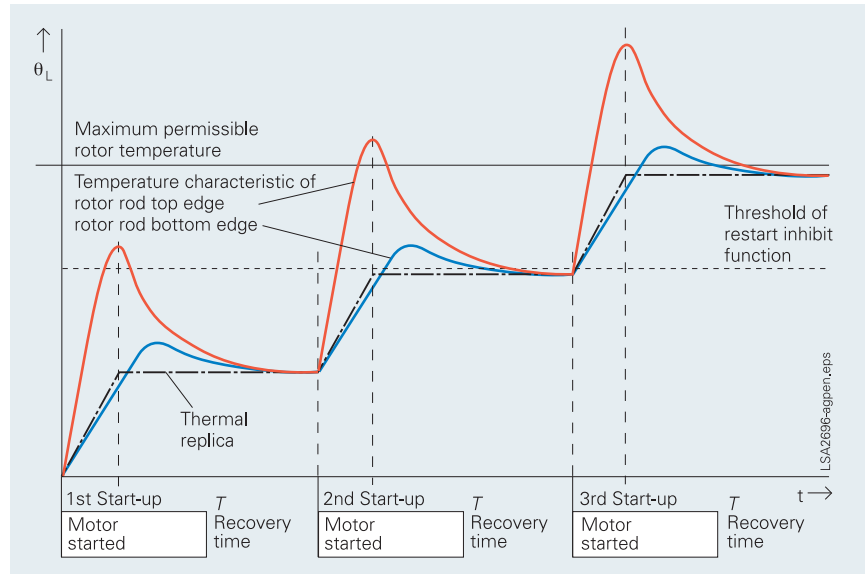


Fig. 11/43 Temperature characteristic at rotor and thermal replica of the rotor (multiple start-ups)

Phase rotation reversal

If the relay is used in a pumped-storage power plant, matching to the prevailing rotary field is possible via a binary input (generator/motor operation via phase rotation reversal).

2 pre-definable parameter groups

In the protection, the setting values can be stored in two data sets. In addition to the standard parameter group, the second group is provided for certain operating conditions (pumped-storage power stations). It can be activated via binary input, local control or DIGSI 4.

Lockout (ANSI 86)

All binary outputs (alarm or trip relays) can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only occur after the lockout state is reset.

Fuse failure and other monitoring

The relay comprises high-performance monitoring for the hardware and software.

The measuring circuits, analog-digital conversion, power supply voltages, memories and software sequence (watch-dog) are all monitored.

The fuse failure function detects failure of the measuring voltage due to short-circuit or open circuit of the wiring or VT and avoids overfunction of the undervoltage elements in the protection functions.

The positive and negative-sequence system (voltage and current) are evaluated.

Filter time

All binary inputs can be subjected to a filter time (indication suppression).

Communication

With respect to communication, particular emphasis has been placed on high levels of flexibility, data integrity and utilization of standards common in energy automation. The design of the communication modules permits interchangeability on the one hand, and on the other hand provides openness for future standards (for example, Industrial Ethernet).

Local PC interface

The PC interface accessible from the front of the unit permits quick access to all parameters and fault event data. The use of the DIGSI 4 operating program during commissioning is particularly advantageous.

Rear-mounted interfaces

Two communication modules on the rear of the unit incorporate optional equipment complements and permit retrofitting. They assure the ability to comply with the requirements of different communication interfaces (electrical or optical) and protocols (IEC 60870, PROFIBUS, DIGSI).

The interfaces make provision for the following applications:

Service interface (fixed)

In the RS485 version, several protection units can be centrally operated with DIGSI 4. By using a modem, remote control is possible. This provides advantages in fault clearance, in particular in unmanned substations.

System interface

This is used to communicate with a control or protection and control system and supports, depending on the module connected, a variety of communication protocols and interface designs. Furthermore, the units can exchange data through this interface via Ethernet and IEC 61850 protocol and can also be operated by DIGSI.

IEC 61850 protocol

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens is of the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus will also be possible with DIGSI.

IEC 60870-5-103

IEC 60870-5-103 is an internationally standardized protocol for communication in the protected area.

IEC 60870-5-103 is supported by a number of protection unit manufacturers and is used worldwide.

The generator protection functions are stored in the manufacturer-specific, published part of the protocol.

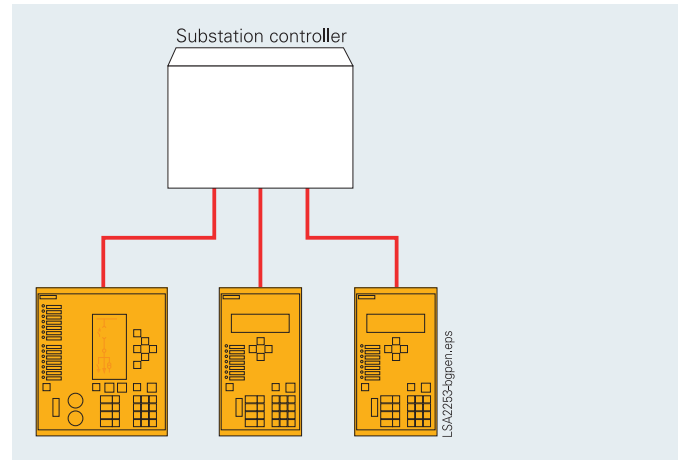


Fig. 11/44 IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

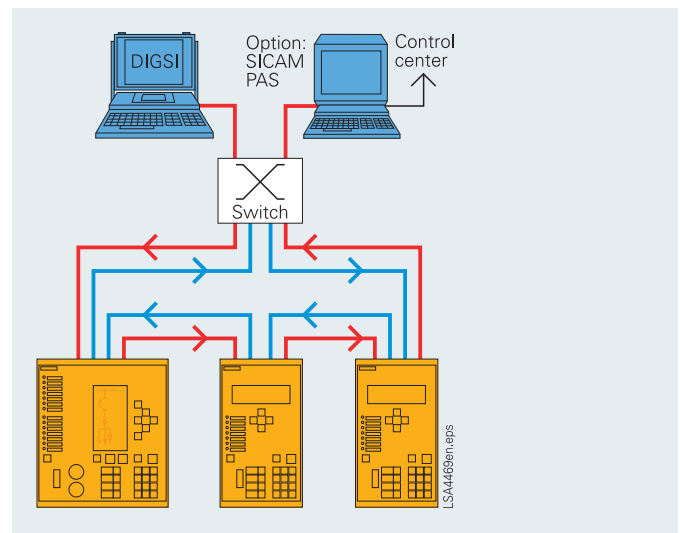


Fig. 11/45 Bus structure for station bus with Ethernet and IEC 61850, fiber-optic ring

PROFIBUS-DP

PROFIBUS is an internationally standardized communication protocol (EN 50170). PROFIBUS is supported internationally by several hundred manufacturers and has to date been used in more than 1,000,000 applications all over the world.

With the PROFIBUS-DP, the protection can be directly connected to a SIMATIC S5/S7. The transferred data are fault data, measured values and information from or to the logic (CFC).

MODBUS RTU

MODBUS is also a widely utilized communication standard and is used in numerous automation solutions.

DNP 3.0

DNP 3.0 (Distributed Network Protocol version 3) is a messaging-based communication protocol. The SIPROTEC 4 units are fully Level 1 and Level 2 compliant with DNP 3.0. DNP 3.0 is supported by a number of protection device manufacturers.

Generator Protection/7UM62

Communication

Safe bus architecture

- RS485 bus
With this data transmission via copper conductors, electromagnetic interference influences are largely eliminated by the use of twisted-pair conductor. Upon failure of a unit, the remaining system continues to operate without any faults.
- Fiber-optic double ring circuit
The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without disturbance.

System solution

SIPROTEC 4 is tailor-made for use in SIMATIC-based automation systems.

Via the PROFIBUS-DP, indications (pickup and tripping) and all relevant operational measured values are transmitted from the protection unit.

Via modem and service interface, the protection engineer has access to the protection devices at all times. This permits remote maintenance and diagnosis (cyclic testing).

Parallel to this, local communication is possible, for example, during a major inspection.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbit/s Ethernet bus, the unit are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 11/45).

Analog output 0 to 20 mA

Alternatively to the serial interfaces up to two analog output modules (4 channels) can be installed in the 7UM62.

Several operational measured values ($I_1, I_2, V, P, Q, f, PF(\cos \varphi), \Theta_{\text{stator}}, \Theta_{\text{rotor}}$) can be selected and transmitted via the 0 to 20 mA interfaces.

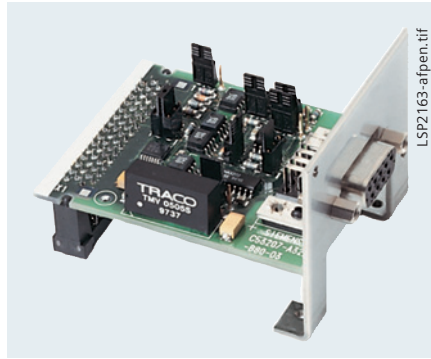


Fig. 11/46 RS232/RS485 Electrical communication module

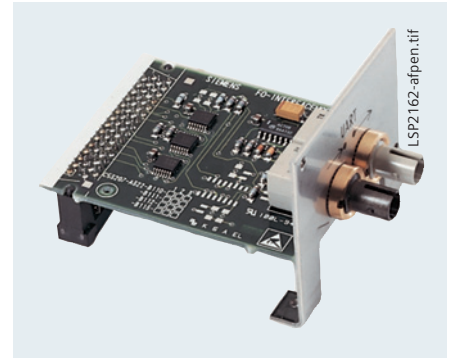


Fig. 11/47 820 nm fiber-optic communication module

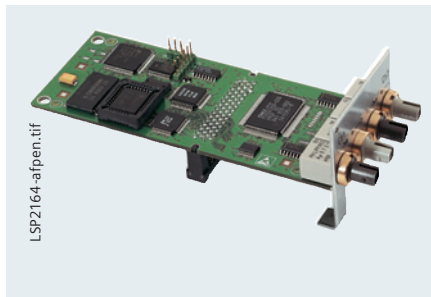


Fig. 11/48 PROFIBUS communication module optical, double-ring

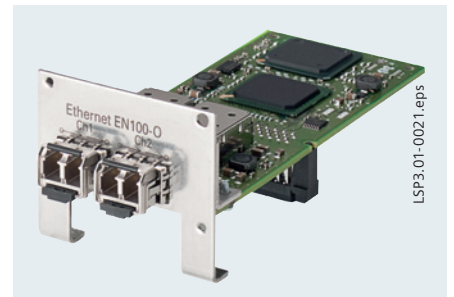


Fig. 11/49 Optical Ethernet communication module for IEC 61850 with integrated Ethernet switch

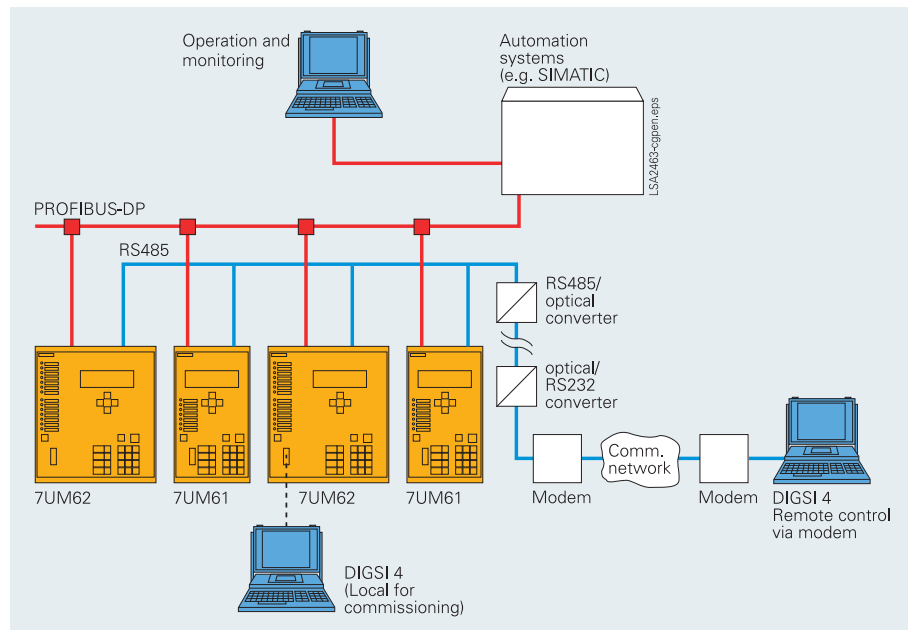


Fig. 11/50 System solution: Communications

Typical connections

Direct generator – busbar connection

Figure 11/51 illustrates the recommended standard connection when several generators supply one busbar. Phase-to-ground faults are disconnected by employing the directional ground-fault criterion. The ground-fault current is driven through the cables of the system.

If this is not sufficient, an grounding transformer connected to the busbar supplies the necessary current (maximum approximately 10 A) and permits a protection range of up to 90 %. The ground-fault current should be detected by means of core-balance current transformers in order to achieve the necessary sensitivity. The displacement voltage can be used as ground-fault criterion during starting operations until synchronization is achieved.

Differential protection embraces protection of the generator and of the outgoing cable. The permissible cable length and the current transformer design (permissible load) are mutually dependent. Recalculation is advisable for lengths of more than 100 m.

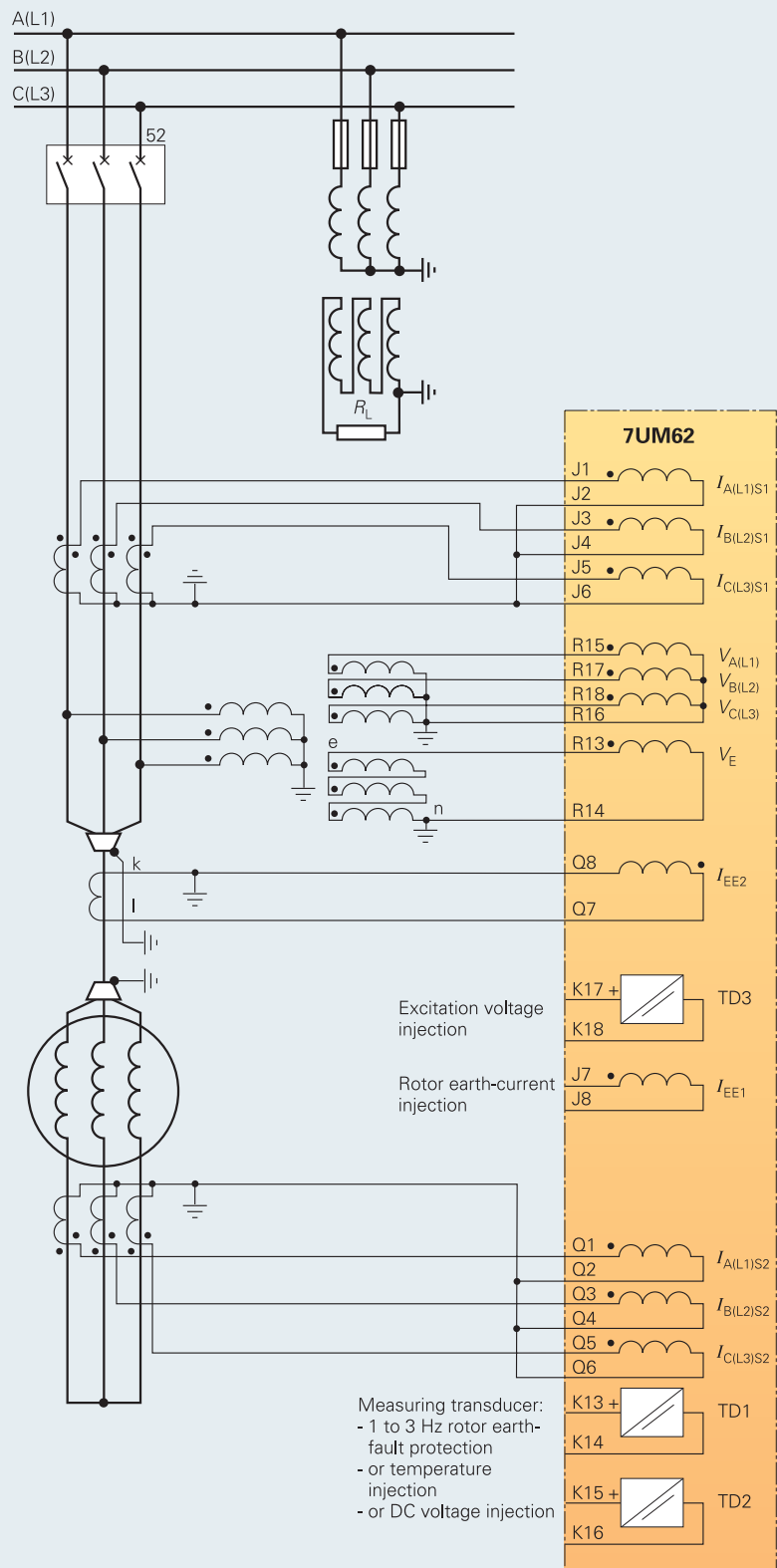


Fig. 11/51

Generator Protection/7UM62

Typical connections

Direct generator – busbar connection with low-resistance grounding

If the generator neutral point has low-resistance grounding, the connection illustrated in Fig. 11/52 is recommended. In the case of several generators, the resistance must be connected to only one generator, in order to prevent circulating currents (3rd harmonic).

For selective ground-fault detection, the ground-current input should be looped into the common return conductor of the two current transformer sets (differential connection). The current transformers must be grounded at only one point. The displacement voltage V_E is utilized as an additional enabling criterion.

Balanced current transformers (calibration of windings) are desirable with this form of connection. In the case of higher generator power (for example, I_N approximately 2000 A), current transformers with a secondary rated current of 5 A are recommended.

Ground-current differential protection can be used as an alternative (not illustrated).

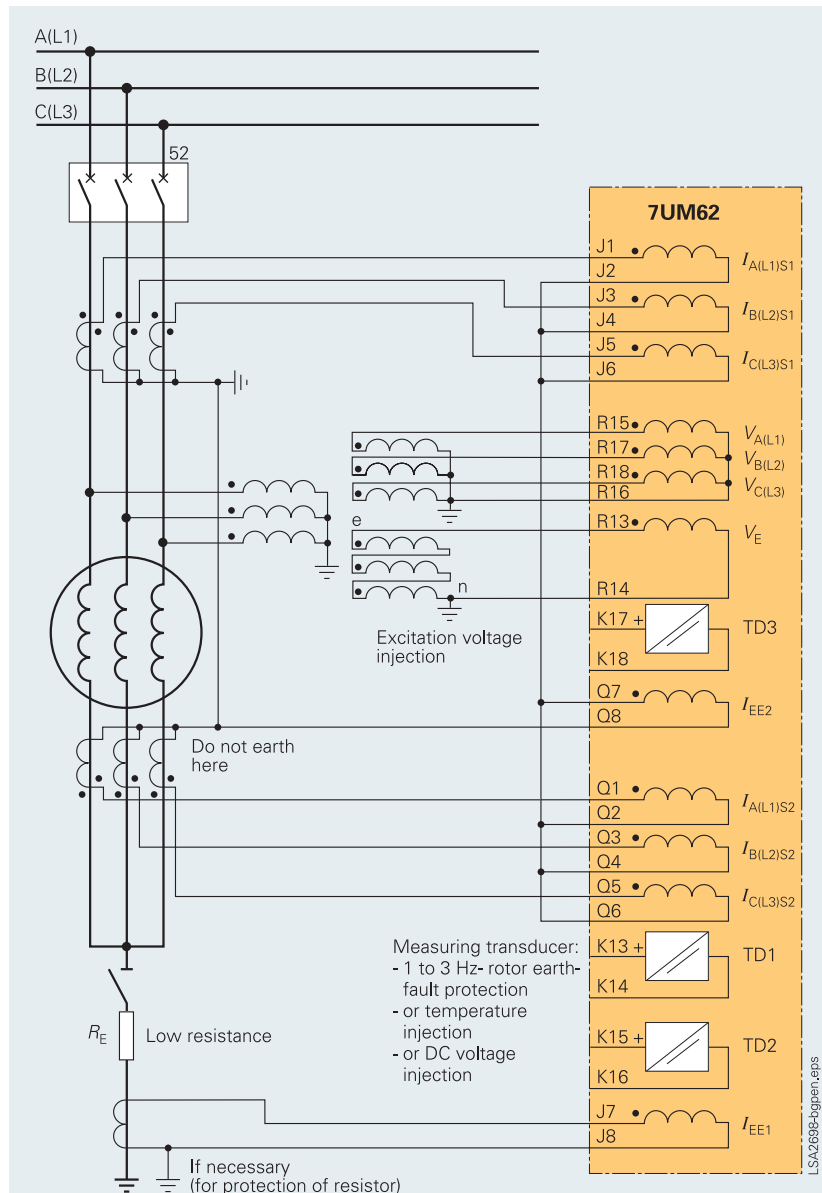


Fig. 11/52

Unit connection with isolated star point

This configuration of unit connection is a variant to be recommended (see Fig. 11/53). Ground-fault detection is effected by means of the displacement voltage. In order to prevent unwanted operation in the event of ground faults in the system, a load resistor must be provided at the broken delta winding. Depending on the plant (or substation), a voltage transformer with a high power (VA) may in fact be sufficient. If not, an grounding transformer should be employed. The available measuring winding can be used for the purpose of voltage measurement.

In the application example, differential protection is intended for the generator. The unit transformer is protected by its own differential relay (e.g. 7UT612).

As indicated in the figure, additional protection functions are available for the other inputs. They are used on larger generator/transformer units (see also Figures 11/56 and 11/58).

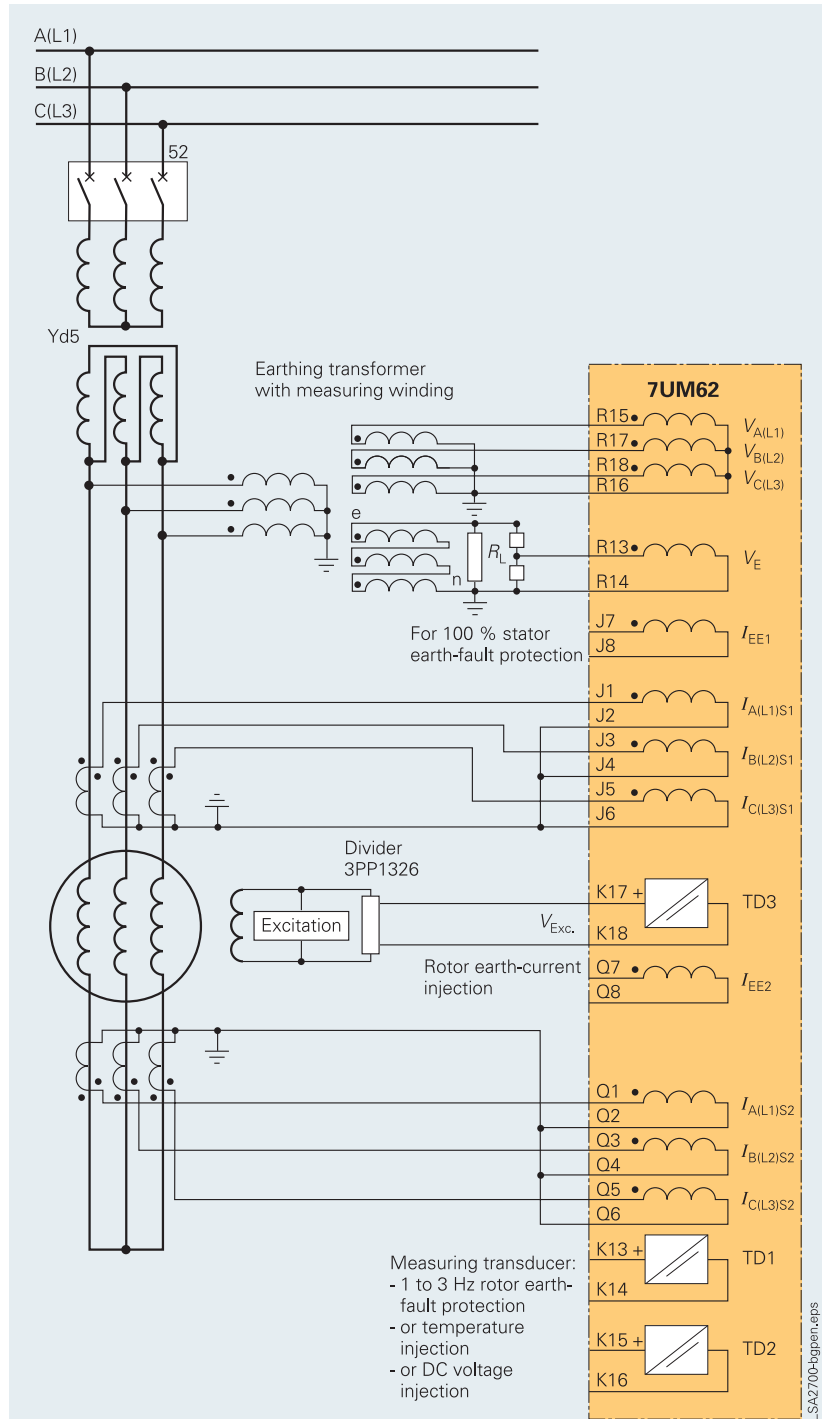


Fig. 11/53

Generator Protection/7UM62

Typical connections

Unit connection with neutral transformer

With this system configuration, disturbance voltage reduction and damping in the event of ground faults in the generator area are effected by a load resistor connected to the generator neutral point.

The maximum ground-fault current is limited to approximately 10 A. Configuration can take the form of a primary or secondary resistor with neutral transformer. In order to avoid low secondary resistance, the transformation ratio of the neutral transformer should be below

$$\left(\frac{V_{Gen}}{\sqrt{3}} / 500 \text{ V} \right)$$

The higher secondary voltage can be reduced by means of a voltage divider.

Electrically, the circuit is identical to the configuration in Fig. 11/53.

In the application opposite, the differential protection is designed as an overall function and embraces the generator and unit transformer. The protection function carries out vector group adaptation as well as other adaptations.

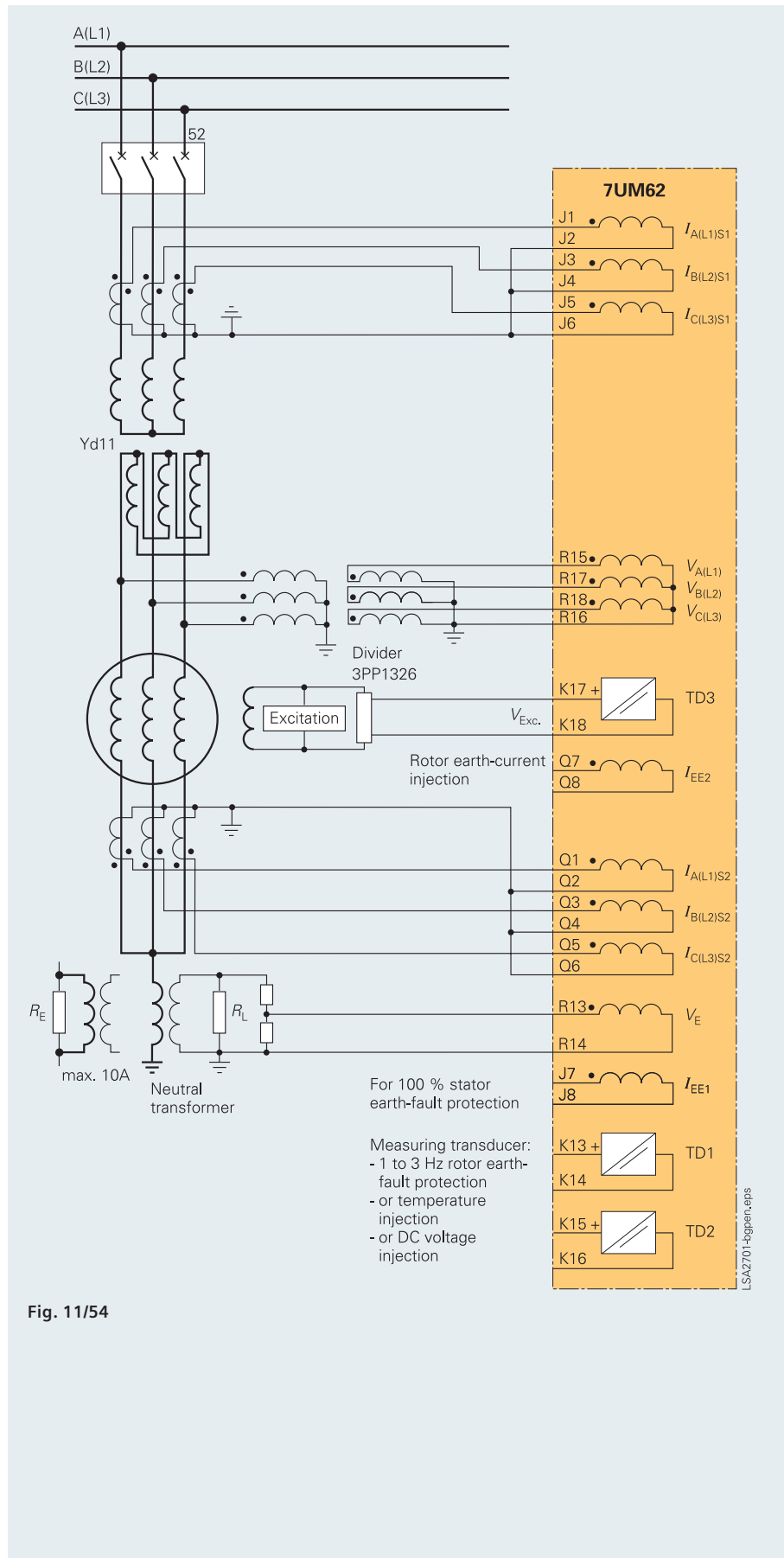


Fig. 11/54

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Voltage transformer in open delta connection (V-connection)

Protection can also be implemented on voltage transformers in open delta connection (Fig. 11/55). If necessary, the operational measured values for the phase-to-ground voltages can be slightly asymmetrical. If this is disturbing, the neutral point (R16) can be connected to ground via a capacitor.

In the case of open delta connection, it is not possible to calculate the displacement voltage from the secondary voltages. It must be passed to the protection relay along a different path (for example, voltage transformer at the generator neutral point or from the grounding transformer).

100 % stator ground-fault protection, ground-fault protection during start-up

Fig. 11/56 illustrates the interfacing of 100 % stator ground-fault protection with voltage injection of 20 Hz, as meant for the example of the neutral transformer. The same interfacing connection also applies to the broken delta winding of the grounding transformer.

The 20 Hz generator can be connected both to the DC voltage and also to a powerful voltage transformer (>100 VA). The load of the current transformer 4NC1225 should not exceed 0.5 Ω.

The 7XT33, 7XT34 and load resistance connection must be established with a low resistance ($R_{\text{Connection}} < R_L$). If large distances are covered, the devices are accommodated in the grounding cubicle.

Connection of the DC voltage protection function (TD 1) is shown for systems with a starting converter. Depending on the device selection, the 7KG6 boosts the measured signal at the shunt to 10 V or 20 mA.

The TD 1 input can be jumpered to the relevant signal.

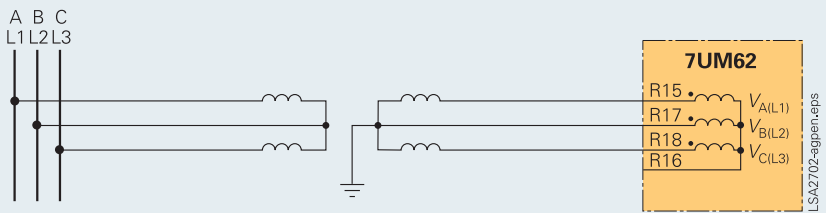


Fig. 11/55

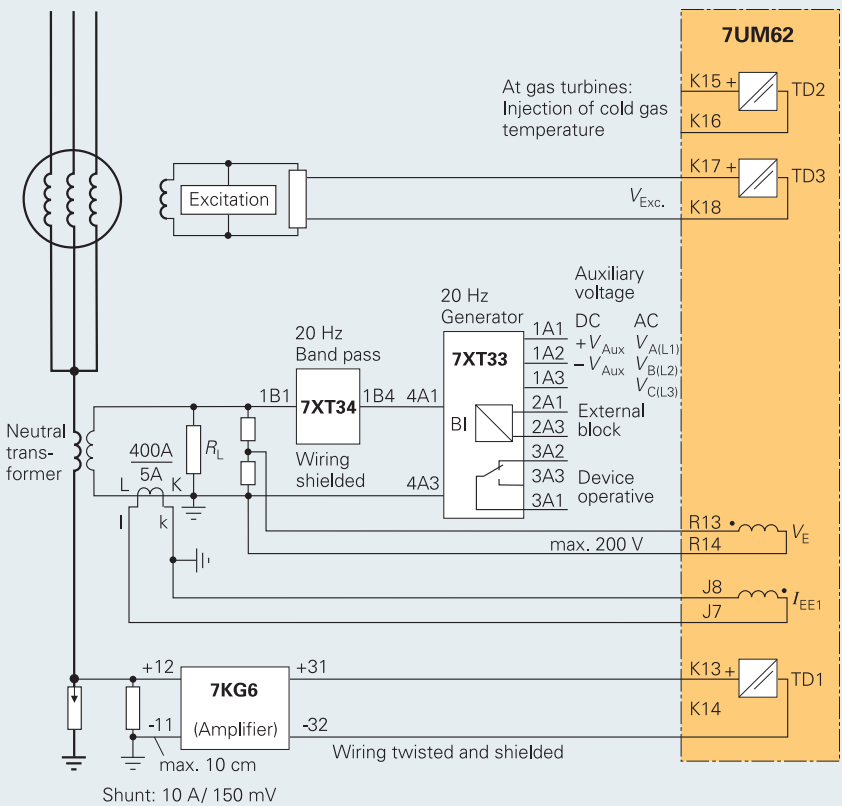


Fig. 11/56

Generator Protection/7UM62

Typical connections

Rotor ground-fault protection with voltage injection at rated frequency

Fig. 11/57 shows the connection of rotor ground-fault protection to a generator with static excitation. If only the rotor current is evaluated, there is no need for voltage connection to the relay.

Ground must be connected to the grounding brush. The external resistors 3PP1336 must be added to the coupling device 7XR61 if the circulating current can exceed 0.2 A as the result of excitation (sixth harmonic). This is the case as from a rated excitation voltage of >150 V, under worst-case conditions.

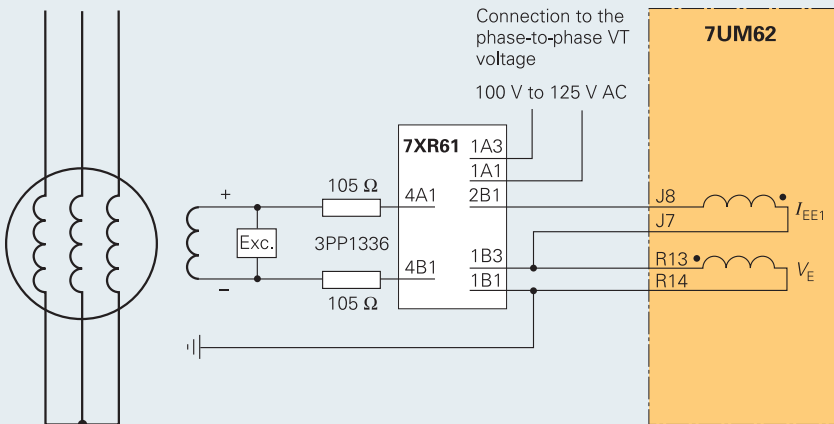


Fig. 11/57

Rotor ground-fault protection with a square wave voltage of 1 to 3 Hz

The measuring transducers TD1 and TD2 are used for this application. The controlling unit 7XT71 generates a square wave voltage of about ± 50 V at the output. The frequency can be jumpered and depends on the rotor ground capacitance. Voltage polarity reversal is measured via the control input and the flowing circular current is measured via the measurement input. Ground must be connected to the grounding brush.

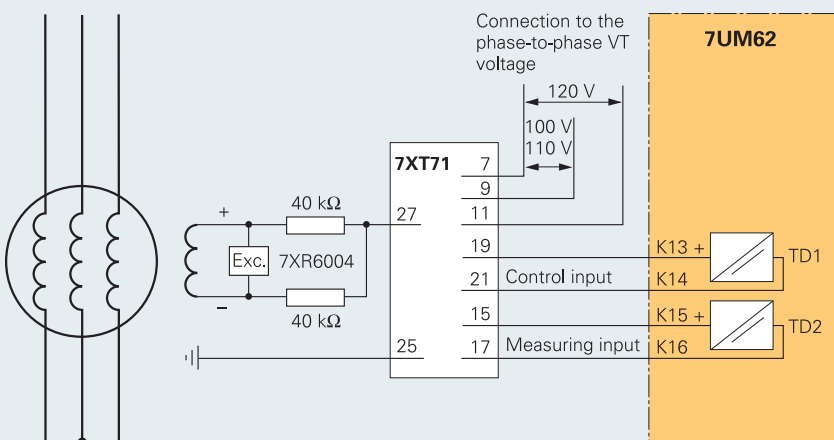


Fig. 11/58

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LSA2705-egpen.eps

Protection of an asynchronous motor

Fig. 11/59 shows a typical connection of the protection function to a large asynchronous motor. Differential protection embraces the motor including the cable. Recalculation of the permissible current transformer burden is advisable for lengths of more than 100 m.

The voltage for voltage and displacement voltage monitoring is generally tapped off the busbar. If several motors are connected to the busbar, ground faults can be detected with the directional ground-fault protection and selective tripping is possible. A core balance current transformer is used to detect the ground current. The chosen pickup value must be slightly higher if there are several cables in parallel.

The necessary shut-down of the motor in the event of idling can be realized with active power monitoring.

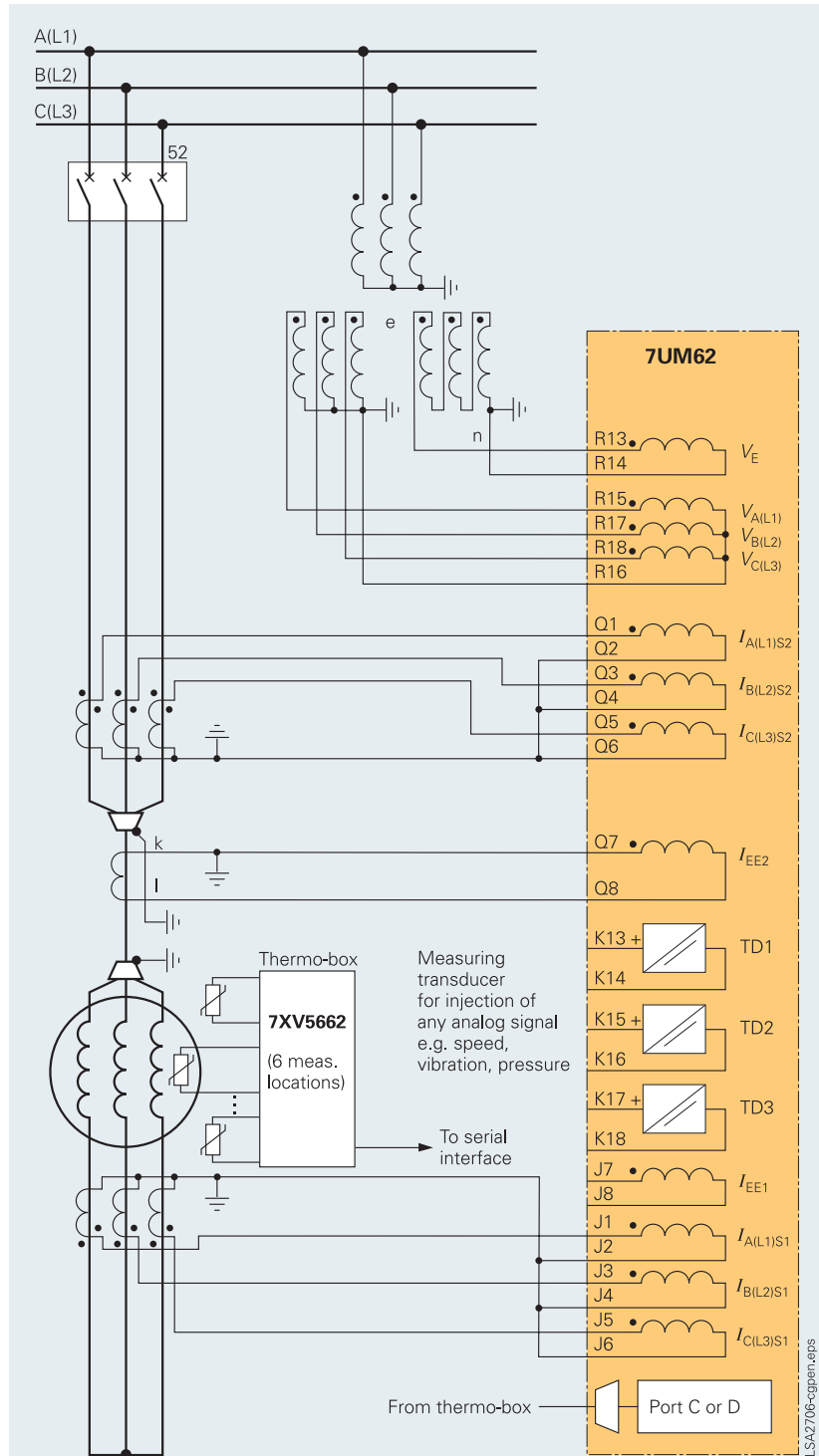


Fig. 11/59

Generator Protection/7UM62

Typical connections

Use of selected analog inputs

Several protection functions take recourse to the same analog inputs, thus ruling out certain functions depending on the application. One input may only be used by one protection function. A different combination can be used by the unit belonging to Protection Group 2, for example.

Multiple use refers to the sensitive ground-current inputs and the displacement voltage input (see Table 11/5).

The same applies to the measuring transducers (Table 11/6).

Current transformer requirements

The requirements imposed on the current transformer are determined by the differential protection function. The instantaneous trip stage ($I_{Diff} >>$) reliably masters (via the instantaneous algorithm) any high-current internal short-circuits.

The external short-circuit determines the requirements imposed on the current transformer as a result of the DC component. The non-saturated period of a flowing short-circuit current should be at least 5 ms. Table 11/7 shows the design recommendations.

IEC 60044-1 and 60044-6 were taken into account. The necessary equations are shown for converting the requirements into the knee-point voltages. The customary practice which presently applies should also be used to determine the rated primary current of the current transformer rated current. It should be greater than or equal to the rated current of the protected object.

	I_{EE1}	I_{EE2}	V_E
Sensitive ground-fault protection	■ ¹⁾	■ ¹⁾	
Directional stator ground-fault protection		■	■
Rotor ground-fault protection (f_n , R-measuring)	■		■
100 % stator ground-fault protection with 20 Hz voltage	■		■
Ground-current differential protection	■ ¹⁾	■ ¹⁾	

1) optional (either I_{EE1} or I_{EE2})

Table 11/5 Multiple use of analog inputs

	TD1	TD2	TD3
Injection of excitation voltage			■
DC voltage time/DC current time protection	■		
Injection of a temperature		■	
Rotor ground-fault protection (1 to 3 Hz)	■	■	
Processing of analog values via CFC	■	■	■

Table 11/6 Multiple use of measuring transducers

Symmetrical short-circuit limiting factor	
Required actual accuracy limiting factor	Resulting rated accuracy limiting factor
$K'_{SSC} = K_{td} \cdot \frac{I_{pSC}}{I_{pn}}$	$K_{SSC} = \frac{R'_b + R_{CT}}{R_{BN} + R_{CT}} \cdot K'_{SSC}$

Current transformer requirements		
	Transformer	Generator
Transient dimensioning factor K_{td}	≥ 4 $\tau_N \leq 100$ ms	$> (4 \text{ to } 5)$ $\tau_N > 100$ ms
Symmetrical short-circuit current I_{pSSC}	$\approx \frac{1}{V_{SC}} \cdot I_{pn, Tr}$	$\approx \frac{1}{X''_d} \cdot I_{pn, G}$
Example	$V_{SC} = 0.1$ $K'_{SSC} > 40$	$X''_d = 0.12$ $K'_{SSC} > (34 \text{ to } 42)$
Note: Identical transformers have to be employed	Rated power ≥ 10 or 15 VA Example: Network transformer 10P10: (10 or 15) VA ($I_{sn} = 1$ or 5 A)	Note: Secondary winding resistance Example: $I_{N, G}$ approx. 1000 to 2000 A 5P15: 15 VA ($I_{sn} = 1$ or 5 A) $I_{N, G} > 5000$ A 5P20: 30 VA ($I_{sn} = 1$ or 5 A)

Knee-point voltage		
IEC	British Standard	ANSI
$V = K_{SSC} (R_{ct} + R_b) I_{SN}$	$V = \frac{(R_{ct} + R_b) I_{SN}}{1.3} \cdot K_{SSC}$	$V = 20 \cdot I_{SN} \cdot (R_{ct} + R_b) \cdot \frac{K_{SSC}}{20}$ $I_{SN} = 5A$ (typical value)
K_{td}	Rated transient dimensioning factor	R_{ct} Secondary winding resistance
I_{pSSC}	Primary symmetrical short-circuit current	V_{SC} Short-circuit voltage (impedance voltage)
I_{pn}	Rated primary current (transformer)	X''_d Subtransient reactance
R'_b	Connected burden	I_{sn} Rated secondary current (transformer)
R_b	Rated resistive burden	t_N Network time constant

Table 11/7 Multiple use of measuring transducers

Hardware	
Analog inputs	
Rated frequency	50 or 60 Hz
Rated current I_N	1 or 5 A
Ground current, sensitive $I_{E\max}$	1.6 A
Rated voltage V_N	100 to 125 V
Measuring transducer	- 10 to + 10 V ($R_i=1\text{ M}\Omega$) or - 20 to + 20 mA ($R_i = 10\ \Omega$)
Power consumption	
With $I_N = 1\text{ A}$	Approx. 0.05 VA
With $I_N = 5\text{ A}$	Approx. 0.3 VA
For sensitive ground current	Approx. 0.05 VA
Voltage inputs (with 100 V)	Approx. 0.3 VA
Capability in CT circuits	
Thermal (r.m.s. values)	100 I_N for 1 s 30 I_N for 10 s 4 I_N continuous
Dynamic (peak)	250 I_N (one half cycle)
Ground current, sensitive	300 A for 1 s 100 A for 10 s 15 A continuous 750 A (one half cycle)
Dynamic (peak)	750 A (one half cycle)
Capability in voltage paths	230 V continuous
Capability of measuring transducer	
As voltage input	60 V continuous
As current input	100 mA continuous
Auxiliary voltage	
Rated auxiliary voltage	DC 24 to 48 V DC 60 to 125 V DC 110 to 250 V and AC 115 V/230 V with 50/60 Hz
Permitted tolerance	-20 to +20 %
Superimposed (peak-to-peak)	$\leq 15\%$
Power consumption	
During normal operation	
7UM621	Approx. 5.3 W
7UM622	Approx. 5.5 W
7UM623	Approx. 8.1 W
During pickup with all inputs and outputs activated	
7UM611	Approx. 12 W
7UM612	Approx. 15 W
7UM623	Approx. 14.5 W
Bridging time during auxiliary voltage failure	
at $V_{aux} = 48\text{ V}$ and $V_{aux} \geq 110\text{ V}$	$\geq 50\text{ ms}$
at $V_{aux} = 24\text{ V}$ and $V_{aux} = 60\text{ V}$	$\geq 20\text{ ms}$
Binary inputs	
Number	
7UM621, 7UM623	7
7UM622	15
3 pickup thresholds	DC 10 to 19 V or DC 44 to 88 V
Range is selectable with jumpers	DC 88 to 176 V ¹⁾
Maximum permissible voltage	DC 300 V
Current consumption, energized	Approx. 1.8 mA

Output relays	
Number	
7UM621	12 (1 NO, 4 optional as NC, via jumper)
7UM622	21 (1 NO, 5 optional as NC, via jumper)
Switching capacity	
Make	1000 W / VA
Break	30 VA
Break (for resistive load)	40 W
Break (for L/R $\leq 50\text{ ms}$)	25 VA
Switching voltage	250 V
Permissible current	5 A continuous 30 A for 0.5 seconds
LEDs	
Number	
RUN (green)	1
ERROR (red)	1
Assignable LED (red)	14
Unit design	
7XP20 housing	For dimensions see dimension drawings, part 14
Degree of protection acc. to EN 60529	
For surface-mounting housing	IP 51
For flush-mounting housing	
Front	IP 51
Rear	IP 50
For the terminals	IP 2x with terminal cover put on
Weight	
Flush mounting housing	
7UM621 (1/2 x 19")	Approx. 7 kg
7UM622 (1/4 x 19")	Approx. 9.5 kg
Surface mounting housing	
7UM621 (1/2 x 19")	Approx. 12 kg
7UM622 (1/4 x 19")	Approx. 15 kg
Serial interfaces	
Operating interface for DIGSI 4	
Connection	Non-isolated, RS232, front panel; 9-pin subminiature connector
Baud rate	4800 to 115200 baud
Time synchronization IRIG B/DCF 77 signal (Format: IRIG-B000)	
Connection	9-pin subminiature connector, terminal with surface-mounting case
Voltage levels	Selectable 5 V, 12 V or 24 V
Service/modem interface (Port C) for DIGSI 4/modem/service	
Isolated RS232/RS485	9-pin subminiature connector
Test voltage	500 V / 50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m

Generator Protection/7UM62

Technical data

System interface (Port B) IEC 60870-5-103 protocol, PROFIBUS-DP, MODBUS RTU	
Isolated RS232/RS485	9-pin subminiature connector
Baud rate	4800 to 115200 baud
Test voltage	500 V / 50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m
PROFIBUS RS485	
Test voltage	500 V / 50 Hz
Baud rate	Max. 12 MBaud
Distance	1000 m at 93.75 kBaud; 100 m at 12 MBaud
PROFIBUS fiber-optic	
Only for flush-mounting housing	ST connector
For surface-mounting housing	Optical interface with OLM ¹⁾
Baud rate	Max. 1.5 MBaud
Optical wavelength	$\lambda = 820 \text{ nm}$
Permissible path attenuation	Max. 8 dB for glass-fiber 62.5/125 μm
Distance	1.6 km (500 kB/s) 530 m (1500 kB/s)
Analog output module (electrical)	2 ports with 0 to 20 mA

System interface (Port B) IEC 61850	
Ethernet, electrical (EN 100) for IEC 61850 and DIGSI	
Connection for flush-mounting case	Rear panel, mounting location "B", two RJ45 connector, 100 Mbit/s acc. to IEEE802.3
for surface-mounting case	At bottom part of the housing
Test voltage	500 V; 50 Hz
Transmission speed	100 Mbits/s
Distance	20 m/66 ft
Ethernet, optical (EN 100) for IEC 61850 and DIGSI	
Connection for flush-mounting case	Rear panel, mounting location "B", LC connector receiver/transmitter
for panel surface-mounting case	Not available
Optical wavelength	$\lambda = 1350 \text{ nm}$
Transmission speed	100 Mbits/s
Laser class 1 acc. to EN 60825-1/2	Glass fiber 50/125 μm or glass fiber 62/125 μm
Permissible path attenuation	Max. 5 dB for glass fiber 62.5/125 μm
Distance	Max. 800 m/0.5 mile

Electrical tests	
<i>Specifications</i>	
Standards	IEC 60255 (product standards) ANSI/IEEE C37.90.0/1.1.2 UL 508 DIN 57435, part 303 For further standards see below
<i>Insulation tests</i>	
Standards	IEC 60255-5
Voltage test (routine test) All circuits except for auxiliary supply, binary inputs communication and time synchronization interfaces	2.5 kV (r.m.s.), 50 Hz
Voltage test (routine test) Auxiliary voltage and binary inputs	3.5 kV
Voltage test (routine test) only isolated communication interfaces and time synchronization interface	500 V (r.m.s. value), 50 Hz
Impulse voltage test (type test) All circuits except for communication interfaces and time synchronization interface, class III	5 kV (peak); 1.2/50 μs ; 0.5 J; 3 positive and 3 negative impulses at intervals of 1 s

EMC tests for noise immunity; type test	
Standards	IEC 60255-6, IEC 60255-22 (product standards) EN 50082-2 (generic standard) DIN 57435 part 303
High frequency test IEC 60255-22-1, class III and DIN 57435 part 303, class III	2.5 kV (peak value), 1 MHz; $\tau = 15 \text{ ms}$ 400 pulses per s; duration 2 s
Electrostatic discharge IEC 60255-22-2 class IV EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; $R_i = 330 \Omega$
Irradiation with RF field, non-modulated IEC 60255-22-3 (report), class III	10 V/m; 27 to 500 MHz
Irradiation with RF field, amplitude-modulated, IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz
Irradiation with RF field, pulse-modulated IEC 61000-4-3/ ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transient interference bursts IEC 60255-22-4, IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50 \Omega$; test duration 1 min Impulse: 1.2/50 μs
High-energy surge voltages (SURGE), IEC 61000-4-5 installation, class III Auxiliary supply	Common (longitudinal) mode: 2 kV; 12 Ω , 9 μF Differential (transversal) mode: 1 kV; 2 Ω , 18 μF
Measurement inputs, binary inputs and relay outputs	Common (longitudinal) mode: 2 kV; 42 Ω , 0.5 μF Differential (transversal) mode: 1 kV; 42 Ω , 0.5 μF
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Magnetic field with power frequency IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak); 1 to 1.5 MHz damped wave; 50 surges per second; duration 2 s; $R_i = 150$ to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per second; both polarities; duration 2 s; $R_i = 80 \Omega$
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz
Damped oscillations IEC 60894, IEC 61000-4-12	2.5 kV (peak value), polarity alternating 100 kHz, 1 MHz, 10 and 50 MHz, $R_i = 200 \Omega$

1) Conversion with external OLM
For fiber-optic interface please complete order number at 11th position with **4** (FMS RS485) or **9** and Order code **LOA** (DP RS485) and additionally order:
For single ring: SIEMENS OLM 6GK1502-3AB10
For double ring: SIEMENS OLM 6GK1502-4AB10

EMC tests for interference emission; type tests	
Standard	EN 50081-x (generic standard)
Conducted interference voltage on lines only auxiliary supply IEC-CISPR 22	150 kHz to 30 MHz Limit class B
Interference field strength IEC-CISPR 22	30 to 1000 MHz Limit class B

Mechanical stress tests

Vibration, shock stress and seismic vibration

During operation

Standards	IEC 60255-21 and IEC 60068
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 g acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 5 g, duration 11 ms, 3 shocks each in both directions of the 3 axes
Seismic vibration IEC 60255-21-2, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 g acceleration (horizontal axis) 8 to 35 Hz: 0.5 g acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes

During transport

Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 g acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 15 g, duration 11 ms, 3 shocks each in both directions 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Half-sinusoidal Acceleration 10 g, duration 16 ms, 1000 shocks in both directions of the 3 axes

Climatic stress test

Temperatures

Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C / -13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	-20 °C to +70 °C / -4 °F to +158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C / +131 °F)	-5 °C to +55 °C / +25 °F to +131 °F
- Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to +131 °F
- Limiting temperature during transport	-25 °C to +70 °C / -13 °F to +158 °F

Humidity	
Permissible humidity stress It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation	Annual average ≤ 75 % relative humidity; on 56 days a year up to 93 % relative humidity; condensation is

Functions

General

Frequency range	11 to 69 Hz
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Definite-time overcurrent protection, directional (ANSI 50, 51, 67)

Setting ranges	
Overcurrent $I>$, $I>>$	0.05 to 20 A (steps 0.01 A); 5 times at $I_N = 5$ A
Time delay T	0 to 60 s (steps 0.01 s) or indefinite
Undervoltage seal-in $V<$	10 to 125 V (steps 0.1 V)
Seal-in time of $V<$	0.1 to 60 s (steps 0.01 s)
Angle of the directional element (at $I>>$)	-90 ° to +90 ° (steps 1 °)
Times	
Pickup time $I>$, $I>>$ at 2 times of set value	Approx. 35 ms
at 10 times of set value	Approx. 25 ms
Drop-off time $I>$, $I>>$	Approx. 50 ms
Drop-off ratio	$I>$: 0.95; $I>>$: 0.9 to 0.99 (steps 0.01)
Drop-off ratio $V<$	Approx. 1.05
Tolerances	
Current pickup (starting) $I>$, $I>>$	1 % of set value or 10/50 mA
Undervoltage seal-in $V<$	1 % of set value or 0.5 V
Angle of the directional element	1 °
Time delays	1 % or 10 ms

Inverse-time overcurrent protection (ANSI 51V)

Setting ranges	
Pickup overcurrent I_P	0.1 to 4 A (steps 0.01 A); 5 times at $I_N = 5$ A
Time multiplier IEC-characteristics T	0.05 to 3.2 s (steps 0.01 s) or indefinite
Time multiplier ANSI-characteristics D	0.5 to 15 (steps 0.01) or indefinite
Undervoltage release $V<$	10 to 125 V (steps 0.1 V)
Trip characteristics	
IEC	Normal inverse; very inverse; extremely inverse
ANSI	Inverse; moderately inverse; very inverse; extremely inverse; definite inverse
Pickup threshold	Approx. 1.1 I_P
Drop-off threshold	Approx. 1.05 I_P for $I_P/I_N \geq 0.3$
Tolerances	
Pickup threshold I_P	1 % of set value or 10/50 mA
Pickup threshold $V<$	1 % of set value or 0.5 V
Time for $2 \leq III_P \leq 20$	5 % of nominal value + 1 % current tolerance or 40 ms

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Technical data

Stator overload protection, thermal (ANSI 49)	
Setting ranges	
Factor k according to IEC 60255-8	0.5 to 2.5 (steps 0.01)
Time constant	30 to 32000 s (steps 1 s)
Time delay factor at stand still	1 to 10 (steps 0.01)
Alarm overtemperature	70 to 100 % related to the trip temperature (steps 1 %)
$\Theta_{Alarm}/\Theta_{Trip}$	0.1 to 4 A (steps 0.01 A); 5 times at $I_N = 5$ A
Overcurrent alarm stage I_{Alarm}	40 to 200 °C (steps 1 °C) or 104 to 392 °F (steps 1 °F)
Temperature at I_N	40 to 300 °C (steps 1 °C) or 104 to 572 °F (steps 1 °F)
Scaling temperature of cooling medium	0.5 to 8 A (steps 0.01), 5 times at $I_N = 5$ A
Limit current I_{Limit}	20 to 150000 s (steps 1 s)
Reset time at emergency start	
Drop-off ratio	
Θ/Θ_{Trip}	Drop-off with Θ_{Alarm}
Θ/Θ_{Alarm}	Approx. 0.99
II_{Alarm}	Approx. 0.95
Tolerances	
Regarding $k \times I_N$	2 % or 10/50 mA; class 2 % according to IEC 60255-8
Regarding trip time	3 % or 1 s: class 3 % according to IEC 60255-8 for $II(k I_N) > 1.25$

Negative-sequence protection (ANSI 46)	
Setting ranges	
Permissible negative sequence $I_2 perm. / I_N$	3 to 30 % (steps 1 %)
Definite time trip stage $I_2 >> I_N$	10 to 200 % (steps 1 %)
Time delays $T_{Alarm}; T_{I_2 >>}$	0 to 60 s (steps 0.01 s) or indefinite
Negative-sequence factor K	1 to 40 s (steps 0.1 s)
Cooling down time $T_{Cooling}$	0 to 50000 s (steps 1 s)
Times	
Pickup time (definite stage)	Approx. 50 ms
Drop-off time (definite stage)	Approx. 50 ms
Drop-off ratios $I_2 perm.; I_2 >>$	Approx. 0.95
Drop-off ratio thermal stage	Drop-off at fall below of $I_2 perm.$
Tolerances	
Pickup values $I_2 perm.; I_2 >>$	3 % of set value or 0.3 % negative sequence
Time delays	1 % or 10 ms
Thermal characteristic	5 % of set point + 1 % current tolerance
Time for $2 \leq I_2 / I_2 perm. \leq 20$	or 600 ms

Underexcitation protection (ANSI 40)	
Setting ranges	
Conductance thresholds 1/xd characteristic (3 characteristics)	0.20 to 3.0 (steps 0.01)
Inclination angle $\alpha_1, \alpha_2, \alpha_3$	50 to 120 ° (steps 1 °)
Time delay T	0 to 50 s (steps 0.01 s) or indefinite
Undervoltage blocking V<	10 to 125 V (steps 0.1 V)
Times	
Stator criterion 1/xd characteristic; α	Approx. 60 ms
Undervoltage blocking	Approx. 50 ms
Drop-off ratio	
Stator criterion 1/xd characteristic; α	Approx. 0.95
Undervoltage blocking	Approx. 1.1
Tolerances	
Stator criterion 1/xd characteristic	3 % of set value
Stator criterion α	1 ° electrical
Undervoltage blocking	1 % or 0.5 V
Time delays T	1 % or 10 ms

Reverse-power protection (ANSI 32R)	
Setting ranges	
Reverse power $P_{Rev.>}/S_N$	- 0.5 to - 30 % (steps 0.01 %)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off time	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off ratio $P_{Rev.>}$	Approx. 0.6
Tolerances	
Reverse power $P_{Rev.>}$	0.25 % $S_N \pm 3$ % set value
Time delays T	1 % or 10 ms

Forward-power protection (ANSI 32F)	
Setting ranges	
Forward power $P_{Forw.<}/S_N$	0.5 to 120 % (steps 0.1 %)
Forward power $P_{Forw.>}/S_N$	1 to 120 % (steps 0.1 %)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time (accurate measuring)	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Pickup time (fast measuring)	Approx. 60 ms (50 Hz); Approx. 50 ms (60 Hz)
Drop-off time (accurate measuring)	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off time (fast measuring)	Approx. 60 ms (50 Hz); Approx. 50 ms (60 Hz)
Drop-off ratio $P_{Forw.<}$	1.1 or 0.5 % of S_N
Drop-off ratio $P_{Forw.>}$	Approx. 0.9 or - 0.5 % of S_N
Tolerances	
Active power $P_{Forw.<}, P_{Forw.>}$	0.25 % $S_N \pm 3$ % of set value at $Q < 0.5 S_N$ at accurate measuring 0.5 % $S_N \pm 3$ % of set value at $Q < 0.5 S_N$ at fast measuring
Time delays T	1 % or 10 ms

Impedance protection (ANSI 21)		Frequency protection (ANSI 81)	
Setting ranges		Setting ranges	
Overcurrent pickup $I>$	0.1 to 20 A (steps 0.01 A); 5 times at $I_N = 5A$	Steps; selectable $f>$, $f<$	4
Undervoltage seal-in $V<$	10 to 125 V (steps 0.1V)	Pickup values $f>$, $f<$	40 to 65 Hz (steps 0.01 Hz)
Impedance Z1 (related to $I_N = 1 A$)	0.05 to 130 Ω (steps 0.01 Ω)	Time delays T	3 stages 0 to 100 s, 1 stage up to 600 s
Impedance Z1B (related to $I_N = 1 A$)	0.05 to 65 Ω (steps 0.01 Ω)	Undervoltage blocking $V_{1<}$	(steps 0.01 s) 10 to 125 V (steps 0.1 V)
Impedance Z2 (related to $I_N = 1 A$)	0.05 to 65 Ω (steps 0.01 Ω)	Times	
Time delays T	0 to 60 s (steps 0.01 s) or indefinite	Pickup times $f>$, $f<$	Approx. 100 ms
Times		Drop-off times $f>$, $f<$	Approx. 100 ms
Shortest tripping time	Approx. 40 ms	Drop-off difference Δf	Approx. 20 mHz
Drop-off time	Approx. 50 ms	Drop-off ratio $V_{1<}$	Approx. 1.05
Drop-off ratio		Tolerances	
Overcurrent pickup $I>$	Approx. 0.95	Frequency	10 mHz (at $V > 0.5 V_N$)
Undervoltage seal-in $V<$	Approx. 1.05	Undervoltage blocking	1 % of set value or 0.5 V
Tolerances		Time delays T	1 % or 10 ms
Overcurrent pickup $I>$	1 % of set value or 10/50 mA	Overexcitation protection (Volt/Hertz) (ANSI 24)	
Undervoltage seal-in $V<$	1 % of set value or 0.5 V	Setting ranges	
Impedance measuring Z1, Z2	$ \Delta Z/Z \leq 5\%$ for $30^\circ \leq \varphi_K \leq 90^\circ$	Pickup threshold alarm stage	1 to 1.2 (steps 0.01)
Time delays T	1 % or 10 ms	Pickup threshold $V/f>>$ -stage	1 to 1.4 (steps 0.01)
Undervoltage protection (definite-time and inverse-time function) (ANSI 27)		Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Setting range		Characteristic values of V/f and assigned times $t(V/f)$	1.05/1.1/1.15/1.2/1.25/1.3/1.35/1.4
Undervoltage pickup $V<$, $V<<$, $V_{p<}$ (positive sequence as phase-to-phase values)	10 to 125 V (steps 0.1 V)	Cooling down time $T_{Cooling}$	0 to 20000 s (steps 1 s) 0 to 20000 s (steps 1 s)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite	Times (Alarm and $V/f>>$ -stage)	
Time multiplier T_M	0.1 to 5 s (steps 0.01 s)	Pickup times at 1.1 of set value	Approx. 60 ms
Times		Drop-off times	Approx. 60 ms
Pickup time $V<$, $V<<$	Approx. 50 ms	Drop-off ratio (alarm, trip)	0.95
Drop-off time $V<$, $V<<$	Approx. 50 ms	Tolerances	
Drop-off ratio $V<$, $V<<$, $V_{p<}$	1.01 or 0.5 V	V/f -pickup	3 % of set value
Tolerances		Time delays T	1 % or 10 ms
Voltage limit values	1 % of set value or 0.5 V	Thermal characteristic (time)	5 % rated to V/f for 600 ms
Time delays T	1 % or 10 ms	90 % stator ground-fault protection, non-directional, directional (ANSI 59N, 64G, 67G)	
Inverse-time characteristic	1 % of measured value of voltage	Setting ranges	
Overvoltage protection (ANSI 59)		Displacement voltage $V_0 >$	2 to 125 V (steps 0.1 V)
Setting ranges		Ground current $3I_0 >$	2 to 1000 mA (steps 1 mA)
Overvoltage pickup $V>$, $V>>$ (maximum phase-to-phase voltage or phase-to-ground voltage)	30 to 170 V (steps 0.1 V)	Angle of direction element	0 to 360 ° (steps 1 °)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite	Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times		Times	
Pickup times $V>$, $V>>$	Approx. 50 ms	Pickup times $V_0 >$, $3I_0 >$	Approx. 50 ms
Drop-off times $V>$, $V>>$	Approx. 50 ms	Drop-off times $V_0 >/ 3I_0 >$	Approx. 50 ms
Drop-off ratio $V>$, $V>>$	0.9 to 0.99 (steps 0.01)	Drop-off ratio $V_0 >$, $3I_0 >$	0.95
Tolerances		Drop-off difference angle	10 ° directed to power system
Voltage limit value	1 % of set value 0.5 V	Tolerances	
Time delays T	1 % or 10 ms	Displacement voltage	1 % of set value or 0.5 V
		Ground current	1 % of set value or 0.5 mA
		Time delays T	1 % or 10 ms

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Technical data

Sensitive ground-fault protection (ANSI 50/51GN, 64R)		Inadvertent energizing protection (ANSI 50, 27)	
Setting ranges		Setting ranges	
Ground current pickup $I_{EE>}$, $I_{EE>>}$	2 to 1000 mA (steps 1 mA)	Current pickup $I_{>>>}$	0.1 to 20 A (steps 0.1 A); 5 times at $I_N = 5$ A
Time delays T	0 to 60 s (steps 0.01 s) or indefinite	Voltage release $V_{1<}$	10 to 125 V (steps 1 V)
Measuring circuit supervision $I_{EE<}$	1.5 to 50 mA (steps 0.1 mA)	Time delay	0 to 60 s (steps 0.01 s) or indefinite
Times		Drop-off time	0 to 60 s (steps 0.01 s) or indefinite
Pickup times	Approx. 50 ms	Times	
Drop-off times	Approx. 50 ms	Reaction time	Approx. 25 ms
Measuring circuit supervision	Approx. 2 s	Drop-off time	Approx. 35 ms
Drop-off ratio $I_{EE>}$, $I_{EE>>}$	0.95 or 1 mA	Drop-off ratio $I_{>>>}$	Approx. 0.8
Drop-off ratio measuring circuit supervision $I_{EE<}$	Approx. 1.1 or 1 mA	Drop-off ratio $V_{1<}$	Approx. 1.05
Tolerances		Tolerances	
Ground current pickup	1 % of set value or 0.5 mA	Current pickup	5 % of set value or 20/100 mA
Time delays T	1 % or 10 ms	Undervoltage seal-in $V_{1<}$	1 % of set value or 0.5 V
		Time delay T	1 % or 10 ms
100 % stator ground-fault protection with 3 rd harmonic (ANSI 59TN, 27TN) (3 rd H.)		Current differential protection (ANSI 87G, 87M, 87T)	
Setting ranges		Setting ranges	
Displacement voltage $V_{0(3^{rd} \text{ harm.})>}$	0.2 to 40 V (steps 0.1 V)	Differential current $I_{D>}I_N$	0.05 to 2 (steps 0.01)
$V_{0(3^{rd} \text{ harm.})<}$		High-current stage $I_{D>>}I_N$	0.8 to 12 (steps 0.1)
Time delay T	0 to 60 s (steps 0.01 s) or indefinite	Inrush stabilization ratio I_{2fN}/I_N	10 to 80 (steps 1 %)
Active-power release	10 to 100 % (steps 1 %) or indefinite	Harmonic stabilization ratio I_{nfN}/I_N ($n = 3^{rd}$ or 4 th or 5 th harmonics)	10 to 80 (steps 1 %)
Positive-sequence voltage release	50 to 125 V (steps 0.1 V) or indefinite	Additional trip time delay T	0 to 60 s (steps 0.01 s) or indefinite
Times		Times	
Pickup time	Approx. 80 ms	Pickup time ($I_D \geq 1.5$ setting value $I_{D>}$)	Approx. 35 ms
Drop-off time	Approx. 80 ms	Pickup time ($I_D \geq 1.5$ setting value $I_{D>>}$)	Approx. 20 ms
Drop-off ratio		Drop-off time	Approx. 35 ms
Undervoltage stage $V_{0(3^{rd} \text{ harm.})<}$	Approx. 1.4	Drop-off ratio	Approx. 0.7
Overvoltage stage $V_{0(3^{rd} \text{ harm.})>}$	Approx. 0.6	Tolerances	
Active-power release	Approx. 0.9	Pickup characteristic	3 % of set value or 0.01 I/I_N
Positive-sequence voltage release	Approx. 0.95	Inrush stabilization	3 % of set value or 0.01 I/I_N
Tolerances		Additional time delays	1 % or 10 ms
Displacement voltage	3 % of set value or 0.1 V		
Time delay T	1 % or 10 ms		
Breaker failure protection (ANSI 50BF)		Ground-current differential protection (ANSI 87GN, 87TN)	
Setting ranges		Setting ranges	
Current thresholds $I_{>BF}$	0.04 to 1 A (steps 0.01 A)	Differential current $I_{E-D} > I_N$	0.01 to 1 (steps 0.01)
Time delay BF-T	0.06 to 60 s (steps 0.01 s) or indefinite	Additional trip time delay	0 to 60 s (steps 0.01 s) or indefinite
Times		Times	
Pickup time	Approx. 50 ms	Pickup time ($I_{E-D} \geq 1.5$ setting value $I_{E-D >}$)	Approx. 50 ms
Drop-off time	Approx. 50 ms	Drop-off time	Approx. 50 ms
Tolerances		Drop-off ratio	Approx. 0.7
Current threshold $I_{>BF}/I_N$	1 % of set value or 10/50 mA	Tolerances	
Time delay T	1 % or 10 ms	Pickup characteristic	3 % of set value
		Additional time delay	1 % or 10 ms

Rotor ground-fault protection with f_N (ANSI 64R) (f_N)	
Setting ranges	
Alarm stage $R_{E, Alarm <}$	3 to 30 k Ω (steps 1 k Ω)
Trip stage $R_{E, Trip <}$	1.0 to 5 k Ω (steps 0.1 k Ω)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Correction angle	- 15 ° to + 15 ° (steps 1 °)
Times	
Pickup time	\leq 80 ms
Drop-off time	\leq 80 ms
Drop-off ratio	Approx. 1.25
Tolerances	
Trip stage $R_{E, Trip <}$,	Approx. 5 % of set value
Alarm stage $R_{E, Alarm <}$	Approx. 10 % of set value
Time delays T	1 % or 10 ms
Permissible rotor ground capacitance	0.15 to 3 μ F
Sensitive rotor fault protection with 1 to 3 Hz (ANSI 64R) (1 to 3 Hz)	
Setting ranges	
Alarm stage $R_{E, Alarm <}$	5 to 80 k Ω (steps 1 k Ω)
Trip stage $R_{E, Trip <}$	1 to 10 k Ω (steps 1 k Ω)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Pickup value of meas. circuit supervision $Q_C <$	0.01 to 1 mA (steps 0.01 mA)
Times	
Pickup time	Approx. 1 to 1.5 s (depends on frequency of 7XT71)
Drop-off time	Approx. 1 to 1.5 s
Drop-off ratio R_E	Approx. 1.25
Drop-off ratio $Q_C <$	1.2 or 0.01 mA
Tolerances	
Trip stage ($R_{E, Trip <}$; Alarm stage $R_{E, Alarm <}$)	Approx. 5 % or 0.5 k Ω at 1 μ F \leq CE < 1 μ F Approx. 10 % or 0.5 k Ω at 1 μ F \leq CE < 3 μ F
Time delays T	1 % or 10 ms
Permissible rotor ground-capacitance	0.15 to 3 μ F
100 % stator ground-fault protection with 20 Hz (ANSI 64G) (100 %)	
Setting ranges	
Alarm stage $R_{SEF <}$	20 to 500 Ω (steps 1 Ω)
Trip stage $R_{SEF <<}$	10 to 300 Ω (steps 1 Ω)
Ground current stage $I_{SEF >}$	0.02 to 1.5 A (steps 0.01 A)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Supervision of 20 Hz generator $V_{20 Hz}$	0.3 to 15 V (steps 0.1 V)
$I_{20 Hz}$	5 to 40 mA (steps 1 mA)
Correction angle	- 60 ° to + 60 ° (steps 1 °)
Times	
Pickup times $R_{SEF <}$, $R_{SEF <<}$	\leq 1.3 s
Pickup time $I_{SEF >}$	\leq 250 ms
Drop-off times $R_{SEF <}$, $R_{SEF <<}$	\leq 0.8 s
Drop-off time $I_{SEF >}$	\leq 120 ms
Drop-off ratio	Approx. 1.2 to 1.7
Tolerances	
Resistance (R_{SEF})	ca. 5 % or 2 Ω
Ground current stage ($I_{SEF >}$)	3 % or 3 mA
Time delays T	1 % or 10 ms

Out-of-step protection (ANSI 78)	
Setting ranges	
Positive sequence current pickup $I_{1 >}$	0.2 to 4 I_1/I_N (steps 0.1 I_1/I_N)
Negative-sequence current pickup $I_{2 <}$	0.05 to 1 I_2/I_N (steps 0.01 I_2/I_N)
Impedances Z_a to Z_d (based on $I_N = 1$ A)	0.05 to 130 Ω (steps 0.01 Ω)
Inclination angle of polygon φ_P	60 to 90 ° (steps 1 °)
Number of out-of-step periods characteristic 1	1 to 10
Number of out-of-step periods characteristic 2	1 to 20
Holding time of pickup t_H	0.2 to 60 s (steps 0.01 s)
Holding time for out-of-step annunciation	0.02 to 0.15 s (steps 0.01 s)
Times	
Typical trip time	Depending from the out-of-step frequency
Tolerances	
Impedance measurement	$ \Delta Z/Z \leq 5 \%$ for $30^\circ \leq \varphi_{SC} \leq 90^\circ$ or 10 m Ω
Time delays T	1 % to 10 ms
DC voltage time / DC current time protection (ANSI 59N (DC) ; 51N (DC))	
Setting ranges	
Voltage pickup $V = >, <$	0.1 to 8.5 V (steps 0.1 V)
Current pickup $I = >, <$	0.2 to 17 mA (steps 0.1 mA)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time (operational condition 1)	Approx. 60 ms
Pickup time (operational condition 0)	Approx. 200 ms
Drop-off time	Approx. 60 ms or 200 ms
Drop-off ratio	0.9 or 1.1
Tolerances	
Voltage	1 % of set value, or 0.1 V
Current	1 % of set value, or 0.1 mA
Time delays T	1 % or 10 ms
Starting time supervision for motors (ANSI 48)	
Setting ranges	
Motor starting current $T_{Start max} I/I_N$	1.0 to 16 (steps 0.01)
Starting current pickup $I_{Start, pickup} I/I_N$	0.6 to 10 (steps 0.01)
Permissible starting time $T_{Start max}$	1.0 to 180 s (steps 0.1 s)
Permissible locked rotor time $T_{Blocking}$	0.5 to 120 s (steps 0.1 s) or indefinite
Times	Depending on the settings
Drop-off ratio	Approx. 0.95
Tolerances	
Current threshold	1 % of set value, or 1 % of I_N
Time delays T	5 % or 30 ms

Generator Protection/7UM62

Technical data

Restart inhibit for motors (ANSI 66, 49 Rotor)		Interturn protection (ANSI 59N(IT))	
Setting ranges		Setting ranges	
Motor starting current $I_{Start\ max} / I_N$	3.0 to 10.0 (steps 0.01)	Displacement voltage $V_{Interturn>}$	0.3 to 130 V (steps 0.1 V)
Permissible starting time $T_{Start\ max}$	3.0 to 120.0 s (steps 0.1 s)	Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Rotor temperature equalization time $T_{Equali.}$	0 to 60.0 min (steps 0.1 min)	Times	
Minimum restart inhibit time $T_{Restart, min}$	0.2 to 120.0 min (steps 0.1 min)	Pick-up times $V_{Interturn>}$	Approx. 60 ms
Permissible number of warm starts n_W	1 to 4	Drop-off times $V_{Interturn>}$	Approx. 60 ms
Difference between warm and cold starts $n_K - n_W$	1 to 2	Drop-off ratio $V_{Interturn>}$	0.5 to 0.95 adjustable
Extensions of time constants (running and stop)	1.0 to 100.0	Tolerances	
Tolerances	1 % or 0.1 ms	Displacement voltage	1 % of set value or 0.5 V
Time delays T		Time delays T	1 % of set value or 10 ms
Rate-of-frequency-change protection (ANSI 81R)		Incoupling of temperature via serial interface (thermo-box) (ANSI 38)	
Setting ranges		Number of measuring sensors	6 or 12
Steps, selectable $+df/dt >$; $-df/dt$	4	Temperature thresholds	40 to 250 °C or 100 to 480 °F (steps 1 °C or 1 °F)
Pickup value df/dt	0.2 to 10 Hz/s (steps 0.1 Hz/s);	Sensors types	Pt100; Ni 100, Ni 120
Time delays T	0 to 60 s (steps 0.01 s) or indefinite	External trip coupling	
Undervoltage blocking $V_{1<}$	10 to 125 V (steps 0.1 V)	Number of external trip couplings	4
Times		Threshold supervision	
Pickup times df/dt	Approx. 200 ms	Setting ranges	
Drop-off times df/dt	Approx. 200 ms	Threshold of measured values	$MV_{1>}$ to $MV_{10<}$
Drop-off ratio df/dt	Approx. 0.95 or 0.1 Hz/s	Assignable measured values	-200 % to +200 % (steps 1 %) P , active power Q , reactive power change of active power ΔP Voltage V_{L1} , V_{L2} , V_{L3} , V_E , V_0 , V_1 , V_2 , V_{E3h} Current $3I_0$, I_1 , I_2 , I_{EE1} , I_{EE2} Power angle φ Power factor $\cos \varphi$ Value at TD1
Drop-off ratio $V<$	Approx. 1.05	Times	
Tolerances		Pick-up times	Approx. 20 – 40 ms
Rate-of-frequency change	Approx. 0.1 Hz/s at $V > 0.5 V_N$	Drop-off times	Approx. 20 – 40 ms
Undervoltage blocking	1 % of set value or 0.5 V	Drop-off to pick-up ratio	
Time delays T	1 % or 10 ms	Threshold $MV_{x>}$	0.95
Vector jump supervision (voltage)		Threshold $MV_{x<}$	1.05
Setting ranges		Trip circuit supervision (ANSI 74TC)	
Stage $\Delta\varphi$	0.5 ° to 15 ° (steps 0.1 °)	Number of supervised trip circuits	1
Time delay T	0 to 60 s (steps 0.01 s) or indefinite		
Undervoltage blocking $V_{1<}$	10 to 125 V (steps 0.1 V)		
Tolerances			
Vector jump	0.3 ° at $V > 0.5 V_N$		
Undervoltage blocking	1 % of set value or 0.5 V		
Time delay T	1 % or 10 ms		
Sensitive ground-fault protection B (ANSI 51GN)			
Setting ranges			
Ground current $I_{EE-B>}$,	0.3 to 1000 mA (steps 0.1 A)		
Ground current $I_{EE-B<}$,	0.3 to 500 mA (steps 0.1 mA)		
Time delays T	0 to 60 s (steps 0.01 s) or indefinite		
Measuring method	- Fundamental, - 3 rd harmonica - 1 ^{rst} and 3 rd harmonics		
Times			
Pick-up times	Approx. 50 ms		
Drop-off times	Approx. 50 ms		
Drop-off ratio $I_{EE-B>}$	0.90 or 0.15 mA		
Drop-off ratio $I_{EE-B<}$	1.1 or 0.15 mA		
Tolerances			
Ground current	1 % of set value or 0.1 mA		
Time delays T	1 % of set value or 10 ms		

Operational measured values	
Description	Primary; secondary or per unit (%)
Currents	$I_{L1, S1}; I_{L2, S1}; I_{L3, S1}; I_{L1, S2}; I_{L2, S2}; I_{L3, S2}; I_{EE1}; I_{EE2}; I_1; I_2; I_{20Hz}$
Tolerance	0.2 % of measurement values or $\pm 10 \text{ mA} \pm 1 \text{ digit}$
Differential protection currents	$I_{DiffL1}; I_{DiffL2}; I_{DiffL3}; I_{RestL1}; I_{RestL2}; I_{RestL3}$
Tolerances	0.1 % of measured or $\pm 10 \text{ mA} \pm 1 \text{ digit}$
Phase angles of currents	$\varphi I_{L1, S1}; \varphi I_{L2, S1}; \varphi I_{L3, S1}; \varphi I_{L1, S2}; \varphi I_{L2, S2}; \varphi I_{L3, S2};$ $< 0.5^\circ$
Tolerances	
Phase angles of currents	
Tolerances	
Voltages	$V_{L1}; V_{L2}; V_{L3}; V_E; V_{L12}; V_{L23}; V_{L31}; V_1; V_2; V_{20 \text{ Hz}}$
Tolerance	0.2 % of measured values or $\pm 0.2 \text{ V} \pm 1 \text{ digit}$
Impedance	R, X
Tolerance	1 %
Power	$S; P; Q$
Tolerance	1 % of measured values or $\pm 0.25 \% S_N$
Phase angle	φ
Tolerance	$< 0.1^\circ$
Power factor	$\cos \varphi$ (p.f.)
Tolerance	1 % $\pm 1 \text{ digit}$
Frequency	f
Tolerance	10 mHz (at $V > 0.5 V_N$; $40 \text{ Hz} < f < 65 \text{ Hz}$)
Overexcitation	V/f ;
Tolerance	1 %
Thermal measurement	$\Theta_{L1}; \Theta_{L2}; \Theta_{L3}; \Theta_{I2}; \Theta_{V/f}, \text{ sensors}$
Tolerance	5 %
Min./max.memory	
Memory	Measured values with date and time
Reset manual	Via binary input Via key pad Via communication
Values	
Positive sequence voltage	V_1
Positive sequence current	I_1
Active power	P
Reactive power	Q
Frequency	f
Displacement voltage (3 rd harmonics)	$V_{E(3^{rd} \text{ harm.})}$
Energy metering	
Meter of 4 quadrants	$W_{P+}; W_{P-}; W_{Q+}; W_{Q-}$
Tolerance	1 %
Analog outputs (optional)	
Number	max. 4 (depending on variant)
Possible measured values	$I_1, I_2, I_{EE1}, I_{EE2}, V_1, V_0, V_{03h}, P , Q , S , \cos \varphi , f, V/f, \varphi, \Theta_S/\Theta_S \text{ Trip}, \Theta_{Rotor}/\Theta_{Rotor \text{ Trip}}, R_E, REF; R_E, REF 1-3Hz; R_{E \text{ SEF}}$
Range	0 to 22.5 mA
Minimum threshold (limit of validity)	0 to 5 mA (steps 0.1 mA)
Maximum threshold	22 mA (fixed)
Configurable reference value 20 mA	10 to 1000 % (steps 0.1 %)

Fault records	
Number of fault records	Max. 8 fault records
Instantaneous values	Max. 5 s
Storage time	Depending on the actual frequency
Sampling interval	(e. g. 1.25 ms at 50 Hz; 1.04 ms at 60 Hz)
Channels	$V_{L1}, V_{L2}, V_{L3}, V_E; i_{L1, S1}; i_{L2, S1}; i_{L3, S1}; i_{EE1}; i_{L1, S2}; i_{L2, S2}; i_{L3, S2}; i_{EE2}; TD1; TD2; TD3$
R.m.s. values	
Storage period	Max. 80 s
Sampling interval	Fixed (20 ms at 50 Hz; 16.67 ms at 60 Hz)
Channels	$V_1, V_E, I_1, I_2, I_{EE1}, I_{EE2}, P, Q, \varphi, R, X, f-f_n$
Additional functions	
Fault event logging	Storage of events of the last 8 faults Puffer length max. 600 indications Time solution 1 ms
Operational indications	Max. 200 indications Time solution 1 ms
Elapsed-hour meter	Up to 6 decimal digits (criterion: current threshold)
Switching statistics	Number of breaker operation Phase-summed tripping current

CE conformity	
This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EEC previous 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 2006/95/EEC previous 73/23/EEC).	
This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).	
The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.	
This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".	

Generator Protection/7UM62

Selection and ordering data

Description	Order No.	Order code
7UM62 multifunction generator, motor and transformer protection relay	7UM62	0
Housing, binary inputs and outputs		
Housing ½ 19", 7 BI, 12 BO, 1 live status contact	1	Continued on next page
Housing ¼ 19", 15 BI, 20 BO, 1 live status contact	2	
Graphic display, ½ 19", 7 BI, 12 BO, 1 live status contact	3	
Current transformer I_N		
1 A ¹⁾ , I _{EE} (sensitive)	1	
5 A ¹⁾ , I _{EE} (sensitive)	5	
Rated auxiliary voltage (power supply, indication voltage)		
DC 24 to 48 V, threshold binary input 19 V ³⁾	2	
DC 60 to 125 V ²⁾ , threshold binary input 19 V ³⁾	4	
DC 110 to 220 V ²⁾ , AC 115 V/230 V, threshold binary input 88 V ³⁾	5	
DC 220 to 250 V, AC 115 V/230 V, threshold binary input 176 V	6	
Unit version		
For panel surface-mounting, 2 tier screw-type terminals top/bottom	B	
For panel flush-mounting, plug-in terminals (2-/3- pin connector)	D	
Flush-mounting housing, screw-type terminal (direct connection, ring-type cable lugs)	E	
Region-specific default setting /function and language settings		
Region DE, 50 Hz, IEC characteristics, language: German, (language can be selected)	A	
Region World, 50/60 Hz, IEC/ANSI characteristics, language: English (UK), (language can be selected)	B	
Region US, 60 Hz, ANSI characteristics, language: English (US), (language can be selected)	C	
Port B (System interface)		
No system interface	0	
IEC 60870-5-103 protocol, electrical RS232	1	
IEC 60870-5-103 protocol, electrical RS485	2	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	3	
Analog output 2 x 0 to 20 mA	7	
PROFIBUS-DP slave, electrical RS485	9	L O A
PROFIBUS-DP slave, optical 820 nm, double ring, ST connector*	9	L O B
MODBUS, electrical RS485	9	L O D
MODBUS, optical 820 nm, ST connector*	9	L O E
DNP 3.0, electrical RS485	9	L O G
DNP 3.0, optical 820 nm, ST connector*	9	L O H
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connectors	9	L O R
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector ⁴⁾	9	L O S
Only Port C (Service interface)		
DIGSI 4 /modem, electrical RS232	1	
DIGSI 4 /modem, temperature monitoring box, electrical RS485	2	
Port C (Service interface) and Port D (Additional interface)	9	M □ □
Port C (Service interface)		
DIGSI 4 /modem, electrical RS232		1
DIGSI 4 /modem, temperature monitoring box, electrical RS485		2
Port D (Additional interface)		
Temperature monitoring box, optical 820 nm, ST connector		A
Temperature monitoring box, electrical RS485		F
Analog outputs 2 x 0 to 20 mA		K

- 1) Rated current can be selected by means of jumpers.
- 2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.
- 3) The binary input thresholds can be selected in stages by means of jumpers.

4) Not available with position 9 = "B"

* Not with position 9 = B; if 9 = "B", please order 7UM62 unit with RS485 port and separate fiber-optic converters.

Description	Order No.
7UM62 multifunction generator, motor and transformer protection relay	7UM62□□-□□□□□-□□□□0
Measuring functions	
Without extended measuring functions	0
Min./max. values, energy metering	3
Function	
Generator Basic	A
Generator Standard	B
Generator Full	C
Asynchronous Motor	F
Transformer	H
Functions (additional functions)	
Without	A
Sensitive rotor ground-fault protection and 100 % stator ground-fault protection	B
Restricted ground-fault protection	C
Network decoupling (df/dt and vector jump)	E
All additional functions	G






1) For more detailed information on the functions see Table 11/3.

Accessories	Description	Order No.
	DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper) Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
	Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
	Professional + IEC 61850 Complete version DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	7XS5403-0AA00
	IEC 61850 System configurator Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM	7XS5460-0AA00
	SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000/XP Professional Edition Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	7XS5410-0AA00

Generator Protection/7UM62

Selection and ordering data

Accessories	Description	Order No.
	Connecting cable Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	7XV5100-4
	Cable between thermo-box and relay – length 5 m/5.5 yd	7XV5103-7AA05
	– length 25 m/27.3 yd	7XV5103-7AA25
	– length 50 m/54.7 yd	7XV5103-7AA50
	Coupling device for rotor ground-fault protection	7XR6100-0CA00
	Series resistor for rotor ground-fault protection (group: 013002)	Short code 3PP1336-0DZ K2Y
	Resistor for underexcitation protection (voltage divider, 20:1) (group: 012009)	3PP1326-0BZ K2Y
	Resistor for stator ground-fault protection (voltage divider, 5:1) (group 013001)	3PP1336-1CZ K2Y
	20 Hz generator	7XT3300-0CA00
	20 Hz band pass filter	7XT3400-0CA00
	Current transformer (400 A/5 A, 5 VA)	4NC5225-2CE20
	Controlling unit f. rotor ground-fault protection (0.5 to 4Hz)	7XT7100-0EA00
	Resistor for 1 to 3 Hz rotor ground-fault protection	7XR6004-0CA00
	Temperature monitoring box (thermo-box) AC/DC 24 to 60 V	7XV5662-2AD10
	AC/DC 90 to 240 V	7XV5662-5AD10

Accessories	Description	Order No.	Size of package	Supplier	Fig.
 Fig. 11/60 Mounting rail for 19" rack	Connector	2-pin 3-pin	1 1	Siemens Siemens	11/61 11/62
 Fig. 11/61 2-pin connector	Crimp connector	CI2 0.5 to 1 mm ²	4000 1	AMP ¹⁾ AMP ¹⁾	
 Fig. 11/62 3-pin connector		CI2 0.5 to 2.5 mm ²	4000 1	AMP ¹⁾ AMP ¹⁾	
	Crimping tool	Type III+ 0.75 to 1.5 mm ²	4000 1	AMP ¹⁾ AMP ¹⁾	
		For type III+ and matching female	1 1	AMP ¹⁾ AMP ¹⁾	
 Fig. 11/63 Short-circuit link for current contacts	Safety cover for terminals	large	1	Siemens	11/35
 Fig. 11/64 Short-circuit link for voltage contacts/indications contacts		small	1	Siemens	11/35

1) Your local Siemens representative can inform you on local suppliers.

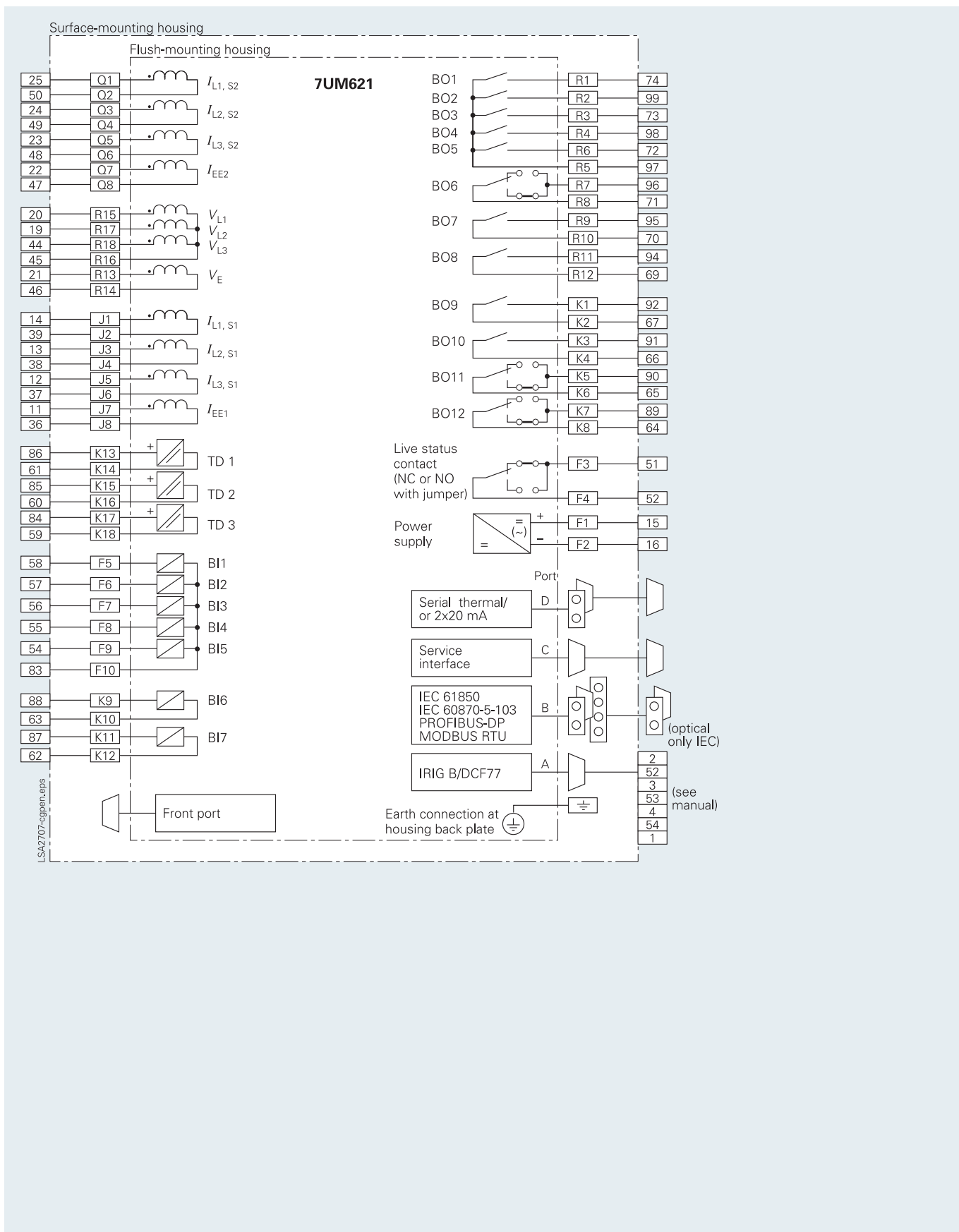


Fig. 11/65 7UM621 and 7UM623 connection diagram (IEC standard)

Generator Protection/7UM62

Connection diagram, IEC

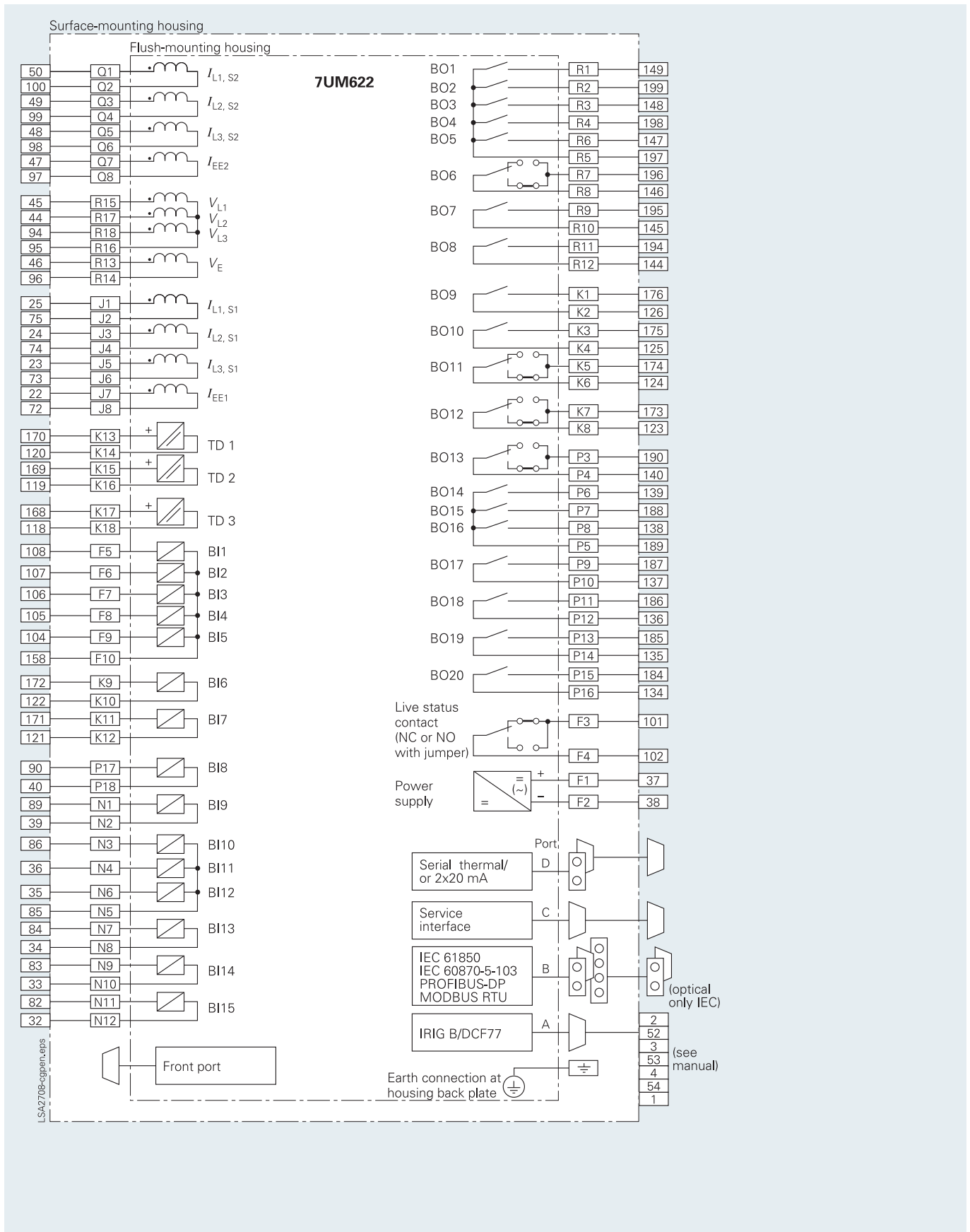


Fig. 11/66 7UM622 connection diagram (IEC standard)

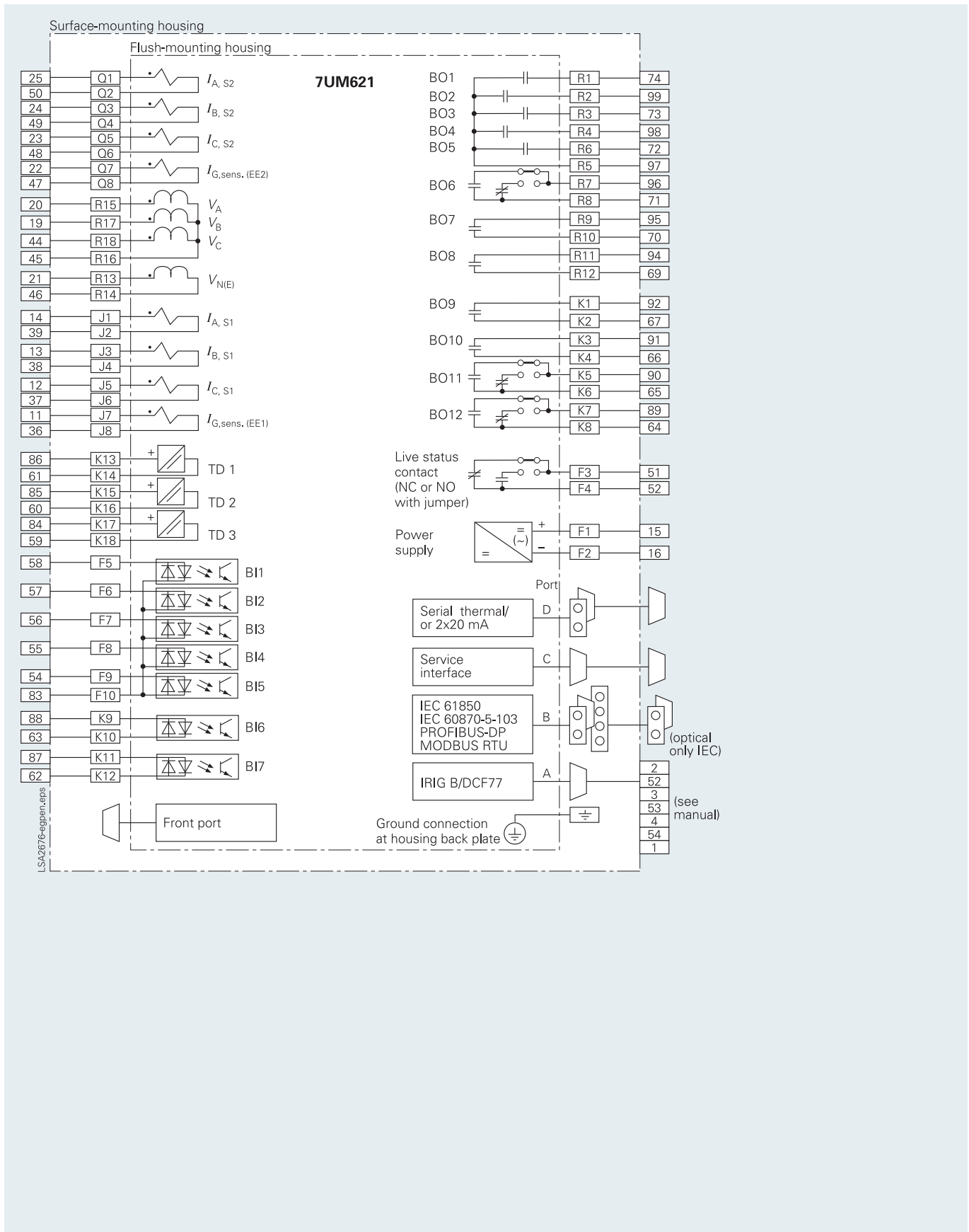


Fig. 11/67 7UM621 and 7UM623 connection diagram (ANSI standard)

Generator Protection/7UM62

Connection diagram, ANSI

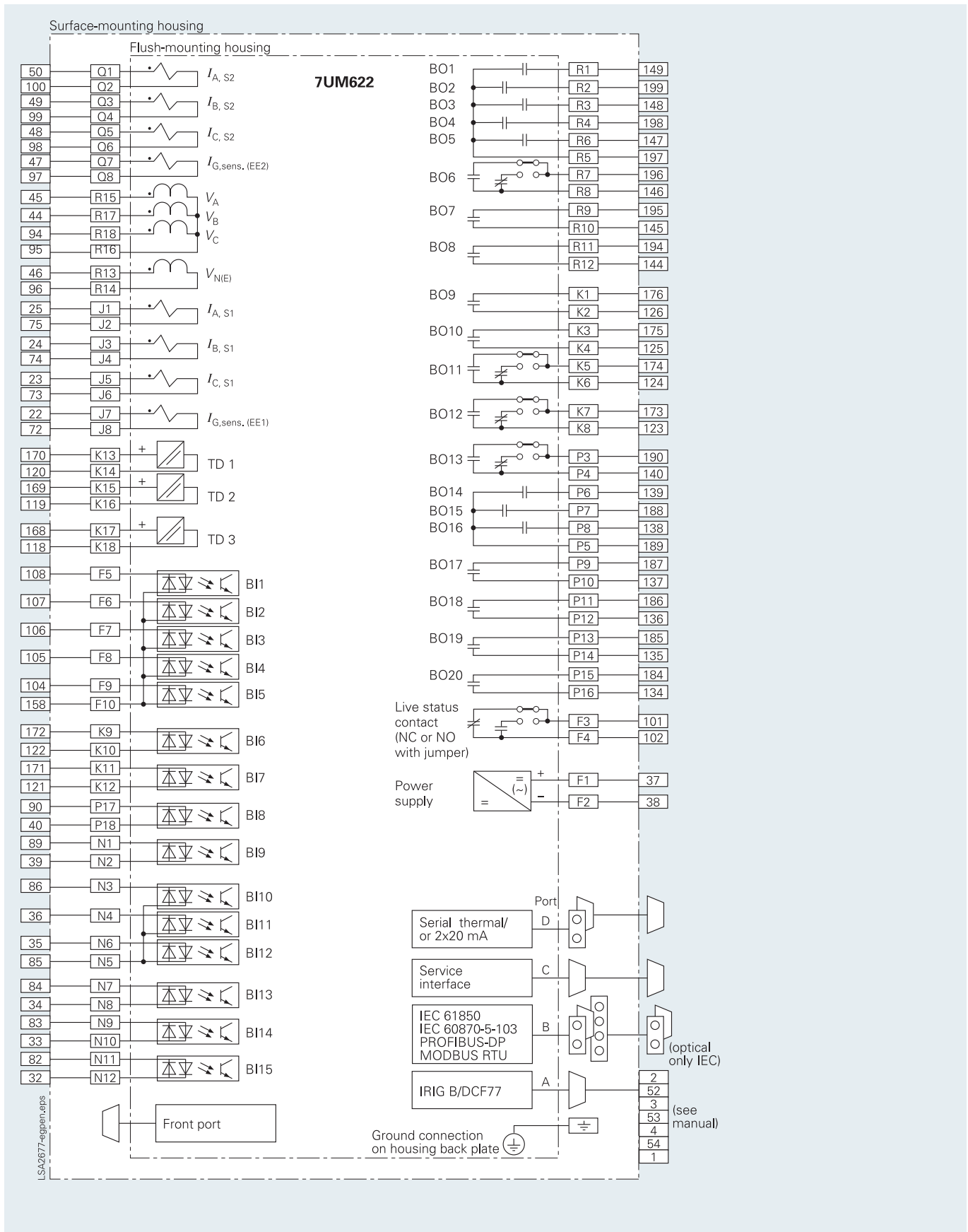


Fig. 11/68 7UM62 connection diagram (ANSI standard)



Fig. 11/69 SIPROTEC 7UW50 tripping matrix

Function overview

Functions

- Hardware tripping matrix
- 28 inputs
- 10 outputs
- One LED is assigned to each input and output

Features

- Easy marshalling of trip signals via diode plugs
- Plexiglass cover prevents unauthorized marshalling

Description

The tripping matrix 7UW50 is a component of the Siemens numerical generator protection system. The tripping matrix provides a transparent, easily programmable facility for combining output commands of the trip outputs of individual protection devices with plant items such as the circuit-breakers, de-excitation etc. The matrix was developed for marshalling tripping commands of large power stations.

With its help, the tripping schematic can be temporarily changed, e.g., on the basis of a generator circuit-breaker revision. If the software matrix incorporated in each generator protection unit is used for marshalling the tripping commands, the marshalling in the protection units must be changed for this purpose.

Generator Protection/7UW50

Selection and ordering data

Description	Order No.
7UW50 tripping matrix	7UW5000-□□A00
Rated auxiliary voltage	
DC 60 V, 110 V, 125 V	4
DC 220 V, 250 V	5
Unit design	
For panel surface-mounting	B
For panel flush-mounting or cubicle mounting	C



Fig. 11/70 SIPROTEC 7RW600 numerical voltage, frequency and overexcitation protection relay

Description

The SIPROTEC 7RW600 is a numerical multifunction protection relay for connection to voltage transformers. It can be used in distribution systems, on transformers and for electrical machines. If the SIPROTEC 7RW600 detects any deviation from the permitted voltage, frequency or overexcitation values, it will respond according to the values set. The SIPROTEC 7RW600 can be used for the purposes of system decoupling and for load shedding if ever there is a risk of a system collapse as a result of inadmissibly large frequency drops. Voltage and frequency thresholds can also be monitored.

The SIPROTEC 7RW600 voltage, frequency and overexcitation relay can be used to protect generators and transformers in the event of defective voltage control, of defective frequency control, or of full load rejection, or furthermore islanding generation systems.

This device is intended as a supplement to Siemens substation systems and for use in individual applications. It has two voltage inputs (V ; V_x) to which a variety of functions have been assigned. While input V serves all of the implemented functions, input V_x is exclusively dedicated to the voltage protection functions. The scope of functions can be selected from three ordering options.

Function overview

Line protection

- Voltage protection
- Frequency protection

Generator protection

- Voltage protection
- Frequency protection
- Overexcitation protection

Transformer protection

- Voltage protection
- Overexcitation protection

Power system decoupling

- Voltage protection
- Frequency protection

Load shedding

- Frequency protection
- Rate-of-frequency-change protection

Status measured values

Monitoring functions

- Hardware
- Software
- Event logging
- Fault recording
- Continuous self-monitoring

Hardware

- Auxiliary voltages:
 - DC 24, 48 V
 - DC 60, 110, 125 V
 - DC 220, 250 V, AC 115 V
- Local operation
- LCD for setting and analysis
- Housing for
 - Flush-mounting 1/6 19-inch 7XP20;
 - Surface-mounting 1/6 19-inch 7XP20

Communication ports

- Personal computer
- Via RS485↔RS232 converter
- Via modem
- SCADA
 - IEC 60870-5-103 protocol
- Bus-capable

Generator Protection/7RW600

Application

Application

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The SIPROTEC 7RW600 voltage, frequency and overexcitation relay can be used to protect generators and transformers in the event of defective voltage control, of defective frequency control, or of full load rejection, or furthermore islanding generation systems.

ANSI	IEC	Protection functions
27	$V < t; t = f(V <)$	Undervoltage protection
59/59N	$V >> t; V > t$	Overtension protection
81/81R	$f >; f <; \left \frac{df}{dt} \right >; + \frac{df}{dt}$	Frequency protection, rate-of-frequency change protection
24	$\frac{V}{f} >; t; \frac{V}{f} = f(t)$	Overexcitation protection

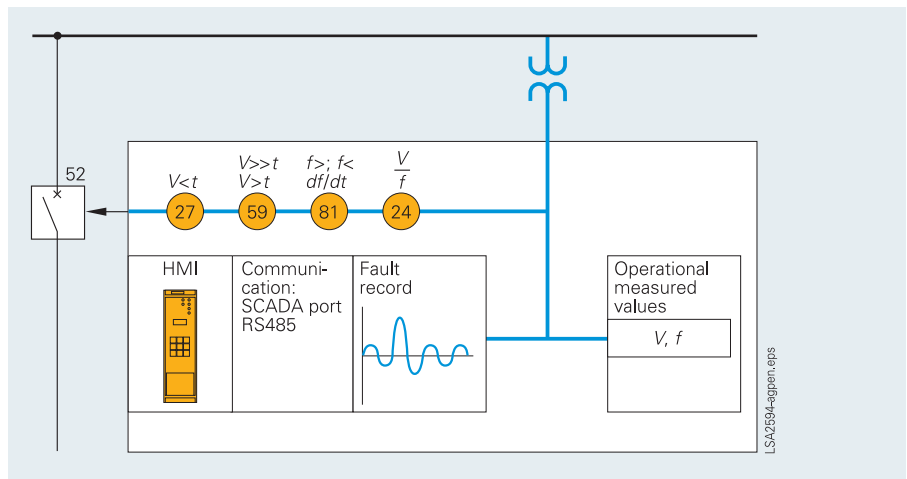


Fig. 11/71 Function diagram

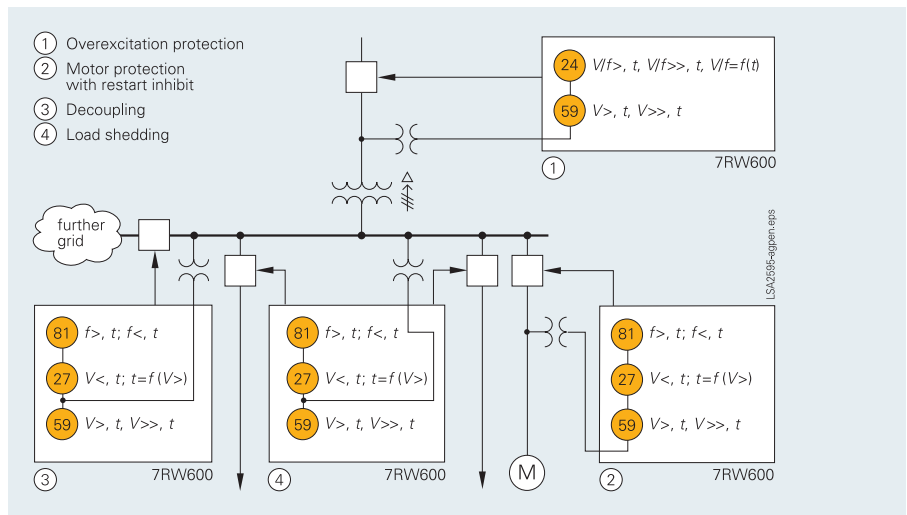


Fig. 11/72



Fig. 11/73 Rear view of surface-mounting housing

Construction

The SIPROTEC 7RW600 relay contains, in a compact form, all the components needed for:

- Acquisition and evaluation of measured values
- Operation and display
- Output of messages, signals and commands
- Input and evaluation of binary signals
- Data transmission (RS485) and
- Auxiliary voltage supply.

The SIPROTEC 7RW600 receives AC voltages from the primary voltage transformer. The secondary rated voltage range, 100 to 125 V, is adapted internally on the device.

There are two device variants available:

- The first version, for panel flush mounting or cubicle mounting, has its terminals accessible from the rear.
- The second version for panel surface mounting, has its terminals accessible from the front.

Protection functions

Overvoltage protection

The overvoltage protection has the function of detecting inadmissible overvoltages in power systems and electrical machines and, in such event, it initiates system decoupling or shuts down the generators.

Two voltage measuring inputs (V , V_x) are provided on the unit. These must be connected to two phase-to-phase voltages. The input voltages are processed separately in two two-stage protective functions. From these, two principle connection variants are derived.

Fig. 11/76, Fig. 11/77, and Fig. 11/78, on page 11/75, show the following connection examples:

Fig. 11/76: Separated connection, used for overvoltage protection and ground-fault detection

Fig. 11/77: Two-phase connection to a voltage transformer

Fig. 11/78: Alternative V connection

Undervoltage protection

The main function of the undervoltage protection is protecting electrical machines (e.g. pumped-storage power generators and motors) against the consequences of dangerous voltage drops. It separates the machines from the power system and thus avoids inadmissible operating states and the possible risk of stability loss. This is a necessary criterion in system decoupling.

To ensure that the protection functions in a physically correct manner, when used in conjunction with electrical machines, the positive-sequence system must be evaluated.

The protection function can be blocked, via a binary input, causing a drop in energizing power. The auxiliary contact of the circuit-breaker can be used for this purpose with the circuit-breaker open. Alternatively, undervoltage acquisition can be activated on a conductor-separated basis ($V < V_x$).

Additionally, it is possible to use an inverse-time undervoltage protection function for motor protection. The tripping time depends in the undervoltage drop. A time grading is possible.

Frequency protection

The frequency protection can be used to protect against overfrequency or against underfrequency. It protects electrical machines and plants/substations against adverse effects in the event of deviations in the rated speed (e.g. vibration, heating, etc.), detects and records frequency fluctuations in the power system, and disconnects certain loads according to the thresholds set. It can also be used for the purposes of system decoupling, and thus improves the availability of in-plant power generation.

The frequency protection function is implemented via voltage input V . From the sampled voltage, the frequency is measured by means of various filter functions. The system thus remains unaffected by harmonics, ripple control frequencies and other disturbances.

The frequency protection function operates over a wide frequency range (25 – 70 Hz).

It is implemented (optionally for overfrequency or for underfrequency) on a four-stage basis; each stage can be individually delayed. The frequency stages can be blocked either via the binary input or by an undervoltage stage.

Rate-of-frequency-change protection

The rate-of-frequency-change protection calculates, from the measured frequency, the gradient of frequency change df/dt . It is thus possible to detect and record any major active power overloading in the power system, to disconnect certain consumers accordingly, and to restore the system to stability. Unlike frequency protection, rate-of-frequency-change protection already reacts before the frequency threshold is undershot. To ensure effective protection settings, power system studies are recommended. The rate-of-frequency-change protection function can also be used for the purposes of system decoupling.

The rate-of-frequency-change protection function is implemented on a four-stage basis; each stage can be individually delayed. It detects and records any negative or positive frequency gradient. The measured result is generally released as soon as the rated frequency is undershot or overshot.

Rate-of-frequency-change protection can also be enabled by an underfrequency or overfrequency stage.

Generator Protection/7RW600

Protection functions, features

Protection functions

Overexcitation protection

The overexcitation protection detects and records any inadmissibly high induction

$$(B \sim \frac{V}{f})$$

in electrical equipment, e.g. generators or transformers, that may occur as a result of a voltage increase and/or frequency drop. Increased induction of this nature may lead to saturation of the iron core, excessive eddy current losses, and thus to inadmissible heating.

It is recommended to use the overexcitation protection function in power systems subject to large frequency fluctuations (e.g. systems in island configuration or with weak infeed) and for electrical block units that are separated from the system.

The overexcitation protection function calculates, from the maximum voltage (V, V_x) and the frequency, the ratio V/f . This function incorporates an independent warning and tripping stage and a curve which is dependent on and adaptable to the object to be protected and which takes due account of the object's thermal behavior. Incorrect adaptation of the voltage transformer is also corrected. The overexcitation protection function is effective over a broad frequency range (25 to 70 Hz) and voltage range (10 to 170 V). The overexcitation protection function can be blocked and the thermal store can be reset separately via binary inputs.

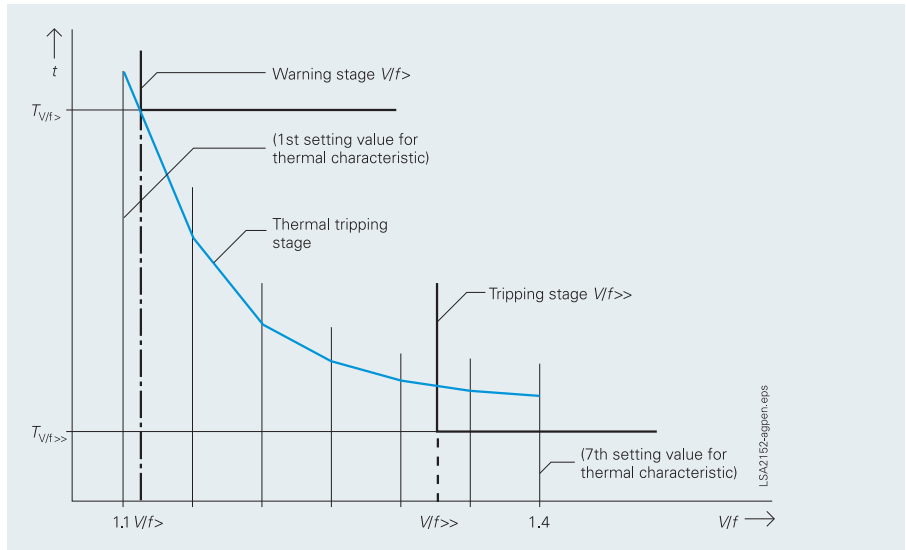


Fig. 11/74 Tripping range of overexcitation protection

Features

Serial data transmission

The SIPROTEC 7RW600 relay is fitted with an RS485 port, via which a PC can be connected, thus providing, in conjunction with the DIGSI operating and analysis program, a convenient tool for configuring and parameter setting. The DIGSI program (which runs under MS-Windows) also performs fault recording and fault evaluation. The SIPROTEC 7RW600 relay can also be linked, via the appropriate converters, either directly or over an optoelectronic connection (optical fiber) to the interface of the PC or substation control system (IEC 60870-5-103 protocol).

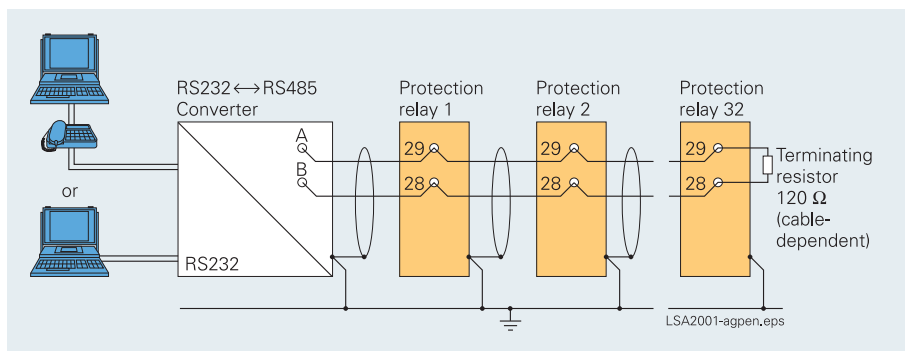


Fig. 11/75 Wiring communication
For convenient wiring of the RS485 bus, use bus cable system 7XV5103 (see part 13 of this catalog)

Connection diagrams

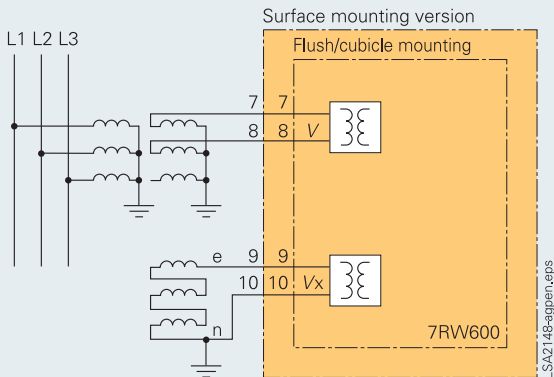


Fig. 11/76 Connection of a phase-to-phase voltage V and a displacement voltage V_x

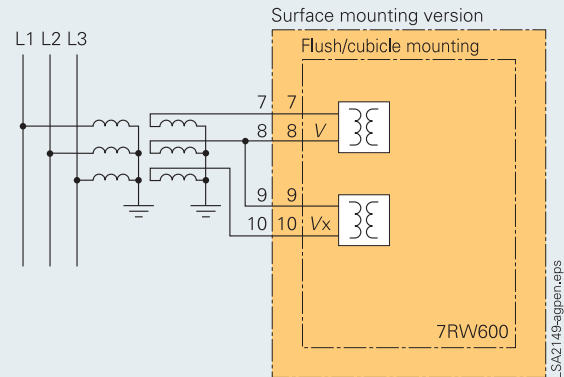


Fig. 11/77 Connection of two phase-to-phase voltages V to one voltage transformer set

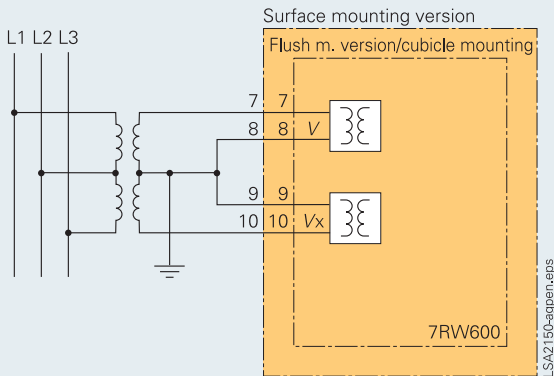


Fig. 11/78 Connection to voltage transformers in V-configuration

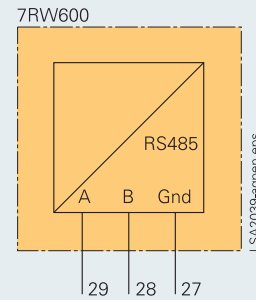


Fig. 11/79 Communication port

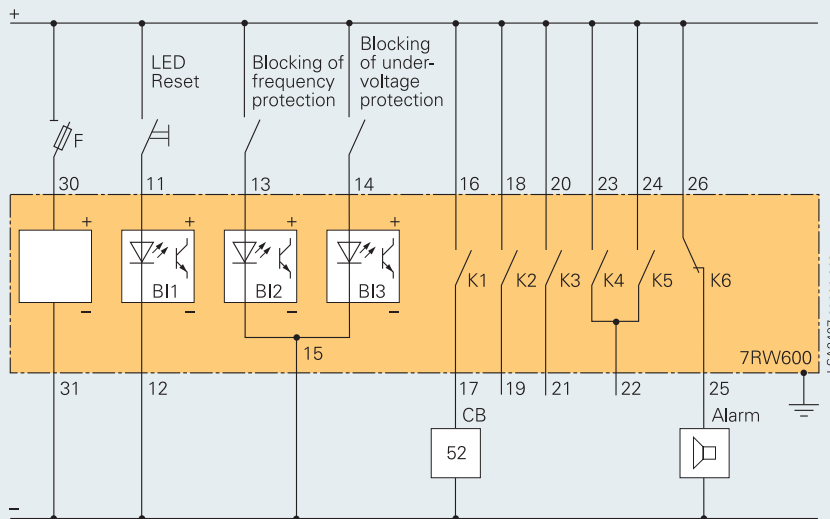


Fig. 11/80 Typical auxiliary voltage wiring

Generator Protection/7RW600

Technical data

Hardware	
<i>Measuring circuits (v.t. circuits)</i>	
Rated voltage V_N	100 to 125 V
Rated frequency f_N	50 or 60 Hz
Dynamic range	170 V
Power consumption	≤ 0.2 VA
Thermal overload capacity, continuous for ≤ 10 s	200 V 230 V
<i>Power supply via integrated DC/DC converter</i>	
Rated auxiliary voltage V_{aux}	DC 24/48 V DC 60/110/125 V DC 220/250 V, AC 115 V
Maximum ripple at rated voltage	≤ 12 %
Power consumption	
Quiescent	Approx. 2 W
Energized	Approx. 4 W
Maximum bridging time following failure of auxiliary voltage	≥ 20 ms at V_{AUX} (DC 24 V) ≥ 50 ms at V_{AUX} (DC 110 V)
<i>Binary inputs</i>	
Number	3
Voltage range	DC 24 to 250 V
Current consumption, independent of operating voltage	Approx. 2.5 mA
2 switching thresholds (adjustable)	17 V, 75 V
<i>Command contacts</i>	
Number of relays, total	6
Number of relays with 2-channel energization	2
Contacts per relay (K1 to K5)	1 NO contact
Contact for relay (K6)	1 NC contact or 1 NO contact (set via jumper)
Switching capacity	
Make	1000 W/VA
Break	30 W/VA
Switching voltage	250 V (AC/DC)
Permissible current, continuous 0.5 s	5 A 30 A
<i>LEDs</i>	
Ready-to-operate (green)	1
Marshallable displays (red)	4
Fault indication (red)	1

<i>Serial port (isolated)</i>	
Type	RS485
Test voltage	AC 2 kV for 1 min
Connections	Data cable at housing, two data wires, one frame reference for connection of a PC or similar
Transmission speed	At least 1200 baud, max. 19 200 baud
<i>Unit design</i>	
Case 7XP20	For dimensions, see dimension drawings, part 14
Weight	
Flush mounting/cubicle mounting	Approx. 4 kg
Surface mounting	Approx. 4.5 kg
Degree of protection to IEC 60529/EN 60529	IP 51

Electrical test	
<i>Specifications</i>	
Standards	IEC 60255-5, ANSI / IEEE C37.90.0
<i>Insulation tests</i>	
Voltage test (routine test)	
All circuits except auxiliary voltage and RS485	2.0 kV (rms), 50 Hz
Auxiliary voltage and RS485 only	DC 2.8 kV
Voltage test (type test)	
Over open command contacts	1.5 kV (rms), 50 Hz
Impulse withstand capability (SWC) test (type test)	5 kV (peak); 1.2 / 50 μs; 0.5 J
All circuits, class III	3 positive and 3 negative impulses at intervals of 5 s
Test crosswise:	
Measurement circuits, pilot-wire connections, power supply, binary inputs, class III, (no tests crosswise over open contacts, RS485 interface terminals)	
<i>EMC tests, immunity; type tests</i>	
Standards	IEC 60255-22 (product standard) EN 50082-x (generic standard) DIN VDE 0435, Part 303
High-frequency test	2.5 kV (peak), 1 MHz, $\tau = 15 \mu\text{s}$, 400 shots/s duration 2 s
IEC 60255-22-1, class III and DIN VDE 0435 Part 303, class III	
Electrostatic discharge	4 kV/6 kV contact discharge
IEC 60255-22-2 and IEC 61000-4-2, class III	8 kV air discharge, both polarities, 150 pF, $R_i = 330 \Omega$
Irradiation with RF field	
Non-modulated, IEC 60255-22-3 (report), class III	10 V/m, 27 to 500 MHz
Amplitude-modulated, IEC 61000-4-3, class III	10 V/m, 80 to 1000 MHz, 80 % AM, 1 kHz
Pulse-modulated, IEC 6100-4-3, class III	10 V/m, 900 MHz, repetition frequency 200 Hz, duty cycle 50 %

EMC tests, immunity; type tests

Fast transients IEC 60255-22-4 and IEC 61000-4-4, class III	2 kV, 5/50 ns, 5 kHz, burst length 15 ms, repetition rate 300 ms, both polarities, $R_i = 50 \Omega$, duration 1 min
Conducted disturbances induced by radio-frequency fields, amplitude-modulated, IEC 61000-4-6, class III	10 V, 150 kHz to 80 MHz, 80 % AM, 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV	30 A/m continuous, 50 Hz 300 A/m for 3 s, 50 Hz 0.5 mT; 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1 (common mode)	2.5 kV to 3 kV (peak), 1 MHz to 1.5 MHz, decaying oscillation, 50 shots per s, duration 2 s, $R_i = 150$ to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1 (common mode)	4 to 5 kV, 10/150 ns, 50 shots per s, both polarities, duration 2 s, $R_i = 80 \Omega$
Radiated electromagnetic interference ANSI/IEEE C37.90.2	10 to 20 V/m, 25 to 1000 MHz, amplitude- and pulse-modulated
High-frequency test Document 17C (SEC) 102	2.5 kV (peak, alternating polarity), 100, 1, 10 and 50 MHz, decaying oscillation, $R_i = 50 \Omega$

EMC tests, emission; type tests

Standard	EN 50081-* (generic standard)
Conducted interference voltage, aux. voltage only CISPR 11, EN 55022, DIN VDE 0878 Part 22, limit value, class B	150 kHz to 30 MHz
Interference field strength CISPR 11, EN 55011, DIN VDE 0875 Part 11, limit value, class A	30 to 1000 MHz

Mechanical stress tests

Vibration, shock stress and seismic vibration

During operation

Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.035 mm amplitude 60 to 150 Hz: 0.5 g acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal acceleration 5 g, duration 11 ms 3 shocks in each direction of 3 orthogonal axes
Seismic vibration IEC 60255-21-3, class 1 IEC 60068-2-59	Sinusoidal 1 to 8 Hz: ± 4 mm amplitude (horizontal axis) 1 to 8 Hz: ± 2 mm amplitude (vertical axis) 8 to 35 Hz: 1 g acceleration (horizontal axis) 8 to 35 Hz: 0.5 g acceleration (vertical axis) Sweep rate 1 octave/min 1 cycle in 3 orthogonal axes

During transport

Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 g acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal acceleration 15 g, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Half-sinusoidal acceleration 10 g, duration 16 ms, 1000 shocks in each direction of 3 orthogonal axes

Climatic stress tests

Temperatures

Recommended temperature during service	-5 to +55 °C (legibility may be impaired > +55 °C)
Temperature tolerances: During service During storage During transport (storage and transport in standard works packaging)	-20 to +70 °C -25 to +55 °C -25 to +70 °C

Humidity

Permissible humidity stress It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation	Annual average ≤ 75 % relative humidity, on 30 days during the year 95 % relative humidity, condensation not permitted!
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Functions

Undervoltage protection

Setting range $V_{<}$, $V_{x<} < V_{p<}$	20 to 120 V (in steps of 1 V)
Delay times	0 to 60 s (in steps of 0.01 s) or ∞ (i.e. non-effective)
Time multiplier for inverse characteristic	0.1 to 5 s
Pickup time	≤ 50 ms
Reset time	≤ 50 ms
Reset ratio	1.05
Tolerances Voltage pickup Delay times	3 % of setting value or 1 V 1 % of setting value or 10 ms

Overvoltage protection

Setting range $V_{>}$, $V_{>>}$ $V_{x>}$, $V_{x>>}$	20 to 170 V (in steps of 1 V) 10 to 170 V (in steps of 1 V)
Delay times	0 to 60 s or ∞ (in steps of 0.01 s)
Pickup time	≤ 50 ms
Reset time	≤ 50 ms
Reset ratio	0.95
Tolerances Voltage pickup Delay times	3 % of setting value or 1 V < 1 % of setting value for $V > V_n$ 1 % of setting value or 10 ms

Generator Protection/7RW600

Technical data

Frequency protection	
Number of frequency stages $f >$ or $f <$	4
Setting range $f >$ or $f <$	40 to 68 Hz (in steps of 0.01 Hz)
Delay times	0 to 60 s or ∞ (in steps of 0.01 s)
Undervoltage blocking	20 to 100 V or ∞ (in steps of 1 V)
Pickup time $f >$, $f <$	Approx. 100 ms
Reset times $f >$, $f <$	Approx. 100 ms
Reset difference	Approx. 20 mHz
Reset ratio (undervoltage blocking)	1.05
Tolerances	
Frequencies $f >$, $f <$	5 mHz at $f = f_N$ and $V = V_N$ 10 mHz at $f = f_N$
Undervoltage blocking	3 % of setting value or 1 V
Delay times	1 % of setting value or 10 ms
Rate-of-frequency-change protection	
Number of rates-of-frequency-changing stages	4
Setting range $\frac{df}{dt}$	0.4 to 10 Hz/s or ∞ (in steps of 0.1 Hz/s)
Delay times	0 to 60 s or ∞ (in steps of 0.01 s)
Undervoltage blocking	20 to 100 V or ∞ (in steps of 1 V)
Pickup time $\frac{df}{dt}$	Approx. 200 ms
Reset ratio pickup $\frac{df}{dt}$	Approx. 0.6
Reset ratio (undervoltage blocking)	1.05
Tolerances	
Changes of frequencies $\frac{df}{dt}$	In the 45 to 50 Hz range 100 mHz/s at $f_N = 50$ Hz and $V = V_N$ In the 54 to 60 Hz range 150 mHz/s at $f_N = 60$ Hz and $V = V_N$
Undervoltage blocking $V <$	3 % of setting value or 1 V
Delay times	1 % of setting value or 10 ms
Overexcitation protection	
Warning stage $\frac{V/V_N}{f/f_N}$	1 to 1.2 (in steps of 0.01)
Tripping stage $\frac{V/V_N}{f/f_N}$	1 to 1.4 (in steps of 0.01)
Delay times, warning and tripping stages	0 to 60 s, or ∞ (in steps of 0.01 s)
Curve values Vif	1.1 / 1.15 / 1.2 / 1.25 / 1.3 / 1.35 / 1.4
Associated delay times	0 to 20000 s (in steps of 1 s)
Cooling-down time	0 to 20000 s (in steps of 1 s)
Voltage transformer adaption factor	0.5 to 2 (in steps 0.01)
Pickup response time (stage curve)	≤ 50 ms
Reset time (stage curve)	≤ 60 ms
Reset ratio	0.95
Tolerances	
Overexcitation Vif	3 % of setting value
Delay times (stage curve)	1 % of setting value or 10 ms
Delay times (dependent curve)	5 % with respect to Vif value ± 0.5 s

Fault recording	
Instantaneous value fault record	
Measured values	V, V_x
Pattern	1.00 ms (50 Hz) 0.83 ms (60 Hz)
Fault record duration	Max. 5 s
Start signal	Tripping, energization, binary input, PC
R.m.s. fault record	
Measured values	$V, V_x, f-f_N$
Pattern	10 ms (50 Hz) 8.3 ms (60 Hz)
Fault record duration	Max. 50 s
Starting signal	Tripping, energization, binary input, PC
Operational measured values	
Measured values	V, V_x, V_1, Vif, f
Measuring range voltage	0 to 170 V
Tolerance	≤ 2 V or 5 %
Measuring range overexcitation	0 to 2.4
Tolerance	≤ 5 %
Measuring range frequency	25 to 70 Hz
Tolerance	≤ 0.05 Hz or 5 MHz at $f = f_N$

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EEC previous 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 2006/195/EEC previous 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".

Generator Protection/7RW600

Selection and ordering data

Description	Order No.
7RW600 numerical voltage, frequency and overexcitation protection relay	7RW6000-□□A□0-□DA0
Rated auxiliary voltage	
DC 24, 48 V	2
DC 60, 110, 125 V	4
DC 220, 250 V, AC 115 V	5
Unit design	
For panel surface mounting, terminals on the side	B
For panel surface mounting, terminals on the top and bottom	D
For panel flush mounting/cubicle mounting, terminals on the rear	E
Languages	
English	0
German	1
Spanish	2
French	3
Scope of functions	
Voltage and frequency protection	0
Voltage, frequency and rate-of-frequency-change protection	1
Voltage and overexcitation protections	2

Accessories	Description	Order No.
	DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper) Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
	Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
	SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000/XP Professional Edition. Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	7XS5410-0AA00
	Converter RS232↔RS485* With communication cable for the SIPROTEC 7RW600 numerical voltage, frequency and overexcitation relay; length 1 m With plug-in power supply unit AC 230 V	7XV5700-0□□00¹⁾
	With plug-in power supply unit AC 110 V	7XV5700-1□□00¹⁾
	Converter, full-duplex FO cable, RS485, with built-in power supply unit Auxiliary voltage DC 24 – 250 V and AC 110/230 V	7XV5650-0BA00
	Manual for 7RW600 English	C53000-G1176-C117-4
	1) Possible versions see part 13, 7XV57 RS232↔RS485 Converter * RS485 bus system up to 115 kbaud, RS485 cable and adaptor 7XV5103-□AA□□ see part 13	

Generator Protection/7RW600

Connection diagrams

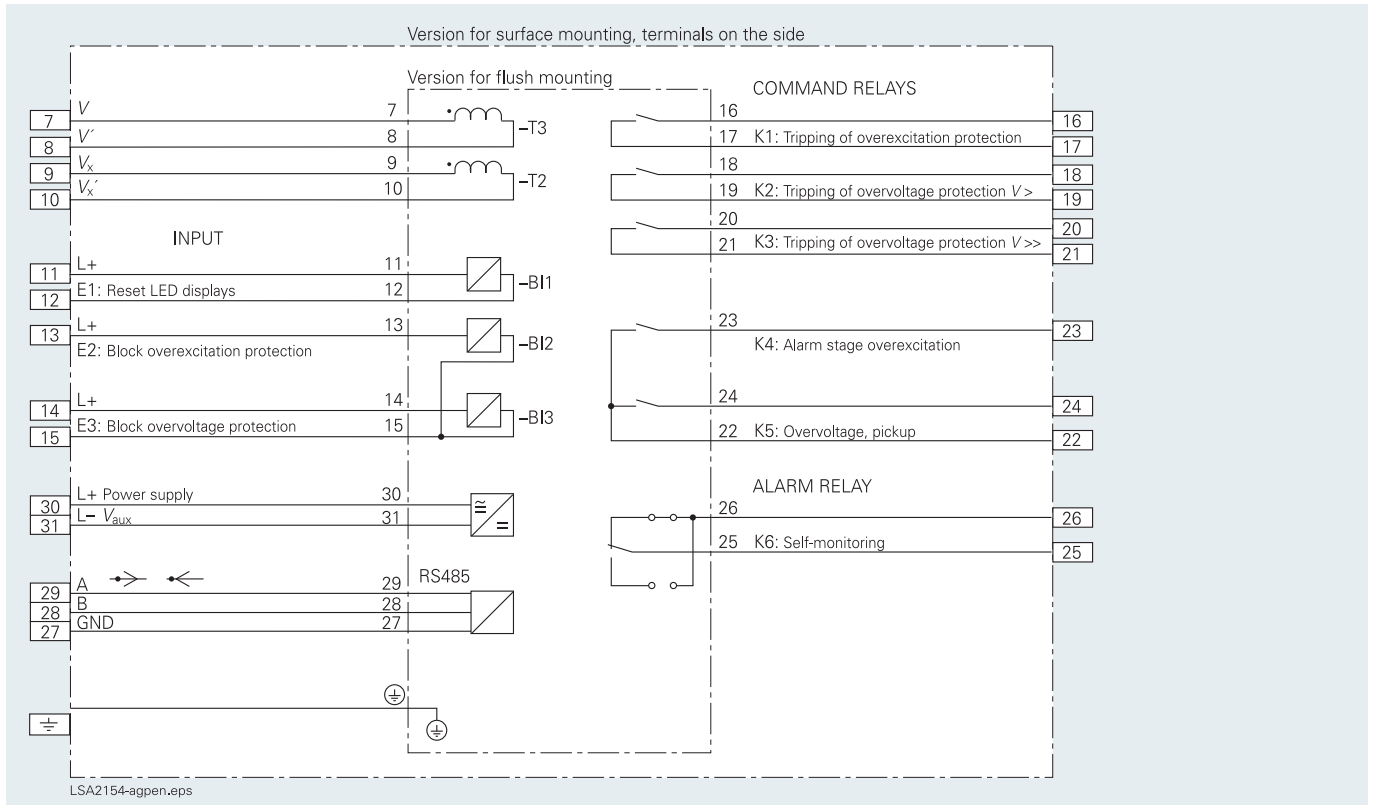


Fig. 11/81 Connection circuit diagram of 7RW600 voltage and frequency protection with presetting of marshallable binary inputs and command contacts. (Ordering Code: 7RW600x-xBxxx-; 7RW600x-xExxx-).

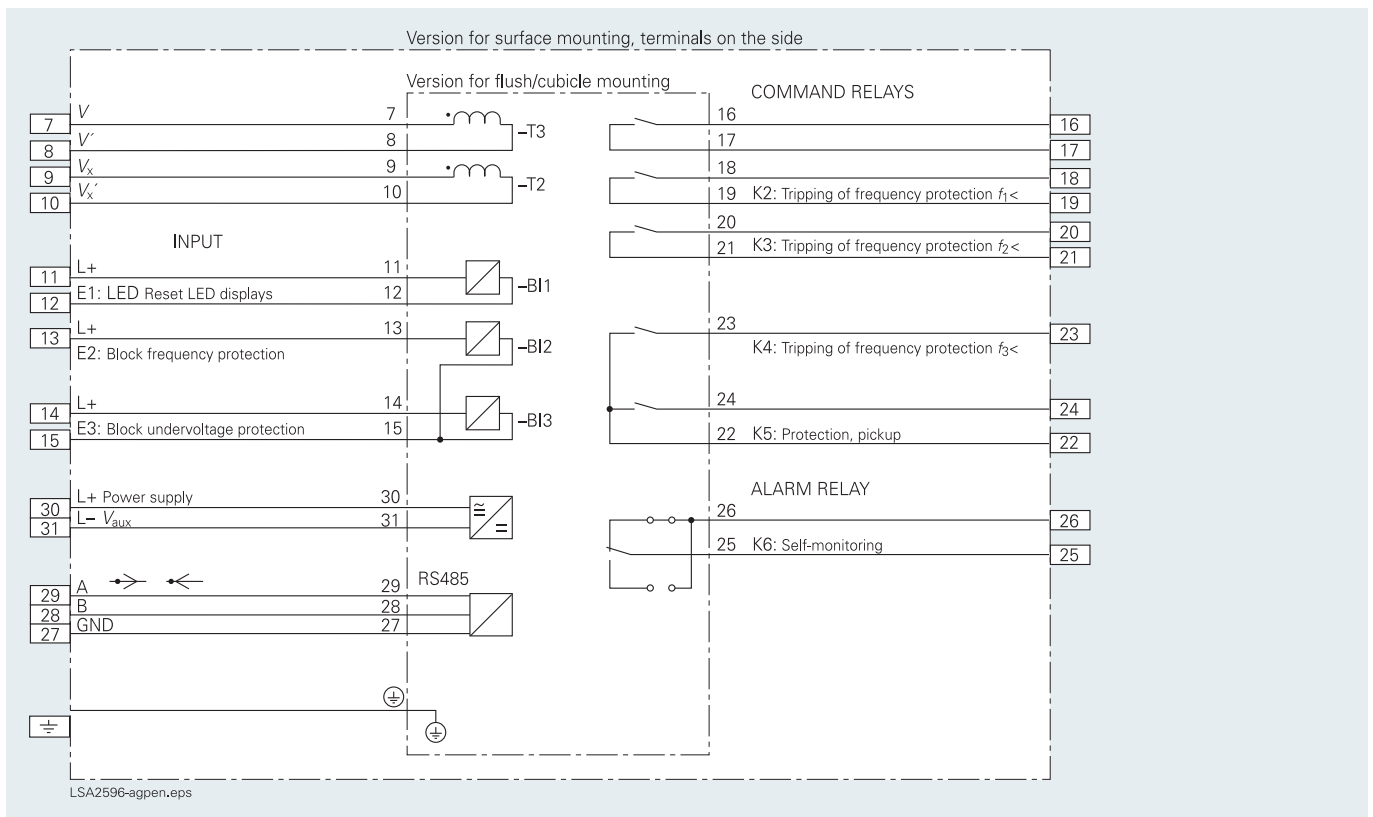


Fig. 11/82 Connection circuit diagram of 7RW600 voltage and overexcitation protection with presetting of marshallable binary inputs and command contacts. (Ordering Code: 7RW600x-xBxxx-; 7RW600x-xExxx-).



Fig. 11/83 SIPROTEC 7VE6 multifunction paralleling device

Description

The 7VE61 and 7VE63 paralleling devices of the SIPROTEC 4 family are multifunctional compact units used for paralleling power systems and generators.

Their technical design ensures highly reliable paralleling due to their 1½-channel or 2-channel measurement method and their hardware design. This is supported by numerous monitoring functions. The units automatically detect the operating conditions. The response to these conditions depends on settings. In "synchronous network switching" mode, the frequency difference is measured with great accuracy. If the frequency difference is almost zero for a long enough time, the networks are already synchronous and a larger making angle is permissible.

If the conditions are asynchronous, as is the case when synchronizing generators, the generator speed is automatically matched to the system frequency and the generator voltage to the system voltage. The connection is then made at the synchronous point, allowing for circuit-breaker make-time.

The 7VE61 paralleling device is a 1½-channel unit (paralleling function + synchro-check) for use with small to medium-size generators and power systems. It is more reliable than 1-channel paralleling devices. It can also be used for synchro-check, with parallel operation of three synchronization points.

For larger generators and power systems with high reliability requirements, the 2-channel 7VE63 is recommended. Two independent methods decide on the connection conditions. The unit also has the full control functions of the SIPROTEC 4 family.

Voltage and frequency functions ($V>$, $V<$, $f>$, $f<$, $f < df/dt$) including voltage vector jump ($\Delta\varphi$) are optionally available for protection or network decoupling applications.

The integrated programmable logic functions (continuous function chart CFC) offer the user a high flexibility so that adjustments can easily be made to the varying requirements on the basis of special system conditions.

The flexible communication interfaces are open to modern communication architectures with control systems.

Function overview

Basic functions

- High reliability with a two-out-of-two design (1½ channels in 7VE61 and 2 channels in 7VE63)
- Paralleling of asynchronous voltage sources
- Balancing commands for voltage and speed (frequency)
- Paralleling of synchronous voltage sources
- Synchro-check function for manual synchronization
- Parameter blocks for use on several synchronizing points (7VE61 max. 4 and 7VE63 max. 8)

Additional functions

- Consideration of transformer vector group and tap changer
- Synchronization record (instantaneous or r.m.s. record)
- Commissioning support (CB-time measurement, test synchronization)
- Browser operation
- Full control functionality of SIPROTEC 4
- Analog outputs of operational measured values
- Functions for protection or network decoupling tasks

Protection functions (option)

- Undervoltage protection (27)
- Overvoltage protection (59)
- Frequency protection (81)
- Rate-of-frequency-change protection (81R)
- Jump of voltage vector monitoring

Monitoring functions

- Self-supervision of paralleling function
- Operational measured values
- 8 oscillographic fault records

Communication interfaces

- System interface
 - IEC 60870-5-103
 - IEC 61850 protocol
 - PROFIBUS-DP
 - MODBUS RTU and DNP 3.0
- Service interface for DIGSI 4 (modem)
- Front interface for DIGSI 4
- Time synchronization via IRIG B/DCF77

Generator Protection/7VE6

Application

Application

The 7VE61 and 7VE63 paralleling devices of the SIPROTEC 4 family are multifunctional compact units used for paralleling power systems and generators.

Their technical design ensures highly reliable paralleling due to their 1½-channel or 2-channel measurement method and their hardware design. This is supported by numerous monitoring functions.

The units automatically detect the operating conditions. The response to these conditions depends on settings.

In "synchronous network switching" mode, the frequency difference is measured with great accuracy. If the frequency difference is almost zero for a long enough time, the networks are already synchronous and a larger making angle is permissible.

If the conditions are asynchronous, as is the case when synchronizing generators, the generator speed is automatically matched to the system frequency and the generator voltage to the system voltage. The connection is then made at the synchronous point, allowing for circuit-breaker make-time.

The 7VE61 paralleling device is a 1½-channel unit (paralleling function + synchro-check) for use with small to medium-size generators and power systems. It is more reliable than 1-channel paralleling devices. It can also be used for synchro-check, with parallel operation of three synchronization points.

For larger generators and power systems with high reliability requirements, the 2-channel 7VE63 is recommended. Two independent methods decide on the connection conditions. The unit also has the full control functions of the SIPROTEC 4 family.

Voltage and frequency functions ($V>$, $V<$, $f>$, $f<$ df/dt) including voltage vector jump ($\Delta\varphi$) are optionally available for protection or network decoupling applications.

Uniform design

The SIPROTEC 4 units have a uniform design and a degree of functionality which represents a whole new quality in protection and control and automation.

Local operation has been designed according to ergonomic criteria. Large, easy-to-read displays (graphic display for 7VE63) were a major design aim. The DIGSI 4 operating program considerably simplifies planning and engineering and reduces commissioning times.

Highly reliable

The 7VE6 hardware is based on 20 years of Siemens experience with numerical protection equipment. State-of-the-art technology and a high-efficiency, 32-bit microprocessor are employed. Production is subject to exacting quality standards.

Special attention has been paid to electromagnetic compatibility, and the number of electronic modules has been drastically reduced by the use of highly integrated circuits.

The software design incorporates accumulated experience and the latest technical knowledge. Object orientation and high-level language programming, combined with the continuous quality assurance system, ensure maximized software reliability.

Programmable logic

The integrated programmable logic function allows the user to implement his own functions for automation of switchgear (interlocking) via a graphic user interface. The user can also generate user-defined messages.

Adjustments can easily be made to the varying power station requirements.

Measurement method

Powerful and successful algorithms based on years of experience have been incorporated. They ensure both a high level of measurement accuracy and effective noise signal suppression. That makes for reliable paralleling even in networks with harmonics. Complementary measurement methods avoid unwanted operation.

Design

The units are available in two designs: the ½ 19" wide 7VE61 and the ½ 19" wide 7VE63. The 7VE61 features a four-line display. The 7VE63 is equipped with a graphic display for visualization of switching states. It also has a larger number of binary inputs and outputs than the 7VE61.

Communication

Flexible and powerful communication is paramount. That is why the paralleling devices have up to five serial interfaces (for details see chapter 4 "Communication"):

- Front interface for connecting a PC
- Service interface for connecting a PC (e.g. via a modem)
- System interface for connecting to a control system via IEC 60870-5-103, IEC 61850, PROFIBUS-DP, MODBUS RTU or DNP 3.0
- Interface for an analog output module (2 – 20 mA) and an input
- For time synchronization via DCF77 or IRIG B.

Operational measured values

In order to assist system management and for commissioning purposes, relevant measured values are displayed as primary and secondary values with unit and values relating to the object to be protected.

The measured values can also be transferred via the serial interfaces.

In addition, the programmable logic permits limit value scans and status indications derived therefrom.

Metered values are available in the form of energy metered values for the active and reactive energy supplied and are also provided by an elapsed-hour meter.

Indications

The SIPROTEC 4 units provide detailed data for analysis of synchronization (fault events from activated protection functions) and for checking states during operation. All indications are protected against power supply failure.

- Synchronization indications (Fault indications)
The last eight synchronizations (faults) are stored in the unit at all times. A fresh synchronization (fault) will erase the oldest one. The fault indications have a time resolution of 1 ms. They provide detailed information on history. The buffer memory is designed for a total of 600 indications.
- Operational indications
All indications that are not directly associated with the synchronization (fault) (e.g. operating or switching actions) are stored in the status indication buffer. The time resolution is 1 ms, buffer size: 200 indications.

Fault recording at up to 10 or 100 seconds

An instantaneous value or r.m.s. value recorder is provided. The firmware permits storage of 8 fault recordings. Triggering can be effected by the synchronization function (starting or closing command), protection function (pickup or tripping), binary input, the DIGSI 4 operating program or by the control system.

The instantaneous value recording stores the voltage input values ($V_a, V_b, V_c, V_d, V_e, V_f$), voltage differences ($V_a-V_d, V_b-V_e, V_c-V_f$), and calculated r.m.s. values $\Delta V, \Delta f, \Delta \alpha$ at 1-ms intervals (or 0.83-ms intervals for 60 Hz). The r.m.s. values are calculated every half cycle. The total duration of the fault recording is 10 seconds. If the time is exceeded, the oldest recording is overwritten.

If you want to record for a longer period for commissioning purposes (for example, to show the effect of balancing commands), r.m.s. value recording is advisable. The relevant calculated values ($V_1, V_2, f_1, f_2, \Delta V, \Delta f, \Delta \alpha$) are recorded at half-cycle intervals. The total duration is 100 seconds.

Time synchronization

A battery-backed clock is a standard component and can be synchronized via a synchronization signal (DCF77; IRIG B via satellite receiver), binary input, system interface or SCADA (e.g. SICAM). A date and time are assigned to every indication.

Freely assignable binary inputs and outputs

Binary inputs, output relays, and LEDs can each be given separate user-specific assignments. Assignment is effected using a software matrix, which greatly simplifies the allocation of individual signals.

To ensure dual-channel redundancy, control of the CLOSE relay (relay R1 and R2) is prioritized and should not be altered. These two relays have a special, highly reliable control and monitoring logic (see Fig. 11/89).

Continuous self-monitoring

The hardware and software are continuously monitored. If abnormal conditions are detected, the unit signals immediately. In this way, a great degree of safety, reliability and availability is achieved.

Reliable battery monitoring

The battery buffers the indications and fault recordings in the event of power supply voltage failure. Its function is checked at regular intervals by the processor. If the capacity of the battery is found to be declining, an alarm indication is generated.

All setting parameters are stored in the Flash-EPROM which are not lost if the power supply or battery fails. The SIPROTEC 4 unit remains fully functional.

Functions

Functional scope of the paralleling function

The units contain numerous individually settable functions for different applications. They cover the following operating modes:

Synchro-check

In this mode, the variables $\Delta V, \Delta f, \Delta \alpha$ are checked. If they reach set values, a release command is issued for as long as all three conditions are met, but at least for a settable time.

Switching synchronous networks

The characteristic of synchronous networks is their identical frequency ($\Delta f \approx 0$). This state is detected, and fulfillment of the ΔV and $\Delta \alpha$ conditions is checked. If the conditions remain met for a set time, the CLOSE command is issued.

Switching asynchronous networks

This state occurs in the power system and generator (open generator circuit-breaker). A check is made for fulfillment of ΔV and Δf conditions and the connection time is calculated, taking account of $\Delta \alpha$, and the circuit-breaker making time. By means of balancing commands (for voltage and frequency), the generator can automatically be put into a synchronous condition.

Switching onto dead busbars

The voltage inputs are checked here. The CLOSE command is issued depending on the set program and the result of measurement. A three-phase connection increases reliability because several voltages must fulfill the conditions (see Fig. 11/84).

The following operating states are possible:

- $V1 < V2 >$
(connection to dead busbar (side 1))
- $V1 > V2 <$
(connection to dead line (side 2))
- $V1 < V2 <$
(forced closing)

Functions

Voltage and frequency band query

Synchronization is not activated until the set limits are reached. Then the remaining parameters (see above) are checked.

Vector group adaptation

If synchronization is effected using a transformer, the unit will take account of the phase-angle rotation of the voltage phasor in accordance with the vector group entry for the transformer. On transformers with a tap changer, the tap setting can be communicated to the unit, for example, as BCD code (implemented in the 7VE63). When using the IEC 61850 communication standard, it is possible to detect tap position indications with a bay control unit (e.g. 6MD66) and to transmit these indications via GOOSE to the 7VE6 paralleling device. Deviations from the rated transformation ratio result in the appropriate voltage amplitude adaptation.

Voltage and frequency balancing

If the synchronization conditions are not fulfilled, the unit will automatically issue balancing signals. These are the appropriate up or down commands to the voltage or speed controller (frequency controller). The balancing signals are proportional to the voltage or frequency difference, which means that if the voltage or frequency difference is substantial, longer balancing commands will be output. A set pause is allowed to elapse between balancing commands to allow the state change to settle. This method ensures rapid balancing of the generator voltage or frequency to the target conditions.

If identical frequency is detected during generator-network synchronization ("motionless synchronization phasor"), a kick pulse will put the generator out of this state.

For example, if the voltage is to be adjusted using the transformer tap changer, a defined control pulse will be issued.

Several synchronizing points

Depending on the ordered scope, several synchronization points can be operated. The data for synchronization of each circuit-breaker (synchronization function group) are stored individually. In the maximum version, the 7VE63 operates up to 8 synchronization points. Selection is made either via the binary input or the serial interface. With the CFC, it is also possible to control the connection of the measured variables or commands via a master relay.

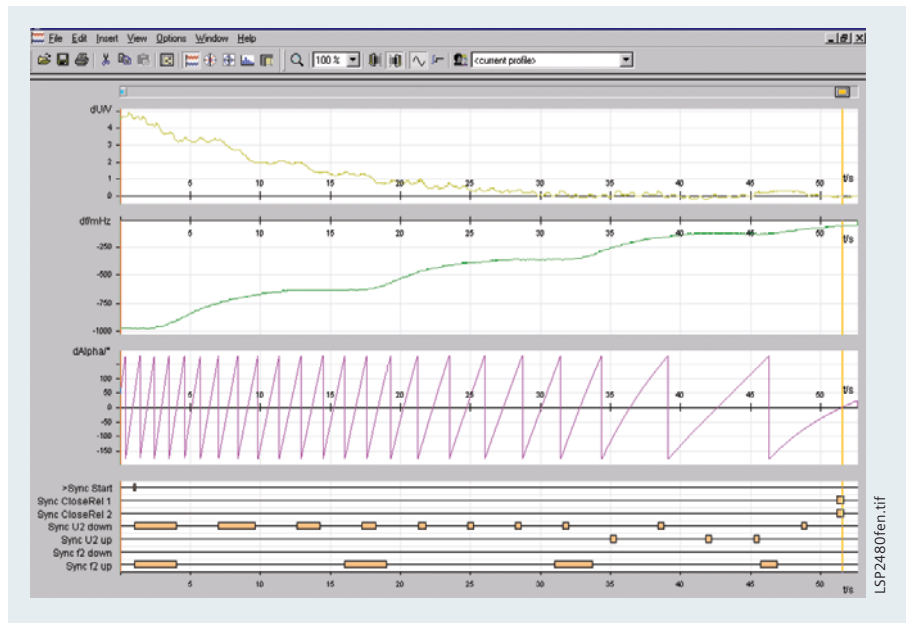


Fig. 11/84 SIGRA 4, synchronization record with balancing commands

Commissioning aids

The paralleling device is designed to be commissioned without an external tester/recorder (see Fig. 11/84). For that purpose, it contains a codeword-protected commissioning section. This can be used to measure the make time automatically with the unit (internal command issue until the CB poles are closed). This process is logged by the fault recording function.

The operational measured values also include all measured values required for commissioning. The behavior of the paralleling function or the unit is also documented in detail in the operational annunciation and synchronization annunciation buffer. The connection conditions are documented in the synchronization record. Test synchronization is also permitted. All actions inside the synchronizer are taken but the two CLOSE relays are not operated (R1 and R2). This state can also be initiated via a binary input.

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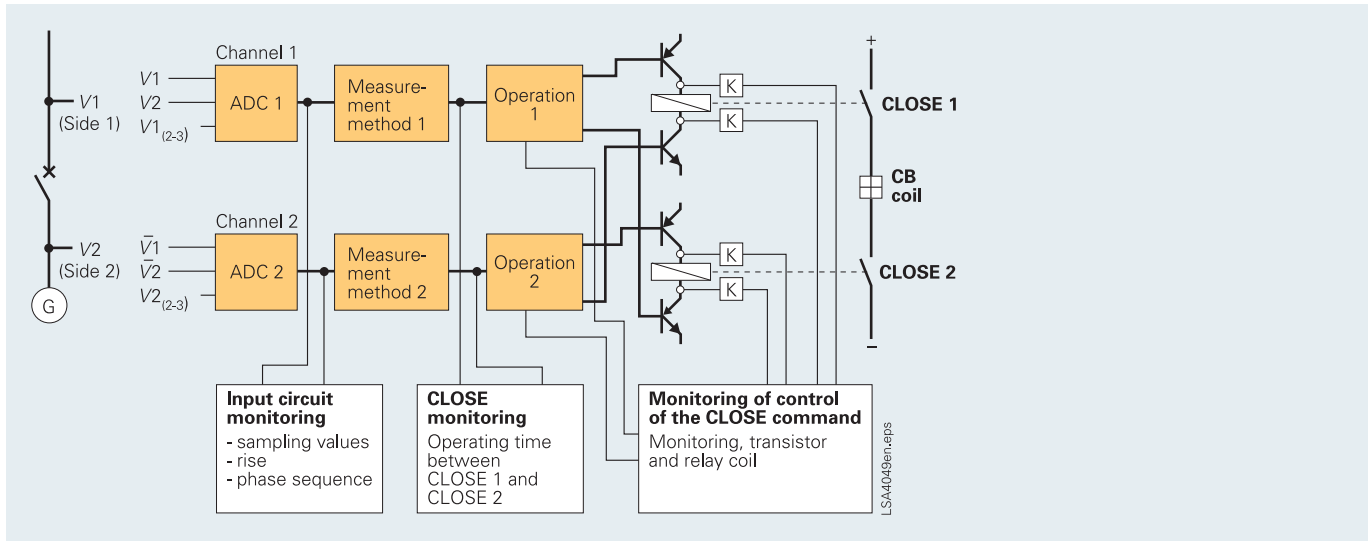


Fig. 11/85 Two-channel redundancy

Great safety and reliability due to multi-channel redundancy

Generator synchronization especially requires units in which unwanted operation can be ruled out. The paralleling device achieves this multi-channel redundancy with a two-out-of-two decision. That means that two conditions for the CLOSURE command must be fulfilled. Fig. 11/85 shows the structure of the two designs.

In the 1½-channel version (7VE61), the paralleling function is the function that gives the CLOSURE command. The synchro-check function acts as a release criterion with rougher monitoring limit settings. Other monitoring functions are also active at the same time (see below).

In the two-channel version (7VE63), two independent methods work in parallel. The CLOSURE command is given when the two methods simultaneously decide on CLOSURE. Fig. 11/86 shows the consistent implementation of dual-channel redundancy.

The measured quantities are fed to two ADCs. The second ADC processes the values rotated through 180° (e.g. V1). The monitoring methods test all the transformer circuits including internal data acquisition for plausibility and they block measurement if deviations are found. The phase-sequence test detects connection errors. The measuring methods 1 and 2 include the measurement algorithms and logic functions.

In keeping with the two-channel redundancy principle, differing measurement methods are used to prevent unwanted operation due to systematic errors.

In addition, numerous methods are also active, such as closure monitoring (synchronization monitoring of both methods). Unwanted relay operation is avoided by two-channel operation of both CLOSURE relays. The two measurement methods operate the transistors crossed over.

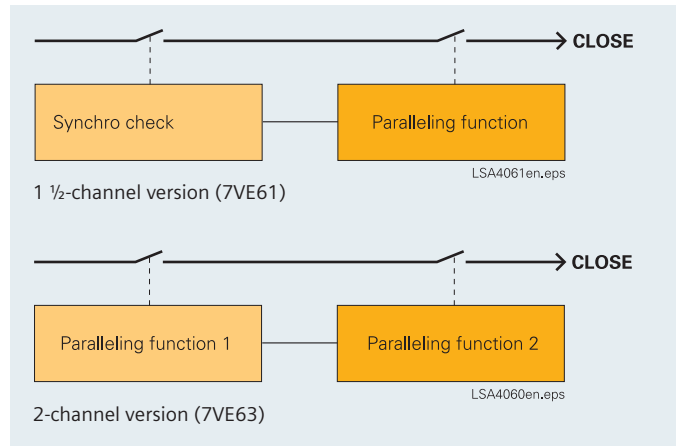


Fig. 11/86 Design of multi-channel redundancy

Moreover, coil operation is monitored in the background. For this purpose, transistors are activated individually and the response is fed back. Both interruptions and transistor breakdown are detected. When faults are found, the unit is blocked immediately.

The plausibility monitoring of set values (valid limits) and selection of the synchronization function groups (only one can be selected) are also supported. In the event of any deviations, messages are output and the paralleling function is blocked.

Generator Protection/7VE6

Functions

Internet technology simplifies commissioning

In addition to the universal DIGSI 4 operating program, the synchronizer contains a Web server that can be accessed via a telecommunications link using a browser (e.g. Internet Explorer). The advantage of this solution is that it is both possible to operate the unit with standard software tools and to make use of the Intranet/Internet infrastructure. Moreover, information can be stored in the unit without any problems. In addition to numeric values, visualizations facilitate work with the unit. In particular, graphical displays provide clear information and a high degree of operating reliability. Fig. 11/87 shows an example of an overview that is familiar from conventional synchronizers. The current status of synchronization conditions is clearly visible. Of course, it is possible to call up further measured value displays and annunciation buffers. By emulation of integrated unit operation, it is also possible to adjust selected settings for commissioning purposes, (see Fig. 11/87).

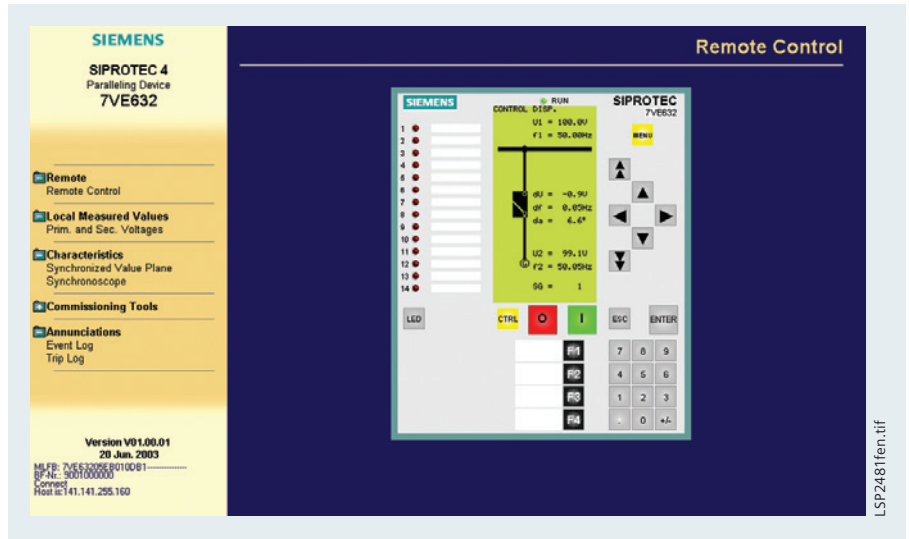


Fig. 11/87 Browser-based operation

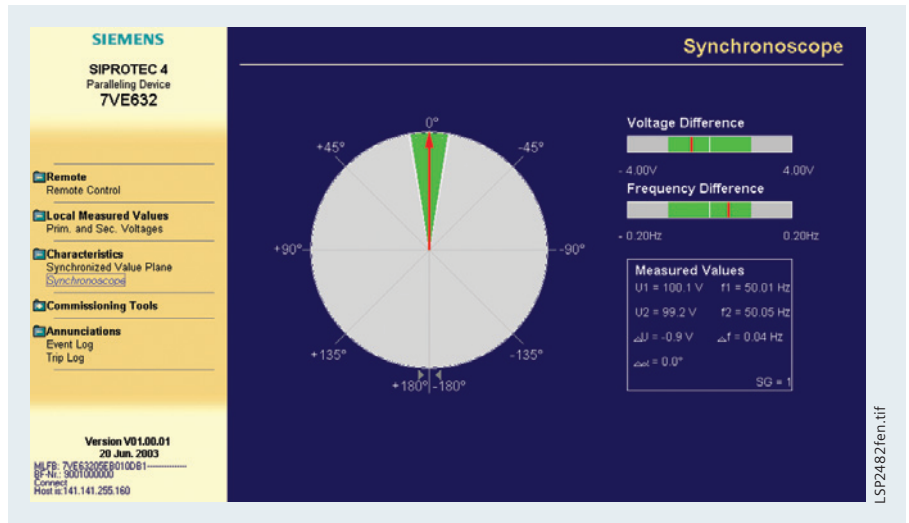


Fig. 11/88 Overview display of the synchronization function

Protection and automation functions

Basic concept

The paralleling function is not performed constantly. Therefore the measured quantities provided at the analog inputs are available for other functions. Voltage and frequency protection or limit value monitoring of these quantities are typical applications. Another possible application is network decoupling. After network disconnection, automatic resynchronization using the CFC is possible on request. To allow for great flexibility, these functions can be assigned to the analog inputs. This is defined for the specific application.

Undervoltage protection (ANSI 27)

The protection function is implemented on two stages and evaluates the voltage at an input assigned to it. Analysis of a phase-to-phase voltage is beneficial as it avoids starting in the event of ground faults. The protection function can be used for monitoring and decoupling purposes or to prevent voltage-induced instability of generators by disconnection.

Overvoltage protection (ANSI 59)

The protection function is implemented on two stages and evaluates the voltage at an input assigned to it. The overvoltage protection prevents impermissible stress on equipment due to excessive voltages.

Frequency protection (ANSI 81)

The protection function is implemented on four stages and evaluates the frequency of an input assigned to it. Depending on the frequency threshold setting, the function can provide overfrequency protection (setting $> f_n$) or underfrequency protection (setting $< f_n$). Each stage can be delayed separately. Stage 4 can be configured either as an overfrequency or underfrequency stage.

The application consists of frequency monitoring usually causing network disconnection in the event of any deviations. The function is suitable as a load shedding criterion.

Rate-of-frequency-change protection (ANSI 81R)

This function can also be assigned to an input. The frequency difference is determined on the basis of the calculated frequency over a time interval. It corresponds to the momentary rate-of-frequency change. The function is designed to react to both positive and negative rate-of-frequency changes. Exceeding of the permissible rate-of-frequency change is monitored constantly. Release of the relevant direction depends on whether the actual frequency is above or below the rated frequency. In total, four stages are available, and can be used optionally.

This function is used for fast load shedding or for network decoupling.

Jump of voltage vector monitoring

Smaller generating plants frequently require the vector jump function. With this criterion it is possible to detect a disconnected supply (e.g. due to the dead time during an automatic reclosure) and initiate generator disconnection. This avoids impermissible loads on the generating plant, especially the drive gearing, if reconnection to the network is asynchronous.

The vector jump function monitors the phase angle change in the voltage.

If the incoming line should fail, the abrupt current discontinuity leads to a phase angle jump in the voltage. This is measured by means of a delta process. The command for opening the generator or coupler circuit-breaker is issued if the set threshold is exceeded.

Vector jump monitoring is performed again for the assigned voltage input. This function is blocked during synchronization.

Threshold monitoring

The threshold function is provided for fast monitoring and further processing in the CFC. Optional monitoring of the calculated voltage (for violation of an upper or lower threshold) at the six voltage inputs is possible. A total of three greater-than and three less-than thresholds are available. The check is made once per cycle, resulting in a minimum operating time of about 30 ms for the voltage. The times can be extended by the internal check time, if necessary (about 1 cycle).

Generator Protection/7VE6

Typical applications

Typical applications

Connection to three-phase voltage transformer

If three-phase voltage transformers are available, connection as shown in Fig. 11/89 is recommended. This is the standard circuit because it provides a high level of reliability for the paralleling function. The phase-sequence test is additionally active, and several voltages are checked on connection to a dead busbar. Interruption in the voltage connection does not lead to unwanted operation. Please note that side 1 (that is, V_1) is always the feed side. That is important for the direction of balancing commands.

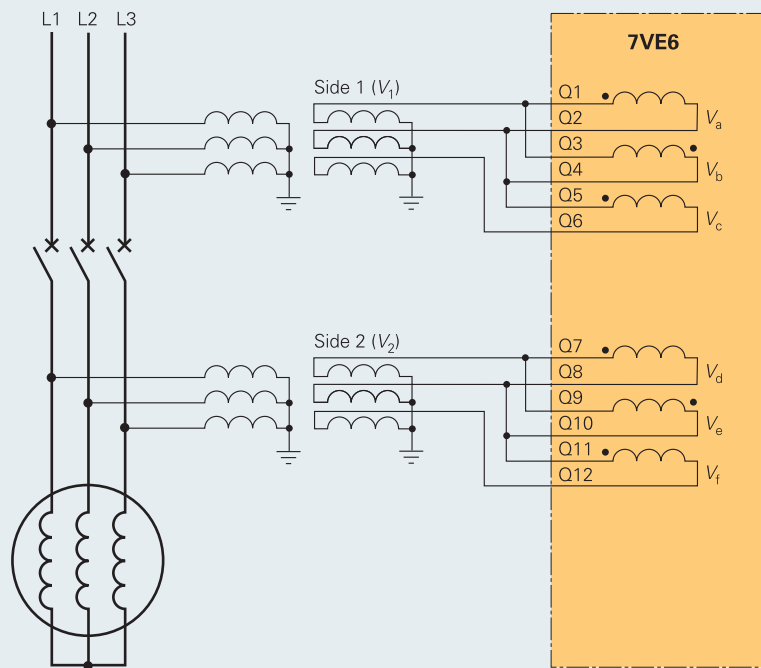


Fig. 11/89

Connection to open delta connection (V-connection) voltage transformer

Fig. 11/90 shows an alternative to Fig. 11/89 for substations in which the voltage transformers have to be V-connected. For the paralleling device, this connection is the electrical equivalent of the connection described above. It is also possible to combine the two: three one-pole isolated voltage transformers on one side and the V-connection on the other. If, additionally, a synchroscope is connected, it must be electrically isolated by means of an interposing transformer.

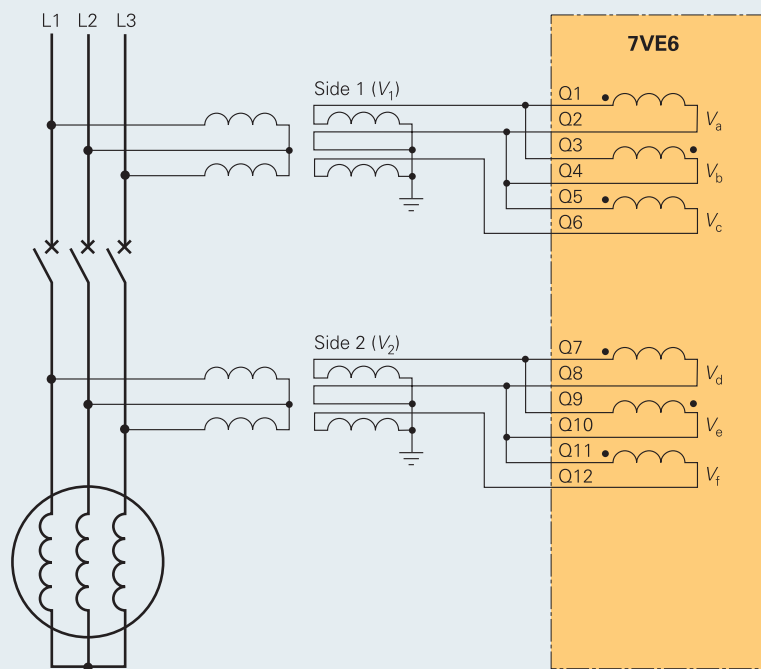


Fig. 11/90

LSA4051en.eps

LSA4051en.eps

Connection to floating voltage transformer

To save costs for the voltage transformer, two-phase isolated voltage transformers are used that are connected to the phase-to-phase voltage (see Fig. 11/91). In that case, the phase-rotation supervision is inactive and reliability restrictions when connecting to the dead busbar must be accepted.

Full two-channel redundancy is ensured.

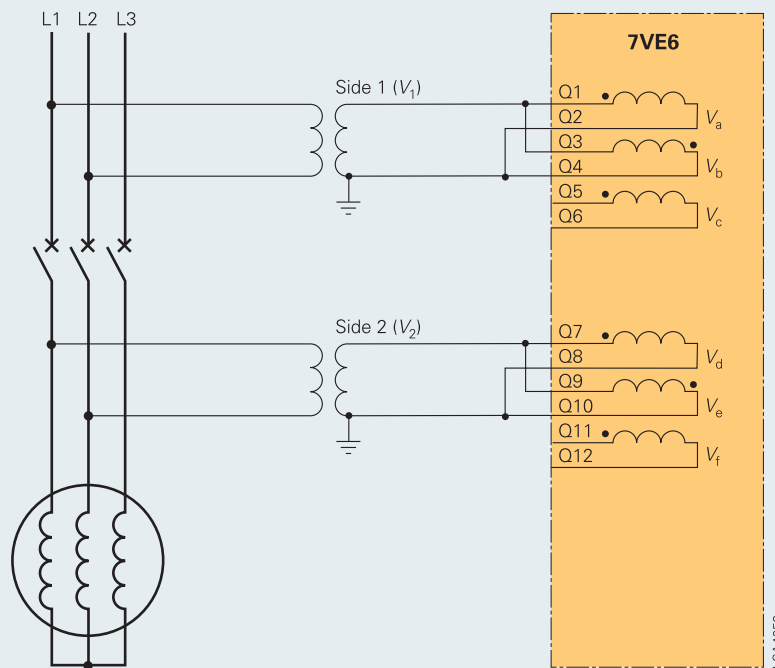


Fig. 11/91

Connection to single-phase isolated voltage transformer

As an alternative to Fig. 11/91, some substations use single-phase isolated voltage transformers (see Fig. 11/92). In this case, only a phase-to-ground voltage is available. This connection should be avoided if possible. Especially in isolated or resonant-(star point) neutral-grounded networks, a ground fault would lead to a voltage value of zero. That does not permit synchronization and the busbar is detected as dead.

If $V_1 <$ and $V_2 >$ connection is permitted, there is a high risk of incorrect synchronization. Furthermore, a ground fault in phase L2 leads to an angle rotation of – for instance – 30° in phase L1. This means that the device switches at a large fault angle.

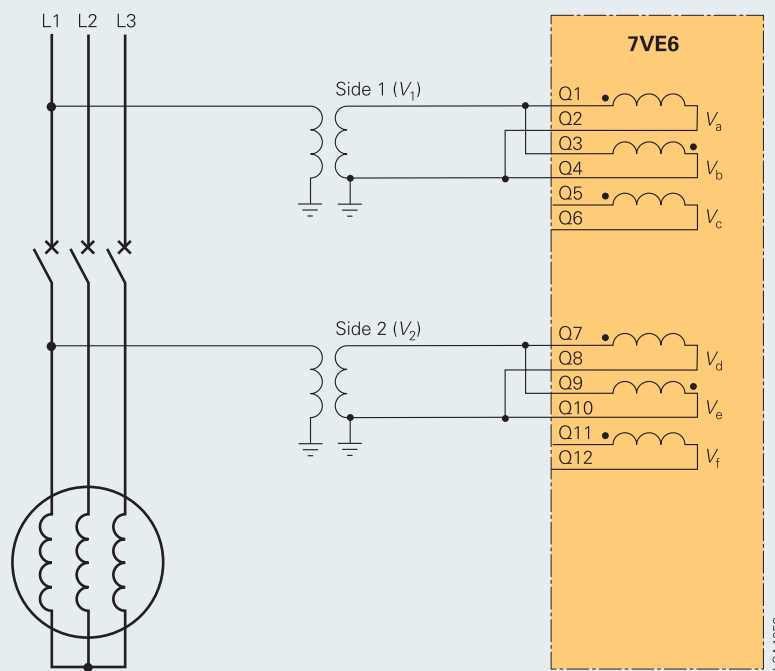


Fig. 11/92

Generator Protection/7VE6

Typical applications

Switching in 16.7 Hz networks for application in traction systems

The unit can also be used for synchronizing railway networks or generators. The connection has to be executed according to Fig. 11/93. No phase sequence test is available here. Two-channel redundancy is ensured.

The voltage inputs permit the application of the 16.7 Hz frequency without any difficulties.

On connection to a dead busbar, a broken wire in the external voltage transformer circuit is not detected. It is recommended to make another interrogation of a second voltage transformer.

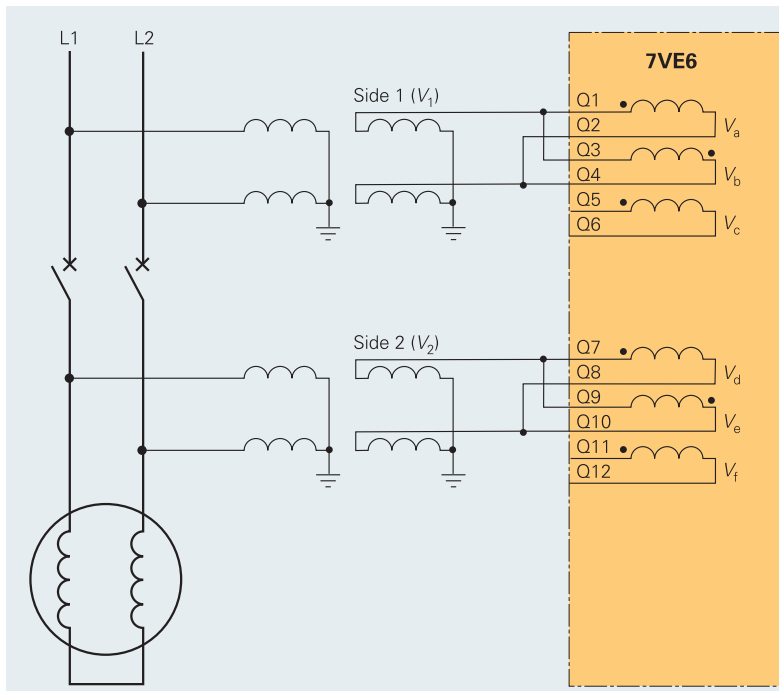


Fig. 11/93

Synchro-check for several synchronizing points

To avoid unwanted operation during manual synchronization or during connection of circuit-breakers in the network, the synchro-check function is used as an enabling criterion. It is fully compatible with all of the connections described above (see Figs. 11/89 to 11/93). With the "synchro-check" ordering option, the paralleling device also allows up to three circuit-breakers to be monitored in parallel. That saves wiring, switching and testing. In particular, that is an application for the 1½ circuit-breaker method. Moreover, on smaller generating plants one unit can be used for up to three generators, which helps reduce costs.

The connection shown in Fig. 11/94 is a single-pole version, which is acceptable for the synchro-check function.

An alternative is the connection for two switching devices (see Fig. 11/95).

The two free voltage inputs can be used for monitoring purposes.

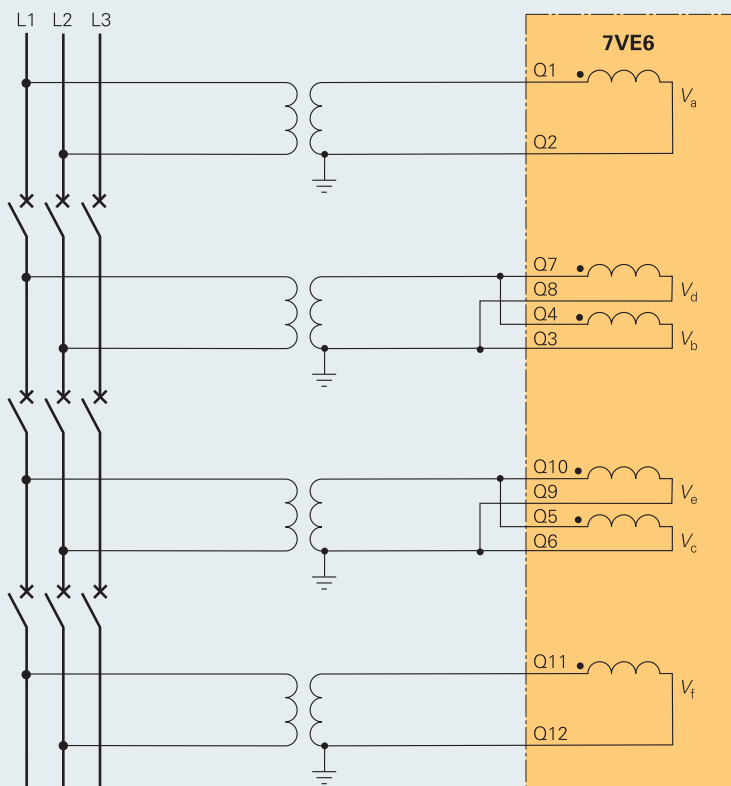


Fig. 11/94

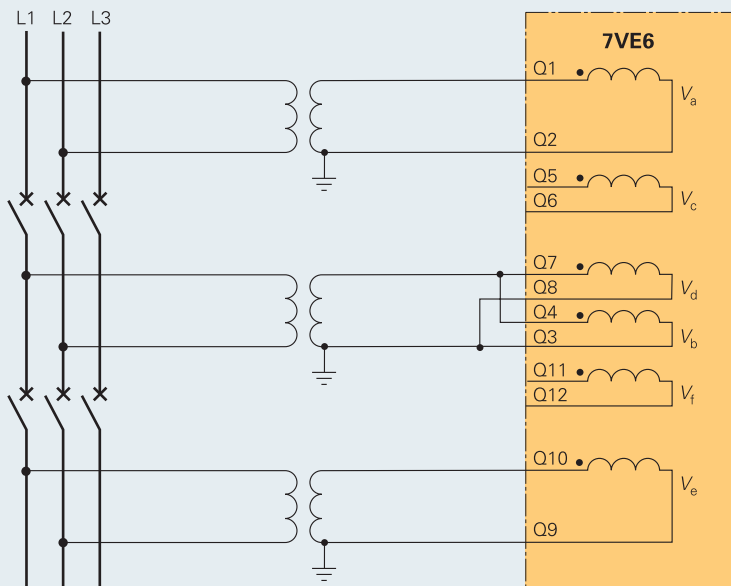
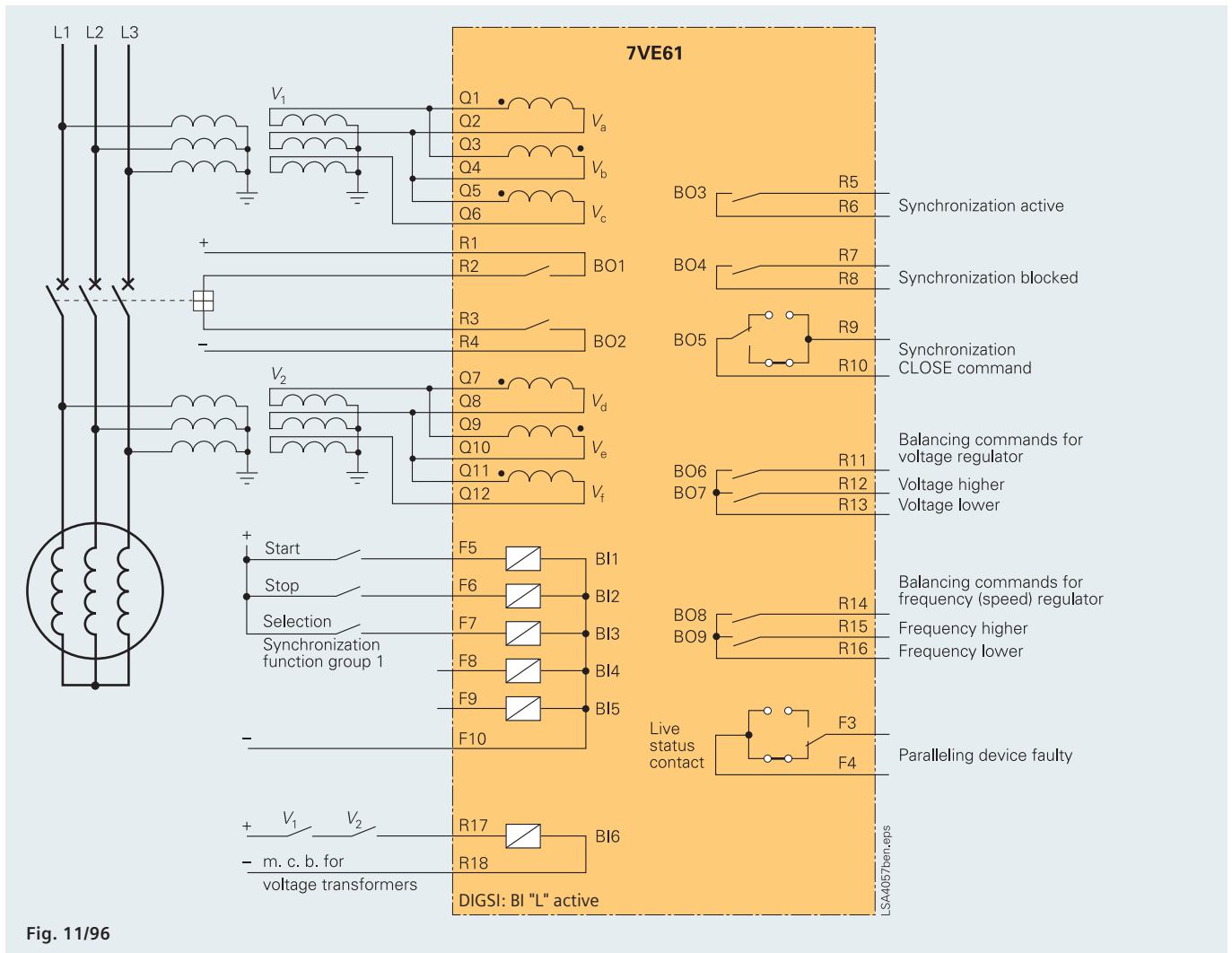


Fig. 11/95

Generator Protection/7VE6

Typical applications



Synchronization of a generator

Fig. 11/96 shows an example of the 7VE61 paralleling device connected to a medium-power generator. Where three-phase voltage transformers are available, direct connection is recommended. The synchronization point and start of synchronization is selected via the binary inputs. If cancellation is necessary, the stop input must be used.

If synchronization onto a dead busbar is permitted, the alarm contact of the voltage transformer miniature circuit-breakers (m.c.b.) must be connected to the unit.

Relays R1 and R2 are used for a CLOSE command. The other relays are used for selected indications and for the balancing commands.

The live status contact operated by the unit self-supervision function must also be wired.

Hardware	
Analog inputs	
Rated frequency	50, 60 or 16.7 Hz
Rated voltage V_N	100 to 125 V
Power consumption Voltage inputs (at 100 V)	Approx. 0.3 VA
Capability in voltage paths	230 V continuous
Auxiliary voltage	
Rated auxiliary voltage	DC 24 to 48 V DC 60 to 125 V DC 110 to 250 V DC 220 to 250 V AC 115 and 230 V (50/60 Hz)
Permitted tolerance	-20 to +20 %
Superimposed AC voltage (peak-to-peak)	≤ 15 %
Power consumption	
Quiescent	
7VE61	Approx. 4 W
7VE63	Approx. 5.5 W
Energized	
7VE61	Approx. 9.5 W
7VE63	Approx. 12 W
Bridging time during auxiliary voltage failure	
at $V_{aux} = 48\text{ V}$ and $V_{aux} \geq 110\text{ V}$	≥ 50 ms
at $V_{aux} = 24\text{ V}$ and $V_{aux} = 60\text{ V}$	≥ 20 ms
Binary inputs	
Quantity	
7VE61	6
7VE63	14
3 pickup thresholds	DC 14 to 19 V, DC 66 to 88 V; DC 117 to 176 V
Range is settable with jumpers	
Maximum permissible voltage	DC 300 V
Current consumption, energized	Approx. 1.8 mA
Output relays	
Quantity	
7VE61	9 (each with 1 NO; 1 optional as NC, via jumper)
7VE62	17 (each with 1 NO; 2 optional as NC, via jumper)
7VE61+7VE63	1 live status contact (NC, NO via jumper)
Switching capacity	
Make	1000 W / VA
Break	30 VA
Break (for resistive load)	40 W
Break (for L/R ≤ 50 ms)	25 W
Switching voltage	250 V
Permissible current	5 A continuous 30 A for 0.5 seconds
LEDs	
Quantity	
RUN (green)	1
ERROR (red)	1
Assignable LED (red)	
7VE61	7
7VE63	14

Unit design	
7XP20 housing	For dimensions see dimension drawings part 14
Degree of protection acc. to EN 60529	
For surface-mounting housing	IP 51
For flush-mounting housing	
Front	IP 51
Rear	IP 50
For the terminals	IP 2x with terminal cover put on
Weight	
Flush-mounting housing	
7VE61 (½ x 19")	Approx. 5.2 kg
7VE63 (½ x 19")	Approx. 7 kg
Surface-mounting housing	
7VE61 (½ x 19")	Approx. 9.2 kg
7VE63 (½ x 19")	Approx. 12

Serial interfaces	
Operating interface for DIGSI 4	
Connection	Non-isolated, RS232, front panel; 9-pin subminiature connector (SUB-D)
Baud rate	4800 to 115,200 baud
Time synchronization IRIG-B / DCF77 signal (Format: IRIG B000)	
Connection	9-pin subminiature connector, (SUB-D), terminal with surface- mounting case
Voltage levels	Selectable 5, 12 or 24 V
Service / modem interface (Port C) for DIGSI 4 / modem / service	
Isolated RS232/RS485	9-pin subminiature connector (SUB-D)
Test voltage	500 V / 50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m
System interface (Port B) IEC 60870-5-103 protocol, PROFIBUS-DP, MODBUS RTU, DNP 3.0) and interface (Port D)	
Isolated RS232/RS485	9-pin subminiature connector (SUB-D)
Baud rate	4800 to 115200 Baud
Test voltage	500 V / 50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m
RS485: PROFIBUS-DP, MODBUS RTU, DNP 3.0	9-pin subminiature connector (SUB-D)
Test voltage	500 V / 50 Hz
Baud rate	
PROFIBUS-DP	Max. 12 MBaud
MODBUS RTU, DNP 3.0	Max. 19200 Baud
Distance	
PROFIBUS-DP	Max. 1000 m with 93.75 kBaud; Max. 100 m with 12 MBaud
MODBUS RTU, DNP 3.0	1000 m
Fiber optic: IEC, PROFIBUS-DP, MODBUS RTU, DNP 3.0	ST connector
PROFIBUS-DP	Double ring
IEC, MODBUS RTU, DNP 3.0	Point-to-point
Baud rate	
PROFIBUS-DP	Max. 1.5 MBaud
MODBUS RTU, DNP 3.0	Max. 19200 Baud
Optical wavelength	λ = 820 nm
Permissible path attenuation	Max. 8 dB, for glass-fiber 62.5/125 μm
Distance	Max. 1.5 km
Analog output module (electrical)	2 ports with 0 to +20 mA

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Technical data

System interface (Port B) IEC 61850			
Ethernet, electrical (EN 100) for IEC 61850 and DIGSI			
Connection for flush-mounting case	Rear panel, mounting location "B", two RJ45 connector, 100 Mbit/s acc. to IEEE802.3		
for surface-mounting case	At bottom part of the housing		
Test voltage	500 V; 50 Hz		
Transmission speed	100 Mbits/s		
Distance	20 m/66 ft		
Ethernet, optical (EN 100) for IEC 61850 and DIGSI			
Connection for flush-mounting case	Rear panel, mounting location "B", LC connector receiver/transmitter		
for panel surface-mounting case	Not available		
Optical wavelength	$\lambda = 1350$ nm		
Transmission speed	100 Mbits/s		
Laser class 1 acc. to EN 60825-1/-2	Glass fiber 50/125 μ m or glass fiber 62/125 μ m		
Permissible path attenuation	Max. 5 dB for glass fiber 62.5/125 μ m		
Distance	Max. 800 m/0.5 mile		
Electrical tests			
<i>Specifications</i>			
Standards	IEC 60255 (product standards) ANSI/IEEE C37.90.0/1.1/2 UL 508 DIN 57435, part 303 For further standards see below		
<i>Insulating tests</i>			
Standards	IEC 60255-5		
Voltage test (100 % test) All circuits except for auxiliary supply, binary inputs, communication and time synchronization interfaces	2.5 kV (r.m.s.), 50/60 Hz		
Voltage test (100 % test) Auxiliary voltage and binary inputs	DC 3.5 kV		
Voltage test (100 % test) only isolated communication interfaces and time synchronization interface	500 V (r.m.s. value), 50/60 Hz		
Impulse voltage test (type test) All circuits except for communication interfaces and time synchronization interface, class III	5 kV (peak); 1.2/50 μ s; 0.5 J; 3 positive and 3 negative impulses at intervals of 5 s		
<i>EMC tests for noise immunity (type test)</i>			
Standards	IEC 60255-6, IEC 60255-22 (product standards) EN 50082-2 (generic standard) DIN 57435 part 303		
High frequency test IEC 60255-22-1, class III and DIN 57435 part 303, class III	2.5 kV (peak value), 1 MHz; $\tau = 15$ ms 400 pulses per s; duration 2 s		
Electrostatic discharge IEC 60255-22-2, class IV EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; $R_i = 330 \Omega$		
Irradiation with RF field, non-modulated IEC 60255-22-3 (report), class III	10 V/m; 27 to 500 MHz		
Irradiation with RF field, amplitude-modulated, IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz		
Irradiation with RF field, pulse-modulated IEC 61000-4-3/ ENV 50204, class III		10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %	
Fast transient interference bursts IEC 60255-22-4, IEC 61000-4-4, class IV		4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50 \Omega$; test duration 1 min	
High-energy surge voltages (SURGE), IEC 61000-4-5 installation, class III		Impulse: 1.2/50 μ s	
Auxiliary supply		Common (longitudinal) mode: 2 kV; 12 Ω , 9 μ F Differential (transversal) mode: 1 kV; 2 Ω , 18 μ F	
Measurement inputs, binary inputs and relay outputs		Common (longitudinal) mode: 2 kV; 42 Ω , 0.5 μ F Differential (transversal) mode: 1 kV; 42 Ω , 0.5 μ F	
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III		10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz	
Magnetic field with power frequency IEC 61000-4-8, class IV; IEC 60255-6		30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz	
Oscillatory surge withstand capability ANSI/IEEE C37.90.1		2.5 to 3 kV (peak); 1 to 1.5 MHz damped wave; 50 surges per second; Duration 2 s; $R_i = 150$ to 200 Ω	
Fast transient surge withstand capability ANSI/IEEE C37.90.1		4 to 5 kV; 10/150 ns; 50 surges per second; both polarities; duration 2 s ; $R_i = 80 \Omega$	
Radiated electromagnetic interference ANSI/IEEE C37.90.2		35 V/m; 25 to 1000 MHz	
Damped oscillations IEC 60894, IEC 61000-4-12		2.5 kV (peak value), polarity alternating 100 kHz, 1 MHz, 10 and 50 MHz, $R_i = 200 \Omega$	
<i>EMC tests for interference emission (type test)</i>			
Standard		EN 50081-x (generic standard)	
Conducted interference voltage on lines only auxiliary supply IEC-CISPR 22		150 kHz to 30 MHz Limit class B	
Interference field strength IEC-CISPR 22		30 to 1000 MHz Limit class B	
Mechanical stress tests			
<i>Vibration, shock stress and seismic vibration</i>			
<i>During operation</i>			
Standards		EC 60255-21 and IEC 60068	
Vibration IEC 60255-21-1, class II IEC 60068-2-6		Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 g acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes	
Shock IEC 60255-21-2, class I IEC 60068-2-27		Half-sinusoidal Acceleration 5 g, duration 11 ms, 3 shocks each in both directions of the 3 axes	

Seismic vibration IEC 60255-21-2, class I IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 g acceleration (horizontal axis) 8 to 35 Hz: 0.5 g acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
During transport	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 g acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I IEC 60068-2-27	Half-sinusoidal Acceleration 15 g, duration 11 ms, 3 shocks each in both directions 3 axes
Continuous shock IEC 60255-21-2, class I IEC 60068-2-29	Half-sinusoidal Acceleration 10 g, duration 16 ms, 1000 shocks in both directions of the 3 axes

Climatic stress test	
Temperatures	
Standards	IEC 60068-2-1, IEC 60068-2-2
Recommended operating limiting temperature	-5 °C to +55 °C / +25 °F to +131 °F
Temporarily permissible operating temperature	-20 to +70 °C (Legibility of display may be impaired above +55 °C / +131 °F)
Limiting temperature during permanent storage (with supplied packing)	-25 °C to +55 °C / -13 °F to +131 °F
Limiting temperature during transport (with supplied packing)	-25 °C to +70 °C / -13 °F to +158 °F
Humidity	
Standards	IEC 60068-2-3
Permissible humidity stress	Annual average ≤ 75 % relative humidity; on 56 days a year up to 93 % relative humidity; condensation is not permit
It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation	

Functions	
General	
Frequency range	25 to 75 Hz ($f_N = 50$ Hz) 30 to 90 Hz ($f_N = 60$ Hz) 8.35 to 25 Hz ($f_N = 16.7$ Hz)

Paralleling function (ANSI 25)	
Setting ranges	
Upper voltage limit V_{max}	20 to 140 V (steps 1 V)
Lower voltage limit V_{min}	20 to 125 V (steps 1 V)
$V <$ for de-energized status	1 to 60 V (steps 1 V)
$V >$ for energized status	20 to 140 V (steps 1 V)
Voltage difference ΔV	0 to 40 V (steps 1 V)
Frequency difference Δf	0 to 2 Hz (steps 0.01 Hz)
Angle difference $\Delta \alpha$	2 to 80° (steps 1°)
Changeover threshold asynchronous – synchronous	0.01 to 0.04 Hz (steps 0.01 Hz)
Angle correction of vector group	0 to 359° (steps 1°)
Matching voltage transformer V_1/V_2	0.5 to 2 (steps 0.01)
Circuit-breaker making time	10 to 1000 ms (steps 1 ms)
Operating time of circuit-breaker	0.01 to 10 s (steps 0.01 s)
Max. operating time after start	0.01 to 1200 s (steps 0.01 s)
Monitoring time of voltage	0 to 60 s (steps 0.1 s)
Release delay	0 to 60 s (steps 0.01 s)
Synchronous switching	0 to 60 s (steps 0.01 s)
Times	
Minimum measuring time	Approx. 80 ms (50/60 Hz) Approx. 240 ms (16.7 Hz)
Drop-off	
Drop-off ratio voltage	Approx. 0.9 ($V >$) or 1 ($V <$)
Drop-off difference frequency	20 mHz
Drop-off difference phase angle	1°
Tolerance	
Voltage measurement	1 % of pickup value or 0.5 V
Voltage difference ΔV	1 % of pickup value or max. 0.5 V (typical < 0.2 V)
Frequency difference Δf	< 10 mHz (synchronous network) < 15 mHz (asynchronous network)
Angle difference $\Delta \alpha$	0.5° with minor slip and approx. rated frequency 3° for $\Delta f < 1$ Hz, 5° for $\Delta f > 1$ Hz
Delay times	1 % or 10 ms
Readjustment commands for synchronization	
Frequency balancing	
Minimum control pulse	10 to 1000 ms (steps 1 ms)
Maximum control pulse	1 to 32 s (steps 0.01 s)
Frequency change of controller	0.05 to 5 Hz/s (steps 0.01 Hz/s)
Setting time of controller	0 to 32 s (steps 0.01 s)
Target value for frequency balancing	-1 to 1 Hz (steps 0.01 Hz)
Kick pulse	Available
Voltage balancing	
Minimum control pulse	10 to 1000 ms (steps 1 ms)
Maximum control pulse	1 to 32 s (steps 0.01 s)
Voltage change of controller	0.1 to 50 V/s (steps 0.1 V/s)
Setting time of controller	0 to 32 s (steps 0.01 s)
Permissible overexcitation ($(V/V_N)/(f/f_N)$)	1 to 1.4 (steps 0.01)
Tolerances	
Minimum control pulse	1 %
Control times	Approx. 5 % or ± 20 ms
Undervoltage protection (ANSI 27)	
Setting range	
Undervoltage pickup $V <, V <<$	10 to 125 V (steps 0.1 V)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup times $V <, V <<$	Approx. 50 ms (150 ms at 16.7 Hz)
Drop-off times $V <, V <<$	Approx. 50 ms (150 ms at 16.7 Hz)
Drop-off ratio $V <, V <<$	1.01 to 1.10 (steps 0.01)
Tolerances	
Voltage limit values	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms

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Technical data

Overvoltage protection (ANSI 59)	
Setting ranges	
Overvoltage pickup $V>$, $V>>$	30 to 170 V (steps 0.1 V)
Time delays T'	0 to 60 s (steps 0.01 s) or indefinite
Time	
Pickup times $V>$, $V>>$	Approx. 50 ms (150 ms at 16.7 Hz)
Drop-off times $V>$, $V>>$	Approx. 50 ms (150 ms at 16.7 Hz)
Drop-off ratio $V>$, $V>>$	0.90 to 0.99 (steps 0.01)
Tolerances	
Voltage limit values	1 % of set value or 0.5 V
Time delays T'	1 % or 10 ms
Frequency protection (ANSI 81)	
Setting ranges	
Steps; selectable $f>$, $f<$	4
Pickup values $f>$, $f<$	40 to 65 Hz (steps 0.01 Hz)
Time delays T'	0 to 60 s (steps 0.01 s) or indefinite
Undervoltage blocking $V<$	10 to 125 V (steps 0.1 V)
Times	
Pickup times $f>$, $f<$	Approx. 100 ms (300 ms at 16.7 Hz)
Drop-off times $f>$, $f<$	Approx. 100 ms (300 ms at 16.7 Hz)
Drop-off difference Δf	Approx. 20 mHz
Drop-off ratio $V<$	Approx. 1.05
Tolerances	
Frequencies	10 mHz at $f = f_N$
Undervoltage blocking	1 % of set value or 0.5 V
Time delays T'	1 % or 10 ms
Rate-of-frequency-change protection (ANSI 81R)	
Setting ranges	
Steps, selectable $+df/dt >$; $-df/dt$	4
Pickup value df/dt	0.1 to 10 Hz/s (steps 0.1 Hz/s);
Time delays T'	0 to 60 s (steps 0.01 s) or indefinite
Undervoltage blocking $V<$	10 to 125 V (steps 0.1 V)
Times	
Pickup times df/dt at 16.7 Hz: times x 3	Approx. 200 to 700 ms (depending on measuring duration)
Drop-off times df/dt at 16.7 Hz: times x 3	Approx. 200 to 700 ms (depending on measuring duration)
Drop-off ratio df/dt	0.02 at 0.99 Hz/s (settable)
Drop-off ratio $V<$	Approx. 1.05
Tolerances	
Rate-of-frequency change	Approx. 0.1 Hz/s at $V > 0.5 V_N$
Measuring duration < 5	Approx. 5 % or 0.15 Hz/s at $V > 0.5 V_N$
Measuring duration > 5	Approx. 3 % or 0.15 Hz/s at $V > 0.5 V_N$
Undervoltage blocking	1 % of set value or 0.5 V
Time delays T'	1 % or 10 ms
Jump of voltage vector monitoring	
Setting ranges	
Stage $\Delta\varphi$	2° to 30° (steps 0.1°)
Time delay T'	0 to 60 s (steps 0.01 s) or indefinite
Undervoltage blocking $V<$	10 to 125 V (steps 0.1 V)
Maximum voltage	10 to 170 V (steps 0.1 V)
Times	
Pickup times $\Delta\varphi$	Approx. 75 ms (225 ms at 16.7 Hz)
Drop-off times $\Delta\varphi$	Approx. 75 ms (225 ms at 16.7 Hz)
Tolerances	
Vector jump	0.5° at $V > 0.5 V_N$
Undervoltage blocking	1 % of set value or 0.5 V
Time delay T'	1 % or 10 ms
External trip coupling	
Number of external trip couplings	4

Threshold value supervision	
Number of steps	6 (3 larger and 3 smaller)
Measured quantity	V_a , V_b , V_c , V_d , V_e , V_f
Setting ranges	2 to + 200 % (steps 1 %)
Times	
Pickup times	Approx. 50 ms (150 ms at 16.7 Hz)
Drop-off times	Approx. 50 ms (150 ms at 16.7 Hz)
Drop-off ratio	0.95
Voltage tolerance	1 % of set value or 0.5 V
Typical operational measured values	
Description	Secondary
Voltages	V_a ; V_b ; V_c ; V_d ; V_e ; V_f ; V_1 , V_2 , ΔV
Tolerance	0.2 % of measured value or $\pm 0.2 V \pm 1$ digit
Phase angle	$\Delta\alpha$
Tolerance	$< 0.5^\circ$
Frequency	f_1 , f_2 , Δf
Tolerance	10 mHz at $f = f_N$ 15 mHz at $f = f_N \pm 10 \%$
Fault records	
Number of fault records	Max. 8 fault records
Instantaneous values	
Storage time	Max. 10 s
Sampling interval	Depending on the actual frequency (e.g. 1 ms at 50 Hz; 0.83 ms at 60 Hz)
Channels	V_a ; V_b ; V_c ; V_d ; V_e ; V_f ; V_d-V_a , V_e-V_b , V_f-V_c , ΔV , Δf , $\Delta\alpha$
R.m.s. values	
Storage period	Max. 100 s
Sampling interval	Fixed (10 ms at 50 Hz, 8.33 ms at 60 Hz)
Channels	V_1 , V_2 , f_1 , f_2 , ΔV , Δf , $\Delta\alpha$
Additional functions	
Fault event logging	Storage of events of the last 8 faults Puffer length max. 600 indications Time solution 1 ms
Operational indications	Max. 200 indications Time solution 1 ms
Elapsed-hour meter	Up to 6 decimal digits
Switching statistics	Number of break operations Number of make operations



CE conformity	
<p>This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EEC previous 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 2006/95/EEC previous 73/23/EEC).</p> <p>This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).</p> <p>The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.</p> <p>This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".</p>	

Description	Order No.	Order code
7VE61 multifunction paralleling unit Housing 1/3 19", 6 BI, 9 BO, 1 live status contact	7VE6110-□□□□□□□□-0□□□□□□□□	
Auxiliary voltage (power supply, indication voltage)		
24 to 48 V DC, threshold binary input 19 V	2	
60 to 125 V DC, threshold binary input 19 V	4	
110 to 250 V DC, 115 to 230 V AC, threshold binary input 88 V DC	5	
220 to 250 V DC, 115 to 230 V AC, threshold binary input 176 V DC	6	
Unit design		
Surface-mounting housing, 2-tier screw-type terminals at top/bottom	B	
Flush-mounting housing, screw-type terminals (direct connection/ring-type cable lugs)	E	
Region-specific default setting/function and language settings		
Region DE, 50 Hz, language German (language selectable)	A	
Region World, 50/60 Hz, language English (GB) (language selectable)	B	
Region US, 60 Hz, language English (US) (language selectable)	C	
Region World, 50/60 Hz, language Spanish (language selectable)	E	
Port B (system interface)		
No system interface	0	
IEC 60870-5-103-protocol, electrical RS232	1	
IEC 60870-5-103-protocol, electrical RS485	2	
IEC 60870-5-103-protocol, optical 820 nm, ST connector	3	
Analog outputs 2 x 0 to 20 mA or 4 to 20 mA	7	
PROFIBUS-DP Slave, electrical RS485	9	L 0 A
PROFIBUS-DP Slave, optical 820 nm, double ring, ST connector ¹⁾	9	L 0 B
MODBUS RTU, electrical RS485	9	L 0 D
MODBUS RTU, optical 820 nm, ST connector ¹⁾	9	L 0 E
DNP 3.0, electrical RS485	9	L 0 G
DNP 3.0, optical 820 nm, ST connector ¹⁾	9	L 0 H
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connectors	9	L 0 R
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector ²⁾	9	L 0 S
Port C (service interface)		
DIGSI 4/modem, electrical RS232	1	
DIGSI 4/modem, electrical RS485	2	
Port C (service interface) and Port D (additional interface)		
Port C (service interface)		
DIGSI 4/modem, electrical RS232	9	M 1 <input type="checkbox"/>
DIGSI 4/modem, electrical RS485	9	M 2 <input type="checkbox"/>
Port D (additional interface)		
Analog outputs 2 x 0 to 20 mA or 4 to 20 mA		K
Scope of functions of the unit		
Synchro-check for up to 3 synchronizing points (with dead bus/line monitoring)	A	
Paralleling function for 2 synchronizing points without balancing commands, 1 1/2-channel, synchro-check in 2 nd channel	B	
Paralleling function for 2 synchronizing points with balancing commands, 1 1/2-channel, synchro-check in 2 nd channel	C	
Paralleling function for 4 synchronizing points with balancing commands, 1 1/2-channel, synchro-check in 2 nd channel	D	
Additional functions		
Without A	A	
Protection and network decoupling function (voltage, frequency and rate-of-frequency-change protection, vector jump)	B	
Additional applications		
Without	0	
Application for traction systems ($f_n = 16.7\text{Hz}$)	1	

1) With position 9 = B (surface-mounting housing) the unit must be ordered with RS485 interface and a separate FO converter.

2) Not available with position 9 = "B"

Accessories	Description	Order No.
	DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper) Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
	Professional Basis and all optional packages on CD-ROM, DIGSI 4 and DIGSI 3	7XS5402-0AA00
	Copper connecting cable Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	7XV5100-4
	Manual 7VE61 and 7VE63 Multifunction Paralleling Device	C53000-G1176-C163-1

Accessories	Description	Order No.	Size of package	Supplier	
 <p>LSP2092-afp.eps</p> <p>Fig. 11/97 Short-circuit link for voltage contacts</p>  <p>LSP2289-afp.eps</p> <p>Fig. 11/98 Mounting rail for 19" rack</p>	Crimp connector CI2 0.5 to 1 mm ²	0-827039-1 0-827396-1	4000 1	AMP ¹⁾ AMP ¹⁾	
	CI2 0.5 to 2.5 mm ²	0-827040-1 0-827397-1	4000 1	AMP ¹⁾ AMP ¹⁾	
	Type III+ 0.75 to 1.5 mm ²	0-163083-7 0-163084-2	4000 1	AMP ¹⁾ AMP ¹⁾	
	Crimping tool	For type III+ and matching female For CI2 and matching female	0-539635-1 0-539668-2 0-734372-1 1-734387-1	1 1	AMP ¹⁾ AMP ¹⁾ AMP ¹⁾ AMP ¹⁾
	19"-mounting rail		C73165-A63-D200-1	1	Siemens
	Short-circuit links	For voltage terminals	C73334-A1-C34-1	1	Siemens
	Safety cover for terminals	large small	C73334-A1-C31-1 C73334-A1-C32-1	1 1	Siemens Siemens
	1) Your local Siemens representative can inform you on local suppliers.				

Generator Protection/7VE6

Connection diagram

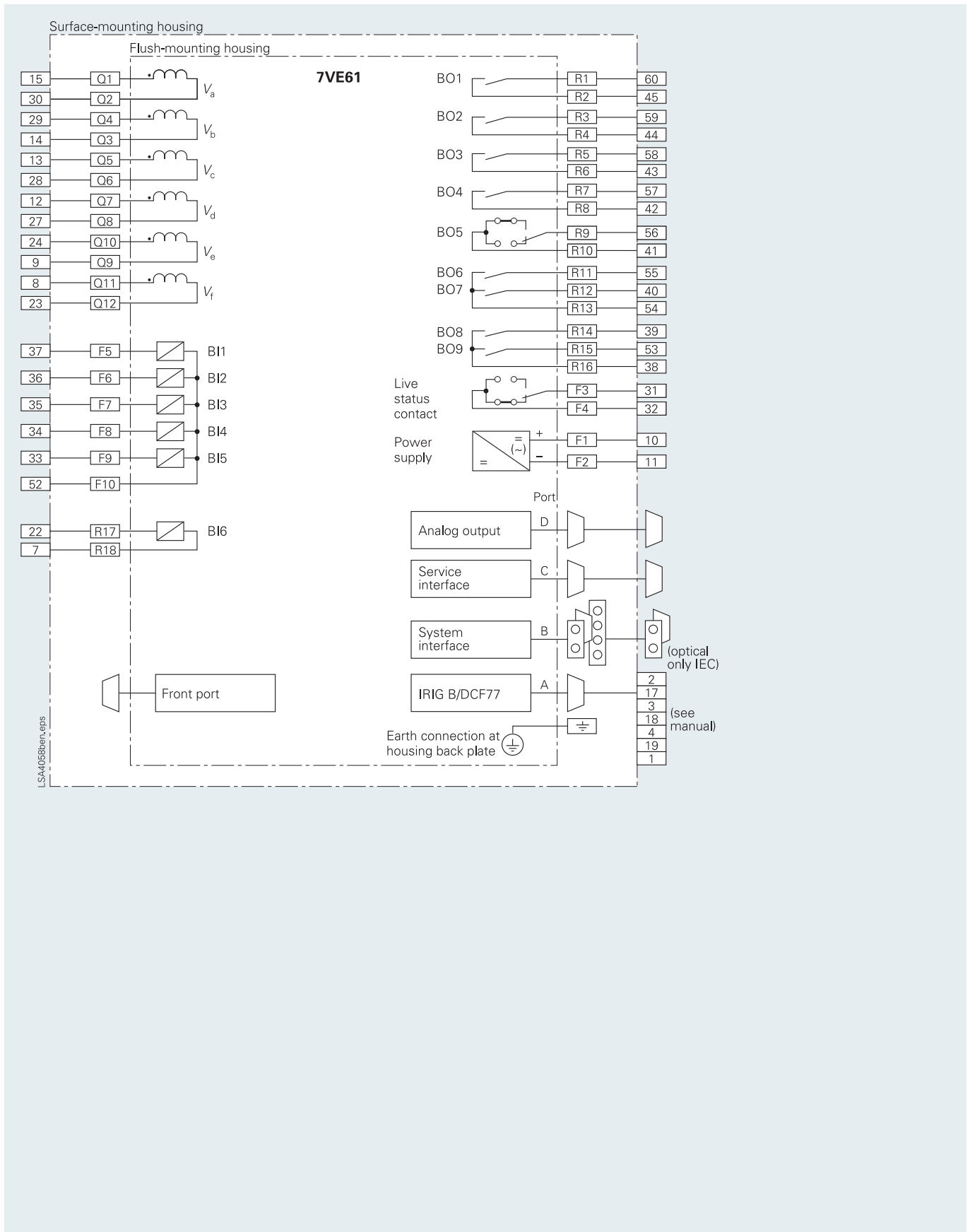


Fig. 11/99 Connection diagram

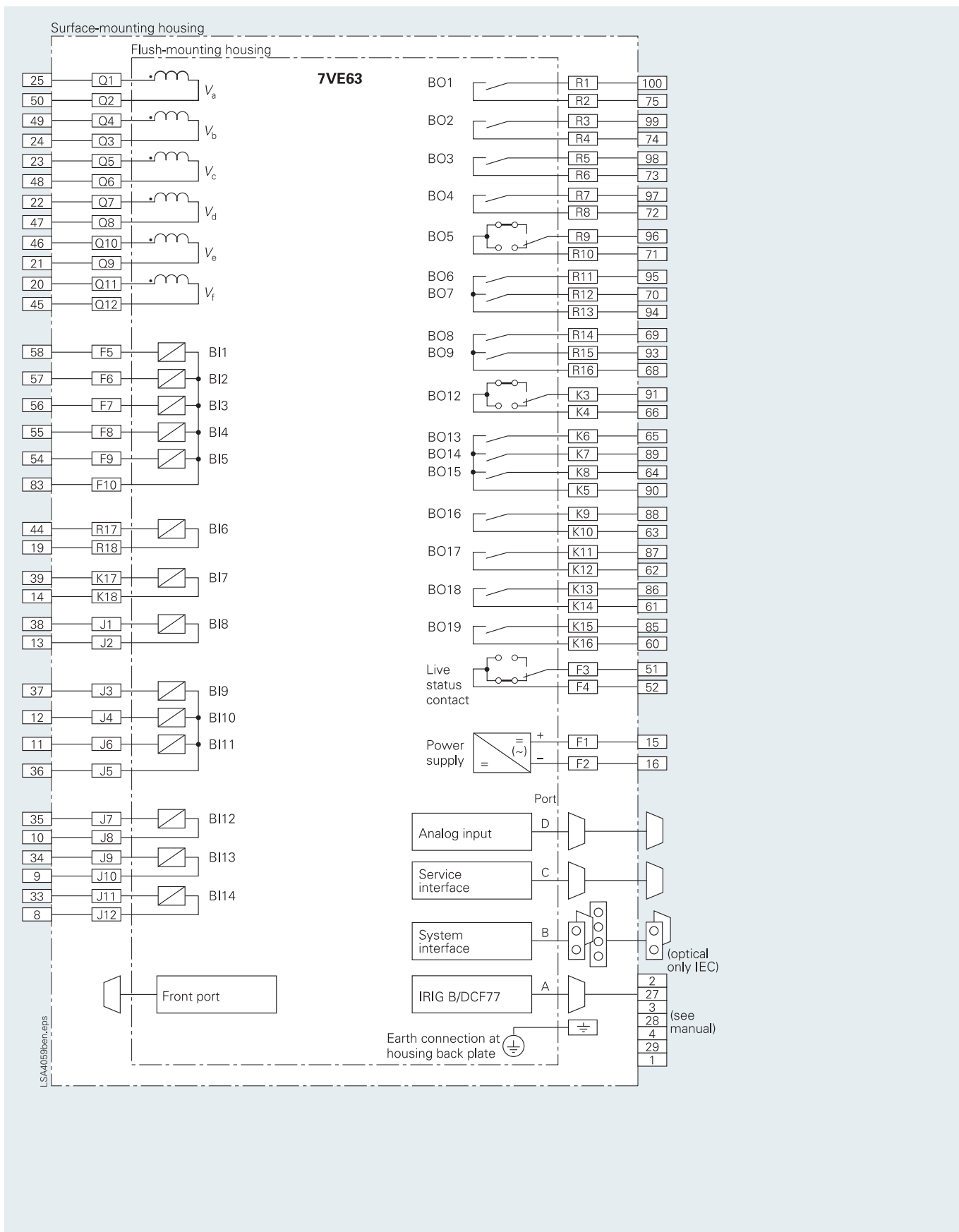


Fig. 11/100 Connection diagram



Fig. 11/101 SIPROTEC 4 7VU683 high speed busbar transfer device

Description

Permanent availability of electricity is essential for reliable production of a great number of processes in power stations and industrial plants where lots of inductive motor are installed. To achieve this, a busbar is normally equipped with two or more independent in-coming power sources to provide the possibility to switch to standby source in case of main source interruption or failure.

The power supply interruption with tens of millisecond has small impact to rotating loads. Thus, the High Speed Busbar Transfer (HSBT) device helps to control and monitor the progress to ensure the fast but reliable switching-over. It can be initiated manually or automatically.

Based on the existing world-wide used SIPROTEC 4 platform, the reliability, stability and efficiency of HSBT 7VU683 are guaranteed. Thanks to its powerful and flexible performance, multi functions are integrated into one system, e.g. power supply transfer, relay protection and supervision.

The compact solution HSBT 7VU683 is designed to fit for the primary diagrams of single busbar (2 CBs) and segmented single busbar (3 CBs). It has incorporated the traditional HSBT philosophy. Additionally, the unique Real Time Fast Transfer mode helps to improve the efficiency.

The integrated protective functions are to protect the tie-CB in segmented single busbar diagram against short-circuit and ground fault. The integrated supervision functions are to monitor the voltage phase sequence and voltage secondary circuit, then gives out alarm in case of failure.

The integrated programmable logic (CFC) allows the users to implement their own functions. The flexible communication interfaces are open for modern communication architectures with control system.

Function overview

High speed busbar transfer function

- Starting conditions
 - NORMAL condition
 - FAULT condition
 - Inadmissible under-voltage
 - Inadmissible under-frequency
 - Inadvertent CB open
- Switching sequences
 - PARALLEL Auto switching sequence
 - PARALLEL Half-Auto switching sequence
 - SIMULTANEOUS switching sequence
 - SEQUENTIAL sequence
- Transfer modes
 - FAST transfer mode
 - REAL-TIME FAST transfer mode
 - IN-PHASE transfer mode
 - RES-VOLT transfer mode
 - LONG-TIME transfer mode
- Single busbar and segmented single busbar supported
- High speed contact with approx. 1ms for closing
- Permission of bi-direction switching settable
- Low voltage load-shedding settable
- CB de-coupling when OPEN failed
- NORMAL start locally or remotely
- Manual CB closing to block HSBT
- ON/OFF set locally or remotely
- HSBT test mode supported

Protection functions for tie-CB

- Overcurrent protection
- Ground overcurrent protection
- Overcurrent protection for busbar energization
- Ground overcurrent protection for busbar energization

Monitoring functions

- Self-supervision of the device
- Oscillographic fault recording
- Phase sequence of busbar voltage
- Voltage circuit of busbar and line

Communication interfaces

- PC front port for setting with DIGSI 4
- System interface
 - IEC 60870-5-103, redundant optional
 - IEC 61850, Ethernet
 - Profibus-DP or Modbus RTU
- Service interface for DIGSI 4 (modem)
- Time synchronization via IRIG B/DCF 77

Generator Protection/7VU683

Application

Application

The 7VU683 high speed busbar transfer (HSBT) device of SIPROTEC 4 family is compact multifunction unit which has been developed for very fast power supply transfer of busbar which is installed with big rotating loads. It accommodates the primary diagram of both single busbar and segmented single busbar. It incorporates all the necessary HSBT conditions and even some protection functions. It is specially suitable for the power supply transfer of:

- Coal-fired power station
- Gas-fired power station
- Combined cycle power station
- Integrated gasification combined cycle (IGCC) power station
- Nuclear power station
- Chemical plant
- Petrochemical plant
- Refinery plant
- Iron and steel plant
- Cement plant

The numerous other additional functions assist the user in ensuring the cost effective system management and reliable power supply. Local operation has been designed according to economic criteria. A large, easy-to-use graphic display is a major design aim.

HSBT function

In station service system of thermal power station and some industrial plants, a lot of asynchronous motor are connected. The restarting motors after some seconds power loss will cause heavy starting current and system voltage drop. On the other hand, the incorrect reconnecting to stand-by power source will even damage the winding of rotor.

The version HSBT 7VU683 is designed for this case. It will evaluate the necessary switching conditions to ensure the fast but secure transfer. Some improvements like as REAL-TIME FAST transfer mode, additional line current criteria will significantly help to the efficiency and safety.

Protection functions for tie-CB

The integrated protections are intend to protect the tie-CB in segmented single busbar diagram against short-circuit or ground fault.

Some special concerning is done to the busbar switch-onto-fault. Protection functions will only be active for a settable time.

Programmable logic

The integrated logic characteristics (CFC) allow the user to implement their own functions and generate user-defined messages.

Measuring values

The measuring values like as U, I, f, dV, df, dj, 3I0, 3V0 and CB closing time can be recorded and displayed.

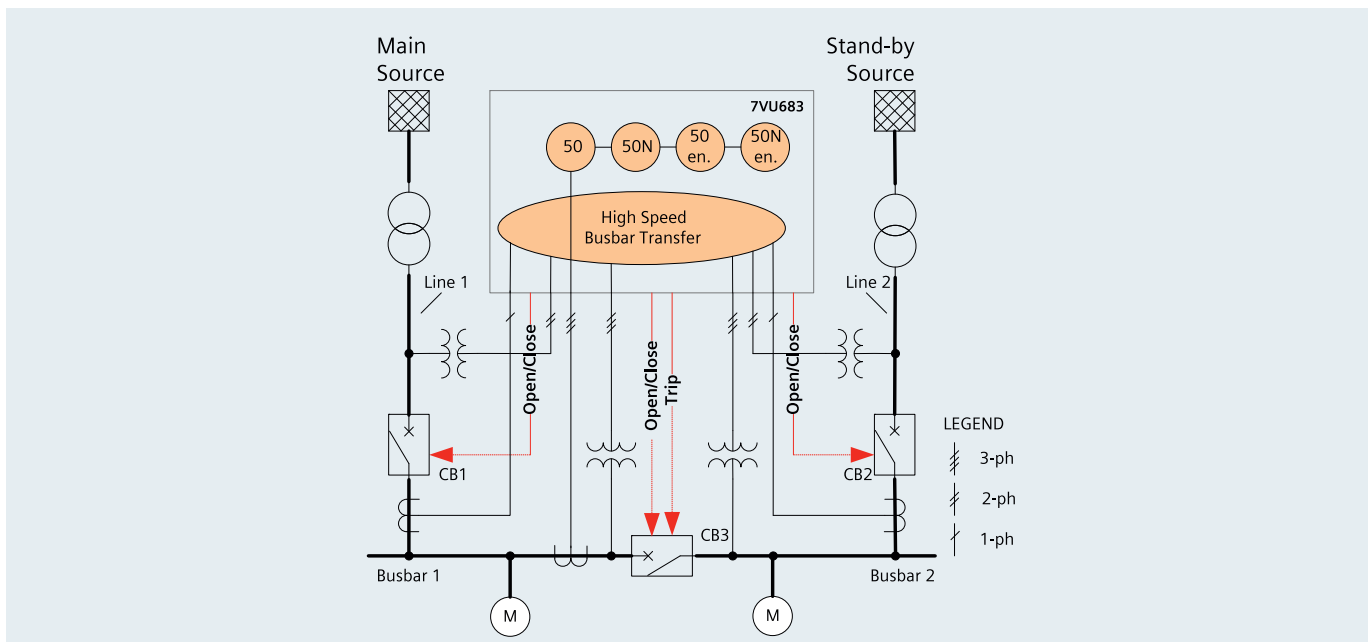


Fig. 11/102 Function diagram

Function	Abbreviation	ANSI Code	2 Line-CBs	2 Line-CBs + 1 Tie-CB
HSBT				
Line1->Line2			X	X
Line2->Line1			X	X
Busbar1->Busbar2				X
Busbar2->Busbar1				X
Busbar1->Line1				X
Busbar2->Line2				X
Protection				
Definite overcurrent protection	I>+V<	50		X
Ground-overcurrent protection	3I0>+3V0>	50N		X
Overcurrent protection for busbar energization	I>+V<	50.en		X
Ground-overcurrent protection for busbar energization	3I0>+3V0>	50N.en		X
Supervision				
Phase sequence		47	X	X
Voltage circuit			X	X

Table 11/8 Functional scope of HSBT 7VU683

Construction

The SIPROTEC 4 units have a uniform design and a degree of functionality which represents a whole new quality. Local operation has been designed according to ergonomic criteria. Large, easy-to-read displays were a major design aim. The device HSBT 7VU683 is equipped with a graphic display thus providing and depicting more information especially in industrial applications. The DIGSI 4 operating program considerably simplifies planning and engineering and reduces commissioning times.

1/1-rack size is the available housing width of the device HSBT 7VU683, referred to a 19" module frame system. The height is a uniform 245 mm. Only flush-mounting housing with screw type terminals is available. All cables can be connected with or without ring lugs.

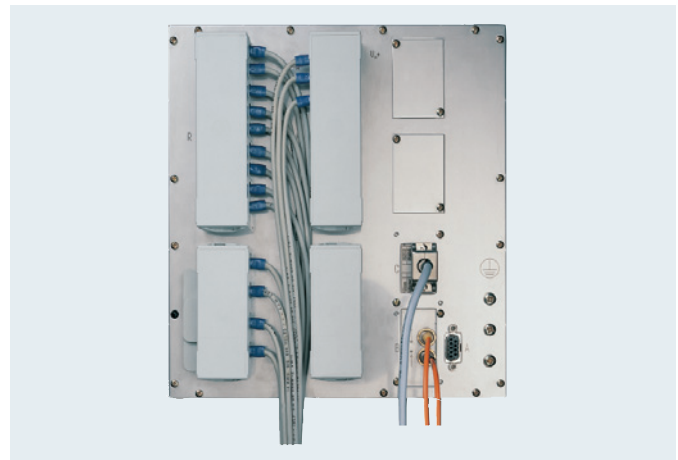


Fig. 11/103 Rear view with wiring terminal safety cover and serial interface

Generator Protection/7VU683

HSBT functions

HSBT functions

Starting conditions

The device HSBT 7VU683 is designed to support the following starting conditions,

- NORMAL condition
- FAULT condition
- Inadmissible Under-voltage condition
- Inadmissible Under-frequency condition
- Inadvertent CB Open condition

The above conditions can be freely combined together, i.e, one of them can be individually switched "OFF".

- NORMAL condition

Under the NORMAL condition, the power system is fault free and the starting command must be manually issued. This command can come from remote control center and/or local controller via wiring connection or communication over protocol, e.g,

- DCS of power station
- Turbine control system
- Local panel

The switching of remote and local starting authority is done by internal CFC logic and controlled by device switching key "Remote/Local". The starting command can only be remotely executed over communication when the switching key is at position "Remote", vice versa.

- FAULT condition

Under the FAULT condition, power system fault must be there on the in-feeder line and the starting command must be externally issued by other device, e.g, protection device.

- Abnormal condition

Under the abnormal condition, voltage disturbance must be there on the busbar due to any causes. The starting command can be internally issued by device HSBT 7VU683 according to the following abnormal conditions

- Inadmissible Under-voltage
- Inadmissible Under-frequency
- Inadvertent CB Open

To secure the starting reliability, line current is used as the additional criterion to the above conditions.

In case the operating CB is manually tripped, transfer must not be started. This can be recognized via indication 17864 ">NonManu.Op.CB1" and 17865 ">NonManu.Op.CB2" in configuration matrix.

Switching sequences

The category HSBT 7VU683 is designed to serve for the following switching sequences according to CBS' operating behavior,

- PARALLEL switching sequence
- SIMULTANEOUS switching sequence
- SEQUENTIAL switching sequence

PARALLEL and SIMULTEOUS switching sequences can exclusively support the starting condition NORMAL while SEQUENTIAL can support all starting conditions.

- PARALLEL switching sequence

If the two sources are allowed to work on busbar in parallel for a short time, the PARALLEL sequence can be used for power supply transfer.

Under PARALLEL sequence, HSBT 7VU683 will firstly issue a CLOSE command to the to-be-closed CB after the device get the starting command. When the closure is successful, the device will trip the to-be-opened CB. The tripping command can be automatically generated by device or derived from manual operation which are dependent on setting,

- PARALLEL Auto sequence
- PARALLEL Half-Auto sequence

Under PARALLEL Auto sequence, the device will automatically issue an OPEN command after a settable time delay when the closure is successful. Under PARALLE Half-Auto sequence, the device will not issue the OPEN command until the Manual Open command arrived. The criterions are as below,

- $df < 8851$ "PARAL. Delta f"
- $|dU| < 8852$ "PARAL. Delta U"
- $dj < 8853$ "PARAL. Delta PHI"

If the to-be-opened CB failed to open, the device will automatically de-couple the to-be-closed CB.

The time sequence under PARALLEL can be understandable via Fig. 11/104 (assumed switching of closing CB2 and opening CB1).

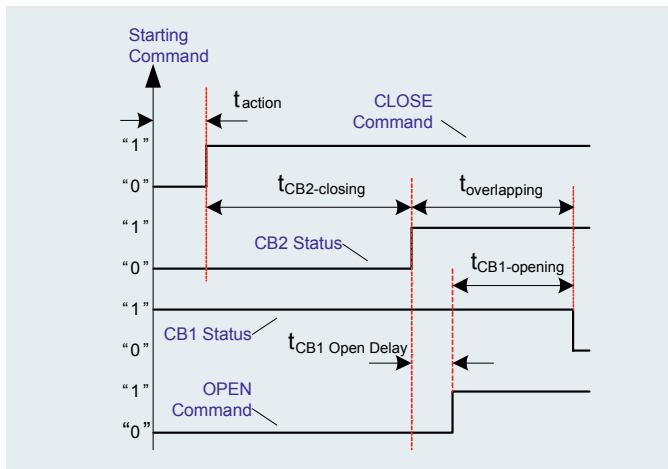


Fig. 11/104 Time sequence of PARALLEL

The advantage of PARALLEL sequence is to avoid any interruption of busbar power supply. PARALLEL Auto sequence should be preferred to reduce the overlapping time of two sources.

- SIMULTANEOUS switching sequence

If the two sources are not allowed to work on busbar in parallel, the SIMULTANEOUS sequence can be used for power supply transfer. Under SIMULTANEOUS sequence, HSBT 7VU683 will firstly issue a OPEN command to the to-be-opened CB after the device gets the starting command. Meanwhile, the device will issue a CLOSE command to the to-be-closed CB if other criterions are met. The overlapping can be avoided via the settable CB close time delay if CB making time is small than breaking time. The criterions are as below,

- $df < 8855$ "SIMUL. Delta f"
- $dj < 8856$ "SIMUL. Delta PHI"

If the to-be-opened CB failed to open, the device will automatically de-couple the to-be-closed CB.

The time sequence under SIMULTANEOUS can be understandable via Fig. 11/105 (assumed switching of closing CB2 and opening CB1).

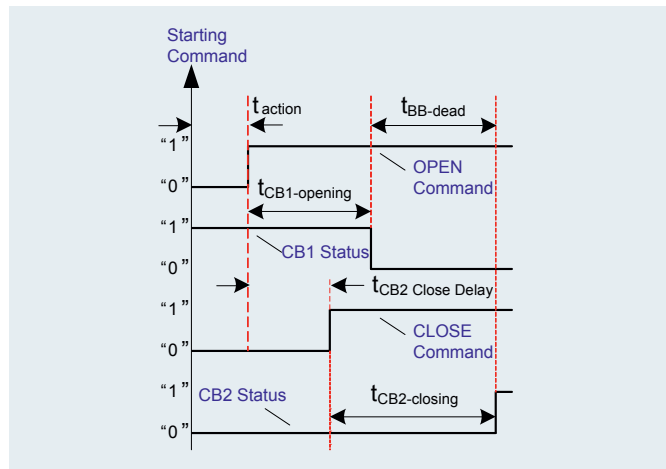


Fig. 11/105 Time sequence of SIMULTANEOUS

Due to the different operating time of the CB (a CB normally opens faster than it close), the power supply of busbar will be interrupted for a few milliseconds. The length of this dead interval depends on the difference of CB operating time.

- SEQUENTIAL switching sequence

Under SEQUENTIAL sequence, HSBT 7VU683 will firstly issue a OPEN command to the to-be-opened CB after the device get the starting command. Differentiate from PARALLEL and SIMULTANEOUS switching sequences, SEQUENTIAL sequence can only issue CLOSE command after the opening succeeded.

The time sequence under SEQUENTIAL can be understandable via Fig. 11/106 (assumed switching of closing CB2 and opening CB1).

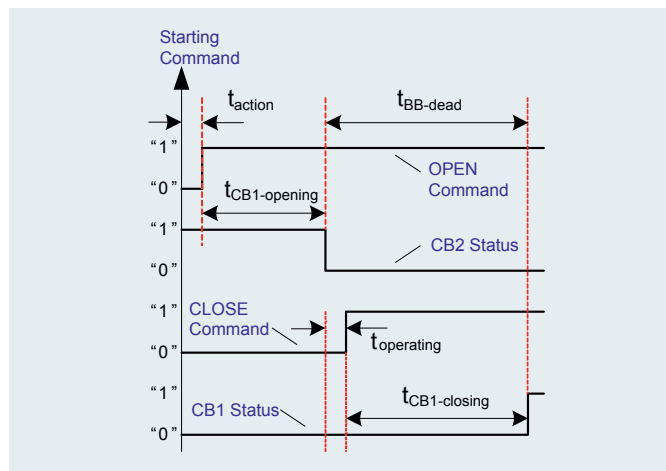


Fig. 11/106 Time sequence of SEQUENTIAL

Generator Protection/7VU683

HSBT functions

Transfer modes

In the station service system of power station and industrial plants, lots of asynchronous motors are connected. In case of the main source interruption, the residual voltage of busbar will be induced by connected asynchronous motors. Fig.11/107 shows the well-known typical diagram of vector trajectory of residual voltage.

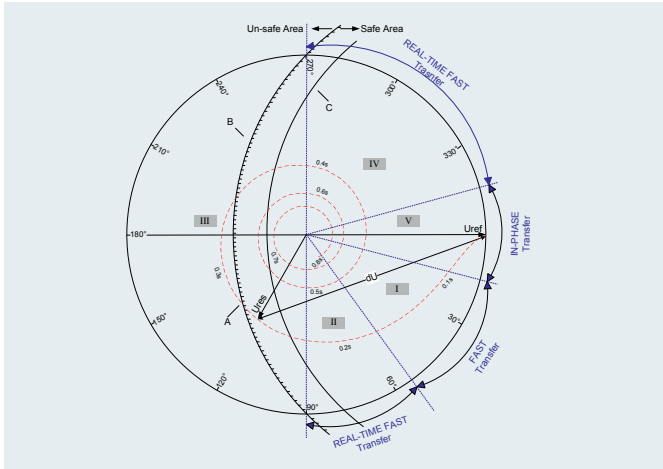


Fig. 11/107 Vector trajectory of residual voltage

Some notes are there regarding curve A according to Fig. 11/110. The amplitude and frequency of residual voltage will decrease regarding time, while the delta phase angle against referred voltage will increase. Fig. 11/108 gives more messages to differential voltage.

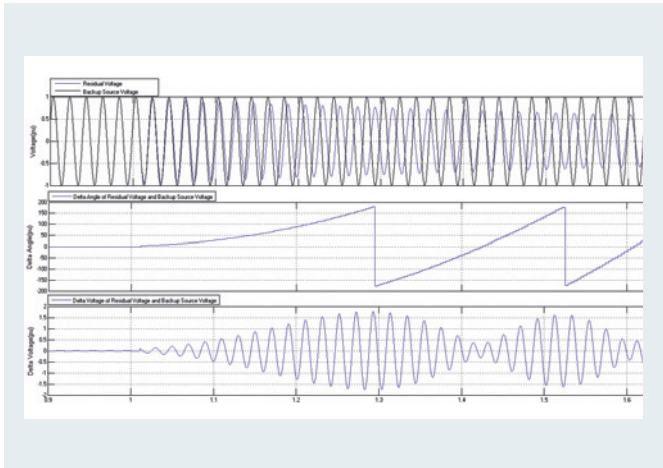


Fig. 11/108 Vector trajectory of residual voltage

The equivalent circuit of residual voltage U_{res} and referred voltage U_{ref} is shown in Fig. 11/109.

The voltage drop on motor U_m at instant of CB closing is calculated by following,

$$U_m = dU \cdot x_m / (x_m + x_s) = k \cdot dU \quad (\text{Equa.-1})$$

Here, x_m and x_s are respectively the equivalent reactance of busbar loading and referred system.

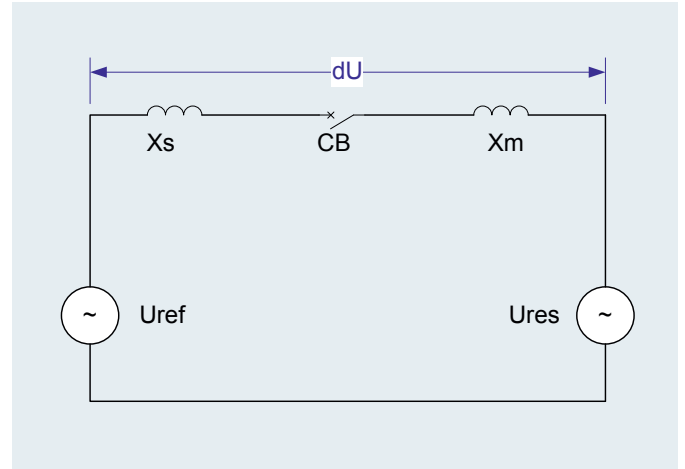


Fig. 11/109 Equivalent circuit of dU

For safety reason, the value $|U_m|$ must not exceed the permissible voltage $k_0/v \cdot |U_n|$. Then, the maximum of permissible differential voltage $|dU|_{max}$ will be,

$$|dU|_{max} = k_0/v / k \cdot |U_n| \quad (\text{Equa.-2})$$

In case $k_0/v = 1.1$ and $k = 0.67$, the calculated $|dU|_{max}$ should be less than $1.64 \cdot |U_n|$ (refer to curve B in Fig. 11/107).

In case $k_0/v = 1.1$ and $k = 0.95$, the calculated $|dU|_{max}$ should be less than $1.15 \cdot |U_n|$ (refer to curve C in Fig. 11/107). This calculation result would be the base for setting.

The plane is divided into two parts by curve B (or curve C). The left is defined as un-safe area because the value $|dU|$ is bigger than the up-limit $|dU|_{max}$ which could damage the winding of stator. Vice versa, the right is safe area.

Based on the above principles, the category HSBT 7VU683 is designed to have the following modes (refer to Fig. 11/107) to fit for the safe transfer,

- FAST transfer mode (area I)
- REAL-TIME FAST transfer mode (area II and III)
- IN-PHASE transfer mode (area IV)
- RES-VOLT transfer mode
- LONG-TIME transfer mode

All of above modes can be freely combined together, i.e, one of them can be individually switched "ON" or "OFF" remotely via communication or locally at device panel.

To be noted that the original dj and $|dU|$ between busbar voltage and standby voltage due to wiring can be automatically compensated by device during configuration.

- FAST transfer mode

The study and testing results show, in most cases the typical values of df , dj and $|dU|$ are smaller enough within the first tens of millisecond from the instant the CB opens. It's good to safe and fast transfer due to the slight shock to motors. If the real-time measured df , dj and $|U_{res}|$ meet the defined criterions, the device will immediately issue the CLOSE command to the to-be-closed CB. The criterions are as below,

- $df < 8858$ "FT Delta f"
- $dj < 8859$ "FT Delta PHI"
- $|U_{res}| > 8860$ "FT U/V BLK"

The typical operating time of 7VU683 in this case is approx. 20ms. As modern vacuum breaker has less making time, e.g, 60ms, the dead time of busbar will be as short as approx. 80ms.

- REAL-TIME FAST transfer mode

When FAST transfer chance is missed, the device will automatically, if activated, turn to next transfer mode REAL-TIME FAST.

This mode has more concerning on the permissible motor voltage, i.e, the differential voltage $|dU|$ across the opened CB must not exceed the value $|dU|_{max}$. The intelligent device 7VU683 then estimates the delta phase angle dj and differential voltage dU at the instant the CB closes based on real-time slipping rate and the settable "CBx Closing Time". If all the quantity of predicted dj and dU , the real-time df and $|U_{res}|$ meet the defined criterions, the device will immediately issue the CLOSE command to the to-be-closed CB. The criterions are as below,

- $df < 8861$ "RTFT Delta f"
- $|dU| < 8862$ "RTFT Delta U"
- $dj < 8863$ "RTFT Delta PHI"
- $|U_{res}| > 8864$ "RTFT U/V BLK"

- IN-PHASE transfer mode

When the residual voltage comes close to the referred voltage, it comes to transfer mode IN-PHASE. It's good for safe transfer if the CB closes at the instant the value dj is zero.

The intelligent device 7VU683 estimates the delta phase angle dj at the instant the CB closes. based on real-time slipping rate and the settable "CBx Closing Time". If all the quantity of predicted dj , the real-time df and $|U_{res}|$ meet the defined criterions,, the device will immediately issue the CLOSE command to the to-be-closed CB. The criterions are as below,

- $df < 8868$ "IN-PHA Delta f"
- $dj < 8869$ "IN-PHA Delta PHI"
- $|U_{res}| > 8870$ "IN-PHA U/V BLK"

- RES-VOLT transfer mode

If the above mentioned transfer modes failed, the transfer can still go on with mode RES-VOLT.

When the residual voltage $|U_{res}|$ under-shots the settable parameter 8871 "RES-VOLT Threshold", the RES-VOLT transfer mode will perform and the device will immediately issue the CLOSE command to the to-be-closed CB. The typical setting could be 30% U_n .

To reduce the shock under low voltage restarting of motors, two stages of Low Voltage Load-Shedding (LVLSH) function are integrated in the device. LVLSH will pickup before the RES-VOLT transfer mode. This function can be activated or de-activated manually on site.

- LONG-TIME transfer mode

The last criterion to start the transfer is LONG-TIME mode if all above mentioned modes failed.

When the transfer time is more than the settable parameter 8872 "LONG-TIME Threshold", the LONG-TIME transfer mode will perform and the device will immediately issue the CLOSE command to the to-be-closed CB. The typical setting could be 3s.

Generator Protection/7VU683

HSBT functions

Switching directions

The device support bi-direction power transfer under NORMAL condition, i.e, the device can transfer the main source of busbar to standby depending on the actual CBS' status, vice versa.

In most cases, the switching is limited from main source to standby source under starting conditions of FAULT, Inadmissible Under-voltage, Inadmissible Under-frequency and Inadvertent CB Open. The requirement can be met by set the parameter 8831 "Mono-direction against NORMAL condition" = "YES". The default setting "YES" can be changed to "NO" if bi-direction transfer is always required in any conditions.

To be noted that power supply 1 is exclusively defined as main source while power supply 2 defined as standby source. Then, if mono-direction against NORMAL condition is required, power supply 1 in Fig. 11/121 to Fig. 11/128 should be identified as main source.

The transfer permission under various starting conditions and switching directions can be referred to below two tables.

CB1 Status	CB2 Status	Switching-over		Voltage Comparison		Busbar Transfer Permitted?				
		From	To			NORMAL	FAULT	Inadmissible Undervoltage	Inadmissible Underfrequency	Inadvertent CB Open
Closed	Open	L1	L2	U_B	U_L2	Yes	Yes	Yes	Yes	Yes
Open	Closed	L2	L1	U_B	U_L1	Yes	No ¹⁾	No ¹⁾	No ¹⁾	No ¹⁾

1) If parameter 8831 "Mono-direction against NORMAL" = "YES", this cell says No. Otherwise, this cell says Yes.

Table 11/9 Transfer permission under default setting, single busbar

CB1 Status	CB3 Status	CB2 Status	Switching-over		Voltage Comparison		Busbar Transfer Permitted?				
			From	To			NORMAL	FAULT	Inadmissible Undervoltage	Inadmissible Underfrequency	Inadvertent CB Open
Closed	Closed	Open	L1	L2	U_B2	U_L2	Yes	Yes	Yes	Yes	Yes
			B2	L2	U_B2	U_L2	Yes	/ ²⁾	/ ²⁾	/ ²⁾	/ ²⁾
Closed	Open	Closed	B1	B2	U_B1	U_B2	Yes	Yes	Yes	Yes	Yes
			B2	B1	U_B2	U_B1	Yes	No ¹⁾	No ¹⁾	No ¹⁾	No ¹⁾
Open	Closed	Closed	L2	L1	U_B1	U_L1	Yes	No ¹⁾	No ¹⁾	No ¹⁾	No ¹⁾
			B1	L1	U_B1	U_L1	Yes	/ ²⁾	/ ²⁾	/ ²⁾	/ ²⁾

1) If parameter 8831 "Mono-direction against NORMAL" = "YES", this cell says No. Otherwise, this cell says Yes.
 2) Not applicable for this cell

Table 11/10 Transfer permission under default setting, segmented single busbar

HSBT test mode

To facilitate the functional testing and site commissioning, the Test Mode is specially designed for this purpose. This function can be activated on site by parameter setting 8820 "HSBT Test Mode" = "Yes" or by indication 18020 ">HSBT Test Mode" via binary input.

If the function HSBT goes into Test Mode, the transfer process is the same except that the CLOSE command will be blocked. Instead, CLOSE command with test mark will be issued for indicating.

HSBT Test Mode could be helpful before the device is put into service. When CB is manually tripped, HSBT 7VU683 picks up and goes into transfer process. Under the assistance of integrated Fault Recorder and Event Log, the operating consequence and settings can be assessed. Optimization to parameter settings can be done based on the assessment.

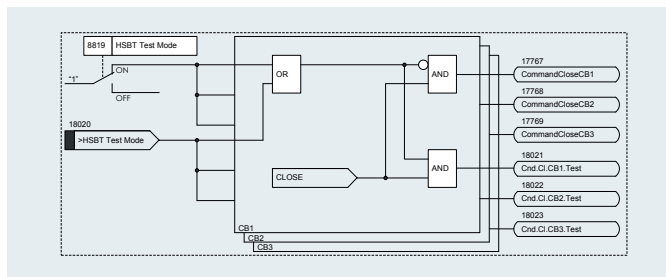


Fig. 11/110 Logic diagram of test mode

Reset of transfer

The default setting is to block the device after once transfer is executed, i.e., either failure or success, the device goes into blocking status till to the reset indication via binary input or LED button on device panel. This can be changed by setting the parameter 8817 "Manual Restart HSBT" = "NO". Then, after once successful transfer, the device will automatically execute a new transfer request before the reset indication arrives. But, after once failed transfer, the device will go into blocking status till to the reset indication.

Sample of oscillographic FAST transfer

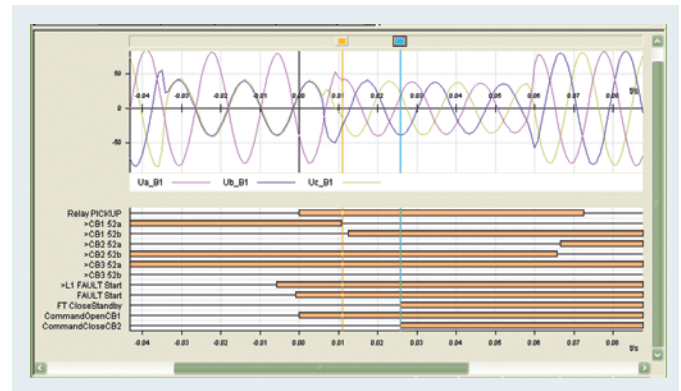


Fig. 11/111 Oscillographic FAST transfer at segmented single busbar

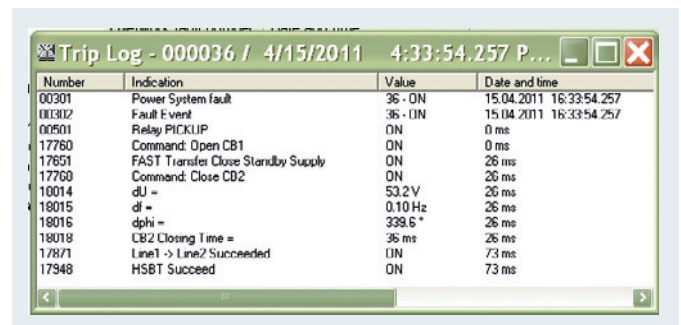


Fig. 11/112 Trip log of FAST transfer at segmented single busbar

Some notes to the two figures,

- Primary connection of segmented single busbar
- Line1 in operating while Line2 in standby, CB3 serve as tie-CB which is in closed status
- Fault is there in Line1 and cleared by protection relay. Meanwhile, HSBT is started
- Switching-over between Line1 and Line2 are defined
- Instant 0ms, device picked up, CommandOpenCB1 issued
- Instant 12ms, CB1 opened
- Instant 26ms, CommandCloseCB2 issued
- Instant 62ms, CB2 closed
- FAST transfer succeeded, approx. 50ms dead time interval of busbar

Generator Protection/7VU683

Protection functions

Protection functions

The Power Supply Transfer device 7VU68 integrates protection functions for tie-CB in primary connection of Segmented Single Busbar. This function can be set **“Enabled”** or **“Disabled”** during configuration.

The protection include the following functions,

- Phase overcurrent protection
- Ground overcurrent protection
- Phase overcurrent protection for Busbar Energization
- Ground overcurrent protection for Busbar Energization

To secure the reliability and sensitivity, the voltage element is additionally introduced to current criterion to release trip command.

For functions of Phase-overcurrent protection and Phase overcurrent for Busbar Energization, compound voltage element is used. The criterion of compound voltage element is illustrated in Fig. 11/113.

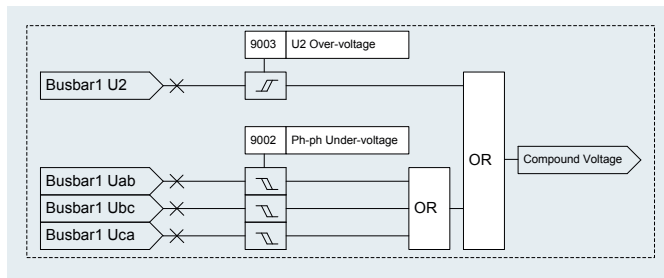


Fig. 11/113 Logic of compound voltage element

For functions of ground overcurrent protection and ground overcurrent protection for Busbar Energization, the element of zero sequence over-voltage is used. The quantity is derived from calculated 3U0 based on measured busbar1 voltage.

The validity of protections in case of busbar energization can be set under parameter 9019A **“Active Time for Busbar Energization”**.

Each of above functions can be separately switched **“ON”** or **“OFF”** remotely via communication or locally at device panel.

Phase-overcurrent protection

This function is designed to detect any short-circuit faults in MV system. The device will evaluate all current inputs at channel I_B and will pickup immediately if one of phase current over-shots the settable threshold.

The function has two stages, one time delay for each stage.

The voltage element can be activated or de-activated under parameter 9001 **“Compound Voltage Control”**.

Ground-overcurrent protection

This function is designed to detect ground fault in MV system. The device will evaluate zero sequence current and will pickup immediately if it over-shots the settable threshold.

The quantity of zero sequence current is derived from calculated 3I0 or measured ground current Ie. This can be set under parameter 9018 **“3I0/Ie Assignment”**.

The function has two stages, one time delay for each stage.

The voltage element can be activated or de-activated under parameter 9011 **“3U0 Control”**.

Phase-overcurrent protection for busbar energization

To avoid any switch-onto-fault, the function phase-over-current protection can be activated for some time after the busbar is energized when tie-CB is closed. An individual function phase-overcurrent protection for busbar energization is specially designed for this utilization.

The function has the same criterion and stages to phase-over-current protection. The function will not be activated until the tie-CB is closed.

Ground-overcurrent protection for busbar energization

To avoid any switch-onto-fault, the function ground-over-current protection can be activated for some time after the busbar is energized when tie-CB is closed. An individual function ground-overcurrent protection for busbar energization is specially designed for this utilization.

The function has the same criterion and stages to ground-over-current protection. The function will not be activated until the tie-CB is closed.

Communication

With respect to communication, particular emphasis has been placed on high levels of flexibility, data integrity and utilization of standards common in energy automation. The design of the communication modules permits interchangeability on the one hand, and on the other hand provides openness for future standards (for example, Industrial Ethernet).

Local PC interface

The PC interface from the front of the unit permits quick access to all parameters and fault event data. The use of the DIGSI 4 operating program during commissioning is particularly advantageous.

Rear mounted interface

At the rear of the unit there is one fixed interface and two communication modules which incorporate optional equipment complements and permit retrofitting. They assure the ability to comply with the requirements of different communication interfaces (electrical or optical) and protocols (IEC 60870, PROFIBUS, DIGSI). The interfaces make provision for the following applications:

Service interface (fixed)

In the RS485 version, several protection units can be centrally operated with DIGSI 4. By using a modem, remote control is possible. This provides advantages in fault clearance, in particular in unmanned substations.

System interface

This is used to communicate with a control or protection and control system and supports, depending on the module connected, a variety of communication protocols and interface designs. Furthermore, the units can exchange data through this interface via Ethernet and IEC 61850 protocol and can also be operated by DIGSI.

IEC 61850 protocol

As of mid-2004, the Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens is of the first manufacturer to support this standard and has 200.000 IEC61850 devices in operation. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus will also be possible with DIGSI.

IEC 60870-5-103

IEC 60870-5-103 is an internationally standardized protocol for communication in the protected area. IEC 60870-5-103 is supported by a numerous of manufacturers and is used worldwide.

PROFIBUS-DP

PROFIBUS is an internationally standardized communication system (EN 50170). PROFIBUS is supported internationally by several hundred manufacturers and has to date been used in more than 1,000,000 applications all over the world. With the PROFIBUS-DP, the device can be directly connected to a SIMATIC S5/S7. The transferred data are fault data, measured values and information from or to the logic (CFC).

MODBUS RTU

MODBUS is also a widely utilized communication standard and is used in numerous automation solutions.

Safe bus architecture

- RS485 bus

With this data transmission via copper conductors, electromagnetic interference influences are largely eliminated by the use of twisted-pair conductor. Upon failure of a unit, the remaining system continues to operate without any faults.

- Fiber-optic double ring circuit

The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without disturbance.

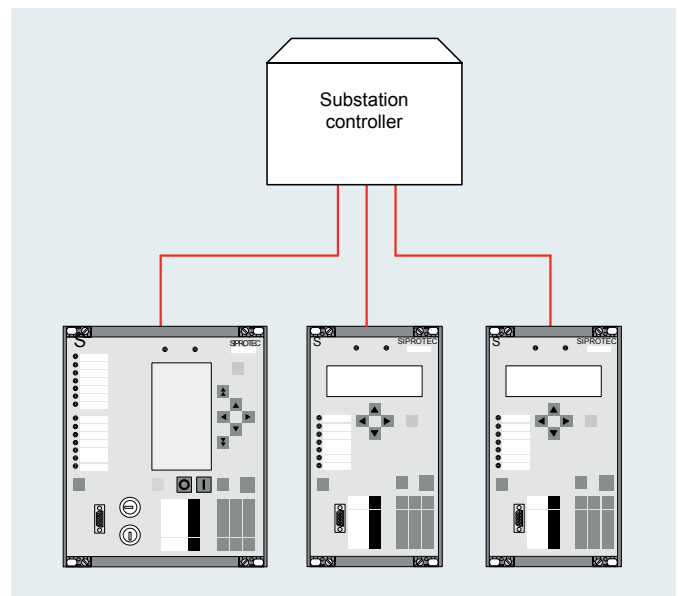


Fig. 11/114 IEC 60870-5-103: Radial electrical or fiber-optic connection

Generator Protection/7VU683

High Speed Busbar Transfer – Communication

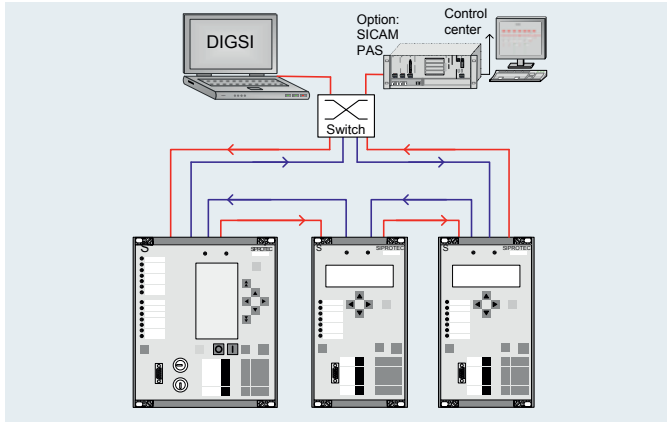


Fig. 11/115 Bus structure for station bus with Ethernet and IEC 61850, fiber-optic ring



Fig. 11/116 Optical Ethernet communication module for IEC 61850 with integrated Ethernet-switch

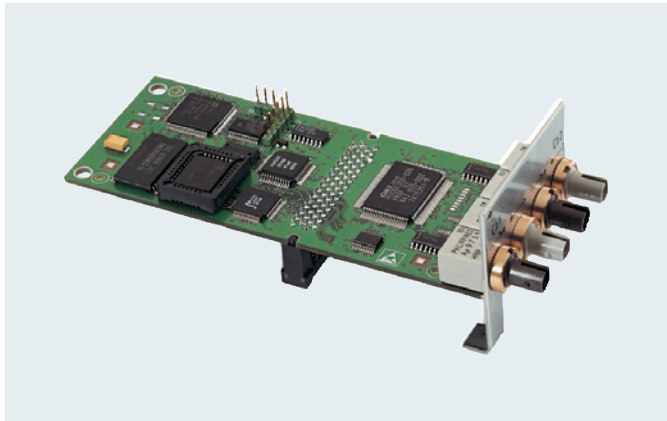


Fig. 11/117 PROFIBUS communication module, optical, double ring

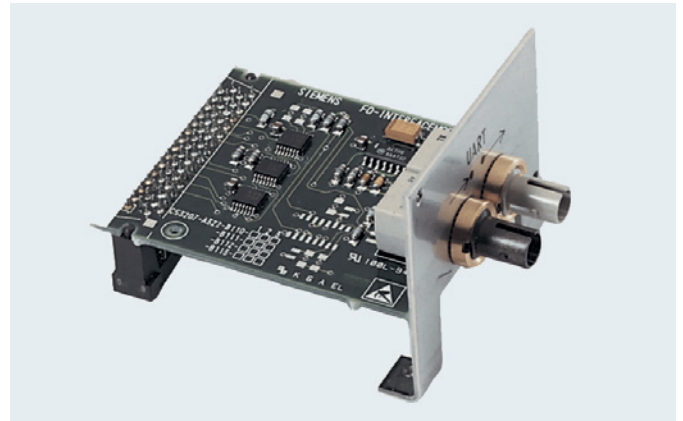


Fig. 11/118 Fiber-optic communication module

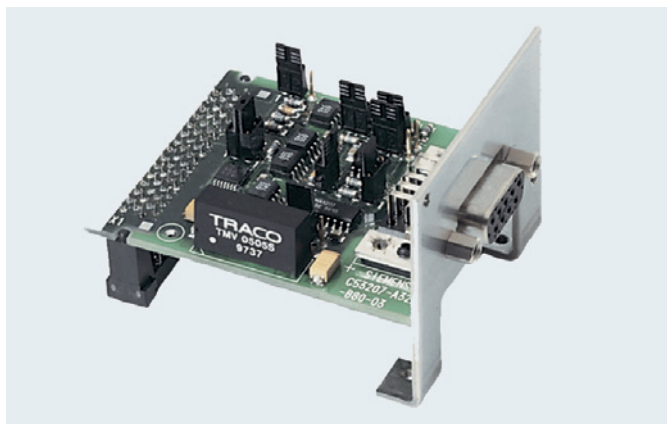


Fig. 11/119 RS232/RS485 electrical communication module

System solution

SIPROTEC 4 is tailor-made for use in SIMATIC-based automation systems.

Via the PROFIBUS-DP, indications (pickup and tripping) and all relevant operational measured values are transmitted from the HSBT device.

Via modem and service interface, the electric engineer has access to the protection devices at all times. This permits remote maintenance and diagnosis (cyclic testing).

Parallel to this, local communication is possible, for example, during a major inspection. For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbit/s Ethernet bus, the unit are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems.

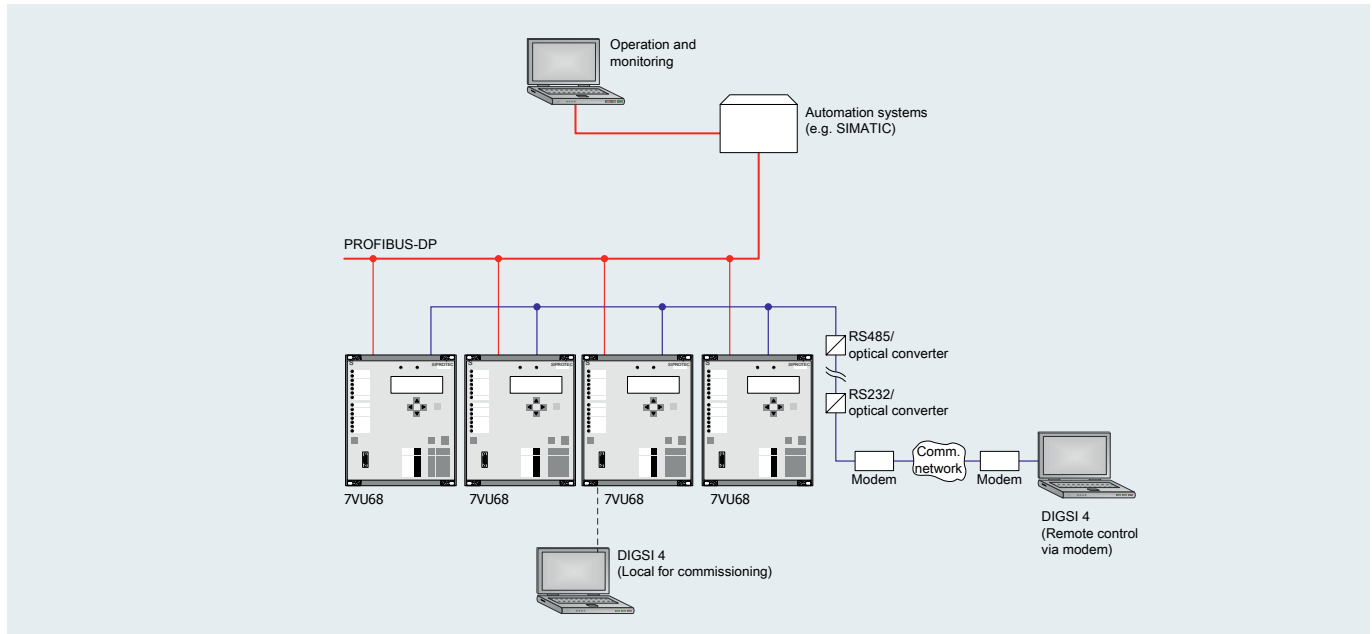


Fig. 11/120 System solution: communication

Generator Protection/7VU683

High Speed Busbar Transfer – Typical applications

Typical applications

Primary connection of single busbar

The device HSBT 7VU683 will automatically determine the switching direction based on the actual CBs' status.

Each switching-over can be individually switched "ON" or "OFF" remotely via communication or locally at device panel.

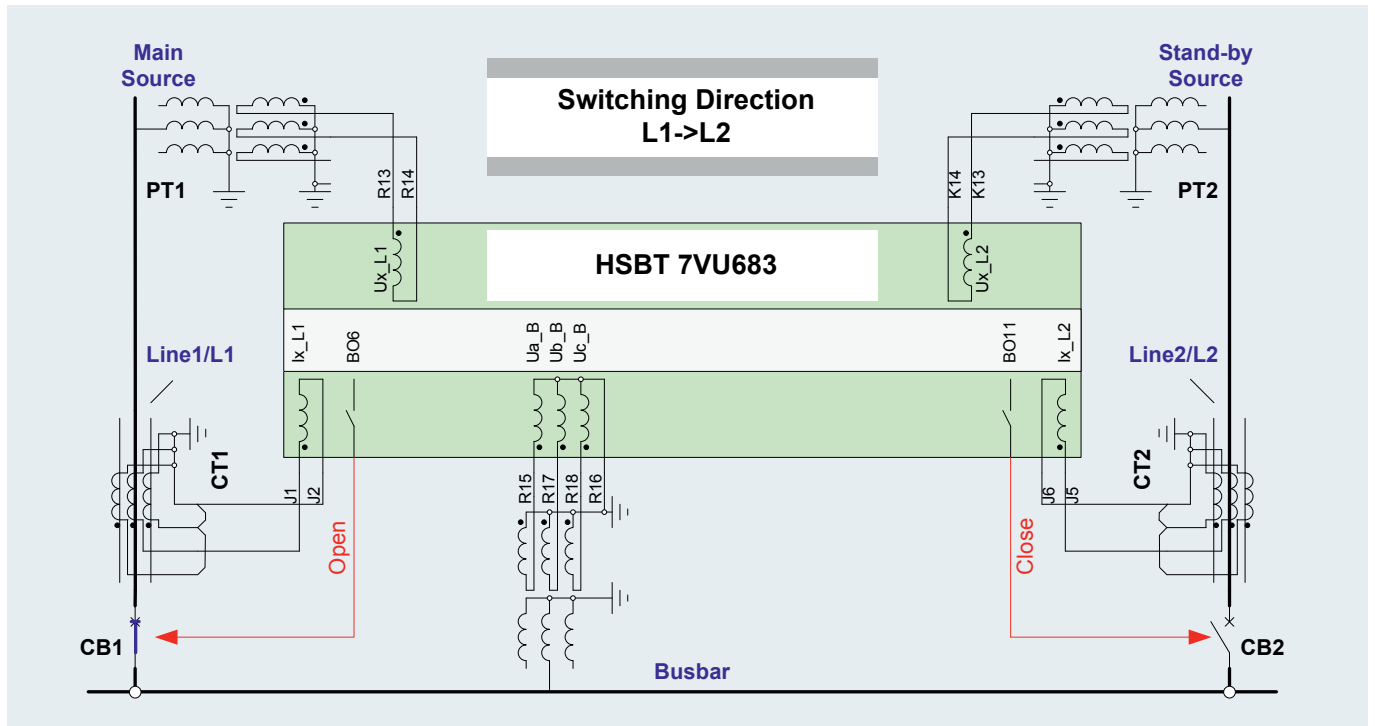


Fig. 11/121 Switching-over L1->L2, single busbar

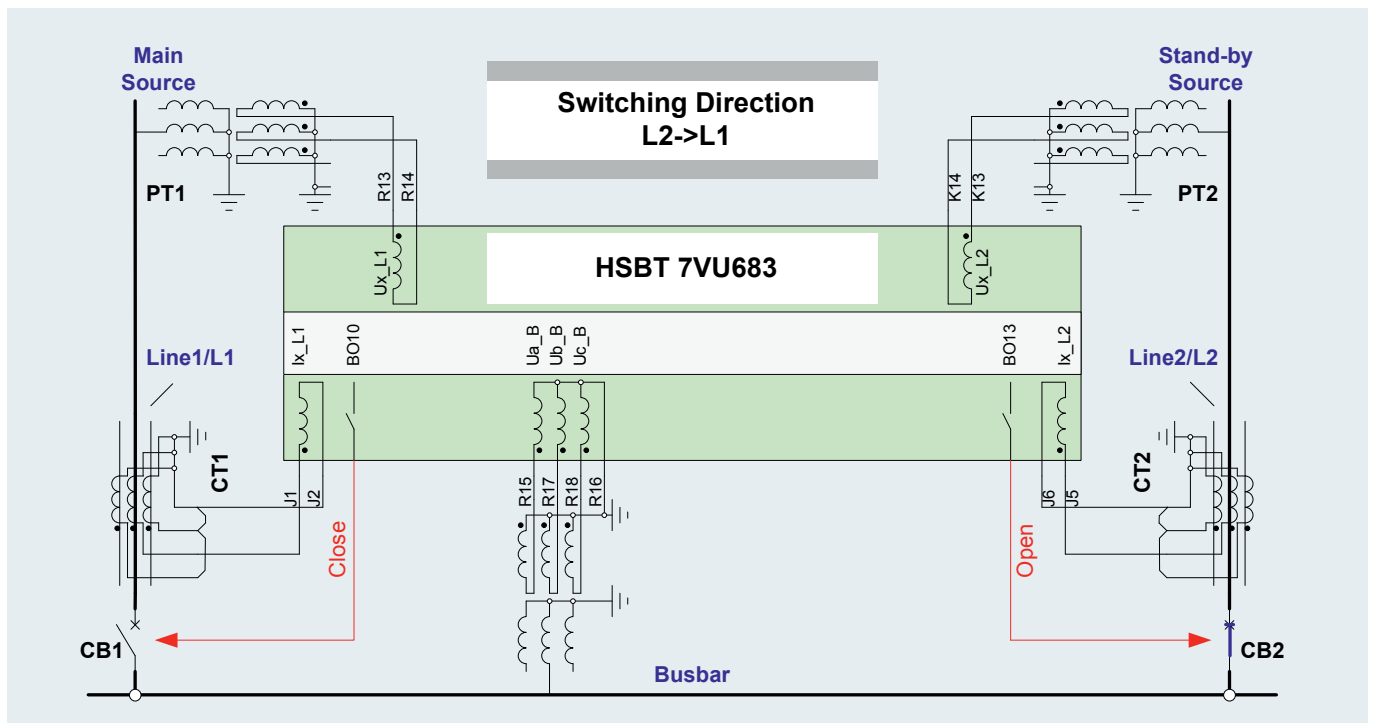


Fig. 11/122 Switching-over L2->L1, single busbar

11

Primary connection of segmented single busbar: CB1 and CB3 are closed, CB2 is opened

In case of these CBs' status, two possible switching directions are there. Then, the starting command of two switching directions must be externally separately routed to device's binary inputs, e.g, starting command L1->L2 routed to BI13, B2->L2 to BI12.

The device will properly execute the switching direction based on the command input under this case.

Each switching-over can be individually switched "ON" or "OFF" remotely via communication or locally at device panel.

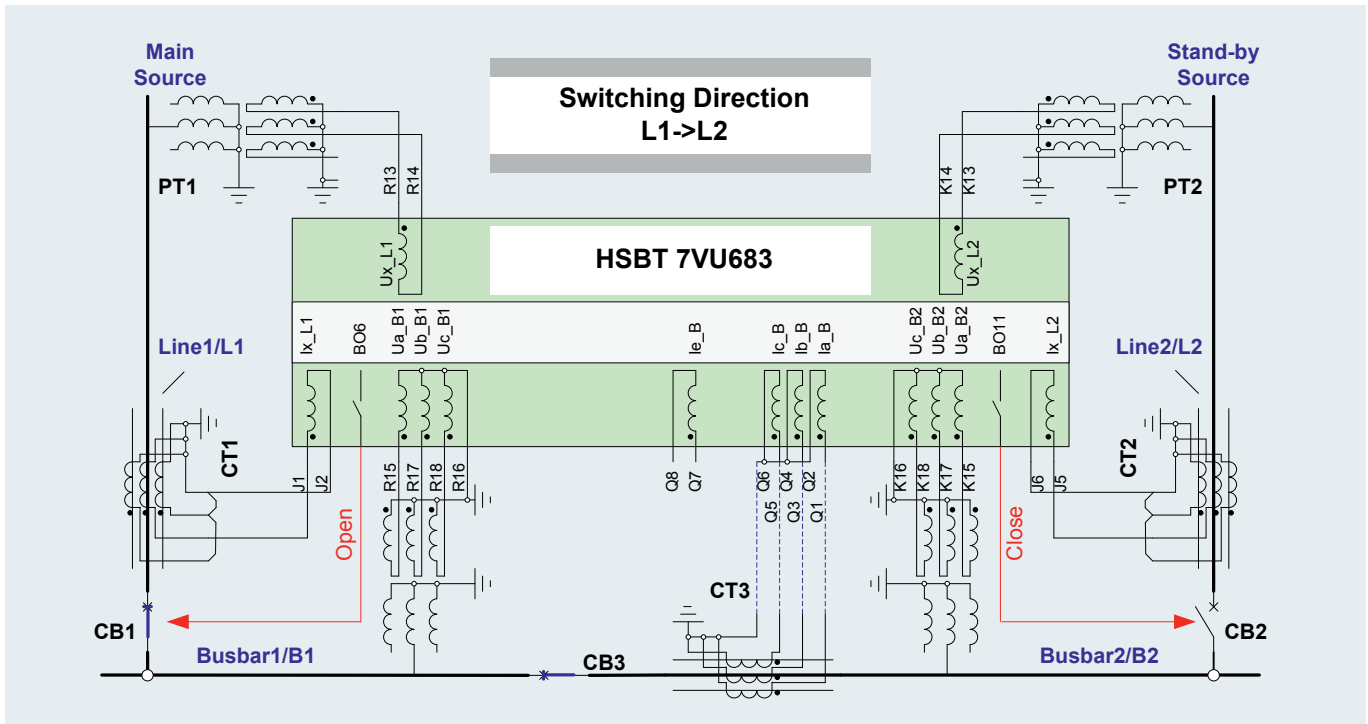


Fig. 11/123 Switching-over L1->L2, segmented single busbar

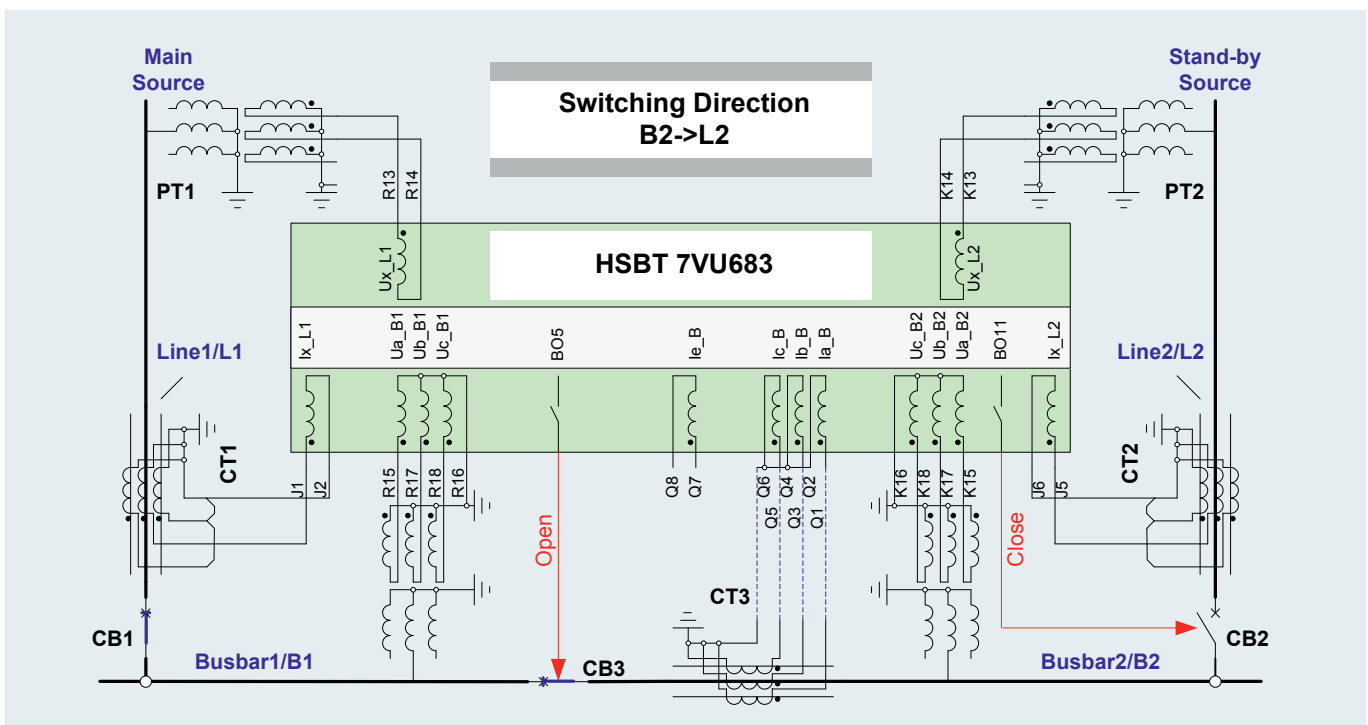


Fig. 11/124 Switching-over B2->L2, segmented single busbar

Generator Protection/7VU683

High Speed Busbar Transfer – Typical applications

Primary connection of segmented single busbar: CB2 and CB3 are closed, CB1 is opened

In case of these CBs' status, two possible switching directions are there. Then, the starting command of two switching directions must be externally separately routed to device's binary inputs, e.g, starting command B1->L1 routed to BI13, L2->L1 to BI12. The device will properly execute the switching direction based on the command input under this case.

Starting command B1->L1 can be designated to BI13 too even if starting command L1->L2 is already there, the reason is only one of these two switching directions will be automatically executed by device based on the actual CBs' status. The same situation applies to L2->L1.

The above switching-overs can be individually switched "ON" or "OFF" remotely via communication or locally at device panel.

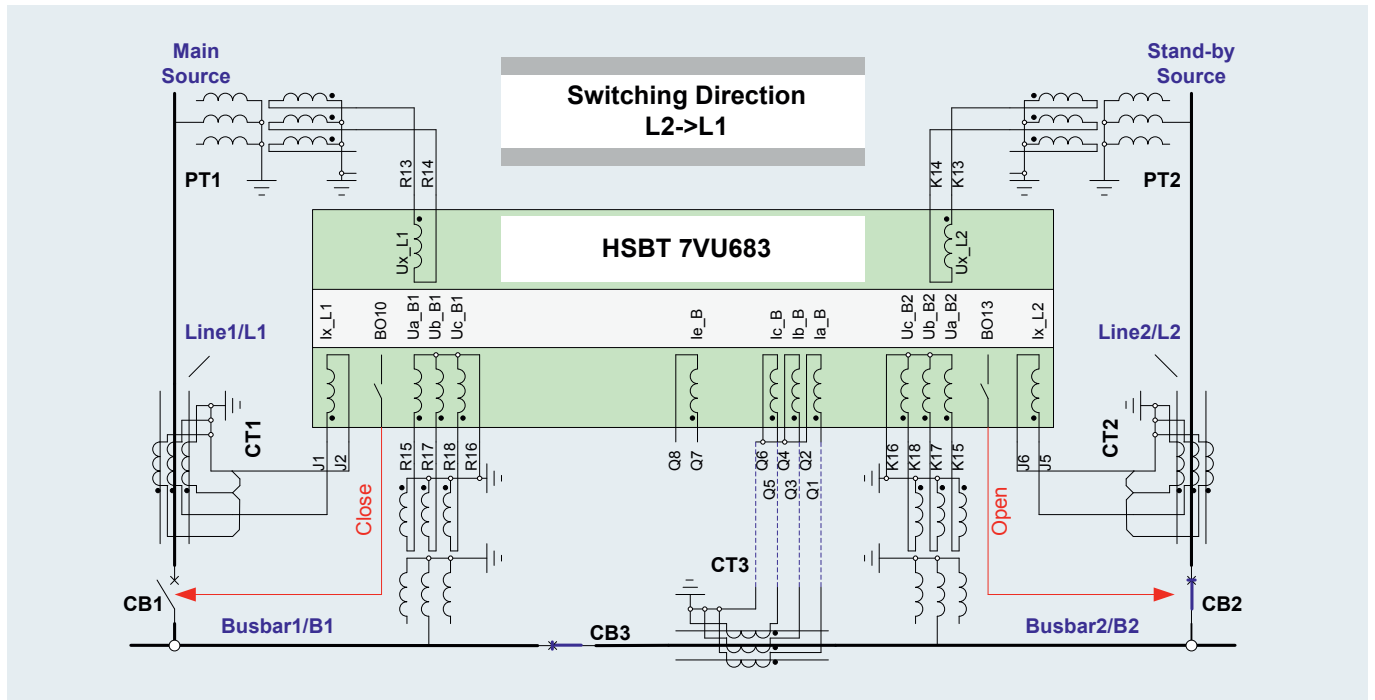


Fig. 11/125 Switching-over L2->L1, segmented single busbar

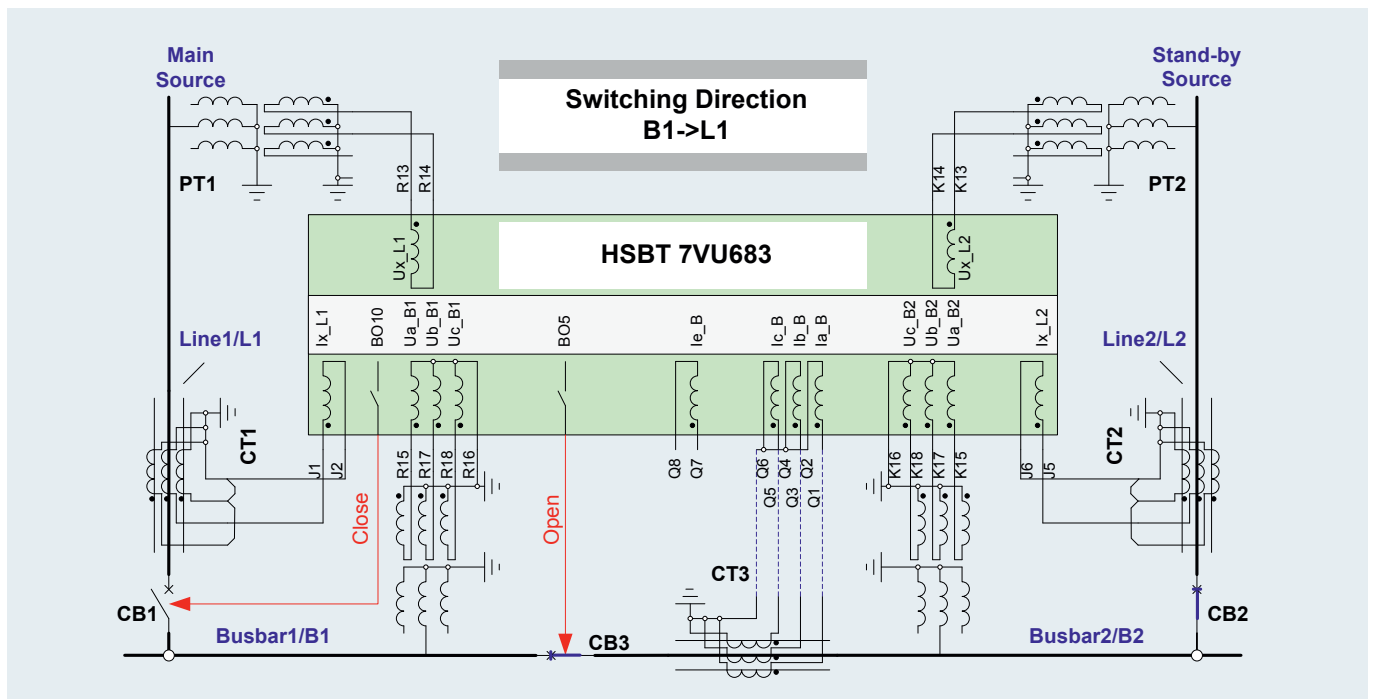


Fig. 11/126 Switching-over B1->L1, segmented single busbar

Primary connection of segmented single busbar: CB1 and CB2 are closed, CB3 is opened

In case of these CBs' status, two possible switching directions are there. Then, the starting command of two switching directions must be externally separately routed to device's binary inputs, e.g. starting command B1->B2 routed to BI13, B2->B1 to BI12. The device will properly execute the switching direction based on the command input under this case.

Starting command B1->B2 can be designated to BI13 too even if starting command L1->L2 and B1->L1 are already there, the reason is only one of these three switching directions will be automatically executed by device based on the actual CBs' status. The same situation applies to B2->B1.

The above switching-overs can be individually switched "ON" or "OFF" remotely via communication or locally at device panel.

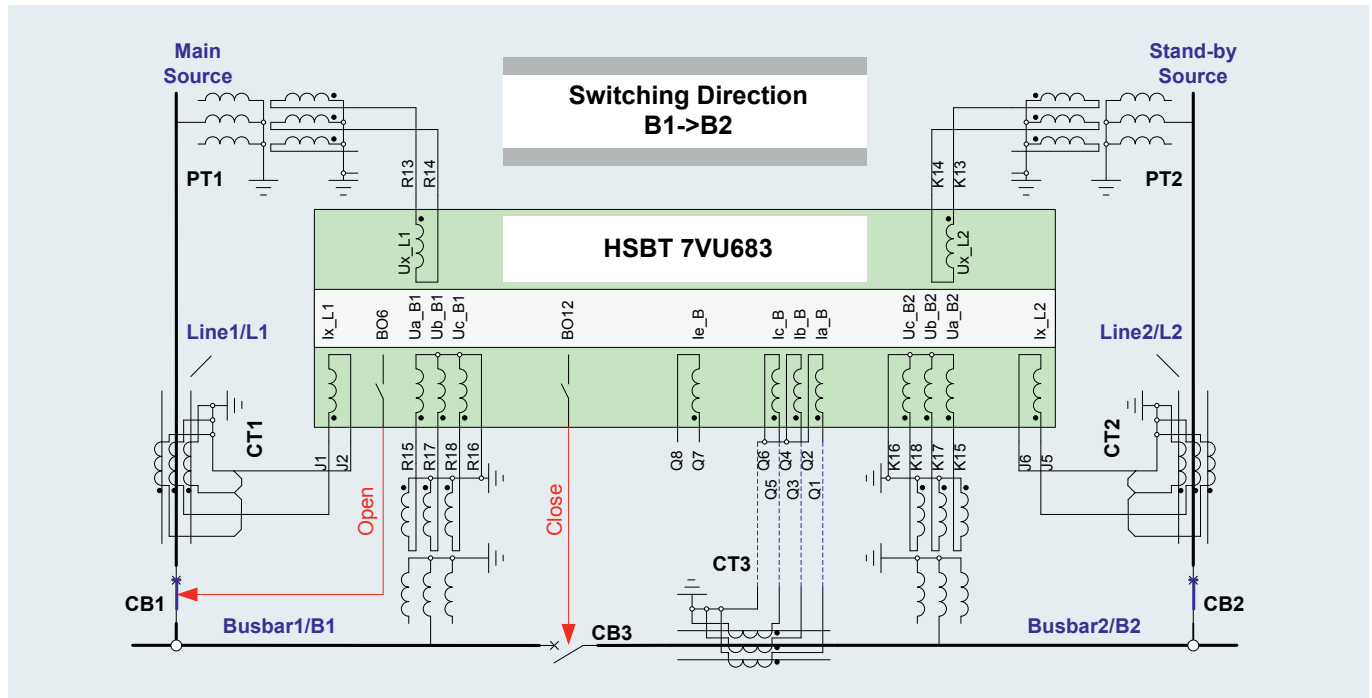


Fig. 11/127 Switching-over B1->B2, segmented single busbar

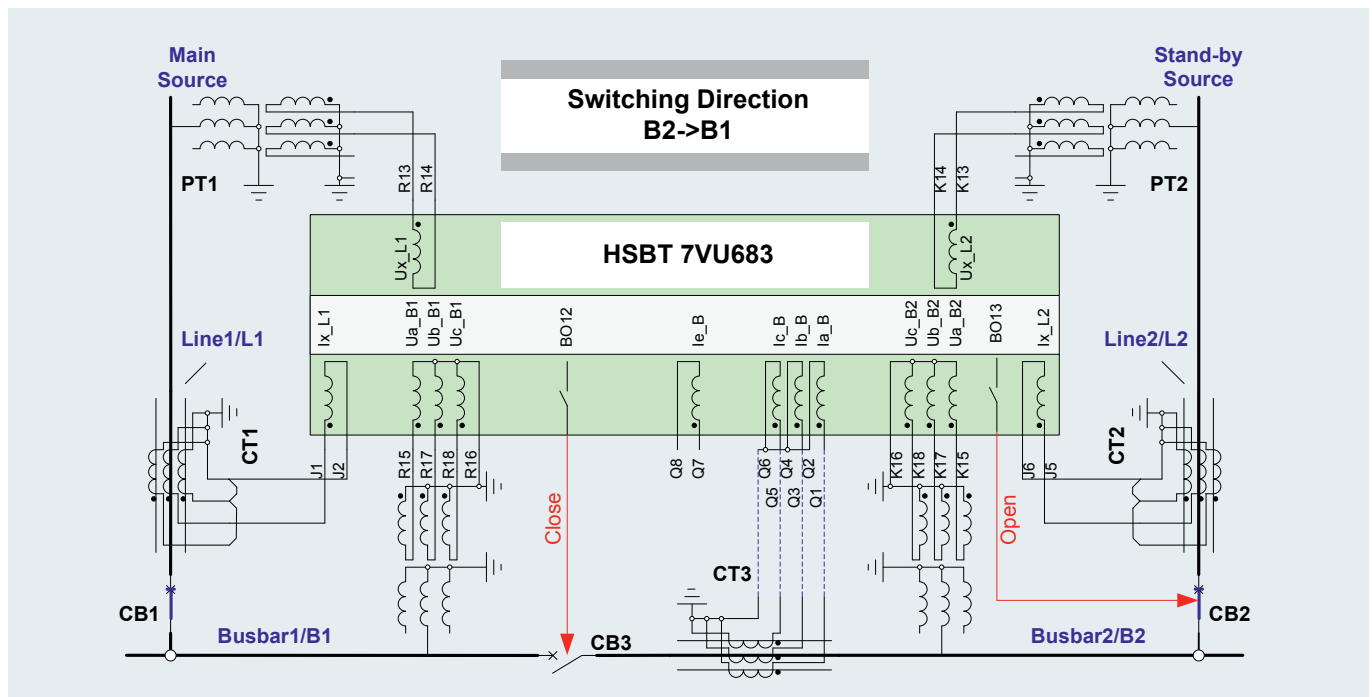


Fig. 11/128 Switching-over B2->B1, segmented single busbar

Generator Protection/7VU683

High Speed Busbar Transfer – Selection and ordering data

Description	Order No.	Short code
	7VU683 □ - □ E □ □ □ - 1 A A 0 - □ □ □	
7VU683 high speed busbar transfer device Housing binary inputs and outputs Housing 1/1 19", 17 BI, 18 BO (incl.5 High Speed), 1 live-status contact		
Current transformer: In		
IN=1A ¹⁾	1	
IN=5A ¹⁾	5	
Auxiliary Voltage		
DC 24 to 48 V, binary input threshold DC 19 V ³⁾	2	
DC 60 to 125 V ²⁾ , binary input threshold DC 19 V ³⁾	4	
DC 110 to 250 V ²⁾ , AC 115/230 V, binary input threshold DC 88 V ³⁾	5	
DC 220 to 250 V ²⁾ , AC 115/230 V, binary input threshold DC 176 V ³⁾	6	
Construction		
Flush-mounting housing, screw-type terminals		E
Region-specific default settings/ language Settings		
Region World, English ⁴⁾ , 50/60Hz		B
Region China, Chinese ⁴⁾ , 50/60Hz		W
Port B: (System port on rear of device)		
No system port	0	
IEC 60870-5-103 Protocol, electrical RS232	1	
IEC 60870-5-103 Protocol, electrical RS485	2	
IEC 60870-5-103 Protocol, 820 nm fibre, ST-connector	3	
Profibus DP Slave, RS485	9	L 0 □
Profibus DP Slave, 820 nm fibre, double ring, ST-connector	9	A
Modbus, RS485	9	B
Modbus, 820 nm fibre, ST-connector	9	D
IEC 60870-5-103 Protocol, redundant RS485	9	E
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45-connector	9	P
IEC 61850, 100 Mbit Ethernet, with integrated switch optical, double, LC-connector	9	R
		S
Port C (Service)		
Port C: DIGSI 4/Modem, electrical RS232;	1	
Port C: DIGSI 4/Modem/ RTD-box, electrical RS485;	2	
Measuring/ fault recording		
Basic measured Values		1
Functions		A
High Speed Busbar Transfer (HSBT) (2 or 3 circuit breakers)		
Protection functions (Overcurrent phase/ground (50, 50N);		
Overcurrent phase/ground for busbar energization		
Supervision functions		
1) Rated current 1/5 A can be selected by means of jumpers.		
2) Transition between the three auxiliary voltage can be selected by mean of jumpers.		
3) The threshold of each binary input can be set via jumpers.		
4) Device language can be selected via DIGSI.		

11

Description	Order No.
<p>DIGSI 4</p> <p>Software for configuration and operation of Siemens protection units running under MS Windows XP Professional Edition, Windows 7 (32- and 64-bit) and Windows Server 2008 R2 64-bit, device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper), Basis</p> <p>Full version with license for 10 computers, on CD-ROM (authorization by serial number)</p>	7XS5400-0AA00
<p>Professional</p> <p>DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)</p>	7XS5402-0AA00
<p>Professional + IEC 61850</p> <p>Complete version</p> <p>DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation) + IEC 61850 system configurator</p>	7XS5403-0AA00
<p>IEC 61850 Systemconfigurator</p> <p>Software for configuration of stations with IEC 61850 communication under DIGSI, Optional package for DIGSI 4 Basis or Professional</p> <p>License for 10 PCs. Authorization by serial number. On CD-ROM</p>	7XS5460-0AA00
<p>SIGRA 4</p> <p>(generally contained in DIGSI Professional, but can be ordered additionally)</p> <p>Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format).</p> <p>Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.</p>	7XS5410-0AA00
<p>Connecting cable</p> <p>Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector)</p> <p>(contained in DIGSI 4, but can be ordered additionally)</p>	7XV5100-4

Generator Protection/7VU683

High Speed Busbar Transfer – Accessories

Description		Order No.	Size of package	Supplier	Fig.
Mounting rail		C73165-A63-D200-1	1	Siemens	11/129
Short-circuit link	For current terminals	C73334-A1-C34-1	1	Siemens	11/130
	For other terminals	C73334-A1-C34-1	1	Siemens	11/131
Safety cover for terminals	Large	C73334-A1-C31-1	1	Siemens	
	Small	C73334-A1-C32-1	1	Siemens	

1) Your local Siemens representative can inform you on local suppliers.

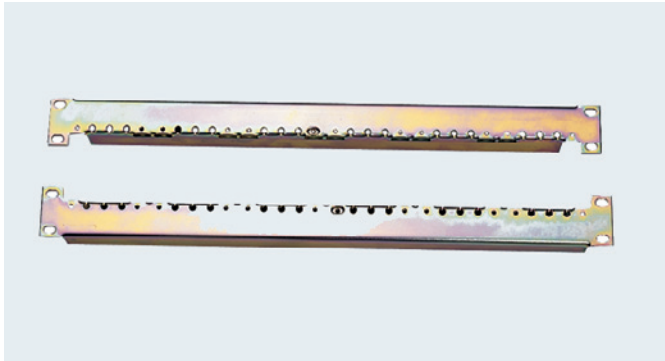


Fig. 11/129 Mounting rail for 19" rack

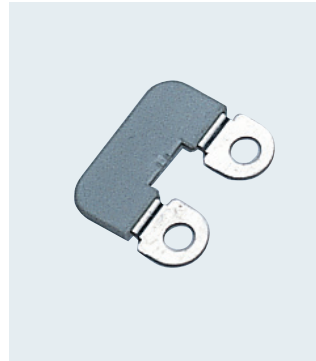


Fig. 11/130 Short-circuit link for current terminals



Fig. 11/131 Short-circuit link for voltage terminals/ indication terminals

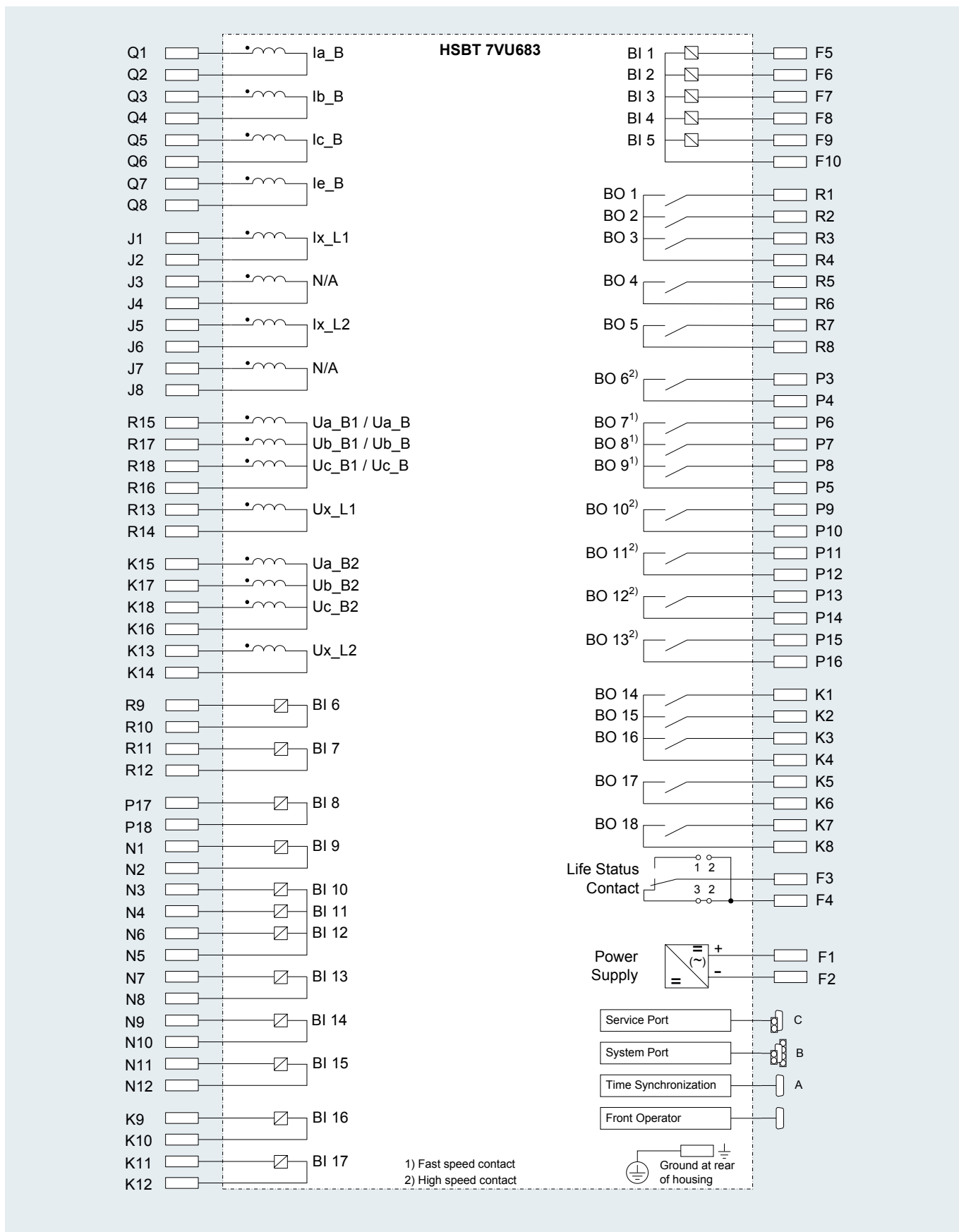


Fig. 11/132 7VU683 connection diagram

Substation Automation

Page

SIPROTEC 4 6MD61 IO-Box

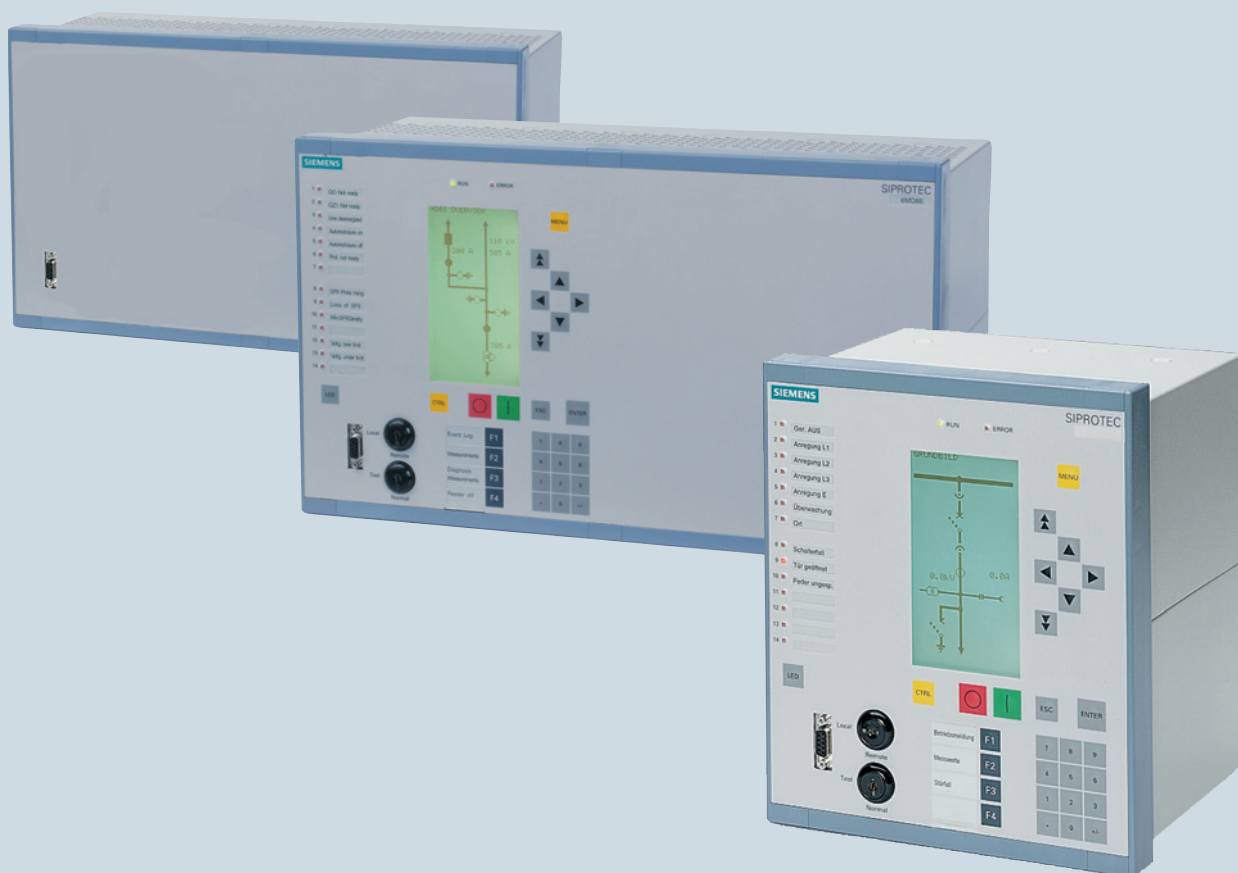
12/3

SIPROTEC 4 6MD63 bay control unit

12/11

SIPROTEC 4 6MD66 high-voltage bay control unit

12/13



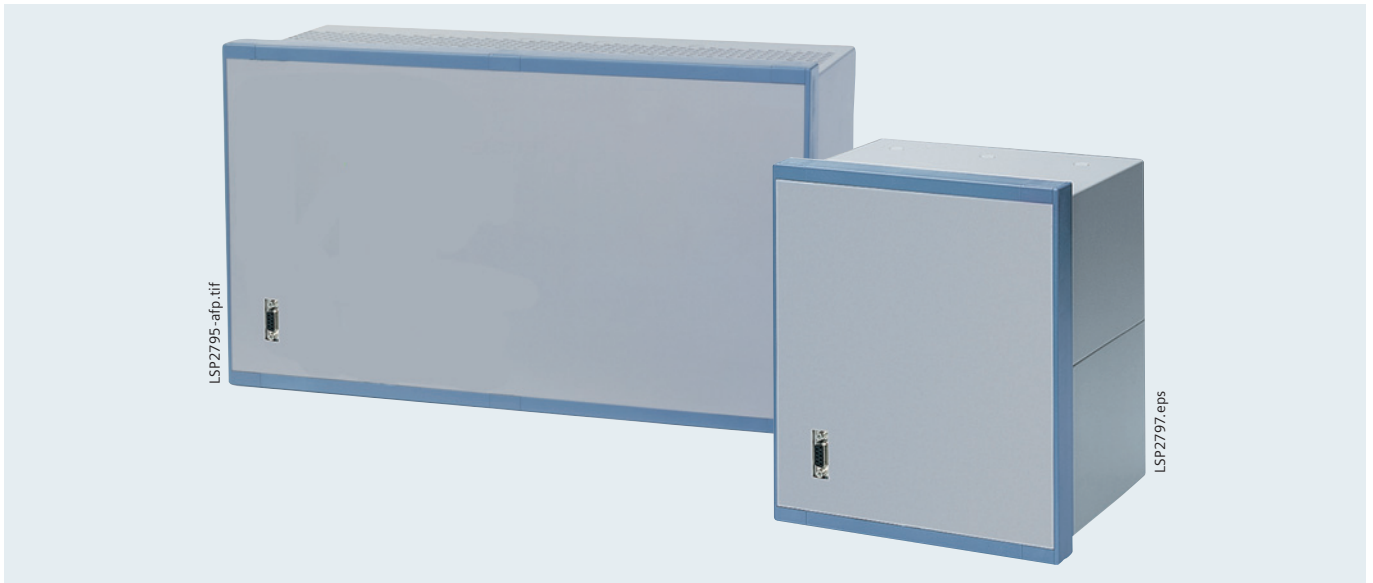


Fig. 12/1 SIPROTEC 4 6MD61 IO-Box

Description

The SIPROTEC 4 6MD61 IO-Box enables in a simple, easy way to enhance the number of binary inputs and outputs in the switchgear. It can be used directly in the bay together with other SIPROTEC 4 units and also together with SICAM PAS to serve as a central process connection.

The IO-Box is based on the SIPROTEC 6MD63 and 6MD66 series, so it can be easily integrated in systems with other SIPROTEC 4 units.

The IO-Box supports a wide range of demand for additional binary inputs (BI) and binary outputs (BO), starting from 20 BI+10 BO and going up to 80 BI+53 BO. All important standard communication protocols are supported.

With IEC 61850-GOOSE communication, a direct information interchange with other SIPROTEC units is possible. For simplification and cost reduction, the IO-Box is available only without automation (CFC), without keypad and without display.

Function overview

Application

- Extension of number of inputs and outputs of bay controller
- Extension of number of inputs and outputs of protection unit
- Central process connection for SICAM PAS

Features

- Standard SIPROTEC hardware for easy configuration with DIGSI
- Full EMC compliance like all other SIPROTEC devices
- Housing can be used for surface mounting or flush mounting (units are always delivered with two mounting rails for surface mounting. These rails can be dismounted for flush mounting)
- Three types with different amount of inputs and outputs available

Monitoring functions

- Operational measured values (only 6MD612)
- Energy metering values (only 6MD612)
- Time metering of operating hours
- Self supervision of relay

Communication interfaces

- IEC 61850 Ethernet
- IEC 60870-5-103 protocol
- PROFIBUS-FMS
- PROFIBUS-DP
- Service interface for DIGSI 4 (modem)
- Front interface for DIGSI4
- Time synchronization via IRIG B / DCF77

Substation Automation/6MD61

Application

Application

The following figures show the most important applications of the SIPROTEC IO-Box 6MD61.

The configuration shown in Fig. 12/2 allows direct GOOSE communication between the SIPROTEC 4 units (6MD66, 7SJ63) and the IO-Boxes, independent of the substation controller. Of course, this configuration is also possible without substation controller. The IO-Box is used as additional digital inputs and measurements (measurements only with 6MD612), and serves as an additional command output.

The communication between IO-Box and the substation controller is established by using the IEC 61850 standard protocol.

Fig. 12/3 shows a configuration in which the IO-Box is used as a central process connection in the cubicle of the substation controller. For example, cubicle signaling lamps or a signaling horn are controlled by the command relays of the IO-Box.

Fig. 12/4 shows the communication for substations with no Ethernet protocol used. In this case, all communication lines go directly to the substation controller. If information from the IO-Box is used for switchgear interlocking, the interlocking logic must be part of the substation controller.

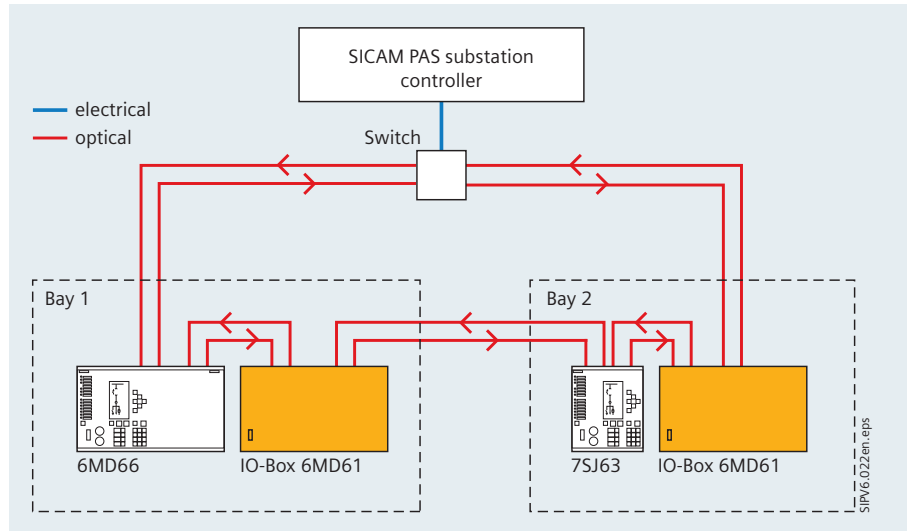


Fig. 12/2 Configuration with IO-Box in IEC 61850 substation

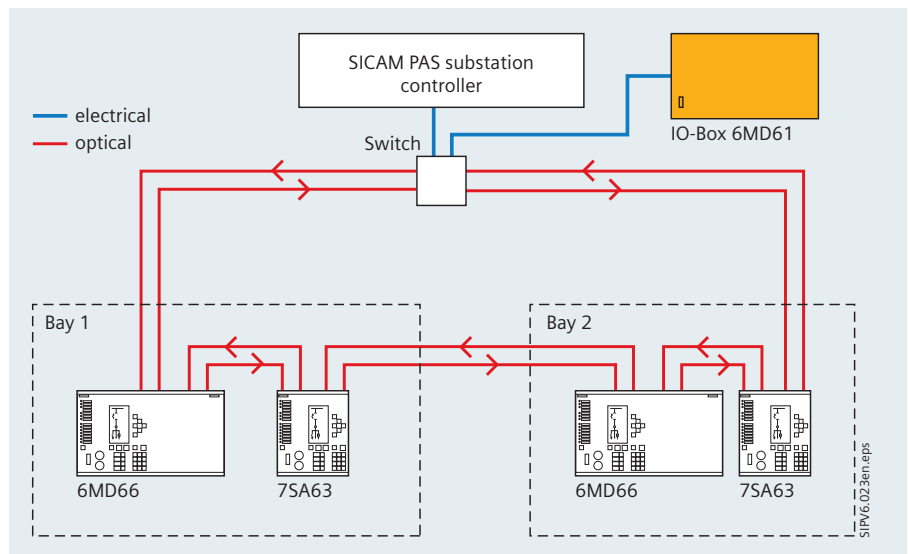


Fig. 12/3 IO-Box as central input/output for SICAM PAS substation controller

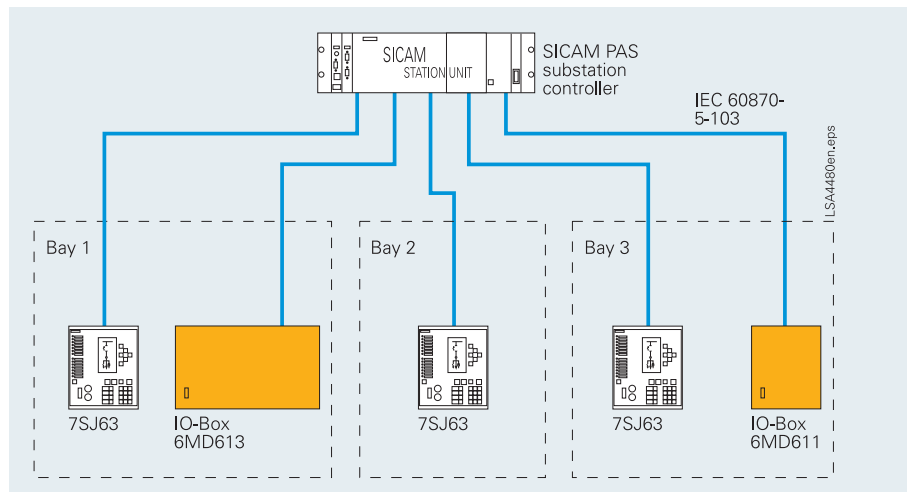


Fig. 12/4 Direct connection of IO-Boxes and protection relays to substation controller via standard protocol

Description	Order No.	Order code
6MD61 IO-Box	6MD61	-0AA0-
20 binary inputs, 6 command relays, 4 (2) power relays, 1 live status contact (similar to 6MD634) in 1/2 19" housing	1	
33 binary inputs, 14 command relays, 8 (4) power relays, 1 live status contact, 2 x 20 mA, 3 x V, 4 x I, (similar to 6MD636) in 1/2 19" housing	2	
80 binary inputs, 53 command relays, 1 live status contact in 1/2 19" housing	3	
Current transformer: rated current I_n		
No analog measured variables	0	
1 A ²⁾	1	
5 A ²⁾	5	
Rated auxiliary voltage (power supply, indication voltage)		
24 to 48 V DC, threshold binary input 19 V	2	
60 V DC, threshold binary input 19 V ²⁾	3	
110 V DC, threshold binary input 88 V ²⁾	4	
220 to 250 V DC, 115 to 230 V AC, threshold binary input 176 V for input No. 8-80 for 6MD613 (C-I/O 4), otherwise threshold 88 V ²⁾	5	
Unit version		
Surface-mounting case, without HMI, mounting in low voltage compartment, screw-type terminals (direct wiring / ring lugs), also usable as flush-mounting case		F
Region-specific default settings/function versions and language settings		
Region DE, 50 Hz, language: German, changeable		A
Region World, 50/60 Hz, language: English (GB), changeable		B
Region US, 60 Hz, ANSI, language: English (US), changeable		C
Region FR, language: French, changeable		D
Region World, language: Spanish, changeable		E
System interface (on rear of unit, port B)		
No system port	0	
IEC 60870-5-103 protocol, electrical RS232	1	
IEC 60870-5-103 protocol, electrical RS485	2	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	3	
PROFIBUS-FMS Slave, electrical RS485	4	
PROFIBUS-FMS Slave, fiber, double ring, ST connector	6	
PROFIBUS DP Slave, electrical RS485	9	L O A
PROFIBUS-DP Slave, 820 nm fiber, double ring, ST connectors	9	L O B
IEC 61850, 100 BaseT (100 Mbit Ethernet electric, double, RJ45 connector)	9	L O R
IEC 61850, 100 Mbit Ethernet, fiber optic, double, LC connectors	9	L O S
Function interface (on rear of unit, port C)		
No function port	0	
DIGSI 4, RS232	1	
DIGSI 4, RS485	2	
DIGSI 4, 820 nm fiber, ST connector	3	

1) Only for position 6 = 2

2) Thresholds can be changed (jumper) for each binary input between 19 V and 88 V, for 6MD613 BI No. 8-80 also to 176 V.

Substation Automation/6MD61

Connection diagram

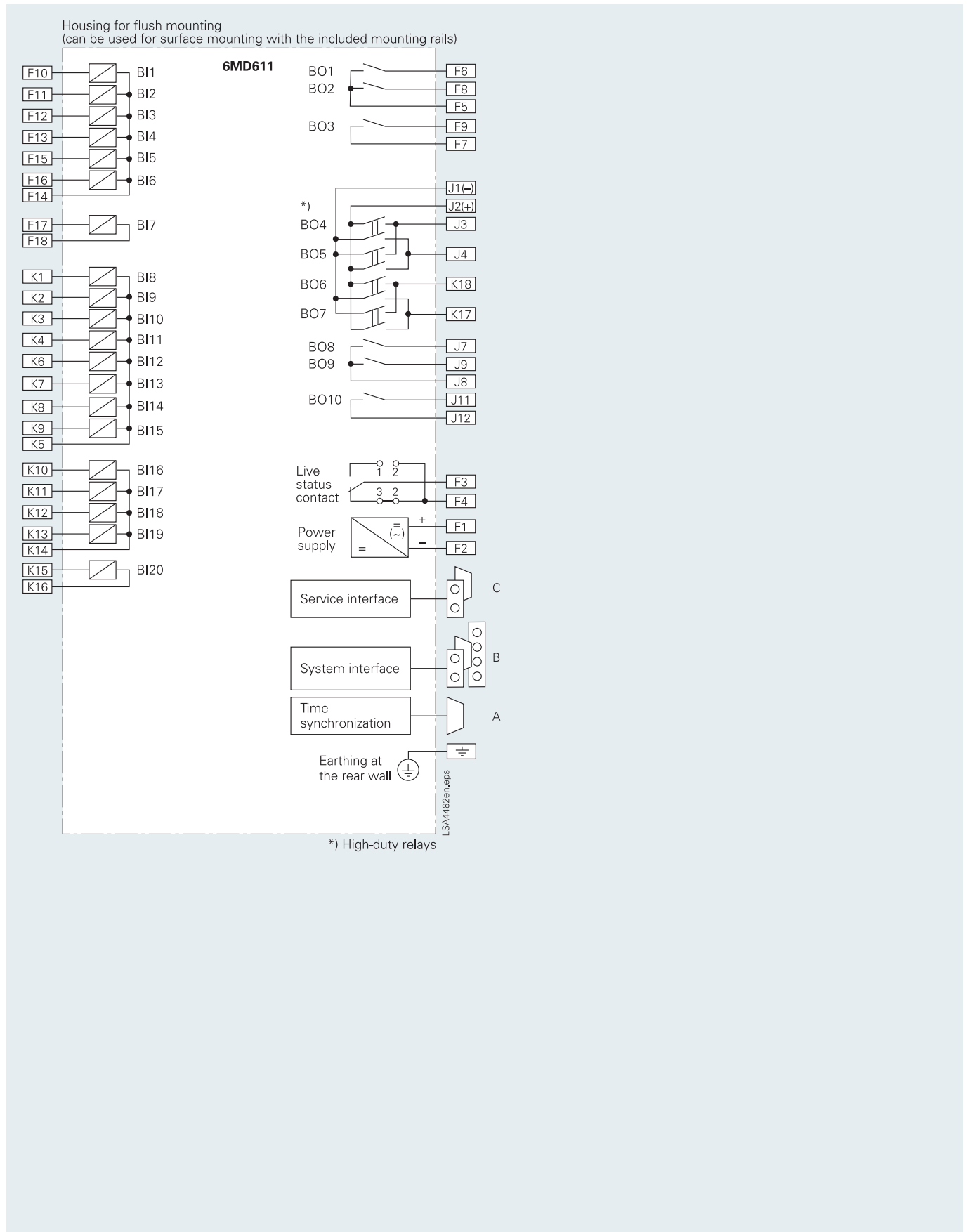


Fig. 12/5 Connection diagram

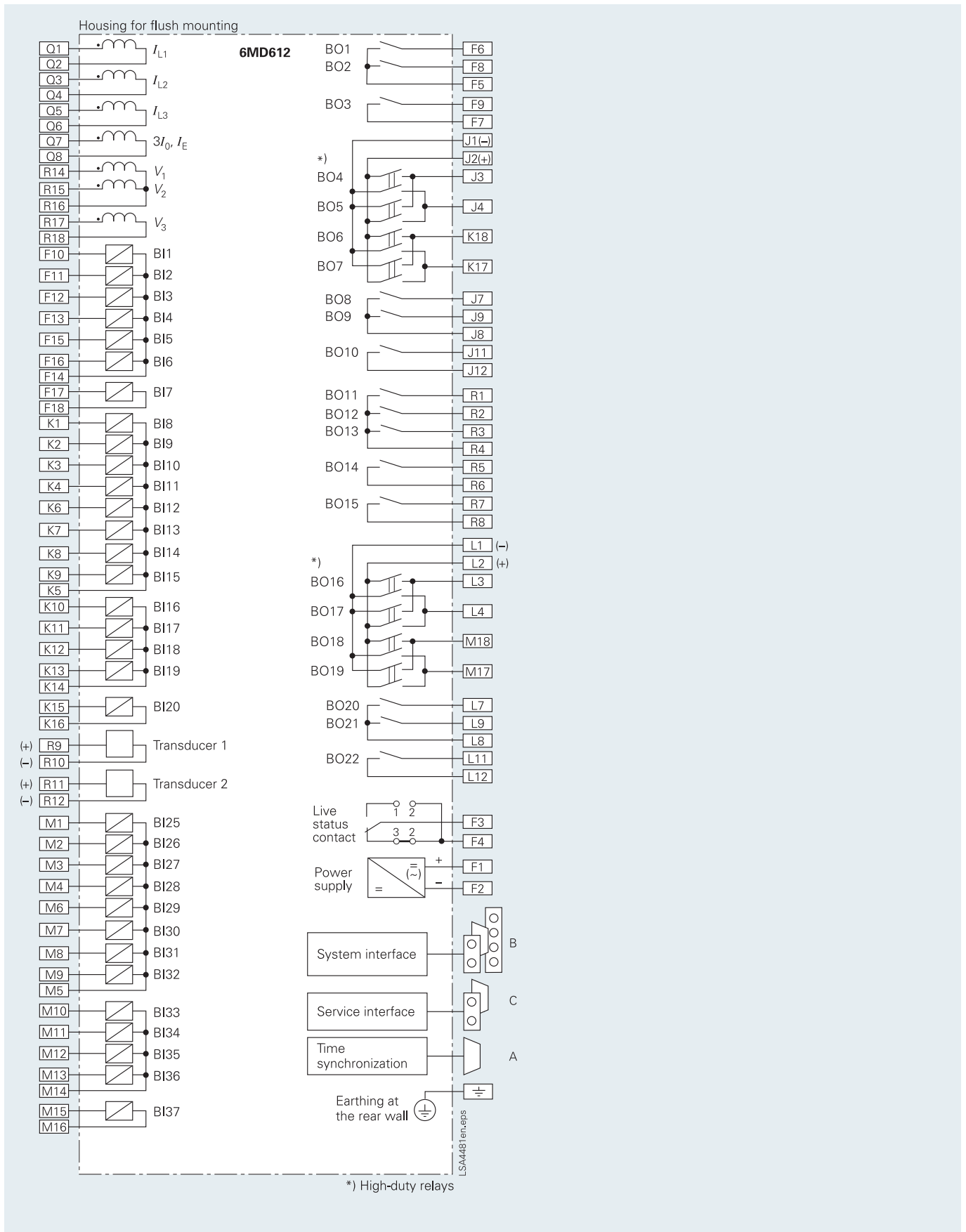


Fig. 12/6 Connection diagram

Substation Automation/6MD61

Connection diagram

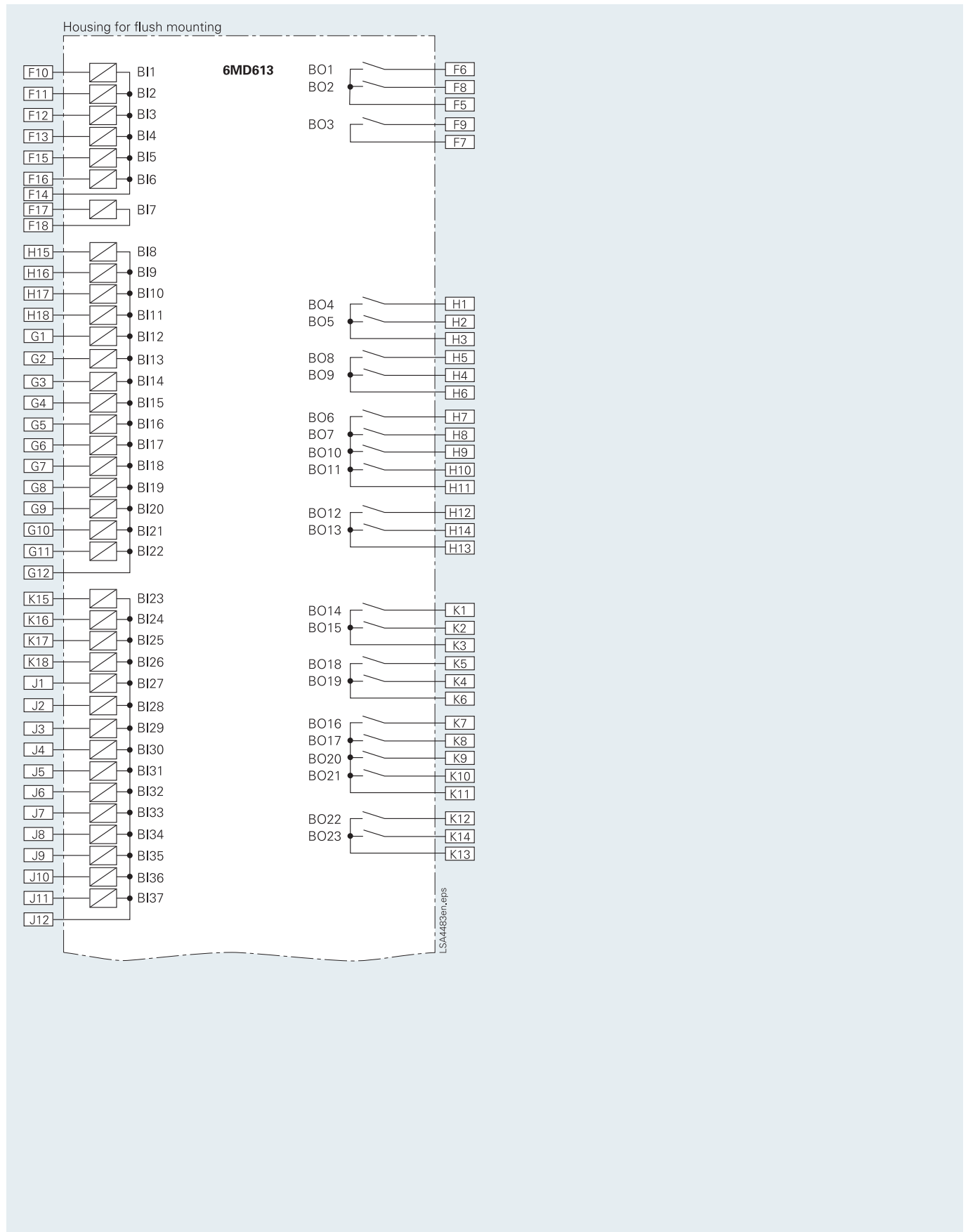


Fig. 12/7 Connection diagram, part 1; continued on the following page

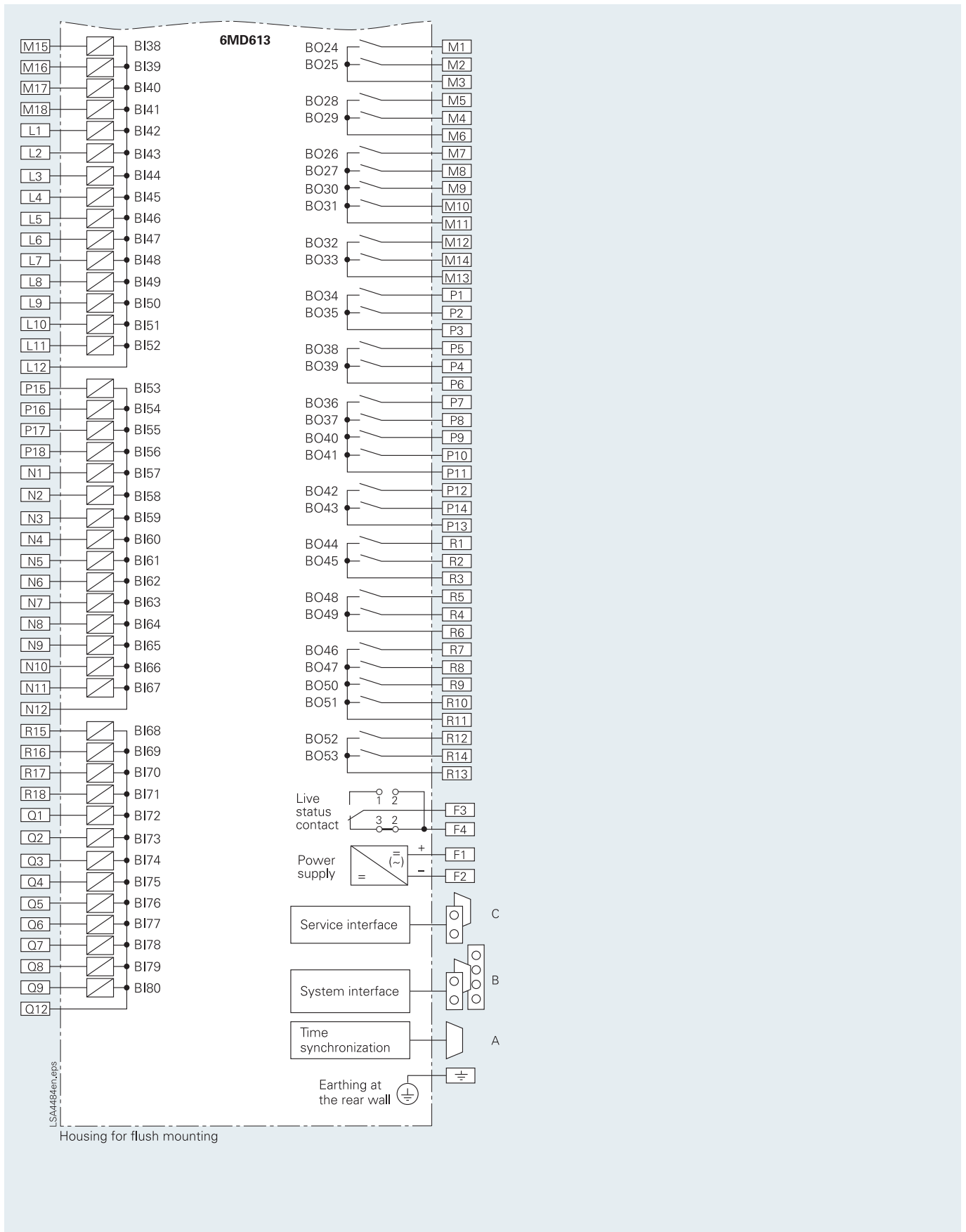


Fig. 12/8 Connection diagram part 2



Fig. 12/9 SIPROTEC 4 6MD63 bay control unit

Description

The 6MD63 bay control unit is a flexible, easy-to-use control unit. It is optimally tailored for medium-voltage applications but can also be used in high-voltage substations.

The 6MD63 bay control unit has the same design (look and feel) as the other protection and combined units of the SIPROTEC 4 relay series. Configuration is also performed in a standardized way with the easy-to-use DIGSI 4 configuration tool.

For operation, a large graphic display with a keyboard is available. The important operating actions are performed in a simple and intuitive way, e.g. alarm list display or switchgear control. The operator panel can be mounted separately from the relay, if required. Thus, flexibility with regard to the mounting position of the unit is ensured.

Integrated key-operated switches control the switching authority and authorization for switching without interlocking.

Function overview

Application

- Optimized for connection to three-position disconnectors
- Switchgear interlocking interface
- Suitable for redundant master station
- Automation can be configured easily by graphic means with CFC

Control functions

- Number of switching devices only limited by number of available inputs and outputs
- Position of switching elements is shown on the graphic display
- Local/remote switching via key switch
- Command derivation from an indication
- 4 freely assignable function keys to speed up frequently recurring operator actions
- Switchgear interlocking isolator/c.-b.
- Key-operated switching authority
- Feeder control diagram
- Measured-value acquisition
- Signal and command indications
- P , Q , $\cos \varphi$ (power factor) and meter-reading calculation
- Event logging
- Switching statistics

Monitoring functions

- Operational measured values
- Energy metering values
- Time metering of operating hours
- Slave pointer
- Self-supervision of relay

Communication interfaces

- System interface
 - IEC 61850 Ethernet
 - IEC 60870-5-103 protocol
 - PROFIBUS-FMS
 - DNP 3.0
 - PROFIBUS-DP
 - MODBUS
 - Service interface for DIGSI 4 (modem)/temperature detection (thermo-box)
 - Front interface for DIGSI 4
 - Time synchronization via IRIG-B/DCF 77

Substation Automation/6MD63

Selection and ordering data

Description	Order No.	Order code
6MD63 bay control unit with local control	6MD63	AA0
Housing, binary inputs (BI) and outputs (BO), measuring transducer		
Housing ½ 19", 11 BI, 8 BO, 1 live status contact	1	
Housing ½ 19", 24 BI, 11 BO, 4 power relays, 1 live status contact	2	
Housing ½ 19", 20 BI, 11 BO, 2 measuring transducer inputs, 4 power relays, 1 live status contact	3	
Housing ½ 19", 20 BI, 6 BO, 4 power relays, 1 live status contact ¹⁾	4	
Housing ¼ 19", 37 BI, 14 BO, 8 power relays, 1 live status contact	5	
Housing ¼ 19", 33 BI, 14 BO, 2 measuring transducer inputs, 8 power relays, 1 live status contact	6	
Housing ½ 19", 33 BI, 9 BO, 8 power relays, 1 live status contact ¹⁾	7	
Current transformer I_n		
No analog measured variables	0	
1 A ²⁾	1	
5 A ²⁾	5	
Rated auxiliary voltage (power supply, indication voltage)		
24 to 48 V DC, threshold binary input 19 V ³⁾	2	
60 to 125 V DC ⁴⁾ , threshold binary input 19 V ³⁾	4	
110 to 250 V DC ⁴⁾ , 115 to 230 V AC, threshold binary input 88 V ³⁾	5	
Unit version		
For panel surface mounting, plug-in terminal, detached operator panel	A	
For panel surface mounting, 2-tier terminal, top/bottom	B	
For panel surface mounting, screw-type terminal, detached operator panel	C	
For panel flush mounting, plug-in terminal (2/3 pin AMP connector)	D	
For panel flush mounting, screw-type terminal (direct connection / ring-type cable lugs)	E	
For panel surface mounting, screw-type terminal (direct connection / ring-type cable lugs), without HMI	F	
For panel surface mounting, plug-in terminal without HMI	G	
Region-specific default settings/function versions and language settings		
Region DE, 50 Hz, IEC, language: German, changeable	A	
Region World, 50/60 Hz, IEC/ANSI, language: English (GB), changeable	B	
Region US, 60 Hz, ANSI, language: English (US), changeable	C	
Region FR, IEC/ANSI, language: French, changeable	D	
Region World, IEC/ANSI, language: Spanish, changeable	E	
System interface (on rear of unit/Port B)		
No system port	0	
IEC 60870-5-103 protocol, electrical RS232	1	
IEC 60870-5-103 protocol, electrical RS485	2	
IEC 60870-5-103 protocol, 820 nm fiber optic, ST connector	3	
PROFIBUS-FMS Slave, electrical RS485	4	
PROFIBUS-FMS Slave, fiber optic, single ring, ST connector ⁵⁾	5	
PROFIBUS-FMS Slave, fiber optic, double ring, ST connector ⁵⁾	6	
PROFIBUS-DP Slave, RS485	9	L O A
PROFIBUS-DP Slave, 820 nm fiber optic, double ring, ST connector ⁵⁾	9	L O B
MODBUS, RS485	9	L O D
MODBUS, 820 nm fiber optic, ST connector ⁵⁾	9	L O E
DNP 3.0, RS485	9	L O G
DNP 3.0, 820 nm fiber optic, ST connector ⁵⁾	9	L O H
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector	9	L O R
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector ⁵⁾	9	L O S
DIGSI 4/modem interface (on rear of unit/Port C)		
No port on rear side	0	
DIGSI 4, electrical RS232	1	
DIGSI 4, electrical RS485	2	
DIGSI 4, optical 820 nm, ST connector	3	
Measuring		
Basic metering (current, voltage)	0	
Slave pointer, mean values, min/max values only for position 7 = 1 and 5	2	

1) Only for position 7 = 0

2) Rated current can be selected by means of jumpers.

3) The binary input thresholds can be selected in two stages by means of jumpers.

4) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

5) Not with position 9 = "B"; if 9 = "B"; please order 6MD6 unit with RS485 port and separate fiber-optic converter.



Fig. 12/10 SIPROTEC 4 6MD66 high-voltage bay control unit

Function overview

Application

- Integrated synchro-check for synchronized closing of the circuit-breaker
- Breaker-related protection functions (Breaker Failure 50BF, Auto-reclosure 79)
- Automation can be configured easily by graphic means with CFC
- Flexible, powerful measured-value processing
- Connection for 4 voltage transformers, 3 current transformers, two 20 mA transducers
- Volume of signals for high voltage
- Up to 14 1 ½-pole circuit-breakers can be operated
- Up to 11 2-pole switching devices can be operated
- Up to 65 indication inputs, up to 45 command relays

Description

The 6MD66 high-voltage bay control unit is the control unit for high voltage bays from the SIPROTEC 4 relay series. Because of its integrated functions, it is an optimum, low-cost solution for high-voltage switchbays.

The 6MD66 high-voltage bay control unit also has the same design (look and feel) as the other protection and combined units of the SIPROTEC 4 relay series. Configuration is performed in a standardized way with the easy-to-use DIGSI 4 configuration tool.

For operation, a large graphic display with a keyboard is available. The important operating actions are performed in a simple and intuitive way, e.g. alarm list display or switchgear control. The operator panel can be mounted separately from the unit, if required. Thus, flexibility with regard to the mounting position of the unit is ensured. Integrated key-operated switches control the switching authority and authorization for switching without interlocking. High-accuracy measurement ($\pm 0.5\%$) for voltage, current and calculated values P and Q are another feature of the unit.

- Can be supplied with 3 volumes of signals as 6MD662 (35 indications, 25 commands), 6MD663 (50 indications, 35 commands) or 6MD664 (65 indications, 45 commands); number of measured values is the same
- Switchgear interlocking
- Inter-relay communication with other devices of the 6MD66 series, even without a master station interface with higher level control and protection
- Suitable for redundant master station
- Display of operational measured values $V, I, P, Q, S, f, \cos \varphi$ (power factor) (single and three-phase measurement)
- Limit values for measured values
- Can be supplied in a standard housing for cubicle mounting or with a separate display for free location of the operator elements
- 4 freely assignable function keys to speed up frequently recurring operator actions

Communication interfaces

- System interface
 - IEC 61850 Ethernet
 - IEC 60870-5-103 protocol
 - PROFIBUS-FMS/-DP
 - Service interface for DIGSI 4 (modem)
 - Front interface for DIGSI 4
 - Time synchronization via IRIG B/DCF 77

Application

Application

Communication

With regard to communication between components, particular emphasis is placed on the SIPROTEC 4 functions required for energy automation.

- Every data item is time-stamped at its source, i.e. where it originates.
- Information is marked according to where it originates from (e.g. if a command originates "local" or "remote")
- The feedback to switching processes is allocated to the commands.
- Communication processes the transfer of large data blocks, e.g. file transfers, independently.
- For the reliable execution of a command, the relevant signal is first acknowledged in the unit executing the command. A check-back indication is issued after the command has been enabled (i.e. interlocking check, target = actual check) and executed.

In addition to the communication interfaces on the rear of the unit, which are equipped to suit the customer's requirements, the front includes an RS232 interface for connection of DIGSI. This is used for quick diagnostics as well as for the loading of parameters. DIGSI 4 can read out and represent the entire status of the unit online, thus making diagnostics and documentation more convenient.

Control

The bay control units of the 6MD66 series have command outputs and indication inputs that are particularly suited to the requirements of high-voltage technology. As an example, the 2-pole control of a switching device is illustrated (see Fig. 12/11). In this example, two poles of the circuit-breaker are closed and 1 pole is open. All other switching devices (disconnectors, grounding switches) are closed and open in 1½-pole control. A maximum of 14 switching devices can be controlled in this manner.

A complete 2-pole control of all switching devices (see Fig. 12/12) is likewise possible. However more contacts are required for this. A maximum of 11 switching devices can be controlled in this manner.

A possible method to connect the switching devices to the bay control unit 6MD66 is shown in Fig. 12/13. There it is shown how three switching devices Q0, Q1, and Q2 are connected using 1½ pole control.

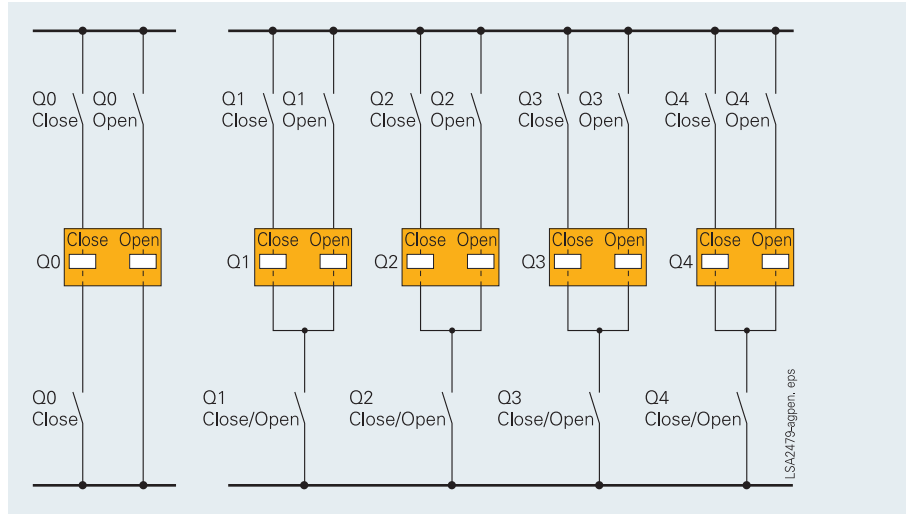


Fig. 12/11 Connection diagram of the switching devices (circuit-breaker 2 poles closed, 1 pole open; disconnector/grounding switch 1½ pole)

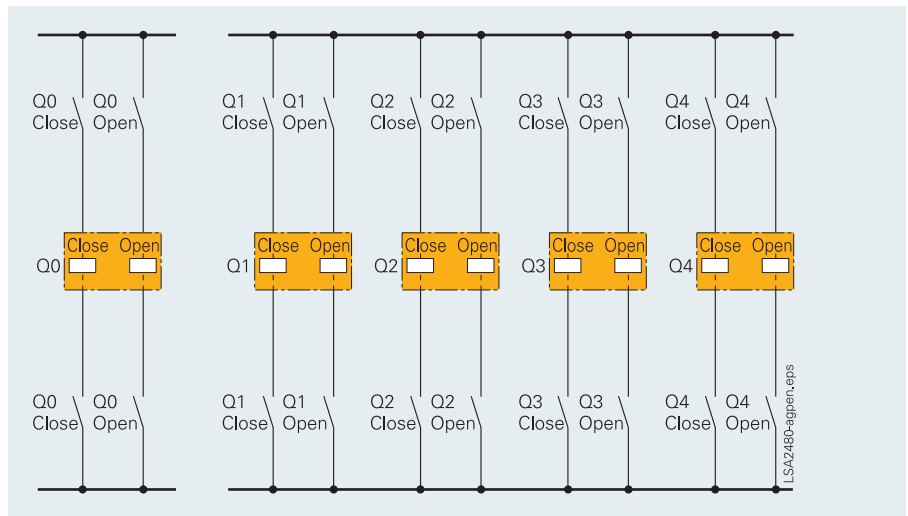


Fig. 12/12 2-pole connection diagram of circuit-breakers and disconnectors

Functions

Switchgear interlockings

Using the CFC (Continuous Function Chart) available in all SIPROTEC 4 units, the bay interlock conditions can, among other things, be conveniently configured graphically in the 6MD66 bay control unit. The inter-bay interlock conditions can be checked via the "inter-relay communication" (see next section) to other 6MD66 devices. With the introduction of IEC 61850 communication, the exchange of information for interlocking purposes is also possible via Ethernet. This is handled via the GOOSE message method. Possible partners are all other bay devices or protection devices which support IEC 61850- GOOSE message.

In the tests prior to command output, the positions of both key-operated switches are also taken into consideration. The upper key-operated switch corresponds to the S5 function (local/remote switch), which is already familiar from the 8TK switchgear interlock system. The lower key-operated switch effects the changeover to non-interlocked command output (S1 function). In the position "Interlocking Off" the key cannot be withdrawn, with the result that non-operation of the configured interlocks is immediately evident.

The precise action of the key-operated switch can be set using the parameter "switching authority".

With the integrated function "switchgear interlocking" there is no need for an external switchgear interlock device.

Furthermore, the following tests are implemented (parameterizable) before the output of a command:

- Target = Actual, i.e. is the switching device already in the desired position?
- Double command lockout, i.e. is another command already running?
- Individual commands, e.g. grounding control can additionally be secured using a code.

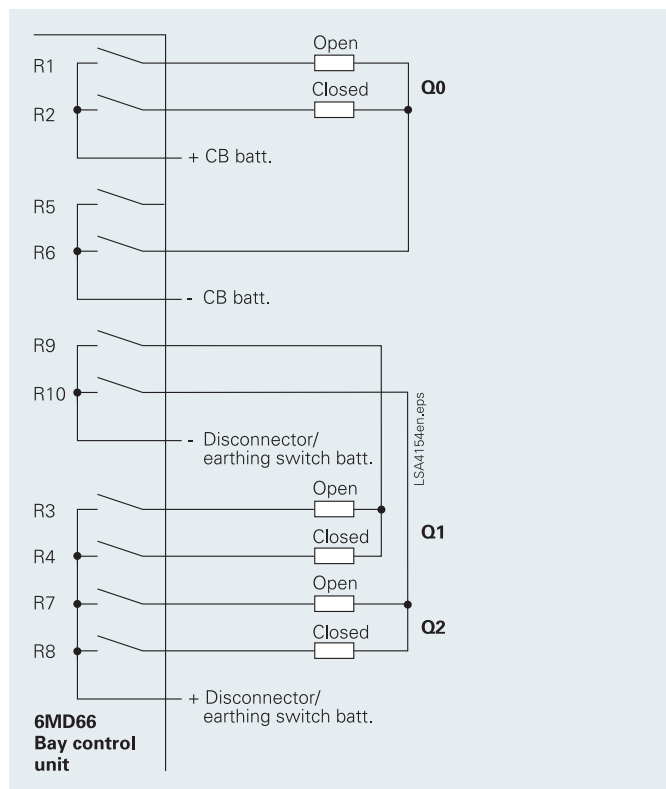


Fig. 12/13 Typical connection for 1 1/2-pole control

Functions

Synchronization

The bay control unit can, upon closing of the circuit-breaker, check whether the synchronization conditions of both partial networks are met (synchro-check). Thus an additional, external synchronization device is not required. The synchronization conditions can be easily specified using the configuration system DIGSI 4. The unit differentiates between synchronous and asynchronous networks and reacts differently upon connection:

In synchronous networks there are minor differences with regard to phase angle and voltage moduli and so the circuit-breaker response time does not need to be taken into consideration. For asynchronous networks however, the differences are larger and the range of the connection window is traversed at a faster rate. Therefore it is wise here to take the circuit-breaker response time into consideration. The command is automatically dated in advance of this time so that the circuit-breaker contacts close at precisely the right time.

Fig. 12/14 illustrates the connection of the voltages.

As is evident from Fig. 12/14, the synchronization conditions are tested for one phase. The important parameters for synchronization are:

$$|U_{\min}| < |U| < |U_{\max}|$$

(Voltage modulus)

$$\Delta\varphi < \Delta\varphi_{\max}$$

(Angle difference)

$$\Delta f < \Delta f_{\max}$$

(Frequency difference)

Using the automation functions available in the bay control unit, it is possible to connect various reference voltages depending on the setting of a disconnector. Thus in the case of a double busbar system, the reference voltage of the active busbar can be automatically used for synchronization (see Fig. 12/15).

Alternatively the selection of the reference voltage can also take place via relay switching, if the measurement inputs are already being used for other purposes.

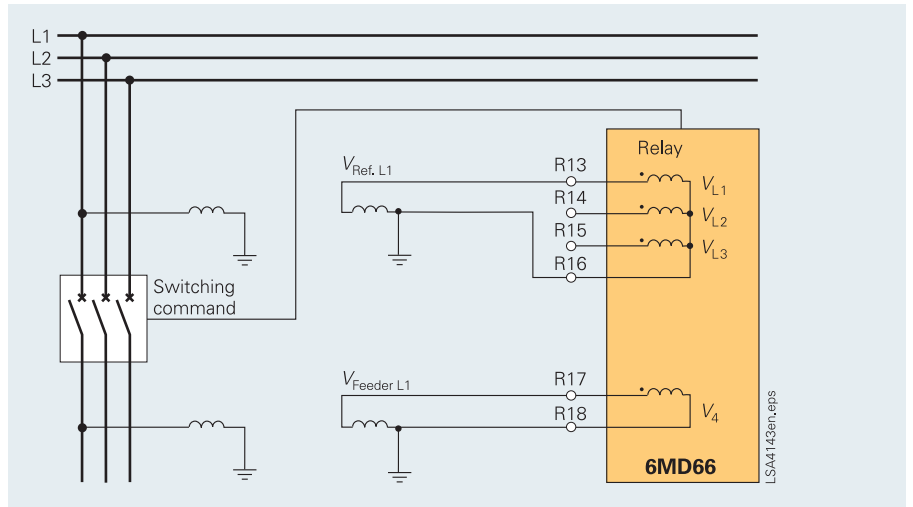


Fig. 12/14 Connection of the measured values for synchronization

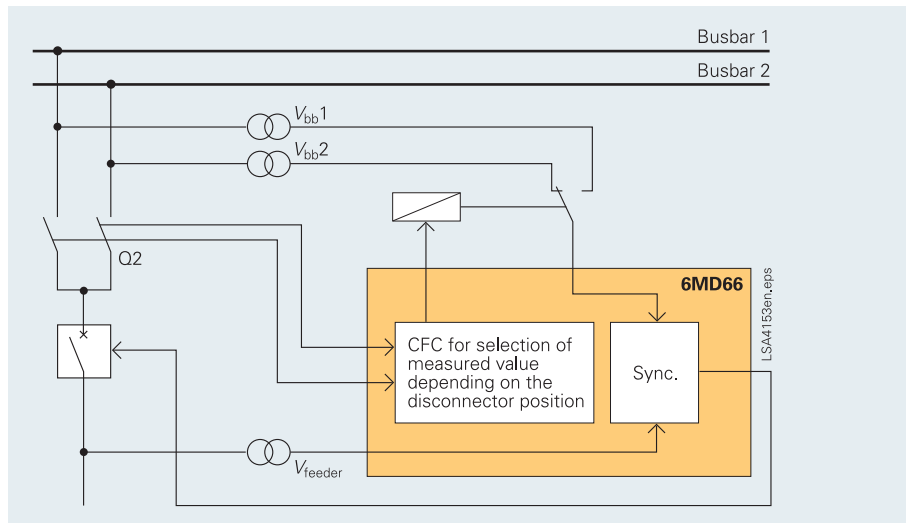


Fig. 12/15 Voltage selection for synchronization with duplicate busbar system

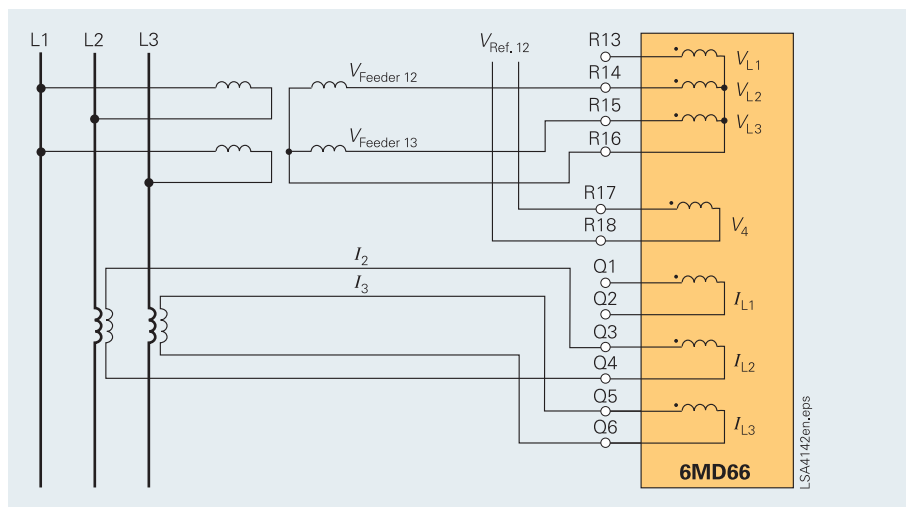


Fig. 12/16 Simultaneous connection of measured values according to a two-wattmeter circuit and synchronization

Synchronization

The bay control unit offers the option of storing various parameter sets (up to eight) for the synchronization function and of selecting one of these for operation. Thus the different properties of several circuit-breakers can be taken into consideration. These are then used at the appropriate time. This is relevant if several circuit-breakers with e.g. different response times are to be served by one bay control unit.

The measured values can be connected to the bay control unit in accordance with Fig. 12/14 (single-phase system) or Fig. 12/16 (two-wattmeter circuit).

The synchronization function can be parameterized via four tabs in DIGSI.

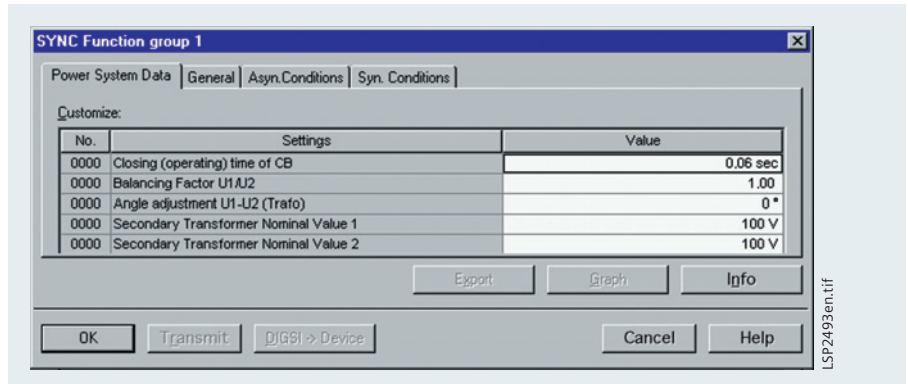


Fig. 12/17 "Power System Data", sheet for parameters of the synchronization function

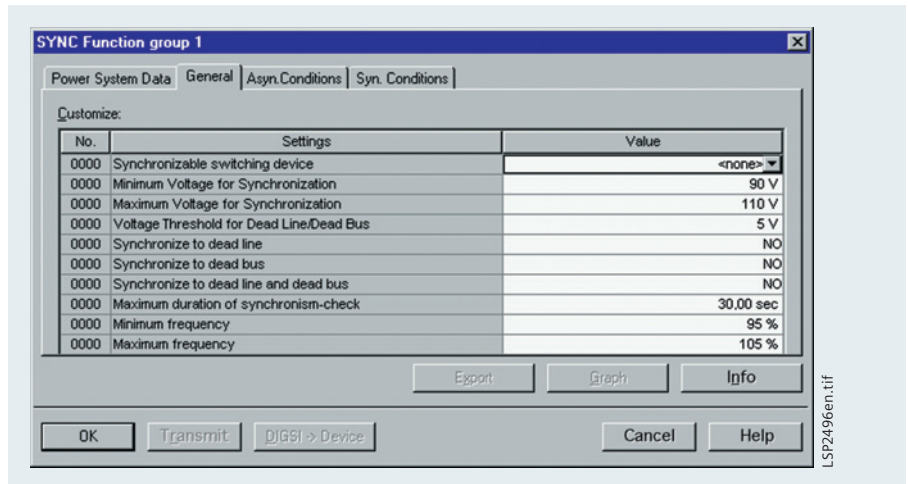


Fig. 12/18 General parameters of the synchronization function

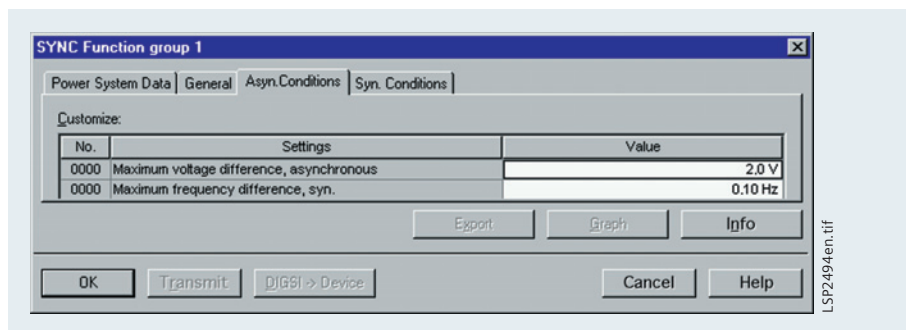


Fig. 12/19 Parameter page for asynchronous networks

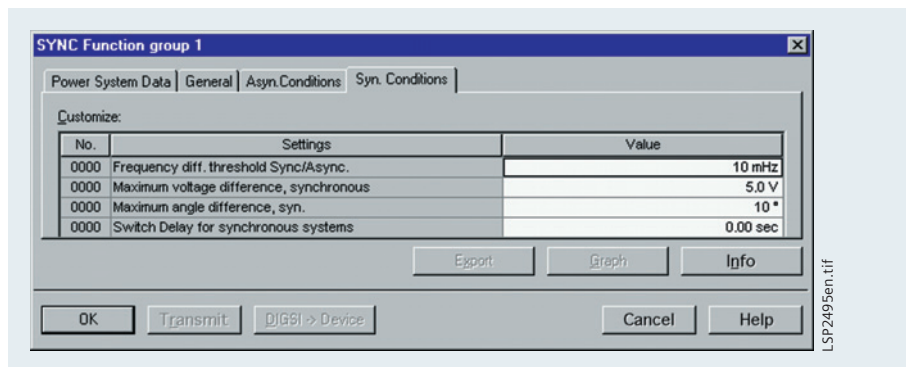


Fig. 12/20 Parameter page for asynchronous networks

Communication

Communication

The device is not only able to communicate to the substation control level via standard protocol like IEC 61850, IEC 60870-5-103 or others. It is also possible to communicate with other bay devices or protection devices. Two possibilities are available.

Inter-relay-communication

The function "inter-relay-communication" enables the exchange of information directly between 6MD66 bay controller devices. The communication is realized via Port "C" of the devices, so it is independent from the substation communication port "B". Port "C" is equipped with a RS485 interface. For communication over longer distances, an external converter to fiber-optic cable can be used.

An application example for inter-relay-communication is shown in Fig. 12/22. Three 6MD66 devices are used for control of a 1½ circuit-breaker bay. One device is assigned to each of the three circuit-breakers. By this means, the redundancy of the primary equipment is also available on the secondary side. Even if one circuit-breaker fails, both feeders can be supplied. Control over the entire bay is retained, even if one bay control unit fails. The three bay control units use the inter-relay-communication for interchange of switchgear interlocking conditions. So the interlocking is working completely independent from the substation control level.

IEC 61850-GOOSE

With the communication standard IEC 61850, a similar function like inter-relay-communication is provided with the "GOOSE" communication to other IEC 61850-devices. Since the standard IEC 61850 is used by nearly all SIPROTEC devices and many devices from other suppliers, the number of possible communication partners is large.

The applications for IEC 61850-GOOSE are quite the same as for inter-relay-communication. The most used application is the interchange of switchgear interlocking information between bay devices. GOOSE uses the IEC 61850 substation Ethernet, so no separate communication port is needed. The configuration is shown in Fig. 12/23. The SIPROTEC devices are connected via optical Ethernet and grouped by voltage levels (110 kV and 20 kV). The devices in the same voltage level can interchange the substation-wide interlocking information. GOOSE uses the substation Ethernet.

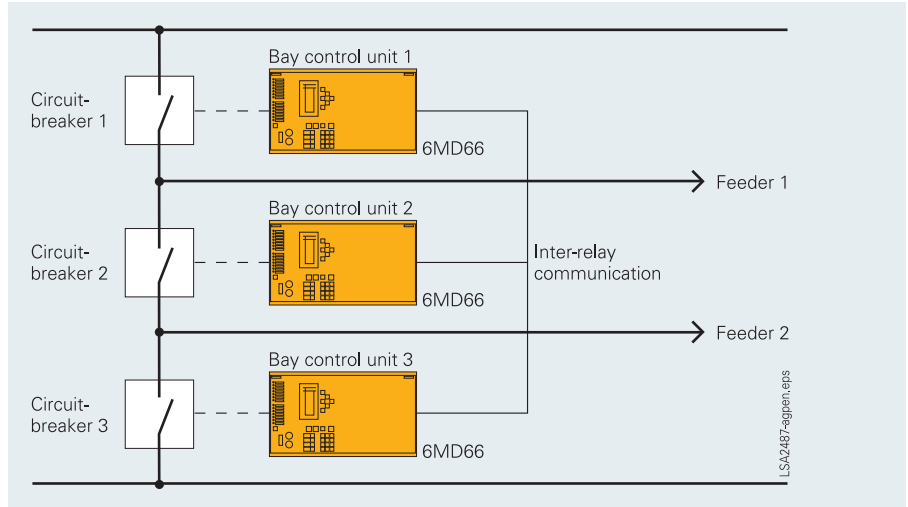


Fig. 12/21 Typical application: 1½ circuit-breaker method (disconnector and grounding switch not shown)

	Source		Type	Destination	
	Display text	Long text 1		6MD64 IRC 1 Couplin	6MD64 IRC 2 Feeder
6MD64 IRC 1 Couplin	Q0	Q0	DM		Q0Coupling
	Q1	Q1	DM		Q1Coupling
	Q2	Q2	DM		Q2Coupling
6MD64 IRC 2 Feeder	Q0	Q0	DM		
	Q1	Q1	DM		
	Q2	Q2	DM		
	Q8	Q8	DM		
	Q9	Q9	DM		

Fig. 12/22 Connection matrix of inter-relay communication in DIGSI 4

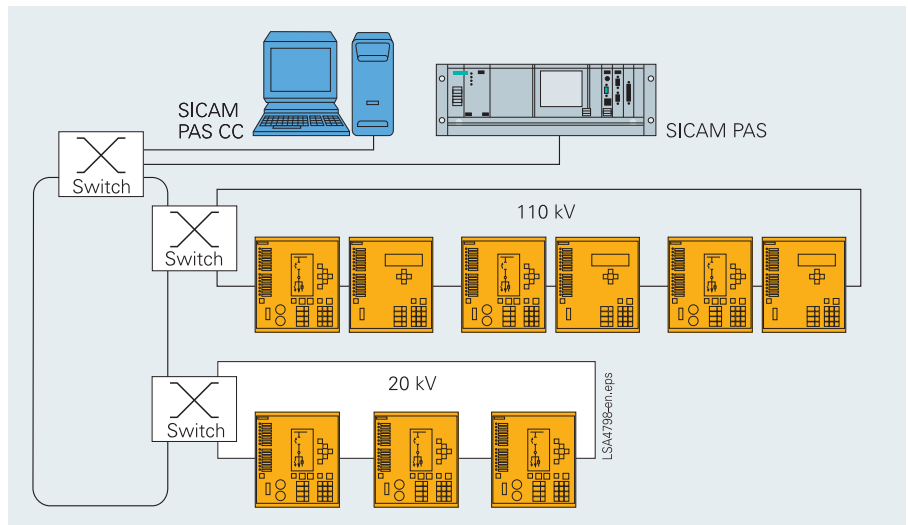


Fig. 12/23 Connection for IEC 61850-GOOSE communication

Like inter-relay-communication, GOOSE also supplies a status information for supervision of the communication. In case of interruption, the respective information is marked as "invalid".

Therefore, non-affected information still can be used for interlocking, and a maximum functional availability is guaranteed.

Measured-value processing

Measured-value processing is implemented by predefined function modules, which are likewise configured using DIGSI 4.

The transducer modules are assigned in the DIGSI 4 assignment matrix to current and voltage channels of the bay control unit. From these input variables, they form various computation variables (see Table 12/1).

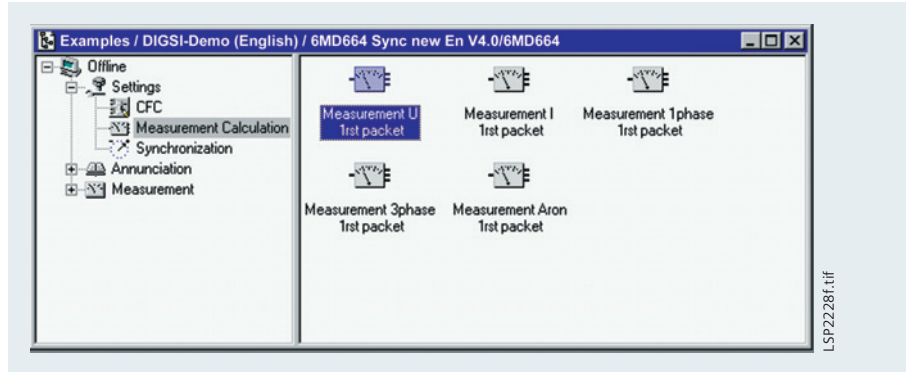


Fig. 12/24 DIGSI 4 Parameter view – transducer packets

The individual transducer modules can be activated in the functional scope of the unit and will then appear in the DIGSI 4 assignment matrix with the input channels and output variables from Table 1. The output variables can then be assigned to the system interface or represented in the measured value window in the display.

Name of the transducer module	Max. availability of transducers on the unit (can be set via the functional scope)	Required input channels	Calculated variables (= output variables)
Transducer V	x 1	V	V, f
Transducer I	x 1	I	I, f
Transducer packet 1 phase	x 3	V, I	V, I, P, Q, S, φ , $\cos \varphi$ (PF), $\sin \varphi$, f
Transducer packet 3 phase	x 1	V1, V2, V3, I1, I2, I3	V0, V1, V2, V3, V12, V23, V31, I0, I1, I2, I3, P, Q, S, φ , $\cos \varphi$ (PF), $\sin \varphi$, f
Transducer packet two-wattmeter circuit	x 1	V1, V2, I1, I2	V12, V13, I2, I3, P, Q, S, φ , $\cos \varphi$ (PF), $\sin \varphi$, f

Table 12/1 Properties of measured-value processing

Sample presentation of the measured value display.

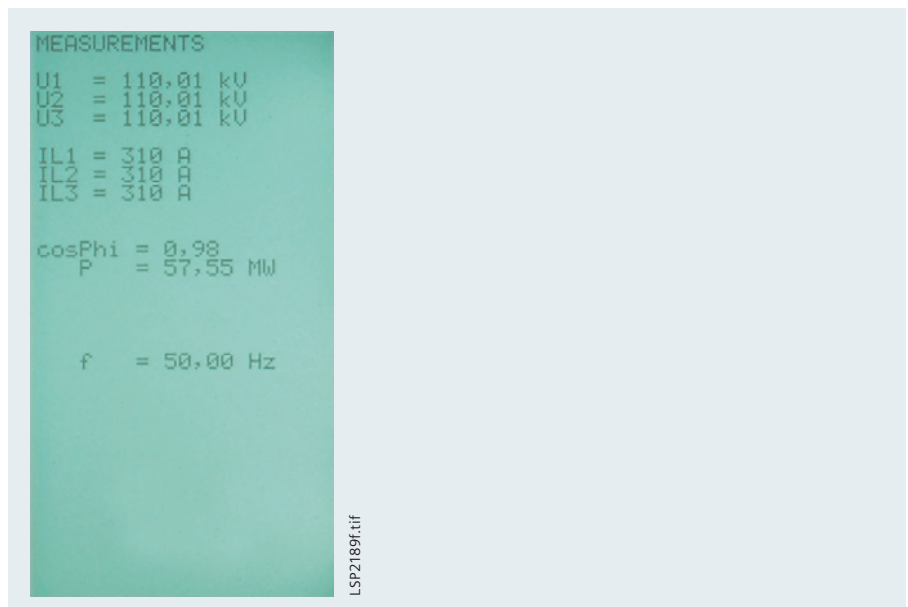


Fig. 12/25

Functions

The connection of the input channels can be chosen without restriction. For the two-wattmeter circuit, the interface connection should be selected in accordance with Fig. 12/26. The two-wattmeter circuit enables the complete calculation of a three-phase system with only two voltage and two current transformers.

Metered values

For internal metering, the unit can calculate an energy metered value from the measured current and voltage values. If an external meter with a metering pulse output is available, the bay control unit can obtain and process metering pulses via an indication input.

The metered values can be displayed and passed on to a master unit. A distinction is made between forward, reverse, active and reactive power (\pm kWh, \pm kvarh).

Automation

With integrated logic, the user can set, via a graphic interface (CFC, Continuous Function Chart), specific functions for the automation of switchgear or substation. Functions are activated via function keys, binary input or via communication interface. Processing of internal indications or measured values is also possible.

Switching authorization/key-operated switch

The switching authorization (control authorization) (interlocked/non-interlocked, corresponds to key-operated S1 in the 8TK interlock system) and the switching authority (local/remote, corresponds to key-operated S5 for 8TK) can be preset for the SIPROTEC 4 bay control unit using key-operated switches. The position of both keys is automatically evaluated by command processing. The key for operation without interlocks cannot be removed when in the position "non-interlocked", such that this mode of operation is immediately recognizable (see also page 12/15, Section "Switchgear interlockings").

Every change in the key-operated switch positions is logged.

Chatter blocking

Chatter blocking feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the communication line to the master unit will not be overloaded by disturbed inputs.

For every binary input, it is possible to set separately whether the chatter blocking should be active or not. The parameters (number of status changes, test time, etc.) can be set once per unit.

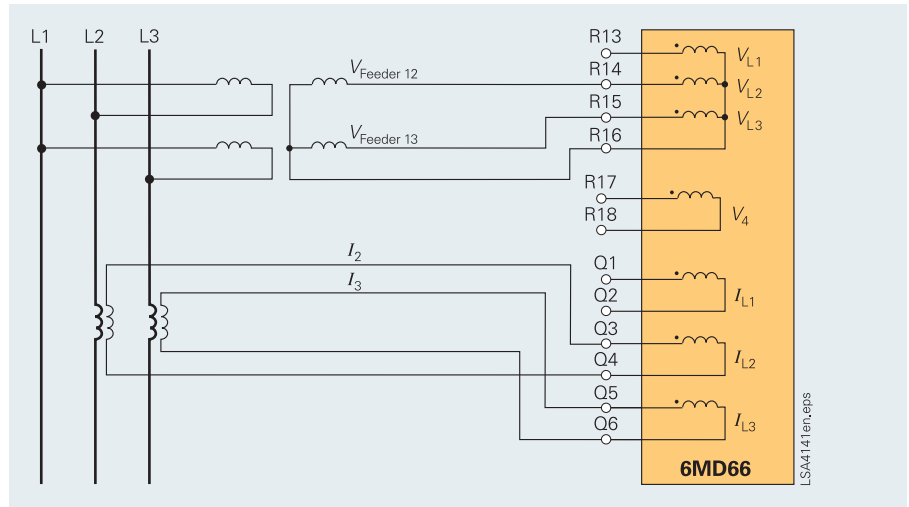


Fig. 12/26 Two-wattmeter circuit (connection to bay control unit)

Indication / measured value blocking

To avoid the transmission of information to the master unit during works on the bay, a transmission blocking can be activated.

Indication filtering

Indications can be filtered and delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time. The filter time can be set from 0 to 24 hours in 1 ms steps. It is also possible to set the filter time so that it can, if desired, be retrigged.

Furthermore, the hardware filter time can be taken into consideration in the time stamp; i.e. the time stamp of a message that is detected as arriving will be predated by the known, constant hardware filter time. This can be set individually for every binary input in a 6MD66 bay control unit.

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Auto-reclosure (ANSI 79)

The 6MD66 is equipped with an auto-reclosure function (AR). The function includes several operating modes:

- Interaction with an external device for auto-reclosure via binary inputs and binary outputs; also possible with interaction via IEC 61850-GOOSE
- Control of the internal AR function by external protection
- 3-pole auto-reclosure for all types of faults; different dead times are available depending on the type of the fault
- 1-pole auto-reclosure for 1-phase faults, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and 2-phase faults, no reclosing for multi-phase faults.
- 1-pole auto-reclosure for 1-phase and 3-pole auto-reclosure for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and 2-phase faults and 3-phase auto-reclosure for multi-phase faults
- Multiple-shot auto-reclosure
- Interaction with the internal synchro-check
- Monitoring of the circuit-breaker auxiliary contacts

In addition to the above-mentioned operating modes, several other operating principles can be employed by means of the integrated programmable logic (CFC). Integration of auto-reclosure in the feeder protection allows the line-side voltages to be evaluated. A number of voltage-dependent supplementary functions are thus available:

- **DLC**
By means of dead-line-check (DLC), reclosure is effected only when the line is deenergized (prevention of asynchronous breaker closure)
- **ADT**
The adaptive dead time (ADT) is employed only if auto-reclosure at the remote station was successful (reduction of stress on equipment).
- **RDT**
Reduced dead time (RDT) is employed in conjunction with auto-reclosure where no teleprotection method is employed: When faults within the zone extension but external to the protected line of a distance protection are switched off for rapid auto-reclosure (RAR), the RDT function decides on the basis of measurement of the return voltage from the remote station which has not tripped whether or not to reduce the dead time.

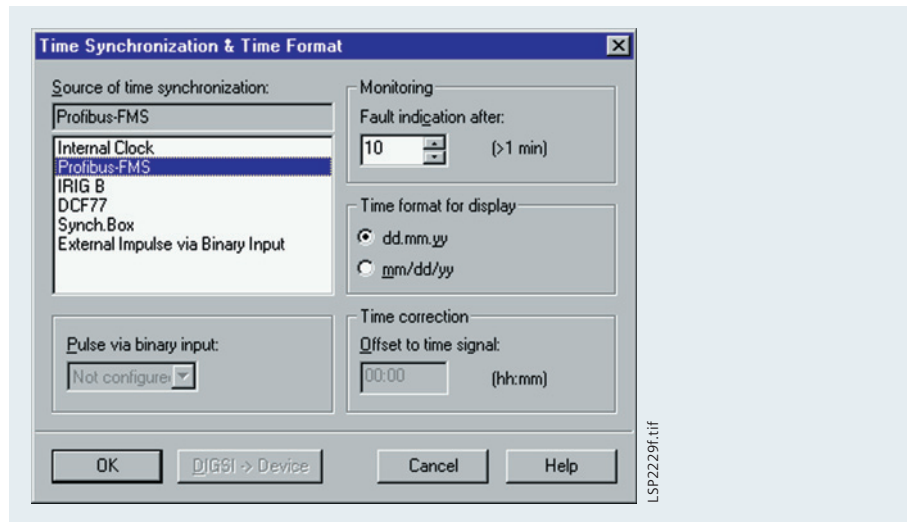


Fig. 12/27 Parameterization of time management

Breaker failure protection (ANSI 50BF)

The 6MD66 incorporates a two-stage circuit-breaker failure protection to detect failures of tripping command execution, for example, due to a defective circuit breaker. The current detection logic is phase-selective and can therefore also be used in single-pole tripping schemes. If the fault current is not interrupted after a settable time delay has expired, a retrip command or a busbar trip command will be generated. The breaker failure protection can be initiated by external devices via binary input signals or IEC 61850 GOOSE messages.

Time management

The 6MD66 bay control units can, like the other units in the SIPROTEC 4 range, be provided with the current time by a number of different methods:

- Via the interface to the higher-level system control (PROFIBUS FMS or IEC 61850)
- Via the external time synchronization interface on the rear of the unit (various protocols such as IRIG B and DCF77 are possible)
- Via external minute impulse, assigned to a binary input
- From another bay control unit by means of inter-relay communication
- Via the internal unit clock.

Fig. 12/27 illustrates the settings that are possible on the DIGSI interface.

DIGSI 4 Configuration tool

DIGSI 4 Configuration tool

The PC program DIGSI 4 is used for the convenient configuration of all SIPROTEC 4 units. Data exchange with the configuration tool SICAM PAS of the energy automation system is possible, such that the bay level information needs only be entered once. Thus errors that could arise as a result of duplicated entries are excluded.

DIGSI 4 offers the user a modern and intuitive Windows interface, with which the units can be set and also read out.

DIGSI 4 configuration matrix

The DIGSI 4 configuration matrix allows the user to see the overall view of the unit configuration at a glance (see Part 3, Fig. 3/3). For example, all allocations of the binary inputs, the output relays and the LEDs are shown at a glance. And with one click of the button, connections can be switched. Also the measuring and metering values are contained in this matrix.

Commissioning

Special attention has been paid to commissioning. All binary inputs and outputs can be read and set directly. This can simplify the wire checking process significantly for the user.

CFC: Reduced time and planning for programming logic

With the help of the CFC (Continuous Function Chart), you can configure interlocks and switching sequences simply by drawing the logic sequences; no special knowledge of software is required. Logical elements, such as AND, OR and time elements, measured limit values, etc. are available.

Display editor

A convenient display editor is available to design the display on SIPROTEC 4 units. The predefined symbol sets can be expanded to suit the user. Drawing a single-line diagram is extremely simple. Operational measured values (analog values) in the unit can be placed where required.

In order to also display the comprehensive plant of the high-voltage switchgear and controlgear, the feeder control display of the 6MD66 bay control unit can have a number of pages.

In this process, several pages of a control display can be configured under one another, and the user can switch between them using the cursor. The number of pages, including the basic display and the feeder control display, should not exceed 10, as otherwise the memory in the unit will be completely occupied.

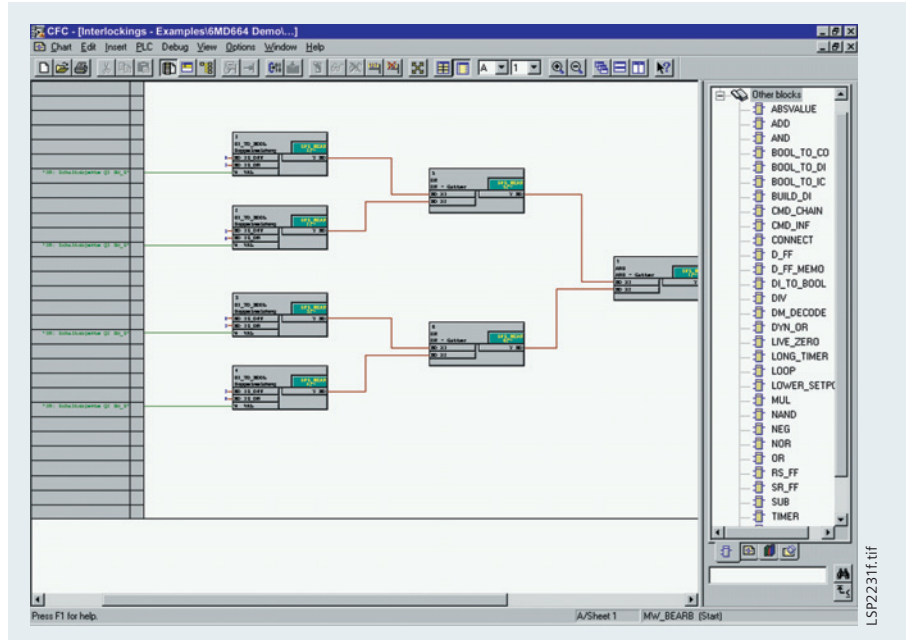


Fig. 12/28 CFC plan for interlocking logic (example)

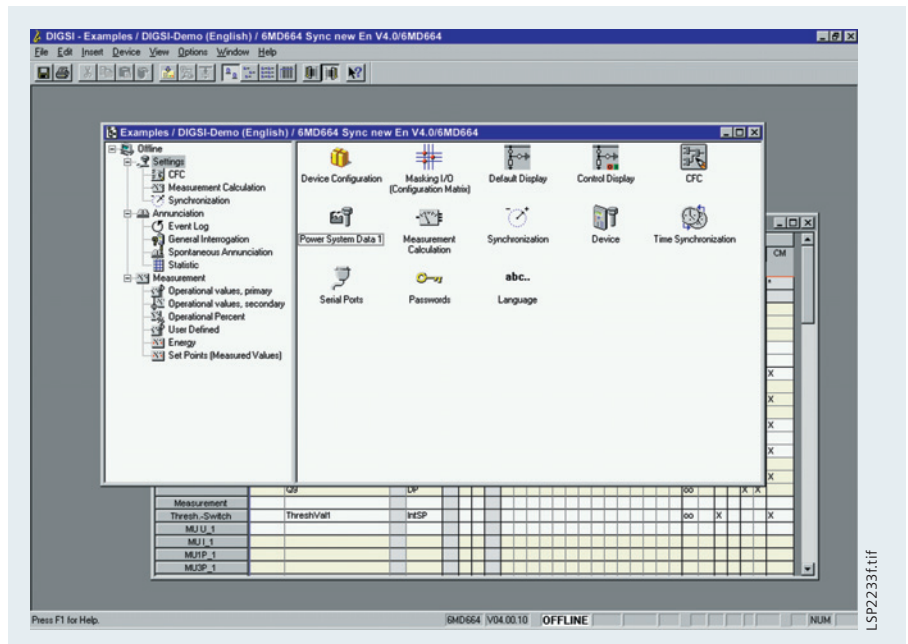


Fig. 12/29 General configuration view of the bay control unit

Fig. 12/29 illustrates the general view of the 6MD66 bay control unit on the DIGSI 4 configuration interface.

As is the case with the SIPROTEC 4 protection units, there is an icon called "Functional Scope". It enables the configuration of measured-value processing and the synchronization function and the protection functions (auto-reclosure and breaker failure protection).

Substation Automation/6MD66

Technical data

Serial interfaces	
<i>System interfaces</i>	
PROFIBUS FMS, Hardware version depending on Order No.:	
PROFIBUS fiber optic cable	ST connector
Baud rate	max 1.5 Mbaud
Optical wave length	820 nm
Permissible path attenuation	max. 8 dB for glassfiber 62.5/125 µm
Distance, bridgeable	max. 1.5 km
PROFIBUS RS485	9-pin SUB-D connector
Baud rate	max. 12 Mbaud
Distance, bridgeable	max. 1000 m at 93.75 kBaud max. 100 m at 12 Mbaud
PROFIBUS RS232	9-pin SUB-D connector
Baud rate	4800 to 115200 baud
Distance, bridgeable	max. 15 m
<i>Time synchronization DCF77/IRIG B signal</i>	
Connection	9-pin SUB-D connector
Input voltage level	either 5 V, 12 V or 24 V
Connection allocation	
Pin 1	24 V input for minute impulse
Pin 2	5 V input for minute impulse
Pin 3	Return conductor for minute impulse
Pin 4	Return conductor for time message
Pin 7	5 V input for minute impulse
Pin 8	24 V input for time message
Pin 5, 9	Screen
Pin 6	Not allocated
Message type (IRIG B, DCF, etc.)	Can be adjusted using parameters
<i>Control interface for RS232 DIGSI 4</i>	
Connection	Front side, non-isolated, 9-pin SUB-D connector
<i>DIGSI 4 interface (rear of unit)</i>	
Fiber optic	ST connector
Baud rate	max. 1.5 Mbaud
Optical wave length	820 nm
Permissible path attenuation	max. 8 dB for glass fiber of 62.5/125 µm
Distance, bridgeable	max. 1.5 km
RS485	9-pin SUB-D connector
Baud rate	max. 12 Mbaud
Distance, bridgeable	max. 1000 m at 93.75 kBaud max. 100 m at 12 MBaud
RS232	9-pin SUB-D connector
Baud rate	4800 to 115200 Baud
Distance, bridgeable	max. 15m
<i>Interface for inter-unit communication</i>	
RS485	9-pin SUB-D connector
Baud rate	max. 12 Mbaud
Distance, bridgeable	max. 1000 m at 93.75 kBaud max. 100 m at 12 Mbaud
Ethernet interface	
<i>IEC 61850 protocol</i>	
Isolated interface for data transfer: to a control center with DIGSI between SIPROTEC 4 relays	Port B, 100 Base T acc. to IEEE 802.3
Transmission rate	1000 MBit

Ethernet, electrical	
Connection for flush-mounting housing/ surface-mounting housing with detached operator panel	Two RJ45 connectors, mounting location "B"
Distance	Max. 20 m/65.6 ft
Test voltage	AC 500 V against ground
Ethernet, optical	
Connection for flush-mounting housing/ surface-mounting housing with detached operator panel	Integrated LC connector for FO connection, mounting location "B"
Optical wavelength	1300 nm
Distance	1.5 km/0.9 miles
Electrical tests	
<i>Specifications</i>	
Standards	IEC 60255 (product standards) ANSI/IEEE C37.90.0/1.1.2 DIN 57435 Part 303 For further standards see specific tests
<i>Insulation tests</i>	
Standards	IEC 60255-5 and IEC 60870-2-1
Voltage test (100 % test) All circuits except for auxiliary supply, binary inputs, communication and time synchro- nization interfaces	2.5 kV (rms), 50 Hz
Voltage test (100 % test) Auxiliary voltage and binary inputs	DC 3.5 kV
Voltage test (100 % test) only isolated communication and time synchronization interfaces	500 V (rms value), 50 Hz
Surge voltage test (type test) All circuits except for communi- cation and time synchronization interfaces, class III	5 kV (peak); 1.2/50 µs; 0.5 J; 3 positive and 3 negative surges at intervals of 5 s
<i>EMC tests for noise immunity; type test</i>	
Standards	IEC 60255-6, IEC 60255-22 (product standards) EN 50082-2 (generic standard) DIN 57 435 Part 303
High frequency test IEC 60255-22-1, class III and DIN 57435 part 303, class III	2.5 kV (peak value), 1 MHz; τ = 15 ms 400 pulses per s; duration 2 s
Discharge of static electricity IEC 60255-22-2 class IV EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; R _i = 330 Ω
Exposure to RF field, non- modulated IEC 60255-22-3 (report), class III	10 V/m; 27 to 500 MHz
Exposure to RF field, amplitude- modulated IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz
Exposure to RF field, pulse- modulated IEC 61000-4-3/ ENV 50204, class III	10 V/m; 900 MHz; repetition frequen- cy 200 Hz; duty cycle 50 %
Fast transient interference bursts IEC 60255-22-4, IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition frequency 300 ms; both polarities; R _i = 50 Ω; test duration 1 min

EMC tests for noise immunity; type test (continued)

High-energy surge voltages (SURGE), IEC 61000-4-5 installation class III Auxiliary supply	Impulse: 1.2/50 μ s common mode: 2 kV; 12 Ω , 9 μ F differential mode: 1 kV; 2 Ω , 18 μ F
Measurement inputs, binary inputs and relay outputs	common mode: 2 kV; 42 Ω , 0.5 μ F differential mode: 1 kV; 42 Ω , 0.5 μ F
Conducted RF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Magnetic field with power frequency IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak); 1 to 1.5 MHz damped wave; 50 surges per second; duration 2 s; $R_i = 150$ to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 impulses per second; both polarities; duration 2 s ; $R_i = 80 \Omega$
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz
Damped oscillations IEC 60894, IEC 61000-4-12	2.5 kV (peak value), 100 kHz polarity alternating, 1 MHz, 10 and 50 MHz, $R_i = 200 \Omega$

EMC tests for interference emission; type tests

Standard	EN 50081-1 (Basic specification)
Radio interference voltage on lines only auxiliary supply IEC-CISPR 22	150 kHz to 30 MHz class B
Interference field strength IEC-CISPR 22	30 to 1000 MHz class B

Mechanical dynamic tests

Vibration, shock stress and seismic vibration

During operation

Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 g acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 5 g, duration 11 ms, 3 shocks each in both directions of the 3 axes
Vibration during earthquake IEC 60255-21-2, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 4 mm amplitude (horizontal axis) 1 to 8 Hz: ± 2 mm amplitude (vertical axis) 8 to 35 Hz: 1 g acceleration (horizontal axis) 8 to 35 Hz: 0.5 g acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes

During transport

Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 g acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 15 g, duration 11 ms, 3 shocks each in both directions 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Half-sinusoidal Acceleration 10 g, duration 16 ms, 1000 shocks in both directions of the 3 axes

Climatic stress tests

Temperatures

Standards	IEC 60255-6	
Recommended temperature during operation	-5 to +55 $^{\circ}$ C	25 to 131 $^{\circ}$ F
Temporary permissible temperature limit during operation (The legibility of the display may be impaired above 55 $^{\circ}$ C/131 $^{\circ}$ F)	-20 to +70 $^{\circ}$ C	-4 to 158 $^{\circ}$ F
Limit temperature during storage	-25 to +55 $^{\circ}$ C	-13 to 131 $^{\circ}$ F
Limit temperature during transport	-25 to +70 $^{\circ}$ C	-13 to 158 $^{\circ}$ F
Storage and transport with standard factory packaging		

Humidity

Permissible humidity stress	Annual average ≤ 75 % relative humidity; on 56 days a year up to 93 % relative humidity; condensation during operation is not permitted
We recommend arranging the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation	

CE conformity

The product meets the stipulations of the guideline of the council of the European Communities for harmonization of the legal requirements of the member states on electro-magnetic compatibility (EMC directive 2004/108/EEC previous 89/336/EEC) and product use within certain voltage limits (low-voltage directive 2006/95/EEC previous 73/23/EEC).

The product conforms with the international standard of the IEC 60255 series and the German national standard DIN VDE 57 435, Part 303. The unit has been developed and manufactured for use in industrial areas in accordance with the EMC standard.

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the directive in conformance with generic standards EN 50081-2 and EN 50082-2 for the EMC directive and EN 60255-6 for the low-voltage directive.

Substation Automation/6MD66

Selection and ordering data

Description	Order No.	Order code
6MD66 high-voltage bay control unit	6MD662	-□□□□□□-0□□□□□□
Processor module with power supply, input/output modules with a total of:		
Number of inputs and outputs		see next page
35 single-point indications, 22 1-pole single commands,		
3 single commands to common potential, 1 live contact, 3 x current		
4 x voltage via direct CT inputs, 2 measuring transducer inputs		
Current transformer I_N		
1 A	1	
1 A / 150 % I_N	2	
1 A / 200 % I_N	3	
5 A	5	
5 A / 150 % I_N	6	
5 A / 200 % I_N	7	
Rated auxiliary voltage (power supply, indication voltage)		
DC 24 to 48 V, threshold binary input 19 V ²⁾	2	
DC 60 V, threshold binary input 19 V ²⁾	3	
DC 110 V, threshold binary input 88 V ²⁾	4	
DC 220 to 250 V, threshold binary input 176 V ²⁾	5	
Unit version		
For panel flush mounting, with integr. local operation, HMI, plug-in terminal (2/3-pole AMP socket)	D	
For panel flush mounting, with integr. local operation, graphic display, keyboard, screw-type terminals (direct connec./ring-type cable lugs)	E	
Region-specific default settings/function and language settings		
Region DE, 50Hz, language: German, changeable	A	
Region World, 50/60 Hz, language: English (GB), changeable	B	
Region US, ANSI, language: English (US), changeable	C	
Region World, 50/60 Hz, language: French, changeable	D	
Region World, 50/60 Hz, language: Spanish, changeable	E	
System interface (on rear of unit, port B)		
No system interface	0	
IEC 60870-5-103 protocol, electrical RS485	2	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	3	
PROFIBUS-FMS Slave, electrical RS485	4	
PROFIBUS-FMS Slave, optical, single ring, ST connector	5	
PROFIBUS-FMS Slave, optical, double ring, ST connector	6	
PROFIBUS-DP Slave, electrical RS485	9	L 0 A
PROFIBUS-DP Slave, 820 nm fiber, double ring, ST plugs	9	L 0 B
PROFIBUS-DP Slave, double electrical RS485 (second module on port D)	9	L 1 A
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector	9	L 0 R
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector	9	L 0 S
Function interface (on rear of unit, port C and D)		
No function interface	0	
DIGSI 4, electrical RS232, port C	1	
DIGSI 4, electrical RS485, port C	2	
DIGSI 4, optical 820 nm, ST connector, port D	3	
With RS485 interface for inter-relay communication, port C and DIGSI 4	4	
With RS485 interface for inter-relay communication, port C and DIGSI 4, with optical 820 nm, ST connector, port D	5	

1) The binary input thresholds can be selected in two stages by means of jumpers.

Description	Order No.	Order code
6MD66 high-voltage bay control unit	6MD662□-□□□□□-0□□□-□□□	
Measured-value processing		
Full measured-value processing and display		A
No measured-value processing and no display		F
Synchronization		
With synchronization		A
Without synchronization		F
Protection function		
Without protection functions		0
With auto-reclosure (AR)		1
With circuit-breaker failure protection		2
With auto-reclosure and circuit-breaker failure protection		3
With fault recording		4

Substation Automation/6MD66

Selection and ordering data

Description	Order No.	Order code
6MD66 high-voltage bay control unit	6MD66	
Processor module with power supply, input/output modules with a total of:		
Number of inputs and outputs		see next page
50 single-point indications, 32 1-pole single commands, 3 single commands to common potential, 1 live contact, 3 x current, 4 x voltage via direct CT inputs 2 measuring transducer inputs 3	3	
65 single-point indications, 42 1-pole single commands, 3 single commands to common potential, 1 live contact, 3 x current, 4 x voltage via direct CT inputs 2 measuring transducer inputs	4	
Current transformer I_N		
1 A	1	
1 A / 150 % I_N	2	
1 A / 200 % I_N	3	
5 A	5	
5 A / 150 % I_N	6	
5 A / 200 % I_N (for 6MD664)	7	
Rated auxiliary voltage (power supply, indication voltage)		
DC 24 to 48 V, threshold binary input 19 V ¹⁾	2	
DC 60 V, threshold binary input 19 V ¹⁾	3	
DC 110 V, threshold binary input 88 V ¹⁾	4	
DC 220 to 250 V, threshold binary input 176 V ¹⁾	5	
Unit version		
For panel surface mounting, detached operator panel, for mounting in low-voltage case, screw-type terminals (direct connec./ring-type cable lugs)		C
For panel flush mounting, with integr. local operation, graphic display, keyboard, screw-type terminals (direct connec./ring-type cable lugs)		E
For panel surface mounting, w/o operator unit, for mounting in low-voltage case, screw-type terminals (direct connec./ring-type cable lugs)		F
Region-specific default settings/function and language settings		
Region DE, 50 Hz, language: German, changeable		A
Region World, 50/60 Hz, language: English (GB), changeable		B
Region US, ANSI, language: English (US), changeable		C
Region World, 50/60 Hz, language: French, changeable		D
Region World, 50/60 Hz, language: Spanish, changeable		E
System interface (on rear of unit, port B)		
No system interface	0	
IEC 60870-5-103 protocol, electrical RS485	2	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	3	
PROFIBUS-FMS Slave, electrical RS485	4	
PROFIBUS-FMS Slave, optical, single ring, ST connector	5	
PROFIBUS-FMS Slave, optical, double ring, ST connector	6	
PROFIBUS-DP Slave, electrical RS485	9	L 0 A
PROFIBUS-DP Slave, optical 820 nm, double ring, ST connector	9	L 0 B
PROFIBUS-DP Slave, double electrical RS485 (second module on port D)	9	L 1 A
PROFIBUS-DP Slave, double optical double ring ST (second module on port D)	9	L 1 B
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector	9	L 0 R
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector	9	L 0 S

1) The binary input thresholds can be selected in two stages by means of jumpers.

Description	Order No.
6MD66 high-voltage bay control unit	6MD66□□-□□□□□-0□□□
Function interface (on rear of unit, port C and D)	
No function interface	0
DIGSI 4, electrical RS232, port C	1
DIGSI 4, electrical RS485, port C	2
DIGSI 4, optical 820 nm, ST connector, port D ¹⁾	3
With RS485 interface for inter-relay communication, port C and DIGSI 4	4
With RS485 interface for inter-relay communication, port C and DIGSI 4, with optical 820 nm, ST connector, port D ¹⁾	5
Measured-value processing	
Full measured-value processing and display	A
No measured-value processing and no display ²⁾	F
Synchronization	
With synchronization	A
Without synchronization	F
Protection function	
Without protection functions	0
With auto-reclosure (AR) incl. fault recording	1
With circuit-breaker failure protection (BF) incl. fault recording	2
With auto-reclosure (AR) and circuit-breaker failure protection (BF) incl. fault recording	3
Fault recording	4

1) Not for double PROFIBUS-DP (position 11 = **9-L1A** or **9-L1B**).

2) Only for position 16 = **0** (without protection functions).

Connection diagrams

Bay unit 6MD662

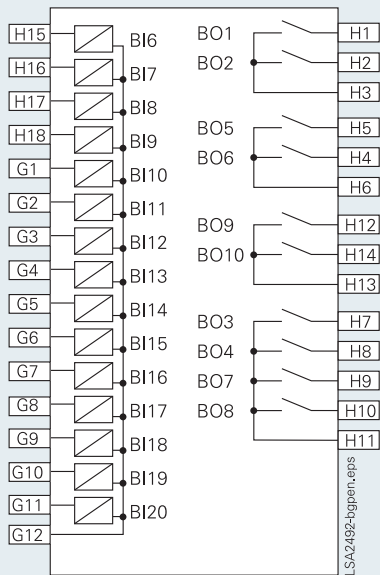


Fig. 12/30 Module 1, indications, commands

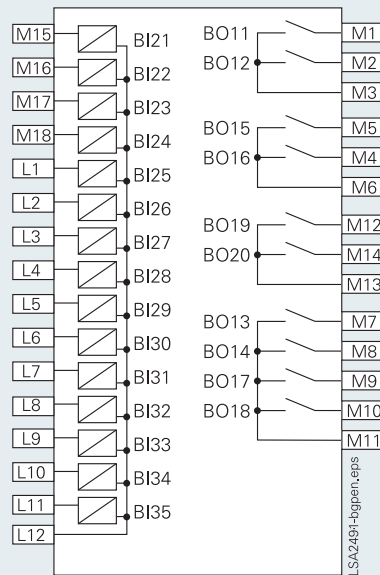


Fig. 12/31 Module 2, indications, commands

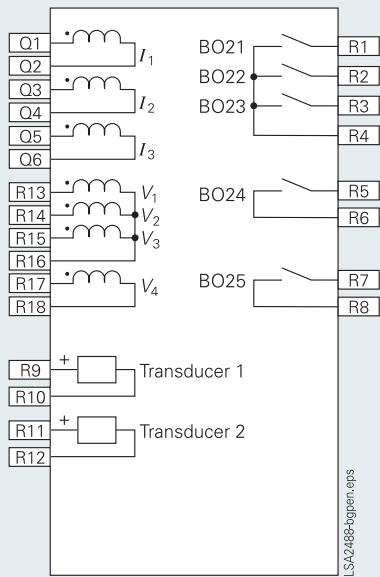


Fig. 12/32 Module 4, measuring values commands

Bay unit 6MD662

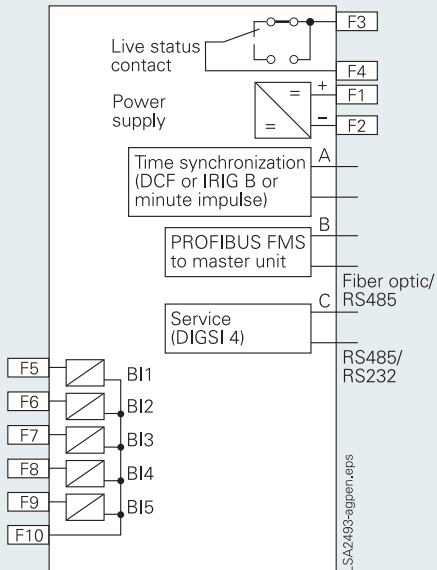


Fig. 12/33 CPU, C-CPU 2
For unit 6MD662*-*-*1-0AA0 and
6MD662*-*-*2-0AA0
(DIGSI interface, electrical,
system interface optical or electrical)

or

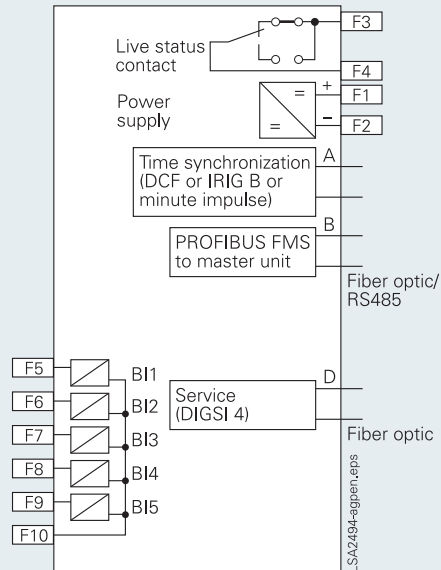


Fig. 12/34 CPU, C-CPU 2
For unit 6MD662*-*-*3-0AA0
(DIGSI interface, optical,
system interface optical or electrical)

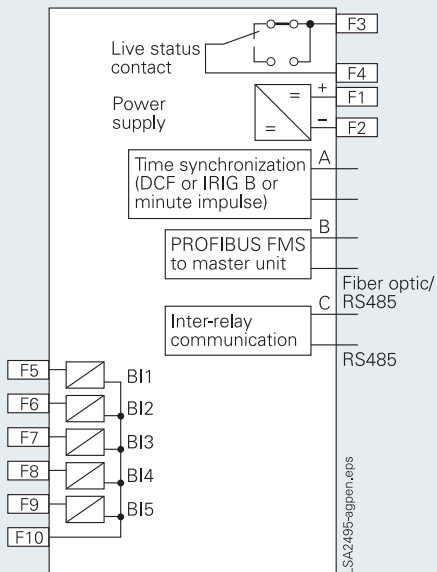


Fig. 12/35 CPU, C-CPU 2
For unit 6MD662*-*-*4-0AA0
(Inter-relay communication interface electrical,
system interface optical or electrical)

or

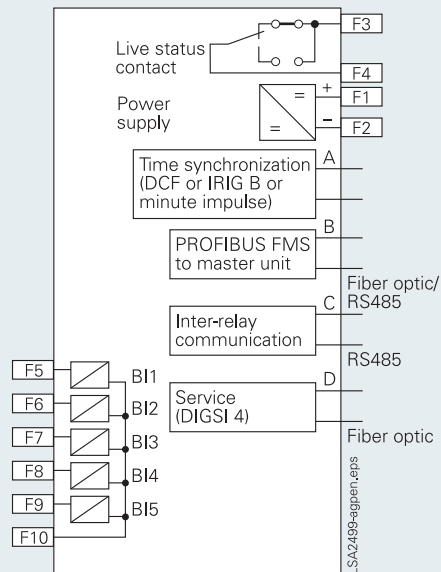


Fig. 12/36 CPU, C-CPU 2
For unit 6MD662*-*-*5-0AA0
(DIGSI interface, optical,
Inter-relay communication
interface electrical,
system interface optical or electrical)

Substation Automation/6MD66

Connection diagrams

Bay unit 6MD664

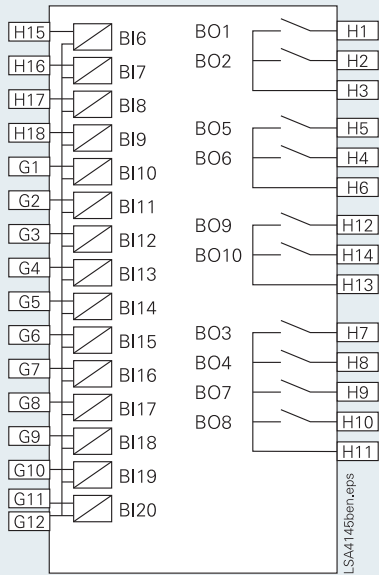


Fig. 12/37 Module 1, indications, commands

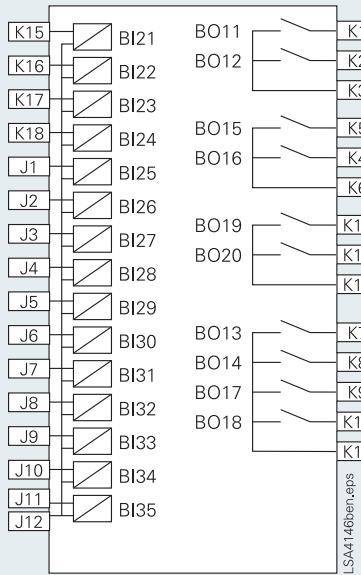


Fig. 12/38 Module 2, indications, commands

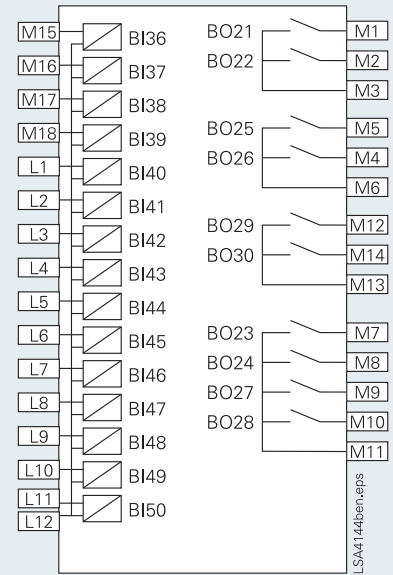


Fig. 12/39 Module 3, indications, commands

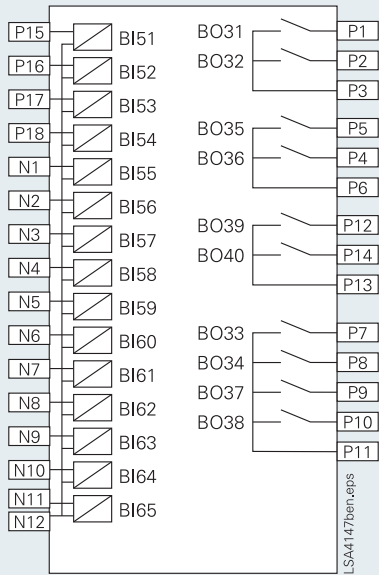


Fig. 12/40 Module 4, indications, commands

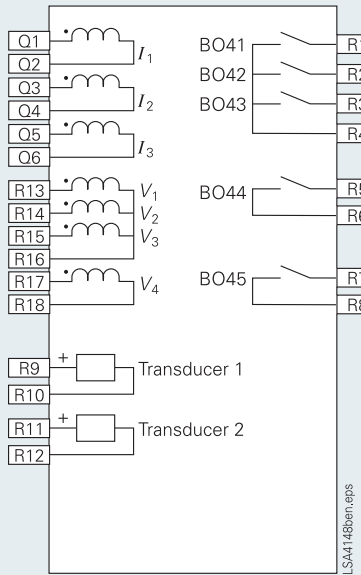


Fig. 12/41 Module 5, measuring values, commands

Bay unit 6MD664

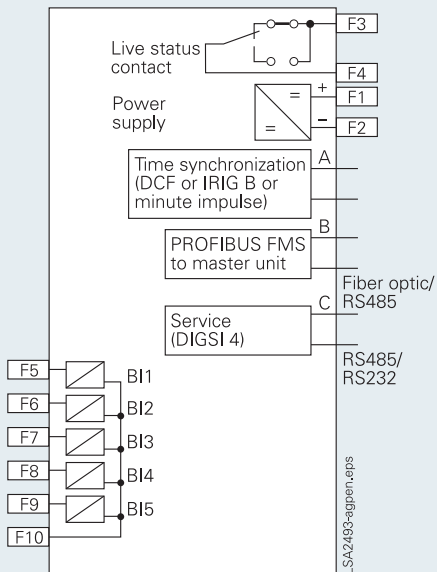


Fig. 12/42 CPU, C-CPU 2
 For unit 6MD664*-*-*1-0AA0
 and 6MD664*-*-*2-0AA0
 (DIGSI interface electric,
 system interface optical optical or electric)

or

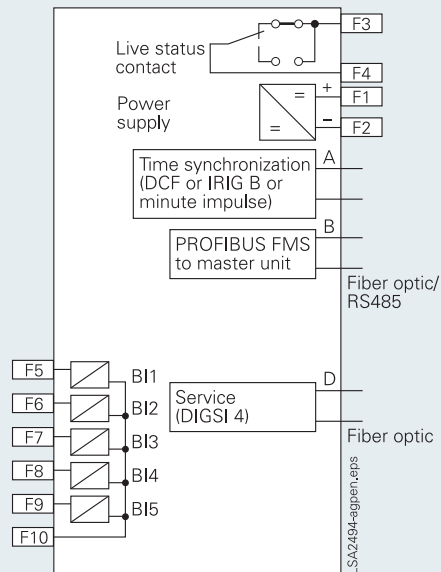


Fig. 12/43 CPU, C-CPU 2
 For unit 6MD664*-*-*3-0AA0
 (DIGSI interface optical,
 system interface optical optical or electric)

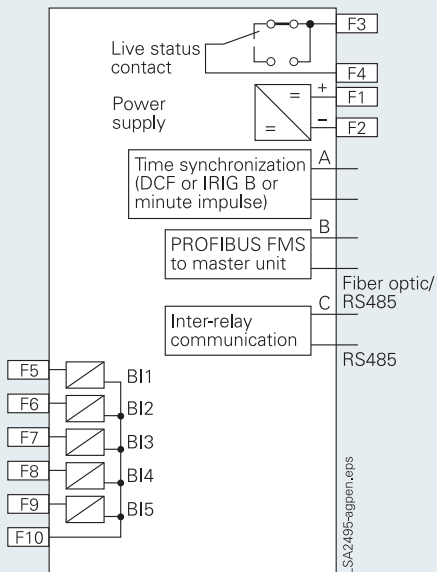


Fig. 12/44 CPU, C-CPU 2
 For unit 6MD664*-*-*4-0AA0
 (Inter-relay communication
 interface electric,
 system interface optical or electric)

or

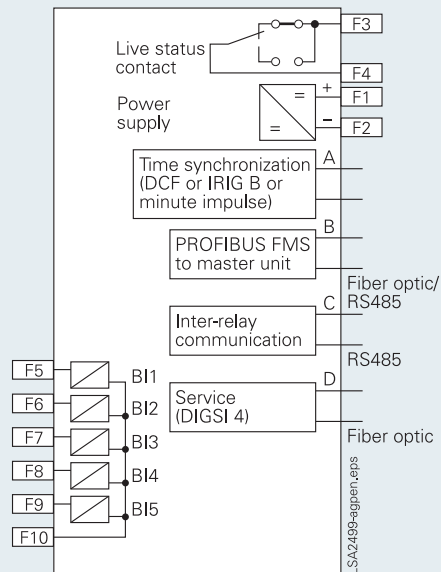


Fig. 12/45 CPU, C-CPU 2
 For unit 6MD664*-*-*5-0AA0
 (DIGSI interface optical,
 Inter-relay communication
 interface electric,
 system interface optical or electric)

Accessories

Page

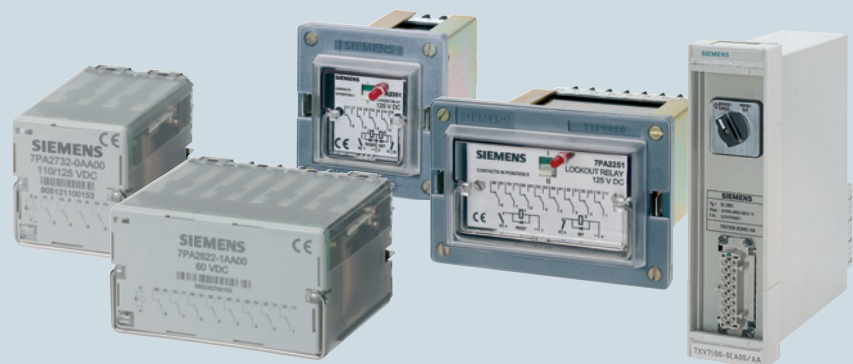
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Fig. 13/1 3RV16 voltage transformer circuit-breaker

Function overview

Application

- Protection of voltage-transformer secondary circuits for the connection of protection relays with voltage-dependent starting element

Functions

- Auxiliary contact of 3RV16 prevents the distance protection tripping via the underimpedance starting in case of a fault in the voltage transformer circuits
- Tripping time of instantaneous element in few milliseconds

Construction

- Snap-on mounting on 35-mm mounting rail, or screw mounting

Description

The voltage transformer circuit-breaker protects the secondary side of voltage transformers used to connect protection relays with voltage-dependent starting. The switch is used for distance protection with low-impedance starting. Special auxiliary contacts reliably prevent low-impedance starting from triggering distance protection if only one error has occurred in the converter line.

The voltage transformer circuit-breaker can also be used to safely disconnect the distance protection relay from the voltage transformer. In this case the special auxiliary contacts also prevent erratic triggering of the distance protection.

Additional fuses are not required. A "Fuse Failure Monitor" (FFM) is also not required.

The circuit-breakers are snap-mounted on a 35-mm mounting rail to EN 50022. Push-in lugs are available for screw-type connection of the circuit-breakers.

The circuit-breaker for voltage transformers also incorporates 2 auxiliary contacts (normally 1 NO + 1 NC). During the closing operation, contact making via the NO contact of the control switch takes place later than via the main contacts, whereas during the opening operation the auxiliary circuits are interrupted at the same time as the main circuits, if not before. This adjustment has the effect of preventing the opening of the circuit-breaker from producing a tripping command via the underimpedance starting of the distance protection relay.

The auxiliary voltage for blocking voltage-dependent starting (underimpedance) must always be routed via the NO contact 11-14.

Accessories/3RV16

3RV16 voltage transformer circuit-breaker

Functions

The voltage transformer circuit-breaker largely corresponds with the circuit-breaker 3RV1, SIRIUS, size S00. Two special characteristics are taken into account for safe prevention of faulty triggering of the distance protection relay.

Auxiliary switch for blocking the distance protection

The main contacts of the circuit-breaker open if the voltage transformer circuit-breaker is tripped or switched off. The distance protection would falsely interpret low impedance as a fault, which results in immediate power cut-out within only a few milliseconds.

To prevent this fault response, special auxiliary contacts with a time-dependent assignment to the circuit-breaker's main contacts (see Technical data) must be provided. The distance protection is blocked with the help of these auxiliary contacts, and thus prevents faulty triggering.

An auxiliary switch for blocking the distance protection relay is available, equipped with 1 changeover contact fitted permanently in the voltage transformer circuit-breaker. This changeover contact can be used as 1 NO (11-14) or 1 NC (11-12) contact. Due to the high contact stability of these auxiliary contacts at the lowest possible rated operational currents $I_e/AC-15 \geq 0.5 \text{ mA}$

at 230 V, it is also suitable for modern solid-state distance protection relays.

The laterally mountable auxiliary switches of the SIRIUS range can be used for signaling functions. They cannot be used for blocking the distance protection relay.

Impedance across the main contacts

There is only minor current flow across the main contacts of the voltage transformer circuit-breaker. To ensure reliable functioning of the distance protection, main contact resistance must be minimal and nearly constant throughout the service life of the circuit-breaker.

This is realized with suitable contacts and contact materials for the 3RV16 voltage transformer circuit-breaker.

Characteristics

The specified tripping characteristics of the thermal overload pickup (a) correspond to the mean value of the leakage bandwidth in cold state; at operating temperature these times are reduced to approx. 25 % of the specified values. The characteristics below are schematic representations. Precise characteristics are available from "Technical Assistance" (E-mail: nst.technical-assistance@siemens.com).

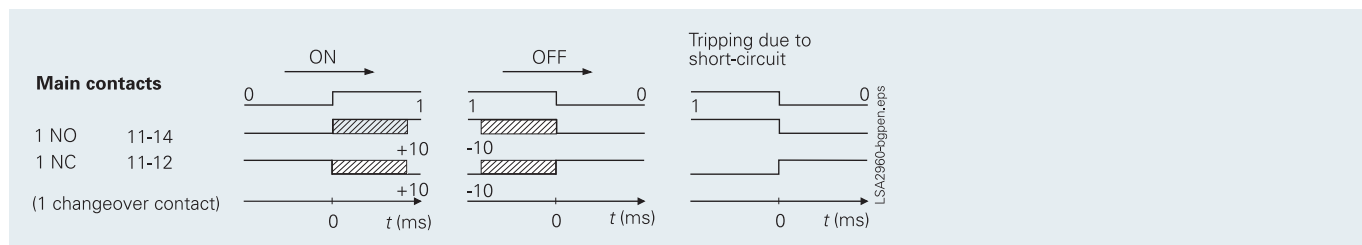


Fig. 13/2 Timing diagram of auxiliary switches for blocking distance protection

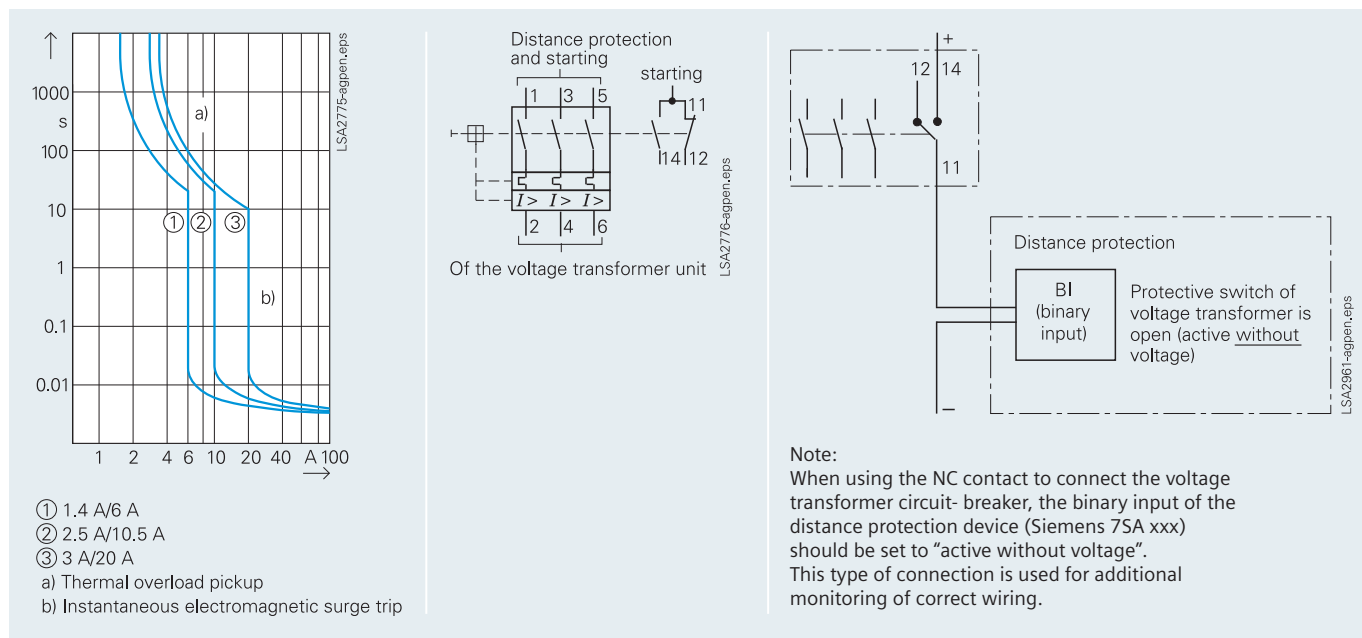


Fig. 13/3 Characteristics

Fig. 13/4 Internal connections

Fig. 13/5 Typical connections

Note:
 When using the NC contact to connect the voltage transformer circuit-breaker, the binary input of the distance protection device (Siemens 7SA xxx) should be set to "active without voltage". This type of connection is used for additional monitoring of correct wiring.

Technical data

Conductor cross-sections, main circuit, 1 or 2 conductors		General technical data		
Type	3RV1611- 1AG14 1CG14 1DG14	Type	3RV1611- 1AG14 1CG14 1DG14	
Terminal type	Screw connection	Rated current	1.4 2.5 3	
Terminal screw	Prozidriv size 2	Permissible ambient temperature		
Solid	2 × (0.5 to 1.5 mm ²); 2 × (0.75 to 2.5 mm ²); (max. 4 mm ²);	During storage / transport	-50 to +80 °C	
Finely stranded with end sleeve	2 × (0.5 to 1.5 mm ²); 2 × (0.75 to 2.5 mm ²)	During operation	-20 to +60 °C (up to 70 °C possible with current reduction)	
Stranded	2 × (0.5 to 1.5 mm ²); 2 × (0.75 to 2.5 mm ²); (max. 4 mm ²)	Rated operational voltage V _E	400 V	
Auxiliary switch for blocking the distance protection		Rated frequency	16.7 to 60 Hz	
With defined time-dependent assignment for blocking distance protection	1 changeover contact, solid-state compatible (usable as 1 NO or 1 NC)	Rated insulation voltage V _I	690 V	
Rated operational current I _E / rated operational voltage V _E	AC-14 0.5 A / V _E 250 V AC-14 1 A / V _E 125 V DC-13 0.27 A / V _E 250 V DC-13 0.44 A / V _E 125 V	Short-circuit breaking capacity at AC 400 V, short-circuit proof up to	50 kA	
Short-circuit protection for auxiliary circuit		Current setting of the thermal overload release	1.4 A 2.5 A 3 A	
Fusible link, gLgG	max. 10 A	Operating value of the instantaneous electromagnetic overcurrent release	6 ± 20 % 10.5 ± 20 % 20 ± 20 %	
Miniature circuit-breaker, C characteristic	max. 6 A	Tripping time of the instantaneous electromagnetic overcurrent release	Approx. 6 ms at 12 A 6 ms at 20 A 6 ms at 40 A	
		Disconnection life:		
		short-circuit current I _p	Max. short-circuit disconnections	
		≤ 0.1 kA	≤ 10	
		0.1 to 2 kA	≤ 3	
		2 kA to 50 kA	1	
		Internal resistance		
		in cold state	> 0.25 Ω ± 6.5 %	
		in heated state	> 0.30 Ω ± 6.5 %	
		Shock resistance	15 g	
		acc. to IEC 60068, Part 2-27		
		Degree of protection	IP 20	
		acc. to IEC 60529		
		Touch protection	Safe against finger touch	
		acc. to DIN VDE 0106 Part 100		
		Service life	Operating cycles	
		mechanical	10000	
		electrical	10000	
		Permissible mounting position	any	

Selection and ordering data

Description	Order No.
3RV16 voltage transformer circuit-breaker	
with 1 auxiliary contact, 1 changeover	
1.4 / 6 A	3RV1611-1AG14
2.5 / 10.5 A	3RV1611-1CG14
3 / 20 A	3RV1611-1DG14
Laterally mountable auxiliary switches 1 NO/NC	3RV1901-1A

4AM□□ auxiliary current transformers, 7XR95 isolating transformers

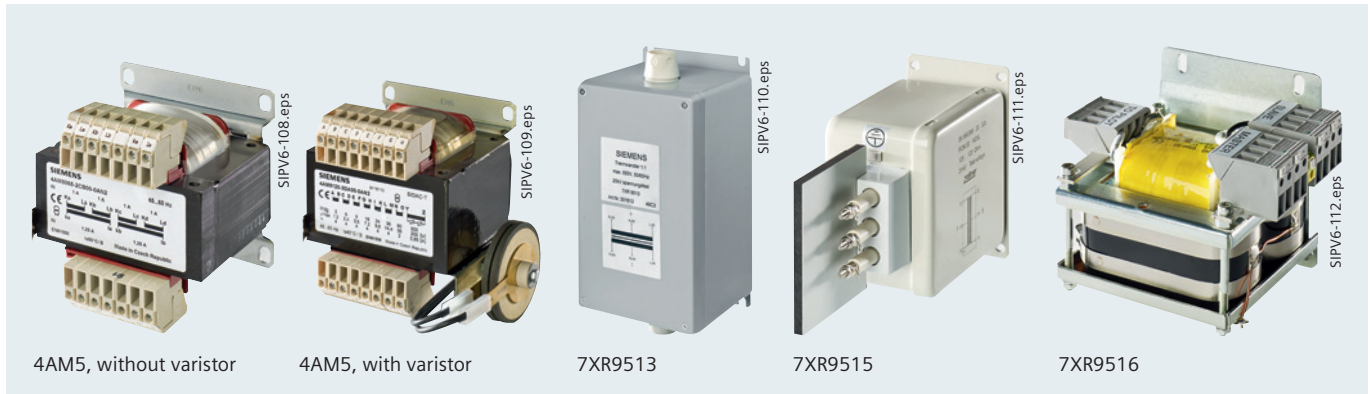


Fig. 13/6 Auxiliary 4AM current and 7XR isolating transformers

Overview

Application	Comment	Climatic requirements according to former DIN 40040	Features
Matching current transformer	Multi-tap aux. current transformer to match different current transformer ratios. 4AM51 70-7AA: Standard version, primarily for transformer differential protection. 4AM52 72-2AA: Version with double thermal withstand capability, e.g. when connecting to wide-range current transformer (continuous rating $2 \times I_N$). 4AM52 72-3AA: Version with higher saturation factor (mainly for the busbar differential protection). Greater overcurrent factor because of higher voltages	HKG HKG HKG	Numerous ratios can be selected using terminal connections (next page) $f_N = 45$ to 60 Hz
Input and matching current transformer	Input and matching current transformer for phase selective busbar differential protection (a.o. for 7SS60, 7UT6) 4AM51 20-1DA: For 1 A C.T.s 4AM51 20-2DA: For 5 A C.T.s ¹⁾	HKG HKG	$f_N = 45$ to 60 Hz with varistor
3-phase summation input C.T.	Input 3-phase summation current transformer for busbar differential protection (a.o. for 7SS60). 4AM51 20-3DA: For 1 A C.T.s 4AM51 20-4DA: For 5 A C.T.s for line differential protection (a.o. for 7SD600) 4AM49 30-6DA: For 5 A 4AM49 30-7DA: For 1 A	HKG HKG HKG HKG	$f_N = 45$ to 60 Hz with varistor $f_N = 45$ to 60 Hz with varistor
Aux. C.T. for C.T. powered tripping circuits	Auxiliary current transformer for C.T. powered trip coils in stations where no battery supply can be made available. 4AM50 65-2CB: For 1 A C.T.s 4AM50 70-8AB: For 5 A C.T.s Suitable for tripping coils with $I_N \leq 0.5$ A or 1 A, $V_N \leq 40$ V or 20 V, $P \leq 20$ VA.	HKD HKD	Unlike transducers, no defined rated power or class accuracy required. $f_N = 45$ to 60 Hz
Isolating transformer	Isolating transformer for pilot wire differential protection. Provides galvanic isolation between pilot wires and relays. 7XR9 513: For differential protection with 1 pair of pilot wires (a.o. for 7SD600) 7XR9 515: For differential protection with 1 pair of pilot wires (a.o. for 7SD600) 7XR9 516: For communication converter 7XV5662-0AC00 (a.o. for SIPROTEC 4 device 7SA522, 7SA6, 7SD52, 7SD61)	HKG HKG –	20 kV insulation 5 kV insulation 20 kV insulation

Climatic requirements: HKG = -25 °C to $+125$ °C relative humidity max. 75 %; annual average < 65 % on 60 days of the year up to 85 % (uniformly distributed over the year); condensation not permissible
HKD = -25 °C to $+125$ °C relative humidity max. 90 %; annual average < 80 % on 30 days of the year up to 100 % (uniformly distributed over the year); condensation permissible

1) If increased thermal withstand is required type 4AM51 20-4DA is recommended.

Accessories/4AM and 7XR

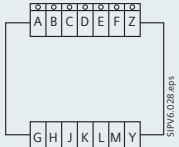
4AM□□ auxiliary current transformers, 7XR□□ isolating transformers

Order No. and technical data

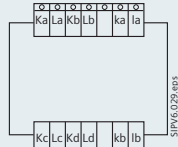
Order No.		Windings of auxiliary current transformers							Weight, approx.			
	Number of windings	A 1	B 2	C 7	D 16	E 6	F 6	G 12	Y 1736	Z		
4AM49 30-6DB00-0AN2	Max. current, continuously Max. voltage	A V	28 0.23	28 0.46	28 0.69	28 1.38	6.5 (5.6)	0.2 400			1.9 kg	
	Number of windings	A 5	B 10	C 15	D 30	E 30	F 30	G 60	Y 1736	Z		
4AM49 30-7DB00-0AN2	Max. current, continuously Max. voltage	A V	4.5 1.15	4.5 2.3	4.5 3.5	4.5 7	1.2 (20)	0.2 400			2 kg	
	Number of windings (in relation to each other)	A 1	B 2	C 7	D 16	E 1	F 2	G 7	H 16	I 7	J 16	
4AM51 70-7AA00-0AN2	Rated current $I_N^{(1)}$ Max. voltage	A V	5 2	5 4	5 14	1 32	5 2	5 4	5 14	1 32	3.6 kg	
4AM52 72-2AA00-0AN2	Rated current $I_N^{(1)}$ Max. voltage	A V	10 2	10 4	10 14	2 32	10 2	10 4	10 14	2 32	5.4 kg	
4AM52 72-3AA00-0AN2	Rated current $I_N^{(1)}$ Max. voltage	A V	5 4	5 8	5 28	1 64	5 4	5 8	5 28	1 64	5.4 kg	
4MA50 65-2CB00-0AN2	Rated current $I_N^{(1)}$ Number of windings	A	1 K _a L _a	1 K _b L _b	1 K _c L _c	1 K _d L _d	Primary windings				2.9 kg	
	Number of windings Rated current $I_N^{(1)}$	A	88 k _a l _a	88 k _b l _b	Secondary windings							
4MA50 70-8AB00-0AN2	Rated current $I_N^{(1)}$ Number of windings	A	5 K _a L _a	5 K _b L _b	5 K _c L _c	5 K _d L _d	Primary windings				2.9 kg	
	Number of windings Rated current $I_N^{(1)}$	A	88 k _a l _a	88 k _b l _b	Secondary windings							
	Number of windings	A 1	B 2	C 4	D 8	E 16	F 32	G 16	H 32	I 500	J Z	
4AM51 20-1DA00-0AN2	Max. current, continuously Max. voltage	A V	6.8 0.4	6.8 0.8	6.8 1.6	6.8 3.2	6.8 6.4	0.85 12.5	200		3.6 kg	
4AM51 20-2DA00-0AN2	Max. current, continuously Max. voltage	A V	26 0.4	26 0.8	26 1.6	26 3.2	not fitted	0.85 200			3.6 kg	
	Number of windings	A 3	B 6	C 9	D 18	E 24	F 36	G 90	H 500	I Z		
4AM51 20-3DA00-0AN2	Max. current, continuously Max. voltage	A V	4 1.2	4 2.4	4 3.6	4 7.2	4 9.6	4 14.4	2 36	0.85 200	3.6 kg	
	Number of windings	A 1	B 2	C 3	D 4	E 6	F 8	G 12	H 500	I Z		
4AM51 20-4DA00-0AN2	Max. current, continuously Max. voltage	A V	17.5 0.4	17.5 0.8	17.5 1.2	17.5 1.6	17.5 2.4	17.5 3.2	8 4.8	0.85 200	3.6 kg	
7XR9 513	Isolating transformer for differential protection with 1 pair of pilotwires	K1 M1 K1 K2 M2 L2		Isolating transformer 1:1, max. 550 V 0.4 A continuously, 3 A 10 s, 10 A 1 s test voltage 20 kV, 50 Hz, 1 min							5 kg	
7XR9 515	Isolating transformer for differential protection with 1 pair of pilotwires	T1 TO PILOT T2 T3 E T4		Isolating transformer 1:1, max. 450 V test voltage 5 kV, 50Hz, 1 min							2 kg	
7XR9 516	Isolating transformer for communication converter	a P m b a m b S		Isolating transformer 1:1, max. test voltage 20 kV, 50 Hz, 1 min							1.4 kg	

1) Thermal withstand with simultaneous loading of all the windings: 1.2 x I_N /continuously; 10 x I_N /10 s; 25 I_N /1 s.

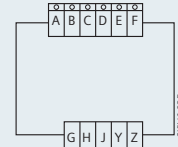
Order No. and technical data



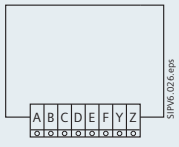
4AM49 30-6DB
4AM49 30-7DB



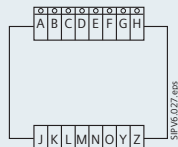
4AM50 65-2CB
4AM50 70-8AB



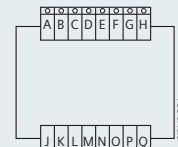
4AM51 20-1DA



4AM51 20-2DA



4AM51 20-3DA
4AM51 20-4DA



4AM51 70-7AA
4AM52 72-2AA
4AM52 72-3AA

Fig. 13/7 Connection of windings

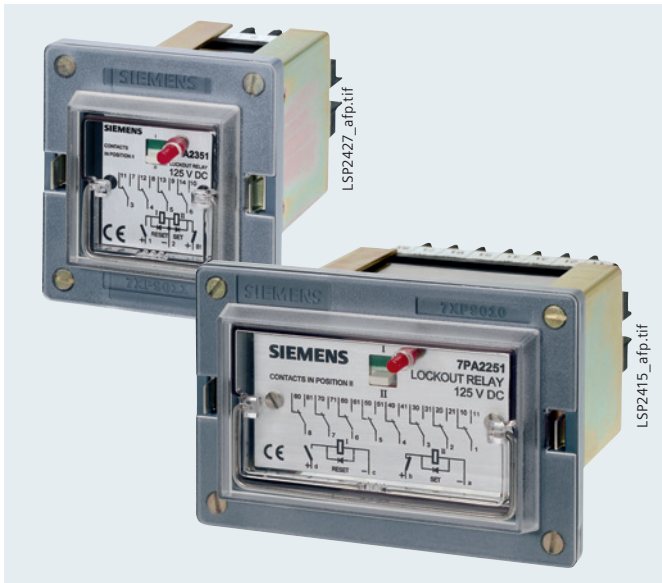


Fig. 13/8 7PA2 auxiliary relays

Description

Due to their quality, reliability and design, these relays are optimal for applications requiring high reliability and availability such as power stations, substations, railway and industrial plants. Typical examples include petrochemical industry, chemical industry, cement industry, rolling mills etc.

The relays comply with the IEC, EN, IEEE standards (type and routine test) and bear the CE mark.

The robust switch contacts are characterized by high make/break capacity, overload capability and continuous current intensity capacity; thus perfect insulation is obtained. Direct control of high-voltage and medium-voltage switchgear is possible.

Their high degree of protection and the transparent cover ensure reliable operation in tropical and/or salty sea air ambient conditions.

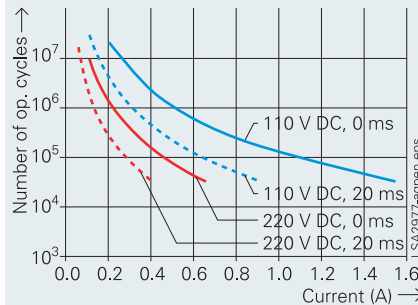
Technical data for 7PA22 and 7PA23

Switching contacts	
Continuous current	10 A
Overload capability	80 A / 200 ms 150 A / 10 ms
Switching current/voltage	40 A / 0.5 s / DC 110 V

Breaking capacity for 10⁵ operating cycles

[DC V]	Non-inductive		Inductive, 20 ms	
	1 contact [A]	2 contacts in series [A]	1 contact [A]	2 contacts in series [A]
24	6.6	12.7	3.2	6.0
60	2.6	4.9	1.4	2.7
125	1.2	2.2	0.6	1.1
220	0.6	1.1	0.3	0.6

V _{max} , open contact	DC 250 V / AC 400 V
Mechanical service life	10 ⁷ operating cycles
Operating temperature	- 10 °C to + 55 °C 14 °F to 131 °F
Max. permissible humidity	93 % at 40 °C / 104 °F
Seismic stress class according to IEEE 501	
Degree of ZPA	3 g acceleration at 33 Hz



Standards

Electrical tests performed according to IEC 60255	
Dielectric test	2 kV/50 Hz/ 1 min
Surge withstand test	5 kV/1.2/50 μs
Insulation	> 2000 MΩ / 500 V _{peak-to-peak}
Flammability tests according to IEC 60692-2-1	
Plastic materials	UL 94: VO, IEC 60695: 850 °C / 30 s 1562 °F / 30 s
Degree of protection acc. to IEC 60529	Relay: IP 40 With socket cover: IP 50
Climatic stress test according to	
IEC 60255-7 dry heat	Non-dissipating unit +70 °C / 96 h 158 °F / 96 h Dissipating unit +55 °C / 96 h 131 °F / 96 h
IEC 60068-2-30 cyclic humid heat	+55 °C / 12 h 131 °F / 12 h
IEC 60068-2-1 cold	100 cycles Non-dissipating unit -10 °C / 2 h 14 °F / 2 h
IEC 60255-7 thermal aging test	At rated voltage V _N +55 °C / 1440 h 131 °F / 1440 h

Accessories / 7PA

7PA22 fast-acting lockout relay

Description

The bistable 7PA22 is a fast-acting lockout relay with eight changeover contacts and is plugged into a mounting frame equipped with a plug-in socket (type 7XP9010) with screw-type terminals at the rear.

Functions

No continuous power consumption. Position indication on the front side. Mechanical reset pushbutton. Position memory with two positions (e.g. for yes / no, open / close, auto / manual, local / remote etc.).

Technical data

While the auxiliary voltage is being supplied to the SET coil, the reset pushbutton must not remain pushed longer than 20 s.

Rated voltages and consumption		
V_N [DC V]	Voltage range [DC V]	Consumption while switching
24	19 – 26	≤ 48 W
30	24 – 33	
60	48 – 66	
110	88 – 121	
125	100 – 137	
220	176 – 242	
Pick-up time	< 10 ms	

General description see page 13/11.
Refer to part 14 for dimension drawings.

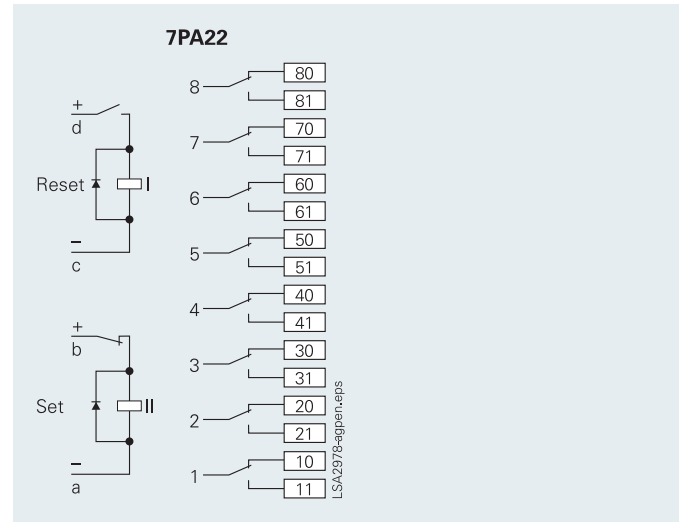


Fig. 13/9 Connection diagram

Selection and ordering data

Description	Order No.
7PA22 fast-acting lockout relay	7PA22 <input type="checkbox"/> 1 - <input type="checkbox"/>
Auxiliary voltage	
DC 24 V	1
DC 60 V	2
DC 110 V	3
DC 220 V	4
DC 125 V	5
DC 30 V	6
Socket	
without socket	0
with flush-mounting socket 7XP9010-1	1

Description	Order No.
Accessories	
Socket as spare part	
Flush mounting	7XP9010-1
Surface mounting	7XP9012-0

Description

The bistable 7PA23 is a fast-acting lockout relay with four changeover contacts and is plugged into a mounting frame equipped with a plug-in socket (type 7XP9011) with screw-type terminals at the rear.

Functions

No continuous power consumption. Position indication on the front side. Mechanical reset pushbutton. Position memory with two positions (e.g. for yes/no, open/close, auto/manual, local/remote etc.).

Technical data

While the auxiliary voltage is being supplied to the SET coil, the reset pushbutton must not remain pushed longer than 20 s.

Rated voltages and consumption		
V_N [DC V]	Voltage range [DC V]	Consumption while switching
24	19 – 26	≤ 24 W
30	24 – 33	
60	48 – 66	
110	88 – 121	
125	100 – 137	
220	176 – 242	
Pick-up time	< 8 ms	

General description see page 13/11.
Refer to part 14 for dimension drawings.

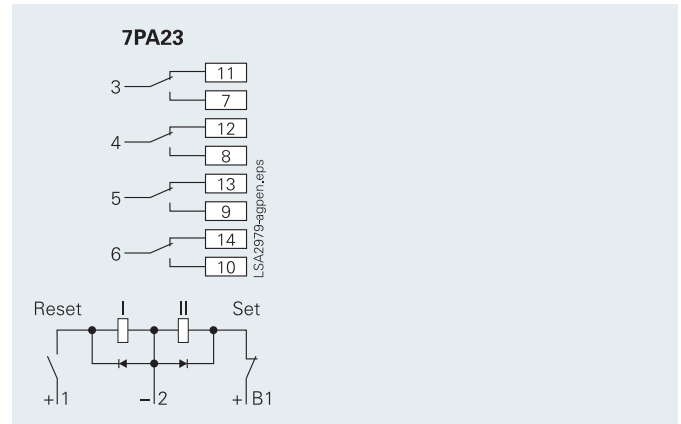


Fig. 13/10 Connection diagram
Contacts represented in position RESET

Selection and ordering data

Description	Order No.
7PA23 fast-acting lockout relay	7PA23 <input type="checkbox"/> 1 - <input type="checkbox"/>
Auxiliary voltage	
DC 24 V	1
DC 60 V	2
DC 110 V	3
DC 220 V	4
DC 125 V	5
DC 30 V	6
Socket	
without socket	0
with flush-mounting socket 7XP9011-1	1

Description	Order No.
Accessories	
Socket as spare part	
Flush mounting	7XP9011-1
Surface mounting	7XP9013-0

7PA26/27/30 auxiliary relays for various applications/trip circuit supervision



Fig. 13/11 7PA2 auxiliary relays

Description

Due to their quality, reliability and design, these relays are optimal for applications requiring high reliability and availability such as power stations, substations, railway and industrial plants. Typical examples include petrochemical industry, chemical industry, cement industry, rolling mills etc.

The relays comply with the IEC, EN, IEEE standards (type and routine test) and bear the CE mark.

The robust switch contacts are characterized by high make/break capacity, overload capability and continuous current intensity capacity; thus perfect insulation is obtained. Direct control of high-voltage and medium-voltage switchgear is possible.

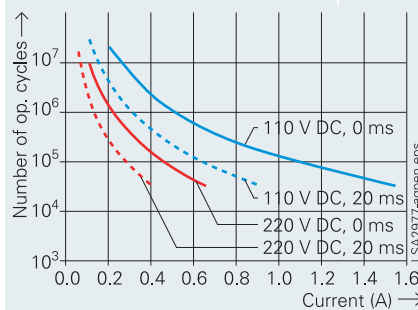
Technical data for 7PA26 and 7PA27

Switching contacts	
Continuous current	10 A
Overload capability	80 A / 200 ms 150 A / 10 ms
Switching current/voltage	40 A / 0.5 s / DC 110 V

Breaking capacity for 10^5 operating cycles

[DC V]	Non-inductive		Inductive, 20 ms	
	1 contact [A]	2 contacts in series [A]	1 contact [A]	2 contacts in series [A]
24	6.6	12.7	3.2	6.0
60	2.6	4.9	1.4	2.7
125	1.2	2.2	0.6	1.1
220	0.6	1.1	0.3	0.6

V_{max} , open contact	DC 250 V / AC 400 V
Mechanical service life	10^7 operating cycles
Operating temperature	-10 °C to +55 °C 14 °F to 131 °F
Max. permissible humidity	93 % at 40 °C / 104 °F



Technical data for 7PA30

Contacts	
Permanent current	8 A
Instantaneous current	15 A
Making capacity	15 A/4 s / DC 110 V
Breaking capacity	0.3 A / DC 110 V
U_{max} opened contact	DC 250 V / AC 400 V
Mechanical life	107 operations
Operating temperature	-10 °C +55 °C
Storage temperature	-30 °C +70 °C
Operating humidity	93 % / 40 °C

Standards

Electrical tests performed	according to IEC 60255
Dielectric test	2 kV/50 Hz/1 min
Surge withstand test	5 kV/1.2/50 μ s
Insulation	> 100 M Ω /DC 500 V
Flammability tests	UL 94: VO
Plastic materials	
Degree of protection acc. to IEC 60529	Relay: IP 40
Climatic stress test according to IEC 60068-2	
Dry cold, operation	- 10 °C
Dry heat, operation	+ 55 °C
Storage and transport	- 25 °C + 70 °C
<i>Immunity test EMC</i>	
EN 60255-22-1	High frequency 1 MHz burst disturbance test: Test level: 1 MHz, 400 imp/s, 2 s Common mode: 2.5 kV Differential mode: 1 kV
EN 61000-4-4	Electrical Fast transient burst: Test level 4 kV, 2.5 kHz, 1 min · 2 kV, 5 kHz, 1 min
EN 61000-4-5	Surge 8/20 μ s (current) 1.2/50 μ s (voltage) Common mode: 2 kV Differential mode: 1 kV
EN 61000-4-3	Radiated electromagnetic field: Test level: 80-1000 MHz, 10 V/m, 80 % AM (1 kHz)
EN 61000-4-3	Digital telephones radiated electromagnetic field: Test level: 900 \pm 5MHz, 10 V/m, 50% (200 Hz) 1.89 GHz \pm 10 MHz, 10 V/m, 50 % (200 Hz)
EN 61000-4-6	Conducted disturbances induced by radio frequency fields. Test level: 0.15-80 MHz, 10 V, 80 % AM(1kHz)
EN 61000-4-2	Electrostatic discharges: Test level: Contact \pm 15 kV; Air mode \pm 15 kV
EN 61000-4-8	Power frequency magnetic field: Test level: 100 A/m 1 min · 1000 A/m 1 s
EN 55011 Class A	Emission test: Test level: Cover: 30-230 MHz, 40 dB (μ V/m) (quasi peak) -10 m 230-1000 MHz, 47 dB (μ V/m) (quasi peak) -10 m Power supply: 0.15-0.5 MHz, 79 dB(μ V) (quasi peak) /66 dB average value 0.5-5 MHz, 73 dB(μ V) (quasi peak) /60 dB average value 5-30 MHz, 73 dB(μ V) (quasi peak) /60 dB average value

Description

The monostable 7PA26 has eight changeover contacts.

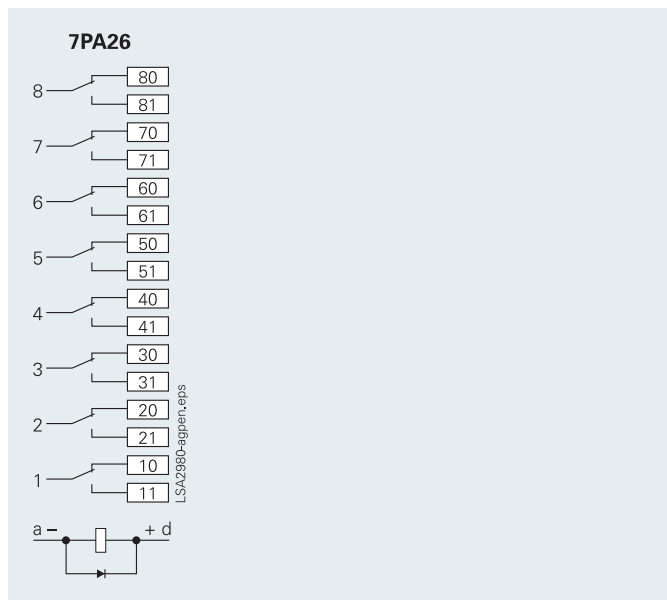


Fig. 13/12 Connection diagram

Technical data

Rated voltages and consumption			
V_N [DC V]	Voltage range [DC V]	Consumption [mA]	
7PA26□20			
24/30	20 – 33	278	
60	48 – 66	100	
110/125	88 – 138	55	
220	176 – 242	28	
7PA26□21			
		Consumption Normal	Peak
24/30	19 – 36	50	0.8 A / 20 ms
60	42 – 72	20	
110/125	77 – 150	14	0.3 A / 20 ms
220	154 – 264	7	
Pick-up time	7PA26□20 < 20 ms 7PA26□21 < 10 ms		
Drop-out time:	< 40 ms		

General description see page 13/15.
Refer to part 14 for dimension drawings.

Selection and ordering data

Description	Order No.
7PA26 monostable relay with 8 changeover contacts	7PA26□2-□AA00-□
Auxiliary voltage	
DC 24/30 V	1
DC 60 V	2
DC 110/125 V	3
DC 220 V	4
Standard, 20 ms	0
Fast, 10 ms	1
Socket	
without socket	0
with flush-mounting socket 7XP9010-3	1
with surface-mounting socket 7XP9012-0	2
Accessories	
Socket as spare part	
Flush mounting	7XP9010-3
Surface mounting	7XP9012-0

Accessories/7PA

7PA27 monostable fast-acting relay

Description

The monostable 7PA27 is a fast-acting relay with four change-over contacts.



Fig. 13/13 Connection diagram

Technical data

Rated voltages and consumption

V_N [DC V]	Voltage range [DC V]	Consumption	
		Normal [mA]	Peak
20/30	19 – 36	28	1 A / 20 ms
60	42 – 72	12	1 A / 20 ms
110/125	77 – 150	8	0.3 A / 20 ms
220	154 – 264	7	0.3 A / 20 ms
Pick-up time	< 8 ms		
Drop-out time:	< 40 ms		

General description see page 13/15.
Refer to part 14 for dimension drawings.

Selection and ordering data

Description	Order No.
7PA27 monostable fast-acting relay	7PA27 □ 2 - 0AA00 - □
Auxiliary voltage	
DC 24/30 V	1
DC 60 V	2
DC 110/125 V	3
DC 220 V	4
Socket	
without socket	0
with flush-mounting socket 7XP9011-2	1
with surface-mounting socket 7XP9013-0	2
Accessories	
Socket as spare part	
Flush mounting	7XP9011-2
Surface mounting	7XP9013-0

Description

The relay is for supervision of the trip circuit of a circuit breaker with three selective trip coils. The trip circuit wiring is supervised from the positive supply to the negative supply whilst the circuit breaker is open or closed.

Functions

The design, quality and rugged construction of the relay make it suitable for applications requiring high levels of reliability/dependability. The high degree of protection guarantees reliable operation over a wide temperature range, even under extreme environmental conditions.

The relay has been tested in accordance with IEC, EN and IEEE standards. The relay is CE marked. The supervision current is always less than 1.4 mA thus avoiding unwanted operation of the trip coil. Correct operation is shown via a green LED.

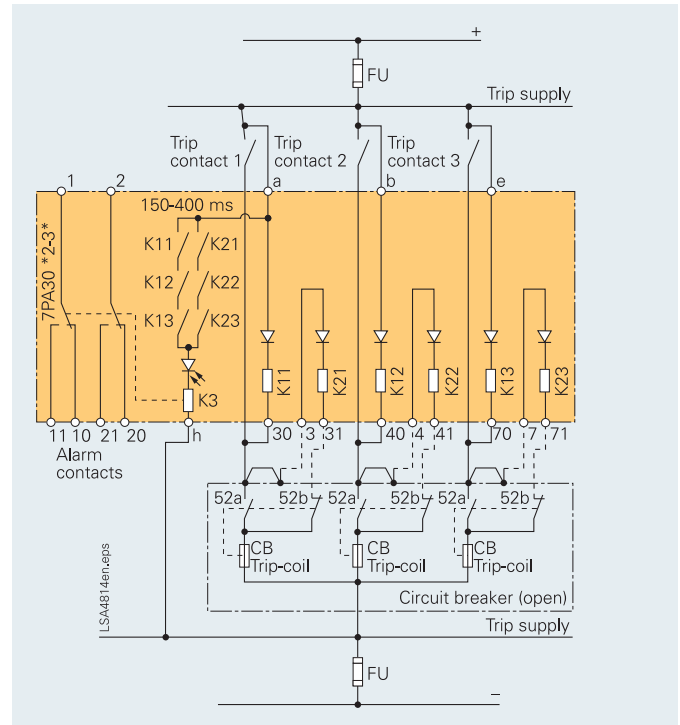


Fig. 13/14 Connection diagram for 3-phase relay

Technical data

Standard voltages and consumption

V_N DC V	Voltage range DC V	Consumption mA	Impedance per phase k Ω /s	Pickup – Drop out voltage DC V
24/30	18 – 33	35	20	between 12 and 18
60	42 – 66	20	44	36 and 42
110/125	77 – 138	20	94	66 and 77
220	154 – 275	15	200	132 and 154

Drop-out time: between 150 ms and 400 ms

Selection and ordering data

Description	Order No.
7PA30 trip circuit supervision (three-phase)	7PA30 <input type="checkbox"/> 2 - 3AA00 - <input type="checkbox"/>
Auxiliary voltage	
DC 24/30 V	1
DC 60 V	2
DC 110/125 V	3
DC 220 V	4
Socket	
without socket	0
with flush-mounting socket 7XP9010-4	1
with surface-mounting socket 7XP9012-0	2
Accessories	
Socket as spare part	
Flush mounting	7XP9010-4
Surface mounting	7XP9012-0

Accessories / 7PA

7PA30 single-phase trip circuit supervision

Description

The relay is for supervision of the trip circuit of a circuit breaker with one trip coil. The trip circuit wiring is supervised from the positive supply to the negative supply whilst the circuit breaker is open or closed.

Functions

The design, quality and rugged construction of the relay make it suitable for applications requiring high levels of reliability/dependability. The high degree of protection guarantees reliable operation over a wide temperature range, even under extreme environmental conditions.

The relay has been tested in accordance with IEC, EN and IEEE standards. The relay is CE marked. The supervision current is always less than 1.4 mA thus avoiding unwanted operation of the trip coil. Correct operation is shown via a green LED.

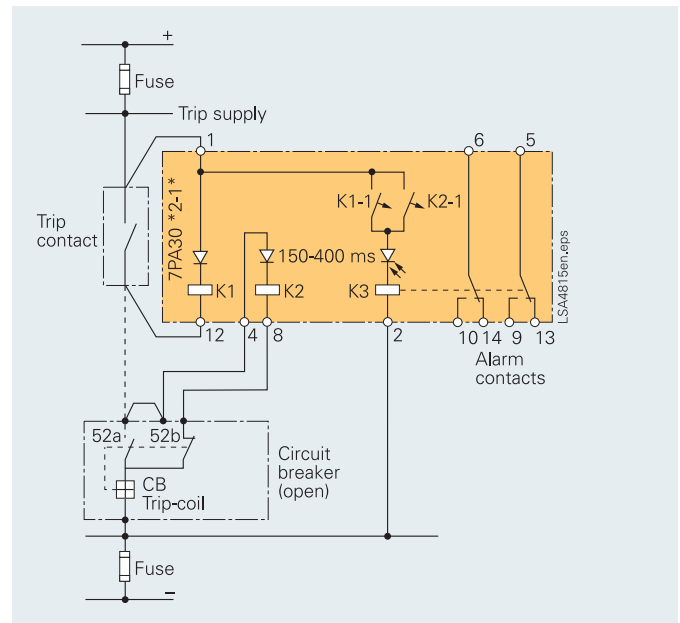


Fig. 13/15 Connection diagram for 1-phase relay

Technical data

Rated voltages and consumption

V_N DC V	Voltage range DC V	Consumption mA	Impedance per phase kΩ/s	Pickup – Drop out voltage DC V
14/30	18 – 33	32	20	between 12 and 18
60	42 – 66	18	44	36 and 42
110/125	77 – 138	18	94	66 and 77
220	154 – 275	13	200	132 and 154

Drop-out time: between 150 ms and 400 ms

Selection and ordering data

Description	Order No.
7PA30 trip circuit supervision (single-phase)	7PA30 <input type="checkbox"/> 2 - 1AA00 - <input type="checkbox"/>
Auxiliary voltage	
DC 24/30 V	1
DC 60 V	2
DC 110/125 V	3
DC 220 V	4
Socket	
without socket	0
with flush-mounting socket 7XP9011-0	1
with surface-mounting socket 7XP9013-0	2
Accessories	
Socket as spare part	
Flush mounting	7XP9011-0
Surface mounting	7XP9013-0



Fig. 13/16 7TS16 annunciation relay

Function overview

- Indications: Four LEDs, latching type, signaling until reset.
- Inputs: Four alarm/trip inputs
 - Input for remote reset
 - Push button for local reset
- Outputs: For each alarm/trip input:
 - One diode 2.5 A
 - One potential free changeover contact
 - One potential free NO contact
 - One common tripping output through diode (2.5 A; V_{max} DC 220 V)
- Contacts:
 - Permanent current 8 A
 - Instantaneous current 15 A
 - Making capacity 15 A / 4 s / DC 110 V
 - Breaking capacity 0.3 A / DC 110 V

Description

The 7TS16 relay features auxiliary trip indication for local and remote signaling. It has four independent output contacts and LED indication. The relay complies with the IEC and EN standards and bears the CE mark.

The 7TS16 is a reliable and versatile high-speed relay with four signal inputs. It has four local LEDs and auto-resetting output contacts, used in SCADA controls. Additionally, it features two diode tripping circuits.

Reset is possible via remote input and via local reset push button.

The reset should not be permanently switched on.

Accessories/7TS16

7TS16 annunciation relay

Technical data

Rated voltages (V_N)	24/30, 110/125, DC 220 V
Voltage range	+10 % – 30 % V_N
Operating temperature	-10 to +55 °C
Operating humidity	93 %/40 °C
Pickup time	< 5 ms
Consumption	
For one trip	
V_N	
DC 24/30 V	1 A/3 ms
DC 110/125 V	3 A/3 ms
DC 220 V	4 A/3 ms
For a permanent trip	
V_N	
DC 24/30 V	21 mA
DC 110/125 V	8 mA
DC 220 V	6.5 mA
For a latched LED	
V_N	
DC 24/30 V	1 mA
DC 110/125 V	3 mA
DC 220 V	5 mA

Standards

Electrical tests performed acc. to IEC 60255-5	
- Dielectric test	2 kV/50 Hz/1 min
- Surge withstand test	5 kV/1.2/50 μ s
High-frequency test acc. to IEC 60255-22-1	
- Common mode	2.5 kV/1 MHz
- Differential mode	1 kV/1 MHz
Inflammability tests	UL94: VO
Plastic materials	
Degree of protection	Relay: IP40
acc. to IEC 60529	
Climatic stress test acc. to IEC 60068-2	
Dry cold, operation	- 10 °C
Dry heat, operation	+ 55 °C
Storage and transport	- 30 °C + 70 °C

Connection diagram

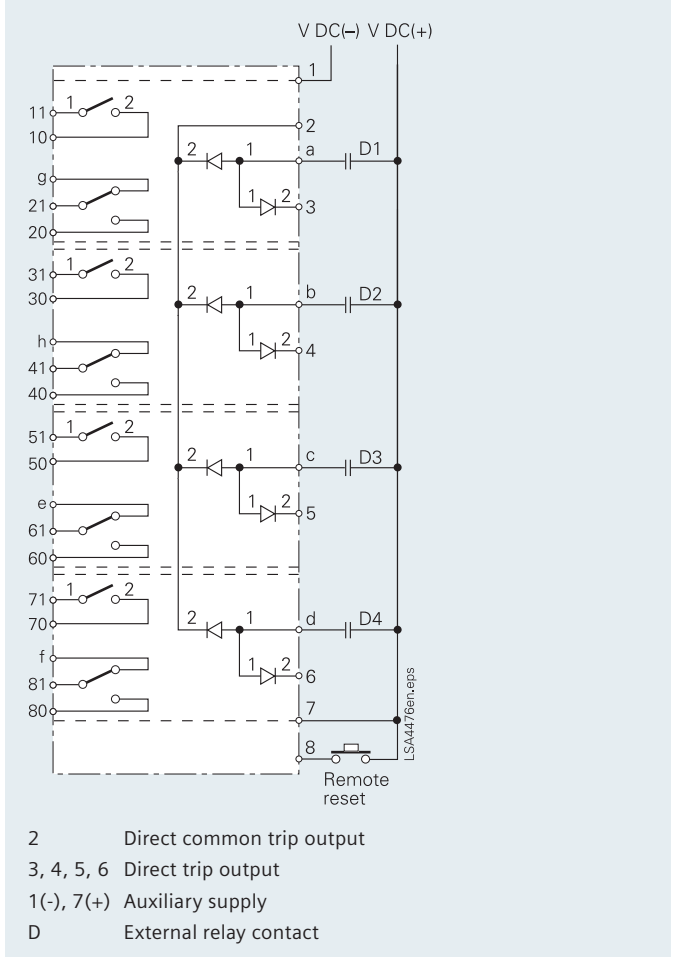


Fig. 13/17 Connection diagram
Contacts represented without auxiliary supply in the relay

Selection and ordering data

Description	Order No.
7TS16 annunciation relay with 4 LEDs	7TS16 <input type="checkbox"/> 2-0AA00- <input type="checkbox"/>
Auxiliary voltage	
DC 24/30 V	1
DC 110/125 V	3
DC 220 V	4
Socket	
without socket	0
With flush-mounting socket 7XP9010-2	1
With surface-mounting socket 7XP9012-0	2
Accessories	
Socket as spare part	
Flush mounting	7XP9010-2
Surface mounting	7XP9012-0



Fig. 13/18 7XV5673 SICAM I/O-Unit – binary I/O mirror, -binary I/O expansion, -contact multiplier

Description

SICAM I/O-Unit 7XV5673 is a binary input/output device and is designed for substations and increased industrial environment requirements. The SICAM I/O-Unit allows the transmission of binary inputs to binary outputs locally or via long distances. It can be used for protection applications, e.g. overcurrent protection, signal comparison, teleprotection or as I/O-expansion in substation automation systems.

Function

Via binary inputs, all kinds of binary signals of switchgear/ protection scheme (for example tripping commands, switch position signal, fault and status indications) are securely detected. This information can directly be distributed at this SICAM I/O-Unit via contacts, or be transmitted via communication links to further SICAM I/O-Units or to automation systems.

Secured telegrams are used for the communication via Ethernet or serial connections. The parameter setting of the SICAM I/O-Unit is simply carried out with a standard Web browser at the PC which is connected by the Ethernet interface.

The SICAM I/O-Unit can be set as:

- I/O mirror: Point-to-point transfer of binary signals between two SICAM I/O-Units via Ethernet or a serial connection. Signal inputs and outputs assignable by the user.
- I/O expansion:
 - Expansion of substation controllers by binary inputs and outputs using standard protocols.
 - Detection and output of binary states by substation controllers via standard protocols Modbus RTU, Modbus TCP or IEC 61850.
 - Extension for protection devices of the compact class 7SJ80 and 7SK80 via connection on their low-cost Ethernet interface (LEM).
- Contact multiplier: Distribution of signals on one or several binary inputs via relay contacts of the same SICAM I/O-Unit, e.g. for isolation between different voltage levels.

Function overview

- Binary inputs
 - 6 ruggedized EMC – hardened binary inputs
 - Pickup voltage threshold settable to DC 19 V, DC 88 V or DC 176 V for different station battery voltages
- Binary outputs
 - 6 command relay outputs
 - Safe state of contacts after loss of connection settable by the user
- Signal/Alarm outputs
 - 4 LED
- Wide-range power supply
 - 24 – DC 250 V \pm 20 % and AC 100 – 230 V 45 – 65 Hz
- Electrical RJ45 Ethernet interface
 - Cascading many devices without additional costs by the use of the integrated switch
- Serial fiber-optic interface (optional)
 - ST-connector, 820 nm for multi-mode fiber 62.5/125 μ m, typical range 2000 m using fiber 62.5 μ m/125 μ m, baud rate 1.2 kBit/s – 187.5 kBit/s settable per software
- Serial RS485-interface (optional)
 - Sub-D plug, 9-pole female
- Protocols, communication
 - MODBUS TCP or MODBUS RTU for connection to a substation controller
 - MODBUS UDP for point-to-point connections between two SICAM I/O-Units
 - SNTP for time synchronization
 - IEC 61850 (GOOSE, MMS, Reporting)
- Housing
 - IP20 rail mounting
- Standards
 - CE, UL, IEC 60255, IEEE 61000 ...
- Environmental conditions
 - EMC hardened binary I/O for substation environment
 - Extended high temperature range up to 85 °C (16 h/day).

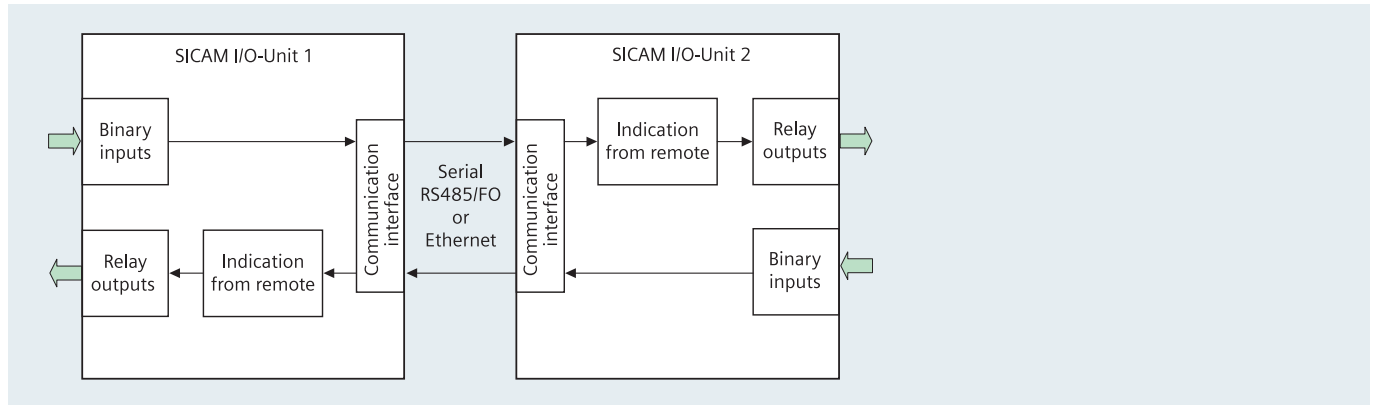


Fig. 13/19 I/O mirror, bi-directional transmission between two devices

Operation features

- Easy parameterization with a standard Internet browser (no special software required)
- Password protection against unauthorized access
- Monitoring of data errors, loss of connection, transfer time and the state of BI, BO.
- Time synchronization with SNTP-Protocol with 1 ms resolution from an external time server over Ethernet. Redundant time servers are supported
- Buffer battery changeable from the front
- Fast I/O mirror: Fast transmission time from BI pickup to contact closing between two SICAM I/O-Units typically 11 ms for high bandwidth connection
- Connection to a substation controller over MODBUS TCP, MODBUS RTU or IEC 61850 (GOOSE, MMS, Reporting) protocol
- Blocking of data transmission with a binary input for testing
- Battery buffered operational event log with 1 ms resolution time stamp
- Assignment of BI/BO signals which shall be logged into the operational buffer
- Integration into network management systems with SNMP – protocol and provided MIB – files.

Application

I/O mirror function

When using the SICAM I/O-Units as I/O mirror according to Fig. 13/19, the devices transmit the binary signals bi-directional. The transmission takes place between the two devices over serial links (option) or over Ethernet networks.

Via the relay output contacts voltages up to AC/DC 250 V and currents up to AC/DC 5 A can be switched. The pick threshold of the binary inputs can be set by the user on different levels.

Signal inputs and outputs can be assigned by the user.

Extension of the transmission distance

An extension of the transmission distance is possible. The following devices can be used:

- With serial optical repeater 7XV5461 scalable up to 170 km
- RS485-FO Converter 7XV5650 for cascading devices
- With different communication converters.

Uni-directional binary signal transmission

When using the SICAM I/O-Units for uni-directional binary signal transmission according to Fig. 13/20, the devices transfer binary signals unidirectional from one device to several devices. In this application, the transmission only takes place in one direction. Input signals (max. 6) from the left unit are sending to output contacts of one or more units on the right side.

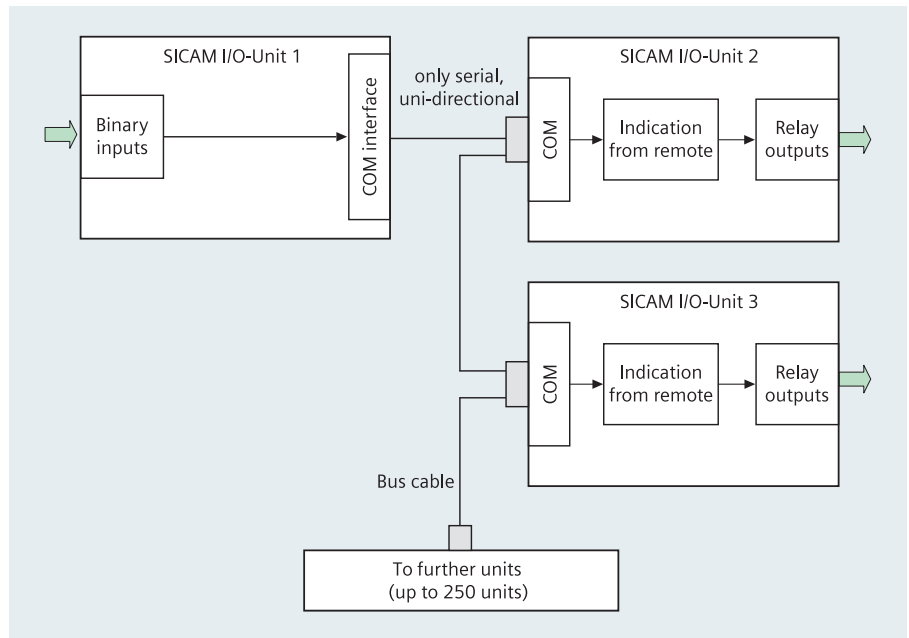


Fig. 13/20 I/O mirror, uni-directional transmission from one to multiple SICAM I/O-Units

I/O expansion of a substation

The SICAM I/O-Unit is used as I/O expansion, according to Fig. 13/21. Binary signals are exchanged between a substation controller (e.g. SICAM PAS) and the SICAM I/O-Units by using the MODBUS TCP protocol over an Ethernet network. If the integrated switch in the SICAM I/O-Unit is used, the units can be operated in a line without using additional external switches as shown in Fig. 13/24. Also IEC 61850 client server communication will be provided in future.

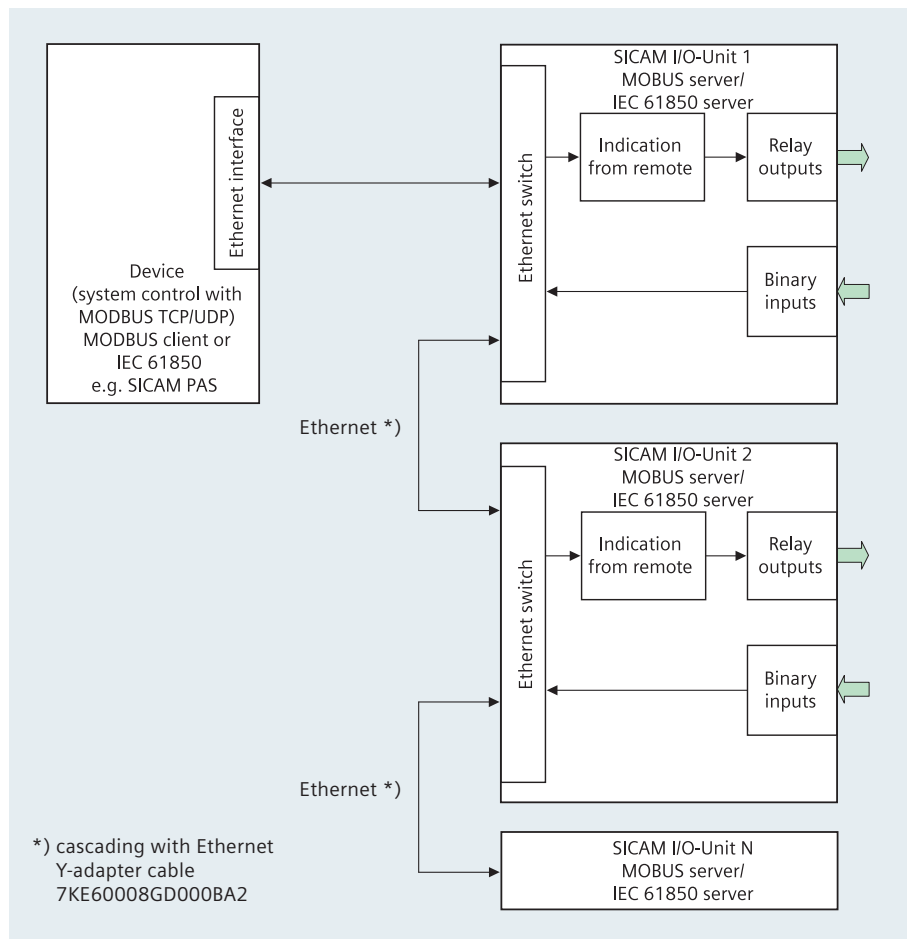


Fig. 13/21 I/O expansion of a substation with binary inputs and outputs

Application

Uni-directional binary signal transmission

Instead of using an Ethernet network there is also the option of serial connection with MODBUS RTU protocol. The link can be done by a RS485-bus line structure or an optical star network.

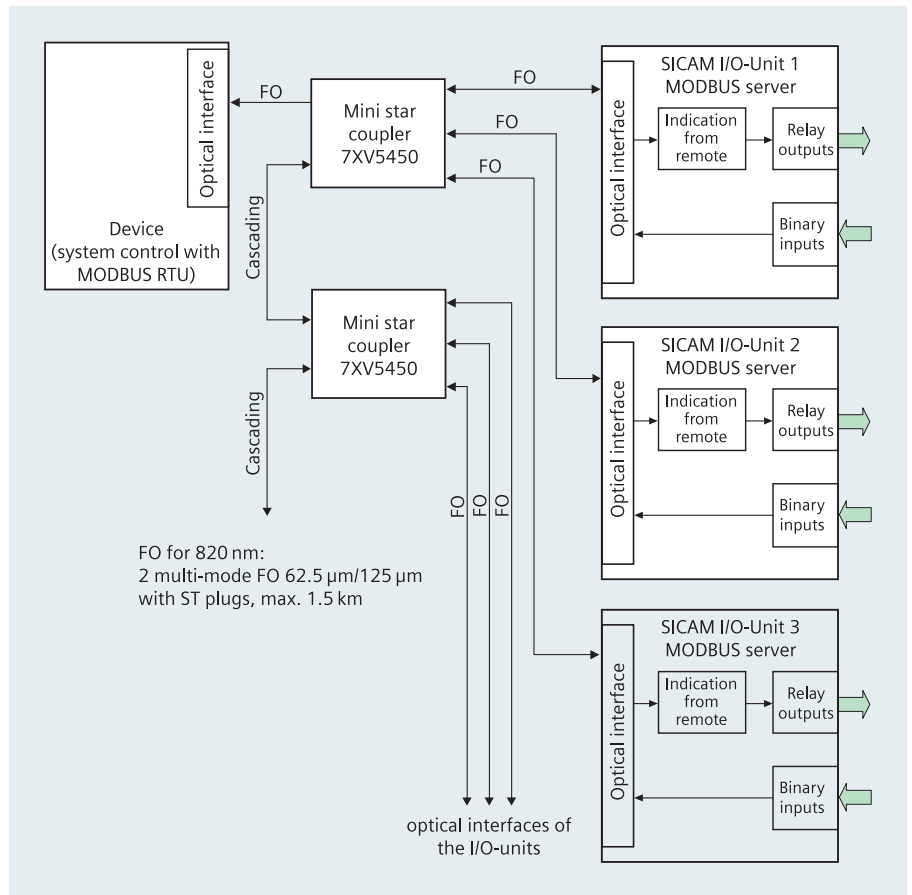


Fig. 13/22 I/O expansion for the connection to substation controller using a serial optical star topology

Contact multiplier

Input signals on one or more binary inputs can be assigned to binary outputs of the local device (Fig. 13/23)

- 1 binary signal on up to 6 relay outputs
- Several binary signals to several relay outputs assignable by the user
- Different voltage levels for inputs and outputs in a wide voltage range to isolate between different voltage levels.

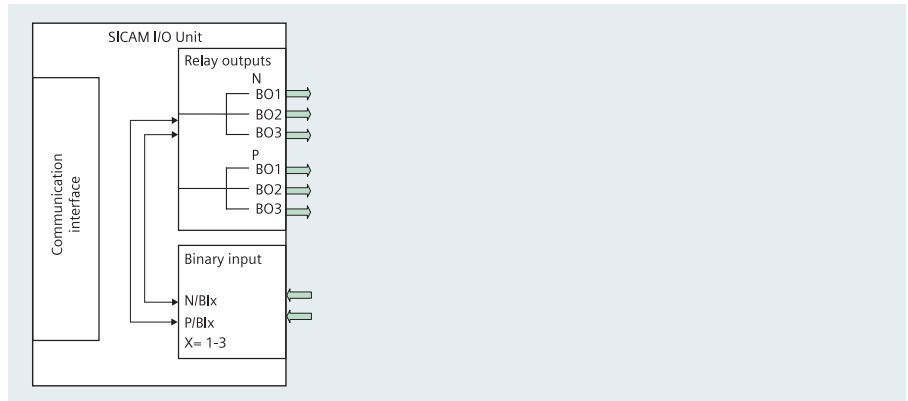


Fig. 13/23 Contact multiplier

Applications for remote transmission of binary signals

Binary signal transmission via communication networks using a G.703.1/X.21 interface

The picture shows the optical connection of an SICAM I/O-Unit to a communication converter (KU-XG) 7XV5662-0AA01, which establishes a connection to a multiplexer with G.703.1 or X.21 interface. This allows the use of this communication converter to transfer the signals via communication network. The average delay time in the network and the signal quality is monitored by the SICAM I/O-Unit. Also loss of connection is indicated. In this case, the state of the binary outputs can be set by the user to a safe condition depending on the application.

A maximum of 6 binary single signals can be transmitted bi-directional via the communication network.

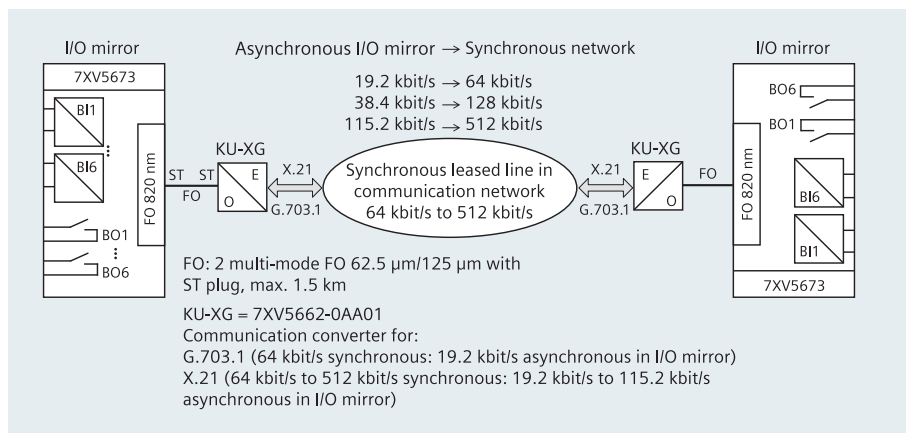


Fig. 13/24 Binary signal exchange over a communication converter with G.703.1/X.21 interface via a communication network

Application

Binary signal transmission via two-wire copper cable with blocking

The picture shows the optical connection of an SICAM I/O-Unit to a communication converter 7XV5662-0AC01, which establishes a connection via pilot wire. Only one pair is necessary for bi-directional signal exchange.

An additional isolation transformer allows 20 kV isolation from the pilot wire connection.

A maximum of 6 binary single signals can be transmitted bi-directionally over the pilot wire. The additional delay caused by the transfer over the communication converter and pilot wire is less than 1 ms.

A typical application is the signal comparison of a directional overcurrent protection device via pilot wires. In this case, the definite overcurrent protection device is connected to the SICAM I/O-Unit via contacts and binary inputs and directional signals are transferred.

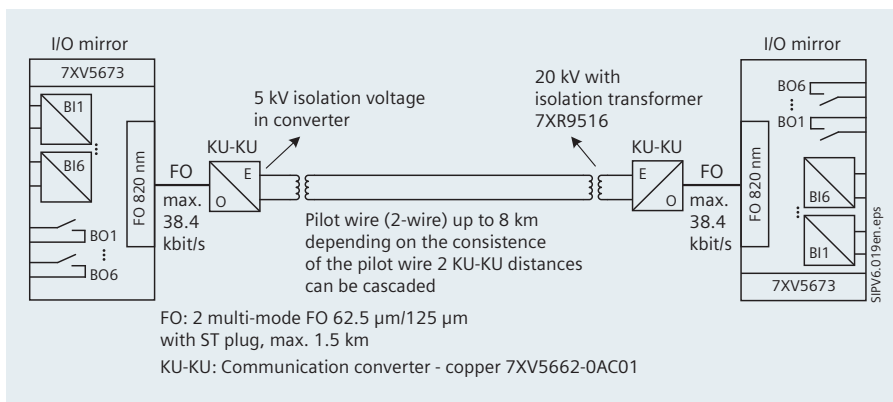


Fig. 13/25 Binary signal exchange of 6 signals via pilot wire connection

Binary signal exchange of over long fiber optic links

The figure shows the optical connection of an SICAM I/O-Unit to a serial optical repeater 7XV5461-0BX00, which establishes a connection to multi-mode or single-mode fiber cables. A max. distance of 170 km can be reached with this application without additional amplifiers.

A maximum of 12 binary signals can be exchanged via long fiber optical connections because the repeater allows connecting two SICAM I/O-Units.

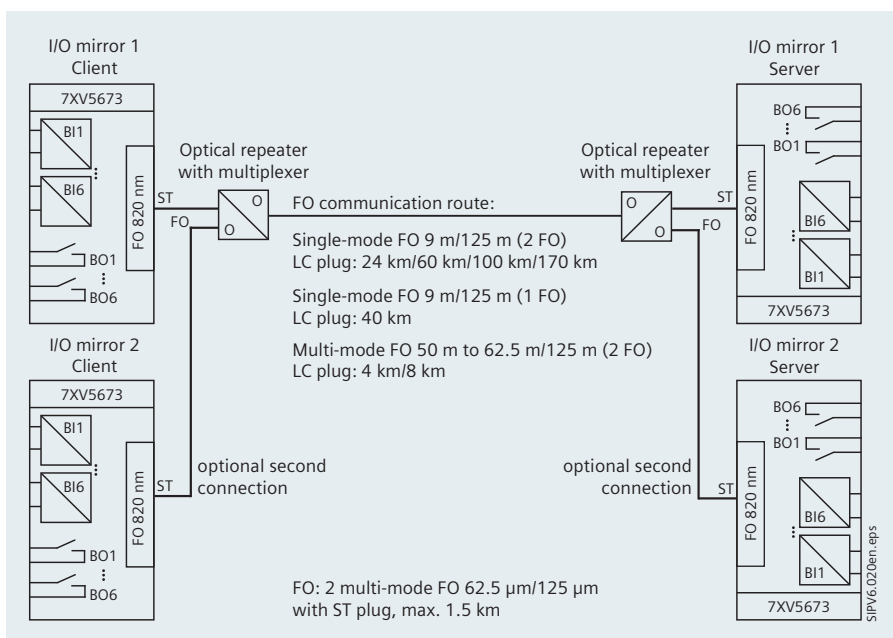


Fig. 13/26 Binary signal exchange of up to 12 signals over long fiber optic links

Binary signal transmission via a communication networks using a G.703.6 interface

The figure shows the optical connection of one up to three SICAM I/O-Units to a communication converter KU-2M 7XV5662-0AD00, which establishes a connection to a multiplexer with a G.703.6 interface (1.44 kbit/s/2 Mbit/s, E1/T1).

A maximum of 18 binary single signals can be transmitted bi-directionally over the communication network. The KU-2M is provided with two optical and one electrical RS232 interface. Two SICAM I/O-Units can be directly connected by an optical cable to the KU-2M. On the RS232 interface, an additional SICAM I/O-Unit can be connected via an optoelectronic converter. Using all input interfaces (2 FO, 1 RS232) of the KU-2M, a maximum of 18 signals can be exchanged bi-directionally.

For long distance connections via Ethernet media converters or Ethernet networks can be used. The SICAM I/O-Unit supports IP – address settings and settings for a standard gateway. The electrical Ethernet interface of the SICAM I/O-Unit is connected to a media converter or switch which transfer the signals of the units over long distance Ethernet connections. The average delay time in the network is measured by the SICAM I/O-Unit.

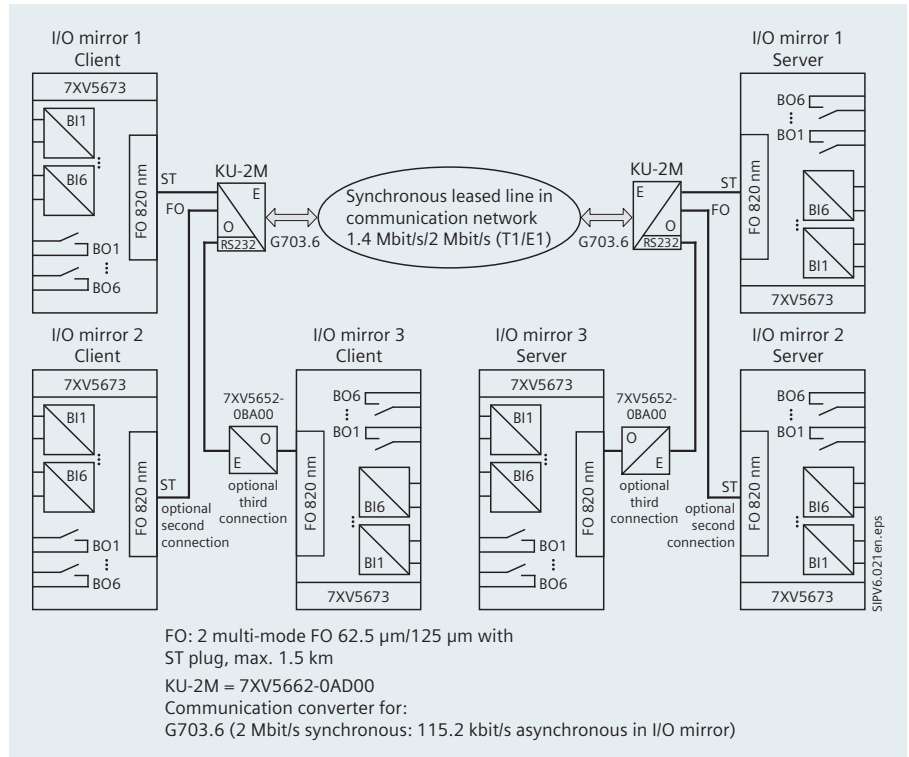


Fig. 13/27 Binary signal exchange with G.703.6 interface via a communication network

Device configuration

The SICAM I/O-Unit is equipped with an integrated Web Server which allows easy setting using standard Internet-Browsers. Fig. 13/28 shows the User interface. All settings are done with the Browser. Also operational log and commissioning aid are supported by the Browser like the indication of the actual state of the inputs and outputs.

For configuring the IEC 61850-GOOSE Subscriber-Configuration, the SICAM I/O Mapping Tool is used. When the substation configuration is ready, the SICAM I/O Mapping reads the SCD data of the substation configuration and creates a binary IEC 61850 parameter set, which can be uploaded over HTML.

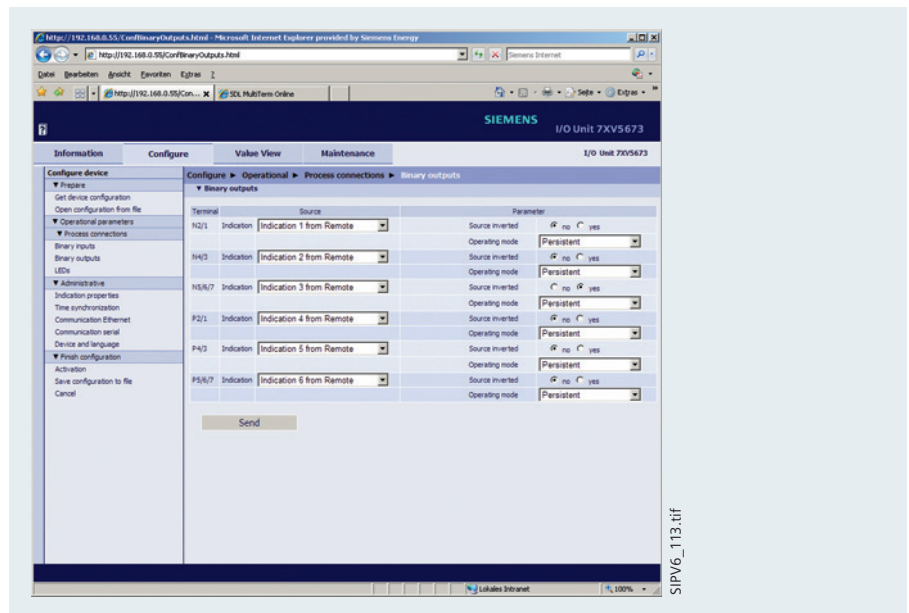


Fig. 13/28 Configuration screen of the SICAM I/O-Unit in the Browser

Application example/Selection and ordering data

Binary signal transmission via a optical-fiber or wireless connection

The application (figure 13/29) shows the electric connection of a SICAM I/O-Unit 7XV5673 to Ethernet-based transmission devices via patch cable, which establish a connection via optical fibers on the remote side or a wireless connection. The connection could also be realized via switches with long-distance modules or via IP networks.

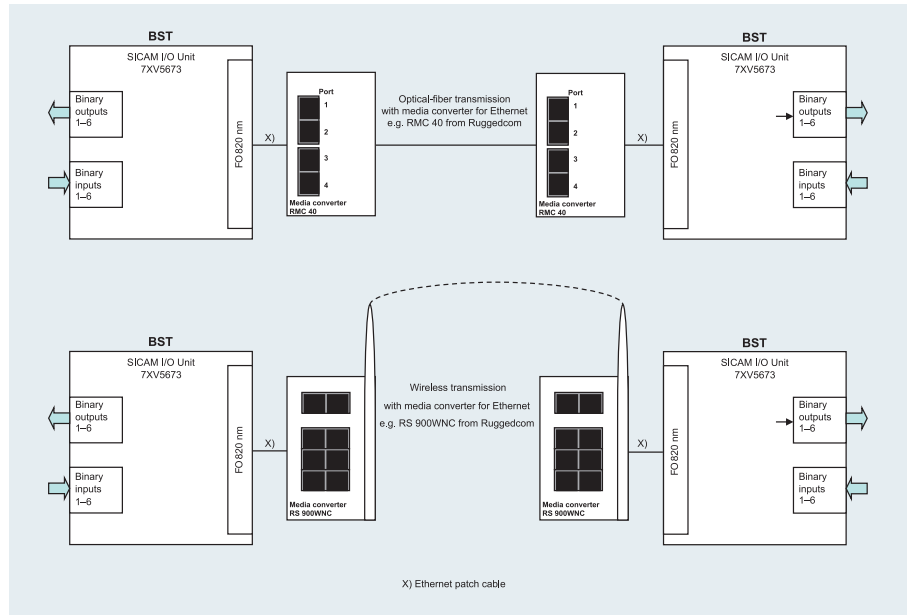


Fig. 13/29 Binary signal transmission via optical fibers or wireless connection; connection via the integrated Ethernet interface to external transmission devices

Technical data/Selection and ordering data

Housing

Dimensions	96 × 96 × 100 mm (W × H × D)
Protection class	IP20
Assembly	DIN rail

In- and output

Binary input	6 with setting threshold voltage
Relais output	6 (2 make contact, 1 change-over contact)

Serial interface

without serial communication
 RS485 – MODBUS RTU, binary signal transmission
 optical, 820 nm – MODBUS RTU, binary signal transmission

Communication interface and communication protocol

Ethernet interface with MODBUS TCP/UDP or binary signal transmission
 Ethernet interface with MODBUS TCP/UDP, binary signal transmission or IEC 61850 (GOOSE, MMS, Reporting)

Specials

Integrated Ethernet switch

Description	Order No.
SICAM I/O-Unit, integrated electrical Ethernet interface, RJ45 connector	7XV5673-0JJ□0-□AA1
Serial interface and communication protocol	
Without serial communication	0
RS485 – MODBUS RTU, binary signal transmission	1
Optisch, 820 nm – MODBUS RTU, binary signal transmission	2
Communication interface and communication protocol	
Ethernet interface with MODBUS TCP/UDP or binary signal transmission	0
Ethernet interface with MODBUS TCP/UDP, binary signal transmission or IEC 61850 (GOOSE, MMS, Reporting)	1
	2
Accessories	
Y cable	77KE6000-8GD00-0BA2

Description

The SICAM AI Unit 7XV5674 is used for the acquisition of analog signals from automation processes and for the transmission of measured values to a connected supervisory system or control center over communication protocol. The modules of the device detect, calculate, analyze and transmit measured values.

SICAM AI Unit offers twelve 20-mA inputs referring to the standard IEC 60688. The 20-mA inputs are divided into 2 groups, on 2 boards each with 6 channels.

Device type:

- DIN rail mounted device
- Plastic case 96 mm x 96 mm x 100 mm (W x H x D)
- Protection class IP20



Fig. 13/30 SICAM AI Unit

Application

The SICAM AI Unit 7XV5674 can support diverse applications. For acquiring DC field signals, SICAM AI Unit 7XV5674 can be applied in the following application fields:

- Protection
- SCADA
- DMS
- EMS systems
- GIS (Gas-Insulated Switchgear) – gas pressure monitoring
- Other industrial processes

For example, 4-mA to 20-mA signals coming from transducers (for example, for monitoring of: power, temperatures, pressure and position) are delivered over standard protocol for further processing, as visualization or connection to other automation processes. The DC inputs from SICAM AI Unit 7XV5674 can be parametrized to support the following ranges:

- DC 0 mA to 20 mA
- DC 4 mA to 20 mA

The measuring accuracy amounts to 0.2% of the rated value (20 mA) under reference conditions. The measuring accuracy amounts to 1.0% of the rated current (20 mA) under environmental impact.

Highlights

- Wide application field (SCADA, protection and automation processes)
- Connection to serial or Ethernet interfaces of SIPROTEC 4 or 5 devices
- Connection to all protection and field devices using IEC 61850-GOOSE messages and IEC 61850 reporting
- Compact and robust design (-25°C to 70°C operation temperature)
- Flexible communication variations (Ethernet, optical fiber or electrical RS485)
- Modbus RTU/TCP, SIPROTEC 20 mA Serial or Ethernet interface to SIPROTEC 5 devices via SUP protocol
- Accurate process measurement (0.2% reference conditions)
- Time synchronization over NTP
- Internal switch allows cost savings
- The integrated web server allows you to configure the parameters via HTML pages using a web browser

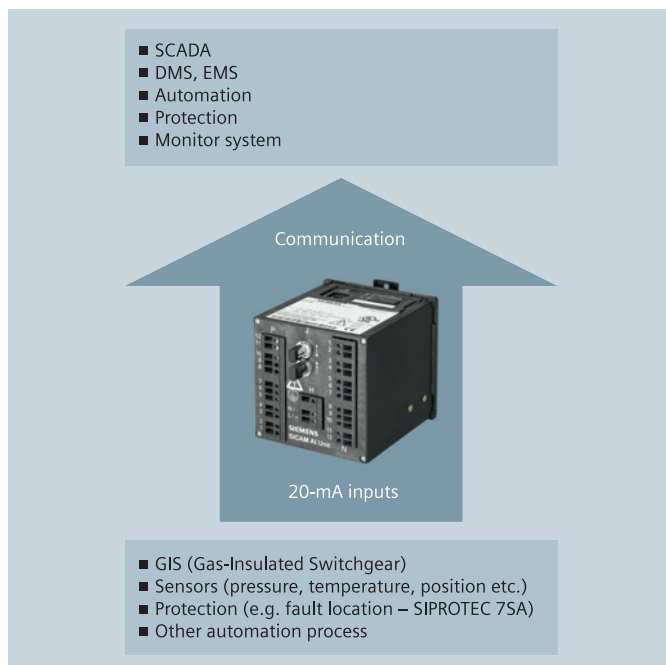


Fig. 13/31 Application example

Description

Measurands

Only direct currents are measured with SICAM AI Unit. The measurement cycles on the board 1 and board 2 are carried out simultaneously. A complete measurement cycle amounts to 642 ms for 6 channels. The measurement of one channel amounts to 107 ms and is repeated after 642 ms.

Limit settings

With the automation functions menu, you can set up to 16 upper or lower limit violations. Limit violations of the upper or lower value range can be output as indications. Up to 4 limit value violations can be signaled at the device via the two binary outputs. 4 group indications can be parameterized and up to 16 logically linked single-point indications can be assigned to each of them.

Communication

To communicate with the substation controller and other peripheral devices, the SICAM AI Unit device has an Ethernet interface and optionally a serial interface (RS485 or optical).

SICAM AI Unit is available in various variants:

- Communication via Ethernet
 - With integrated Ethernet switch: Modbus TCP protocol
 - With integrated Ethernet switch: Modbus TCP protocol and IEC 61850 protocol

Via Ethernet, the following functions are supported:

- Connection to SIPROTEC 5 devices via SUP (Slave Unit/Protocol)
- Device parameterization
- Transmission of measured data
- Transmission of indications
- Time synchronization via NTP
- Communication protocols Modbus TCP and IEC 61850 (reporting and GOOSE)
- Integrated Ethernet switch

With the Ethernet switch that is integrated in the device, further network components can be cascaded via a Y cable, and can therefore also be incorporated in an existing network with IEC 61850 or another Ethernet protocol.

Serial interface

The serial interface as electrical RS485 or optical can be chosen:

- Without serial interface
- With RS485 interface
- With optical interface

The serial interface supports the following functions:

- Transmission of measured data
- Transmission of indications
- Time synchronization via Modbus RTU

If the serial interface is selected, you can use either the Modbus RTU or the SIPROTEC RTU 20 mA communication protocol.

Time synchronization

During operation, SICAM AI Unit needs the date and time for all time-relevant processes. This ensures that a common time basis exists when communicating with peripheral devices and enables time stamping of the process data.

The following types of time synchronization can be executed:

- External time synchronization via Ethernet NTP (preferred)
- External time synchronization via field bus using the Modbus RTU communication protocol
- Internal time synchronization via RTC – Real Time Clock – (if external time synchronization is not available)

Indications signaled by LEDs

SICAM AI Unit automatically monitors the functions of its hardware, software and firmware components. The LEDs on the top side of the housing indicate the current device status.

Parameterization

No special software is needed for parameterization. You can set the parameters from your computer via HTML pages and a web browser. Internet Explorer 6 (or higher) is necessary for this purpose.

Accessories

The following components are optionally available:

- Device manual E50417-G1140-C492 (download available at www.siprotec.com)
- Y cable, order no. 7KE6000-8GD00-0BA2
- Ethernet patch cables (CAT6) RS485 cables for SIPROTEC devices 6XV1 830-0E
- RS485 bus connectors for SIPROTEC devices, 6ES7972-0BA42-0XA0, 6ES7972-0BB42-0XA0
- RS485 cable for SIPROTEC device 6XV1 830-0E
- Order information for assembled fiber-optic cable (FO cable) can be found in the SIPROTEC download area at www.siemens.com/siprotec under accessories, 6XV81xx.
- Further details on the accessories of the device can be found at: www.siprotec.com.

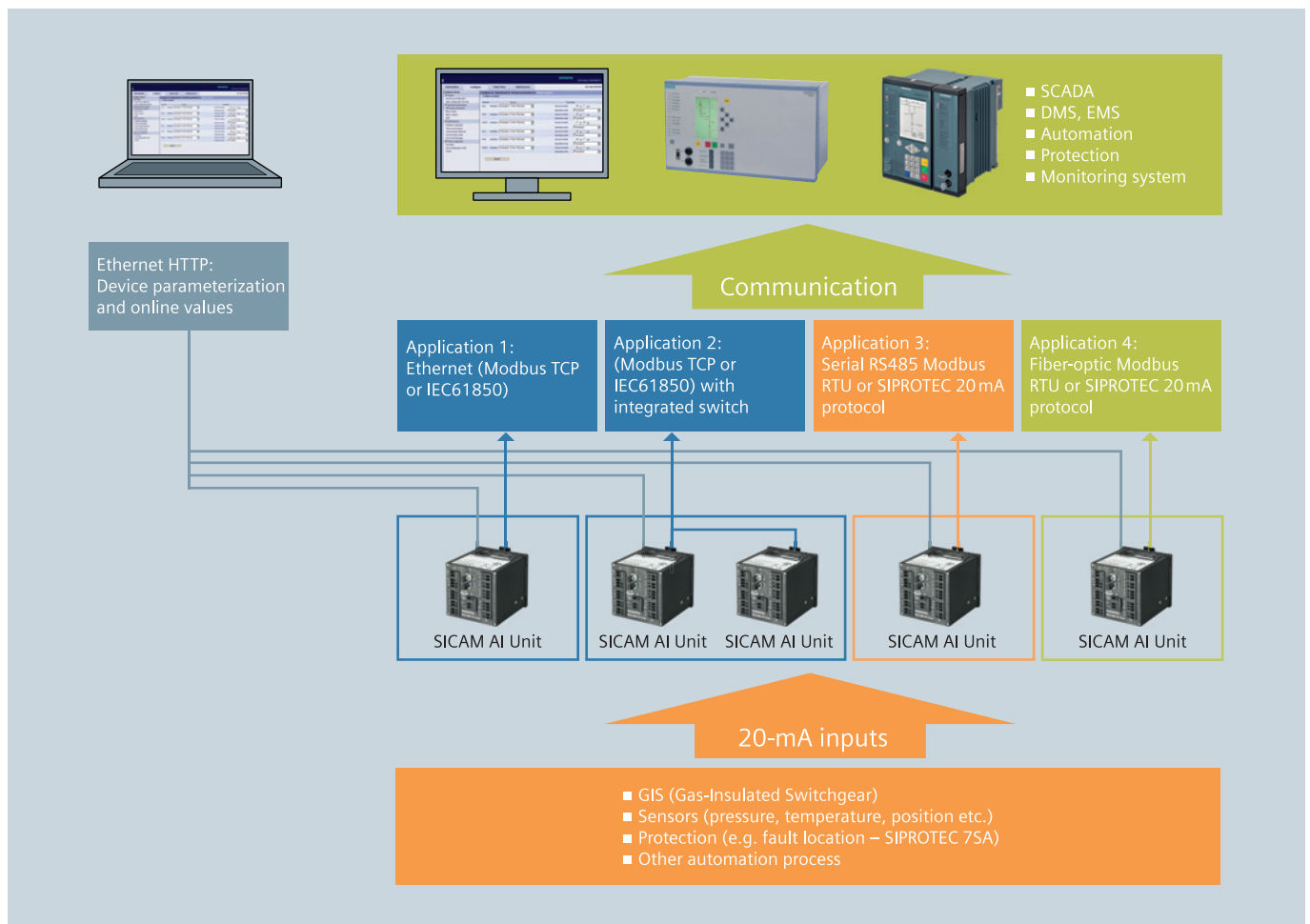


Fig. 13/32 Application example

Accessories / 7XV5674

Selection and ordering data

Description	Order No.
SICAM AI Unit	7XV 5 6 7 4 - 0 K K <input type="checkbox"/> 0 - <input type="checkbox"/> A A 1
Device	
Twelve 20-mA inputs for SIPROTEC devices	
DIN rail mounting unit, IP20	
Case 96 mm x 96 mm x 100 mm	
Power supply: DC 24-240V, AC 100-230V	
Ethernet interface, connection RJ45	
Integrated Ethernet switch	
Web server for parameterization	
UL certification	
Serial interface and communication protocol	
Without serial communication	0
RS485, 9-pol. Sub-D plug – Serial Modbus RTU and SIPROTEC 20 mA protocol FO 820 nm	3
ST connector – Serial Modbus RTU and SIPROTEC 20 mA protocol	4
Ethernet interface and communication protocol	
Ethernet interface with Modbus TCP/UDP	
Ethernet interface with Modbus TCP/UDP and IEC 61850 reporting and GOOSE	
Communication interface and communication protocol	
Ethernet interface with Modbus TCP/UDP or binary signal transmission	1
Ethernet interface with Modbus TCP/UDP, binary signal transmission or IEC 61850 (GOOSE, MMS, reporting)	2

Accessories for Communication 6XV8100 F.O. Cable

Description	Order No.	
Fiber-optical indoor cable	6XV8100-0DA□1-0A□□	
F. O. link cable W/ 2 fibres, Fiber type PMMA S980/1000, PE-Insulation diam. = 2.2mm black, Good resistance to oil, petrol, acid and leach, Cable for simply systems of loads, For links inside a cubicle, Cable type L46916-U2-U19, V-2 x 1S980/1000PE		
Variants		
Both side with FSMA-connectors		
Length 0,5 m	2	A 5
Length 1,0 m	2	B 0
Length 1,5 m	2	B 5
Length 2,0 m	2	C 0
Length 2,5 m	2	C 5
Length 3,0 m	2	D 0
Length 3,5 m	2	D 5
Length 4,0 m	2	E 0
Both side with ST-connectors		
Length 0,5 m	4	A 5
Length 1,0 m	4	B 0
Length 1,5 m	4	B 5
Length 2,0 m	4	C 0
Length 2,5 m	4	C 5
Length 3,0 m	4	D 0
Length 3,5 m	4	D 5
Length 4,0 m	4	E 0
One side FSMA other ST-connectors		
Length 0,5 m	5	A 5
Length 1,0 m	5	B 0
Length 1,5 m	5	B 5
Length 2,0 m	5	C 0
Length 2,5 m	5	C 5
Length 3,0 m	5	D 0
Length 3,5 m	5	D 5
Length 4,0 m	5	E 0

Description	Order No.	
Fiber-optical duplex outdoor cables¹⁾	6XV8100-0BD□□-□□□□	
Fibre-optic duplex data line outdoor, 2 Break-out elements, Fiber type glass 62.5/125um, Halogen-free and flame-retardend, Nonmetallic rodent protection, External dimension Ø=9.2 mm black, Internal dimension Ø=2.5mm orange, For indoor an outdoor use (base material AT-VHBH 2G62,5/125)		
Variants		
Connector		
without	0	1
One side with FSMA connector prefabricated	1	1
Both sides with FSMA connector prefabricated	2	1
With ST and LC-connector prefabricated	3	1
Both sides with ST connector prefabricated	4	1
With FSMA and ST connector prefabricated	5	1
Both sides with LC-connector prefabricated	6	1
Both sides with FC/PC connector prefabric	7	1
One side FC/PC other with LC con prefabric.	8	1
One side ST other with SC connector prefabric.	1	2

Accessories / 6XV8100

Selection and ordering data

Description	Order No.
Fiber-optical duplex outdoor cables ¹⁾	6XV8100-0BD □ □ - □ □ □ □
100 meter lengths	
Length 0 m +	0
Length 100 m +	1
Length 200 m +	2
Length 300 m +	3
Length 400 m +	4
Length 500 m +	5
Length 600 m +	6
Length 700 m +	7
Length 800 m +	8
Length 900 m +	9 ²⁾
10 meter lengths	
Length 0 m +	A
Length 10 m +	B
Length 20 m +	C
Length 30 m +	D
Length 40 m +	E
Length 50 m +	F
Length 60 m +	G
Length 70 m +	H
Length 80 m +	J
Length 90 m +	K
1 meter lengths	
Length 0 m +	A
Length 1 m +	B
Length 2 m +	C
Length 3 m +	D
Length 4 m +	E
Length 5 m +	F
Length 6 m +	G
Length 7 m +	H
Length 8 m +	J
Length 9 m +	K
1000 meter lengths	
Length 0 m +	0
Length 1000 m +	1
Length 2000 m +	2

Length selection:

To 490 m is the staggering 10 m

From 500 m is the staggering 50 m

Interlengths on inquiries with the supplier

1) Attention: For order volume up to 204,- EUR a handling fee of 38,50 EUR will be charged.

2) Attention: For this configuration please append the short-code "N1A" to the order-number.

Description	Order No.
Fiber-optical duplex indoor cables¹⁾	6XV8100-0BE□□-□□□0
Fiber-optic duplex data line indoor, 2 Break-out elements, Fiber type glass 62.5/125um, Halogenfree and flame-retardend, External dimension Ø=2.8x4.5mm orange, Internal dimension Ø=1.7mm orange, number print. For indoor use (base material I-VHH 2x1xG62.5/125)	
Variants	
Connector	
without	0 1
One side with FSMA connector prefabricated	1 1
One side FSMA other SC connector prefabr.	1 2
One side FSMA other LC-connector prefabr.	1 3
Both sides with LC-connector prefabricated	1 4
One side FSMA other FC/PC connector prefabr.	1 5
One side ST other SC connector prefabr.	1 6
One side ST other LC-connector prefabr.	1 7
One side ST other E2000 connector prefabr.	1 8
Both sides with FSMA connector prefabr.	2 1
One side with ST connector prefabricated	3 1
Both sides with ST connector prefabricated	4 1
One side FSMA other ST connector prefabr.	5 1
One side FSMA/K other ST connector prefabr.	6 1
Both sides with FSMA/K connector prefabr.	7 1
Both sides with FC/PC connector prefabr.	8 1
Both sides with SC connector prefabr. / crossbred	2 2
Both sides with E2000 connector prefabr.	2 3
One side FC/PC other LC-connector prefabr.	2 4
One side SC other LC-connector prefabr.	2 5
One side ST other FC/PC connector prefabr.	2 6
Both sides with ST con. and fibre angle prefabr.	2 7
100 meter lengths	
Length 0 m +	0
Length 100 m +	1
Length 200 m +	2
Length 300 m +	3
Length 400 m +	4
Length 500 m +	5
Length 600 m +	6
Length 700 m +	7
Length 800 m +	8
Length 900 m +	9 ²⁾
10 meter lengths	
Length 0 m +	A
Length 10 m +	B
Length 20 m +	C
Length 30 m +	D
Length 40 m +	E
Length 50 m +	F
Length 60 m +	G
Length 70 m +	H
Length 80 m +	J
Length 90 m +	K

Accessories / 6XV8100

Selection and ordering data

Description	Order No.
Fiber-optical duplex indoor cables ¹⁾	6XV8100-0BE□□-□□□0
1 meter lengths	
Length 0 m +	A
Length 1 m +	B
Length 2 m +	C
Length 3 m +	D
Length 4 m +	E
Length 5 m +	F
Length 6 m +	G
Length 7 m +	H
Length 8 m +	J
Length 9 m +	K

Length selection:

To 49 m is the staggering 1 m

From 50 m is the staggering 10 m

Interlengths on inquiries with the supplier

1) Attention: For order volume up to 204,- EUR a handling fee of 38,50 EUR will be charged.

2) Attention: For this configuration please append the short-code "N1A" to the order-number.

Description	Order No.
Fiber-optical duplex outdoor cables with MTRJ-connectors ¹⁾	6XV8100-0BF <input type="text" value="1"/> - <input type="text" value=""/> <input type="text" value="A"/> <input type="text" value=""/>
Fiber-optic duplex data line outdoor, 2 Break-out elements, Fiber type glass 62.5/125um, Halogen-free and flame-retardend, Nonmetallic rodent protection, External dimension Ø=8.3 mm black, Internal dimension Ø=1.8mm orange, For indoor and outdoor use (base material AT-VHBH 2G62.5/125)	
Variants	
Connector	
One side with MTRJ connector, other side with FSMA/K connector prepared	1
One side with MTRJ connector, other side with ST connector prepared	2
Both sides with MTRJ connector prepared	3
100 meter lengths	
Length 0 m +	0
Length 100 m +	1
Length 200 m +	2
Length 300 m +	3
Length 400 m +	4
Length 500 m +	5
Length 600 m +	6
Length 700 m +	7
Length 800 m +	8
Length 900 m +	9 ²⁾
10 meter lengths	
Length 0 m +	A
Length 10 m +	B
Length 20 m +	C
Length 30 m +	D
Length 40 m +	E
Length 50 m +	F
Length 60 m +	G
Length 70 m +	H
Length 80 m +	J
Length 90 m +	K
1000 meter lengths	
Length 0 m +	0
Length 1000 m +	1
Length 2000 m +	2

Length selection:

To 490 m is the staggering 10 m

From 500 m is the staggering 50 m

Interlengths on inquiries with the supplier

1) Attention: For order volume up to 204,- EUR a handling fee of 38,50 EUR will be charged.

2) Attention: For this configuration please append the short-code "N1A" to the order-number.

Accessories/6XV8100

Selection and ordering data

Description	Order No.
Fiber-optical duplex indoor cables with MTRJ-connectors ¹⁾	6XV8100-0BG <input type="checkbox"/> 1 - <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 0
Fiber-optic duplex data line indoor, 2 Break-out elements, Fiber type glass 62.5/125um, Halogenfree and flame-retardend, External dimension Ø=2.8x4.5mm orange, Internal dimension Ø=1.7mm orange, Number print, for indoor use (base material I-VHH 2x1xG62.5/125)	
Variants	
Connector	
One side with MTRJ connector, other side with FSMA/K connector prepared	1
One side with MTRJ connector, other side with ST connector prepared	2
Both sides with MTRJ connector prepared physical crossbred	3
One side with MTRJ connector, other side with SC connector prepared	4
One side with MTRJ connector, other side with LC-connector prepared	5
Both sides with MTRJ connector prepared physical uncrossed	6
100 meter lengths	
Length 0 m +	0
Length 100 m +	1
Length 200 m +	2
Length 300 m +	3
Length 400 m +	4
Length 500 m +	5
Length 600 m +	6
Length 700 m +	7
Length 800 m +	8
Length 900 m +	9 ²⁾
10 meter lengths	
Length 0 m +	A
Length 10 m +	B
Length 20 m +	C
Length 30 m +	D
Length 40 m +	E
Length 50 m +	F
Length 60 m +	G
Length 70 m +	H
Length 80 m +	J
Length 90 m +	K
1 meter lengths	
Length 0 m +	A
Length 1 m +	B
Length 2 m +	C
Length 3 m +	D
Length 4 m +	E
Length 5 m +	F
Length 6 m +	G
Length 7 m +	H
Length 8 m +	J
Length 9 m +	K

Length selection:

To 49 m is the staggering 1 m

From 50 m is the staggering 10 m

Interlengths on inquiries with the supplier

1) Attention: For order volume up to 204,- EUR a handling fee of 38,50 EUR will be charged.

2) Attention: For this configuration please append the short-code "N1A" to the order-number.

Description	Order No.
Fiber-optical duplex indoor cables¹⁾	6XV8100-0CF□□-□□□0
Fiber-optic duplex data line indoor, 2 Break-out elements, Fiber type glass E9/125um, Halogenfree and flame-retardend, External dimension Ø=3.9x6.8mm yellow, Internal dimension Ø=2.8mm red+green, number print. For indoor use/Diff. protec. (base material I-VHH 2x1xE9/125)	
Variants	
Connector	
without	0 1
One side with ST connector prefabricated other side with SC connector prefabricated	1 1
One side ST other side LC-connector prefabr.	1 2
One side FC/PC other side SC connector prefabr.	2 1
One side with ST connector prefabricated	3 1
Both sides with ST connector prefabricated	4 1
Both sides with LC-connector prefabricated	5 1
One side with FC/PC connector prefabricated	6 1
Both sides with FC/PC connector prefabricated	7 1
One side with FC/PC connector prefabricated other side with ST connector prefabricated	8 1
One side with E2000 connector prefabricated	1 3
One side E2000 other side ST connector prefabr.	1 4
One side E2000/APC 8° other side ST connector prefabricated	1 5
One side FC/PC other side LC-connector prefabr.	1 6
One side SC other side LC-connector prefabr.	1 7
Both sides with SC connector prefabricated	1 8
One side DIN other side LC-connector prefabr.	2 2
One side SC/APC 9° other side LC-connector prefabr.	2 3
One side SC/APC 9° other ST connector prefabr.	2 4
One side E2000/APC 8° other ST connector prefabr.	2 5
100 meter lengths	
Length 0 m +	0
Length 100 m +	1
Length 200 m +	2
Length 300 m +	3
Length 400 m +	4
Length 500 m +	5
Length 600 m +	6
Length 700 m +	7
Length 800 m +	8
Length 900 m +	9 ²⁾
10 meter lengths	
Length 0 m +	A
Length 10 m +	B
Length 20 m +	C
Length 30 m +	D
Length 40 m +	E
Length 50 m +	F
Length 60 m +	G
Length 70 m +	H
Length 80 m +	J
Length 90 m +	K

Accessories/6XV8100/7KE600

Selection and ordering data

Description	Order No.
Fiber-optical duplex indoor cables¹⁾	6XV8100-0CF□□-□□□0
1 meter lengths	
Length 0 m +	A
Length 1 m +	B
Length 2 m +	C
Length 3 m +	D
Length 4 m +	E
Length 5 m +	F
Length 6 m +	G
Length 7 m +	H
Length 8 m +	J
Length 9 m +	K

Length selection:

To 49 m is the staggering 1 m

From 50 m is the staggering 10 m

Interlengths on inquiries with the supplier

1) Attention: For order volume up to 204,- EUR a handling fee of 38,50 EUR will be charged.

2) Attention: For this configuration please append the short-code "N1A" to the order-number.

7KE600 Ethernet Patch Cable

Description	Order No.
Ethernet patch cable with double shield (SFTP) LAN connector on both sides	7KE6000-8GD0□-□AA□
SIMEAS R ↔ HUB HUB ↔ PC	
Length 0.5 m	0 0 5
Length 1.0 m	0 1 0
Length 2.0 m	0 2 0
Length 3.0 m	0 3 0
Length 5.0 m	0 5 0
Length 10.0 m	1 0 0
Length 15.0 m	1 5 0
Length 20.0 m	2 0 0
Ethernet patch cable, cross-over connection with double shield (SFTP) LAN connector on both sides	7KE6000-8GE0□-□AA□
HUB ↔ HUB SIMEAS R ↔ PC	
Length 0.5 m	0 0 5
Length 1.0 m	0 1 0
Length 2.0 m	0 2 0
Length 3.0 m	0 3 0
Length 5.0 m	0 5 0
Length 10.0 m	1 0 0
Length 15.0 m	1 5 0
Length 20.0 m	2 0 0

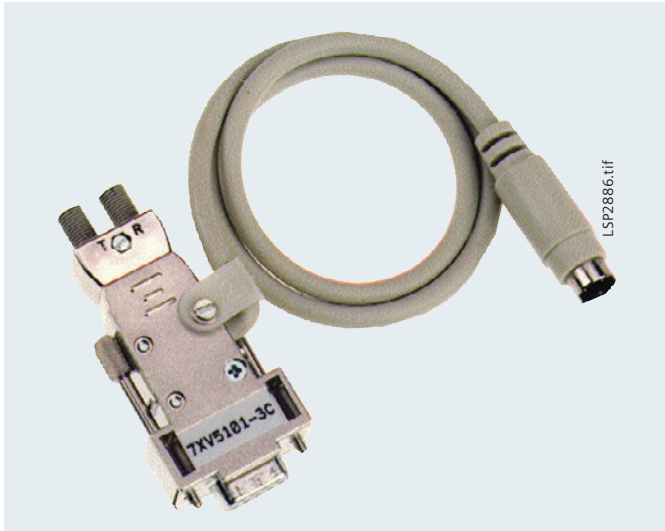


Fig. 13/33 Connector modules/adapters 7XV5101-3C

Description

Connector modules 7XV5101

Optical connection of protection relays with an electrical (non-isolated) RS232 interface, e.g. to a star coupler, for centralized control is made possible with the fiber-optic RS232 connector modules.

Thus, further devices such as PCs or notebooks, modems or serial data switches can be effectively protected against electromagnetic interference. An appropriate connector module is available for each of the above-mentioned applications. These fiber-optic RS232 connector modules are housed in a SUB-D plug casing and can be directly plugged into the respective interfaces of the pertaining devices. No further settings are required. In its normal position, the optical interface is set to steady light OFF. Data transmission is fully duplex and transparent. The optical interface with FSMA connectors has an operational wavelength of 820 nm and can reach distances of up to 1500 m with 62.5/125 μm multi-mode FO cables.

Accessories/7XV5101

Technical data, selection and ordering data

Technical data	
Housing	7XV5101- 3C
Plastics, metal-plated	■
Dimensions 72 × 32 × 17 mm	■
Via external keyboard connector located at the notebook	■
Electrical interfaces	
Bridge contact 7 – 8, 1 – 4 – 6 9-pin	■
Optical interfaces	
FSMA connector (screw-type) T = transmit, R = receive	■
Optical power 27 μW (-15.7 dBm) ¹⁾	■
Sensitivity 1 μW (-30 dBm) ¹⁾	■
Optical budget 7 dB (+3 dB backup) ¹⁾	■
Wavelength 850 nm	■
Transmission range 1500 m (with 62.5 μm multi-mode FO cable) 800 m (with 50 μm multi-mode FO cable)	■
1) Valid for 62.5 μm FO cable.	

Selection and ordering data	
Description	Order No.
7XV5101 fiber-optic connector module 820 nm – RS232	7XV5101-3C
9-pin female connector for notebook	

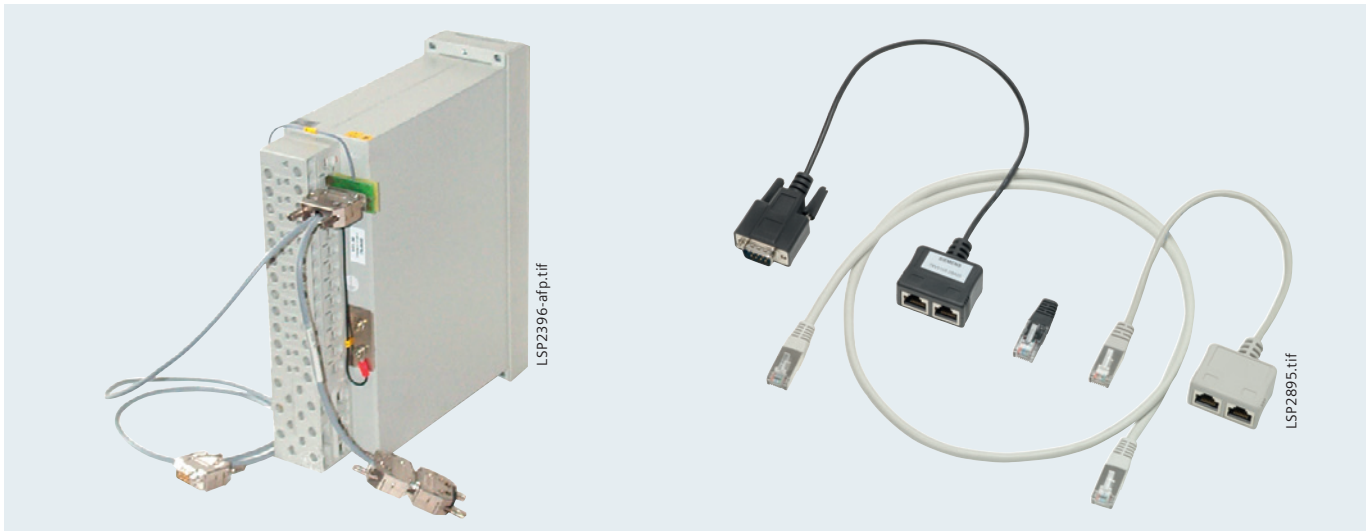


Fig. 13/34 RS485 bus cable system (left) / 7XV5103 cable and connector modules / adapters (right)

Description

The RS485 bus is a low-cost half-duplex communication bus, which, due to its relatively high interference immunity, is not only used for monitoring and control in industrial systems, but is now increasingly used for SCADA and protection applications by utilities in substations. Protocols, such as DIGSI, IEC 60870-5-103, DNP 3 and MODBUS up to 115 kbit/s, are used between a station master and up to 31 slave devices on shielded twisted-pair (STP) cable. In ideal conditions, the length of the bus may be up to 1000 m. This requires correct configuration of the bus, use of suitable cables, and connector connectors, as well as correct termination of the bus. Devices with different termination methods require special adaptors to achieve the highest possible interference immunity. The RS485 bus systems 7XV5103 are optimized in this respect for our control and protection product range.

With the ordering code 7XV5103, two different RS485 bus systems are available.

When combining the required components for a RS485 bus, the corresponding application examples contained in this document can be of assistance.

The bus system with 9-pin SUB-D connectors has long been applied in systems with SIPROTEC protection devices, 7XV5 converters, and master units. Connection to the individual devices is achieved directly with a special Y-cable or with a corresponding adapter cable to devices with different termination methods. The bus terminates in a 9-pin SUB-D bus terminating connector with an integrated 220-Ω resistor.

On some SIPROTEC devices, the serial signals are routed to RJ45 female connectors on the communication module, as is the case, for example, with the redundant IEC 60870-5-103 module. There the bus is based on double-shielded CAT 5 patch cables. Connection of the individual devices to the two redundant buses is achieved via two special Y-adapter cables each. The buses each terminate with a RJ45 bus terminating connector with a 120-Ω resistor.

A combination of the two bus systems and the different device interfaces or a combination of the two systems is also possible using the Y-adapter cable 7XV5103-2BA00.

Function overview

- For data transfer up to 115 kbit/s (e.g. DIGSI, IEC 60870-5-103, DNP 3)
- Variable bus structure with shielded cables of various lengths.
- Metal-plated, shielded connector housings with reduced mounting depth and strain relief.
- Bus termination with terminating connectors and integrated resistor.
- Connection of the SIPROTEC 4 protection devices with redundant IEC 60870-5-103 interface via the Y-adapter cable and RJ45 connector.
- Connection of the SIPROTEC 4 protection devices with RS485 interface and SUB-D connector directly, or via a Y-adapter cable.
- Adapter/cable for compact protection devices with RS485 interface on screw-type terminals, e.g. 7SJ600, 7SD600, 7RW600 etc.
- Connection to various RS485 converters, e.g. 7XV5650/51.
- Combination of both bus systems is possible.
- Max. length of the bus within a common grounding system may be up to 1000 m.

Please note that this system must not be used for PROFIBUS-FMS or PROFIBUS-DP. These have their own bus system with components suitable for use with PROFIBUS.

Application

Application

Notes on configuring the RS485 bus system

The housings of all devices connected to the bus must be solidly grounded to a common ground to avoid dangerous ground currents flowing via the cable shields.

Larger distances, especially into other buildings with separate grounding system should preferably be covered via converters (e.g. 7XV5650/51) using FO links.

The RS485 bus must be linear, i.e. tee-offs from the bus (e.g. a terminal strip) to the connected bus devices must not be used. This would form a star configuration, which has negative influence on the functionality.

The bus must be terminated at the first device (usually the master) and at the last device with a bus terminating resistor to avoid interference due to reflection. No further terminating resistors must be connected between these terminals.

As all of the devices, maximum 32 (including the master) are listening in on the RS485 bus, all the devices on the bus must be set to the same baud rate and the same data format.

The slaves must all have different device addresses.

Within the system, only one master may be active at any one time and only one slave may respond.

The bus system with 9-pin SUB-D connectors

The bus system with 9-pin SUB-D bus terminating connectors has long been used with SIPROTEC protection devices, the converters 7XV5 and Siemens master units. Connection of individual devices to devices with various connection modes is achieved directly via specialized Y cables, or via suitable adapter cables. The bus terminates at a 9-pin SUB-D bus terminating connector with an integrated 220-Ω resistor.

Specifications

- Direct connection to SIPROTEC 4 protection devices with RS485 interface via a FO-RS485 converter 7XV5650/51
- Adapter/cable for compact protection devices with RS485 interface on screw-type terminals, e.g. 7SJ600, 7SD600, 7RW600 etc.
- 4 cable lengths from 1 to 10 meters
- Shielded twisted-pair (STP) cable with 9-pin SUB-D connector connectors
- Metal-plated, shielded connector housings with reduced mounting depth and strain relief
- Data transfer up to 115 kbit/s (e.g. DIGSI, IEC 60870-5/VDEW)
- Maximum length of the bus up to 1000 m within a common grounding system
- Bus termination with terminating connectors and integrated 220-Ω resistor

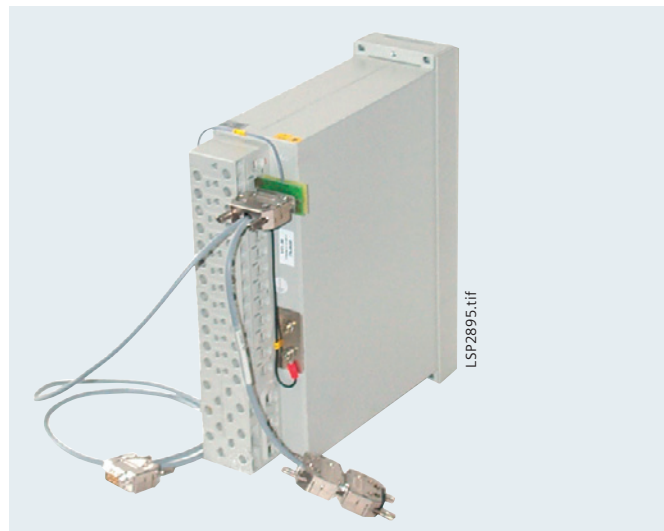


Fig. 13/35 Protection unit connected to the RS485 bus

Application example 1:

The 9-pin male connector of the Y bus cable S1 always comes from the master side and provides the connection to the slaves via the 1, 3, 5 or 10-m cable and 9-pin male connector S2. At the connector S2 a 20-cm long cable with a 9-pin female connection B3 is provided to extend the bus. The compact protection devices, e.g. 7SJ600 are directly connected via the adapter cable 7XV5103-2AA00 with female connector B2 or an RS485 adapter 7XV5103-3AA00. After the final device, a bus terminating connector 7XV5103-5AA00 is connected to connector B3 to terminate the bus.

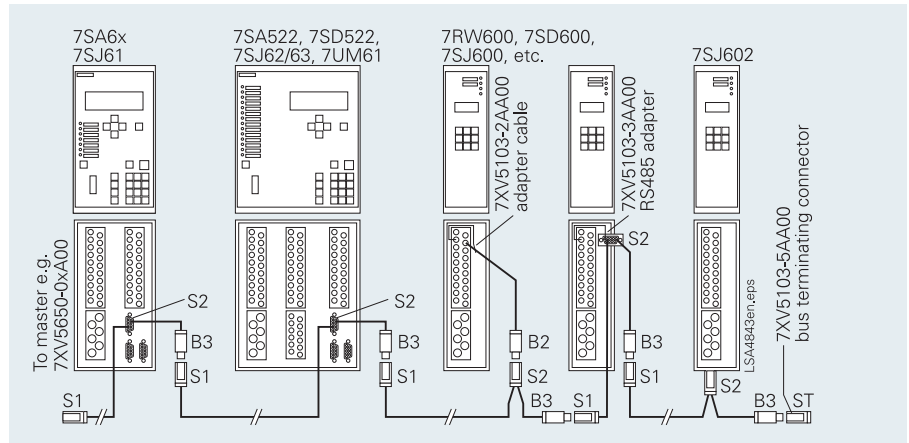


Fig. 13/36 SIPROTEC protection devices on the RS485 bus

Selection and ordering data

Description	Order No.
RS485 Y-bus cable shielded twisted pair with 9-pin SUB-D connectors 7XV5103 RS485 bus with SUB-D connectors	7XV5103-0AA□□
Length 1 m	0 1
Length 3 m	0 3
Length 5 m	0 5
Length 10 m	1 0
RS485 bus extension cable STP with 9-pin SUB-D connector	7XV5103-1AA□□
Length 10 m	1 0
Length 20 m	2 0
Length 30 m	3 0
Length 40 m	4 0
Length 50 m	5 0
RS485 adapter	7XV5103-□AA00
Adapter cable with STP with ferrule/9-pin SUB-D connector for units with screw-type terminals or compact protection units, e.g. 7SJ600, 7SD600 etc.	2
RS485 adapter with 9-pin SUB-D connector formounting on screw-type terminals on compact protection units, e.g. 7SJ600, 7SD600 etc.	3
Bus terminating connector 220-Ω, 9-pin SUB-D connector	5
RS485 cable to thermo-box (RTD)	7XV5103-7AA□□
For connection between the 7XV5662-□AD10 thermo-box and SIPROTEC 4 units (port C or port D with RS485 interface)	
Length 5 m	0 5
Length 25 m	2 5
Length 50 m	5 0

Application

Bus system with RJ45 patch cables

The bus system with RJ45 connectors was specially developed for SIPROTEC devices for communication modules with serial RJ45 connectors and is built with low cost double-shielded CAT 5 patch cables.

Connection of the individual devices to the two redundant buses is achieved via two special Y-adapter cables each. The buses each terminate with a RJ45 bus terminating connector with an integrated 120-Ω resistor.

Specifications

- Low-cost bus structure with shielded patch cables (CAT 5) with RJ45 connectors
- Cable lengths from 0.5 to 20 meters (7KE6000-8G)
- Connection of SIPROTEC 4 protection devices with redundant IEC 60870-5-103 interfaces via Y-adapter with RJ45 connector
- Connection of SIPROTEC 4 protection devices with RS485 interface via Y-cable to SUB-D connector
- Adapter/cable for compact protection devices, e.g. 7SJ600, 7SD600, 7RW600 etc.
- Metal-plated connector housings with strain relief of the cable connections
- Compact connectors
- Data transfer up to 115 kbit/s (e.g. DIGSI, IEC 60870-5/VDEW)
- Maximum extension of the bus of up to 800 m within a common grounding system
- Bus termination with terminating connectors and integrated 120-Ω resistor
- Connection to the FO-RS485 converter 7XV5650 or the bus system with SUB-D connector via Y-adapter

Notes on configuring the RS485 bus system (application examples 2 and 3, see page 13/9)

The housings of all devices connected to the bus must be solidly grounded to a common ground to avoid dangerous ground currents flowing via the cable shields.

Larger distances, especially into other buildings with separate grounding system should preferably be covered via converters (e.g. 7XV5650/51) using FO cables.

The RS485 bus must be linear, i.e. tee-offs from the bus (e.g. a terminal strip) to the connected bus devices must not be used.



Fig. 13/37 Bus system with RJ45 patch cable

This would form a star configuration, which has negative influence on the functionality.

Only CAT 5 double-shielded patch cables (e.g. 7KE6000) must be used as the bus cables. The maximum bus length must not exceed 800 m.

The bus must be terminated at the first device (usually the master) and at the last device with a bus terminating resistor to avoid interference due to reflection. No further terminating resistors must be connected between these terminals.

As all of the devices, maximum 32 (including the master) are listening in on the RS485 bus, all the devices on the bus must be set to the same baud rate and the same data format. The slaves must all have different device addresses.

Within the system on each bus, only one master may be active at any one time and only one slave may respond.

Application example 2: Connection of SIPROTEC 4 to a (redundant) control system

The RS485 bus cable system with patch cables (CAT 5) was developed as a low-cost alternative to the previous systems 7XV5103 with SUB-D connectors. The advantages are the widespread use of patch cables throughout the world and the compact dimensions of the RJ45 connector. This allows a redundant IEC 60870-5-103 interface with a single interface module within a SIPROTEC 4 device.

Two different Y-adapters permit implementation of a RS485 bus with patch cables and connection of devices having RS485 interfaces and different designs of interface connector. Both Y-adapters have two RJ45 female connectors in parallel to facilitate the implementation of the buses. The approx. 20 cm long connection cable to the device either has a RJ45 or SUB-D connector.

Devices with SUB-D connector (e.g. Master RTU, 7XV5650/51, SIPROTEC 4 devices with SUB-D) are connected using the Y-adapter 7XV5103-2BA00.

Devices with RJ45 connector such as SIPROTEC 4 with redundant IEC 60870-5-103 interface are connected with the Y-adapter 7XV5103-2CA00. For the redundant bus system 2 Y-adapters are required per SIPROTEC 4 device.

After the final device the bus is terminated with a bus terminating connector 7XV5103-5BA00. For the redundant bus system, a bus terminating resistor is required for each bus.

Application example 3: Central operation of SIPROTEC 4 units with DIGSI 4

The RS485-bus cable system with patch cables (CAT 5) was developed as a low-cost alternative to the previous systems 7XV5103 with SUB-D connectors. The advantages are the widespread use of patch cables throughout the world and the compact dimensions of the RJ45 connector.

The Y-adapter 7XV5103-2BA00 allows for the implementation of a RS485 bus with patch cables and the connection of various SIPROTEC devices having RS485 interfaces. The Y-adapters have two RJ45 female connectors in parallel to facilitate the implementation of the buses. The approx. 20 cm long connection cable to the device has a RJ45 with suitable pin allocation.

Devices with an RS485 interface and SUB-D connector (7XV5650/51, SIPROTEC 4 devices) with SUB-D are connected using the Y-adapter 7XV5103-2BA00.

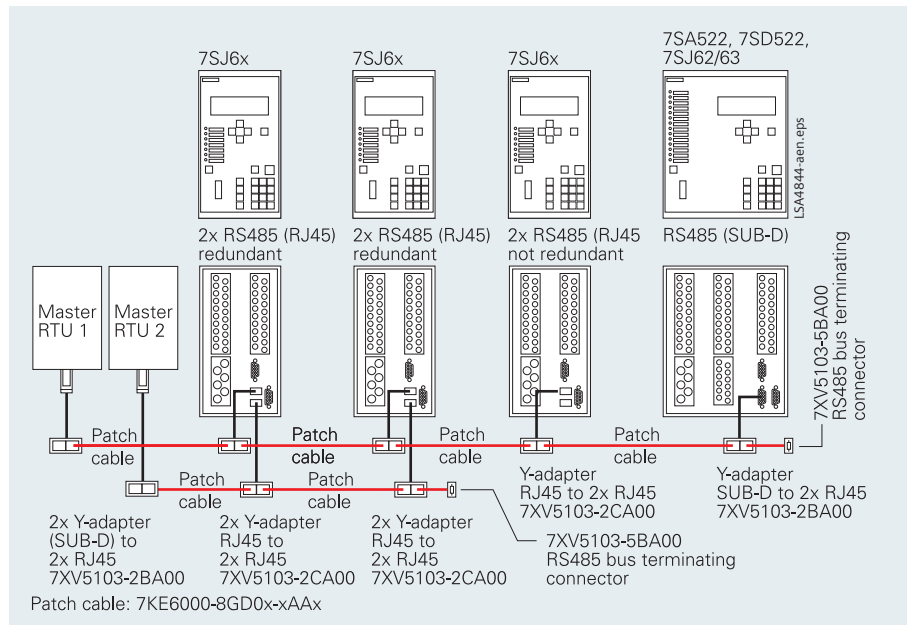


Fig. 13/38 Connection of SIPROTEC 4 to a (redundant) control system

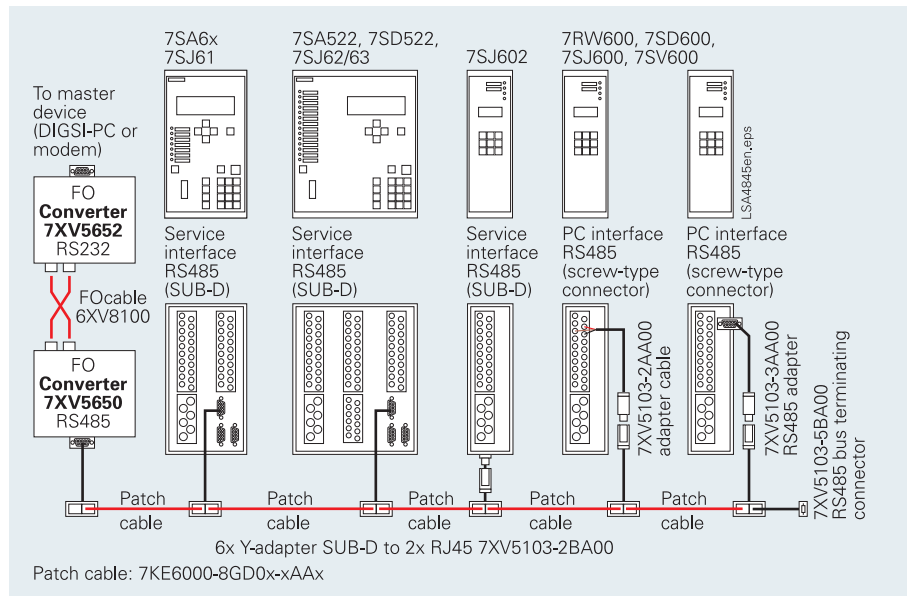


Fig. 13/39 Central operation of SIPROTEC 4 units with DIGSI 4

Devices with an RS485 interface on screw-type connectors require an additional adapter for 9-pin SUB-D to single core, e.g. 7XV5103-2AA00 or 7XV5103-3AA00.

After the last device, the bus is terminated with a bus terminating connector 7XV5103-5BA00

Accessories/7XV5103

Selection and ordering data

Description	Order No.
RS485 adapter/accessories	7XV5103-□□□00
Adapter cable STP with ferrule/9-pin SUB-D connection for devices with screw-type terminals or compact protection devices, e.g. 7SJ600	2 A A
Y-adapter cable for connection of SIPROTEC 4 or other devices with a 9-pin SUB-D connection to a RS485 bus with patch cables (RJ45)	2 B A
Y-adapter cable for connection of SIPROTEC 4 with a redundant T103 interfacemodule to a RS485 bus with patch cables (RJ45) 2 C A	2 C A
RS485 adapter with 9-pin SUB-D connection formounting on screw-type terminals with compact protection devices, e.g. 7SJ600, 7SD600 etc.	3 A A
Bus terminating connector 220-Ω in a 9-pin SUB-D connector	5 A A
Bus terminating connector 120-Ω in a RJ45 connector	5 B A
Patch cable CAT 5 shielded with RJ45 connectors	7KE6000-8GD0□-□AA0/BB
See Accessories for Communication 7KE6000-8Gx	

Application example 4: Connecting the two bus systems 7XV5103

The Y-adapter 7XV5103-2BA00 enables configuration of the RS485 bus with RJ45 patch cables and connection of SIPROTEC devices with an RS485 interface with a SUB-D connector.

Use of an additional gender changer (female-female) enables connection of a RS485 bus with Y-bus cables 7XV5103-0AAxx instead of a SIPROTEC device.

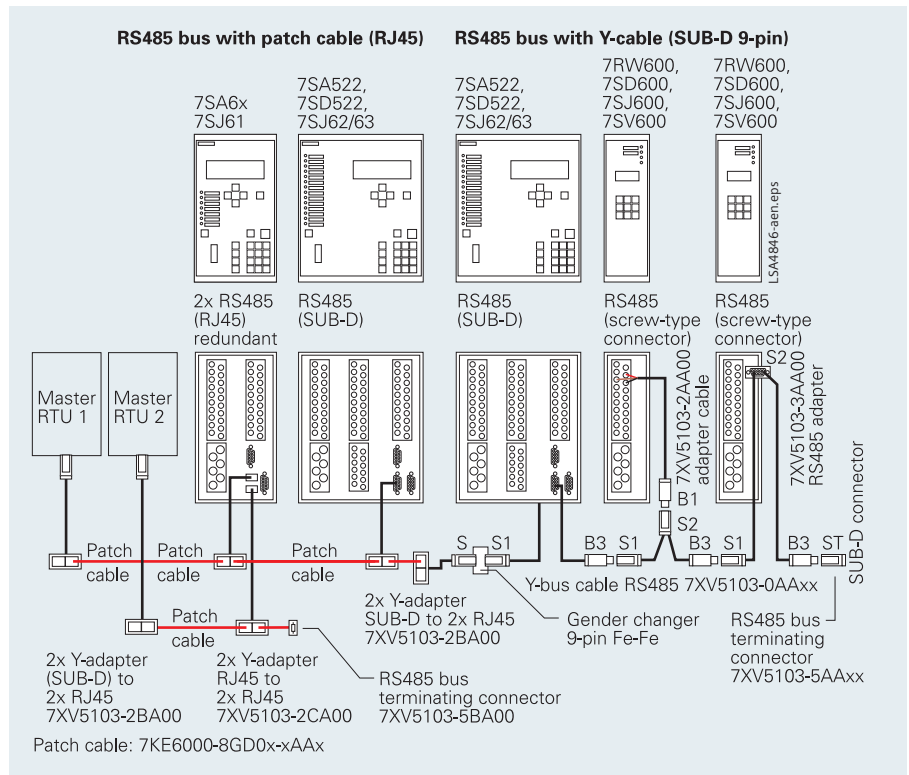


Fig. 13/40 Connecting the two 7XV5103 bus systems

Accessories/7XV5103

Selection and ordering data

Description	Order No.
RS485 Y-bus cable shielded twisted-pair with 9-pin SUB-D connector	7XV5103-0AA <input type="checkbox"/> <input type="checkbox"/>
Length 1 m	0 1
Length 3 m	0 3
Length 5 m	0 5
Length 10 m	1 0
RS485 bus extension cable STP with 9-pin SUB-D connector	7XV5103-1AA <input type="checkbox"/> <input type="checkbox"/>
Length 10 m	1 0
Length 20 m	2 0
Length 30 m	3 0
Length 40 m	4 0
Length 50 m	5 0
RS485 adapter/accessories	7XV5103- <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 00
Adapter cable STP with ferrule/9-pin SUB-D connector for devices with screw-type terminals or compact protection devices, e.g. 7SJ600	2 A A
Y-adapter cable for connection of SIPROTEC 4 or other devices with 9-pin SUB-D connection to a RS485 bus with patch cables (RJ45)	2 B A
Y-adapter cable for connection of SIPROTEC 4 with a redundant T103 interface module to a RS485 bus with patch cables (RJ45)	2 C A
RS485 adapter with 9-pin SUB-D connector formounting to screw-type terminals for compact protection devices, e.g. 7SJ600, 7SD600 etc.	3 A A
Bus terminating connector 220-Ω in a 9-pin SUB-D connector	5 A A
Bus terminating connector 120-Ω in a RJ45 connector	5 B A
RS485 cable to thermo-box (RTD)	7XV5103-7AA <input type="checkbox"/> <input type="checkbox"/>
Connection cable for thermo-box 7XV5662-xAD to SIPROTEC 4 Open cable ends, each 5/20 cm with ferrules to 9-pin SUB-D connector with an integrated 220-Ω terminating resistor	
Length 5 m	0 5
Length 25 m	2 5
Length 50 m	5 0
Patch cable CAT 5 shielded with RJ45 connector	7KE6000-8GD0 <input type="checkbox"/> - <input type="checkbox"/> AA0/BB
See Accessories for Communication 7KE6000-8G	



Fig. 13/41 Mini star-coupler

Function overview

One optical input and up to 4 optical outputs

- Distance spanned: 1.5 km with 62.5/125 μm multi-mode fiber
- Multiple mini star-couplers cascadable
- RS232 interface for local access
- Baud rate via FO: up to 1.5 Mbaud; Baud rate with RS232: Up to 115 kbaud
- Protocol transparency
- Light idle state: Light ON/light OFF selectable
- Wide-range power supply with self-monitoring function and alarm contact
- Optical ST connectors

Description

The mini star-coupler multiplies an optical signal received at an input for up to four outputs. A signal received at one of the outputs is transmitted via the input interface to a central unit or to an upstream mini star-coupler or converter.

As the mini star-coupler does not transmit selectively to individual outputs, the protocols used for data transmission must operate with unique DTE addresses, so all units "hear" the central interrogation, but only the addressed unit answers to the request (e.g. IEC 60870-5-103 or DIGSI).

Data are transmitted in transparent full-duplex mode. An RS232 interface is provided for direct serial communication with DTEs at each mini star-coupler. As long as this interface is in use, the optical input interface to the central unit is blocked.

Cascading mini star-couplers replace the 7XV5300 star coupler.

Application, construction

Application

The mini star-coupler allows SIPROTEC relays to be centrally accessed or remotely interrogated with DIGSI via optical interfaces. The component is cascadable, so that star topologies or ring topologies can be configured. A ring structure ensures that all four outputs are used. The mini star-coupler has a local RS232 interface socket. By connecting a PC to this interface and using the 7XV5100-4 cable, the optical input is disconnected to avoid data collision due to local and remote access concurring at the same time.

Construction

The 7XV5450 mini star-coupler is provided with a snap-on mounting housing for a 35 mm EN 50022 rail. Auxiliary power supplies can be connected via screw-type terminals. The fiber-optic cables are connected by ST connectors. The unit is free of silicone and halogen as well as flame-retardant.

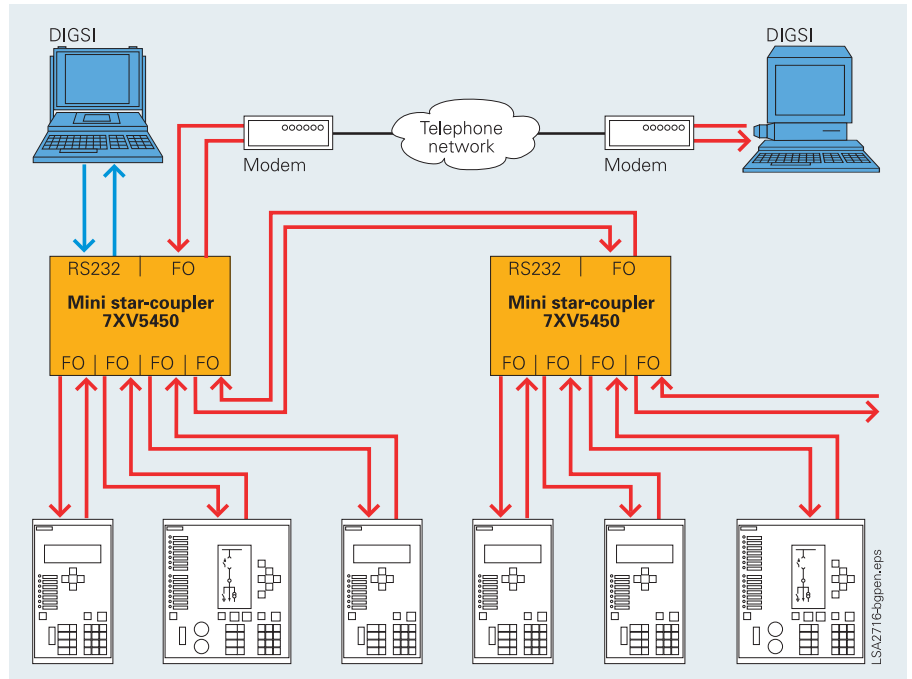


Fig. 13/42 Star topology with mini star-couplers

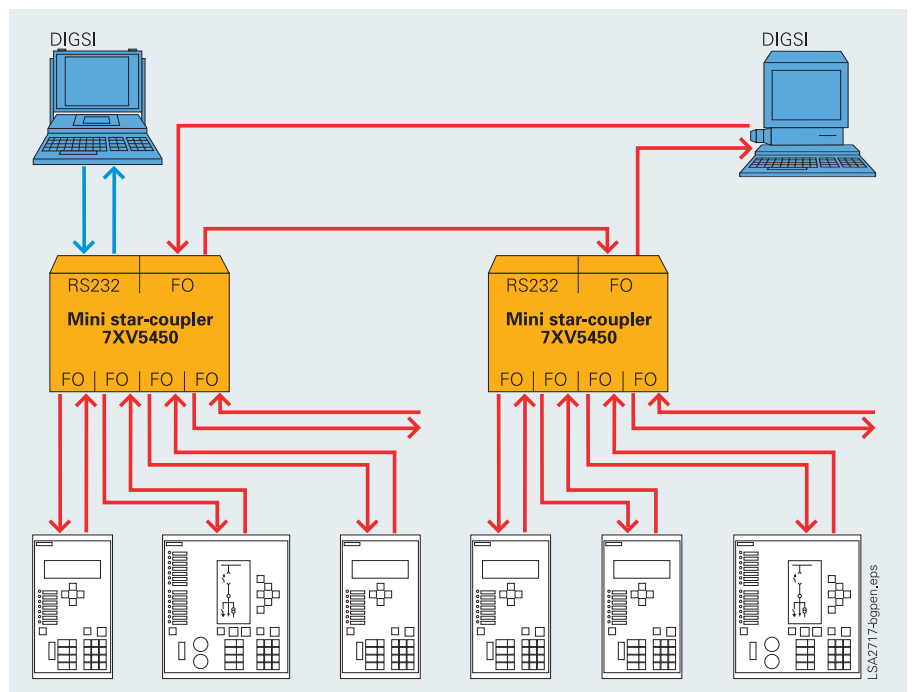


Fig. 13/43 Ring structure with mini star-couplers

Technical data

Rated auxiliary voltage

DC 24 to 250 V and AC 60 to 230 V ± 20 % without switchover

Current consumption

Approx. 0.25 to 0.4 A

LEDs

3 LEDs	Operating voltage o.k. Receiving data Sending data
Green	
Yellow	
Yellow	

Connectors

Power supply	2-pole Phoenix screw-type terminal
FO cables	Multi-mode fiber with ST connectors
RS232	9-pin SUB-D socket
Alarm contact	2-pole Phoenix screw-type terminal

Light idle state

Light ON/OFF selectable By jumpers

Housing

Plastic housing, EG90, charcoal grey; 90 × 75 × 105 mm (W × H × D)
for snap-on mounting on 35 mm EN 50022 rail

Selection and ordering data

Description	Order No.
7XV5450 mini star-coupler Optical mini star-coupler with plastic housing for snap-on mounting onto 35 mm rail. Rated auxiliary voltage DC 24 – 250 V and AC 110 – 220 V with alarm relay. Connection of up to 4 protection units to a star coupler via FO cable for 62.5/125 µm and 850 nm wavelength, max. distance 1.5 km. Connection of PC or modem to a star coupler via FO cable for 62.5/125 µm and 850 nm wavelength, max. distance 1.5 km. Connection also by 9-pin RS232 connector. Cascadable Fiber-optic connectors with ST connector	7XV5450-0BA00

7XV5461 two-channel serial optical repeater (for 1 mono-mode FO cable)



Fig. 13/44 Optical repeater with integrated 1300 nm/1550 nm wavelength multiplexer for one single mono-mode FO-cable

Function overview

- Two independent multiplexed 820 nm Ports 1/2 with ST connectors for max. 1.5 km via 50/125 μm and 62.5/125 μm multi-mode FO cable.
- Data rate of serial Ports 1/2 from 300 bit/s – 4.096 Mbit/s. Automatic baud rate adjustments to synchronous and asynchronous serial signals; no settings necessary.
- Powerful 1300 nm/1550 nm port with LC-single connector for distances up to 40 km via one 9/125 μm mono-mode FO cable
- DC 24 to 250 V and AC 115/230 V wide-range power supply with alarm relay.
- Data exchange display by LED
- Integrated commissioning support

Description

The optical repeater exchanges serial optical signals over long distances via only one single mono-mode FO cable. It converts serial optical 820 nm signals at Port 1 and Port 2 in the range 300 bit/s – 4.096 Mbit/s to 1300/1550 nm for one mono-mode FO cable. Both synchronous and asynchronous signals can be connected at Port 1/2. Two independent, serial 820 nm inputs with ST connectors are available, which are multiplexed to Port 3. Two devices with an optical 820 nm interface, for example the 7SD5/7SD610 line differential protection relay or the RS232/820 nm 7XV5652 converter, can be connected to Ports 1 and 2 via multi-mode FO cables for distances of up to 1.5 km. Signal transmission at Port 3 is achieved via the single LC connector at wavelengths of 1300 nm/1550 nm for connection of mono-mode FO cable up to 40 km. The device can be connected to DC battery voltages and AC supply sources. Loops can be activated for Port 1/2 for commissioning purposes, so that the input signals can be mirrored at each port to support commissioning of the fiber optical links.

Application, technical data

Application

Until now, two FO cables are required for the bidirectional transmission of protection signals. With the repeater with integrated wavelength multiplexer one FO cable is sufficient: Two protection relays e.g. 7SD52/7SD610 differential protection or 7SA52/7SA6 distance protection, exchange information via Port 1 (po1). Interference-free data exchange is performed via one optical mono-mode FO cable up to a max. distance of 40 km. Protection remote control with DIGSI is connected to Port 2 of the repeater via a 7XV5450 mini star-coupler. This port provides the serial connection to the other substation with a PC on which DIGSI is installed. In this way, the remote protection devices can be remotely interrogated via Port 2. The baud rate is optimally set to 57.6 kbit/s so that there is no difference from local operation. The data of the devices on the other substation can be changed or read out during commissioning and operation. Alternatively, it is possible to connect substation control devices, RTU or additional protection data transmission to Port 2. This makes for optimum use of the long-distance optical cable for two separate serial connections for transmitting serial data between 300 bit/s and 4.096 Mbit/s.

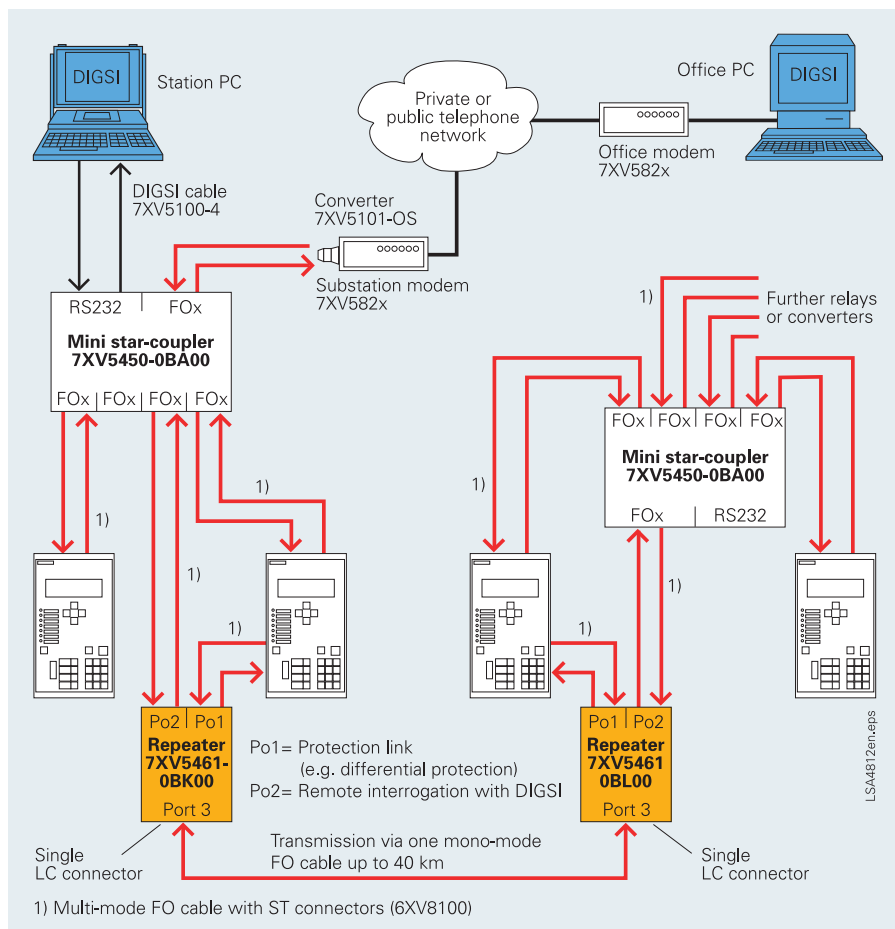


Fig. 13/45 Transfer of protection data signals and remote control/integration via one mono-mode FO cable
(Note: Devices 7XV5461-0BK00 and 7XV5461-0BL00 must be used in pairs)

Technical data

Connections

Ports 1 / 2	ST connector for 820 nm for 50/125 μm and 62.5/125 μm multi-mode FO cable
Port 3	LC-single connector for 1300 nm/1550 nm for 9/125 μm mono-mode FO cable
Screw-type terminals	2-pole screw-type terminals for auxiliary voltage supply 3-pole make/break contact for alarm relay

Housing

Interference-free 188 x 56 x 120 mm metal housing for mounting on 35 mm DIN rail to EN 50032.
Weight 0.8 kg. Degree of protection acc. to EN 60529: IP41

Power supply

Wide range DC 24 to 250 V or AC 115/230 V

Displays

4 LEDs	
Green	Power supply
Red	Alarm relays
2 yellow	Data exchange indication

Description	Order No.
Two-channel serial optical repeater with integrated wavelength multiplexer	7XV5461 - 0B□00
Connection of two serial optical inputs with ST connector for 62.5/125 µm multi-mode FO cable up to 1.5 km, from 300 bit/s – 4.096 Mbit/s 24 – 250 V DC, 115/230 V AC wide-range power supply Alarm relay and LED for operational and fault display Optical 1550 nm output with LC-single connector for 9/125 µm mono-mode FO cable for distances up to 40 km (permissible path attenuation 25 dB)	K
Optical 1300 nm output with LC-single connector for 9/125 µm mono-mode FO cable for distances up to 40 km (permissible path attenuation 25 dB)	L

7XV5461 two-channel serial optical repeater (for duplex-mono-mode FO cables)



Fig. 13/46 Optical repeater with wide-range power supply

Function overview

- Two independent multiplexed 820 nm ports with ST connectors for max. 1.5 km via 50/125 μm and 62.5/125 μm duplex-multi-mode FO cable.
- Data rate of serial ports 1/2 from 300 bit/s – 4.096 Mbit/s. Automatic baud rate adjustment to synchronous and asynchronous serial signals; no settings necessary.
- Powerful 1300 nm/1550 nm port with LC-Duplex connector for distances up to 24 km / 60 km / 100 km / 170 km via 9/125 mm duplex-mono-mode FO cable
- DC 24 to 250 V and AC 115/230 V wide-range power supply with alarm relay.
- Data exchange display by LED
- Integrated commissioning support

Description

The optical repeater transmits serial optical signals over long distances via duplex-mono-mode FO cables. It converts serial optical 820 nm signals at Port 1 and Port 2 in the range of 300 bit/s to 4.096 Mbit/s. Both synchronous and asynchronous signals can be connected. Two independent, serial 820 nm inputs with ST connectors are available, which are multiplexed to Port 3. Two devices with an optical 820 nm interface, for example the 7SD5 / 7SD6 line differential protection relay or the RS232/ 820 nm 7XV5652 converter, can be connected to Ports 1 and 2 via duplex-multi-mode FO cables for distances of up to 1.5 km. Signal transmission at Port 3 is achieved via the LC-Duplex connector at wavelengths of 1300 nm/1550 nm for connection of a duplex-mono-mode FO cable. For Port 3 there are three options for max. 25 km (1300 nm) / 60 km (1300 nm) and 100 km / 170 km (1550 nm) optical fiber lengths. The device can be connected to all battery voltages and AC supply sources. Loops can be activated for Ports 1/2 for commissioning purposes, so that the input signals can be mirrored at the port in question.

Description	Order No.
7XV5461 two-channel serial optical repeater (for duplex-mono-mode FO cables)	7XV5461 - 0B□00
Connection of two serial optical inputs with ST connector for 62.5/125 µm multi-mode FO cable up to 1.5 km, from 300 bit/s to 4.096 Mbit/s 24 to 250 V DC, 115/230 V AC wide-range power supply Fault relay and LED for operational and fault display	
Optical 1300 nm output with LC-Duplex connector for 9/125 µm mono-mode FO cable for distances up to 24 km (permissible path attenuation 13 dB)	G
Optical 1300 nm output with LC-Duplex connector for 9/125 µm mono-mode FO cable for distances up to 60 km (permissible path attenuation 29 dB)	H ¹⁾
Optical 1550 nm output with LC-Duplex connector for 9/125 µm mono-mode FO cable for distances up to 100 km (permissible path attenuation 29 dB)	J ¹⁾
Optical 1550 nm output with LC-Duplex connector for 9/125 µm mono-mode FO cable for distances up to 170 km (permissible path attenuation 43 dB)	M
1) When ordering options H/J an additional attenuator is required if the devices are used for distances < 20 km	

7XV5461 two-channel serial optical repeater (for duplex-multi-mode FO cables)



Fig. 13/48 Optical repeater with wide-range power supply

Description

The optical repeater transmits serial optical signals over long distances via duplex-multi-mode FO cables. It converts serial optical 820 nm signals at Port 1 and Port 2 in the range 300 bit/s – 1.5 Mbit/s to 1300 nm for duplex-multi-mode fiber cables. Both synchronous and asynchronous signals can be connected. Two independent, serial 820 nm inputs with ST connectors are available, which are multiplexed to Port 3. One transmit (Tx) and one receive (Rx) signal is supported (no RTS/CTS handshake signals). Two devices with an optical 820 nm interface, for example the 7SD52/7SD610 line differential protection relay or the RS232/820 nm 7XV5652 converter, can be connected to Ports 1 and 2 via duplex-multi-mode FO cables for distances of up to 1.5 km. Signal transmission at Port 3 is achieved via the LC-Duplex connector at wavelengths of 1300 nm for connection of a duplex-multi-mode FO cable. For Port 3 there are two options for a max. of 4 km (1300 nm) and 8 km (1300 nm) optical fiber lengths. The device can be connected to all battery voltages and AC supply sources. Loops can be activated for Ports 1/2 for commissioning purposes, so that the input signals can be mirrored at the port in question.

Function overview

- Two independent multiplexed 820 nm ports with ST connectors for a max. of 1.5 km via 50/125 μm and 62.5/125 μm duplex-multi-mode FO cable.
- Data rate of serial Ports 1/2 from 300 bit/s – 1.5 Mbit/s. Automatic baud rate adjustment to synchronous and asynchronous serial signals; no settings necessary.
- Powerful 1300 nm port with LC-Duplex connector for distances up to 4 km/8 km via 50/125 mm / 62.5/125 mm duplex-multi-mode FO cable
- DC 24 to 250 V and AC 115/230 V wide-range power supply with alarm relay.
- Data exchange display by LED
- Integrated commissioning support with test loop feature

Typical applications

Two protection relays (for example 7SD52/7SD610 differential protection or 7SA52/7SA6 distance protection) exchange information via Port 1. Interference-free data exchange is performed via optical duplex-multi-mode FO cable up to a distance of 4/8 km. Protection remote control with DIGSI is connected to Port 2 of the repeater via 7XV5450 mini star-coupler. This port provides the serial connection to the other substation with a PC where DIGSI is installed. The protection relays on the remote substation can be interrogated remotely via Port 2. The baud rate is optimally set to 57.6 kbit/s so that there is no difference from local operation. During commissioning and operation, the data of the device in the other substation can be changed and read out. Alternatively, it is possible to connect a substation control system or additional protection data transmission to Port 2. This makes for optimum use of the long-distance optical fiber for two separate serial connections for transmitting data between 300 bit/s and 4.096 Mbit/s.

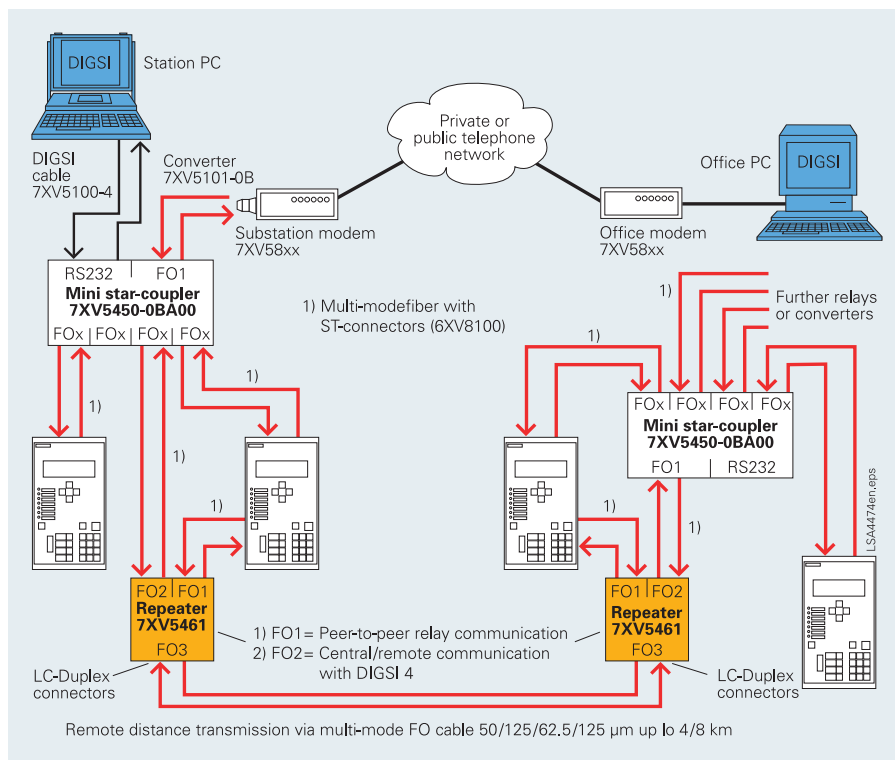


Fig. 13/49 Transfer of protection data and remote control of a substation via an optical long-distance connection

Technical data

Connections

Ports 1/2	ST connector for 820 nm for 50/125 μm and 62.5/125 μm multi-mode FO cable
Port 3	LC-Duplex connector for 1300 nm for 50/125 μm / 62.5/125 μm multi-mode FO cable
Screw-type terminals	2-pole screw-type terminals for auxiliary voltage supply 3-pole make/break contact for alarm relay

Housing

188 × 56 × 100 mm aluminum housing for mounting on 35 mm DIN rail to EN 50032. Weight 0.8 kg.
Degree of protection acc. to EN 60529: IP41

Power supply

Wide range 24 to 250 V DC without connector jumpers, AC 115/230 V

Displays

4 LEDs	
Green	Power supply
Red	Alarm relays
2 yellow	Data exchange

Description	Order No.
Two-channel serial optical repeater (for duplex multi-mode FO cables)	7XV5461 - 0B□00
Connection of two serial optical inputs with ST connector for 62.5/125 µm multi-mode FO cable up to 1.5 km, from 300 bit/s to 1.5 Mbit/s DC 24 to 250 V, AC 115/230 V wide-range power supply Fault relay and LED for operational and fault display Optical 1300 nm output with LC-Duplex connector for 50/125 µm / 62.5/125 µm multi-mode FO cable for distances up to 4 km (permissible path attenuation 13 dB)	F
Optical 1300 nm output with LC-Duplex connector for 50/125 µm / 62.5/125 µm multi-mode FO cable for distances up to 8 km (permissible path attenuation 29 dB)	E



Fig. 13/50 Active mini star-coupler

Function overview

One optical input and 4 optical outputs or one RS485 input and 5 optical outputs

- RS232 interface for local access
- RS485 interface for bus structure
- Baud rate and data format can be set independently for each port
- Baud rate 1200 baud – 115 kbaud
- Data format 8N1, 8N2, 8E1
- Max. distance: 1.5 km with 62.5/125 µm multi-mode FO cable
- Light idle state: Light ON/light OFF selectable
- Wide-range power supply with self-supervision function and alarm contact
- Optical ST connectors

Description

Five optical ports allow the active mini star-coupler to centrally or remotely communicate with devices with serial interfaces using different baud rates and data formats. Using a simple ASCII sequence, only one of the available output channels is switched to a transparent full duplex operation. The active mini star-coupler can be used with any terminal program or for SIPROTEC protection relays with the DIGSI operating program. Each of the input and output channels can be parameterized independently to the device attached by adjustable baud rates and data formats or as input or output ports. For communication with more than 5 devices, the active mini star-coupler can be cascaded together with an RS485 bus in half-duplex mode with further devices.

Please note:

The 7XV5450 passive mini star-coupler is recommended for controlling several SIPROTEC 3 or SIPROTEC 4 devices with DIGSI or for communication by a remote control system.

Application, construction

Application

Using the integrated optical interfaces of the active mini star-coupler, data transmission for the protection relays V1/2, SIPROTEC 3 or 4 can be performed centrally or remotely with DIGSI. When using the RS485 bus structure each active mini star-coupler provides five optical outputs. An RS232 interface is available for local operation with a notebook. The control PC (directly or via modem) always operates with the same data format, while the interfaces to the different protection relays using other formats are adapted accordingly. For V1/2 protection relays, a 7XV5101-0A plug-in connector module is required for each relay and each port must be connected to a separate port.

Construction

The active mini star-coupler is provided with a snap-on mounting housing for a 35 mm EN 50022 rail. Auxiliary power supplies can be connected via screw-type terminals. The fiber-optic cables are connected by ST connectors. The unit is free of silicone and halogen as well as flame-retardant.

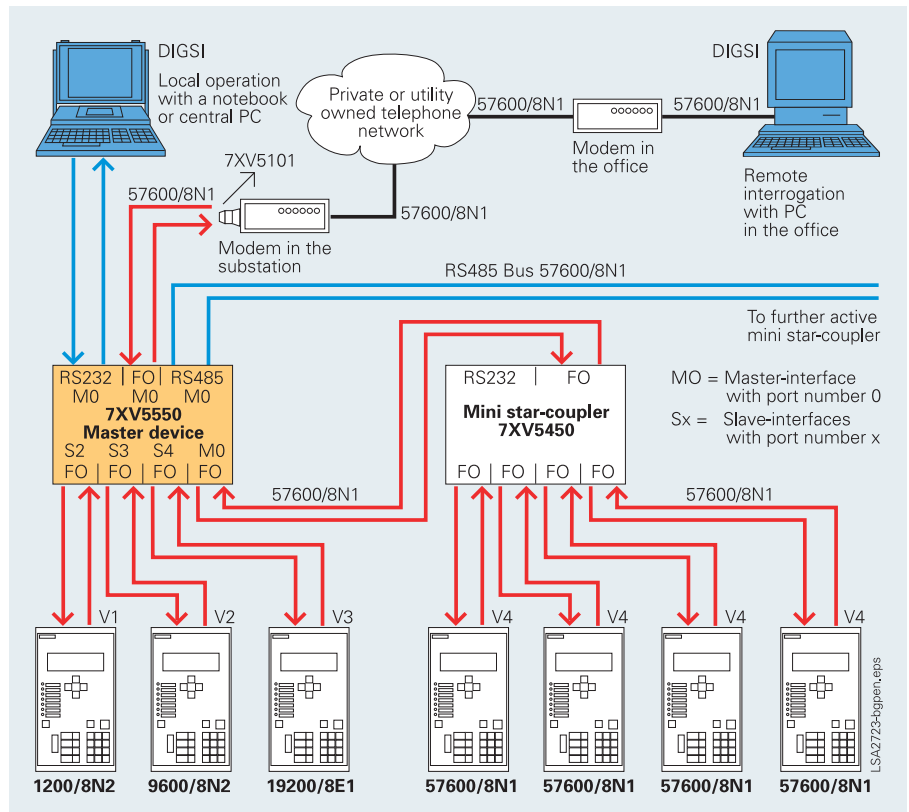


Fig. 13/51 Data transmission via using the integrated optical interfaces of the mini star-coupler

Technical data

Rated auxiliary voltage

DC 24 to 250 V and AC 60 to 230 V ± 20 % without switchover

LEDs

3 LEDs	
Green	Operating voltage o.k.
Yellow	Receiving data
Yellow	Sending data

Connectors

Power supply	2-pole Phoenix screw-type terminal
FO connections	820 nm ST connectors
RS232	9-pin SUB-D socket
RS485	2-pole Phoenix screw-type terminal
Alarm contact	2-pole Phoenix screw-type terminal

Light idle state

Light ON/OFF selectable By jumpers

Housing

Plastic housing, EG90, charcoal grey; 90 × 75 × 105 mm (W × H × D)
for snap-on mounting on 35 mm EN 50022 rail

Selection and ordering data

Description	Order No.
7XV5550 active mini star-coupler Optical active mini star-coupler with plastic housing for snap-on mounting onto 35 mm rail. Rated auxiliary voltage DC 24 – 250 V and AC 110 – 230 V with alarm relay. Connection of up to 4 protection units to an active mini star-coupler via FO cable for 62.5/125 µm and 850 nm wavelength, max. distance 1.5 km. Connection of PC or modem to an active mini star-coupler via FO cable for 62.5/125 µm and 850 nm wavelength, max. distance 1.5 km. Connection also by 9-pin RS232 connector. Cascadable Fiber-optic connectors with ST connector	7XV5550-0BA00



Function overview

- Baud rates 9.6 – 115 kbaud
- Topologies:
7XV5650: Optical star
7XV5651: Optical line, RS485 bus
- Protocol transparency
- Light idle state: Light ON/light OFF selectable
- Distance: 1.5 km with 62.5/125 μ m FO cable
- 120 Ω terminator for RS485 bus, activated/deactivated by DIP switch
- Wide-range power supply with self-supervision function and fault output relay

Fig. 13/52 RS485 – FO converter

Description

The RS485 – FO converter allows up to 31 devices to be connected with a bus-capable electrical RS485 interface. It provides an optical link-up to a central unit or a star coupler. The converter has been designed for use in substations for interference-free transmission of serial data with rates between 9.6 and 115.2 kbaud by multi-mode FO cable.

The 7XV5651 converter is designed to act as a T-coupler, data can be distributed in a line structure system, forming a basis for building up cost-effective optical bus systems.

The version 7XV5650 is designed for star topology via fiber-optic connection.

Application

Application

The converters can be used in an optical line structure or in an optical star structure. Application in optical line structure allows relays to be connected interference-free via fiber-optic cables; for indoor installation, a cost-effective RS485 bus can be used.

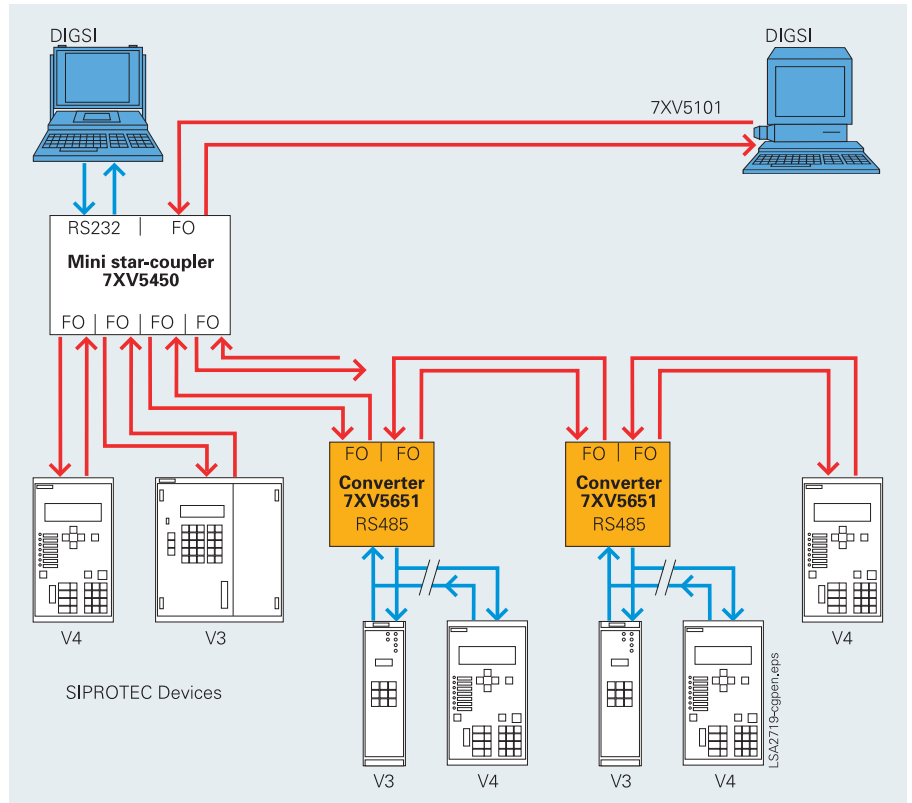


Fig. 13/53 Optical line structure with connected RS485 interfaces

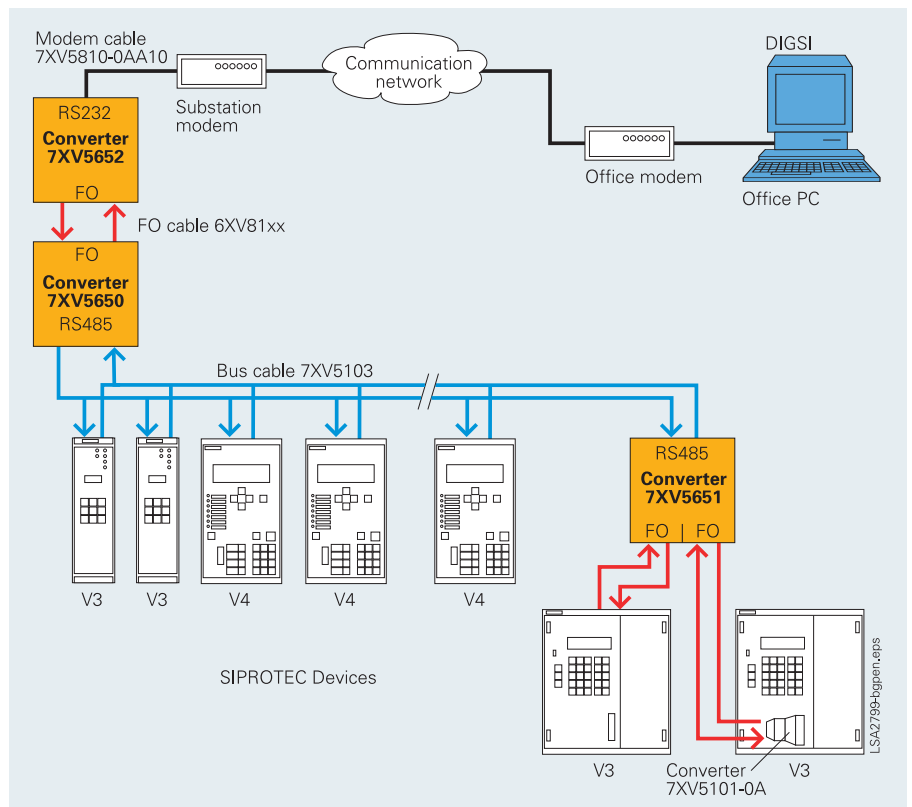


Fig. 13/54 Connection of optical interfaces to an RS485 bus

Several units equipped with FO interface and DIGSI or IEC 60870-5-103 protocol can be connected to an existing RS485 bus structure.

Within one system, the data format and the baud rate have to be set to the same values.

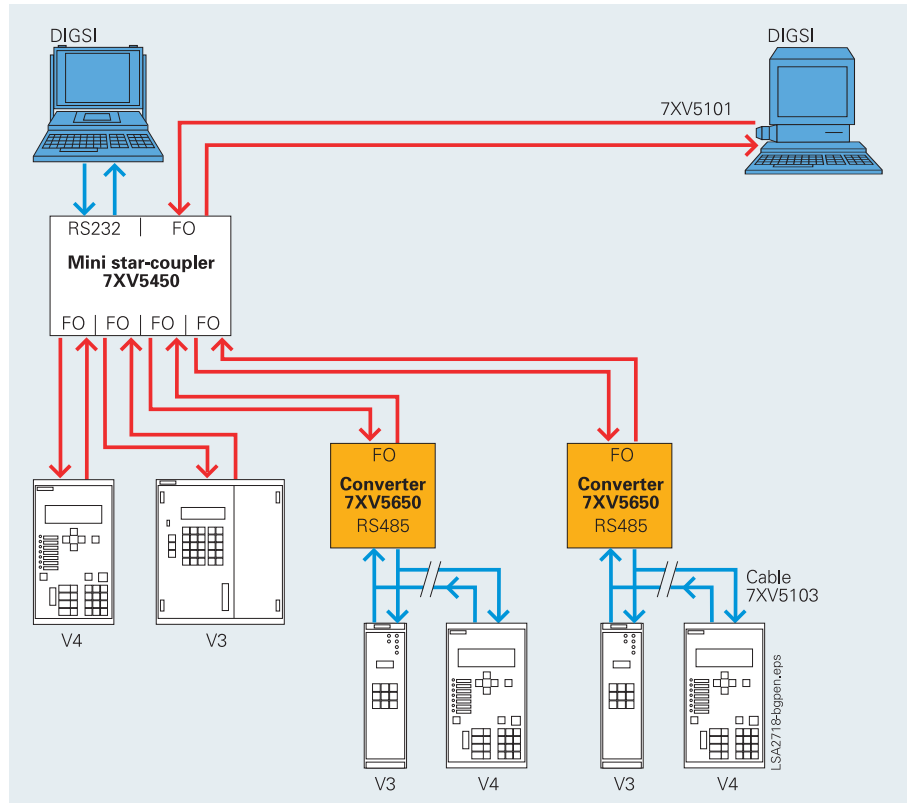


Fig. 13/55 Optical star structure with connected RS485 interfaces

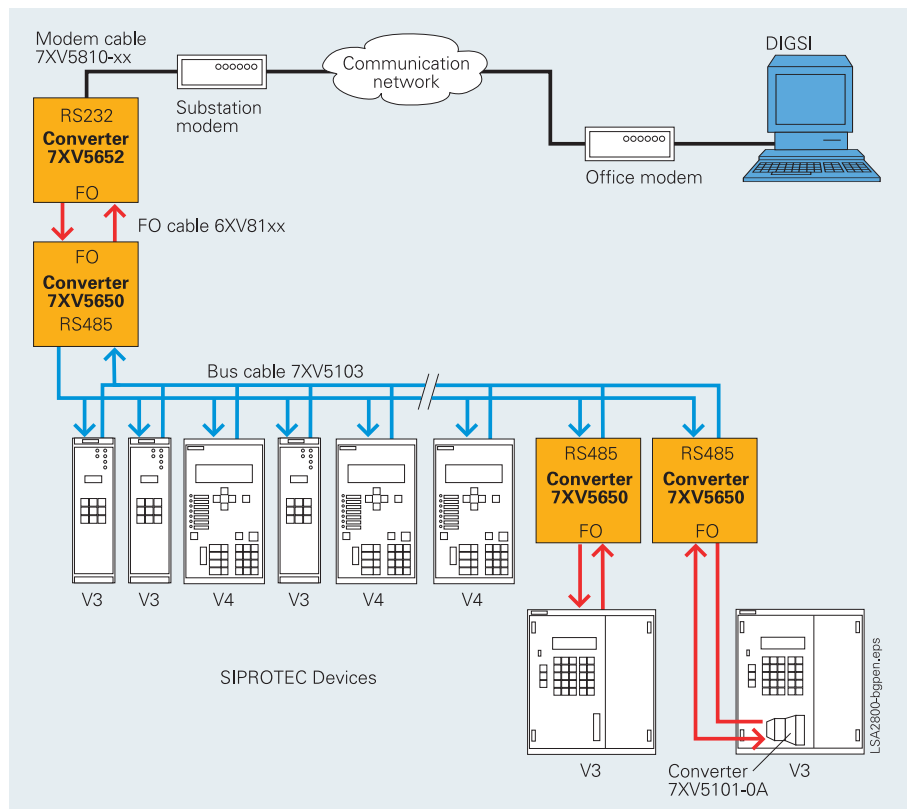


Fig. 13/56 Connection of optical interfaces to an RS485 bus

Accessories/7XV5650/51

Construction, technical data, selection and ordering data

Construction

The converter is provided with a snap-on mounting housing for a 35 mm EN 50022 rail. Auxiliary power supplies can be connected via screw-type terminals.

The fiber-optic cables are connected by ST connectors. The unit is free of silicone and halogen as well as flame-retardant.

Technical data

<i>Rated auxiliary voltage</i>	
DC 24 to 250 V and AC 60 to 230 V	± 20 % without switchover
<i>Current consumption</i>	
Approx. 0.2 to 0.3 A	
<i>LEDs</i>	
2 / 3 LEDs Green Yellow Yellow	Operating voltage o.k. Receiving data on FO channel 1 Sending data on FO channel 2 (7XV5651 only)
<i>Connectors</i>	
Power supply	2-pole Phoenix screw-type terminal
FO	820 nm ST connector
RS485	9-pin SUB-D socket 2-pole Phoenix screw-type terminal
Alarm contact	2-pole Phoenix screw-type terminal
<i>Light idle state</i>	
Light ON/OFF selectable	
<i>Housing</i>	
Plastic housing, EG90, charcoal grey; 90 × 75 × 105 mm (W × H × D) for snap-on mounting on 35 mm EN 50022 rail	

Selection and ordering data

Description	Order No.
7XV565 RS485 – FO converter	7XV565 <input type="checkbox"/> - 0BA00
Converter with 1 RS485 interface and 2 FO cables for transmission rates from 9.6 kbaud to 115 kbaud With plastic housing for snap-on mounting on 35 mm rail. Rated auxiliary voltage DC 24 – 250 V and AC 110 – 230 V with alarm contact. Connection of units with RS485 interface by 9-pin SUB-D connector or screw-type terminals. Connection of PC or modem to a star coupler via FO cable for 62.5/125 µm or 50/125 µm and 850 nm wavelength. Fiber-optic connectors: FO 820 nm with ST connector	
1 channel	0
2 channels	1



Fig. 13/57 RS232 – FO converter

Function overview

- Serial baud rates up to 115 kbaud
- No setting of baud rate necessary
- Protocol transparency
- Light idle state: Light ON/light OFF selectable
- Distance: 3 km with 62.5/125 μ m FO cable
- Wide-range power supply with self-supervision function and alarm contact
- Supports the serial TxD and RxD lines of the RS232 interface.
- No handshake lines supported

Description

The RS232 – FO converter is used to convert serial RS232 signals to FO transmission signals in full duplex mode. It has one FO channel for transmission and one for receiving, as well as a protected RS232 interface rated to withstand 2 kV discharges, thus allowing direct connection to the serial system interface of SIPROTEC relays. It is designed to be used in substations for isolated, interference-free transmission of serial signals to a central unit, a star coupler or a PC.

The converter supports the conversion of serial TxD (transmit) and RxD (receive) signals to an optical output. No handshake signals are supported.

Application, construction

Application

With the serial RS232 – FO converter, an existing RS232 interface at a SIPROTEC relay can be upgraded to an optical 820 nm interface to connect the relay with further optical components for central and remote interrogation with DIGSI. Another application is the interfacing between a line differential relay and a communication network, which provides electrical RS232 inputs. The connection between the communication room, where the converter is located, and the relay is executed without interference via multi-mode FO cables (Fig. 13/58).

Construction

The converter is provided with a snap-on mounting housing for a 35 mm EN 50022 rail. Auxiliary power supplies can be connected via screw-type terminals. The fiber-optic cables are connected by ST connectors. The unit is free of silicone and halogen as well as flame-retardant.

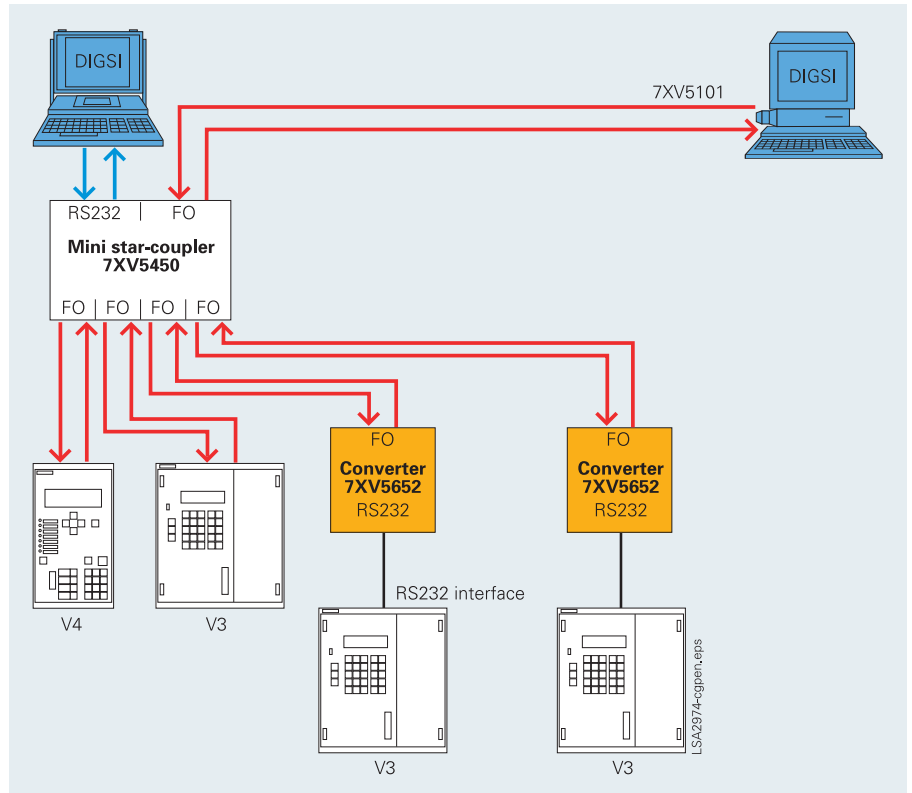


Fig. 13/58 Remote interrogation with the RS232 interface

Technical data

Rated auxiliary voltage

DC 24 to 250 V and AC 60 to 230 V	± 20 % without switchover
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Current consumption

Approx. 0.1 to 0.2 A	
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LEDs

1 LED Green	Operating voltage o.k.
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Connectors

Power supply	2-pole Phoenix screw-type terminal
FO cables	820 nm ST connector
RS485	9-pin SUB-D socket
Alarm contact	2-pole Phoenix screw-type terminal

Light idle state

Light ON/OFF selectable	
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Housing

Plastic housing, EG90, charcoal grey; 90 × 75 × 105 mm (W × H × D)
for snap-on mounting on 35 mm EN 50022 rail

Selection and ordering data

Description	Order No.
7XV5652 RS232 – FO converter For conversion of FO to RS232 (V.24) signals up to 115 kbaud With plastic housing for snap-on mounting on 35 mm rail Rated auxiliary voltage DC 24 – 250 V and AC 110 – 230 V with alarm contact. Connection of units with RS232 interface by 9-pin SUB-D connector Connection of PC, star coupler, modem via FO cable for 62.5/125 µm and 850 nm wavelength Fiber-optic connectors: FO 820 nm with ST connector	7XV5652-0BA00



Fig. 13/59 Binary transducer

Description

The transducer registers binary information from contacts via two binary inputs and forwards it interference-free to the second transducer via fiber-optic cable. The indications/signals received by this second transducer are put out via its contacts. The two contacts can be used as trip contacts. The transducer is equipped with independent and bidirectional binary inputs (2) and contact outputs (2).

The transducer has been designed for application in substations. Highly reliable, telegram-backed serial data transmission is used between the transducers. Transmission errors and failure of the data link are indicated via an alarm contact, i.e. a permanent supervision of power supply and the datalink is integrated in the transducer.

Function overview

- 2 isolated binary inputs (DC 24 to 250 V)
- 2 isolated trip contacts
- Fast remote trip via a serial point-to-point link of up to 115 kbaud/12 ms.
- Telegram-backed interference-free transmission via FO cable
- Permanent data link supervision and indication
- Distance of approx. 3 km via multi-mode FO cable 62.5/125 μ m
- Transmission of up to 170 km via mono-mode FO cable with 7XV5461 repeater
- Transmission via communication networks and leased lines and pilot wires with 7XV5662-0AC01 communication converters
- Wide-range power supply with self-supervision function and alarm relay

Application, construction

Application

The bidirectional transducer registers binary information at two binary inputs and forwards it via fiber-optic cable to a second transducer, which outputs the signals via contacts. Distances of about 3 km can be covered directly via multi-mode fiberoptic cables. The 7XV5461 repeater is available for distances up to 170 km via mono-mode fiber-optic cable. (Fig. 13/60)

With two transducers connected to 7XV5461, up to four binary signals can be transferred. One application is phase-selective intertripping.

With a communication converter, the transducer can be interfaced to different kinds of communication links. Modern $N \times 64$ kbit/s digital networks can be used. Existing pilot wires can also be used for data exchange between the relays. The data to be exchanged includes directional signals, intertrip signals and other information.

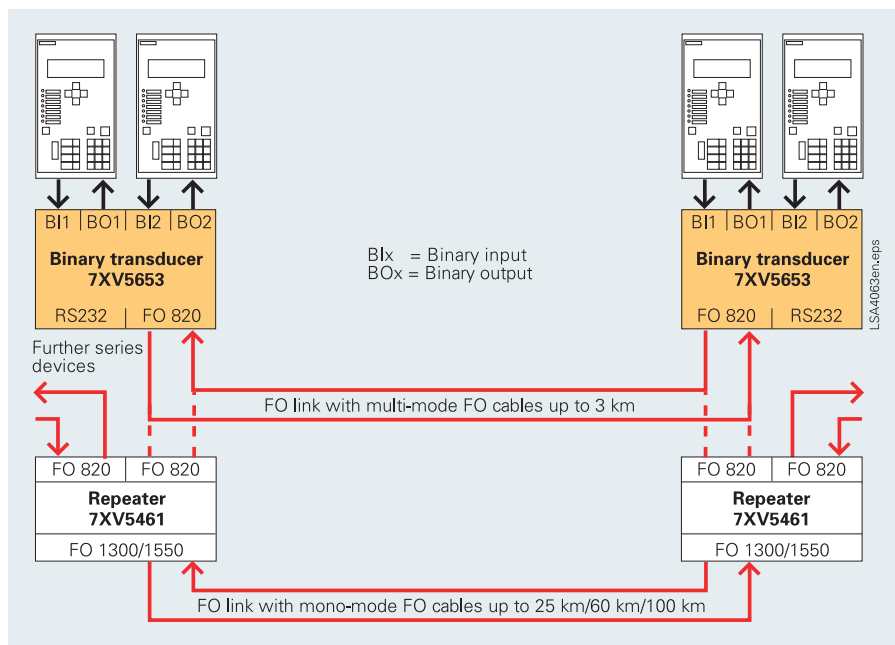


Fig. 13/60

Construction

The converter is provided with a snap-on mounting housing for a 35 mm EN 50022 rail. Auxiliary power supplies can be connected via screw-type terminals. The fiber-optic cables are connected by ST connectors. The unit is free of silicone and halogen as well as flame-retardant.

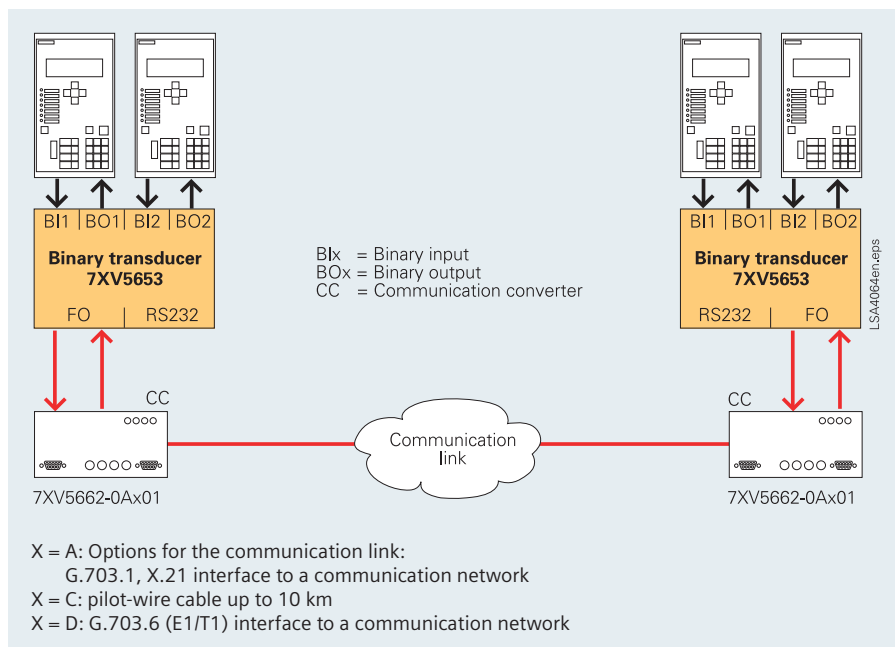


Fig. 13/61

Technical data

Rated auxiliary voltage

DC 24 to 250 V and AC 60 to 230 V ± 20 % without switchover

Current consumption

Approx. 0.15 to 0.25 A

LEDs

6 LEDs	
1 x green	Operating voltage o.k.
2 x yellow	Contact unit ½ active
2 x yellow	Command relay ½ active
1 x red	Alarm

Connectors

Power supply	2-pole Phoenix screw-type terminal
FO connection	820 nm FSMA screw-type connector
FO connection	820 nm ST connector
Binary inputs	4-pole Phoenix screw-type terminal
Alarm contact	2-pole Phoenix screw-type terminal

Light idle state

Light ON/OFF selectable

Housing

Plastic housing, EG90, charcoal grey; 90 × 75 × 105 mm (W × H × D)
for snap-on mounting on 35 mm EN 50022 rail

Selection and ordering data

Description	Order No.
7XV5653 two-channel binary transducer Binary signal transducer Plastic housing, for snap-on mounting onto 35 mm EN 50022 rail Rated auxiliary voltage DC 24 to 250 V and AC 110 to 230 V with alarm relay, 2 binary inputs, 2 trip contacts, 1 alarm relay with potential-free contact for pilot-wire supervision Connection to a second transducer via FO cable for 62.5/125 μm and 820 nm wavelength (ST connectors). Max. distance 3 km. Connection to a second transducer via a communication system with a RS232 interface, 9-pin SUB-D connector, baud rate settable by DIP-switches Fiber-optic connectors with ST connector	7XV5653-0BA00



Fig. 13/62 Front view of the Ethernet modem

Function overview

- RS232 interface for data transfer and configuration of the modems
- Serial data rate and data format (RS232 / RS485) for the terminal devices is selectable from 2.4 kbit/s up to 57.6 kbit/s with data format 8N1, 8E1
- FO interface for serial data transfer
- 10 Mbit Ethernet interface (LAN) to the 10/100 Mbit Ethernet network
- Increased security with password protection and IP address selection is possible
- Exchange of serial data via Ethernet network between two Ethernet modems (e.g. DIGSI protocol, IEC 60870-5-103 protocol)
- Exchange of serial protocols via Ethernet without gaps in the telegram structure

Description

A control PC and protection relays can exchange serial data via an Ethernet network using two Ethernet modems 7XV5655. Connection to the Ethernet modem is in each case made via the asynchronous serial interface of the terminal devices. In the modem the serial data is packed into the secure IP protocol as information data, and is transferred between the modems using the Ethernet connection. Conformity with the standard and gap-free transmission of serial DIGSI or IEC 60870-5-103/101 telegrams (frames) via the network is ensured by the modem which receives the serial telegram communication and packs the serial IEC telegrams into blocks for communication via the Ethernet. Data is transmitted in full duplex mode, the serial handshake is not supported. Connection is set up between the IP address of the dialing modem in the office and the IP address of the answering modem in the substation and is configured prior to dial up with DIGSI by means of AT commands via the RS232 interface.

The substation modem may be configured to have password protection, and provides the additional security feature, permitting access only from defined IP addresses, e.g. only that of the office modem. The modem is accessed with DIGSI Remote like a normal telephone modem with the exception that instead of telephone numbers, IP addresses are assigned by the network administrator for each modem.

Application

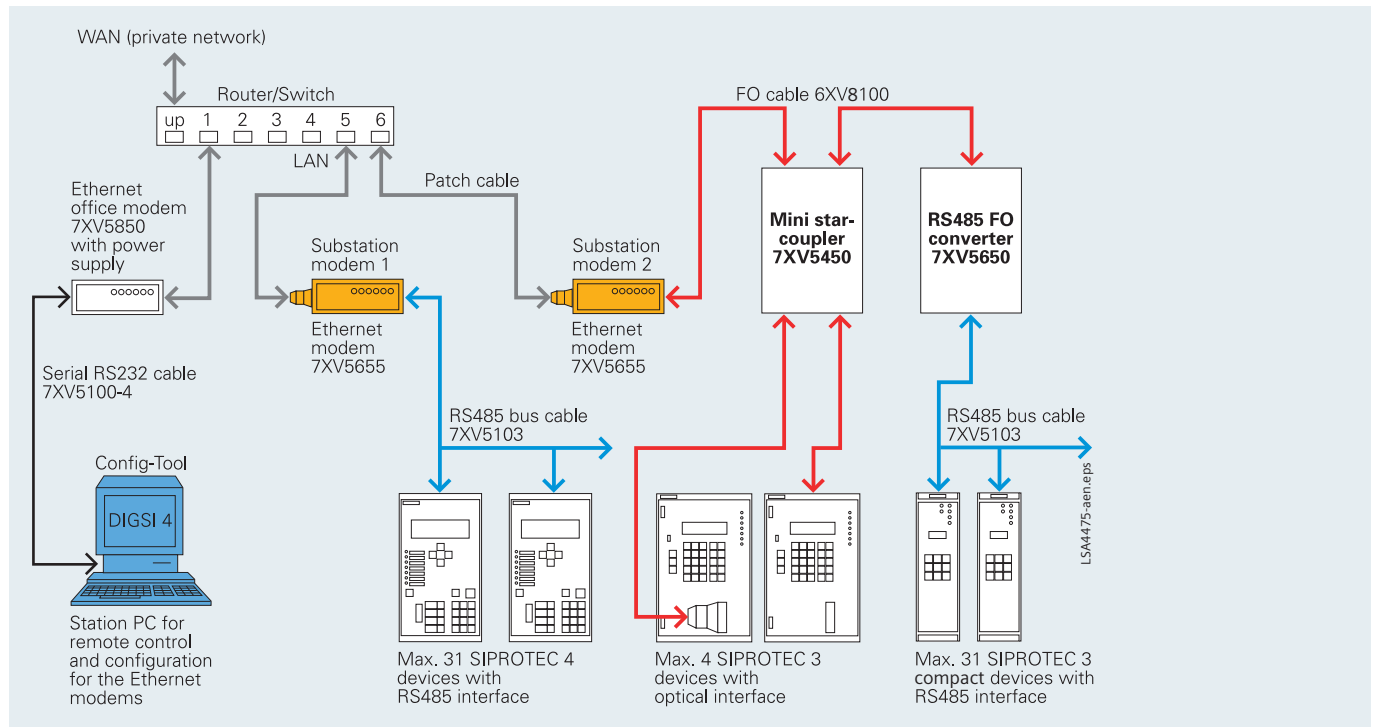


Fig. 13/63 Operation of various SIPROTEC protection unit generations via Ethernet modems

Application

Using the office computer and DIGSI 4, both substations 1 and 2 may be dialed up via the Ethernet modems. An IP point-to-point data connection is established between the office and corresponding substation modem when dialed up via the network. This is maintained until the office modem terminates the connection. The serial data exchange takes place via this data connection whereby the modem converts the data from serial to Ethernet with full duplex mode. Between the office modem and the office PC the highest data rate e.g. 57.6 kbit/s for SIPROTEC 4 devices is always used. The serial data rate of the substation modem is adapted to the data rate required by the protection relays e.g. substation modem 1 with 57.6 kbit/s for SIPROTEC 4 and substation modem 2 with 9.6 kbit/s for SIPROTEC 3 devices. These settings are only pre-set once in the modem.

The Ethernet modems are integrated similarly to telephone modems in DIGSI 4. Instead of the telephone number, the pre-set IP address assigned to the modem is selected. If later an Ethernet connection is available in the substation, the existing modem can be replaced by an Ethernet modem. The entire serial bus structure and cabling may remain unchanged.

Technical data

Connections

RS232 interface 9-pin SUB-D or
 RS485 interface 9-pin SUB-D settable by switches
 FO interface 820 nm with ST connectors for the connection to 62.5/125 µm multi-mode FO cables.
 Ethernet 10BaseT, 10/100 Mbit, RJ45 connector
 Power supply / Fail safe relay with screw-type terminals

Housing

Rail mounting, plastic, charcoal grey, 90 x 90 x 107 (W x H x D) in mm

Wide-range power supply / fail safe relay

Auxiliary voltage DC 24 to 250 V and AC 115/230 V connected with screw-type terminals
 Fail safe relay for power supervision connected with screw-type terminals

Indication (8 x LED)

Power	Operating voltage o.k.	System	RS232 connection established
RS232 Tx/D	Transmitting data to RS232	RS232 Rx/D	Receiving data from RS232
LAN Tx	Transmitting data to LAN	LAN Rx	Receiving data from LAN
Error	Error on RS232	Link LAN	LAN connection established

Selection and ordering data

Description	Order No.
<p>Ethernet modem</p> <p>Ethernet modem for serial, asynchronous transmission of data up to 57.6 kbit/s via the 10/100 Mbit Ethernet and configuration software DIN-rail device mounting device suitable for substation. Connection to Ethernet via RJ45 connector. Serial connection SUB-D 9-pin socket RS232/RS485 interface settable by switches. FO interface 820 nm for 62.5/125 µm multi-mode-FO cables. Auxiliary supply DC 24 – 250 V and AC 115/230 V. Fail safe contact for device supervision. With gender-changer (pin-pin) for adaptation to DIGSI-cable 7XV5100-4 (cable not included in the scope of supply).</p>	7XV5655 - 0BB00



Fig. 13/64 Front view of Ethernet serial hub for substation

Description

By means of the serial hub and the associated configuration software it is possible to establish serial communication via an Ethernet network between a PC or notebook running DIGSI 4 and SIPROTEC protection relays. The configuration software installs virtual serial interfaces (COM ports) on the PC. Each COM port is allocated to a serial hub within the network by means of its IP address. This must be set in the serial hub. The PC is connected to the network via Ethernet interface. The protection relays are connected via an RS232/RS485 or FO interface to the serial hub. Connection with DIGSI is achieved via the virtual COM port on the PC and the IP address of the serial hub in the substation. The serial data is packed as user data into a secure IP protocol in the PC and transferred via the Ethernet connection to the serial hub. The requirements regarding standard compliant gap-free transmission of serial DIGSI or IEC 60870-5-103/101 telegrams (frames) via the network is complied with by the communication driver on the PC and the serial hub which monitor the serial telegram communication. The serial IEC telegrams are transferred in blocks across the Ethernet. Data communication is full duplex. Control signals of the serial interfaces are not used.

Function overview

- Configuration software for Windows NT/2000/XP to configure virtual COM ports on the PC and for configuration of the serial hub.
- RS232/RS485 – interfaces for data transfer and configuration of the serial hub
- FO interface for serial data transfer
- Serial data rate and data format (RS232) for the terminal devices is selectable from 2.4 kbit/s up to 57.6 kbit/s with data format 8N1, 8E1.
- 10 Mbit Ethernet interface (LAN) to the 10/100 Mbit Ethernet network.
- Better security with password protection for the access to the protection relays via the serial hub
- Exchange of serial data via Ethernet network (e.g. DIGSI protocol, IEC 60870-5-103 protocol)
- Exchange of serial protocols via Ethernet without gaps in the telegram structure

Application

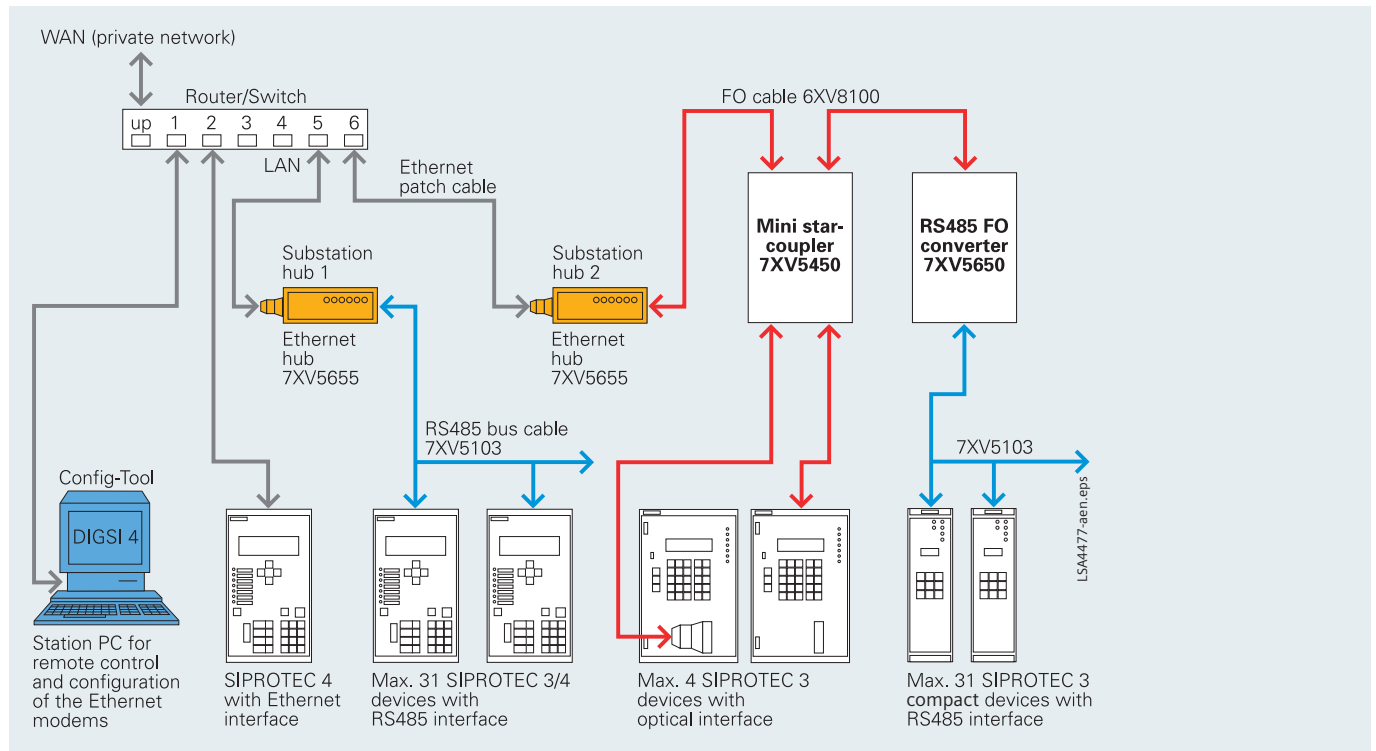


Fig. 13/65 Operation of various SIPROTEC protection unit generations via serial hub

Application

From the office PC running DIGSI 4 it is possible to select one of the serial hubs 1 and 2 via one of the virtual COM ports. In DIGSI 4, when the COM port is selected, a IP point-to-point data connection via the network is established and maintained between the office and the relevant substation modem until the interface is released. The serial data exchange takes place via this data link, whereby the data conversion from serial to Ethernet is full duplex. The office PC towards the network is always operating with high data rate, as the data is fed to the network via the network driver on the PC. The serial data rate of the serial hub in the substation is adapted to the baud rate set in the protection relay, e.g. serial hub 1 with 57.6 kbit/s for SIPROTEC 4 and serial hub 2 with 9.6 kbit/s for SIPROTEC 3 devices. These parameters must be pre-set

on the serial hub. With DIGSI 4 the serial hubs are integrated by means of further serial COM ports (max. 254). The connection to the IP address of the serial hub in the network is achieved by opening the corresponding COM port. If an Ethernet network to the substation or in the substation is available, serial data can then be transferred via this network.

The existing serial star or bus structure with cabling in the substation can still be used.

SIPROTEC 4 devices from version 4.6 and newer with integrated Ethernet interface may be connected directly to the router or switch by means of a patch cable.

Technical data

Connections

RS232 interface 9-pin SUB-D socket or
 RS485 interface 9-pin SUB-D socket selectable via DIL switch.
 FO interface 820 nm with ST connectors for connection to multi-mode FO cables.
 Ethernet 10BaseT, 10/100 Mbit, RJ45 connector to Ethernet
 Auxiliary voltage/alarm relay (5 terminals)

Housing

Rail mounting, plastic, charcoal grey, 90 x 90 x 107 (W x H x D) in mm

Wide-range power supply/fail safe relay

Auxiliary voltage DC 24 to 250 V and AC 115/230 V connected with screw-type terminals
 Alarm relay for monitoring of the device

Indication (8 x LED)

Power	Operating voltage o.k.	System	RS232 connection established
RS232 Tx/D	Transmitting data to RS232	RS232 Rx/D	Receiving data from RS232
LAN Tx	Transmitting data to LAN	LAN Rx	Receiving data from LAN
Error	Error on RS232	Link LAN	LAN connection established

Selection and ordering data

Description	Order No.
Ethernet hub for substations Serial hub for serial, asynchronous transfer of data up to 57.6 kbit/s via 10/100 Mbit Ethernet including configuration software. Connection to the Ethernet via RJ45 connector. Serial connection with S232/RS485 interface via SUB-D 9-pin socket or optical with 820 nm ST connector and multi-mode FO cable. Wide-range auxiliary supply for DC 24 – 250 V and AC 115/230 V. With gender-changer (pin-pin) for adaptation to DIGSI cable 7XV5100-4 (cable not included in the scope of supply).	7XV5655 - 0BA00



Fig. 13/66 Communication converter for X.21/RS422 and G.703.1

Description

The communication converter CC-XG for coupling to a communication network is a peripheral device linked to the protection device via fiber-optic cables, which enables serial data exchange between two protection relays. A digital communication network is used. The electrical interfaces in the CC-XG for the access to the communication device are selectable as X.21 (64 kbit/s, 128 kbit/s, 256 kbit/s or 512 kbit/s) or G.703.1 (64 kbit/s). At the opposite side, the data are converted by second communication converter so that they can be read by the second device. The communication converters thus allow two protection devices to communicate synchronously and to exchange large data volumes over large distances. Typical applications are the serial protection interfaces of differential protection and distance protection of SIPROTEC 4 devices 7SD52/53, 7SD61, 7SA52, 7SA6, and SIPROTEC 5 devices 7SD8, 7SA8 and 7SL8, where 7XV5662-0AA00 has to be used.

Should asynchronous serial data of differential protection 7SD51 or of the binary signal transducer 7XV5653/7XV5673 be transmitted, the device 7XV5662-0AA00 has to be used (asynchronous from 300 bit/s to 115.2 kbit/s dependent on the baudrate of X.21 or G.703.1 interface). Interference-free connection to the protection device is achieved by means of a multi-mode fiber-optic cable, with ST connectors at the CC-XG. The maximum optical transmission distance is 1.5 km (0.93 mile).

The CC-XG should be mounted or installed respectively near the DCE (data communication equipment) in the same cubicle frame or at least in the same room. The electrically connectable distance should be as short as possible; a few meters are favorable.

The data transfer between the protection devices is realized as a point-to-point connection that is bit-transparent. Data must be exchanged via dedicated communication Channels within the same communication system (not via switching points).

Function overview

- Optical interface with ST connector for connection to the protection unit
- Distance: 1.5 km (0.93 mile) with 62.5/125 μm and 50/125 μm multi-mode FO cable between CC-XG and the protection unit/serial device
- Electrical interface to the communication device via SUB-D connector (X.21, 15 pins, automatic detection and setting to 64, 128, 256 or 512 kbit/s or G.703.1, 9 pins, 64 kbit/s).
- Synchronous and Asynchronous mode now within one device, selectable by push-button.
- Synchronous data exchange for SIPROTEC 4 protection relays 7SD52/53, 7SD61, 7SA52, 7SA6, and all SIPROTEC 5 protection relays e.g. 7SD8, 7SA8 and 7SL8.
- Asynchronous data exchange for 7SD51 protection relay, Binary signal transmitter, 7XV5653/7XV5673 or other devices with asynchronous interface
- Monitoring of:
 - auxiliary supply voltage,
 - X.21: clock signal of communication network; G703.1: Receive dates are on and correspond to the standardized pulse mask.
 - and internal logic
- Fail safe relay (1 changeover contact, SIPROTEC standard)
- Loop test function selectable by push-button
- Wide-range power supply unit (PSU) for DC 24 to 250 V and AC 115 to 230 V

*) in preparation

Applications, functions, technical data

Application

Synchronous serial data exchange between two devices from same type:

SIPROTEC 4 : distance protection with teleprotection and differential protection (7SA52/6,7SD52/53/61); devices have to be equipped with optical module FO5.

SIPROTEC 5 : all device types possible(e.g.7SD8/A8/L8); devices have to be equipped with USART-AD-1FO or USART-AE-2FO.

Asynchronous serial data exchange between two devices from same type:

SIPROTEC 3 : differential protection (7SD51). Binary signal transmitter, SICAM I/O-Unit: I/O Mirror, bidirectional transmission of binary signals e.g. for teleprotection (7XV5653, 7XV5673).

Functions

The protection unit is optically linked to the CC-XG, which makes interference-free data transfer between the CC-XG and the protection unit possible. The communication converter is located close to the communication device. It adapts the FO active interface of the protection relay to the electrical specifications of the communication network interface. The interface types – optionally X.21/RS422 or G.703.1 – can be set by a push-button at the top of the device. The required transmission rate is automatically detected and set by the CC-XG.

Data transfer between the protection units is effected on the basis of a point-to-point connection, furthermore it is a synchronous, bit-transparent transmission via the communication network.

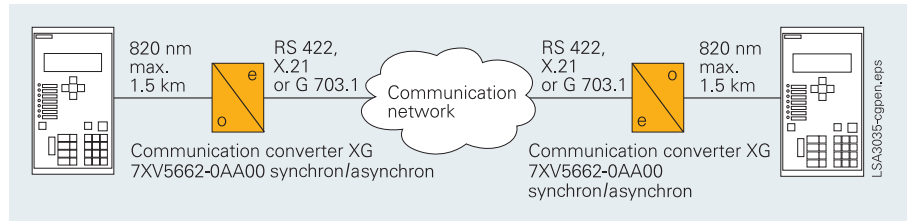


Fig. 13/67 Connection of two protection devices via a communication network linked with 7XV5662-0AA00 in synchronous or asynchronous mode.

Technical data

Rated auxiliary voltage

DC 24 to 250 V	± 20 %
AC 115 to 230 V	± 20 %
Power consumption	Approx. 2,5 W, <9,5 VA

LEDs

4 LEDs	
LED 1	Red: Error and loop mode
LED 2	-Green: the device operates in synchronous mode. -Yellow: the device operates in asynchronous mode.
LED 3	-Green: the device operates in synchronous mode -Yellow: the device operates in asynchronous mode.
LED 4	- Green: The device communicates via the G.703.1 interface. -Yellow: The device communicates via the X.21 interface.

Connectors

Power supply	2-pole screw-type terminal
Alarm/ready contact	3-pole make/break contact
Serial G.703.1 interface	9 pole SUB-D connector for 4-pole receive and transmit line
X.21 interface	15-pin SUB-D connector for electrical X.21/RS422 interface
FO cable	820 nm, 2 ST connectors for Tx/D and Rx/D for 62.5/125 μm multi-mode FO (max. distance to protection unit 1.5 km/0.93 mile)

Housing

Steel sheet housing	Dimensions 188 × 55 × 120 mm (W × H × D)
Weight	Approx. 0.8 kg
Degree of protection	According to EN 60529: IP41
For snap-on mounting onto 35 mm	EN 50022 rail

Operating modes of CC-XG 7XV5662-0AA00

Synchronous operation with	7SA52/6,7SD52/53/61; and all SIPROTEC 5 types possible e.g. 7SD8/A8/L8	
	<i>G.703.1: Interface selectable by push-button</i>	
	Setting in the protection unit	Automatic setting in CC-XG
	64 kbit/s per parameter	64 kbit/s
	<i>X.21/RS422: Interface selectable by push-button</i>	
	Setting in the protection unit	Automatic setting in CC-XG:
64 kbit/s per parameter	64 kbit/s	
128 kbit/s per parameter	128 kbit/s	
256 kbit/s per parameter	256 kbit/s	
512 kbit/s per parameter	256 kbit/s	
Asynchronous operation with	7SD51, 7XV5653/7XV5673 and units with asynchronous serial interface (no handshake supported, only serial TxD and RxD signals are supported)	
	<i>G.703.1: Interface selectable by push-button</i>	
	Setting in protection unit	Automatic setting in CC-XG
	max. 19.2 kbit/s	64 kbit/s
	<i>X.21/RS422: Interface settable by push-button</i>	
	Setting in protection unit	Automatic setting in CC-XG
	max. 19.2 kbit/s async.	64 kbit/s
	max. 38.4 kbit/s async.	128 kbit/s
	max. 57.6 kbit/s async.	256 kbit/s
	max. 115.2 kbit/s async.	512 kbit/s

Selection and ordering data

Description	Order No.
Communication converter for X.21/RS422/G.703.1 interface Converter to synchronous or asynchronous serial coupling of protection units with optical inputs/ outputs with ST connector to communication devices with electrical X.21/RS422 or G.703.1 interface. Connection to protection unit via FO cable for 62.5/125 µm and 820 nm wavelength, max. distance 1.5 km (0.93 mile), ST connectors Electrical with X.21/RS422 (15-pin SUB-D connector) or G.703.1 (9 pole SUB-D connector) Automatic detection and setting of baud rate. Interface type selectable by push-button. For synchronous operation with 7SD52/53, 7SD61, 7SA52, 7SA6, and all SIPROTEC 5 protection relays e.g. 7SD8, 7SA8 and 7SL8. For asynchronous operation with 7SD51, Binary signal transmitter, 7XV5653/7XV5673 or serial devices	7XV5662 - 0AA00



Fig. 13/68 Communication converter for pilot wires

Description

The communication converter copper (CC-CO) is a peripheral device linked to the protection device which enables serial data exchange between two protection relays. It uses a single pair of copper wires (pilot wire) that may be part of a telecommunications cable or of any other suitable symmetrical communications cable (no PuApin cable). At the opposite side, the data are converted by a second communication converter so that they can be read by the second protection device. The communication converters (master/slave) thus allow two protection devices to communicate synchronously and to exchange large data volumes over considerable distances. Typical applications are the protection interfaces of differential protection and distance protection of the devices 7SD5, 7SD6, 7SA52 and 7SA6, where 7XV5662-0AC00 must be used (synchronous connection with 128 kbit/s). Should asynchronous serial data of differential protection 7SD5 or of the binary signal transducer 7XV5653 be transmitted, the device 7XV5662-0AC01 must be used (asynchronous from 300 bit/s to 38.2 kbit/s).

Interference-free connection to the protection device is achieved by means of a multi-mode fiber-optic cable, with ST connectors at the CC-CO. The maximum optical transmission distance is 1.5 km (0.93 mile). The data transfer between the protection devices is realized as a point-to-point connection that is bit-transparent. Data must be exchanged via dedicated pilot wires, not via switching points.

Function overview

- Optical interface with ST connector for connection to the protection unit
- Distance: 1.5 km with 62.5/125 μm multi-mode FO cable between CC-CO and the protection unit
- Electrical interface to the pilot wire (line) with 2 screw-type terminals. 5 kV isolated
- Synchronous data exchange for 7SD52, 7SD6, 7SA6 and 7SA52 via pilot wire (typ. 15 km) (CC-CO version -0AA00)
- Asynchronous data exchange for 7SD51, 7XV5653 or other units with asynchronous interface (CC-CO version -0AA01) (typ. 15 km)
- Loop test function selectable by jumpers in CC-CO
- Master or slave mode of the CC-CO selectable by jumper (one master and one slave device required at the end of the pilot wire, factory presetting: master mode)
- Wide-range power supply with self-supervision function and alarm contact

Application, functions

Application

The CC-CO can be used for two applications.

One application is the synchronous serial data exchange (converter version – 0AA00) between SIPROTEC 4 differential relays (7SD52, 7SD6) and/or the serial teleprotection between distance relays (7SA6 and 7SA52). The relays have to be equipped with an optical 820 nm plug-in module “FO5”.

Another application is the transmission of asynchronous serial data via pilot wires to the line differential protection relay 7SD51 or the binary signal transmitter 7XV5653. Other serial devices may also be used.

If the maximum distance between the protection units is longer than spanned by two CC-CO, the converters can be cascaded (see Fig. 13/70). A power supply between the two master units is required. If the isolation level is higher than 5 kV (provided by the pilot wire inputs of the units), external isolation transformers (barrier transformers) can be used on both sides. These transformers offer 20 kV isolation voltage and thus help to avoid hazardous high voltages at the inputs of the CC-CO, which might be induced by a short-circuit from a parallel power line or cable.

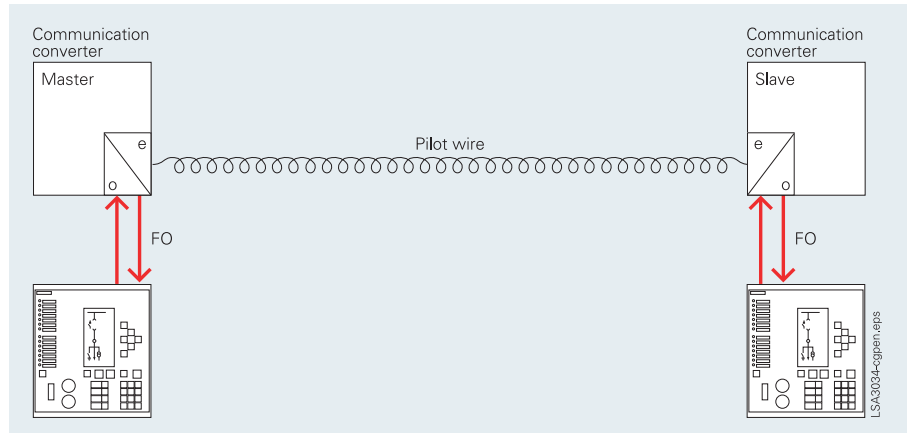


Fig. 13/69

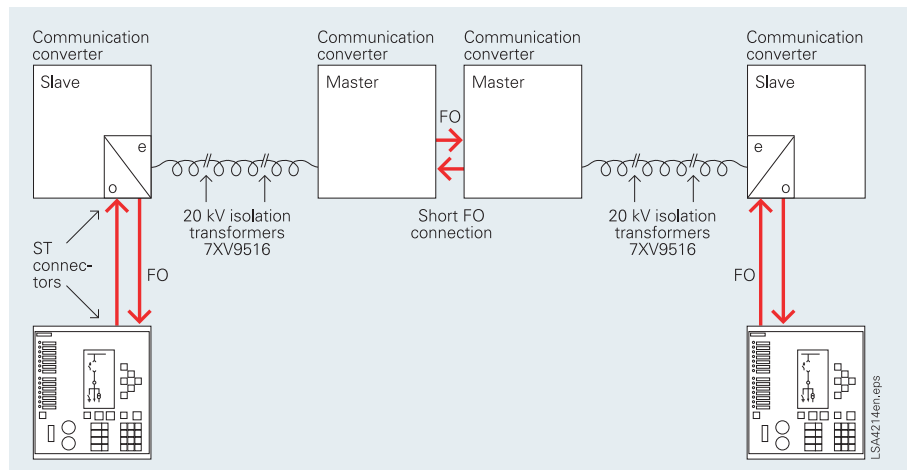


Fig. 13/70

Functions

The protection unit is optically linked to the CC-CO, which makes interference-free data transfer between the CC-CO and the protection unit possible. The communication converter is located close to the pilot wire. It converts serial data of the protection unit into a frequency-modulated signal. This signal is transmitted via one pair of copper wires of a pilot wire/communication line (bi-directional, full duplex operation).

By means of jumpers, one unit is defined as “master” and the other unit as “slave”. In a “training” during commissioning, the electrical characteristics of the pilot wire are measured by pressing a pushbutton, and the CC-COs are tuned to these characteristics.

The measured characteristics are used as parameters that will be adhered to for optimal data transfer. Digital data transfer makes a low insulation level of the pilot wire possible, because no high voltages are produced on the pilot wire during short-circuit conditions.

Data transfer between the protection units is effected on the basis of a point-to-point connection, furthermore it is a synchronous, bit-transparent transmission. Due to the telegram-backed data exchange, mal-operation is ruled out.

Technical data

Rated auxiliary voltage

DC 24 to 250 V	± 20 %
AC 115/230 V	± 20 % without switchover

LEDs

4 LEDs	
LED 1	Red: Line activation
LED 2	Yellow: Line transparent
LED 3	Yellow: Data transfer
LED 5	Green: Power ON

Connectors

Power supply	2-pole screw-type terminal
Alarm/ready contact	3-pole make/break contact
Pilot wire	2-pole for pilot-wire connection 5-kV isolated inputs
FO cable	820 nm, 2 ST connectors for TxD and RxD for 62.5/125 µm multi-mode FO (max. distance to protection unit 1.5 km)

Pushbutton

Measuring and training of parameters of the pilot wire

Housing

Aluminum die-cast housing	Dimensions 188 x 56 x 120 mm (W x H x D)
Weight	Approx. 0.8 kg
Degree of protection	According to EN 60529: IP41
For snap-on mounting onto 35 mm	EN 50022 rail

Operating mode

Synchronous operation with	7XV5662-0AC00 for 7SD52, 7SD6, 7SA52 and 7SA6 Setting in the protection unit: 128 kbit/s per parameter Setting in CC-CO: 128 kbit/s. No setting required
Asynchronous operation with	7XV5662-0AC01 for 7SD51, 7XV5653 and units with asynchronous serial interface (no handshake supported, only serial TxD and RxD signals are supported) Max. baud rate for protection unit: 38.4 kbit/s Max. baud rate for CC-CO 128 kbit/s. No setting required
Max. distance with pilot wire	AWG 22/0.33 mm ² / 51.7 Ω/km: max. 11 km AWG 26/0.13 mm ² / 137 Ω/km: max. 4.5 km Shielded twisted pair (STP) recommended. Max. loop resistance: 1400 Ω Attenuation < 40 dB at 80 kHz

Selection and ordering data

Description	Order No.
Communication converter for pilot wires	7XV5662 - 0AC0 <input type="checkbox"/>
Converter for synchronous or asynchronous serial coupling of protection units with optical inputs/outputs with ST connector to conventional pilot wires. 5-kV isolation of unit analog inputs towards the pilot wires. Connection to protection unit via FO cable for 62.5/125 µm and 820 nm wavelength, max. distance 1.5 km, ST connectors Synchronous serial data 128 kbit/s Asynchronous serial data rate max. 57.2 kbit/s For synchronous operation with 7SD52, 7SD6, 7SA6, 7SA52	0
For asynchronous operation with 7SD51, 7XV5653 for other units	1



Fig. 13/71 Communication converter

Function overview

- Interference-free protection data transfer of two independent serial data signals, selectable either in synchronous or asynchronous mode.
- PC interface for operation of devices at the remote line end.
- Network interface as E1 or T1 format for connection to multiplexer.
- Wide-range power supply from DC 24 V to 250 V and AC 115/230 V with failsafe relay.
- Indication of the data exchange via LED
- Integrated commissioning aid (loop test)

Description

The CC-2M communication converter is used for serial data transmission over long distances via a communication network. It converts synchronous or asynchronous serial 820 nm optical input signals at inputs FO1 and FO2 to a network interface and again returns these signals at the remote terminal via the latter's interfaces. FO1 and FO2 may be configured independently for either synchronous or asynchronous operation, but must be set to the same operating mode at both ends. In synchronous mode, the interface should only be used for exchanging the protection data of the 7SD5/7SD6 differential protection or 7SA52/7SA6 distance protection and is preconfigured for 512 kbit/s. In asynchronous mode, the interface can be used for connection of devices with baud rates between 1.2 to 115.2 kbit/s. A further asynchronous electrical RS232 interface is provided for max. 115.2 kbit/s. It provides for the connection of a serial PC interface with DIGSI and thereby the operations interface to SIPROTEC devices at the remote end. The G.703.6 network interface is provided in the form of 4-way screw terminals and can be configured as a 2-Mbit/s interface with European E1 format or as a 1.544-Mbit/s interface in the American T1 format. All settings of the device are made with jumpers, so that no special PC software is required.

Application

Application

Two protection devices e.g. 7SD52/7SD610 differential protection or 7SA52/7SA6 distance protection, exchange protection data via FO1. Interference-free data exchange is performed via the communication network, the devices being connected synchronously with 512 kbit/s (connection 1; see Fig. 13/72). Protection remote control with DIGSI is connected to FO2 of the converter via a 7XV5450 mini star-coupler. This port provides the serial connection to the other substation with a PC on which DIGSI is installed. In this way, the remote protection devices can be remotely interrogated via FO2 (connection 2). The baud rate is optimally set to 57.6 kbit/s for SIPROTEC 4 devices, so that there is no difference from local operation. The data of the devices on the other substation can be changed and read out during commissioning and operation.

Alternatively, it is possible to connect a substation control system or additional protection data transmission to FO2.

This makes for optimum use of the 1.544/2 Mbit/s transmission channel for two separate serial connections. In addition, an asynchronous serial connection is available via the RS232 interface, which can be used to temporarily operate devices of the other substation with DIGSI.

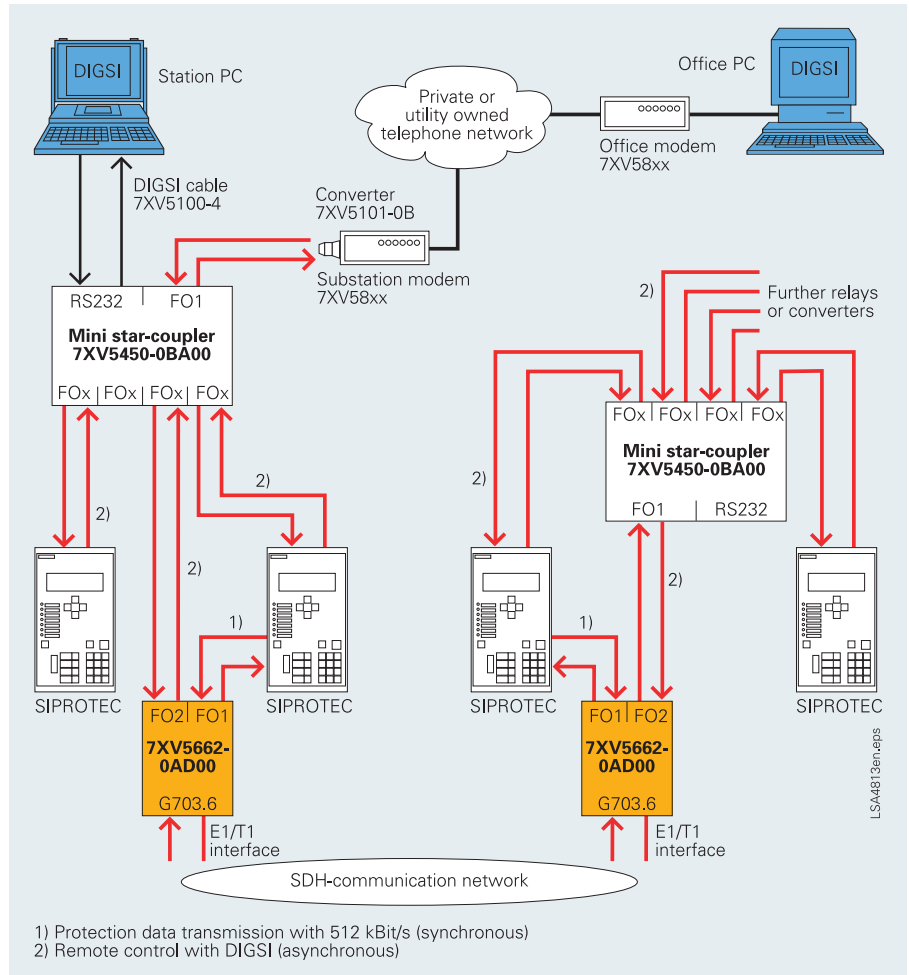


Fig. 13/72 Protection data transmission and remote control of a substation via a communication network

LSA4813en.eps

Technical data

Connections

FO 1 / 2	ST plug / 820 nm for 50/125 µm or 62.5/125 µm multi-mode FO cable (max. 1.5 km)
RS232	For asynchronous connection from 1.2 – 115.21 kbit/s
Power supply	2-pole screw-type terminal
Fail safe relay	3-pole screw-type terminal with NC/NO contact
Network E1/T1	4-pole screw-type terminal

Housing

Aluminium housing 188 × 56 × 120 mm for mounting on 35 mm rail mounting according to EN 50032 weight 0.8 kg. Protection class according to EN 60529: IP41

Power supply

Wide range DC 24 to 250 V and AC 115/230 V, 50/60 Hz

Displays

4 LEDs	
Green	Power supply
Red	Fault alarm
2 yellow	Data transfer

Selection and ordering data

Description	Order No.
<p>Two-channel serial 1.544/2 Mbit/s communication converter</p> <p>Conversion of 2 independent serial FO interfaces with synchronous or asynchronous data to a E1 network interface with 2 Mbit/s (G.703.6) or T1 network interface (1.544 Mbit/s). Two independent serial optical input channels with ST connectors and 820 nm for multi-mode FO cable for a max. of 512 kbit/s / 115.2 kbit/s for synchronous/asynchronous data. An electrical serial RS232 interface with a max. 115.2 kbit/s constructed as a 9-pin SUB-D socket for connection with DIGSI 7XV5104 cable. Connection from multiplexer to the E1/T1 network interface via a 4-poles crew-type terminal. Wide-range power supply of DC 24 V to 250 V and AC 115/230 V. A make/break fail safe contact for power supply faults or interruption of the data connection. All settings are made with jumpers in the device (presetting for E1 and synchronous serial data input).</p>	7XV5662 - 0AD00

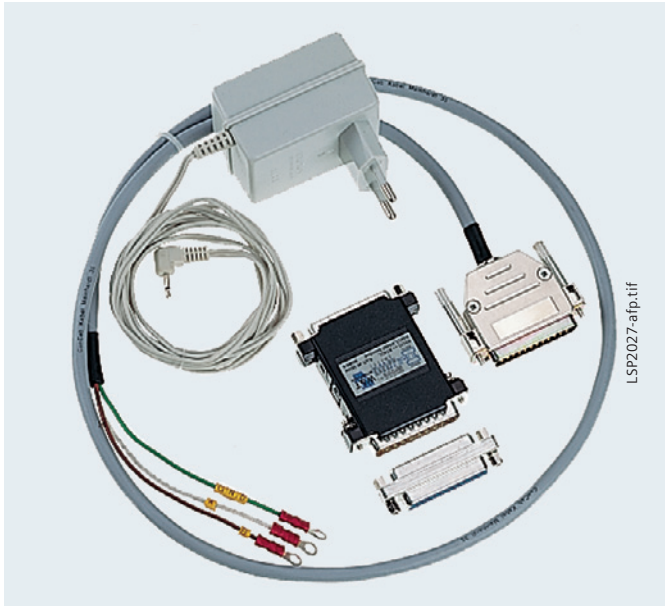


Fig. 13/73 RS232 – RS485 converter

Function overview

- Minimum baud rate: 9600 baud
- Maximum baud rate: 115 kbaud
- No setting of baud rate necessary
- Compact plug casing
- Power supply via plug in PSU
- Maximum 31 relays at RS485 bus
- Complete set for connecting 1 relay to RS485 bus

Description

Up to 31 SIPROTEC 4 relays with an electrical, bus-capable RS485 interface to a PC for centralized control can be connected via the RS232↔RS485 converter.

The converter is housed in an expanded plug casing. The interfaces are connected to 25-pin female connectors. The auxiliary voltage is supplied via a plug-in power supply unit attached to the side. Auxiliary voltages of AC 110 or 230 V make operation with all common AC networks possible.

A twisted and shielded cable with two wires is required for the RS485 bus. The protection relays are connected to the bus in series. Data transmission at a speed of 19.2 kbaud with a bus length of up to approximately 1000 m is possible.

The converter, plug-in power supply unit and the connecting cable to the first relay are included in the scope of supply.

Applications, functions

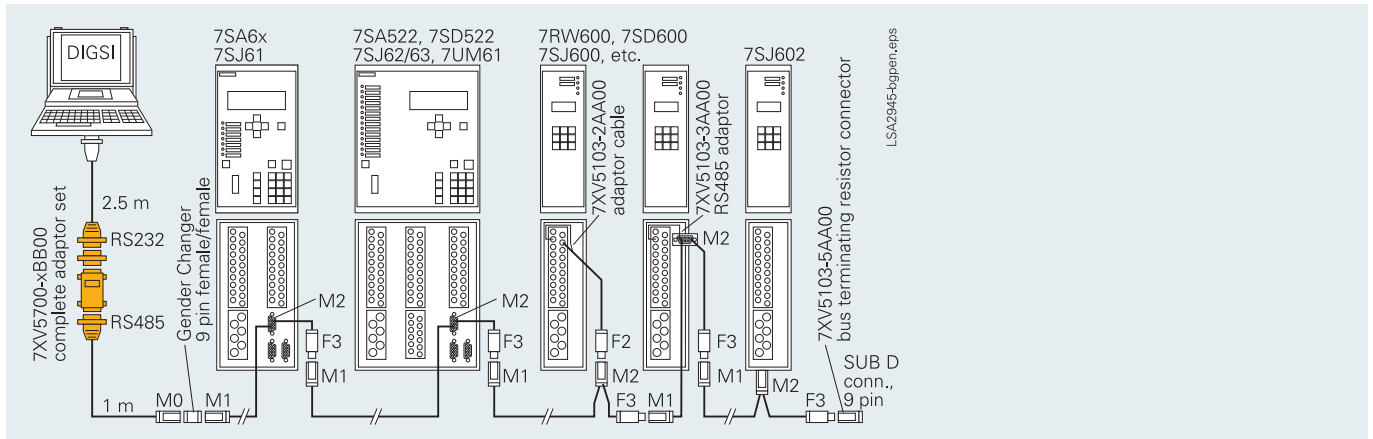


Fig. 13/74 Protection units connected to the RS485 bus

Note

The converter may not be used with a substation modem due to non-existing isolation.

It is recommended to use the 7XV5650 and 7XV5651 converters in conjunction with the substation modem.

Applications

The RS232↔RS485 converter allows up to 31 SIPROTEC 4 protection relays with electrical busable RS485 interfaces to be connected to a PC notebook.

The converter is housed in an expanded plug casing. The interfaces are connected to 25 pin female connectors. The RS485 interface has a terminating resistor. The auxiliary voltage is supplied via a plug-in power supply unit attached to the side. Auxiliary voltages of AC 110 V or 230 V make operation with all common AC networks possible.

Functions

The converter works according to the master/slave principle. In idle state, the RS232 interface is inactive while the RS485 interface is switched to the receiving mode. During communication, the PC (master) sends data to the RS232 interface, which are transmitted (half duplex) to the protection unit (slave) by the converter at the RS485 interface. After data transmission, the RS485 interface is once again switched to the receiving mode. Vice versa, data supplied by the protection unit are sent back by the converter to the RS232 interface and to the PC.

No handshake signals are being processed during communication. This means that data sent by the PC are mirrored, which may cause problems in special applications.

Connections

The PC is connected to the converter by means of a DIGSI cable e.g. 7XV5100-2.

A twisted and shielded cable with two wires is required for the RS485 bus. The conductor cross section has to be adapted to the ring cable lugs and the SUB-D connectors. The individual wires protruding from the shield should be kept as short as possible. The shield is connected to the housing ground at both ends. The protection units are connected in series to the bus. The shield between the converter and the protection units, or between the protection units, is connected at both sides. Whenever substantial cable lengths or high baud rates are involved, a terminating resistor of 220 ohm should be applied between signal lines A and B at the last protection unit. Data transmission at a speed of 19.2 kbit/s, with a bus length of up to approx. 1000 m, is possible.

Technical data

Design

Plug chassis	Plastics
Dimensions	63 × 94 × 16 mm (W × H × D)
Degree of protection	IP20

Power supply

Power supply	AC 110 or 230 V
Via	Plug-in power supply unit

Electrical interfaces

Type	RS232 to RS485 (non-isolated)
Assignment	See Fig. 13/74

CE conformity, standards

This product is in conformity with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to the electromagnetic compatibility (EMC Council Directive 2004/108/EG previous 89/336/EEC).	Conformity is proved by tests performed by Siemens AG in accordance with the generic standards EN 50081-1 and EN 50082-2.
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Selection and ordering data

Description	Order No.
7XV5700 RS232 – RS485 converter	7XV5700-□□□00
Rated auxiliary voltage	
Via plug-in auxiliary power supply unit (PSU) 230 V / 50 Hz AC	0
Via plug-in auxiliary PSU 110 V / 60 Hz AC	1
Connecting cable	
With RS485 connecting cable for 7SJ60, 7RW60, 7SD6, 7SV60, length 1 m	A
With RS485 connecting cable for SIMEAS Q and SIPROTEC 4, length 1 m	B
With RS485 connecting cable for SIMEAS T, length 1 m	C
Without RS232 connecting cable	A
With RS232 connecting cable 7XV5100-2 for PC / notebook, 9 pin	B
With RS232 adaptor, 25-pin connector (male) to 9-pin connector (female) for PC / notebook	C



Fig. 13/75 USB – RS485 converter cable

Function overview

- Compact connector housing
- USB 2.0/1.1 interface Type A
- RS485 interface 9-pin SUB-D
- Max. bus length 800 m
- Termination resistances switchable
- Baudrates 300 to 115000 baud
- Indicated data transfer (data LED)
- Protocol transparency (not only for PROFIBUS)
- Power supply via USB connector (no galvanic separation)
- Compatible with 7XV5103 bus system (with gender changer 9-pin female / female)

Description

The USB converter cable with its special pin assignment allows temporary connection of up to 31 Siemens protection devices having an electrical RS 485 interface to a PC with a USB interface for direct or central control with DIGSI 4.

The converter is connected directly to the PC via a standard USB connector (type A). The RS485 connector (9-pin SUB-D male) may be used for direct connection to SIPROTEC 4 devices with RS485 interface modules. To connect individual compact devices with an RS485 interface on terminals, e.g. 7SJ600, 7SD600, 7RW600, etc., the 7XV5103-2AA00 or -3AA00 adapter is required. Using the gender changer (female-female), which is included, the converter may also be connected to the 7XV5103 bus system, which enables communication with all the devices connected to the bus. Because the cable includes a switchable bus termination, it may be connected at either end or in the middle of the bus. The converter draws all the power it needs via the USB interface of the PC.

Application

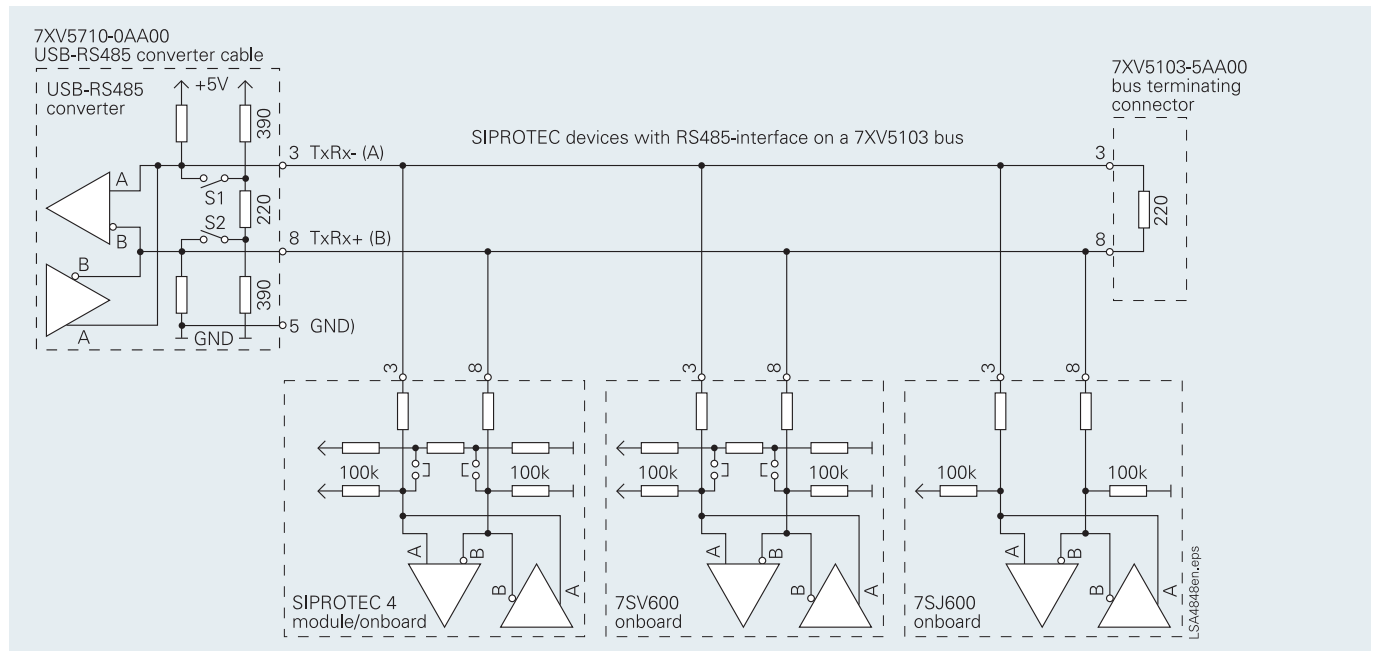


Fig. 13/76 PRS485 bus with USB converter cable 7XV5710 and several SIPROTEC devices (connection diagram)

Application

Data transfer

Before the converter cable is first used, a USB driver must be installed from the CD supplied. The driver creates a new virtual COM port, which may then be selected by the application, e.g. DIGSI 4. The converter works in half-duplex mode on the master/slave principle.

In the quiescent state, the USB interface is inactive and the RS485 interface is ready to receive. For communication, the PC, acting as the master, transmits its data to the USB interface, which in turn forwards the data from the converter at the RS485 interface to the protection device (slave). Following this, the RS485 interface is switched back to receive. Data coming from the protection is now transmitted in the other direction to the USB interface and PC by the converter. A data LED indicates when data transfer is active.

Connection of the compact devices, e.g. 7SJ600 with terminals (without bus cables 7XV5103)

A shielded twisted pair (STP) cable must be used for the RS485 bus. The conductor cross-section must be suitable for termination with ring lugs or SUB-D connectors. The protection devices are connected to the bus in line (not in star or ring topology). The core ends protruding from the shield should be kept as short as possible.

The shield must be connected to the housing ground at both ends. At the last protection device, a 220-ohm terminating resistor is connected between data cores A and B.

Termination of the RS485 bus

The RS485 bus is a two-wire bus (half duplex) over which up to 32 devices (participants) can exchange their data on the master/slave principle. All devices are connected to the bus in line (not in star or ring topology). At the first and last devices, a 220-ohm bus terminating resistor is connected between pin 3 (A) and pin 8 (B), irrespective of whether this is a master or slave device.

The SIPROTEC protection devices are preferably connected to the bus as a slave behind a master, e.g. 7XV5710 or 7XV5650/51 RS484 converter. In these converters (1st device) the terminating resistor may be implemented by additional pull-up/pull-down resistors via DIL switches (S1, S2). The "low-resistance" pull-up/pull-down resistors are essential in various SIPROTEC bus applications, i.e. the use of other converters may result in problems.

In the protection devices, the terminating resistor must only be activated at the last device on the bus using the jumpers provided for that purpose. If this is not possible in the device, an external terminating resistor, e.g. 7XV5103-5AA00 must be applied behind the last device (see Fig. 13/76).

In this example, the terminating resistors of the converter cable are active (default), the terminating resistors that are available at some of the protection devices remain inactive. The bus is terminated after the last device with the 7XV5103-5AA00 bus terminating connector or an external resistor (220 W). If the last protection device has a switchable terminating resistor, this may also be activated to ensure termination.

Accessories/7XV5710

Technical data, selection and ordering data

Product	USB converter cable 7XV5710-0AA00
Handshake	None
TX/RX switchover	Automatic
Serial data transmission channels	Half-duplex 2-wire
Power supply	+5 V via USB (max. 80 mA) Module logs on with 96 mA at the USB Max. 38 mA ready (converter on, no data transmission) Max. 80 mA full-duplex 4-core operation, (max. data rate)
Serial transmission rates	300, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200 bits/s
Status indication	Tx and Rx - 3 mm LED red
Operating temperature	-5 up to +70°C
Driver software	Windows 98, Windows 98 SE, Windows 2000, ME, XP, Vista 32/64, Windows 7 32/64.
Certification	No administrator rights required. CE-compliant / RoHS-compliant
Application	Non-permanent installation with SIPROTEC – devices

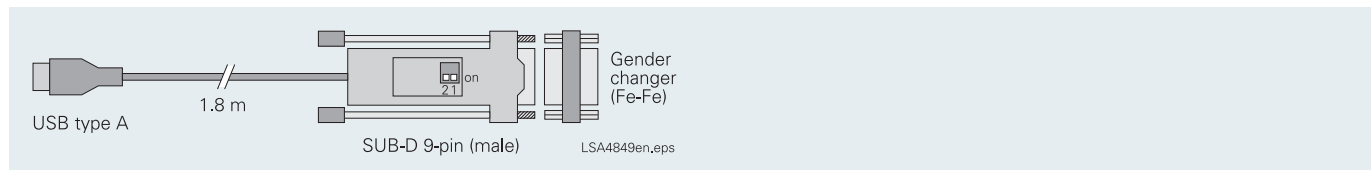


Fig. 13/78 68 USB converter cable with connector.
 Default switch position:
 S1+S2ON = terminating resistor active
 Dimensions: 75 × 32 × 15 (l × w × h)

Selection and ordering data

Description	Order No.
USB – RS485 converter cable USB 2.0 /1.1 with connector type A to RS485 with 9-pin SUB-D male connector, pin assignment for SIPROTEC 4 and SIMEAS Q, bus termination switchable, power supply via USB interface, incl. 9-pin female-female gender changer and driver CD For the connection of individual compact protection devices with the RS485 interface on terminals, e.g.. 7SJ600, 7SD600, 7RW600, etc., the 7XV5103-2AA00 adapter cable or the 7XV5103-3AA00 adapter is required	7XV5710 - 0AA00

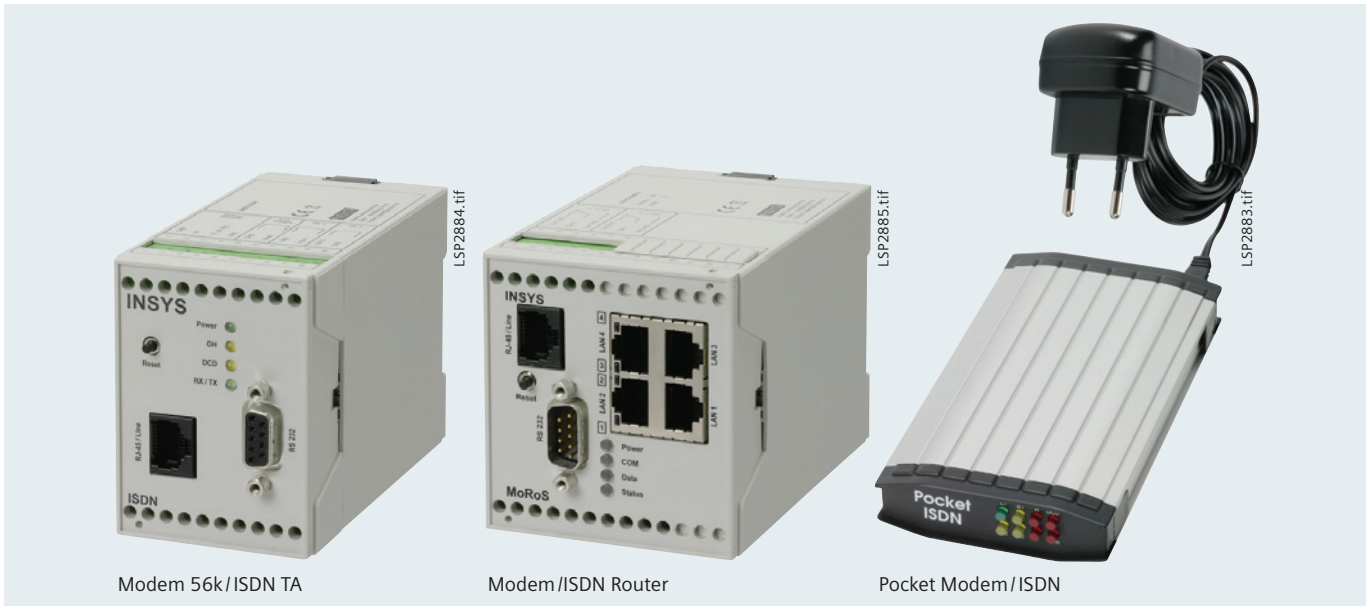


Fig. 13/79 Industrial modems

Description

Depending on the available infrastructure and transmission requirements, various modems and routers are available for the remote communication with SIPROTEC protection devices using DIGSI.

The existing infrastructure may consist of analog or digital (ISDN) transmission networks, which may be private (internal telephone system) or a leased line. This may determine the corresponding combinations of the modems or routers. A suitable combination usually consists of a desktop device with plug adapter in the office, and a rail-mounted device in the substation (see Application). The rail-mounted devices may be operated with an optional wide-range power supply adapter with all alternating current networks as well as station batteries.

The desktop analog modem "Pocket 56k" as the office device and the rail-mounted "Modem 56k" in the substation ensure a secure serial data communication with SIPROTEC 3 devices using 8E1 (with parity bit) up to 19.2 kbit/s, or with SIPROTEC devices using 8N1 up to 57.6 kbit/s.

With the same analog modem "Pocket 56k" in the office it is possible to establish a connection to SIPROTEC 4 devices with EN100 interfaces in a local Ethernet network using the rail-mounted modem router "MoRoS Modem 56k" in the substation.

Using the digital modem "Pocket ISDN" as a desktop device in the office and the "ISDN TA" as a rail-mounted device in the substation ensures secure serial data communication with SIPROTEC 3 devices using 8E1 (with parity bit) up to 19.2 kbit/s, or with SIPROTEC 4 devices using 8N1 up to 57.6 kbit/s.

With the same digital modem "Pocket ISDN" in the office, it is also possible to communicate with SIPROTEC 4 devices with an EN100 interface module in a local Ethernet network using a rail-mounted ISDN router "MoRoS ISDN" in the substation.

Other combinations, especially with devices from other manufacturers are strictly not recommended.

All versions are suitable for application in control systems, and substations as well as in areas of energy supply and distribution. The modems can be deployed internationally (certificates of approval see "Technical Data"). As a rule, no certification is required for use in internal networks.

Application

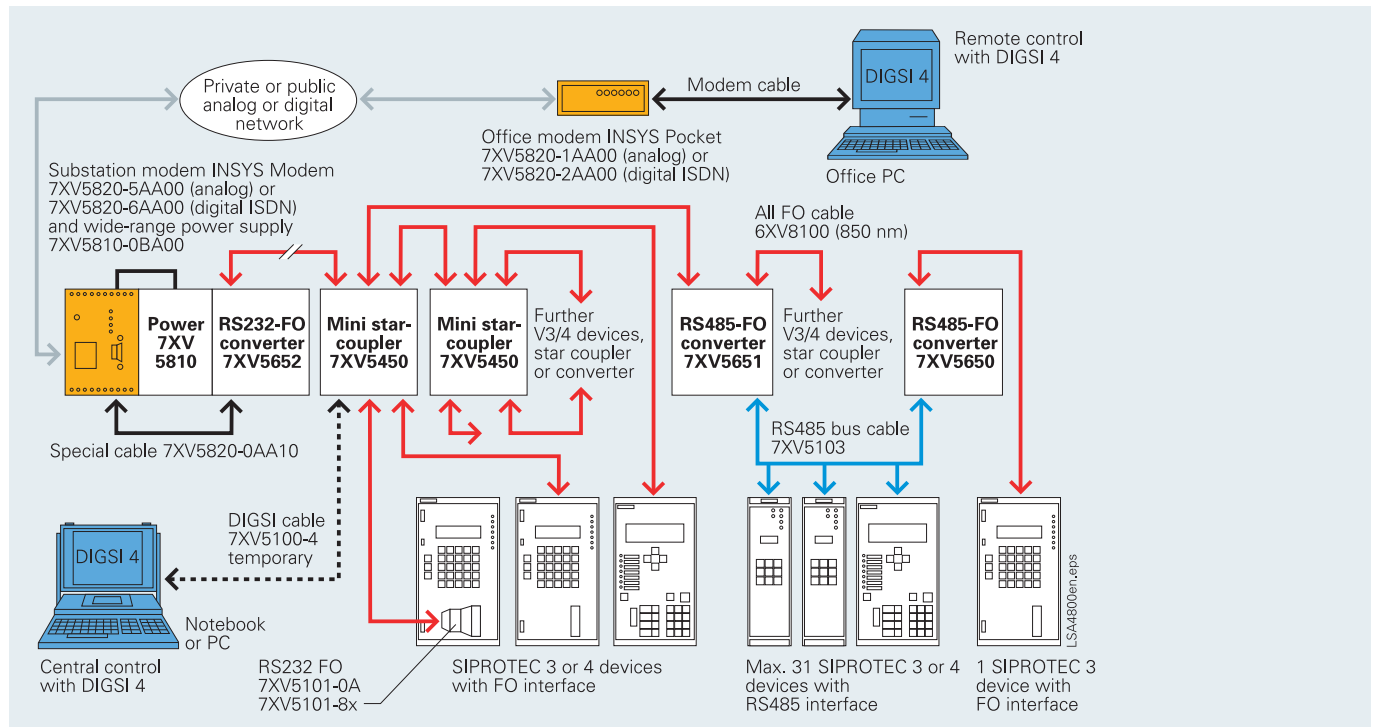


Fig. 13/80 Remote control of SIPROTEC 3 and 4 devices over INSYS Pocket to INSYS Modem, mini star-coupler or RS485 bus with DIGSI 4

Application

Example 1: Remote operation of SIPROTEC 3 devices via modem

This application example illustrates remote operation of SIPROTEC 3 protection devices with an optical interface and compact protection devices with an RS485 interface using analog modems (7XV5820-1 and -5) or digital ISDN modems (7XV5820-2 and -6). Connection to protection or bay control RTUs via an optical interface is achieved with a star configuration using cascadable star couplers. The compact protection devices with RS485 interface are connected via a FO-RS485 converter and the RS485 bus system 7XV5103. SIPROTEC 4 devices may be connected optically or electrically, depending on the available service interface

To ensure secure lightning protection, galvanic separation between the substation modem and the protection devices must be implemented by means of an optical barrier. The substation

modem with the 7XV5652 RS232-FO converter is preferably located in a communication or control room while the 7XV5450 star coupler or 7XV5650/51 FO-RS485 converter is located in the first protection cubicle. If the protection devices are to be controlled centrally in the substation using a notebook, this is achieved by plugging a DIGSI cable into the first star coupler, which disables the optical interface and enables the RS232 connection.

Communication with the modems is transparent. Secure data transfer to the SIPROTEC 3 devices is achieved with the data format 8E1 (with parity bit). The data transmission rate depends on the slowest device (9.6 kbit/s or 19.2 kbit/s) and must be set to be equal for all devices. The SIPROTEC 4 devices can then only be operated with this data rate which is relatively slow for SIPROTEC 4.

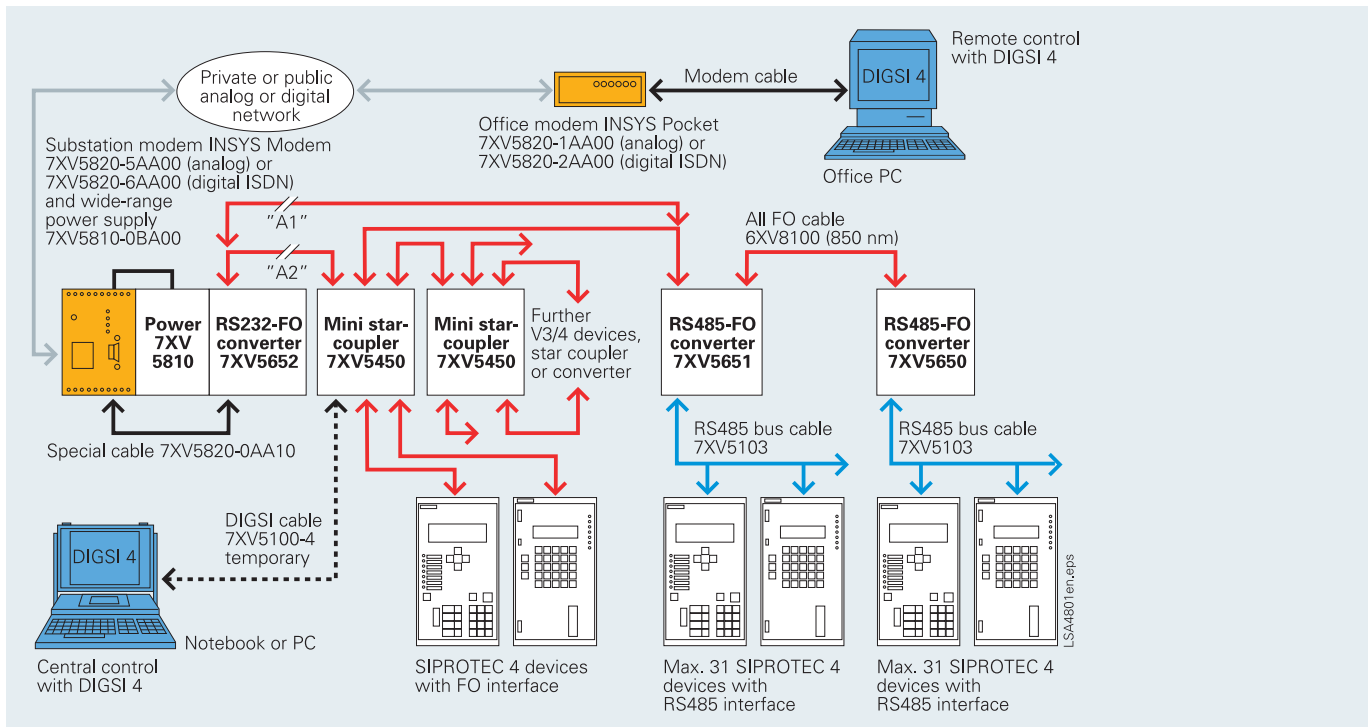


Fig. 13/81 Remote control of SIPROTEC 4 devices over INSYS Pocket to INSYS Modem, mini star-coupler or RS485 bus with DIGSI 4

Example 2: Remote operation of SIPROTEC 4 devices via modem

This application example illustrates remote operation of SIPROTEC 4 devices with an optical or RS485 interface via analog modems (7XV5820-1 and -5) or the very much faster digital ISDN modems (7XV5820-2 and -6). Connection of the protection or RTU devices with optical interface is achieved via cascable star couplers. The devices with RS485 interfaces are connected via the FO-RS485 converter and the RS485 bus system 7XV5103.

To ensure secure lightning protection of the RS485 bus, galvanic separation should always be implemented between the substation modem and the protection devices by means of an optical barrier. The substation modem with the RS232-FO converter 7XV5652 is preferably located in a communication or control room while the first FO-RS485 converter 7XV5651/50 is located in the first protection cubicle ("A1").

If the protection devices are to be centrally controlled in the substation, an additional star coupler must be used ("A2"). By plugging the DIGSI cable into the first star coupler, the optical interface is disabled and the RS232 connection is established. If no mini star coupler is used, central operation is only possible via the electrical interface of the RS232 converter. The modem plug must be disconnected for this purpose.

A secure communication via the modems is possible with the standard data format 8N1, with data compression and error correction. The data transmission rate is determined by the slowest device (38.4 kbit/s or 57.6 kbit/s) and must be set to be the same on all devices.

Application

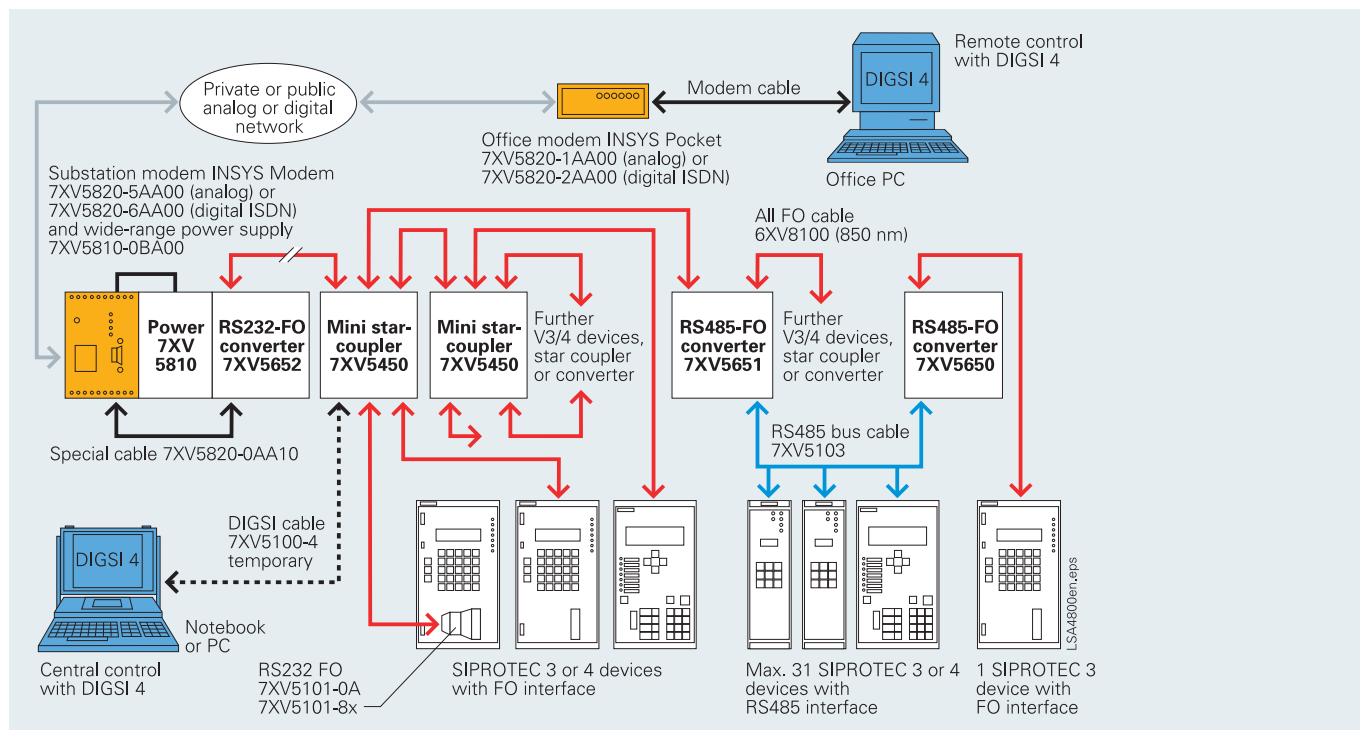


Fig. 13/82 Remote control of SIPROTEC 4 devices with EN100 Ethernet module with DIGSI 4 over INSYS Pocket Modem/ISDN to INSYS Modem/ISDN router with switch and external optical/electrical switch

Example 3: Remote operation of SIPROTEC 4 devices with Ethernet interfaces via a modem-router

This application example shows remote operation of SIPROTEC 4 protection devices with an optical or electrical EN100 Ethernet interface via an analog or digital ISDN office modem, (7XV5820-1 or -2), to a modem or digital ISDN router (7XV5820-7 and -8). This router with an integrated 4-way switch together with the RUGGEDCOM switches connected via a patch cable form a local subnet.

The protection or RTU devices with optical EN100 interface are connected to the RUGGEDCOM switches in a ring structure. The protection / RTU devices with an electrical EN100 interface are directly connected to the modem-router and switch or to the electrical interfaces of the RUGGEDCOM switches by means of double-shielded patch cables. To minimize any possible interference, the electrical connections with patch cables should be kept as short as possible.

Remote connection from the office to the substation is established by means of a password-protected DUN connection under Windows. The connection is then "transparent" and the protection devices can be operated with DIGSI 4 in the local subnet with their own IP addresses.

If the protection devices are to be conveniently centrally controlled using a notebook in the substation, the notebook with an Ethernet interface can be logged into the local subnet with a patch cable.

Secure communication via modems is performed at 57.6 kbit/s, with standard data format 8N1 with data compression and error correction



Fig. 13/83 7XV5810/7XV5820 pocket modem

Description

Data communication in the private, commercial and industrial applications is becoming ever more important.

INSYS Pocket Modem 56k and INSYS Pocket ISDN TA fascinate with their sophisticated engineering and their shapely compact metal housing.

The devices are ideal as remote stations for our DIN rail series.

Technical data

Modem	7XV5820-1AA00	7XV5820-2AA00
Network interface, line requirement	Analog telephone network	ISDN net, S0/I.430 Euro ISDN DSS1
Data transmission rate	Up to 56 kbits/s	64 kbit/s
Software update	Flash	Flash
Approvals	R & TTE, CTR21	R & TTE, CTR3
Application	For international use	Europe
Standards	Developed according to CE directives, manufactured according to ISO 9002	Developed according to CE directives, manufactured according to ISO 9002
Features		
Configuration	Remote configuration, AT commands	Local, via PC terminal, remote via ISDN
Connection	Auto answer mode, hardware-handshake Speed adjustable, sleep mode, auto-bauding, display caller ID	Auto answer mode with optional phone number verification
Data format	10 and 11 bit: 7E1, 7O1, 7N2, 7E2, 7O2, 8N1, 8E1, 8O1, 8N2	B channel: V.110, X.75, V.120, X.25/X.31, HDLC (PPP), T70NL, T90NL D channel: 1TR6 DSS1, VNx
Protocols	V.92, V.90, V.34+, V.34, V.32bis, V.32, V.23, V.22bis, V.22, V.21, Bell Norm 103/212, Fax class 1/2	–
Compression	MNP5, V.42 bis, MNP 10, 10 EC, V.44	–
Error correction	MNP 2/3/4 and V.42	–
Security functions	Security call-back, alarm transmission, SMS to fixed network or as fax over AT command, selective call answer, line-in-use detection, selectable key-abort	Access protection via approved phone number (accessible), password protection of remote configuration
Electrical features		
Power supply	DC 9 ... 10 V (with plug power supply AC 230 V)	DC 5 V (with plug power supply AC 100 to 230 V)
Consumption	Approx. DC 140 mA	Max. 100 mA at 5 V/500 mW
Interface to application	RS232, 9-pin SUB-D jack	RS232, 9-pin SUB-D jack
Interface to network	RJ-12 (Western)	RJ-45 connector
Physical features		
Size in mm (W × D × H)	71 × 128 × 22	71 × 128 × 22
Temperature range	0 to 55 °C	0 to 55 °C
Humidity	0 to 95 % (non-condensing)	0 to 95 % (non-condensing)

Accessories/7XV5820

7XV5820 INSYS modem 56k Profi, 7XV5820 INSYS ISDN TA Profi



Fig. 13/84 7XV5820 modem

Description

With the INSYS Modem 56k Profi any application can be connected to the analog telephone network, which is available worldwide. The INSYS ISDN 4.0 can easily be connected to the digital ISDN network.

Both modems enhance pure data communication with alarming and security functions: alarms with a user-defined text as an SMS, fax or e-mail are triggered by digital inputs. Data connections (INSYS Modem 56k) and remote control are protected by passwords. The INSYS 56k modem establishes a connection only to a predefined number in response to an incoming call if the security call-back is activated. Selective call answer allows only data calls from specified numbers.

The digital outputs can be controlled remotely. The INSYS 56k modem controls these outputs by data connection as well as by DTMF tones from a tone dial phone. The digital outputs can be configured to display the connections status.

Technical data

Modem	7XV5820-5AA00	7XV5820-6AA00
Network interface	2-wire leased or dial-up line	S0/1.430 Euro ISDN network, DSS1
Data transmission rate	Max. 56 kbit/s	Max. 68 kbit/s (channel building 128 kbit/s)
Digital in-/outputs	2 alarm inputs/2 control outputs	2 alarm inputs/2 control outputs
Watchdog	Yes	–
Software update	–	Flash update
Approvals	–	R & TTE, CTR3
Application	–	Europe
Standards	–	Developed according to CE directives
Features		
Configuration	AT commands via serial line, remote configuration	AT commands, configuration over serial line, remote configuration, CAPI
Connection	Auto-answer mode, idle connection ctrl, auto-bauding, number storage, hard-/software handshake International settings, caller ID presentation, SMS to fixed-line telephone network, fixed serial speed, sleep mode	
Alarm functions	Triggered by alarm input or AT command: send SMS, (send fax and collective fax message 7XV5820-5AA00), establish data connection, transmit message over data connection	
Output control	AT command (local & remote) DTMF	AT command, configurator, connection status
Security functions	Password protection for connection, remote control and security callback Selective call answer, watchdog	Number identification (CLIP)
Data formats	10 and 11 bit: 7E1, 7O1, 7N2, 7E2, 7O2, 8N1, 8E1, 8O1, 8N2 Bit transparent	
Protocols, error correction, compression	V.32bis, V.32, V.23, V.22, V.22bis, V.21, V.34+, V.90, V.92, Bell Norm 103/212, Fax Class ½, MNP 2/3/4, V.42, MNP 10, MNP 10 EC, MNP 5 V.42bis	B channel: X.75, X.25/X.31, HDLC/PPP, V.110, V.120 asynchronous; D channel: X.31
Electrical features		
Supply voltage	DC 10 to 60 V	DC 10 to 60 V
Current consumption	Transmission: 200 mA (at 12 V) Standby: 160 mA (at 12 V)	40 mA
Inuts/outputs	SPDT (single-pole double-throw) switches by galvanically isolated relays, max. voltage DC 30 V/AC 42 V, max. current: DC 1 A/AC 0.5 A	
Serial line speed	300 bit/s to 115.2 kbit/s	1.2 to 230.4 kbit/s
Physical features		
Housing size in mm (W × D × H)	55 × 110 × 75	55 × 110 × 75
Temperature range	0 to 55 °C	0 to 70 °C
Humidity	0 to 95 % (non-condensing)	0 to 90 % (non-condensing)



Fig. 13/85 7XV5820 Modem-Router-Switch (MoRoS)

Description

Modem-Router-Switch by INSYS combines a modem, a router and a 4-port switch. The dial-in and dial-out functionality enables remote maintenance and operation of devices in an Ethernet network.

The MoRoS device is available with an integrated analog modem or with ISDN-TA. The integrated 4-port switch allows for direct connection of up to four network devices. The MoRoS device has an international 56k modem for global application. The configuration of the MoRoS device is easy and fast via a Web interface.

MoRoS by INSYS is a device that combines modem, router and switch functions for the remote maintenance of Ethernet-enabled products, e.g. PLC, HMI, etc.

Function overview

- Integrated communication module (analog modem or ISDN-TA)
- Dial-in
- Dial-out (dial-on-demand)
- 4-port switch with 10/100 Mbits/s
- DHCP server and client
- Integrated configuration interface with help function
- Authentication for up to 10 users (dial-in)
- Dialing filter for dial-out
- Authentication via PAP, CHAP, MS-CHAP, MS-CHAP 2
- Easy configuration
- Local or remote configuration
- Firmware update (local and remote)
- 2 digital inputs and outputs
- Buffered RTC (real time clock)
- Full NAT
- DNS relay
- Serial Ethernet Server¹⁾
- VPN¹⁾
- Firewall¹⁾

1) version MoRoS PRO only

Technical data

Modem	7XV5820-7/-8AA00MoRoS	
Certifications	R & TTE, CTR2 (dial-up line), CTR3 (ISDN), CE	
Dial-up line	Transmission rate 56 kbits/s	
ISDN	Transmission rate 64 kbits/s	
Configuration	Web interface, AT command (via Web interface), local and remote	
Router		
Function	Dial-in, dial-out	
Authentication	10 users for dial-in, authentication via PAP, CHAP, MS-CHAP, MS-CHAP 2	
Dialing filter (dial-out)	Filtering of IP addresses and / or ports	
Configuration	Web interface, AT command (via Web interface), local and remote	
DHCP server and client		
Watchdog (ext. hardware watchdog)		
RTC (buffered real time clock)		
Full NAT		
VPN ¹⁾		
Firewall ¹⁾		
Serial Ethernet server ¹⁾		
Switch		
Ports	4	
Operating mode	10/100 Mbits/s for full and half duplex operation	
Auto detect	Automatically recognizes patch and cross-over cables; automatic speed adjustment	
Configuration		
Web interface	Local/remote	
Additional features	Digital inputs and outputs, firmware update local/remote	
Supply		
Voltage	DC 10 V to 60 V	
Power input	Approx. 2.5 W (during connection)	
Physical features		
Housing size in mm	70 × 110 × 75 mm	
Operating temperature	0 to 55 °C	
Humidity	0 to 95 % (non-condensing)	
Weight	10.58 oz	

Accessories/7XV5820

Selection and ordering data

Description	Order No.
7XV5820 modem/modem-router	7XV5820-□AA00
Analog Pocket Modem 56k Desktop device, with plug-in power supply AC 230 V	1
Digital Pocket Modem ISDN 64k Desktop device, with plug-in power supply AC 100 to 230 V	2
Analog Modem 56k for DIN rail-mounting, power supply DC 10 to 60 V	5
Digital Modem ISDN 64k for DIN rail-mounting, power supply DC 10 to 60 V	6
Analog Modem-Router with 4-way switch for DIN rail-mounting, power supply DC 10 to 60 V	7
Digital ISDN Router with 4-way switch for rail-mounting DC 10 to 60 V	8
Modem/Modem-Router Accessories	7XV5820-0AA10
Data cable from modem to 7XV5300, 7XV5450, 7XV5550, 7XV5652 2 × SUB-Dconnector, 9-pin female, length 2 m	



Fig. 13/86 7XV5850 Ethernet modem

Function overview

- DIGSI supports the administration and the setting-up of connections via the Ethernet network.
- RS232 interfaces for data transfer and configuration of the modem.
- Serial baud rate and data format (RS232) for the terminal devices is selectable from 2400 Bd up to 57.6 kBd with data format 8N1, 8E1.
- An Ethernet interface LAN to the 10/100 Mbit network.
- Better security with password protection and IP address selection is possible.

Description

A control PC and protection units can exchange serial data via an Ethernet network using two Ethernet modems 7XV5850 and 7XV5655. Connection to the Ethernet modem is in each case made via the asynchronous serial interface of the terminal units. In the modem, the serial data is packed into the secure IP protocol as information data, and is transferred between the modems using the Ethernet connection. Conformity with the standard and gap-free transmission of serial DIGSI or IEC 60870-5-103/101 telegrams via the network is ensured by the modem which receives the serial telegram communication and packs the serial IEC telegrams into blocks for communication via the Ethernet. The data is transmitted in full duplex mode; serial control wires are not supported. Connection is established between the IP address of the dialing modem in the office and the IP address of the pick-up modem in the substation, and is configured prior to dialing up with DIGSI by means of AT commands via the RS232 interface.

The substation modem may be configured to have password protection, and provides the additional security feature, whereby access is only permitted from defined IP addresses, e.g. only that of the office modem. The modem is accessed with DIGSI Remote like a normal telephone modem with the exception that instead of telephone numbers, IP addresses are assigned by the network administrator for each modem.

Application

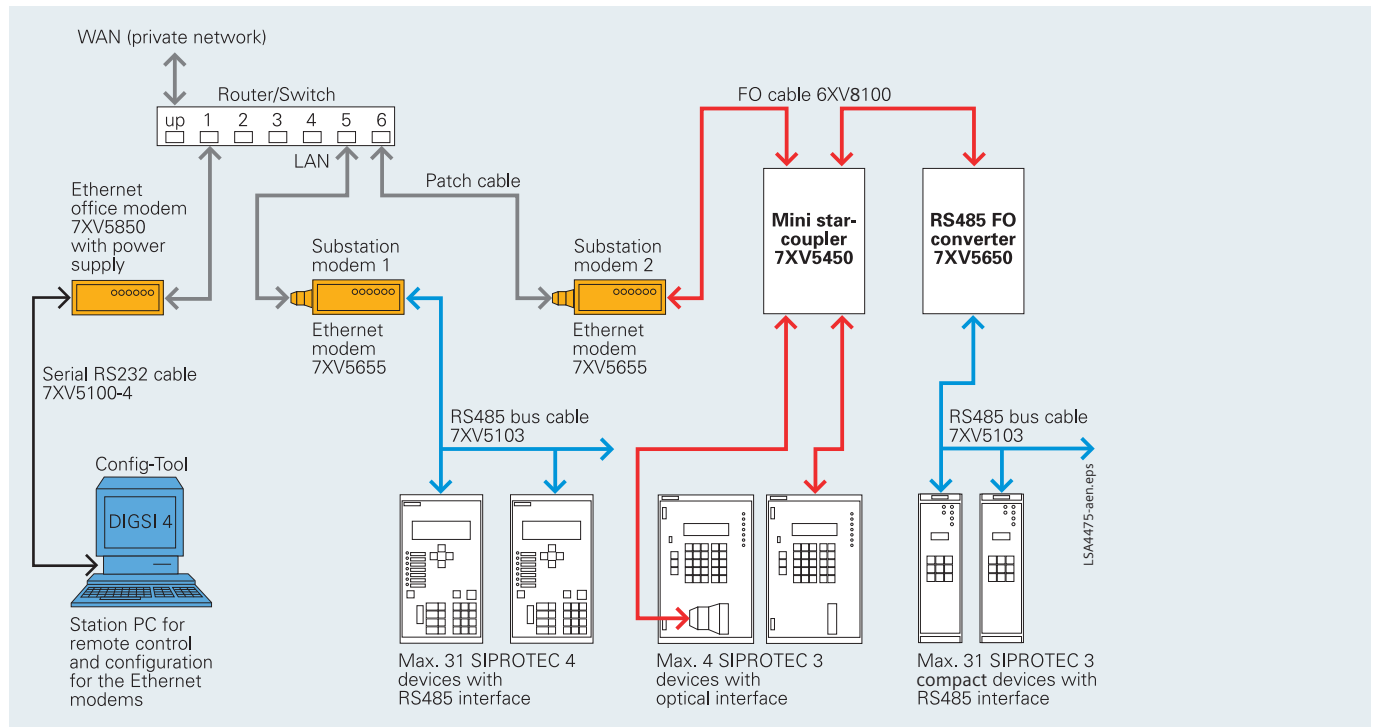


Fig. 13/87 Operation of various SIPROTEC protection unit generations via Ethernet modems

Using the office computer and DIGSI 4, both substation 1 and 2 may be dialed up via Ethernet modems. A TCP/IP point-to-point data connection is established between the office modem and corresponding substation modem when dialed up via the network. This is maintained until the office modem terminates the connection. The serial data exchange takes place via this data connection, with the modem converting the data from serial to Ethernet with full duplex mode. Between the office modem and the office PC, the highest baud rate is always used, e.g. 57.6 kB for SIPROTEC 4 units. The serial baud rate of the substation modem is adapted to the baud rate required by the protection relays, e.g. substation modem 1 with 57.6 kB for SIPROTEC 4 and substation modem 2 with 9.6 kB for SIPROTEC 3 units. These settings are only defined once in the modem. The Ethernet modems are integrated in DIGSI 4 similar to telephone modems. Instead of the telephone number, the preset IP address assigned to the modem is selected.

If later an Ethernet connection is available in the substation, the existing modem can be replaced by an Ethernet modem. The entire serial bus structure and cabling may remain unchanged.

Technical data

Connections

RS232 interface 9-pin, SUB-D connector
 Ethernet 10BaseT, 10/100 Mbit, RJ45
 Power supply (see below)

Desktop device for office use 7XV5850-0AA00

Housing Desktop housing, plastic, charcoal grey, 46 × 109 × 74 (W × H × D) in mm
 Supply Wide-range plug-in power supply, auxiliary voltage AC 100 – 240 V
 Scope of supply With RS232 cable for Notebook/PC. With Ethernet cable (cross-over) 2 m

Indication (8 × LED)

Power	Operating voltage o.k.
RS232 TxD	Transmitting data to RS232
LAN Tx	Transmitting data to LAN
Error	Error on RS232
System	RS232 connection established
RS232 RxD	Receiving data from RS232
LAN Rx	Receiving data from LAN
Link LAN	LAN connection established

Selection and ordering data

Description	Order No.
Ethernet Modem Ethernet modem for serial, asynchronous transmission of data up to 57.6 kbit via the 10/100 Mbit Ethernet and configuration software Desktop device (office version) Connection to Ethernet via RJ45 connector, serial connection SUB-D 9-pin socket including wide-range power supply AC 100/240 V With cross-over Ethernet patch cable 2 m for configuration With serial connection cable to PC 2 m	7XV5850 - 0AA00



Fig. 13/88 SCALANCE X204RNA HSR

Overview

The SCALANCE X-200RNA (Redundant Network Access) managed Industrial Ethernet network access devices with HSR functionality (High-availability Seamless Redundancy Protocol in accordance with IEC 62439-3) are used to connect up to two non-HSR-enabled terminal devices or network segments to a ring-shaped HSR network structure. They can also be used for simple and redundant transition from HSR to PRP (Parallel Redundancy Protocol) network structures.

- Electrical or optical connection to stations or network in accordance with the port type of the devices
- Media redundancy thanks to duplicate transmission of frames in ring-shaped networks
- High system availability since frames are sent simultaneously via two routes in the ring
- No reconfiguration times of the ring-shaped networks are required in the event of an error due to duplicate transmission of frames in the ring
- Simple and redundant connection of HSR and PRP network structures
- Redundant 24 V DC power input or wide-range power supply unit, depending on device version
- SNMP access, integrated Web server and automatic e-mail transmission function for remote diagnostics and signaling via the network

Benefits

- Ideal solution for establishing Industrial Ethernet networks with high network availability (seamless media redundancy through parallel data transfer in parallel network topologies)
- Seamless data transmission in ring-shaped network structures for high-availability systems (e.g. process automation)
- Fast and easy diagnosis with LEDs on the device, through the integral Web server and through signaling contacts
- Integration of the SCALANCE X-200RNA network access points into the existing network management infrastructure through SNMP access
- Simple commissioning without mandatory configuring
- Module replacement without the need for a programming device, using the C-PLUG swap media for backing up the configuration data

Application

The SCALANCE X-200RNA Industrial Ethernet network access points with HSR functionality enable low-cost connection of non-HSR-enabled terminal devices to ring-shaped networks in which high availability is demanded. The devices with degree of protection IP20 are designed for operation in the control cabinet.

Product versions

- Network access point in plastic enclosure with electrical ports
 - SCALANCE X204RNA; for connecting up to two non-HSR-enabled terminal devices to ring-shaped networks with four electrical ports
- Network access point in metal enclosure with electrical and optical ports, as well as a wide-range power supply unit for use under extended ambient conditions
 - SCALANCE X204RNA EEC; for connecting up to two non-HSR-enabled terminal devices to ring-shaped networks with two electrical terminal device ports and two optical/electrical combo ports for network connection
 - SCALANCE X204RNA EEC; with configurable functionality (PRP or HSR) for connecting up to two non-HSR-enabled terminal devices to ring-shaped networks with two electrical terminal device ports and two optical/electrical combo ports for network connection

Features

- Device diagnostics with LEDs (power, link status, data communication)
- Remote diagnostics possible via signaling contact (fault signaling contact can be set locally using SET button), SNMP, and Web browser
- With its extended ambient conditions, the SCALANCE X204RNA EEC is suitable for use in electric power substations and distribution systems (IEC 61850-3, IEEE 1613)

Accessories/SCALANCE X-200RNA

SCALANCE X204RNA HSR

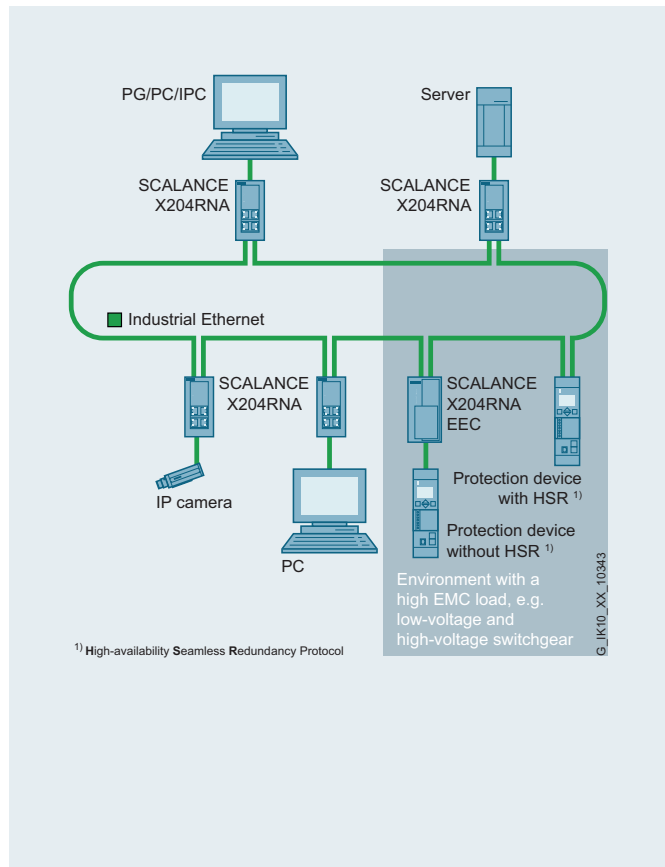


Fig. 13/89 Seamless, ring-shaped network with HSR redundancy protocol

More information

Further products and completions in the catalog IK PI.

For more information on Redundant Network Access see <http://www.siemens.com/RNA>

To assist in selecting the right Industrial Ethernet switches as well as configuration of modular variants, both the SIMATIC NET Selection Tool and the TIA Selection Tool are available:

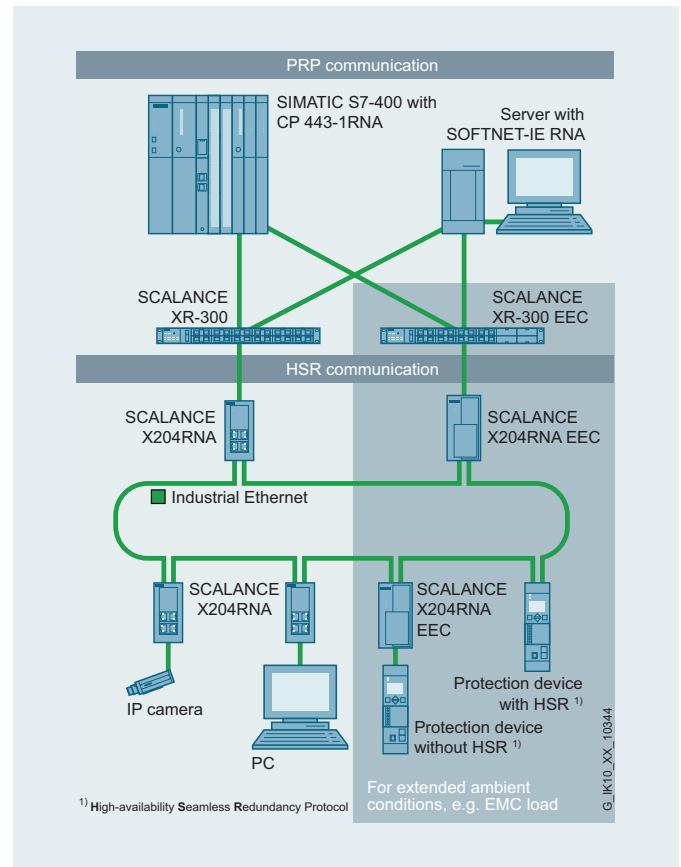


Fig. 13/90 Redundant transition from ring-shaped HSR network structure to parallel PRP network structure by means of SCALANCE X204RNA

Online version:
<http://www.siemens.de/snst>

Offline version:
<http://www.siemens.de/snst-download>

TIA Selection Tool:
<http://www.siemens.com/tia-selection-tool>

Selection and ordering data

Description	Order No.
SCALANCE X204RNA for HSR networks	6GK5204-0BA00-2MB2
SCALANCE X204RNA EEC for HSR networks	6GK5204-0BS00-2NA3
SCALANCE X204RNA EEC for both HSR and PRP networks	6GK5204-0BS00-3PA3
SFP transceivers	
SFP991-1 (multi-mode, glass to max. 3 km)	6GK5 991-1AD00-8AA0
SFP991-1LH+ (single-mode, glass to max. 70 km, LH+)	6GK5 991-1AE00-8AA0
SFP991-1LD (single-mode, glass to max. 26 km)	6GK5 991-1AF00-8AA0
IE FC RJ45 Plug 180	
RJ45 plug connector for Industrial Ethernet with a rugged metal housing and integrated insulation-displacement/terminal contacts for connecting Industrial Ethernet FC installation cables, with a 180° cable outlet, for network components and CPs/CPU with Industrial Ethernet interface	6GK1 901-1BB10-2A□0
1 pack = 1 unit	A
1 pack = 10 unit	B
1 pack = 50 unit	B



Fig. 13/91 SCALANCE X204RNA PRP

Overview

The SCALANCE X-200RNA (Redundant Network Access) managed Industrial Ethernet network access points with PRP functionality (Parallel Redundancy Protocol in accordance with IEC 62439-3) are used to connect up to two non-PRP-enabled terminal devices or network segments to parallel networks.

- Electrical or optical connection to stations or networks in accordance with the port type of the devices
- Redundancy thanks to duplicate transmission of frames in two parallel, separate networks
- High system availability since frames are sent simultaneously over two separate networks
- Reconfiguration times in a subnetwork do not affect the propagation time because the frames are transmitted via two separate networks (seamless redundancy)
- Redundant 24 V DC voltage infeed or wide-range power supply unit, depending on device version
- SNMP access, integrated Web server and automatic e-mail transmission function for remote diagnostics and signaling via the network

Benefits

- Ideal solution for establishing Industrial Ethernet networks with high network availability (seamless media redundancy through parallel data transfer in parallel network topologies)
- The reconfiguration time of a subnetwork does not influence frame transmission
- Fast and easy diagnosis with LEDs on the device, through the integral Web server and through signaling contacts
- Integration of the SCALANCE X-200RNA network access devices into the existing network management infrastructure through SNMP access
- Simple commissioning without mandatory configuring
- Module replacement without the need for a programming device, using the C-PLUG swap media for backing up the configuration data

Application

The SCALANCE X-200RNA Industrial Ethernet network access devices enable low-cost connection of non-PRP-enabled terminal equipment to parallel, separate networks in which high availability is demanded. The devices with degree of protection IP20 are designed for operation in the control cabinet.

Product versions

- Network access point in plastic enclosure with electrical ports
 - SCALANCE X204RNA; for connecting up to two non-PRP-enabled terminal devices to two redundant networks with four electrical ports
- Network access point in metal enclosure with electrical and optical ports, as well as a wide-range power supply unit for use under extended ambient conditions
 - SCALANCE X204RNA EEC; for connecting up to two non-PRP-enabled terminal devices to two redundant networks with two electrical terminal device ports and two optical/electrical combo ports for network connection
 - SCALANCE X204RNA EEC; with configurable functionality (PRP or HSR) for connecting up to two non-HSR-enabled terminal devices to ring-shaped networks with two electrical terminal device ports and two optical/electrical combo ports for network connection

Features

- Device diagnostics with LEDs (power, link status, data communication)
- Remote diagnostics possible via signaling contact (signal screen can be set locally using buttons), SNMP, and Web browser
- With its extended ambient conditions, the SCALANCE X204RNA EEC is suitable for use in power switching and distribution systems (IEC 61850-3, IEEE 1613)

Accessories/SCALANCE X-200RNA

SCALANCE X204RNA PRP

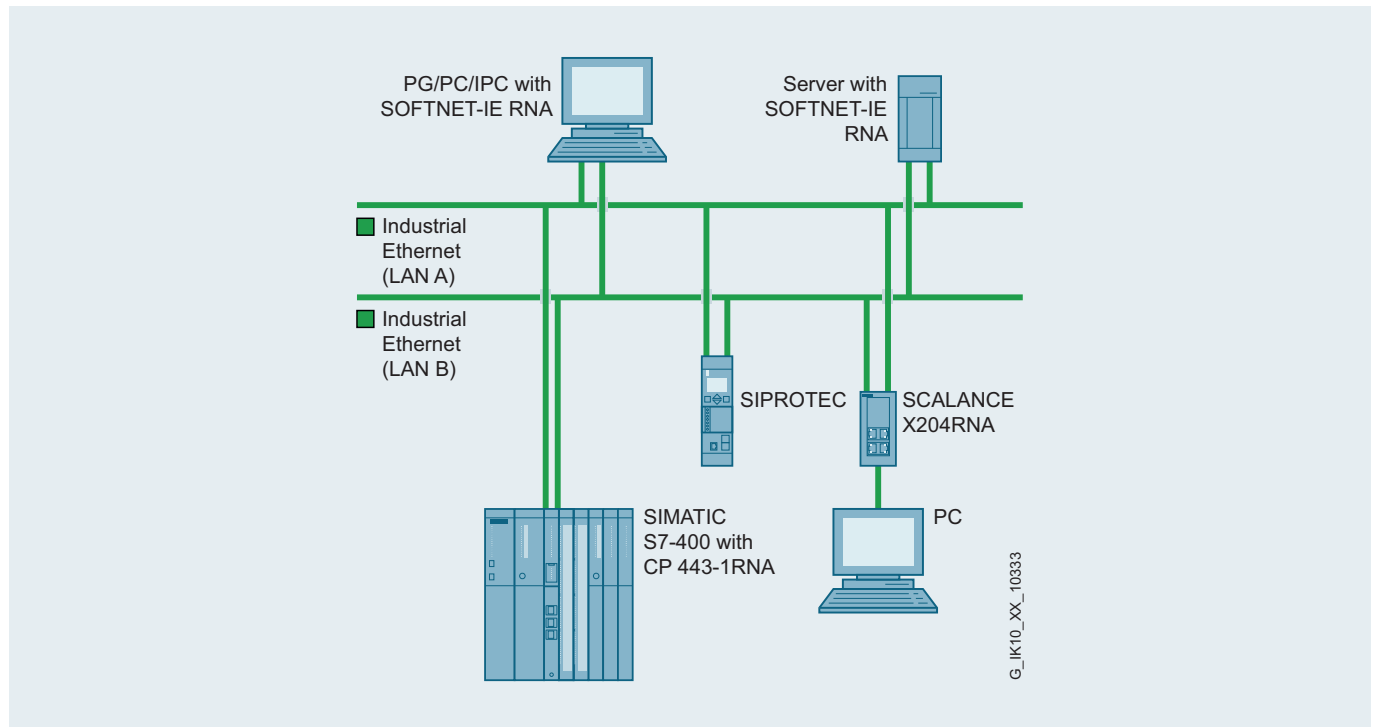


Fig. 13/92 Seamless, parallel networks with PRP redundancy protocol

More information

Further products and completions in the catalog IK PI.

To assist in selecting the right Industrial Ethernet switches as well as configuration of modular variants, both the SIMATIC NET Selection Tool and the TIA Selection Tool are available:

Online version:
<http://www.siemens.de/snst>

Offline version:
<http://www.siemens.de/snst-download>

TIA Selection Tool:
<http://www.siemens.com/tia-selection-tool>

Selection and ordering data

Description	Order No.
SCALANCE X204RNA for PRP networks	6GK5204-0BA00-2KB2
SCALANCE X204RNA EEC for PRP networks	6GK5204-0BS00-3LA3
SCALANCE X204RNA EEC for both HSR and PRP networks	6GK5204-0BS00-3PA3
SFP transceivers	
SFP991-1 (multi-mode, glass to max. 3 km)	6GK5 991-1AD00-8AA0
SFP991-1LH+ (single-mode, glass to max. 70 km, LH+)	6GK5 991-1AE00-8AA0
SFP991-1LD (single-mode, glass to max. 26 km)	6GK5 991-1AF00-8AA0
CP 443-1RNA	6GK7 443-1RX00 0XE0
IE FC RJ45 Plug 180	6GK1 901-1BB10-2A□0
RJ45 plug connector for Industrial Ethernet with a rugged metal housing and integrated insulation-displacement/terminal contacts for connecting Industrial Ethernet FC installation cables, with a 180° cable outlet, for network components and CPs/CPU with Industrial Ethernet interface	
1 pack = 1 unit	A
1 pack = 10 unit	B
1 pack = 50 unit	B



Fig. 13/93 SOFTNET-IE RNA

Overview

- SOFTNET-IE RNA (Redundant Network Access) is the software for connecting a PC to networks with PRP (Parallel Redundancy Protocol in accordance with IEC 62439-3) capability
- High level of plant availability thanks to duplicate transmission of frames in two parallel, separate networks
- Reconfiguration times in a subnetwork do not affect the propagation time because the frames are transmitted via two separate networks (seamless redundancy)
- Integration in network management systems through support for SNMP
- Configuring tools are included in the scope of delivery of the communication software in each case

Benefits

- Ideal solution for establishing Industrial Ethernet networks with high network availability (seamless media redundancy through parallel data transfer in parallel network topologies)
- No additional programming overhead required in the PC
- High availability of the overall plant
- Secures the investment thanks to the use of the existing applications and the flexible application options
- Simple integration into the existing network management systems thanks to the access to the diagnostic data via SNMP as the standard interface

Application

The SOFTNET-IE RNA software package enables low-cost connection of PCs with two network interfaces to parallel, separate networks in which high availability is demanded.

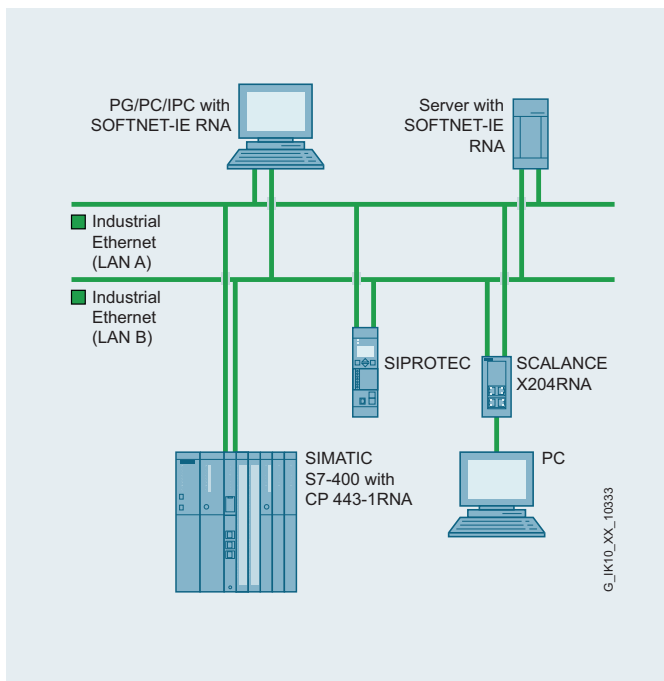


Fig. 13/94 Parallel PRP network structure with SOFTNET-IE RNA and SCALANCE X204RNA

Accessories/SOFTNET-IE RNA

Selection and ordering data

Description	Order No.
SOFTNET-IE RNA Software for connecting PCs to PRP-enabled networks with integrated SNMP, runtime software, software and electronic manual on CD-ROM, license key on USB flash drive, Class A	
SOFTNET-IE RNA V8.1 For 32-bit Windows XP; German/English • Single License for one installation	6GK1 711-1EW08-1AA0
SOFTNET-IE RNA V8.2 For 32/64-bit Windows 7 Professional/Ultimate; for 64-bit Windows 2008 Server R2; German/English • Single License for one installation	6GK1 711-1EW08-2AA0
Software Update Service For 1 year with automatic extension; requirement: current software version	6GK1 711-1EW00-3AL0
Upgrade From V8.1 to V8.2 • Single License for one installation	6GK1711-1EW00-3AE0



Fig. 13/95 SCALANCE S

Overview

The security modules of the SCALANCE S range can be used to protect all devices of an Ethernet network against unauthorized access. In addition, SCALANCE S612 or SCALANCE S623 also protects the data transmission between devices or network segments (e.g. automation cells) against data manipulation and espionage; they can also be used for secure remote access over the Internet.

- Control of the data traffic due to stateful inspection firewall:
 - Protection against operator mistakes
 - Prevention of unauthorized access
 - Prevention of faults and communications overload
- Authentication of the communication devices and encryption of the data transmission with VPN protects against espionage and manipulation.
- Rugged, industry-standard devices (e.g. extended temperature range, redundant power supply)
- Easy and clear configuration with the Security Configuration-Tool (SCT)
- The communication is protocol-independent protected
- Remote access via the Internet possible without restrictions and with any provider

Benefits

Prevents industrial networks against unauthorized access. If necessary it is possible with S623 to establish a DMZ (demilitarized zone) for data exchange between networks without direct access to the automation network.

With establishing the cell protection concept:

- Protection of any Ethernet-based automation device,
- Protection of several devices with one security module
- Reduction of risks, due to net segmentation (creation of secure communication islands)
- Secure data transmission between the automation cells possible
- With user-specific firewall rules it is possible to assign also user and not only to devices specific access rights.

Product versions

SCALANCE S602

- Stateful inspection firewall to protect network segments against unauthorized access
- Connection via 10/100/1000-Mbit/s ports

SCALANCE S612

- Like S602. Additional 128 VPN tunnels simultaneously possible.

SCALANCE S623

- Like S612. Additional RJ45 DMZ port (DMZ: "demilitarized zone") for secure connection of, for example, remote maintenance modems, laptops, or an additional network. This yellow port is protected by firewalls from the red and green ports and can also terminate VPNs.

Accessories/SCALANCE S

SCALANCE S

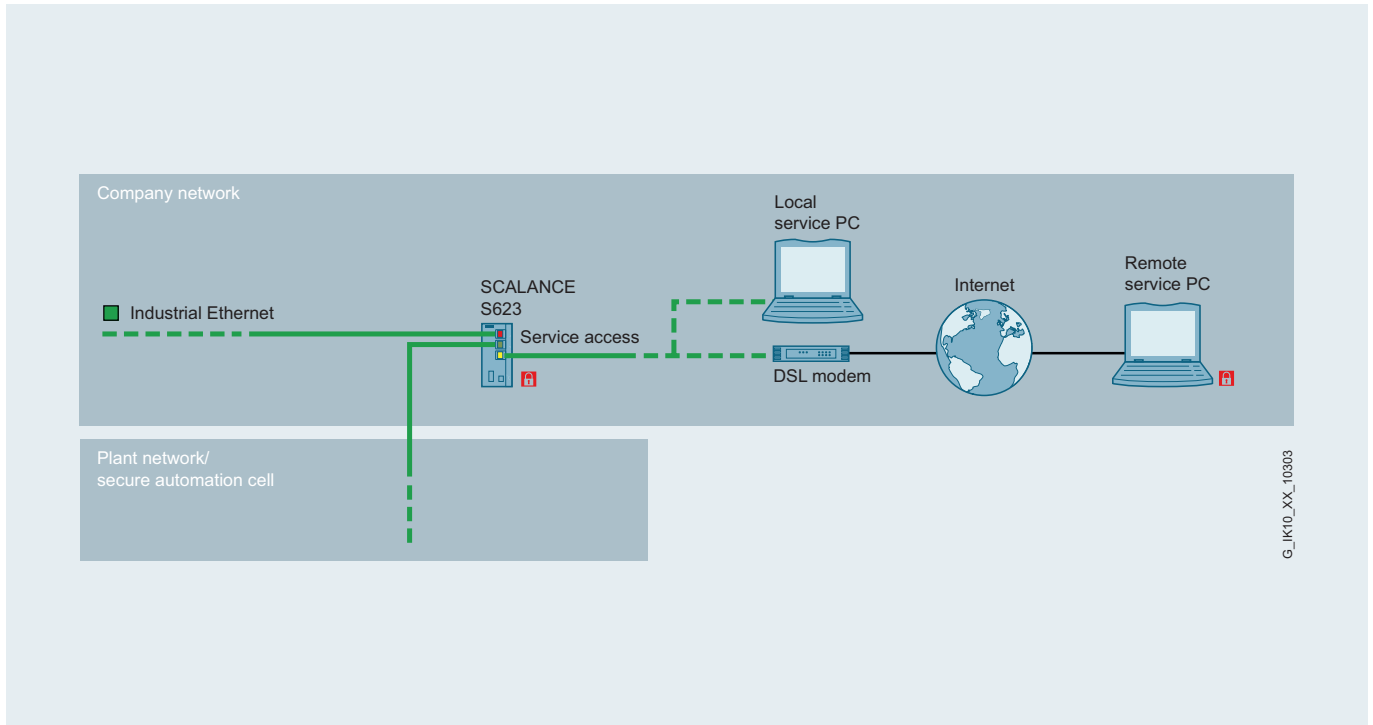


Fig. 13/96 Connection of a local or remote service PC (via Internet access) by use of the DMZ port of the SCALANCE S623

More information

More information can be found here:
www.siemens.de/industrialsecurity

Selection and ordering data

Description	Order No.
SCALANCE S602	6GK5 602-0BA10-2AA3
SCALANCE S612	6GK5 612-0BA10-2AA3
SCALANCE S623	6GK5 623-0BA10-2AA3
SOFTNET Security Client V4 (for 32/64-bit Windows 7 Professional, Ultimate)	6GK1 704-1VW04-0AA0
IE FC RJ45 Plug 180	6GK1 901-1BB10-2A□0
RJ45 plug connector for Industrial Ethernet with a rugged metal housing and integrated insulation-displacement/terminal contacts for connecting Industrial Ethernet FC installation cables, with a 180° cable outlet, for network components and CPs/CPU with Industrial Ethernet interface	
1 pack = 1 unit	A
1 pack = 10 unit	B
1 pack = 50 unit	B

G_IK10_XX_10303



Fig. 13/97 SCALANCE M874-2/SCALANCE M874-3

Overview

- EDGE/HSPA+ router for wireless IP communication of Industrial Ethernet-based automation systems via mobile wireless networks
- Integrated security functions with firewall
- Both VPN server and VPN client
- Numerous tunnel protocols available: IPsec, OpenVPN
- User-specific login

Benefits

- Monitoring and controlling wirelessly connected telecontrol substations with low investment and operating costs
- Reduction in traveling costs and telephone charges due to remote programming and diagnostics by means of mobile radio networks
- User-friendly diagnostics by means of terminal clients and short download times due to the higher speed with HSPA+
- High security thanks to IPsec-based VPN functionality and firewall
- Savings in configuring time thanks to the SCALANCE S Security Module through tailored VPN configuration
- Can be used worldwide thanks to GSM quad band technology and UMTS penta band technology (observe national regulations!)

Application

- The SCALANCE M874 devices are universal. Due to their design and electrical characteristics, the routers are particularly suitable for use in industrial applications.
- Remote programming and maintenance worldwide by means of mobile radio networks
- Energy-saving concepts for plants, e.g. through status-dependent speed control of pumps in remote stations

- Control and monitoring of
 - Sewage treatment plants, water treatment
 - Oil and gas supplies
 - District heating networks
 - Power distribution
 - Pumping stations
 - Traffic systems
 - Buildings
 - Wind generators and photovoltaic plants
- Linking of mobile stations, with central monitoring and control

Function

Interfaces

- 1 digital input and 1 digital output for signaling errors or failure
- Rugged plastic housing for DIN rail mounting
- 2 Ethernet ports for Industrial Ethernet
- Diagnostics LEDs for modem status, field strength, connection checks, VPN status and DI/DO channels
- Connection to the 24 V DC power supply
- 1 x SMA connector for 2G/3G antenna

Supported mobile wireless standards

M874-2: 2G (GPRS, EDGE)

M874-3: 2G (GPRS, EDGE) and 3G (UMTS, HSPA+)

Protocols

- DNS, DynDNS, no-ip

Management

- Web interface for configuration and management
- CLI for configuration and management
- SNMP and MIBs, TRAPS are supported

Security and routing

- Secure data transfer with encryption and identification (authentication) of the communication participants thanks to the use of VPN (IPsec, OpenVPN). Multiple VPN tunnels possible at the same time.
- Login and firewall function for specific assignment and checking of access rights
- Routing and port forwarding with NAT, NAPT and 1:1 NAT is supported

Diagnostics and logging

- SysLog is supported
- Expanded event management with alarms via e-mail, SMS, DO
- Log table

Time synchronization

- Network Time Protocol (NTP) is supported
- Simple Network Time Protocol (SNTP) is supported

Accessories/SCALANCE M

SCALANCE M874-2/SCALANCE M874-3

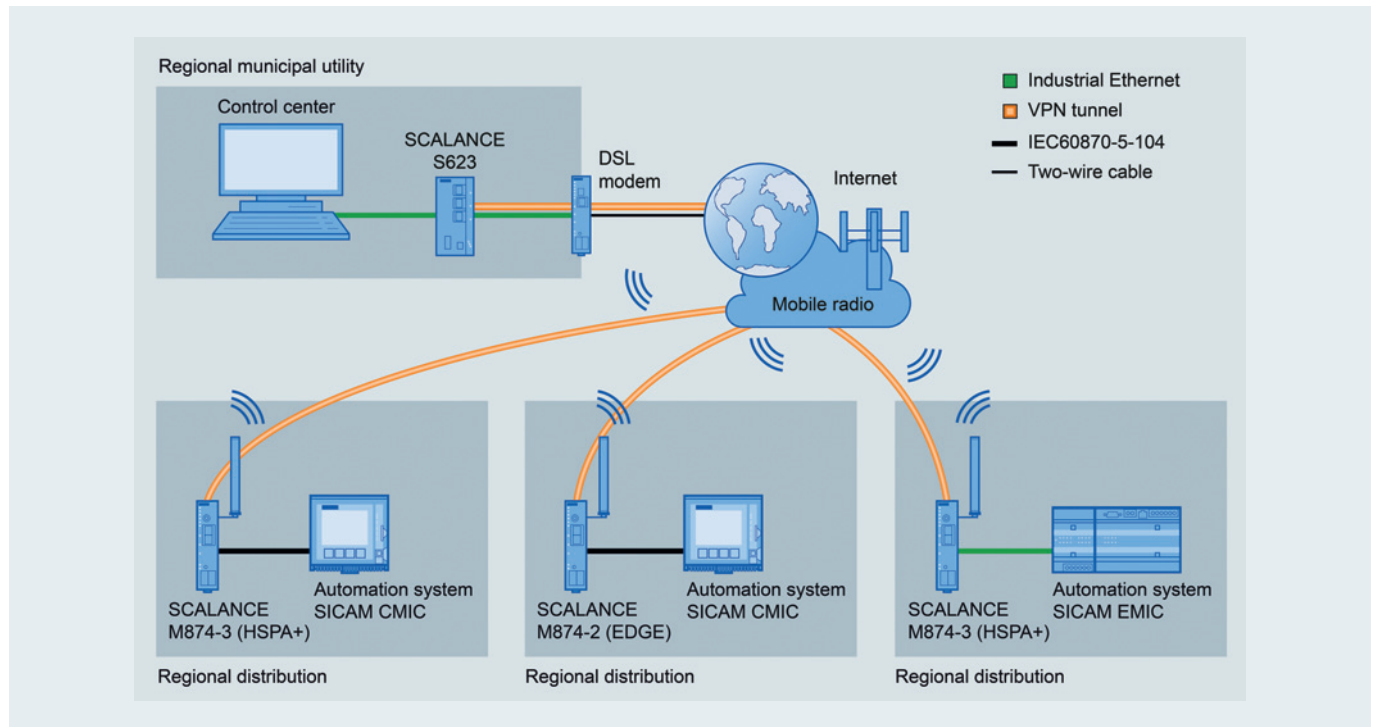


Fig. 13/98 Transparent transport of telecontrol protocols, e.g. IEC 60870-5-104 in the Energy Automation environment

More information

Visit us at our SIMATIC NET website:

www.siemens.com/automation/simatic-net

There you will find information on products and solutions, current information on SIMATIC NET as well as events and specialist publications.

At www.siemens.com/automation/net/catalog, you have direct access to descriptions of the SIMATIC NET products.

Selection and ordering data

Description	Order No.
SCALANCE M874-2	6GK58742AA002AA2
SCALANCE M874-3	6GK58743AA002AA2
IE FC RJ45 Plug 180	6GK1 901-1BB10-2A□0
RJ45 plug connector for Industrial Ethernet with a rugged metal housing and integrated insulation-displacement/terminal contacts for connecting Industrial Ethernet FC installation cables, with a 180° cable outlet, for network components and CPs/CPU with Industrial Ethernet interface	
1 pack = 1 unit	A
1 pack = 10 unit	B
1 pack = 50 unit	B

RUGGEDCOM RS900 – 9-Port Managed Ethernet Switch with Fiber Optical Uplinks



Fig. 13/99 RUGGEDCOM RS900

Overview

The RS900 from the RUGGEDCOM product line is a 9-port industrially hardened, fully managed Ethernet switch specifically designed to operate reliably in electrically harsh and climatically demanding environments. The RS900 provides a high level of immunity to electromagnetic interference and heavy electrical surges typical of environments found in substation and distribution automation, and also on plant floors or in curb side traffic control cabinets. An operating temperature range of -40 to +85 °C (-40 to +185 °F) coupled with hazardous location certification (Class 1 Division 2) allows the RS900 to be placed in almost any location. The RS900 is packaged in a compact, galvanized steel enclosure that allows either DIN or panel mounting for efficient use of cabinet space. The RS900 provides an integrated power supply with a wide range of voltages (88-300V DC or 85-264V AC) for worldwide operability or dual-redundant, reversible polarity, 24V DC and 48V DC power supply inputs for high-availability applications requiring dual or backup power inputs. The RS900's superior ruggedized design coupled with the embedded Rugged Operating System (ROS®) provides improved system reliability and advanced networking features making it ideally suited for creating Ethernet networks for mission-critical, real-time control applications. The versatility and wide selection of fiber optics allow the RS900 to be used in a variety of applications. The RS900 provides up to three 100-Mbps fiber optical Ethernet ports for creating a fiber optical backbone with high noise immunity and long haul connectivity. All RUGGEDCOM products are backed by a five-year warranty and unsurpassed technical support.

Function overview of the RS9xx product family

The RS900 is part of a product family of small form factor, managed Ethernet switches feature optional DIN rail mounting and single-mode fiber, allowing for long-range links. The RS9xx series also provides built in security features to ensure traffic segregation between multiple applications. These devices are the perfect choice for creating an Ethernet network for mission-critical, real-time control applications where space is limited.

RS900

- Managed Ethernet switch with fiber uplinks
- 9 ports: 6 10/100BaseTX + optional 3 100BaseFX or 3 10/100BaseTX

RS9xxG

- Managed Ethernet switch
- 8 Ports: 6 10/100/1000BaseTX + optional 2 1000BaseX (gigabit) or 10 Ports: 8 10/100BaseTX + 2 1000BaseX (gigabit)

Function

Ethernet Ports

- Up to 9 Ports: 6 Base 10/100BaseTX ports with option for 3 additional fiber or copper ports
- Industry-standard fiber optical connectors: LC, SC, ST, MTRJ
- Multi-mode and single-mode optical transceivers
- Long haul optics allow distances up to 90 km

Cyber Security Features

- Multi-level user passwords
- SSH/SSL (128-bit encryption)
- Enable/disable ports, MAC-based port security
- Port-based network access control (802.1x)
- VLAN (802.1Q) to segregate and secure network traffic
- RADIUS centralized password management
- SNMPv3 authentication and 56-bit encryption

RuggedRated™ for Reliability in Harsh Environments

- Immunity to EMI and heavy electrical surges
- Meets IEEE 1613 class 1 (electric utility substations)
- Exceeds IEC 61850-3 (electric utility substations)
- Exceeds IEC 61800-3
- Exceeds IEC 61000-6-2
- Hazardous Location Certification: Class 1 Division 2
- -40 °C to +85 °C operating temperature (no fans)
- Conformal coated printed circuit boards (optional)

Rugged Operating System (ROS®) Features

- Simple plug and play operation – automatic learning, negotiation, and crossover detection
- MSTP 802.1Q-2005 (formerly 802.1s)
- RSTP (802.1w) and Enhanced Rapid Spanning Tree (eRSTP™) network fault recovery (<5 ms)
- Quality of Service (802.1p) for real-time traffic
- VLAN (802.1Q) with double tagging and GVRP support
- Link aggregation (802.3ad)
- IGMP Snooping for multicast filtering
- Port configuration, status, statistics, mirroring, security
- Industrial automation features (e.g. Modbus)

Accessories/RUGGEDCOM

RUGGEDCOM RS900 – 9-Port Managed Ethernet Switch with Fiber Optical Uplinks

Management Tools

- Web-based, Telnet, CLI management interfaces
- SNMP v1/v2/v3 (56-bit encryption)
- Remote Monitoring (RMON)
- Rich set of diagnostics with logging and alarms

Universal Power Supply Options

- Fully integrated power supply
- Universal high-voltage range: 88-300V DC or 85-264 V AC
- Dual low-voltage DC inputs: 24V DC (10-36 V DC) or 48V DC (36-72V DC)
- Terminal blocks for reliable maintenance-free connections
- CSA/UL 60950 safety approved to +85 °C

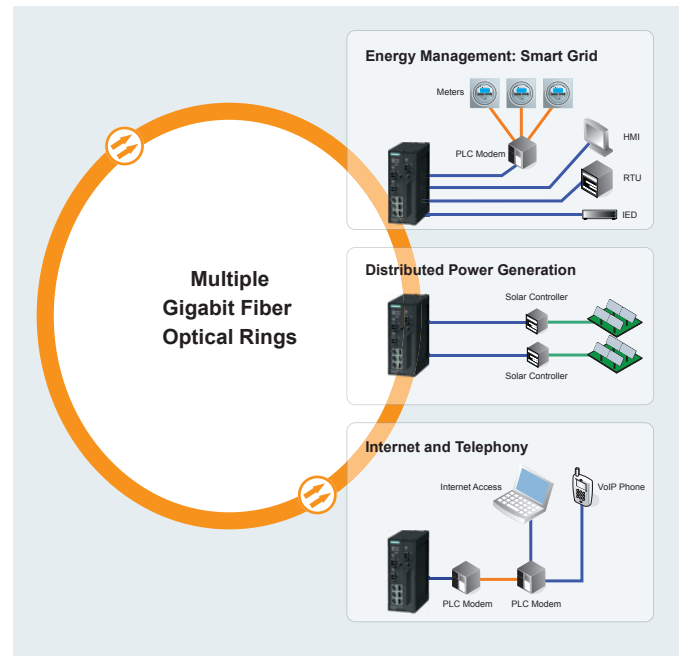


Fig. 13/100 The architecture illustrates the Ethernet backbone network interconnecting distribution substations via fiber optic links and the connection of multiple innovative applications to the common multi-purpose communications network.

Warranty

5 years – applicable to design or manufacturing related product defects.

Information and order data

www.siemens.com/ruggedcom

<http://www.siemens.com/ruggedcom-selector>

Description	Order No.
RS900	6GK6090-...
IE FC RJ45 Plug 180	6GK1901-1BB10-2A□0
RJ45 plug connector for Industrial Ethernet with a rugged metal housing and integrated insulation-displacement/terminal contacts for connecting Industrial Ethernet FC installation cables, with a 180° cable outlet, for network components and CPs/CPUs with Industrial Ethernet interface	
1 pack = 1 unit	A
1 pack = 10 unit	B
1 pack = 50 unit	B



Fig. 13/101 RUGGEDCOM RSG2100

Overview

The RUGGEDCOM RSG2100 is an industrially hardened, fully managed, modular Ethernet switch, specifically designed to operate reliably in electrically harsh and climatically demanding utility substation and industrial environments. The RSG2100's superior RuggedRated™ hardware design coupled with the embedded Rugged Operating System (ROS®) provides improved system reliability and advanced cyber security and networking features making it ideally suited for creating secure Ethernet networks for mission-critical, real-time control applications. The RSG2100's modular flexibility offers 10BaseFL/100BaseFX/1000BaseX fiber and 10/100/1000BaseTX and micro-D copper port combinations. Optional front or rear mount connectors make the RSG2100 highly versatile for any application and can support multiple fiber connectors (ST, MTRJ, LC, SC) without loss of port density. The RSG2100 is packaged in a rugged galvanized steel enclosure with industrial-grade DIN, panel, or 19" rack-mount mounting options.

Function overview of the RSG2x00 product family:

The RSG2100 is part of a product family of 19" managed gigabit Ethernet switches.

- Up to 9 ports: 1000BaseX (Gigabit) and/or 10/100/1000BaseTX or up to 19 ports: 3 1000BaseX (Gigabit) + 16 10/100BaseX or
- Up to 32 ports: 24 10/100BaseTX and optional 4 1000BaseX (Gigabit) or 8 100BaseX
- Power over Ethernet (PoE) version available

Function

Ethernet Ports

- Up to 3-Gigabit Ethernet ports – copper and/or fiber
- Up to 16-Fast Ethernet ports – copper and/or fiber
- 2 port modules for tremendous flexibility
- Non-blocking, store and forward switching
- Supports many types of fiber (multi-mode, single-mode, bi-directional single strand)
- Long haul optics allow Gigabit distances up to 70 km
- Multiple connector types (ST, MTRJ, LC, SC, RJ45, micro-D)

Cyber Security Features

- Multi-level user passwords
- SSH/SSL (128-bit encryption)
- Enable/disable ports, MAC-based port security
- Port-based network access control (802.1X)
- VLAN (802.1Q) to segregate and secure network traffic
- RADIUS centralized password management
- SNMPv3 authentication and 56-bit encryption

RuggedRated™ for Reliability in Harsh Environments

- Immunity to EMI and heavy electrical surges
- Meets IEEE 1613 class 1 (electric utility substations)
- Exceeds IEC 61850-3 (electric utility substations)
- Exceeds IEC 61800-3
- Exceeds IEC 61000-6-2
- Hazardous Location Certification: Class 1 Division 2
- -40°C to +85°C operating temperature (no fans)
- Conformal coated printed circuit boards (optional)

Rugged Operating System (ROS®) Features

- Simple plug and play operation – automatic learning, negotiation, and crossover detection
- MSTP 802.1Q-2005 (formerly 802.1s)
- RSTP (802.1W) and Enhanced Rapid Spanning Tree (eRSTP™) network fault recovery (<5 ms)
- Quality of Service (802.1P) for real-time traffic
- VLAN (802.1Q) with double tagging and GVRP support
- Link aggregation (802.3ad)
- IGMP Snooping for multicast filtering
- Port Rate Limiting and Broadcast Storm Limiting
- Port configuration, status, statistics, mirroring, security
- SNTP time synchronization (client and server)
- Industrial automation features (e.g. Modbus)

Management Tools

- Web-based, Telnet, CLI management interfaces
- SNMP v1/v2/v3
- Remote monitoring (RMON)
- Rich set of diagnostics with logging and alarms

Universal Power Supply Options

- Fully integrated, redundant (optional) power supplies
- Universal high voltage range: 88-300 V DC or 85-264 V AC
- Low voltage ranges: 24 V DC (10-36 V DC), 48 V DC (36-72 V DC)
- Screw or pluggable terminal blocks
- CSA/UL 60950 safety approved to +85°C

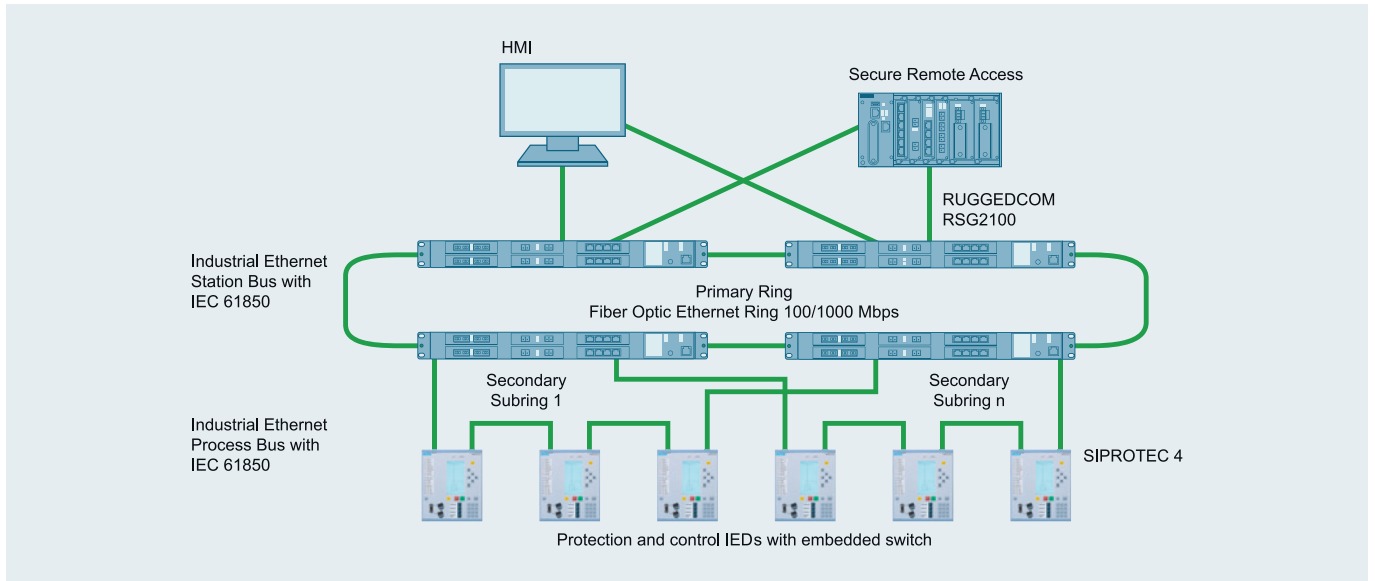


Fig. 13/102 Simplified diagram of IEC 61850 architecture for high and mid voltage substations with RUGGEDCOM switches enabling core Ethernet network.

Warranty
5 years – applicable to design or manufacturing related product defects.
Information and order data
www.siemens.com/ruggedcom
http://www.siemens.com/ruggedcom-selector

Description	Order No.
RSG2100	6GK6021-...
IE FC RJ45 Plug 180	6GK1 901-1BB10-2A□0
RJ45 plug connector for Industrial Ethernet with a rugged metal housing and integrated insulation-displacement/terminal contacts for connecting Industrial Ethernet FC installation cables, with a 180° cable outlet, for network components and CPs/CPU with Industrial Ethernet interface	
1 pack = 1 unit	A
1 pack = 10 unit	B
1 pack = 50 unit	B



Fig. 13/103 RUGGEDCOM RSG2488

Overview

The RUGGEDCOM RSG2488 is the first utility grade, field upgradable, non blocking 28 Gigabit port, layer 2 switch ideally suited for applications within utility substation and distribution; the RSG2488 is designed to reduce rack space needs, cut sparing costs and minimize time-to-repair while eliminating routine maintenance, delivering increased network availability and lowest total cost of ownership.

The RSG2488 is the latest addition to Siemens' extensive portfolio of products for industrial communication. The RSG2488 can operate reliably in electrically harsh and climatically demanding environments, e.g. in utility substation and distribution but also in networks for intelligent transportation solutions and infrastructure as well as rail systems along the entire rail line.

With an operating temperature range of -40 °C to +85 °C, a 1U form factor, extruded all-aluminum enclosure, fanless thermal management and optional conformal coating, the RSG2488 can be placed in almost any location. In meeting all specifications of the IEC 61850-3 and IEEE 1613 standards, the RSG2488 satisfies even the highest requirements in applications where switching transients and extreme EMI conditions are a possibility.

The RSG2488 provides a fully modular design with ports that can be configured as 10/100/1000TX copper, 100FX or 1000SX fiber. Exchange and expansion of the ports can be done quickly and directly on-site. With its modular, vertical loading design and dual redundant hot swappable power supplies, the RSG2488 provides users with the flexibility and field maintenance simplicity needed to efficiently implement, maintain and evolve a broadband local area network.

The RSG2488's RuggedRated™ hardware design and proven Rugged Operating System (ROS®) offer improved system reliability, advanced cyber security and advanced networking features which make it ideal for creating secure Ethernet networks for mission-critical applications in harsh environments.

Benefits

Field Replaceable Media Modules

- Easy remedy for commissioning mistakes – keeps commissioning on schedule
- Reduced sparing costs
- Reduced system downtime

Hot swappable power supplies

- Minimizes system downtime for weakest link
- Simplifies RMA process
- Reduced sparing costs

Fanless

- No routine maintenance required – eliminates major point of failure

High-Density 28 Port Gigabit Design

- Reduces required rack space
- Gives network architects greater flexibility

Native IEEE 1588v2 (planned in Q3/2013)

- Eliminates discrete timing solutions
- Makes evolution to future applications (like 61850 process bus) simple and economic

Mature and proven ROS® management system

- Track record in substation automation
- Reuse of existing tools, training, support, etc.

Utility Grade:

- IEC 61850-3
- IEEE 1613

Application

The RUGGEDCOM RSG2488 Industrial Ethernet switch supports cost-effective configuration of Ethernet line, ring and star topologies when high availability for mission-critical applications in harsh environments is required.

Accessories/RUGGEDCOM

Managed 28 Gigabit Port Ethernet Rack switch, RUGGEDCOM RSG2488

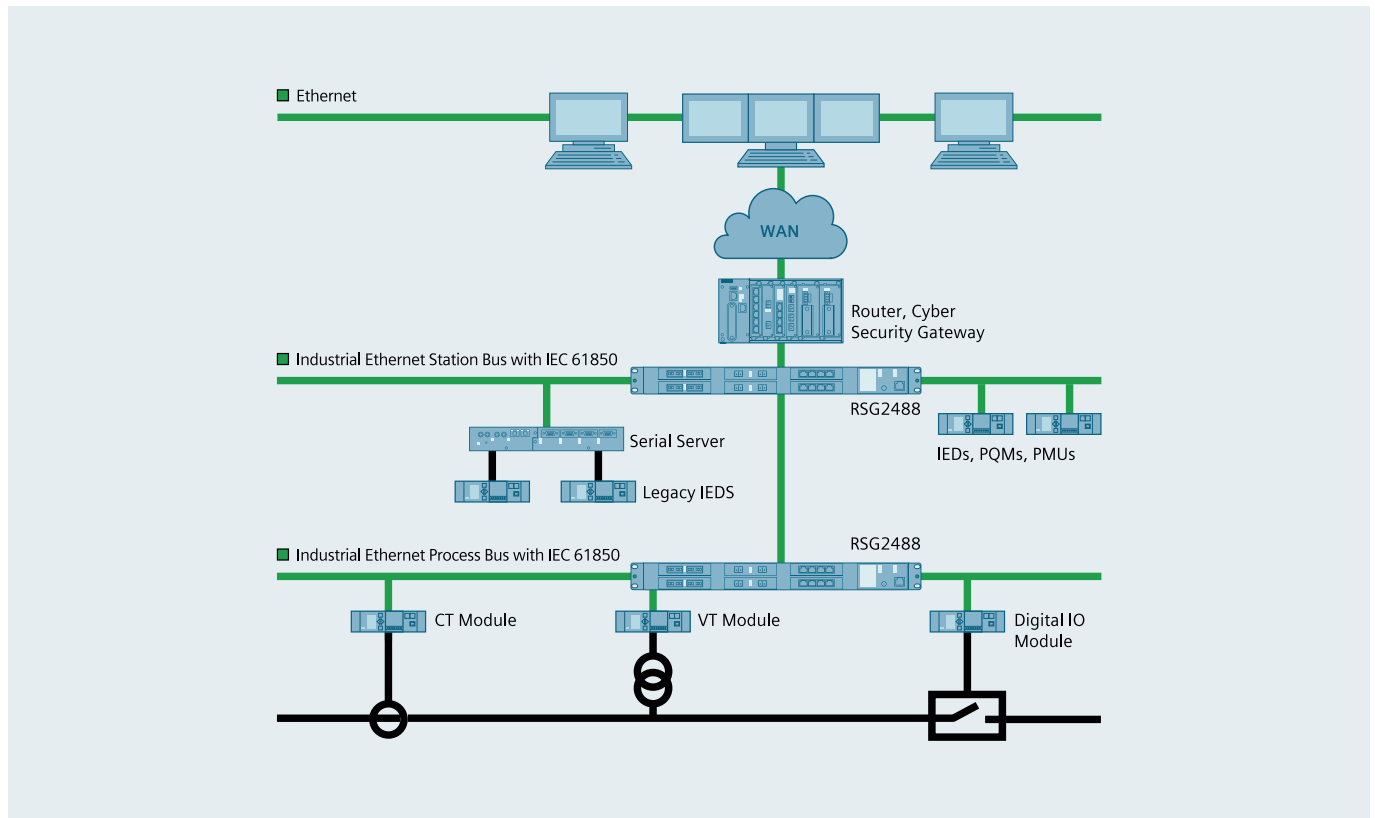


Fig. 13/104 Use-case: high level architecture

Function

ROS® 4.0 Product Features

Cyber Security Features

- Multi-level user passwords
- SSH/SSL (128-bit encryption)
- VLAN (802.1Q) to segregate and secure network traffic
- RADIUS centralized password management
- SNMPv3 authentication and 56-bit encryption

Rugged Operating System Features

- Simple plug and play operation – automatic learning, negotiation, and crossover detection
- MSTP 802.1Q-2005 (formerly 802.1s)
- RSTP (802.1W) and Enhanced Rapid Spanning Tree (eRSTP™) network fault recovery
- Quality of Service (802.1P) for real-time traffic
- VLAN (802.1Q) with double tagging and GVRP support
- Port configuration, status, statistics, mirroring, security
- SNTP time synchronization (client and server)

Management Tools System Features

- Web-based, Telnet, CLI management interfaces
- SNMP v1/v2/v3
- Remote monitoring (RMON)
- Rich set of diagnostics with logging and alarms

ROS® 4.1 Product Features (planned in Q3/2013)

Cyber Security Features

- Enable/Disable Ports
- Mac-Based Port Security
- 802.1x Port-Based Network Access Control

Rugged Operating System Features

- IGMP snooping
- Link Aggregation (802.3ad)
- Static MCAST filtering
- Port Security (802.1X)
- Port rate-limiting
- IEEE 1588 v2
 - 1-Step
 - 2-Step

Description	Order No.
<p>RSG2488</p> <p>Ethernet switch for setting up electrical and/or optical Industrial Ethernet networks; all ports can optionally be equipped with optical or electrical 2-port media modules; all ports support Gigabit Ethernet (non-blocking) eRSTP, RMON, IGMP Snooping/Querier, network management via SNMP and web server</p> <p>2 x 10/100/1000 Mbit/s slots for 2-port media modules, electrical or optical 6 x 10/100/1000 Mbit/s slots for 4-port media modules, electrical or optical</p> <p>Order Codes RSG2488- _____ M PS1 PS2 S1 S2 S3 S4 S5 S6 S7 S8 MOD</p> <p>M: Mounting Options</p> <ul style="list-style-type: none"> • DP = DIN and Panel Mount Kit • RD = 19" Rack, DIN, and Panel Mount Kit • 00 = No Mounting Option <p>Slots S1 to S6</p> <ul style="list-style-type: none"> • 2424 = Empty • 24CG01 = 4 x10/100/1000Tx RJ45 • 24FG01 = 4 x1000SX - MM, 850nm, LC, 500m • 24FG02 = 4 x1000LX - SM, 1310nm, SC, 10km • 24FG03 = 4 x1000LX - SM, 1310nm, LC, 10km • 24FG50 = 4 x1000LX SFP - Blank (no optical transceiver) • 24FG51 = 4 x1000SX SFP - MM, 850nm, LC, 500m • 24FG52 = 4 x1000LX SFP - SM, 1310nm, LC, 10km • 24FG53 = 4 x1000LX SFP - SM, 1310nm, LC, 25km • 24FG54 = 4 x1000LX SFP - SM, 1550nm, LC, 70km • 24FXA01 = 4 x100FX - MM, 1300nm, ST • 24FXA02 = 4 x100FX - MM, 1300nm, SC • 24FXA11 = 4 x100FX - MM, 1300nm, LC • 24FXA04 = 4 x100FX - SM, 1310nm, ST, 20km • 24FXA05 = 4 x100FX - SM, 1310nm, SC, 20km • 24PTP1 = Precision Time Protocol (PTP) Source Card: Input <p>Slots S7 – S8</p> <ul style="list-style-type: none"> • XXXX = Empty • 22CG01 = 2 x10/100/1000Tx RJ45 • 22FG50 = 2 x1000LX SFP - Blank (no optical transceiver) • 22FG51 = 2 x1000SX SFP - MM, 850nm, LC, 500m • 22FG52 = 2 x1000LX SFP - SM, 1310nm, LC, 10km • 22FG53 = 2 x1000LX SFP - SM, 1310nm, LC, 25km • 22FG54 = 2 x1000LX SFP - SM, 1550nm, LC, 70km <p>MOD: Manufacturing Modification</p> <ul style="list-style-type: none"> • XX = None • C01 = Conformal Coating 	<p>6GK6024-...</p>
<p>IE FC RJ45 Plug 180</p> <p>RJ45 plug connector for Industrial Ethernet with a rugged metal housing and integrated insulation-displacement/terminal contacts for connecting Industrial Ethernet FC installation cables, with a 180° cable outlet, for network components and CPs/CPU's with Industrial Ethernet interface</p> <p>1 pack = 1 unit 1 pack = 10 unit 1 pack = 50 unit</p>	<p>6GK1 901-1BB10-2A□0</p> <p style="text-align: right;">A B B</p>

Further Information: www.siemens.com/ruggedcom, <http://www.siemens.com/ruggedcom-selector>



Fig. 13/105 SITOP Power Supply

Benefits

- Reliable output voltage due to high-quality power supplies with flexible wide-range input and high overload capability
- High energy efficiency due to high efficiency and low standby losses
- Increased availability through optional add-on modules for protection against power supply failure, power failure, or fault-related overload in the 24 V circuit
- Comprehensive support in engineering by selection tool, CAx data, or product documentation

Overview

- Different SITOP product lines offer reliable power supplies for almost all line voltages, outputs, and requirements for regulated 24 V DC and other output voltages
- Redundancy modules decouple power supply units of the same type so that a defective power supply unit cannot affect the intact one
- SITOP DC UPS modules with two different types of energy storage expand the range of 24 V power supply units for uninterruptible DC power supply:
 - High-capacity and durable capacitors for buffering in the minute range, also for applications with IP65 degree of protection
 - Maintenance-free battery modules for continued operation, even for hours
- The selectivity module distributes the 24 V supply among several feeders and monitors them for fault-related overload. The electronic add-on module detects short-circuits even in long, high-impedance lines and reliably switches off the load circuit.

Accessories/SITOP Power Supply

SITOP Power Supply

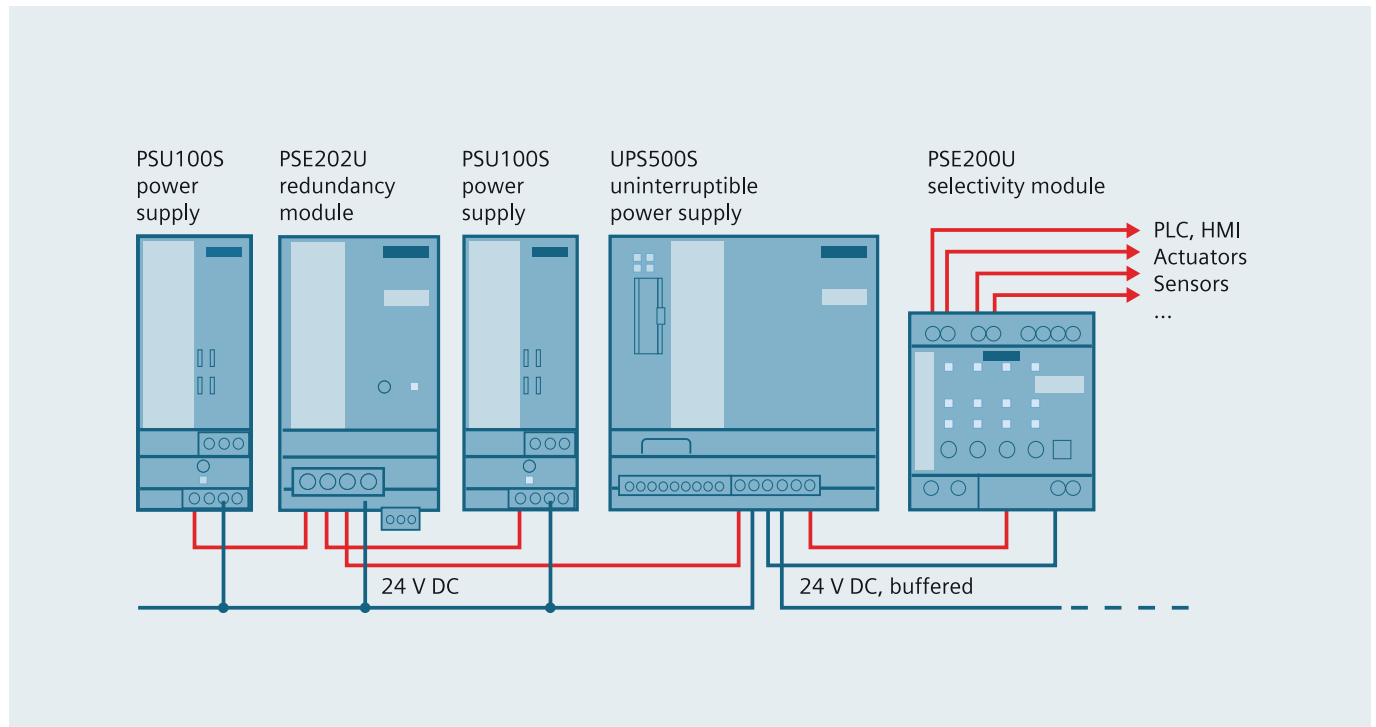


Fig. 13/106 Configuration with SITOP smart (PSU100S) and add-on modules

Ordering data

Product line, application	Output
Power Supply 24 V DC	
SITOP compact – the slim power supply up to 100 W for control boxes, single-phase	0.6 A, 1.3 A, 2.5 A, 4.0 A
LOGO!Power – flat power supply up to 100 W for distribution boards, single-phase	1.3 A, 2.5 A, 4.0 A
SITOP smart – the high-performance standard power supply up to 1000 W for 1-phase and 3-phase networks	single-phase: 2.5 A, 5 A, 10 A, 40 A 3-phase: 10 A, 20 A, 40 A
SITOP modular – technology power supply up to 1000 W for demanding solutions for 1-, 2- and 3-phase	single-phase: 5 A, 10 A, 20 A, 40 A 3-phase: 20 A, 40 A
Expansion Modules for Power Supply 24 V DC	
Redundancy modules SITOP PSE202U	10 A, 40 A
DC UPS SITOP UPS500S with capacitors (incl. USB interface)	7 A, 15 A, 2.5 kW – 20 kW
DC UPS with battery modules (optionally with serial interface or USB)	6 A, 15 A, 40 A, 1.2 Ah – 12 Ah
Selectivity modules SITOP PSE200U (optionally with single-channel signaling)	4 x 0.5 ... 3 A 4 x 3 ... 10 A

Further information on the ordering data, technical data, and power supplies with other output voltages: see Catalog KT10.1



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Fig. 13/107 7XV5662-6AD10 RTD-box TR1200

Function overview

- 3-digit temperature display
- 12 inputs for temperature sensors, 1 to 12 sensors can be connected
- Pt 100 thermostats with 2- or 3-conductor technology
- 1 error relay (potential-free change-over contact)
- RS485 interface (ZIEHL standard protocol and MODBUS RTU protocol)
- LED signal the measuring channel, error state, relay function and RS485 activity
- Code lock prevents parameter manipulation
- TR600 compatible (to replace one TR600 with 6 sensors connected)
- Universal power-supply AC/DC 24 to 240 V
- Snap-on mounting onto 35 mm standard rail EN 60715

Description

The RTD-box TR1200 can capture up to 12 temperatures with 12 measuring inputs. 2- and 3-conductor Pt 100 sensors are supported. For the 2-conductor mode, the measured conductor resistance can be compensated for with a corresponding setting. The measurement of temperatures may be simulated for commissioning purposes.

The output of measured values to the protection device is compatible with TR600 and implemented with bus cable 7XV5103-7AAxx via a RS485 bus.

All settings are done via 3 push buttons on the front of the device. Entry can be blocked via a code.

The TR1200 has a wide-range power supply from DC 24 – 250 V and AC 115/230 V as well as an alarm relay. Sensor failure or sensor short-circuit are alarmed and transmitted via protocol to the SIPROTEC device.

Application

Communication via RS485 bus

The RTD-box TR1200 is connected via a RS485 interface to one SIPROTEC 4 bay device with thermo function (e.g. 7SJ6, 7UT6, 7UM6) or to the compact protection 7SK80 via a serial RS485-interface (Port B).

The special cable 7XV5103-7AAxx is used for the connection. In the event of remote measuring locations, the connections may also be done using multi-mode fiber-optic conductors and the converter 7XV5650 (see Fig. 13/108).

For detailed information please visit www.siemens.com/siprotec

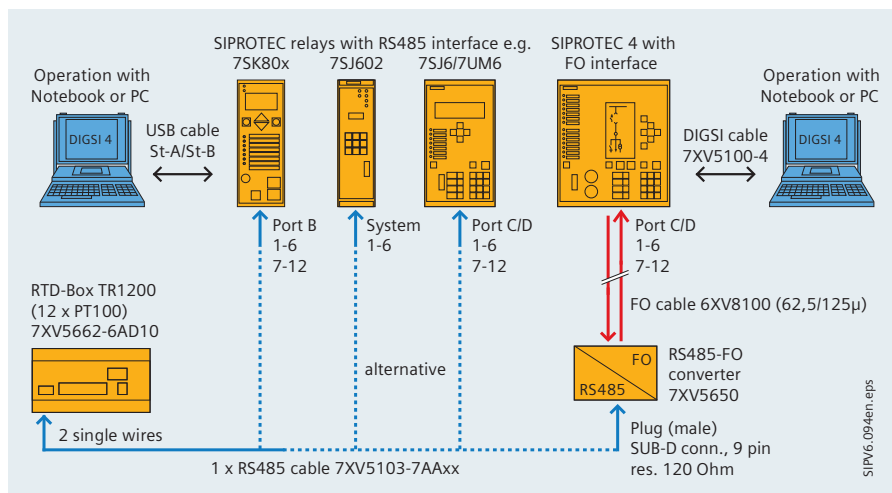


Fig. 13/108 Connection of devices via a serial RS485 bus or FO cable

Technical data

Rated auxiliary voltage	
Auxiliary voltage V_S	AC/DC 24 – 240 V, 0/45 – 65 Hz < 5 VA
Tolerance	DC 20.4 – 297 V, AC 20 – 264 V
Relay output	
Number	1 changeover contact (CO)
Switching voltage	Max. AC 415 V
Switching current	Max. 5 A
Switching power	Max. 2000 VA (ohmic load) Max. 120 W at DC 24 V
De-rating factor with $\cos \varphi = 0.7$	0.5
U_L electrical ratings:	AC 250 V, 3 A general use D300 1 A AC 240 V
Rated operating current I_E AC 15 DC 13	$I_E = 2$ A $V_E = 250$ V $I_E = 2$ A $V_E = 24$ V $I_E = 0.2$ A $V_E = 125$ V $I_E = 0.1$ A $V_E = 250$ V
Recommended fuse	T 3.5 A (gL)
Contact service life, mech.	1×10^7 switching operations
Contact service life, electr.	1×10^5 switching operations at AC 250 V/5 A
Sensor connection	
Number	$12 \times$ Pt 100 according to EN 60751
Measuring cycle/measuring time	0.25 to 3 s (depending on the number of sensors)
Measuring cycle/circuit resistance	0.25 to 30 s (per measuring cycle of sensor)
Measuring range	-199 to 850 °C
Resolution	1 °C
Accuracy	± 0.5 % of measured value ± 1 K
Sensor current	≤ 0.8 mA
Temperature drift	< 0.04 °C/K
Short circuit	< 15 Ohm
Interruption	> 400
Sensor resistance + circuit resistance	Max. 500 Ohm

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<i>RS485 interface</i>	
Device address	0 to 96
Baud rate	4800, 9600, 19200 bit/s
Parity	N, O, E (no, odd, even)
Max. cable length	1000 m at 19200 bit/s
Serial protocol	Serial RTD – Protocol Ziehl/SIPROTEC See manual for detailed protocol description
<i>Test conditions</i>	
Acc. to	EN 61010
Rated impulse voltage insulation	4000 V
Overvoltage category	III
Pollution rate	2
Rated insulation level V_i	300 V
Duty cycle	100 %
Perm. ambient temperature	- 20 °C to + 65 °C EN 60068-2-2 dry heat
Electrical isolation	Power supply – measuring inputs DC 3820 V
No electrical isolation	RS 485 interface – measuring inputs
<u>EMC-tests</u>	EN 61326-1
EMC test for noise emission	EN 61000-4-3
Fast transient disturbances/Burst	EN 61000-4-4 ± 4 kV Pulse 5/50 ns, $f = 5$ kHz, $t = 15$ ms, $T = 300$ ms
High-energy surge voltages (SURGE)	IEC 61000-4-5 ± 1 impulse: 1.2 / 50 µs (8/20 µs)
Electrostatic discharge	IEC 61000-4-2 ± 4 contact discharge, ± 8 kV air discharge
<i>Housing</i>	
Housing type	V8, distribution panel mounting
Size (W × H × D)	140 x 90 x 58 mm
Depth/Width	55 mm/8 TE
Circuit termination single strand	Per 1 × 1.5 mm ²
Braided conductor with crimp lug	Per 1 × 1.0 mm ²
Tightening torque of terminal screw	0.5 Nm (3.6 lb.in)
Protection class of housing/terminals	IP30/IP20
Mounting vertical/horizontal	Optional
Affixing	Snap-on mounting onto standard rail mounting 35 mm acc. to EN 60715 or screw mounting (with 2 additional brackets)
Weight	Approx. 370 g

Selection and ordering data

Description	Order No.
Resistance temperature detector (RTD-box) TR1200 Distributed input-box for 12 RTD-connections Pt100 Rail mounting plastic Protection class IP21 1 serial interface RS485 for communication with SIPROTEC devices for measurements and fault reports. Wide-range power supply AC 24 to 240 V/ Note: The device can be operated in a 7XV5662-2AD10 or 7XV5662-5AD10 compatible mode.	7XV5662 - 6AD10

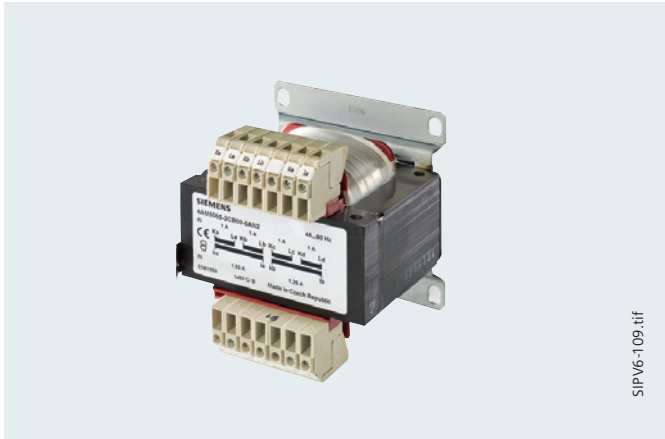


Fig. 13/109 7XV5662-7AD10 universal relay/RTD-box TR800

Description

The universal relay TR800 Web has 8 measuring/sensor inputs and is able to capture 8 temperatures via PT100- (Ni100 and Ni120) elements. The measuring values 1 – 6 may be transmitted to SIPROTEC 4 devices with thermo function via protocol. Two universal relays with a total of 12 measuring inputs can be connected.

Connection is established via a serial RS485 interface (see Fig. 13/112). The TR800 is protocol compatible with the TR600 (7XV5662-3AD10, 7XV5662-5AD10) on the serial RS485 interface, and transmits the 6 temperatures in the same format. In this mode, the TR800 can replace the TR600.

In the case of 7SK80 motor protection, the connection may alternatively be made via the Ethernet interface, if the system interface is (pre-)assigned (see Fig. 13/110 + 13/111). The universal relay is operated and configured via the Ethernet interface with a Web browser. Three conductor thermo elements are supported. For the dual conductor connection the measured line resistance can be compensated for by a software setting. Furthermore, temperatures can be simulated to test the thermo-function in the SIPROTEC devices.

Alternatively to thermo sensors, 8 analog values DC 0/4 – 20 mA and DC 0 – 10 V may be measured. The output can be scaled and the designation (°C, V, A, %) can be adapted in the TR800. The transmission to the SIPROTEC – device however takes place via the RTD – protocol in temperature format. 6 of the 8 analog sensor values are available there. With 2 TR800 12 values are available. For example 5.5 mA is transferred with a temperature value of 55 in this way and may either be displayed as temperature in the SIPROTEC device or compared with a set limit via a threshold value. This allows for the processing of analog dimensions in SIPROTEC devices with thermo function or their transmission to a substation control unit (e.g. SICAM PAS). In the bay control unit 6MD66 V4.8 (available since 05/2009) all 8 measuring inputs are available.

The TR800 has a wide-range power supply from DC 24 V – 250 V and AC 115/230 V as well as an alarm relay. Sensor failure or sensor short-circuit are alarmed and transmitted via protocol to the SIPROTEC device.

Function overview

- 8 measuring inputs:
 - Pt 100, Pt 1000 in 2- or 3-conductor technology
 - KTY 83 or KTY 84
 - Thermocouples type B, E, J, K, L, N, R, S, T
 - DC 0 to 10 V, 0/4 to DC 20 mA
 - Resistance 500 Ohm, resistance 30 kOhm
- 4 relay-outputs (each potential-free changeover contact)
- Ethernet interface (http, https, UDP, MODBUS, Bonjour, UpNP, SNMP)
- RS485 interface (Standard ZIEHL- and MODBUS RTU protocol)
- Universal power-supply AC/DC 24 to 240 V
- Integrated Web server for configuration, read-out of measured data, user-management email-alarms, data- and alarm-logging
- Time-dependent control (day/night)
- Real-time clock with synchronization with time server.

Application

Application

Communication with one TR800 Web via Ethernet interface

If one universal relay TR800 is sufficient for the measured-value capturing, it may be connected directly to the protection device with a CAT5 patch cable (e.g. 7SK80x/ Port A). The setting of the TR800 Web is done prior to connection with the same cable via a PC using a Web browser. A TR800 can also be interrogated by two or more SIPROTEC devices. IP-address and the UDP-Port of the TR800 may be set in the SIPROTEC device. In this way, one SIPROTEC device may use temperatures 1 – 3 and another device can use the temperatures 3 – 6 for processing. Each device, however, reads in all 6 temperature values (Fig. 13/110).

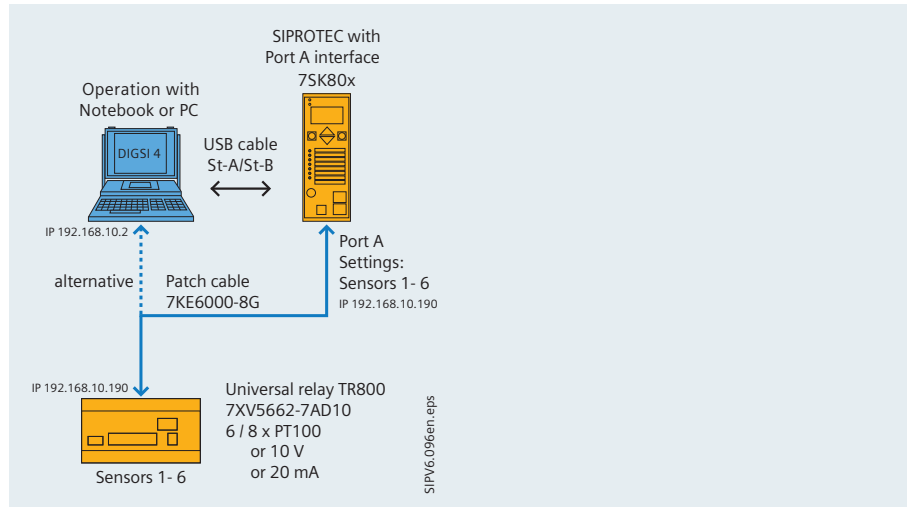


Fig. 13/110 Connection of one device via Ethernet

Communication with two TR800 Web via Ethernet interface

If two TR800 are applied on big motors for the purpose of measured-value capturing, a substation hardened switch (e.g. RUGGEDCOM RS900 or Hirschmann RSR20) must be used. The switch, the two TR800 Web relays, the protection device and the operating PC constitute an autonomous subnet when they are connected via patch cables (1:1). They may also be part of a larger Ethernet network.

DIGSI 4 and Web browser can run in parallel on the operating PC. Accordingly, one of the two TR800 Web and the protection device can be applied and read out during normal operation. (Fig. 13/111).

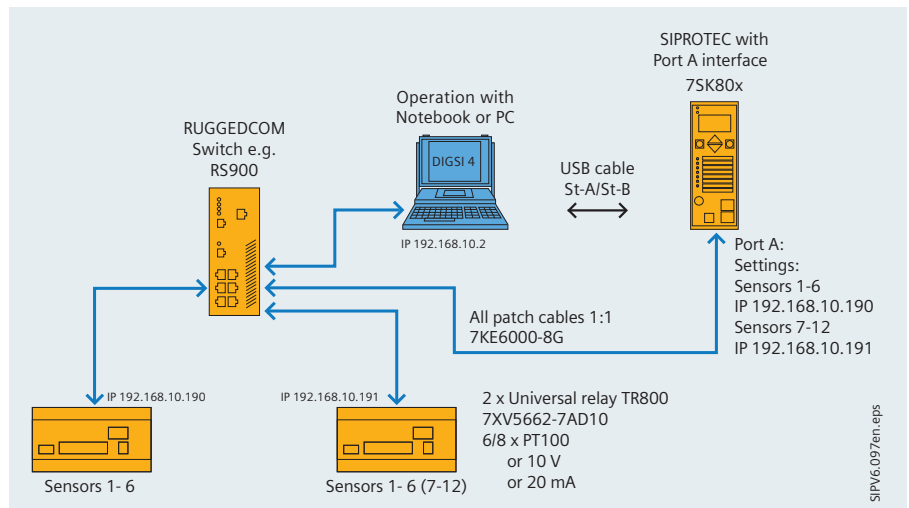


Fig. 13/111 Connection of two devices via Ethernet

Communication via RS485 bus

One or two TR800 may be connected via a RS485 interface to a SIPROTEC 4 device with thermo function (7SJ6, 7UT6, 7UM6), or the compact device 7SK80.

For connection purposes the special cables 7XV5103-7AAxx are used. In the case of remote measuring points a connection can also be established via a multi-mode FO cable and the converter 7XV5650.

For different applications, 3 modes of operation are available. All three modes are compatible with thermo box TR600 with 6 measuring inputs. The mode of operation is set via the RS485 address of the TR800 Web.

For detailed information please visit www.siemens.com/siprotec

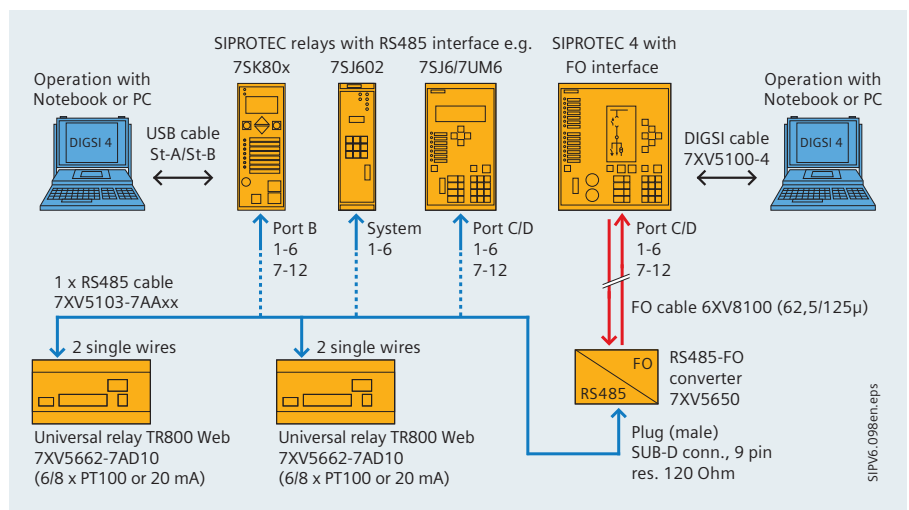


Fig. 13/112 Connection via serial RS485 bus or FO cable

Rated auxiliary voltage													
Auxiliary voltage V_S	AC/DC 24 to 240 V, 0/45 to 120 Hz < 4 W < 8 VA												
Tolerance	DC 20.4 to 297 V, AC 20 to 264 V												
Insulation	AC 2000 V												
Relay output													
Number	4 x 1 changeover contact (CO)												
Switching voltage	Max. AC 415 V												
Switching current	Max. 5 A												
Switching power	Max. 2000 VA (ohmic load) Max. 120 W at DC 24 V												
De-rating factor with $\cos \varphi = 0.7$	0.5												
U_L electrical ratings	AC 250 V, 3 A general use AC 240 V ¼ hp. 2.9 FLA AC 120 V ¼ hp. 3.0 FLA C 300 D 300 1 A AC 240 V												
Rated operating current I_E AC 15 DC 13	<table border="0"> <tr> <td>$I_E = 3$ A</td> <td>$V_E = 250$ V</td> </tr> <tr> <td>$I_E = 2$ A</td> <td>$V_E = 24$ V</td> </tr> <tr> <td>$I_E = 0.2$ A</td> <td>$V_E = 125$ V</td> </tr> <tr> <td>$I_E = 0.1$ A</td> <td>$V_E = 250$ V</td> </tr> </table>					$I_E = 3$ A	$V_E = 250$ V	$I_E = 2$ A	$V_E = 24$ V	$I_E = 0.2$ A	$V_E = 125$ V	$I_E = 0.1$ A	$V_E = 250$ V
$I_E = 3$ A	$V_E = 250$ V												
$I_E = 2$ A	$V_E = 24$ V												
$I_E = 0.2$ A	$V_E = 125$ V												
$I_E = 0.1$ A	$V_E = 250$ V												
Recommended fuse	T 3.5 A (gL)												
Contact service life, mech.	1×10^7 switching operations												
Contact service life, electr.	1×10^5 switching operations at AC 250 V/6 A												
Real-time clock													
	Buffered for 7 days. Continuous synchronization via SNTP on the Ethernet interface is possible												
Test conditions													
Acc. to	EN 61010-1												
Rated impulse voltage insulation	4000 V												
Pollution rate	2												
Rated insulation level V_i	300 V												
Duty cycle	100 %												
Perm. ambient temperature	- 20 °C to + 65 °C EN 60068-2-1 dry heat												
Seismic safety EN 60068-2-6	2 to 25 Hz ± 1.6 mm 25 to 150 Hz 5 g												
Electrical isolation	Ethernet – measuring input min. DC 500 V												
No electrical isolation	RS 485 interface – measuring inputs												
EMC tests	EN 61326-1												
EMC test for noise emission	EN 61000-4-3												
Fast transient disturbances/Burst	EN 61000-4-4 ± 4 kV Pulse 5/50 ns, $f = 5$ kHz, $t = 15$ ms, T = 300 ms												
High-energy surge voltages (SURGE)	IEC 61000-4-5 ± 1 impulse: 1.2/50 μ s (8/20 μ s)												
Electrostatic discharge	IEC 61000-4-2 ± 4 contact discharge, ± 8 kV air discharge												
Ethernet connection	10/100 MBit Auto-MDIX (no cross-over cable required)												
Sensor connection													
Measuring cycle/measuring time (for 8 measured values)	< 3 s												
Pt100, Pt1000 according to EN 60751:													
	Measured range °C		Short circuit Ohm	Interruption Ohm	Sensor resistance + circuit resistance Ohm								
Sensor	min.	max.	<	>	> max.								
Pt 100	-199	860	15	400	500								
Pt 1000	-199	860	150	4000	4100								
When connecting Ni100 or Ni120 sensors, the conversion is done in the SIPROTEC device. The TR800 is configured with Pt100 sensors.													

Accessories/7XV5662

Technical data, selection and ordering data

<i>Sensor connection (continued)</i>			
Accuracy	± 0.5 % of measured value ± 0.5 K		
Sensor current	≤ 0.6 mA		
Temperature drift	< 0.04 °C/K		
<i>Voltage/current input</i>			
	Input resistance	Maximum input signal	Accuracy of final value
0 – 10 V	12 kΩ	27 V	0,1 %
0/4 – 20 mA	18 Ω	100 mA	0.5 %
Temperature drift	< 0.02 %/K		
<i>Resistance measurement</i>			
Accuracy 0.0 ... 500.0 Ω	0.2 % of measured value ± 0.5 Ω		
Accuracy 0 ... 30.00 kΩ	0.5 % of measured value ± 2 Ω		
Sensor current	≤ 0.6 mA		
<i>Housing</i>			
Housing type	V8, distribution panel mounting		
Size (W × H × D)	140 × 90 × 58 mm		
Depth / Width	55 mm / 8 TE		
Circuit termination single strand	Per 1 × 1.5 mm ²		
Braided conductor with crimp lug	Per 1 × 1.0 mm ²		
Tightening torque of terminal screw	0.5 Nm (3.6 lb.in)		
Degree of protection of housing/terminals	IP30 / IP20		
Mounting vertical/horizontal	Optional		
Affixing	Snap-on mounting onto standard rail mounting 35 mm acc. to EN 60715 or screw mounting (with 2 additional brackets)		
Weight	Approx. 370 g		

Selection and ordering data

Description	Order No.
Universal relay/RTD-box TR800 Distributed input-box for 6/8 RTD-connections (RTD-box) or 6/8 × 20 mA, or 0 – 10 V Rail mounting plastic Protection class IP21 1 serial interface RS485 for communication of measurements 1 RJ45 interface for parameter setting via Web browser and communication of measurements Wide-range power supply AC/DC 24 to 240 V Note: The device can be operated in a 7XV5662-2AD10 or 7XV5662-5AD10 compatible mode.	7XV5662 - 7AD10



Fig. 13/113 7XV5662-8AD10 RTD-box TR1200 IP (Ethernet)

Description

The RTD-box TR1200 IP has 12 sensor inputs which allow measurement of up to 12 temperatures by Pt100 sensors.

Three conductor sensors are supported. For two conductor operation compensation of the measured conductor resistance is possible via a corresponding setting.

All settings on the TR1200 IP can be done through 3 keys on the front of the device or in a Web browser (e.g. Internet Explorer).

If Ni100 or Ni120 sensors are applied, the measured values have to be adapted in the protection device. The 7SK80 supports this with its integrated RTD functionality.

The measured-value output to the protection device is done via Ethernet network with RJ45 connectors.

Note: The SIPROTEC 4 system interface with EN100 module does not support the temperature detection of the RTD-box TR1200 IP.

Function overview

- 3-digit digital display for the temperature of up to max. 12 measuring points
- 12 sensor inputs; 1 to 12 sensors can be connected
- PT100 in 2- or 3-conductor technology, when connecting Ni100 or Ni120, conversion to the correct temperature in the evaluation unit is required, SIPROTEC devices (e.g. 7SK80) support this function. The EN100 module in the SIPROTEC 4 units does not support the TR1200 IP
- 1 alarm relay (1 changeover contact)
- Electric 10 MBit/s Ethernet interface (RTD IP protocol from ZIEHL, or MODBUS IP protocol)
- Read-out display, configuration, simulation and firmware update via Web browser
- Tested with Mozilla Firefox 3.5 and Microsoft Internet Explorer 8.0
- LEDs for measurement allocation, error, relay status and Ethernet interface
- Code protection against manipulation of the setpoint values
- Wide-range power supply AC/DC 24 to 240 V
- Distributor housing for panel mounting 8 TE, front-to-back size 55 mm
- Mounting on 35 mm DIN EN 60715 standard rail.

Application

Measurement of up to 12 measured values with a TR1200 IP

To get up to 12 measured values one RTD-box TR1200 IP is connected via a double screened CAT5 patch cable (1:1 or crossed-over) directly to the protection device (e.g. 7SK80x/Port A).

The protection device is set using DIGSI 4 program running on a Notebook via the USB-front interface.

The RTD-box TR1200 IP is set either through the front keys or by using a Web browser running on the Notebook via the Ethernet interface. For this purpose the patch cable must be unplugged from the protection device and then re-plugged into the Notebook.

Tip: If during commissioning a common switch is temporarily inserted using three patch cables, the protection device can be set from a PC using DIGSI 4 in parallel with the TR1200 IP.

For detailed information please visit:
www.siemens.com/siprotec

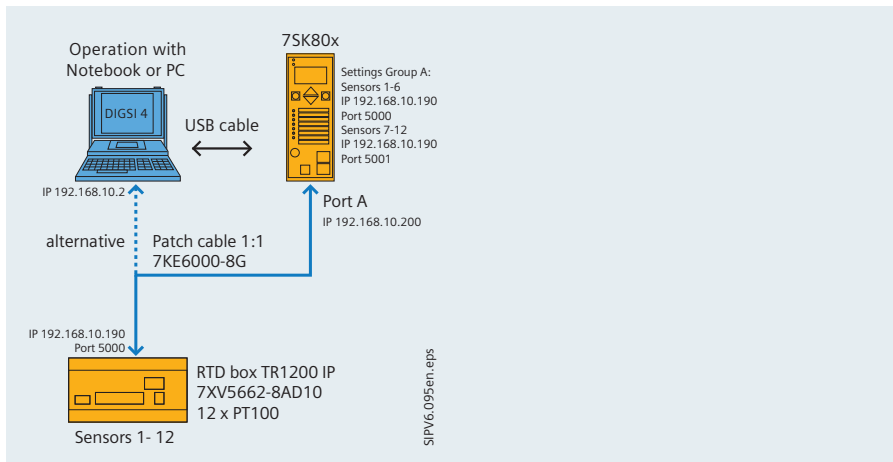


Fig. 13/114 Connection of a device via Ethernet

Technical data

Rated auxiliary voltage

Control voltage V_S	AC/DC 24 – 240 V, 0/45 – 65 Hz < 5 VA DC 20.4 – 297 V, AC 20 – 264 V
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Relay output

Number	1 changeover contact (CO)	
Switching voltage	Max. AC 415 V	
Switching current	Max. 5 A	
Breaking capacity	Max. 2000 VA (resistive load) Max. 120 W at DC 24 V	
Reduction factor at $\cos \varphi = 0.7$	0.5	
U_L electrical ratings:	AC 250 V, 3 A general use AC 240 V 1/4 hp. 2.9 FLA AC 120 V 1/10 hp. 3.0 FLA C 300 D300 1 A AC 240 V	
Rated operating current I_E	AC 15	$I_E = 1$ A $V_E = 400$ V
		$I_E = 2$ A $V_E = 250$ V
	DC 13	$I_E = 2$ A $V_E = 24$ V
		$I_E = 0.2$ A $V_E = 125$ V
		$I_E = 0.1$ A $V_E = 250$ V
Recommended series fuse	T 3.5 A (gL)	
Contact service life, mech.	1 x 10 ⁷ switching operations	
Contact service life, electr.	1 x 10 ⁵ switching operations at AC 250 V / 5 A	
	2 x 10 ⁵ switching operations at AC 250 V / 3 A	
	6 x 10 ⁵ switching operations at AC 250 V / 1 A	

<i>Temperature measurement</i>						
Measurement time sensor	0.25 to 3 s (dependent on the number of sensors)					
Measurement time sensor	0.25 to 30 s (for measurement cycle of one sensor)					
Measurement range	-199 °C to 850 °C					
Resolution	1 °C					
<i>Sensor connection</i>						
12 x PT100 acc. to EN 60751, connection of Ni100 and Ni120 sensors possible. Conversion of the measured values must be performed in the evaluation unit.						
	Measured range °C		Short circuit Ohm	Interruption Ohm	Sensor resistance + circuit resistance Ohm	
Sensor	min.	max.	<	>	> max.	
Pt 100	-199	860	15	400	500	
Tolerance	± 0.5 % of measurement ± 1 K					
Sensor current	≤ 0.8 mA					
Temperature drift	< 0.04 °C/K					
<i>Ethernet interface</i>						
Transmission speed	10 MBit/s					
IP adress	Standard: 192.182.1.100, adjustable					
Subnetwork mask	Standard: 255.255.255.0, adjustable					
UDP port	Standard: 5000 (5001), adjustable					
Max. cable length	20 m when using CAT 5 patch cable					
Max. response time RTD/MODBUS	< 700 µs					
<i>Test conditions</i>						
Acc. to	EN 61010					
Rated impulse withstand voltage	4000 V					
Surge category	III					
Pollution level	2					
Rated insulation voltage V_i	300 V					
Operating time	100 %					
Permissible ambient temperature during operation	- 20 °C to + 65 °C EN 60068-2-2 dry heat					
EMC – noise immunity	EN 61000-6-2					
EMC – noise emission	EN 61000-6-4					
Galvanic insulation						
Control voltage – measurement input	DC 3820 V					
Ethernet – control voltage – measurement input	DC 500 V					
<i>Housing</i>						
Housing type	V8, distribution panel mounting					
Dimensions (W × H × D)	140 x 90 x 58 mm					
Front-to-back size/Width 55 mm / 8 TE						
Wiring connection single strand	Each 1 x 1.5 mm ²					
Finely stranded with wire end ferrule	Each 1 x 1.0 mm ²					
Starting torque of the terminal screw	0.5 Nm (3.6 lb.in)					
Protection class housing/terminals	IP30 / IP20					
Mounting position	Arbitrary					
Mounting	Snap-on mounting onto standard rail 35 mm acc. to EN 60715 or screw mounting (with 2 additional bars)					
Weight	Approx. 350 g					

Accessories/7XV5662

Selection and ordering data

Description	Order No.
<p>Resistance temperature detector (RTD-box) TR1200 IP (Ethernet)</p> <p>Distributed input-box for 12 RTD-connections Pt100</p> <p>Rail mounting plastic</p> <p>Protection class IP21</p> <p>1 Ethernet interface for communication with SIPROTEC devices for measurement and fault reports.</p> <p>Wide-range power supply AC/DC 24 to 240 V</p>	<p>7XV5662 - 8AD10</p>



Fig. 13/115 7XV75 test switch

Function overview

The following versions are available in a flush-mounting housing:

- For feeder protection without an open star point
- For feeder protection without an open star point and with additional contacts
- For feeder protection without an open star point for two CT cores or separate ground-fault CT
- For feeder protection with an open star point
- For feeder protection with an open star point and independently switchable trip and CT circuits
- For a 3-winding transformer differential protection
- For feeder protection without an open star point with 4th CT and 4th VT input (three-stage test switch)

Description

The 7XV75 test switch serves for testing protection relays including CT circuits and command contacts. With the help of the switches located on the front side, the current and voltage inputs as well as the circuits of the protection relay to be tested are interrupted and applied to the front side. Via this plug-in connector, currents and voltages can be fed by an injection test set and the different commands and indications can be tested.

Accessories/7XV75

7XV75 test switch

Technical data

Test switch

Rated operating voltage V_n	AC 400 V
Rated operating current I_n	6 A
Test current capacity	for 1 s 150 A for 10 s 60 A

Unit design

Metal housing	7XP20
Dimension	1/6 of 19" wide
Weight	Approx. 3.4 kg

Selection and ordering data

Description	Order No.
7XV75 test switch	7XV750□-□CA00
Without open star point for feeder protection	0
With open star point for feeder protection	1
For 3-winding transformer differential protection	2
Without open star point for two CT cores or separate ground-fault CT	3
Without open star point for feeder protection with 4 th CT and 4 th VT input (three-stage test switch)	6
Without open star point for feeder protection and with additional contacts	7
With open star point and independently switchable trip and CT circuits for feeder protection	8
Front test plugconnection	
With 16-pin Harting connector	0
With 16 banana connectors (not available for 7XV7506)	1
Connecting cable 7XV6201 for 7XV75 test switch with 2 meter cable	
with 16-pin Harting connector and 17 isolated banana connectors 4 mm with cable marks	7XV6201-5
with 16-pin Harting connector and 17 cable end sleeves with cable marks	7XV6201-6



Fig. 13/116 SNTP Master/Server 7SC80

Description

The hardware variant of the 7SC80 integrates an SNTP server and a GPS module.

With it the first substation hardened SNTP server with GPS receiver is available for precise time synchronization for all SIPROTEC 4/5 protective relays and all other SNTP-capable devices, e.g. SICAM T/Q80 or 3rd-party products. The few configuration settings (e.g. IP-address) will be done with DIGSI 4.

With additional 12 binary inputs and 8 binary outputs included.

The communication redundancy protocols RSTP/PRP/HSR and IEC 61850 are supported completely. With these features the SNTP Server with optical interfaces can be operated directly as part of SIPROTEC ring networks.

A GPS antenna kit with antenna, mounting and 25 m cable is available separately.

Features

- External GPS antenna kit with flat roof/wall mounting, 25 m cable RG59 and adapter cable BNC/SMB is available separately
- GPS-antenna interface (SMB-connector)
- USB-Port for configuration with DIGSI 4
- Default equipped with 2 electrical Ethernet ports RJ45
- Dual armed connection in Active-Standby configuration
- Equipped with 2 optical Ethernet interfaces (optional)
- Detached operation possible, with single-mode interfaces up to 24 km
- Complete support of redundant ring structures with RSTP/PRP/HSR Protocol

- Stainless steel housing
- Fulfills EMC requirements in substations
- Extended temperature range -50 °C - +85 °C
- Robust against heavy GOOSE load in IEC 61850 networks
- Can be used as central data concentrator, e.g. recording of GOOSE messages
- Supports IEC 61850 Edition1 and Edition 2
- Integration in IEC 61850 substation controller (with max. 6 Clients)
- Integration in DIGSI 4 IEC 61850 system configurator
- Additional deployment for automation (CFC)
- Remote Access
- Optimized for use together with SIPROTEC devices and EA-Products

Hardware Interfaces

12 Binary inputs

- 8 and 4 inputs with common ground

8 Binary outputs

- All relays freely configurable

1 Live contact

- Changeover

Power supply/Battery voltage

- Auxiliary voltage DC 24/48 V, DC 60–250 V and AC 110–230 V ± 20 %

Ethernet interface RJ45

- 2 x 100 Mbit/s

Optical interface (optional)

- LC-connector, 1300 nm multi-mode fiber 50/62.5 µm typ. distance up to 4 km

Optical interface (optional)

- LC- connector, 1300 nm single-mode fiber 9 µm typ. distance up to 24 km

USB-interface

- Configuration with DIGSI 4

SMB-connector

- To connect to an active GPS-antenna, 5 V supply, max. 50 mA

Housing

- Stainless steel, IP40 for surface mounting, access to battery without opening housing

EMC

- In accordance with SIPROTEC protective relays

Accessories/7SC80

SNTP Master/Server 7SC80

Applications

With the 7SC80 SNTP time server all Ethernet attached devices can be synchronized via SNTP protocol (Simple Network Time Protocol) at a millisecond accuracy base. The transmitted time is standardized UTC-time or local time. For this application all (protection) devices need a suitable Ethernet interface, e.g. in SIPROTEC 4 port B (EN100 module) is needed. The GPS antenna is mounted to an outside wall or flat roof with line of sight to the sky (order separately). The SNTP server will be mounted close to the antenna and will be typically supplied with the same auxiliary voltage as the protective relays. By using the optical interfaces, any EMC influence is excluded, even with long distances between SNTP Server and protective relays. By using the 7SC80 for time synchronization the typical accuracy is ± 1 ms. A dedicated network for time synchronization is not necessary. The deployment of 7SC80 in redundant SNTP time server scenarios is possible as well. The integration in DIGSI-projects can be done with the complete 7SC80 parameter set; the usage of SNTP.ICD files is no longer necessary. In the protective relays the time source has to be adjusted to „Ethernet NTP“. Local time settings, e.g. summer/winter time switchover or time offset, can be considered as well.

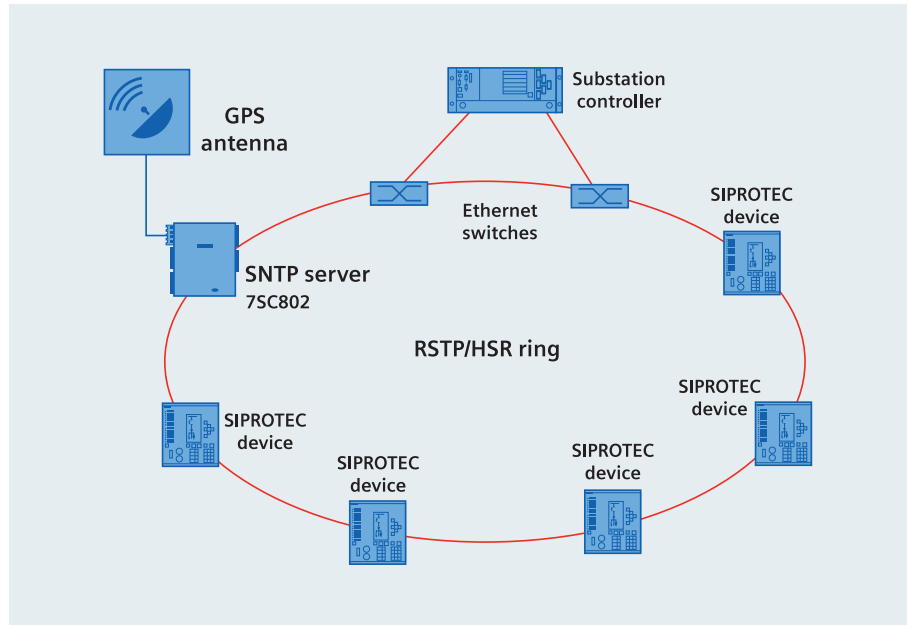


Fig. 13/117 Example of a redundant integration of a 7SC80 SNTP server in an optical SIPROTEC ring network

Selection and ordering data

Description	Order No.
SNTP Master/Server 7SC80	7SC8022- <input type="checkbox"/> AB97-3FNO-L0 <input type="checkbox"/>
Rated auxiliary voltage	
DC 60 V to 250 V; AC 115 V; AC 230 V	1
DC 24 V/48 V	2
System interface	
100 Mbit Ethernet, electrical, 2 x RJ45 connector	R
100 Mbit Ethernet, with integrated switch, optical, 2 x LC connector multi-mode	S
100 Mbit Ethernet, with integrated switch, optical, 2 x LC connector single-mode 24 km	T
GPS antenna kit	7XV5663-0AA00
Indirect lightning protection	7XV5664-0LA00

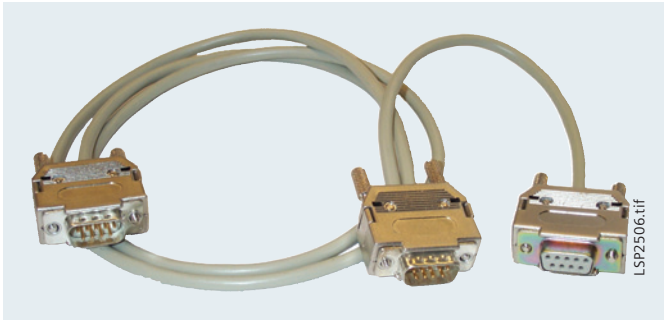


Fig. 13/118 RS485 bus system

Description

The evaluation of fault records, operational alarms and fault signals calls for millisecond-accurate determination of the absolute time. The SIPROTEC 4 units have an internal clock on a quartz basis, which deviates from the normal time after a while. Radio clocks are therefore used for precise synchronization; they set the clocks in the devices via time signals or protocols such as DCF77 or IRIG-B. All the devices are connected in parallel with an electrical bus, so that all of them receive the time information at the same time at Port A. By means of the prefabricated bus cables and adapters 7XV5104 the SIPROTEC 4 units can be connected via their IRIG-B interface directly to the sync.-transceiver 7XV5654. The maximum length of the electrical bus when prefabricated cables are used is 20 m. Relevant applications are described in the manual for the sync.-transceiver 7XV5654.

Function overview

- Opto-electrical solution for SIPROTEC 4 devices with IRIG-B interface (Port A)
- Direct connection of SIPROTEC 4 devices with IRIG-B interface to sync.-transceiver 7XV5654
- Adapter/cable for cascading and matching to other converters
- 4 orderable cable lengths from 1 m to 10 m
- 2-core, twisted and shielded cable with 9-pin SUB-D connectors
- Metal plug connector casings with fixing screws and strain relief for cable connections
- Compact dimensions of the plugs
- Max. extent of electrical bus 20 m within building

Accessories/7XV5104

Application, selection and ordering data

Application

Notes on the IRIG-B bus

In this system solution only the DC 24 V time synchronization inputs of the SIPROTEC 4 units are used (see below). 7XV5105 cables are available for synchronizing the differential protection relays with an additional seconds pulse.

The housings of all bus users must be properly mutually grounded, as otherwise dangerous ground potential currents can flow via the bus cable shield.

Typical applications

The 9-pin male connector of the Y-bus cable S1 always comes from the direction of the radio clock or sync.-transceiver and provides via the 1, 3, 5 or 10 m cable and the 9-pin male connector the connection to the first and subsequent bus devices. At connector S2 a 9-pin female connector B3 is provided (on a 20 m long cable) to extend the bus. If more than six SIPROTEC 4 units are to be connected to the sync.-transceiver 7XV5654, the adapter 7XV5104-3AA00 splits the connection X1 of the sync.-transceiver into two buses for a maximum of 6 units each. (For typical applications see 7XV5654 manual).

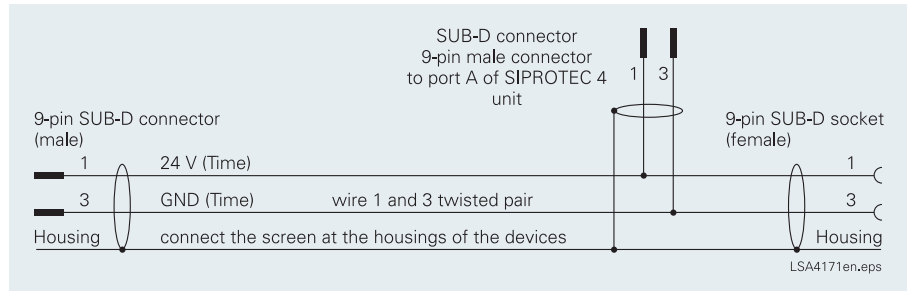


Fig. 13/119

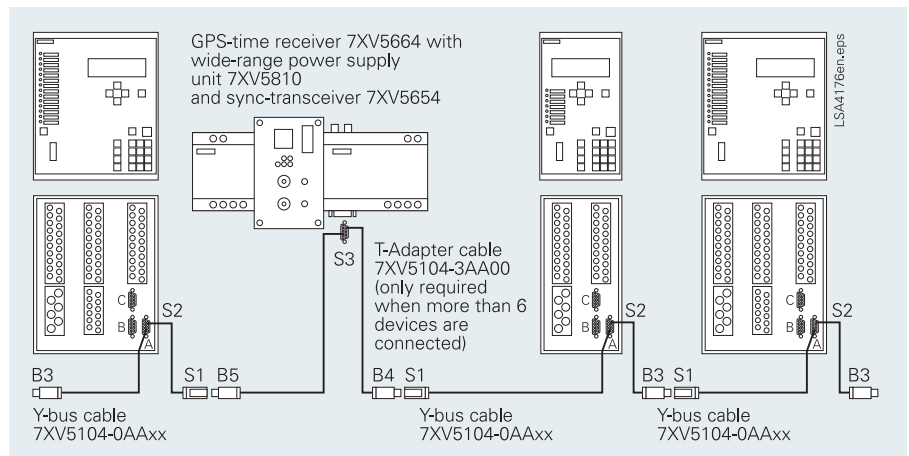


Fig. 13/120 Connection of max. twelve SIPROTEC 4 units to the IRIG-B bus via prefabricated Y-bus cable

Selection and ordering data

Description	Order No.
Y-connection cable IRIG-B/DCF77	7XV5104-0AA□□
Y-connection cable for SIPROTEC 4 unit with IRIG-B/DCF77 connection and bus extension. Copper cable 2-wire, shielded, with 9-pin SUB-D connectors Length 1 m	0 1
Length 3 m	0 3
Length 5 m	0 5
Length 10 m	1 0
Extension cable (copper)	
Cable for the bus length extension. Copper cable 2-wire, shielded, with 9-pin SUB-D connector Length 10m	7XV5104-1AA10
Adapter/accessories	7XV5104-□AA00
Adapter cable to sync.-transceiver 7KE6000-8Ax, length 0.3m, shielded, 2 wires with end sleeves to 9-pin SUB-D connector (female)	2
T-adapter cable to sync.-transceiver 7XV5654-0BA00 Splits connector X1 into 2 buses formax. six SIPROTEC 4 units per bus 9-pin SUB-D connector (male) to 2 x 9-pin SUB-D connector (female) Copper cable 2-wire, shielded (length 0.3m)	3

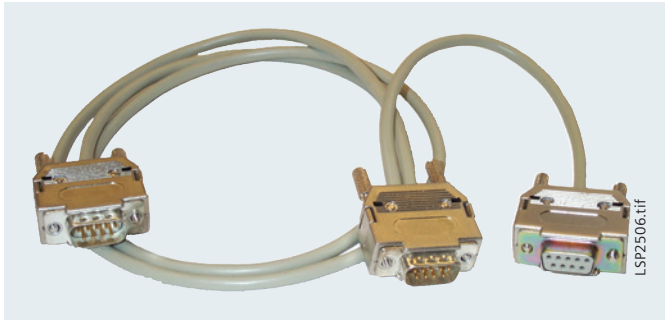


Fig. 13/121 Y-cable 7XV5105

Description

The evaluation of fault records, operational alarms and fault signals calls for a millisecond-accurate absolute time stamp. The differential protection relays have an internal clock on a quartz basis, by means of which the protection is normally synchronized. In special applications, GPS radio clocks are used to synchronize the 7SD5 differential protection relays with the absolute time. These clocks send a time telegram together with a microsecond-accurate seconds pulse, so that the transmission time in both the sending and the receiving direction can be precisely measured. All the devices in each system are connected in parallel via an electrical bus, so that all devices receive the time information and the seconds pulse at the same time. By means of the prefabricated bus cables 7XV5105, the 7SD5 relays can be connected via their IRIG-B interface (Port A) directly to the sync.-transceiver 7XV5654. The maximum length of the electrical bus when the prefabricated cables are used is 20 m. Relevant applications are described in the manual for the sync.-transceiver 7XV5654.

Function overview

- Opto-electrical solution for SIPROTEC 4 7SD5 differential protection relays with IRIG-B interface (Port A)
- Direct connection of 7SD5 protection relays via IRIG-B interface to sync.-transceiver 7XV5654
- Transmission of time telegram and seconds pulse at the same time
- 4 orderable cable lengths from 1 m to 10 m
- 4-wire, twisted and shielded cable with 9-pin SUB-D connectors
- Metal plug connector casing of compact dimensions, with fixing screw and strain relief for cable connections
- Max. extent of electrical bus 20 m within building

Accessories/7XV5105

Application, selection and ordering data

Application

Notes on the IRIG-B bus

In this system solution only the DC 24 V time synchronization inputs (Port A) of the SIPROTEC 4 protection relays are used. 2-core 7XV5104 cables are available for time synchronization of the SIPROTEC 4 protection relays without additional seconds pulse.

The housings of all bus users must be properly mutually grounded, as otherwise dangerous ground potential currents can flow via the bus cable shield.

Typical applications

The 9-pin male connector of the Y-bus cable S1 always comes from the direction of the radio clock or sync.-transceiver and provides via the 1, 3, 5 or 10 m cable and the 9-pin male connector the connection to the first and subsequent bus devices. At connector S2 a 9-pin female connector B3 is provided (on a 20 m long cable) to extend the bus. If more than six SIPROTEC 4 units are to be connected to the radio clock, up to 4 sync.-transceivers 7XV5654 can be connected, each with 6 protection relays. (For typical applications see the 7XV5654 manual).

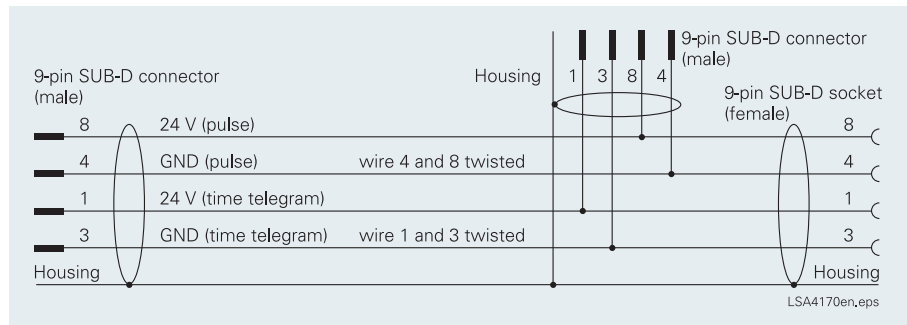


Fig. 13/122

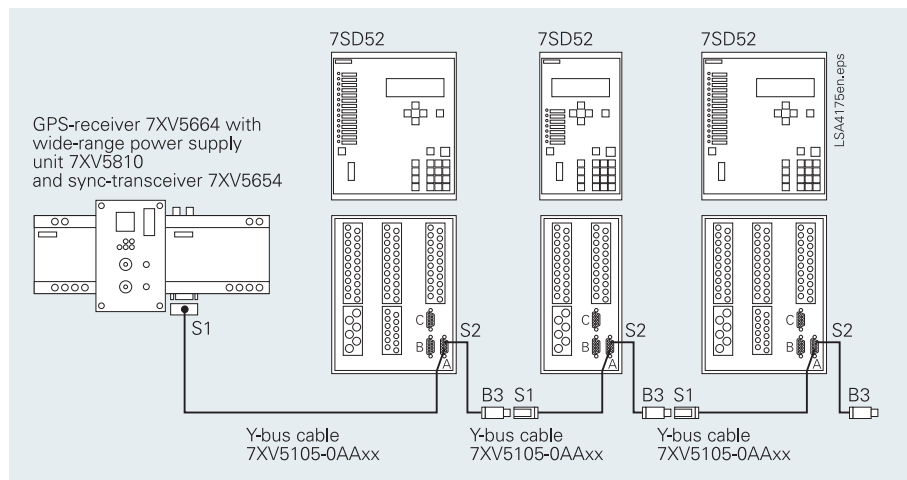


Fig. 13/123 Connection of max. six SIPROTEC 4 protection relays 7SD5 to the IRIG-B bus via prefabricated Y-bus cable

Selection and ordering data

Description	Order No.
Y-connection cable IRIG-B / DCF77	7XV5105-0AA <input type="checkbox"/> <input type="checkbox"/>
Y-connection cable for direct connection of a SIPROTEC 4 differential protection relay with IRIG-B / DCF77 connection to sync.-transceiver 7XV5654 and bus extension. Copper cable 4-wire, shielded, with 9-pin SUB-D connectors	
Length 1 m	0 1
Length 3 m	0 3
Length 5 m	0 5
Length 10 m	1 0
Extension cable (copper)	
Cable for the bus length extension. Copper cable 2-wire, shielded, with 9-pin SUB-D connector	
Length 10 m	7XV5104-1AA10
Adapter/accessories	
Adapter cable to sync.-transceiver 7KE6000-8Ax, length 0.3 m, shielded, 4 wires with end sleeves to 9-pin SUB-D connector (female)	7XV5104-2AA00



Fig. 13/124 GPS/DCF77 time synchronization system

Description

With the GPS-time signal receiver 7XV5664-0 and additional components wide-range power supply 7XV5810, mini star-coupler 7XV5450 and sync-transceiver 7XV5654, a comprehensive solution for time synchronization of any number of SIPROTEC protection devices is possible. A simple PC-Software (included in the scope of delivery) facilitates the setting of the receiver via a RS232 interface. The transmission of the time signals (telegrams or impulses) takes place, immune to disturbances, via a FO cable to the protection cubicles, where the time signals are electrically converted with the Sync-Transceiver. The standard version can, with the output of special protocols, also be used for the synchronisation of further devices, e.g. Reyrolle ARGUS 1 or SIMEAS Q80. For the SIPROTEC line differential protection 7SD52 or for SIMEAS R-PMU, the special version provides a highly accurate pulse per second. The GPS antenna with 25 m cable to the receiver is included in the scope of delivery. Lightning protection is optionally available.

Function overview

- GPS exterior antenna with wall mounting and 25 m cable RG59, lightning protection is optional GPS-antenna input (BNC-plug)
- PC-input, RS232 (9-pol. Sub-D plug) with operating program and 1m connection cable
- 2 optical signal outputs FL1/2 for FO cable 62,5/125 µm and ST-plug for disturbance free transmission of the signals
- Auxiliary voltage DC 18-60 V/optionally with wide-range power supply 7XV5810-0AA10, DC 24-250 V/AC 100 – 230 V.
- Aluminium housing for rail mounting.

Standard Version 7XV5664-0CA00:

- Signal outputs FL1/2: telegrams selectable IRIG-B, DCF77-, NMEA, IEC60870-5-103, second or minute impulses.
- 3D-mode with at least 4 satellites or
- Fix-mode with at least 1 satellite.

Special Version 7XV5664-0AA00:

- Signal outputs FL1/2: fixed telegrams
FL 1 = highly accurate second impulse
FL 2 = IRIG-B or DCF77
- Only 3D-mode with at least 4 satellites.

Application

Application

The "Normal Time" standard application

With the GPS-time signal receiver 7XV5664-0CA00 all connected protection devices are synchronized to "Normal Time". In this way, the internal clock of the protection devices is synchronized by a standardized telegram e.g. IRIG-B, DCF77, IEC60870-5-103, NMEA or a minute impulse.

For this purpose the protection devices provide suitable interfaces e.g. SIPROTEC 4 provides Port A.

The antenna is mounted to an outside wall with free sight to the sky and the optional lighting protection is looped into the antenna cable.

The GPS-time signal receiver is mounted close to the antenna, and is either supplied with auxiliary voltage via the optional wide-range power supply from the AC mains, or the substation battery.

The transmission of the time telegrams or synchronizing impulses takes place, immune to interference, with FO cable to the protection devices distributed in the plant. An extension of the optical star structure can be implemented with the mini star-coupler 7XV5450. For the conversion of the FO signals to 24 V signals as required by the SIPROTEC 4 time synchronization interfaces (Port A), sync-transceivers 7XV5654 are implemented.

Detailed application examples may be found in the manual of the sync-transceivers 7XV5654.

The SIPROTEC 4 protection devices are connected to the sync-transceiver 7XV5654 via "Port A" with the specially designed bus cable system 7XV5104 (see Fig.13/125). Note: No bus termination resistance is required here.

All SIPROTEC protection devices with internal clock

may be synchronized with the minute impulse from the GPS receiver via a binary input. For this purpose the internal clock of the protection device is set at each full minute to the exact beginning of the new minute. A pre-condition for this method is that the internal clock of the protection device is set correctly once, and the auxiliary voltage is buffered against failure. If the time tracking fails for a longer period, the difference between the internal clock of the protection device and the normal time must be smaller than one minute. Daylight saving time must, if desired, be set manually.

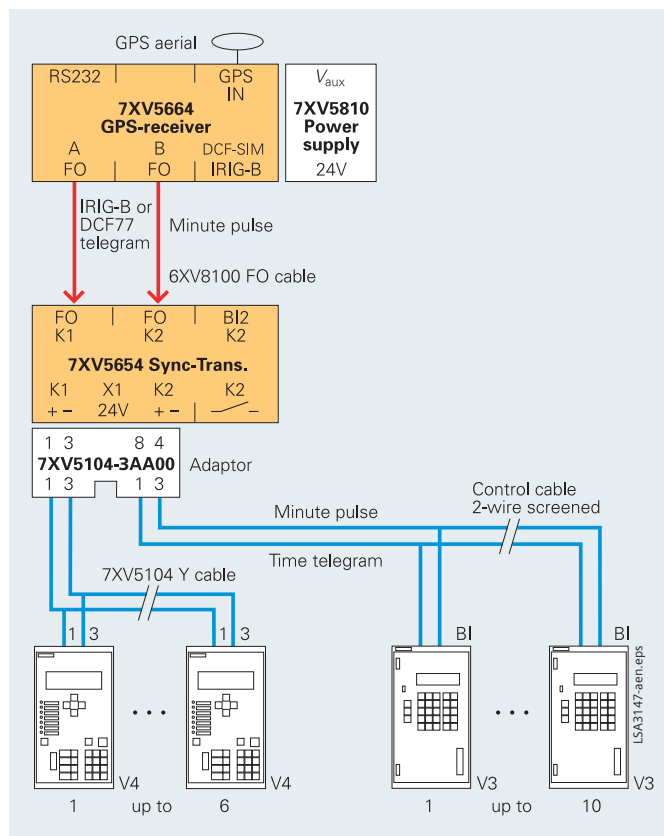


Fig. 13/125 SIPROTEC 4 protection unit with GPS-time synchronization

Protection devices are fitted with a binary input, which captures the minute impulse using a corresponding voltage (24–60 or wide range DC 24–250 V) and provides this to the internal clock. The distribution of the impulse to the protection devices takes place via a 2-wire bus, which must consist of a screened twisted pair. All devices must be located in the same grounded system, the cable screens must be connected to the housing on both sides.

If both channels of the GPS-receiver are set to the minute impulse, up to 20 SIPROTEC 3 devices may be connected. Alternatively, a coupling of both output channels of the sync-transceivers with the DIL-switches S1/3 is possible.

Description	Order No.
GPS-time signal receiver	7XV5664-0□A00
GPS-timing signal receiver "Special Version" for the time synchronization of SIPROTEC 4 differential prot. devices or SIMEAS R-PMU (Phasor Measurement Unit), with 25 m coaxial cable, PC software with cable (without wide-range power supply unit 7XV5810-0BA00)	A
GPS-timing signal receiver "Standard-Version" for the time synchronization of SIPROTEC 4 protection devices, with 25 m coaxial cable, PC software with cable (without wide range power supply unit 7XV5810-0BA00)	C
Lightning protection with plugs for connection to the antenna cable	L
Additional accessories for time synchronization	
Wide-range power supply (universal) Universal supply voltage (DC 48...250 V ± 20 %, AC 60...230 V ± 20 %) Output voltage DC 24 V/6 W, short-circuit proof, alarm contact	7XV5810-0BA00
Sync-transceiver Sync-transceiver for conversion of 2 optical timing signals to DC 24 V for the time synchronizing interface of SIPROTEC 4 (Port A) 2 optical inputs with ST-plugs and 2 electrical outputs for max. 12 SIPROTEC4 relays or 20 SIPROTEC 3 relays. Minute or second pulse for special applications is also supported.	7XV5654-0BA00
Y-bus cable for time synchronizing SIPROTEC 4 (standard) Y-bus cable 2-core screened with 9 pole sub-D connector and metallic housing for clock synchronization SIPROTEC 4	7XV5104-0AA□□
Length 1 m	0 1
Length 3 m	0 3
Length 5 m	0 5
Length 10 m	1 0
Bus length extension cable (standard) Cable for the bus length extension. Copper cable with 2-wires, shielded with 9-pole sub-D plugs. Length 10 m	7XV5104-1AA10
Adapter cable to sync.-transceiver 7KE6000-8 (standard) Adapter cable to sync.-transceiver 7KE6000-8Ax. Length 0,3 m. Shielded, 2-wires with crimp lugs to 9-pole sub-D plug (female)	7XV5104-2AA00
Adapter cable for 2 busses (standard) Adapter cable 2 core screened for sync-transceiver 7XV5654-0BA00 for distribution of 2 busses for each 6 SIPROTEC 4 relays	7XV5104-3AA00
Y-bus cable for time synchronizing SIPROTEC4 Diff.-protection and SIMEAS R-PMU (special) Y-bus cable 2-core screened with 9 pole sub-D connector and metallic housing for clock synchronization SIPROTEC 4, e.g. 7SD5	7XV5105-0AA□□
Length 1 m	0 1
Length 3 m	0 3
Length 5 m	0 5
Length 10 m	1 0
Bus length extension cable (special) Cable for the bus length extension. Copper cable with 4-wires, shielded with 9-pole sub-D plugs. Length 10 m	XV5105-1AA10



Fig. 13/126 GPS Time Synchronization Unit 7XV5664-1

Description

The GPS time synchronization unit (receiver) 7XV5664-1, together with additional components like mini-star coupler 7XV5450, Sync-Transceiver 7XV5654 and prepared cable with plugs, is a comprehensive solution for time synchronization of any number of SIPROTEC protection devices.

The transmission of the time signals (telegram or impulse) takes place, immune to disturbances and over long distances, via a FO cable to the protection cubicles. A sync-transceiver converts the optical signals into electrical signals (< 200 ns delay). The 7XV5664-1 supports protocols like IRIG-B or DCF77 which can be used for the synchronization of further devices, e.g. SIMEAS R, SIMEAS R-PMU or PQ devices like SIMEAS Q80 V3.

The GPS-antenna has to be mounted with a free view to the whole sky, on the top of a roof or an outside wall. Within the antenna cable, the surge protector has to be mounted close to the antenna. The GPS time synchronization unit can be connected to usual AC supply or a station battery.

A simple PC-Software (included in the shipment) facilitates the setting of the receiver via an RS232 interface.

Features/shipment

- Time receiver with integrated high precision clock, as well as accurate hold over behavior. Accuracy ± 250 ns.
- Special hard- and firmware, specially designed for the highly precise synchronizing of SIPROTEC and SIMEAS devices. Type test according to 2004/108/EG, 2006/95/EG, 93/68/EWG and EN 61010-1:2010, CAT II, Poll.2.
- 3 variable programmable optical outputs with ST-plugs for 50/125 μ m or 62.5/125 μ m, 850 nm multi-mode fiber, for disturbance-free transmission of the signals/telegrams.
- Supported telegrams (parallel possible): IRIG-B (B003+4, B006+7, AFNOR, C37.118). DCF77 for UTC or local time (summer time). DCF77 modified for SIMEAS R V3. Highly precise second or minute pulse.
- GPS outdoor antenna with wall mounting, and 50 m RG58 cable (BNC- and N-plug)
- Lightning protection with 5 m RG58 cable (N-plug).
- Auxiliary voltage DC/AC 100–240V (50/60 Hz).
- Fail-safe relay (change-over contact, SIPROTEC Standard).
- Operating program and 3 m connection cable, PC-input RS232 (9-pol. Sub-D plug).
- Aluminum housing for DIN rail mounting.

Additional components: optional

- **7XV5654-0BA00**
Sync-Transceiver:
2 x FO-Input for 62.5/125 μ m with ST-plug
2 x electrical output, DC 24 V / max. 50 mA per channel
- **7XV5104-xAAxx**
Bus cable system for time synchronization (2 core)
- **7XV5105-xAAxx**
Bus cable system for precise synchronization (4 core)
(for synchronization using also highly precise pulse per second)
- **7KE6000-8AK or -8AL**
SIMEAS Sync-Transceiver:
1 x FO-Input for 62.5/125 μ m, ST-plug
1 x electrical output, DC 24 V / max. 20 mA, screw-type terminal



Fig. 13/127 Additional components

Accessories/7XV5664-1

GPS Time Synchronization Unit 7XV5664-1

Application

Standard Application, Time Synchronization of SIPROTEC 4/5

Using the GPS Time Synchronization Unit 7XV5664-1, the internal time of all connected protection devices can be synchronized. In this way, the internal clock of the protection devices is synchronized by a standardized telegram, e.g. IRIG-B or DCF77. IRIG-B C37.118 is the preferred telegram for SIPROTEC 5.

For this purpose the protection devices SIPROTEC 4 and SIPROTEC 5 provide suitable interfaces for time synchronizing, e.g. SIPROTEC 4 provides Port A, SIPROTEC 5 Port G.

The transmission of the time telegrams or synchronizing impulses takes place via the three optical outputs, immune to interference with FO cable to the protection devices, distributed in the substation. An extension of the optical star structure can be implemented with a mini star coupler 7XV5450.

For the conversion of the FO signals to 24 V signals as required by the SIPROTEC time synchronization interfaces, Sync-Transceivers 7XV5654 are implemented.

Detailed application examples can be found in the manual of the Sync-Transceivers 7XV5654.

The SIPROTEC 4 and SIPROTEC 5 protection devices are connected to the Sync-Transceiver 7XV5654 using the specially designed bus cable system 7XV5104 (see figure 13/128).

Note: No bus termination resistance is required here.

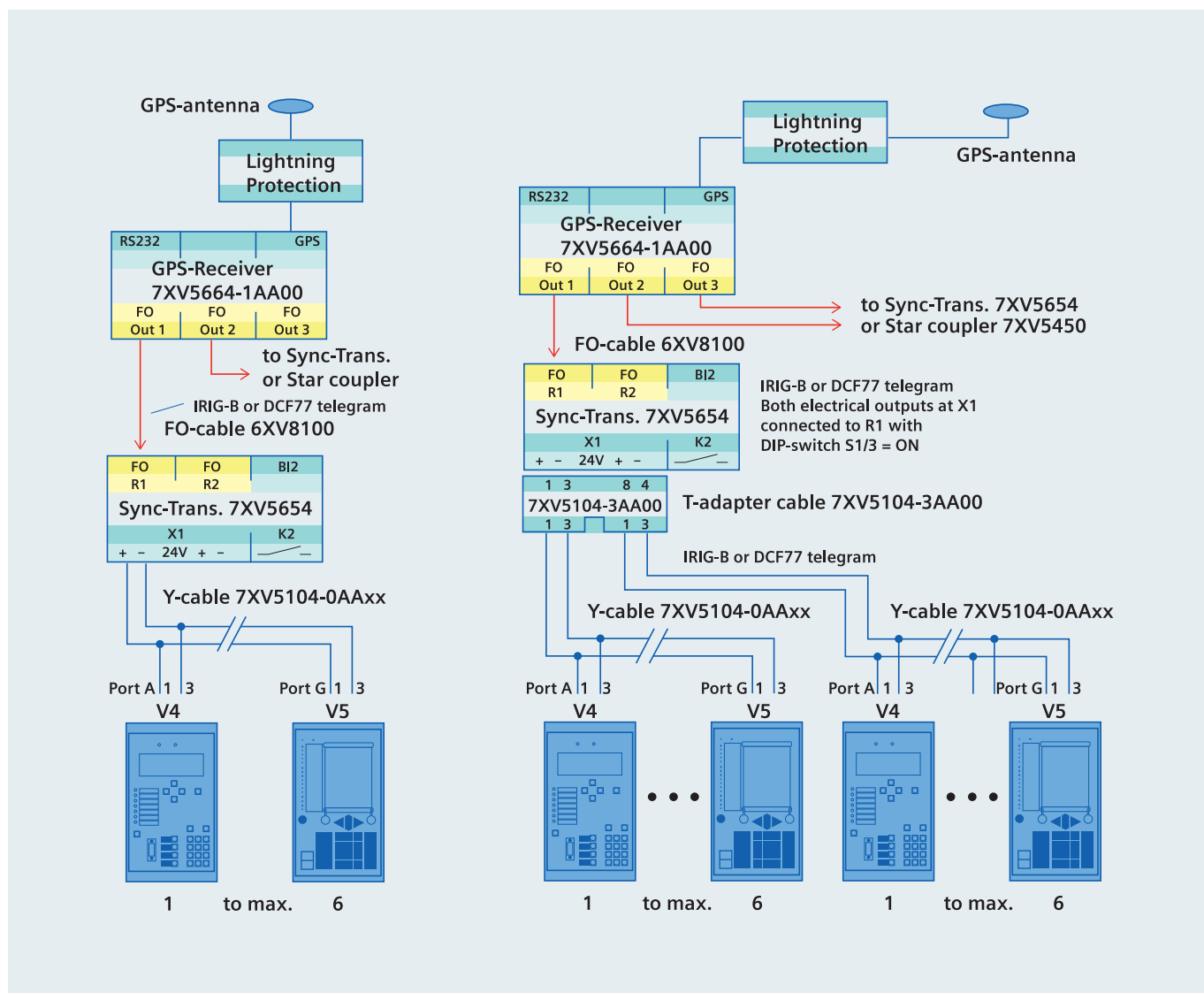


Fig. 13/128 SIPROTEC 4/5 protection devices with IRIG-B or DCF77 time synchronization

Overall Time Synchronization of SIPROTEC 3 / 4 / 5 / PMU, 7KE85, SIMEAS R-PMU and SICAM Q80 V3

Note: Often it is useful to synchronize all devices in a substation from the same source. E.g. to compare recordings of different devices, a synchronized time stamp of different devices can help. To achieve this aim, it is useful only to use one clock, e.g. 7XV5664-1, centrally for all devices.

The GPS Time Synchronization Unit 7XV5664-1 is able to supply three different time signals/telegrams at the same time in parallel on its three optical outputs. The connection to different devices is shown in the figure 13/129.

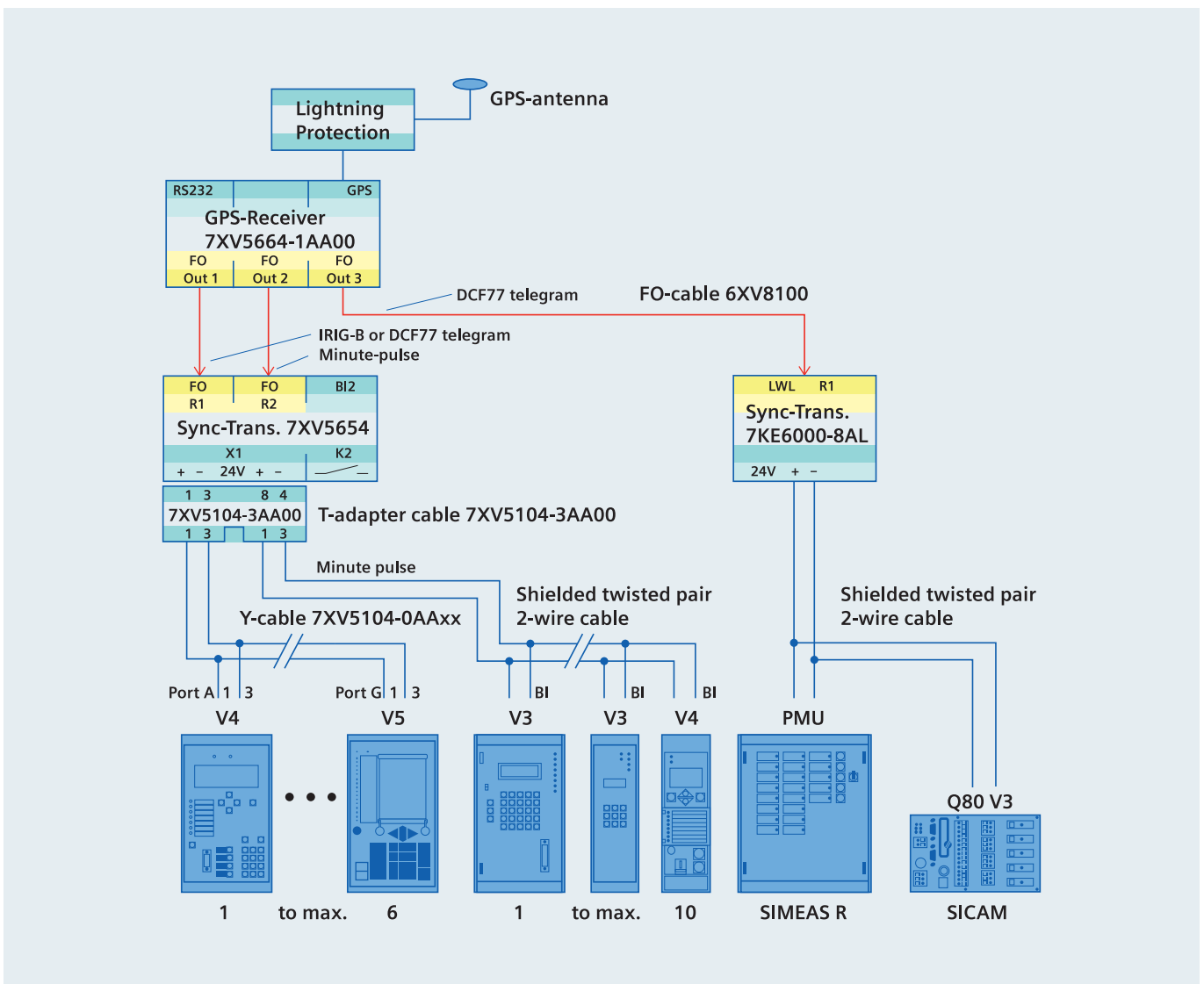


Fig. 13/129 Overall time synchronization of SIPROTEC 3 / 4 / 5 / PMU, 7KE85, SIMEAS R-PMU V4 and SICAM Q80 V3. Parallel use of different time signals / telegrams.

Accessories/7XV5664-1

GPS Time Synchronization Unit 7XV5664-1

Devices of type SIPROTEC 4 (port A) and SIPROTEC 5 (port G) are connected to optical port "Out 1" of the GPS time synchronization unit, using channel R1 of the Sync-Transceiver, via T-plug and bus cable system 7XV5104. IRIG-B or DCF77 telegrams are used. Detailed information for both telegrams can be found in the manual of the devices.

The GPS Time Synchronization Unit 7XV5664-1 has special hardware and firmware, and is specially designed for the highly precise synchronizing of SIPROTEC and SIMEAS devices.

Due to its highly precise abilities, the 7XV5664-1 is able to send the IRIG-B C37.118 telegram in an extended high quality, which is a requirement for the PMU applications of SIPROTEC and SIMEAS.

If the PMU-function (Phasor Measurement Unit) is used, the devices SIPROTEC 5/PMU/7KE85 are connected via a 2-core cable 7XV5104. IRIG-B C37.118 is used to synchronize the PMU-function. Detailed information can be found in the application descriptions and manuals of the PMU devices.

SIMEAS R-PMU V4 is synchronized using the highly precise rising edge of the signal in the DCF77-telegram at optical output, e.g. FO Out 3. The 7KE6000-8AK/L converts the optical signals into electrical signals.

SIMEAS R V3 is synchronized using the modified DCF77-telegram. The Sync-Box is not necessary if the 7XV5664-1 is used.

SICAM Q80 V3 is synchronized using the rising edge of the signal in the DCF77-telegram at optical output, e.g. FO Out 3. The 7KE6000-8AK/L converts the optical signals into electrical signals.

Detailed application description can be found in Downloads Power Quality, within document:

"SIMEAS R and SIMEAS R-PMU Time Synchronization Application Note".

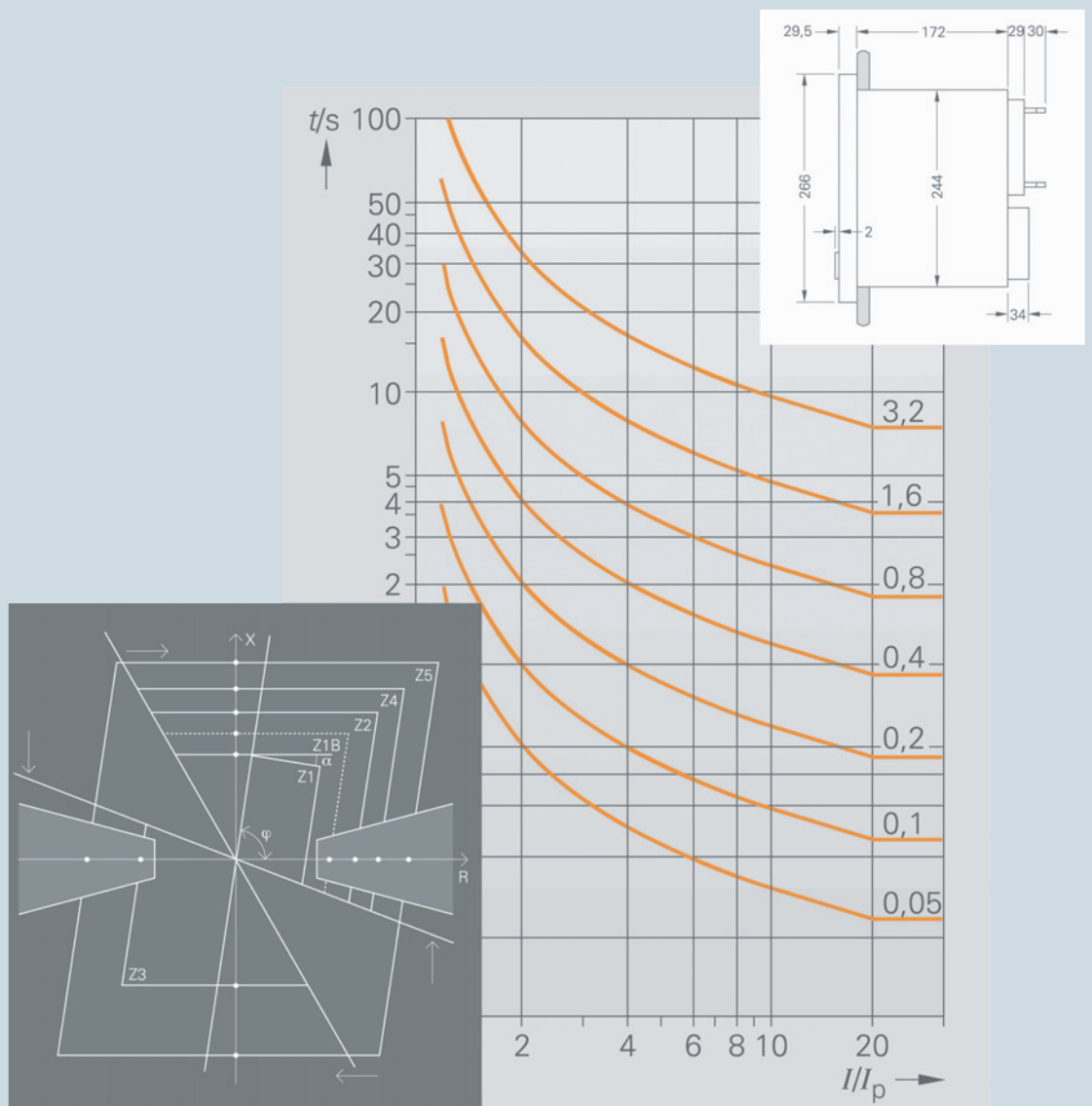
All SIPROTEC Protection Devices with internal clock (e.g. SIPROTEC V3 and SIPROTEC Compact) can be synchronized using minute impulse from the GPS receiver via a binary input. For this purpose the internal clock of the protection device is set at each full minute to the exact beginning of the new minute. A precondition for this method is that the internal clock of the protection device is set correctly once, and the auxiliary voltage is buffered against failure. If the time tracking fails for a longer period, the difference between the internal clock of the protection device and the actual time has to be smaller than one minute. Summer and winter time have to be set manually, if desired.

Protection devices are fitted with a binary input, which captures the minute impulse using a corresponding voltage (24-60 or wide range 24-250 VDC) and provides this to the internal clock. The distribution of the impulse to the protection devices takes place via a 2-wire bus, which has to consist of a screened twisted pair. All devices must be located in the same grounded system, the cable screens must be connected to the housing on both sides.

Description	Order No.
GPS time synchronization unit (receiver)	7XV5664-1AA00
Specific GPS time synchronization unit specific for precise synchronizing of SIMEAS R/R-PMU V4, SIPROTEC 5-PMU and 7KE85 and also for the normal SIPROTEC and PQ time synchronizing, e.g. SICAM Q80 V3. Time receiver with integrated clock, with GPS antenna, lightning protection and 50 m (+5 m) RG58 cable. 3 programmable optical outputs (high precision pulse, IRIG-B, DCF77) with ST-plugs for 50/125 µm or 62.5/125 µm, 850 nm multi-mode fiber. Auxiliary voltage DC/AC 100–240 V (50/60 Hz). With fail-safe relay, change-over contact. DIN rail mounting. Parameterization-SW and -cable.	
Additional Accessories for Time Synchronization	
Sync-Transceiver	7XV5654-0BA00
Sync-Transceiver for conversion of 2 optical timing signals to DC 24 V for the time synchronizing interface of SIPROTEC 4/5. 2 optical inputs with ST-plugs and 2 electrical outputs. Minute or second impulse for special applications is also supported.	
Y-bus cable for time synchronizing SIPROTEC 4/5 (2-core)	7XV5104-0AA <input type="checkbox"/> <input type="checkbox"/>
Y-bus cable 2-core screened with 9-pole sub-D connector and metallic housing for clock synchronization SIPROTEC 4/5 Length 1 m	0 1
Length 3 m	0 3
Length 5 m	0 5
Length 10 m	1 0
Bus length extension cable (2-core)	
Cable for bus length extension. Copper cable with 2-wires, shielded with 9-pole sub-D plugs. Length 10 m	7XV5104-1AA10
Adapter cable to Sync.-Transceiver 7KE6000-8 (2-core)	
Adapter cable to Sync.-Transceiver 7KE6000-8Ax. Length 0.3 m. Shielded, 2-wires with crimp lugs to 9-pole sub-D plug (female)	7XV5104-2AA00
Adapter cable for 2 Busses (2 times 2-core)	
Adapter cable 2-core screened for Sync-Transceiver 7XV5654-0BA00 for distribution with 2 busses for max. 6 SIPROTEC 4/5 relays.	7XV5104-3AA00
Y-bus cable (4-core, with second pulse) for precise synchronizing of SIPROTEC 4/5 Diff.-Protection	7XV5105-0AA <input type="checkbox"/> <input type="checkbox"/>
Y-bus cable 4-core screened with 9-pole sub-D connector and metallic housing for clock synchronization of SIPROTEC 4/5, e.g. 7SD Length 1 m	0 1
Length 3 m	0 3
Length 5 m	0 5
Length 10 m	1 0
Bus length extension cable (4-core, with pulse per second) for precise synchronizing of SIPROTEC 4/5 Diff.-Protection	
Cable for bus length extension. Copper cable with 4-core, shielded with 9-pole sub-D plugs. Length 10 m.	7XV5105-1AA10
SIMEAS Sync-Transceiver (for SICAM/SIMEAS devices)	7KE6000-8AL
Sync-Transceiver for connection to interface of SICAM/SIMEAS devices. 1 x FO-Input for 62.5/125 µm, ST-plug 1 x electrical output, DC 24 V / max. 20 mA, screw-type terminal.	

Appendix

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Dimension drawings	14/7
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Appendix

Relay characteristics

Inverse-time characteristics of TOC relays											
Fig.	IEC 60255-3				ANSI/IEEE						
	Normal inverse	Very inverse	Extremely inverse	Long inverse	Inverse	Short inverse	Long inverse	Definite inverse	Moderately inverse	Very inverse	Extremely inverse
	14/1	14/2	14/3	14/4	14/5	14/6	14/7	14/8	14/9	14/11	14/13
Relay											
7SD5	■	■	■	■	■	■	■	■	■	■	■
7SD610	■	■	■	■	■	■	■	■	■	■	■
7SJ450*-***00-0	■	■	■								
7SJ450*-***00-1									■	■	■
7SJ460*-***00-0	■	■	■								
7SJ460*-***00-1									■	■	■
7SJ600	■	■	■	■	■	■	■	■	■	■	■
7SJ602	■	■	■	■	■	■	■	■	■	■	■
7SJ61	■	■	■	■	■	■	■	■	■	■	■
7SJ62	■	■	■	■	■	■	■	■	■	■	■
7SJ63	■	■	■	■	■	■	■	■	■	■	■
7SJ64	■	■	■	■	■	■	■	■	■	■	■
7UM61	■	■	■		■			■	■	■	■
7UM62	■	■	■		■			■	■	■	■
7UT612	■	■	■	■	■	■	■	■	■	■	■
7UT613	■	■	■	■	■	■	■	■	■	■	■
7UT63	■	■	■	■	■	■	■	■	■	■	■

Inverse-time overcurrent protection characteristics according to IEC 60255 and BS142.

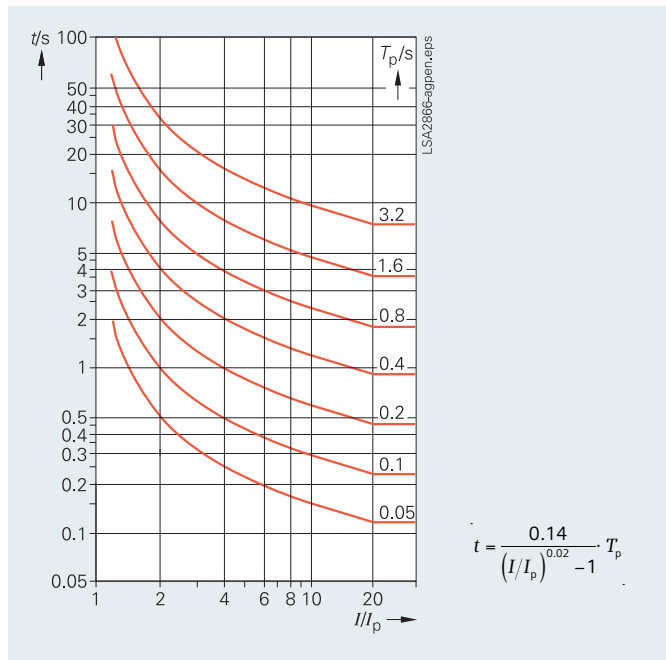


Fig. 14/1 Inverse

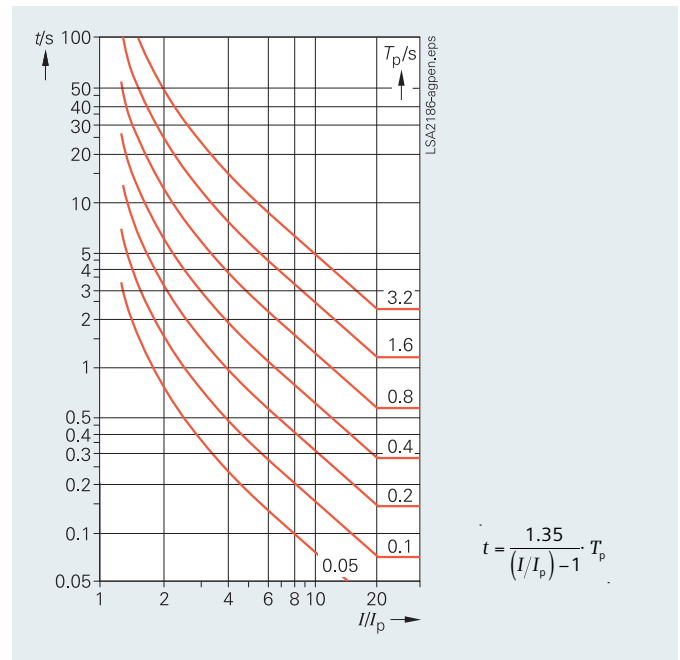


Fig. 14/2 Very inverse

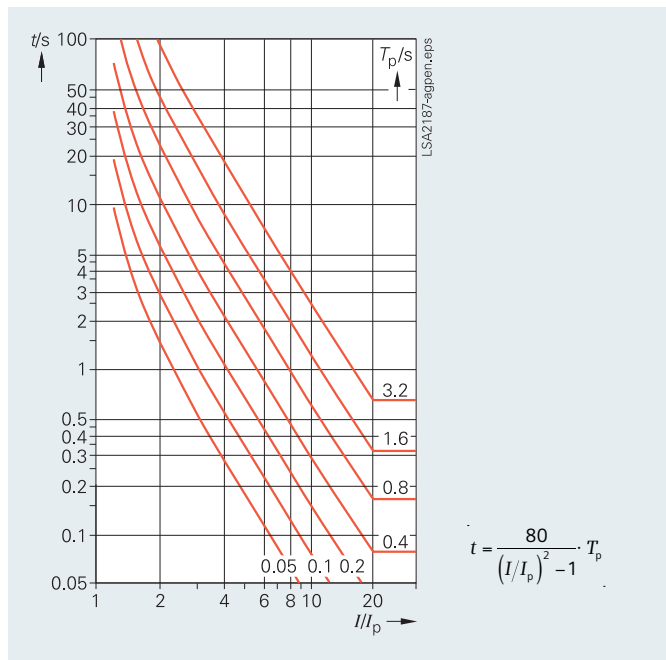


Fig. 14/3 Extremely inverse

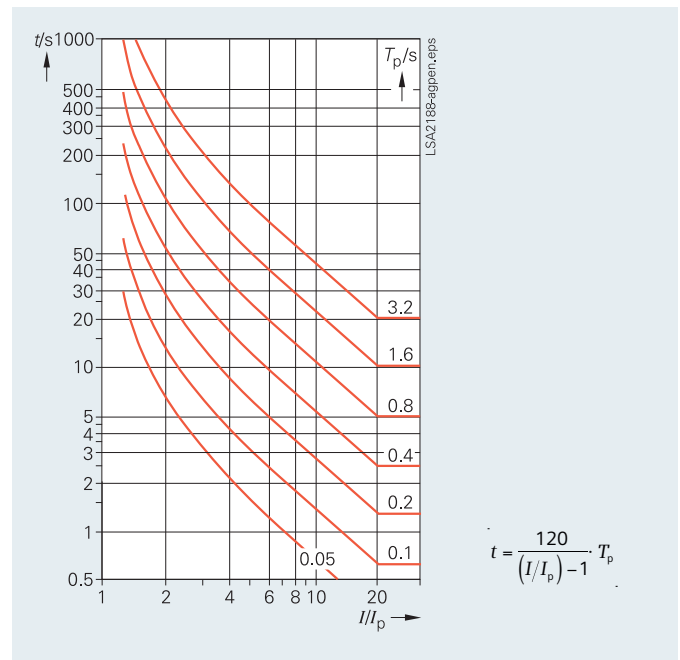


Fig. 14/4 Long inverse

I = current
 t = tripping time
 I_p = pickup setting
 T_p = time multiplier setting

Appendix

Relay characteristics

Inverse-time overcurrent protection characteristics according to ANSI (IEEE) C37.112

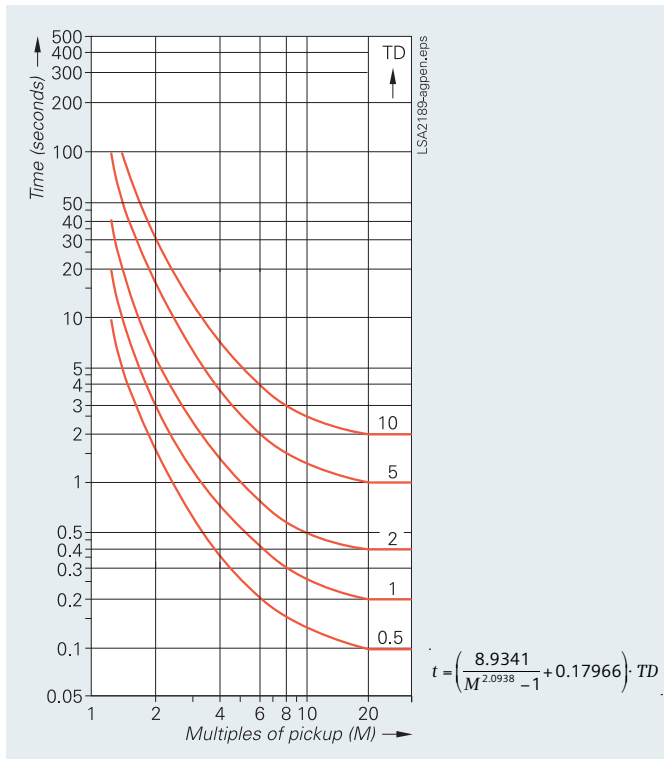


Fig. 14/5 Inverse

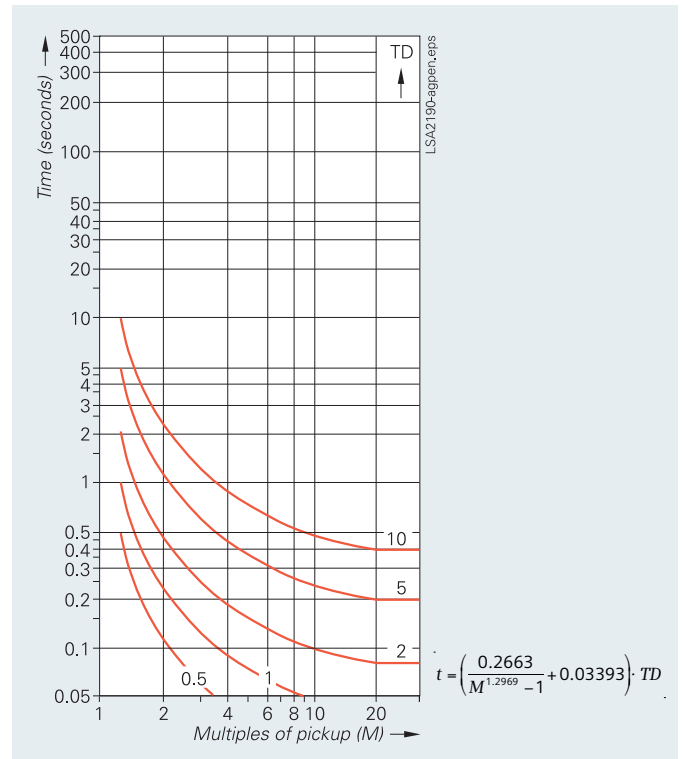


Fig. 14/6 Short inverse

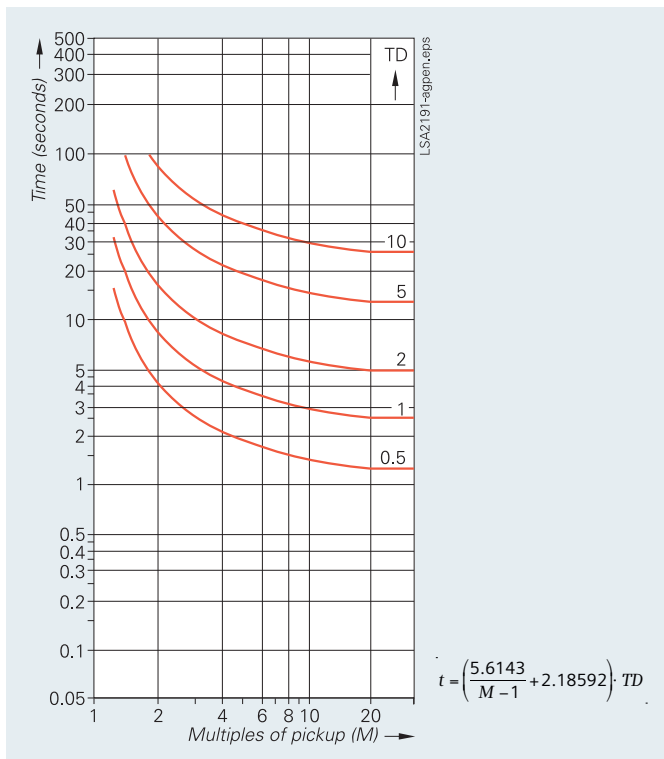


Fig. 14/7 Long inverse

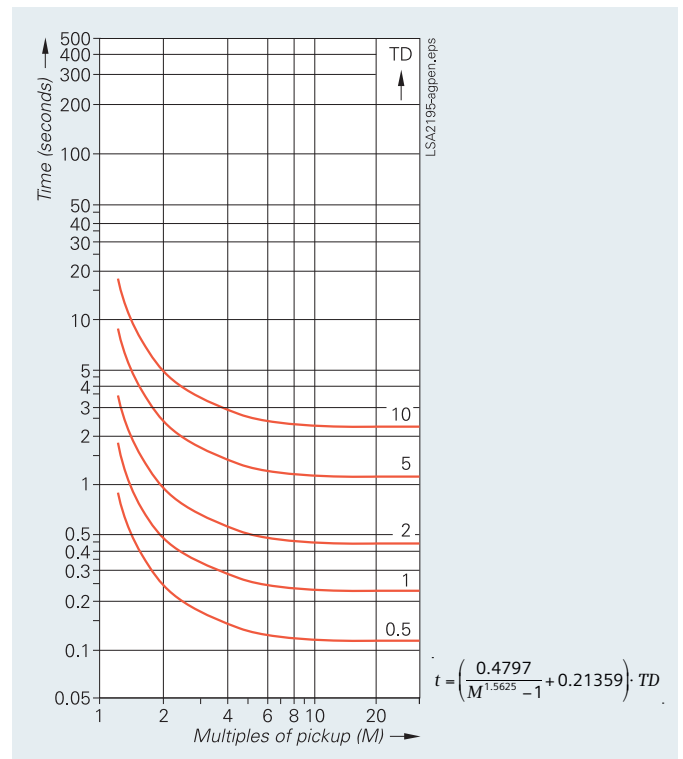


Fig. 14/8 Definite inverse

t = tripping time in seconds

M = current in multiples of pickup setting (I/I_p) range 0.1 to 4

TD = time dial

Inverse-time overcurrent protection characteristics according to ANSI (IEEE) C37.112

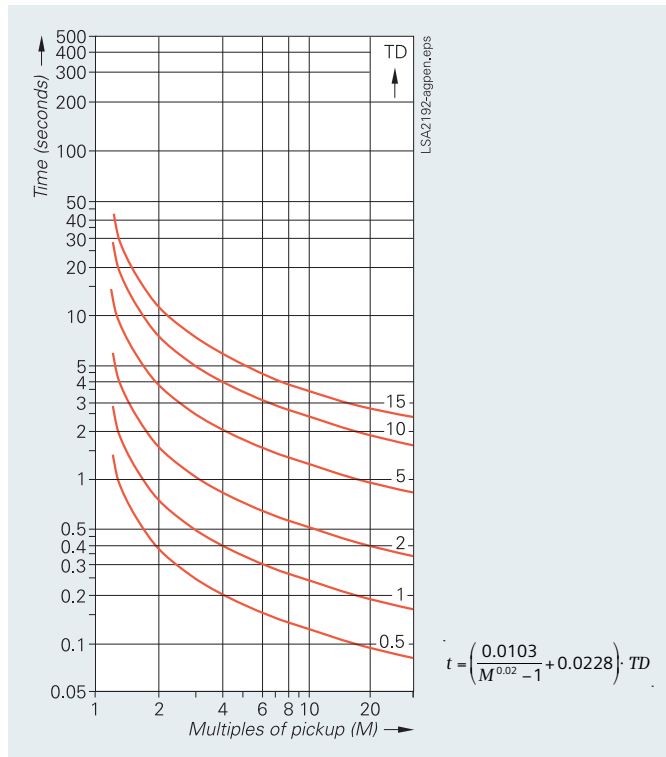


Fig. 14/9 Moderately inverse

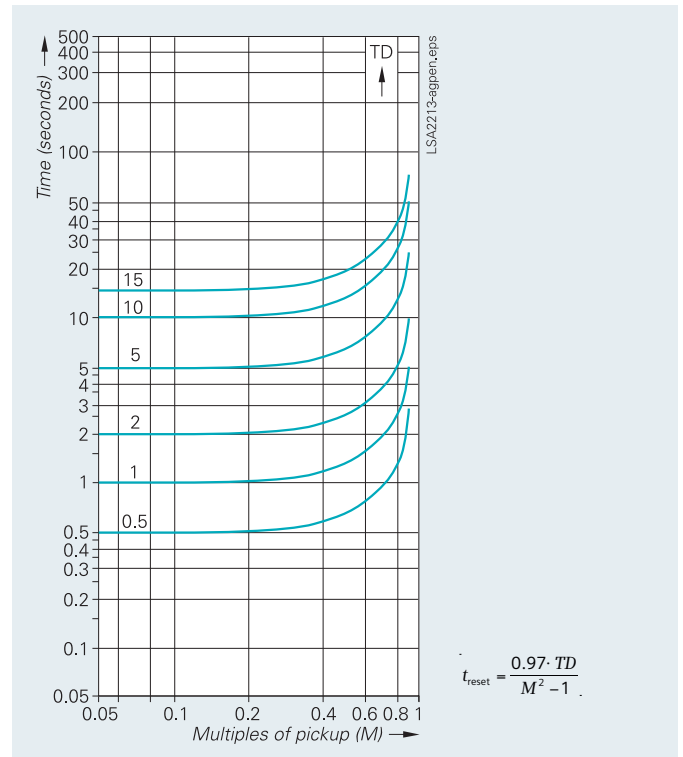


Fig. 14/10 Reset moderately inverse

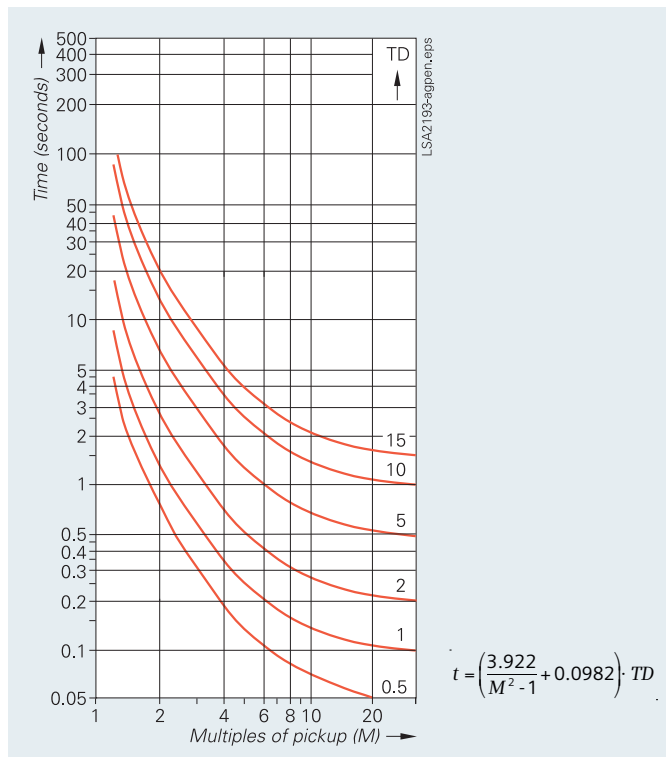


Fig. 14/11 Very inverse

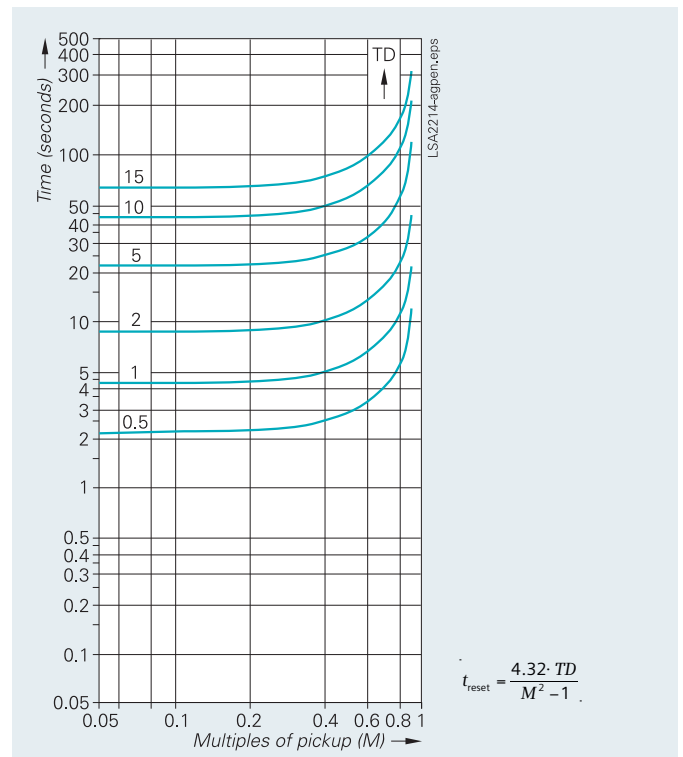


Fig. 14/12 Reset very inverse

t = tripping time in seconds

M = current in multiples of pickup setting (I/I_p) range 0.1 to 4

TD = time dial

Appendix

Relay characteristics, pinout of communication port

Inverse-time overcurrent protection characteristics according to ANSI (IEEE) C37.112

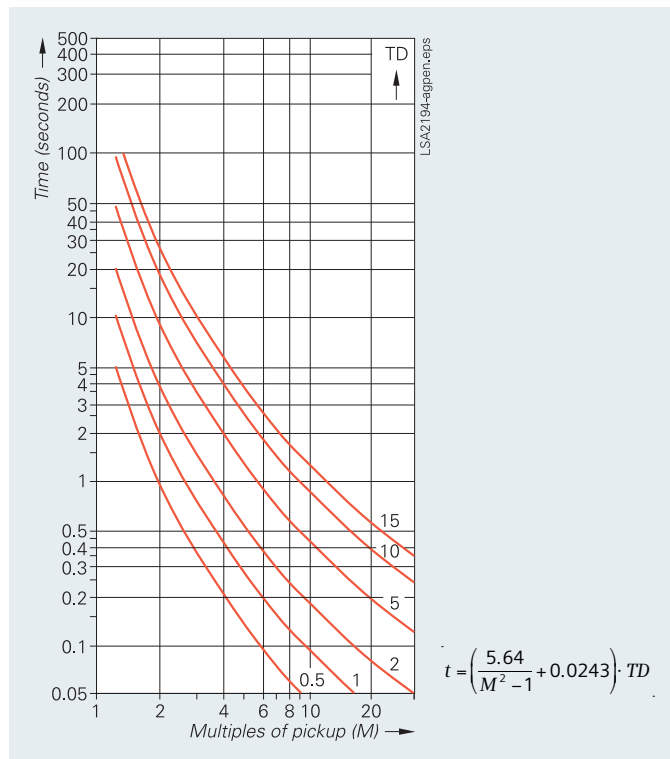


Fig. 14/13 Extremely inverse

t = tripping time in seconds

M = current in multiples of pickup setting (I/I_p) range 0.1 to 4

TD = time dial

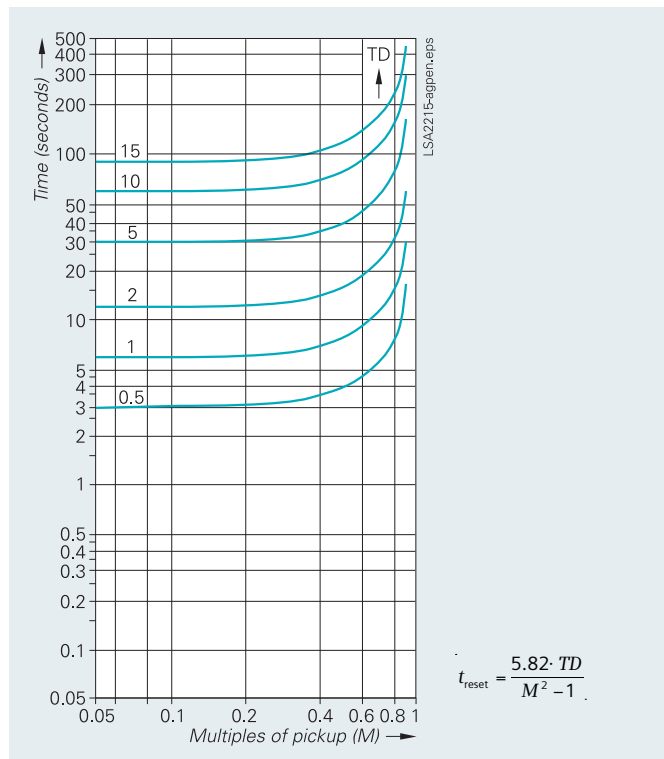


Fig. 14/14 Reset extremely inverse

Pinout of communication port

Pin no.	PC interface at front	Port A: Time synchronization		Port B: System interface			Port C/D Rear service interface or protection data interface	
		RS232 IEC 60870-5-103	RS485 IEC 60870-5-10	RS485 PROFIBUS-FMS Slave, PROFIBUS-DP Slave	RS485 MODBUS, DNP 3.0	RS232	RS485	
1	–	P24 input 24 V	Shield (with shield ends electrically connected)					
2	R x D	P5 input 5 V	R x D	–	–	–	R x D	–
3	T x D	common return	T x D	A/A' (RxD/TxD-N)	B/B' (RxD/TxD-P)	A	T x D	A
4	–	–	–	–	CNTR-A (TTL)	RTS (TTL level)	–	–
5	GND	Shield	GND	C/C' (GND)	C/C' (GND)	GND1	GND	C (GND)
6	–	–	–	–	+ 5 V voltage supply (max. Load < 100 mA)	VCC1	–	–
7	RTS	P12 input 12 V	RTS	–*)	–*)	–	RTS	(RTS RS232 used)
8	CTS	–	CTS	B/B' (RxD/TxD-P)	A/A' (RxD/TxD-N)	B	CTS	B
9	–	Shield	–	–	–	–	–	–

*) Pin 7 also can carry the RS232 RTS signal to an RS485 interface. Pin 7 must therefore not be connected

Relay	Flush/cubicle-mounting version		Surface-mounting version		Detached HMI	
	Page	Fig.	Page	Fig.	Page	Fig.
4AM4	-	-	14/24	14/57	-	-
4AM5	-	-	14/24	14/55, 14/56	-	-
6MD61	14/16	14/28	-	-	-	-
6MD63	14/12, 14/14	14/24, 14/26	14/14, 14/15	14/27	14/16	14/28
6MD66	14/14	14/26	14/15	14/27	14/16	14/28
7PA22	14/21	14/39, 14/41	14/21, 14/22	14/39, 14/47	-	-
7PA23	14/21, 14/22	14/40, 14/42	14/21, 14/22	14/40, 14/48	-	-
7PA26	14/23	14/49, 14/50	14/22	14/47	-	-
7PA27	14/22	14/46	-	-	-	-
7PA30	14/21, 14/22	14/41, 14/42, 14/44, 14/45	14/22	14/44, 14/45, 14/47, 14/48	-	-
7RV16	14/21	14/37	14/21	14/37	-	-
7RW600	14/8	14/15	14/8, 14/9	14/16, 14/17	-	-
7SA522	14/12, 14/14	14/24, 14/26	14/15	14/27	-	-
7SA61	14/11, 14/12, 14/13, 14/14	14/22, 14/24, 14/25, 14/26	14/11, 14/15	14/23, 14/27	-	-
7SA63	14/11, 14/12, 14/14	14/22, 14/24, 14/26	14/11, 14/15	14/23, 14/27	-	-
7SA64	-	-	-	-	14/16	14/28
7SD5	14/12, 14/14	14/24, 14/26	14/15	14/27	-	-
7SD600	14/8	14/15	14/8, 14/9	14/16, 14/17	-	-
7SD610	14/11	14/22	14/11	14/23	-	-
7SJ45	14/9	14/18	14/9	14/19	-	-
7SJ46	14/9	14/18	14/9	14/19	-	-
7SJ600	14/8	14/15	14/8, 14/9	14/16, 14/17	-	-
7SJ602	14/10	14/20	14/10	14/21	-	-
7SJ61	14/11	14/22	14/11	14/23	-	-
7SJ62	14/11	14/22	14/11	14/23	-	-
7SJ63	14/12, 14/14	14/24, 14/26	14/15	14/27	14/16	14/28
7SJ64	14/11, 14/12, 14/14	14/22, 14/24, 14/26	14/11, 14/15	14/23, 14/27	14/16	14/28
7SN600	14/8	14/15	14/8, 14/9	14/16, 14/17	-	-
7SS522 central unit	14/18	14/32	14/18	14/32	-	-
7SS523 bay unit	14/17	14/29	14/17	14/30	-	-
7SS525	14/18	14/31	-	-	-	-
7SS60	14/8, 14/20	14/15, 14/36	-	-	-	-
7SV600	14/8	14/15	14/8, 14/9	14/16, 14/17	-	-
7TS16	14/22	14/45	14/22	14/45, 14/47	-	-
7UM61	14/11, 14/12	14/22, 14/24	14/11, 14/15	14/23, 14/27	-	-
7UM62	14/12, 14/14	14/24, 14/26	14/15	14/27	-	-
7UT6	14/11, 14/12, 14/14	14/22, 14/24, 14/26	14/11, 14/15	14/23, 14/27	-	-
7VE61	14/11	14/22	14/11	14/23	-	-
7VE63	14/12	14/24	14/15	14/27	-	-
7VK610/7VK611	14/11, 14/12	14/22, 14/24	14/11, 14/15	14/23, 14/27	-	-
7XR9	-	-	14/23	14/52, 14/53, 14/54	-	-
7XV5450	14/19	14/34	14/19	14/34	-	-
7XV5461	-	-	14/19	14/34	-	-
7XV5550	14/19	14/33	14/19	14/33	-	-
7XV5650/51/52/53/55	14/19, 14/21	14/33, 14/38	14/19, 14/21	14/33, 14/38	-	-
7XV5662	-	-	14/19, 14/21	14/34, 14/38	-	-
7XV5673	-	-	14/23	14/51	-	-
7XV75	14/20	14/35	-	-	-	-

Appendix

Dimension drawings in mm/inch

Dimension drawings for 1/6 x 19" housing (7XP20)

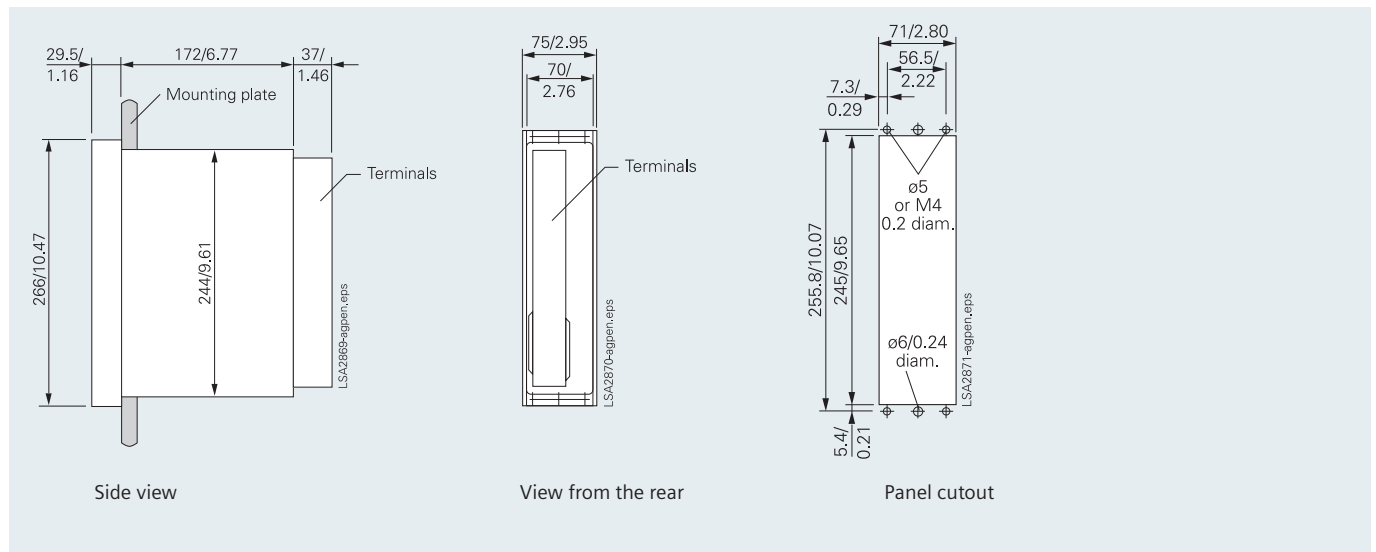


Fig. 14/15 Housing for panel flush mounting/cubicle mounting, terminals at rear (1/6 x 19")

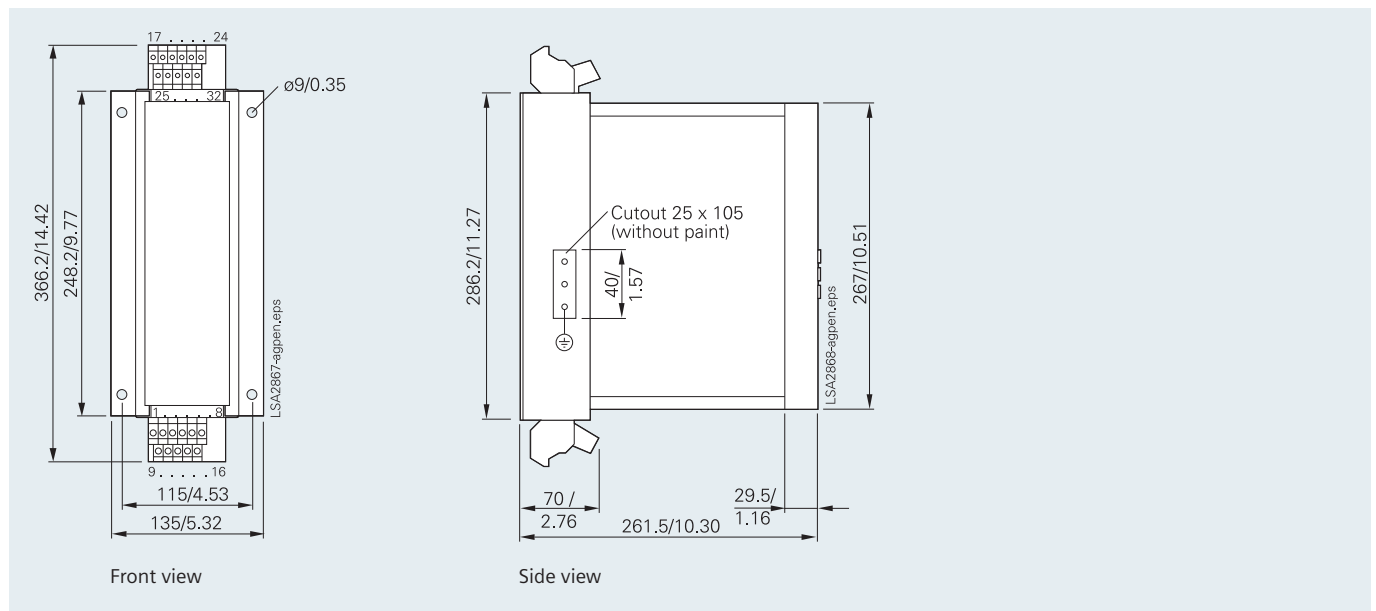


Fig. 14/16 Housing for surface mounting, terminals at top and bottom (1/6 x 19")

Dimension drawings for 1/6 × 19" housing (7XP20)

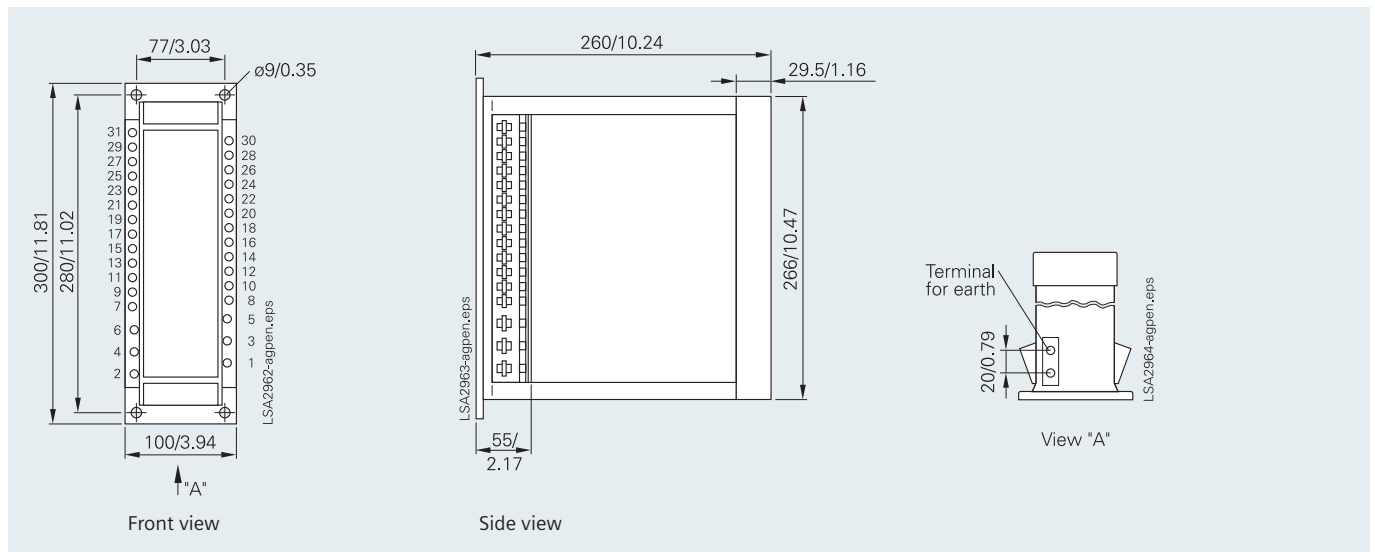


Fig. 14/17 Housing for panel surface mounting, terminals on the side (1/6 × 19")

Dimension drawings for SIPROTEC easy

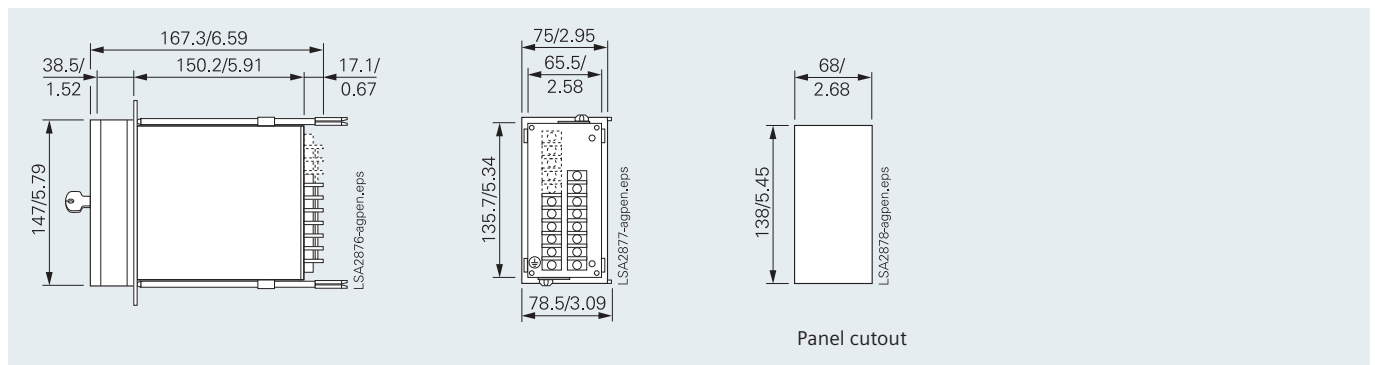


Fig. 14/18 7SJ45, 7SJ46 housing for panel flush mounting

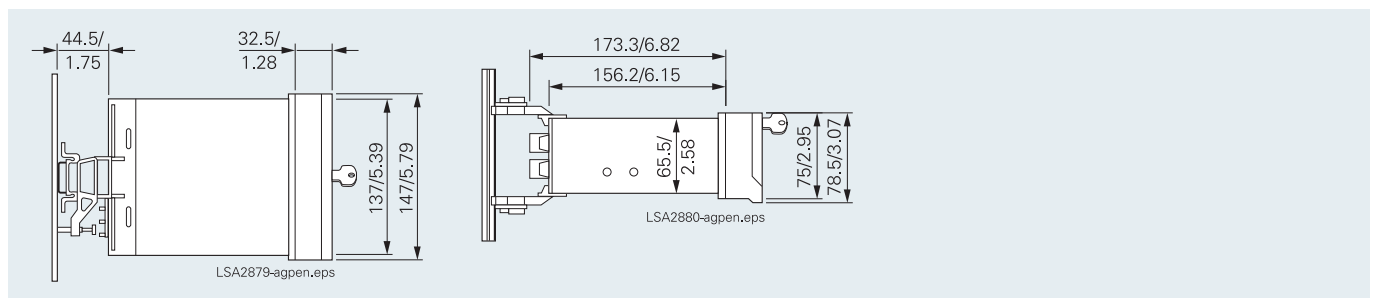


Fig. 14/19 7SJ45, 7SJ46 housing for rail mounting

Dimension drawings for SIPROTEC 4 1/3 x 19" housing (7XP20)

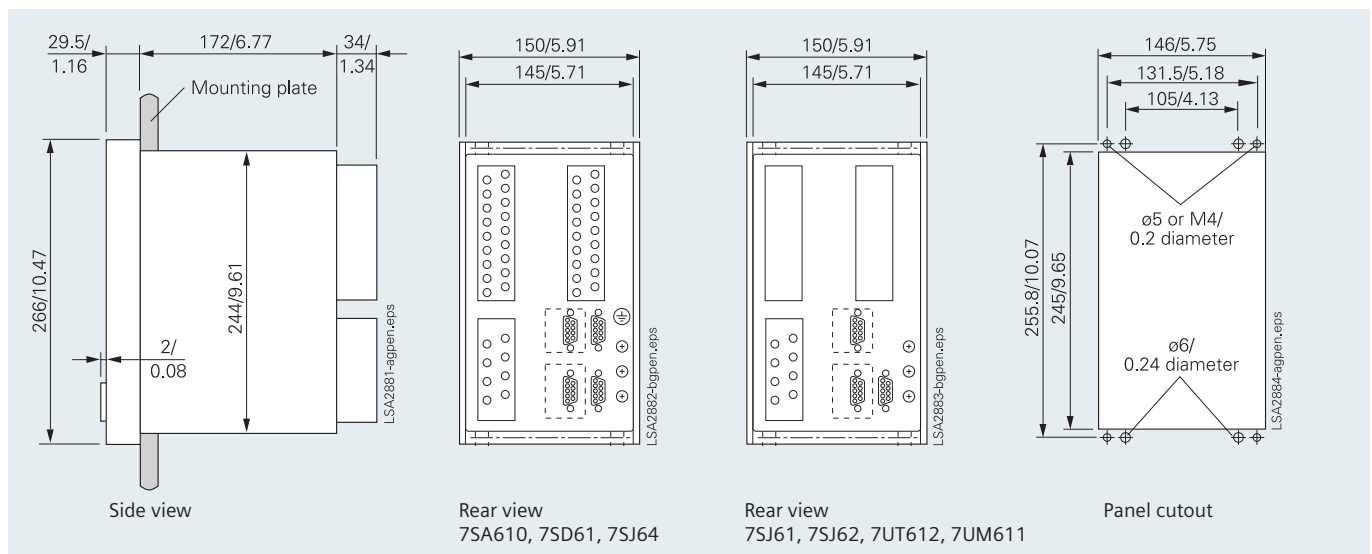


Fig. 14/22 Housing for panel flush mounting / cubicle mounting (1/3 x 19")

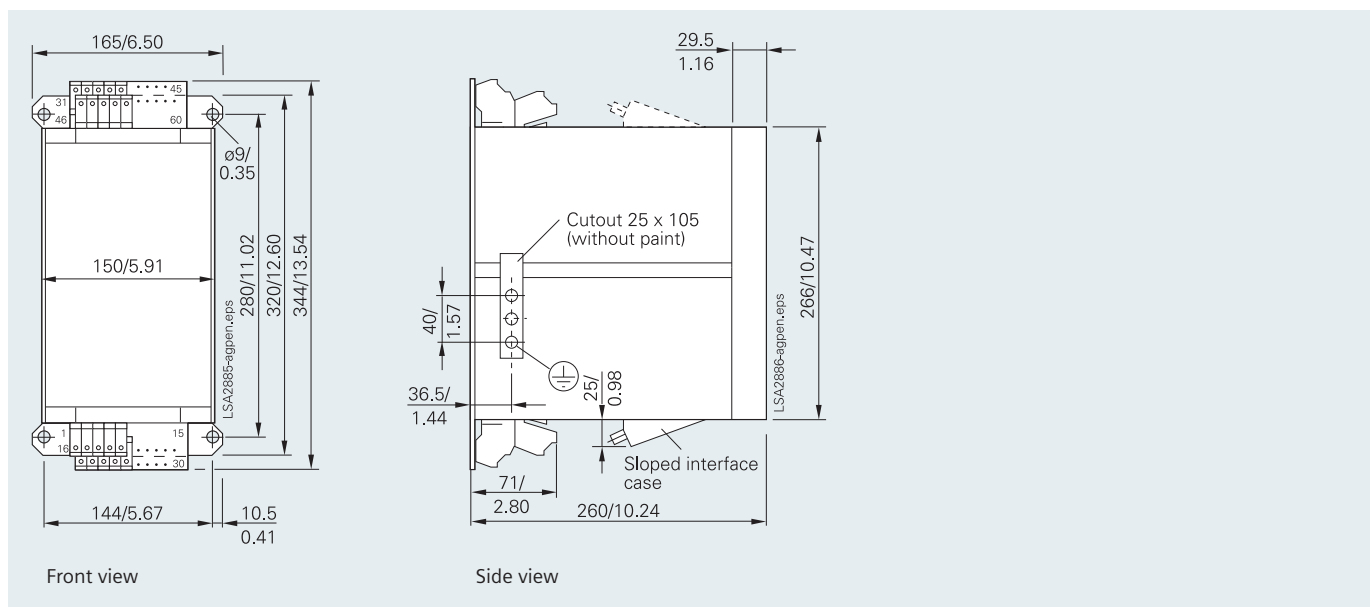


Fig. 14/23 1/3 x 19" surface-mounting housing, terminals at top and bottom

Appendix

Dimension drawings in mm/inch

Dimension drawings for SIPROTEC 4
 $\frac{1}{2} \times 19''$ flush-mounting housings (7XP20)

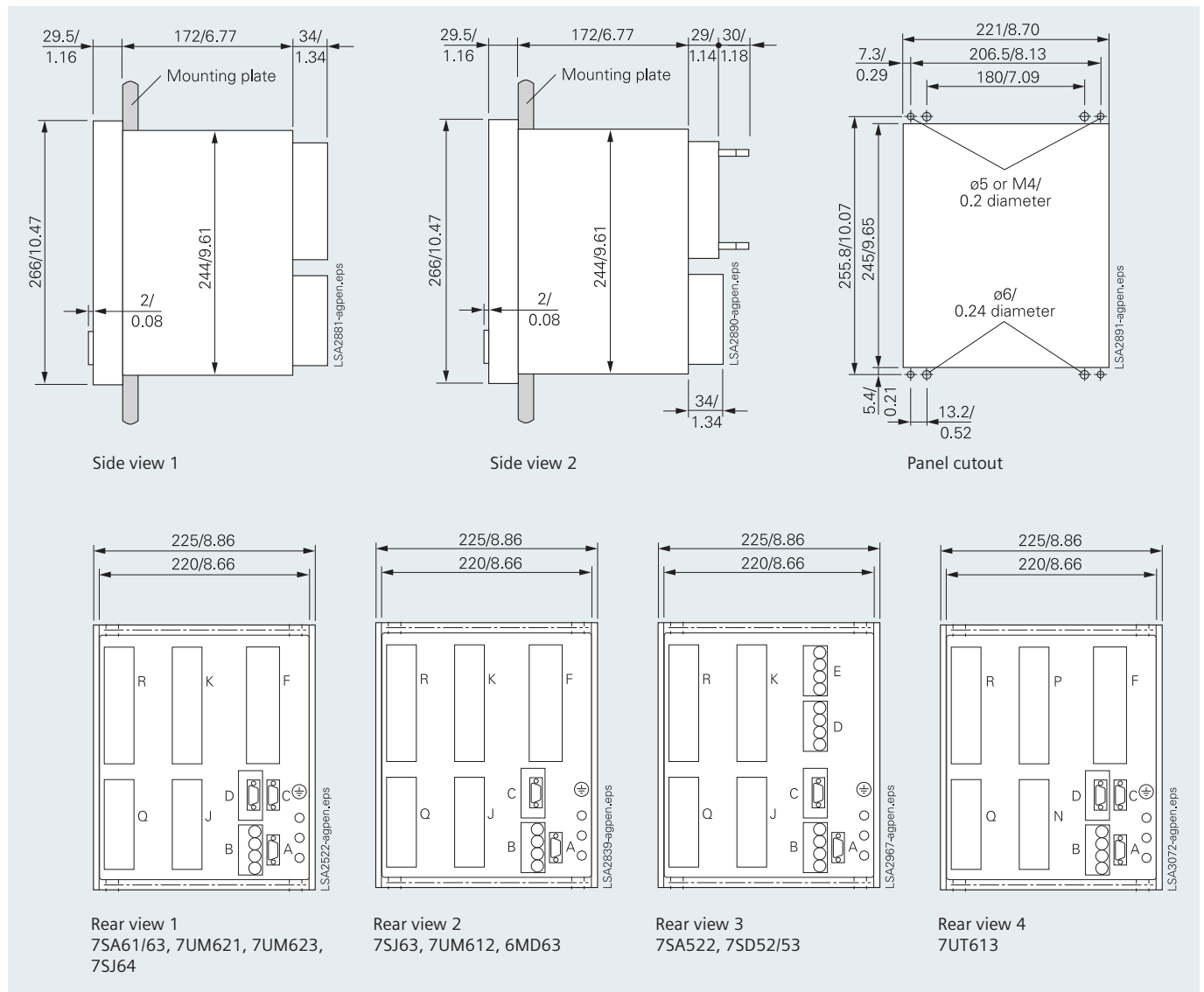


Fig. 14/24 $\frac{1}{2} \times 19''$ flush-mounting housing

Dimension drawings for SIPROTEC 4 2/3 × 19" flush-mounting housings (7XP20)

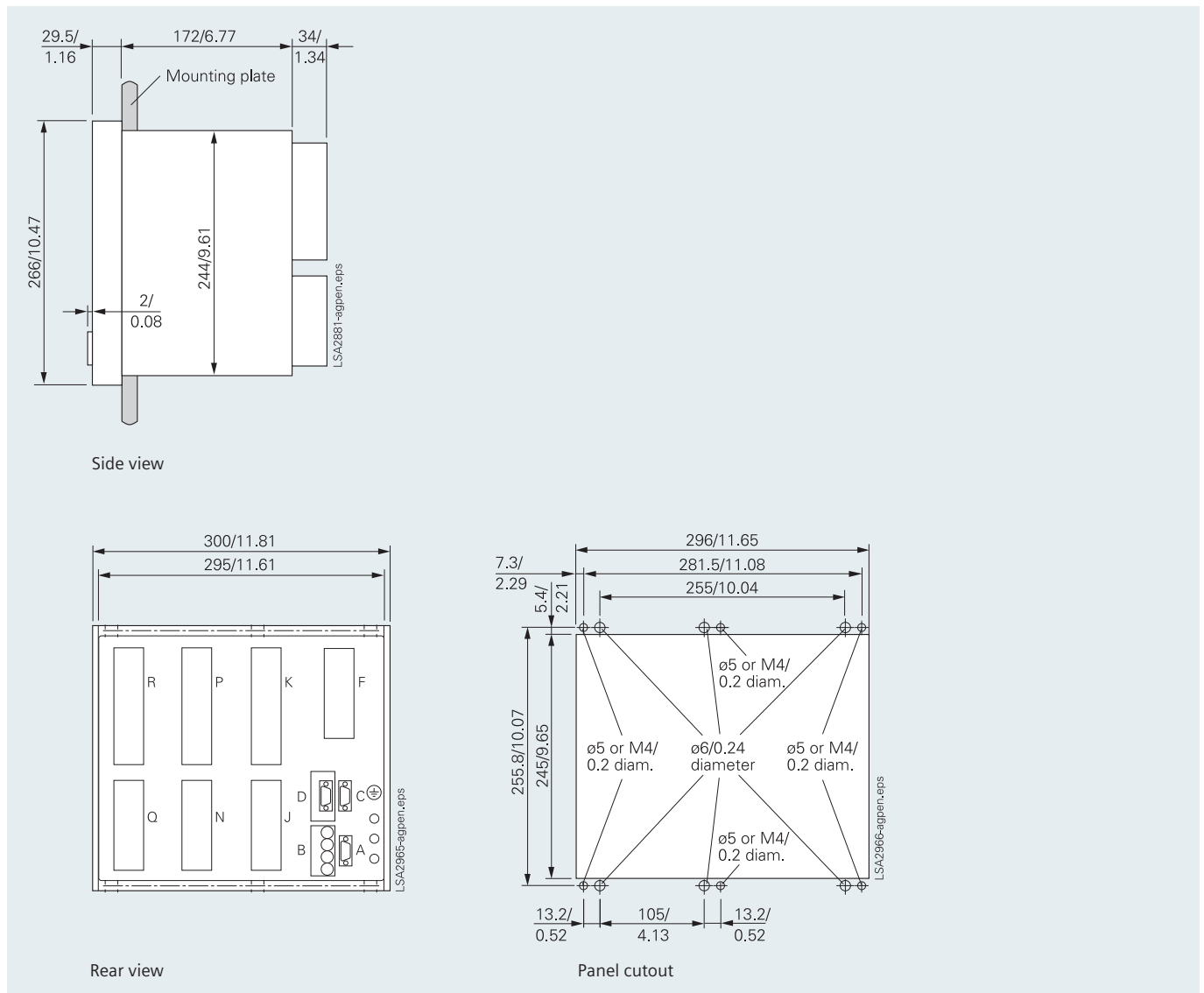


Fig. 14/25 2/3 × 19" flush-mounting housing for 7SA613

Appendix

Dimension drawings in mm/inch

Dimension drawings for SIPROTEC 4
 $\frac{1}{4} \times 19''$ flush-mounting housings (7XP20)

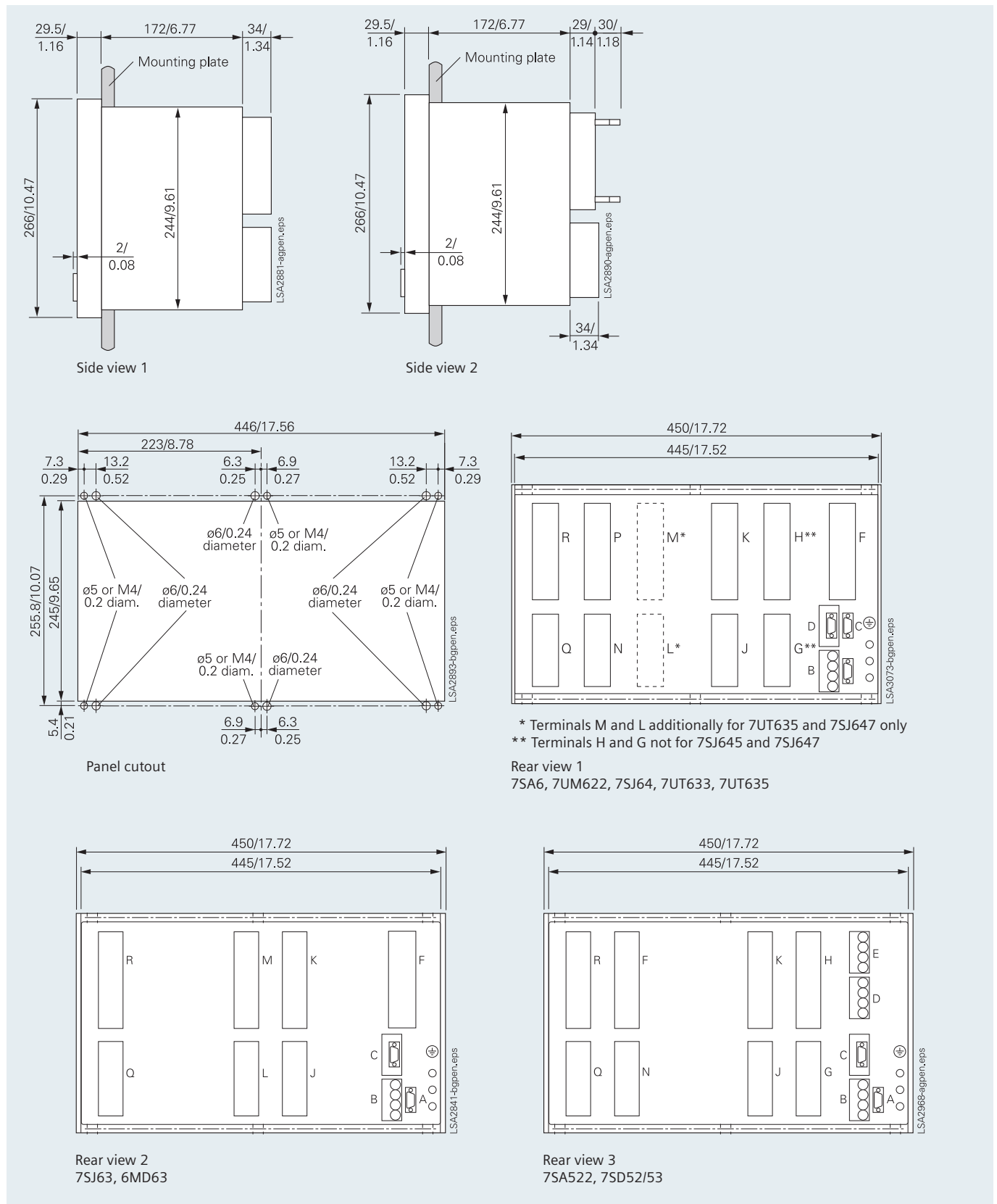
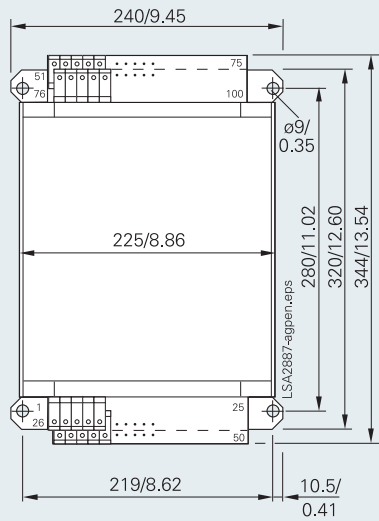


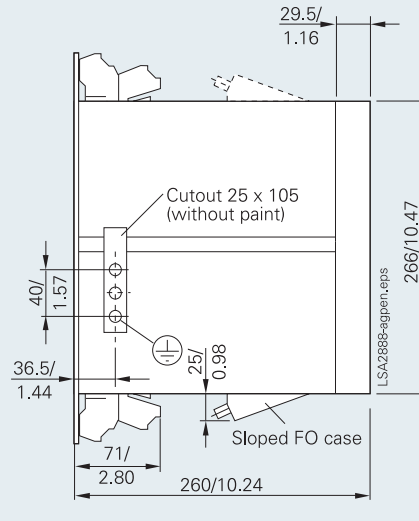
Fig. 14/26 $\frac{1}{4} \times 19''$ flush-mounting housing

Dimension drawings for SIPROTEC 4

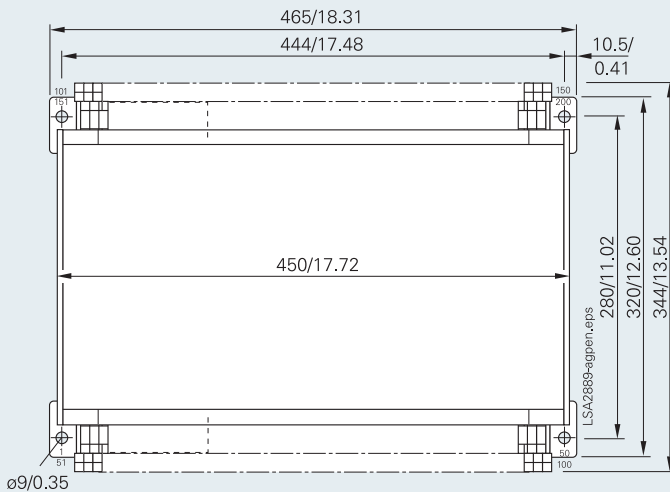
1/2 and 1/4 x 19" surface-mounting housing (7XP20)



Front view
1/2 x 19" surface-mounting,
terminals at top and bottom housing 7XP20



Side view



Front view
1/4 x 19" surface-mounting housing 7XP20
(without sloped FO case)

Fig. 14/27 1/2 and 1/4 x 19" surface-mounting housing

Appendix

Dimension drawings in mm/inch

Dimension drawings for SIPROTEC 4
 1/2 and 1/1 × 19" housings with detached operator panel

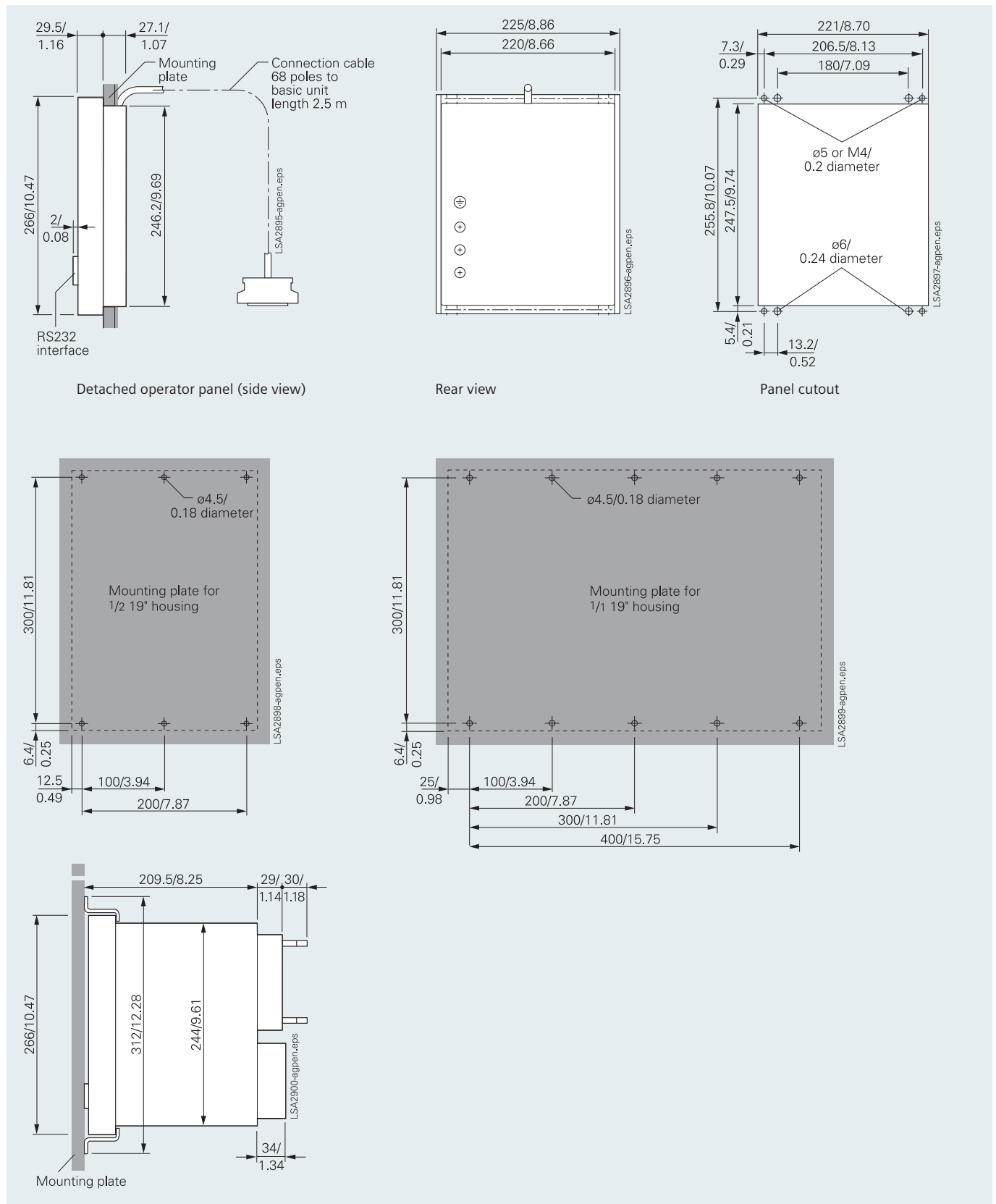


Fig. 14/28 Housing with detached or no operator panel

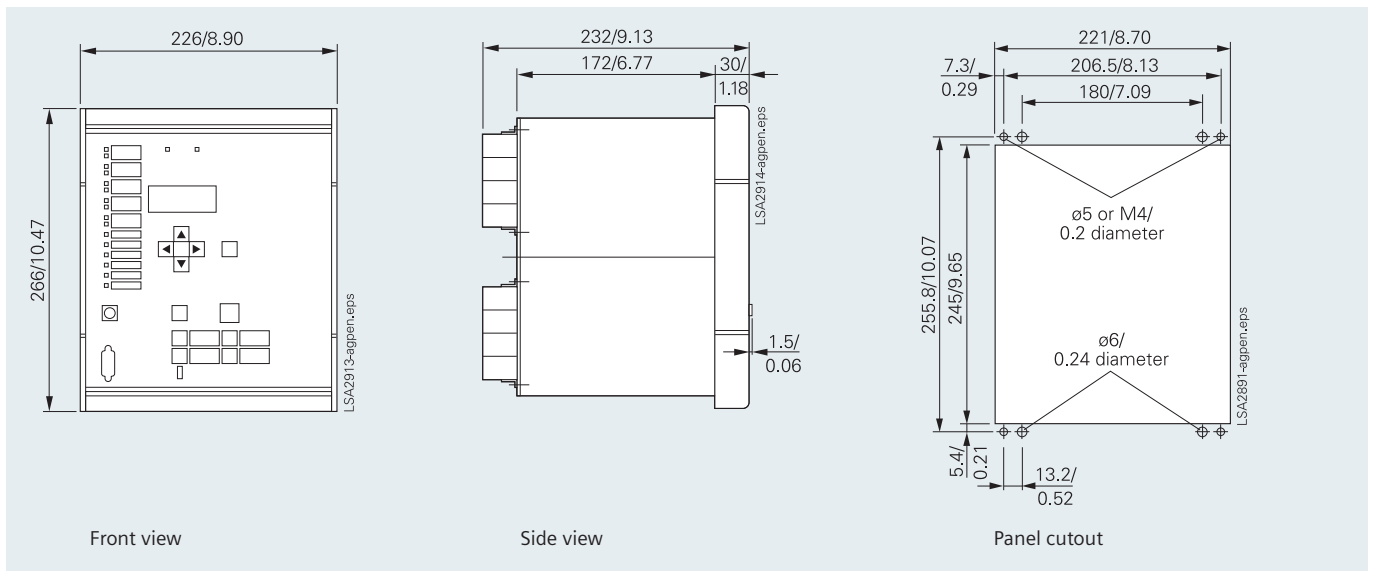


Fig. 14/29 7SS523 bay unit in 7XP2040-2 housing for panel flush mounting/cubicle mounting

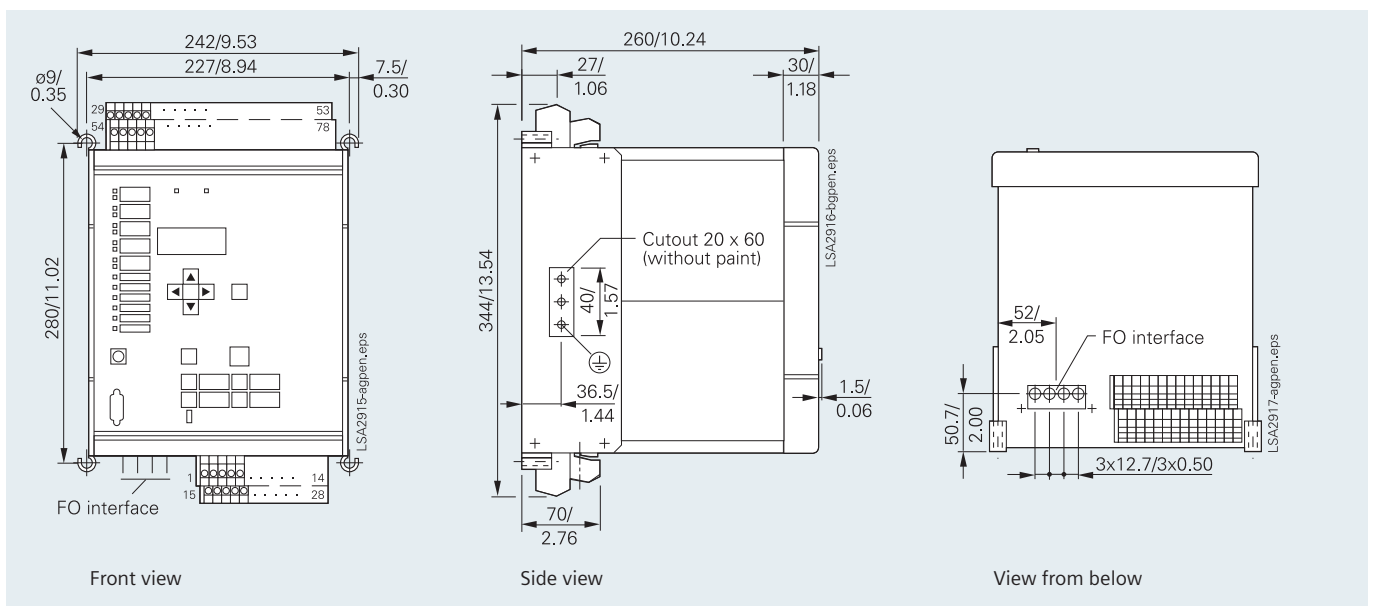


Fig. 14/30 7SS523 bay unit in 7XP2040-1 housing for panel surface mounting

Dimension drawings in mm/inch

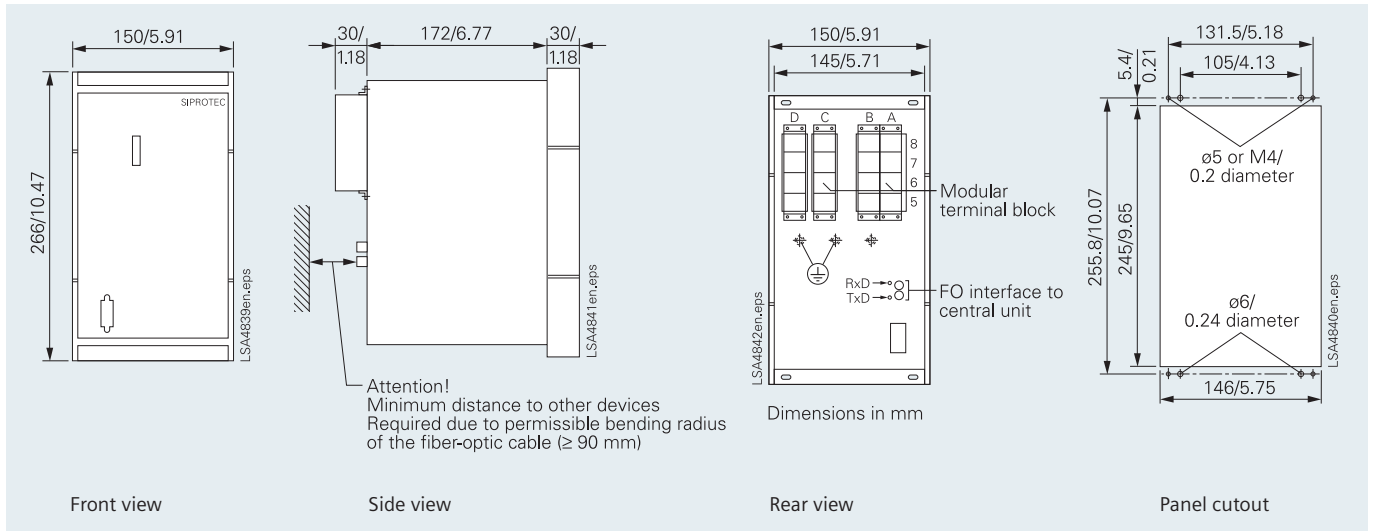


Fig. 14/31 7SS525 busbar and breaker failure protection unit for panel flush mounting/cubicle mounting with housing for wall mounting

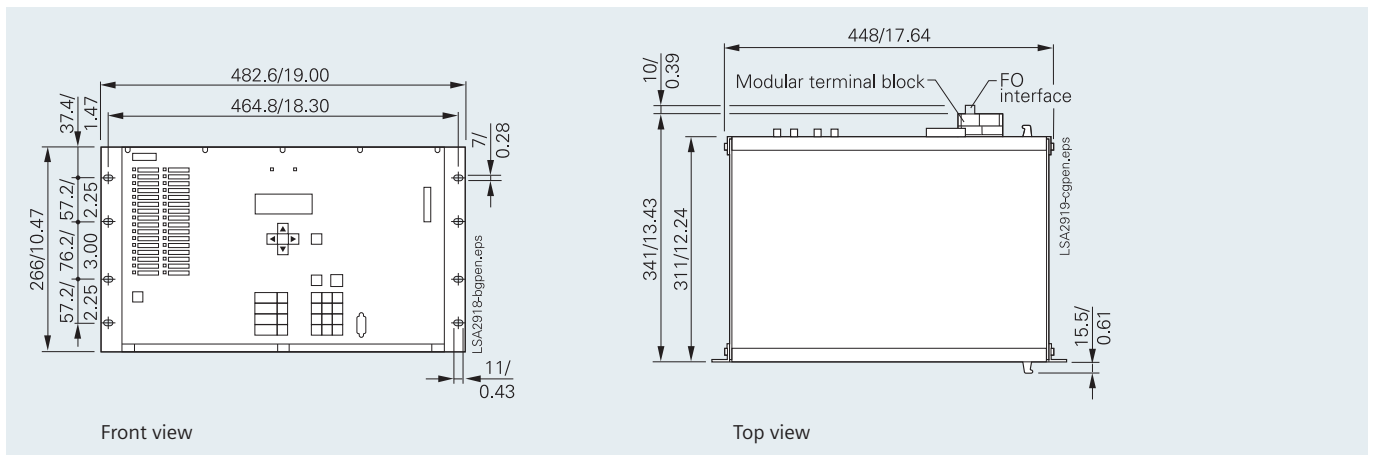


Fig. 14/32 7SS522 central unit in SIPAC subrack

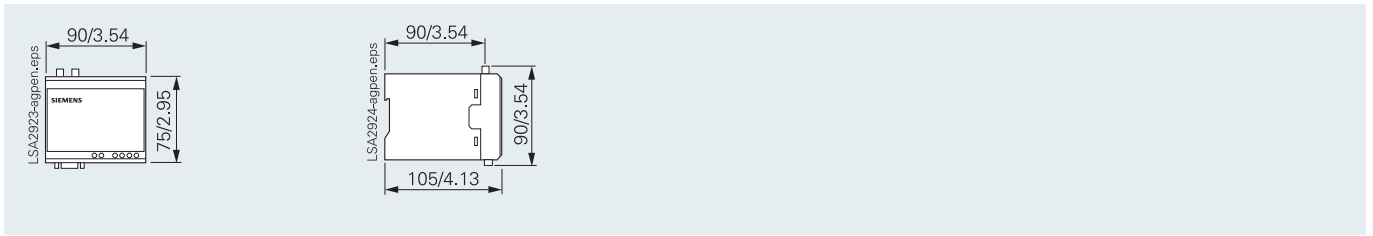


Fig. 14/33 Converter devices for rail mounting

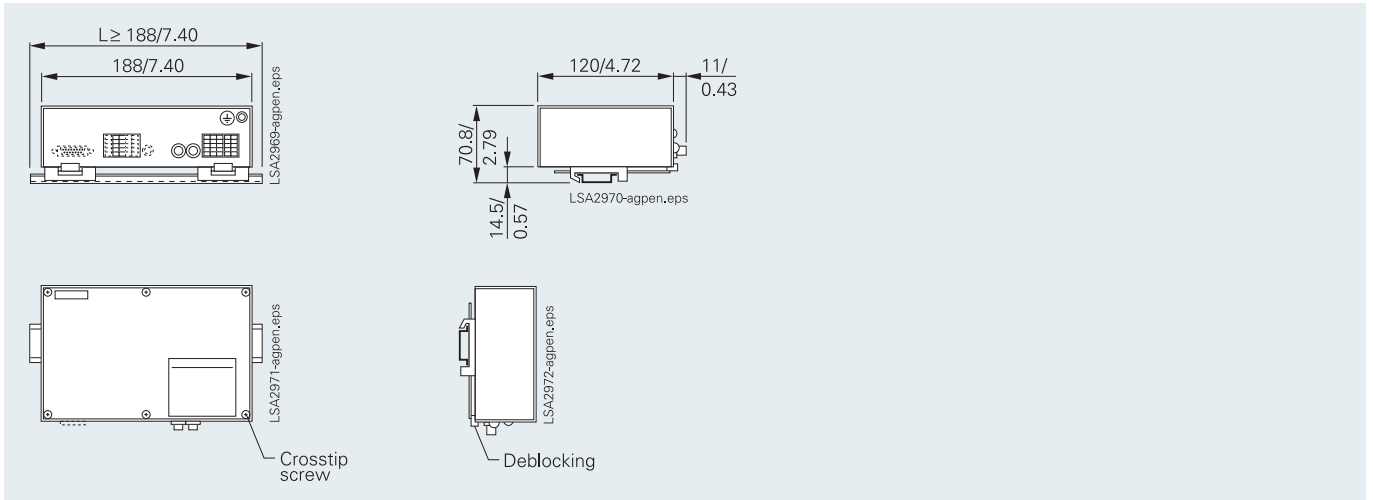


Fig. 14/34 7XV5662 communication converter

Appendix

Dimension drawings in mm/inch

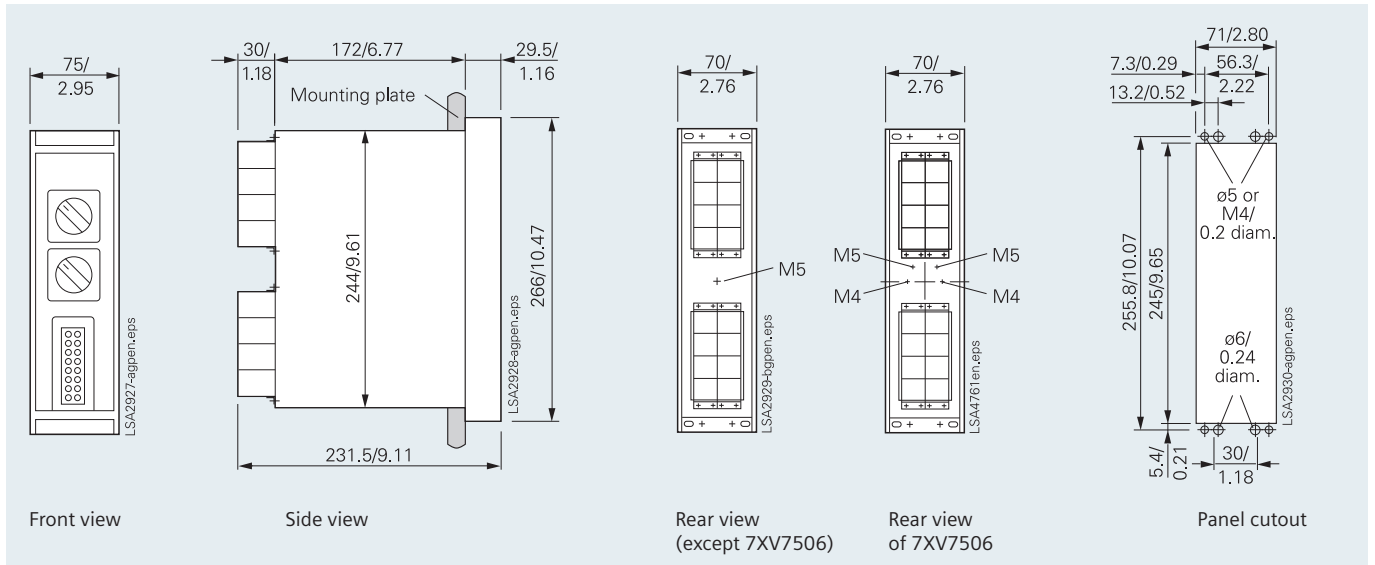


Fig. 14/35 7XV75 with housing 7XP2020-2 (for panel flush mounting)

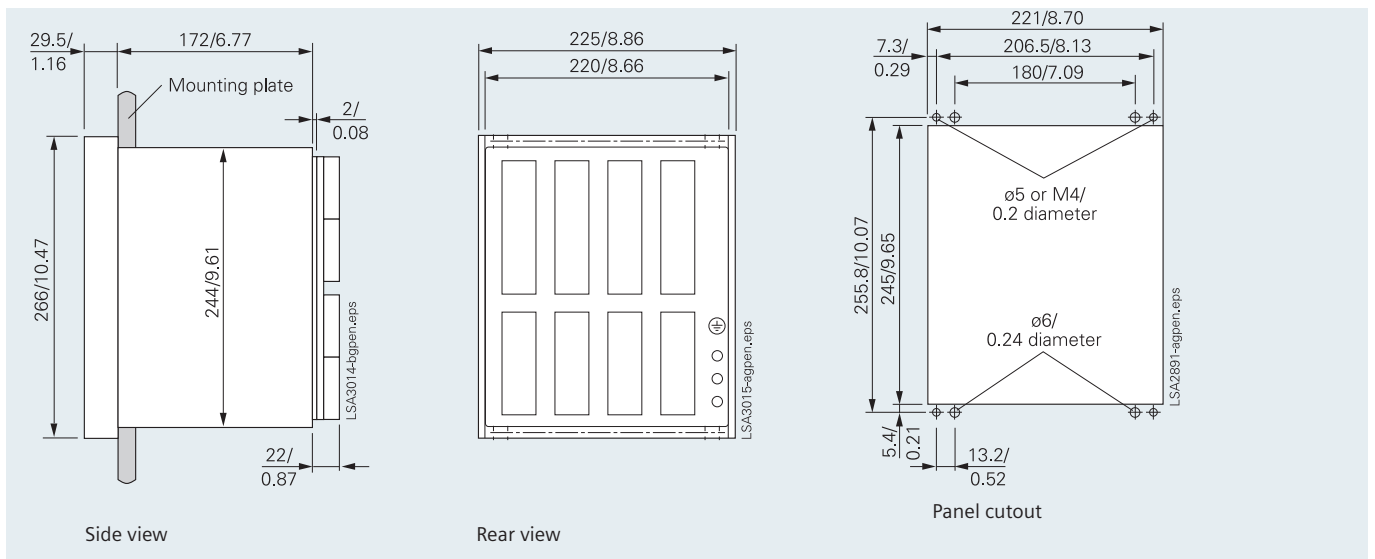


Fig. 14/36 Housing 7XP204 of the peripheral modules (7SS60) or panel or cubicle flush mounting

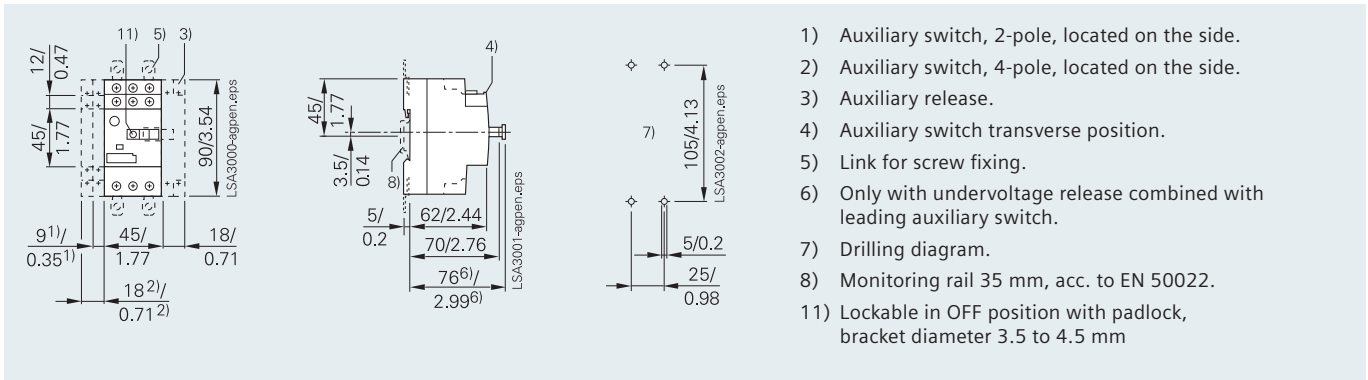


Fig. 14/37 7RV16 circuit-breaker

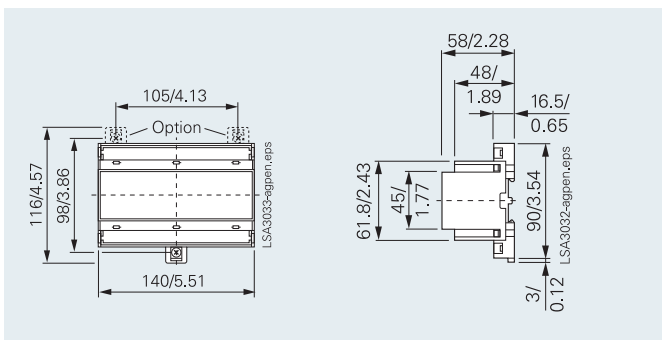


Fig. 14/38 Resistance temperature detector (RTD-box)

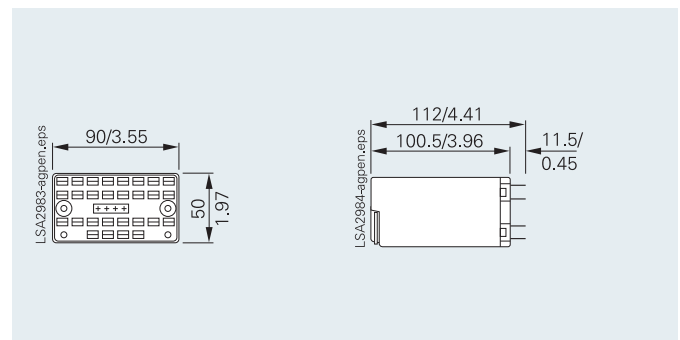


Fig. 14/39 7PA22 auxiliary relay

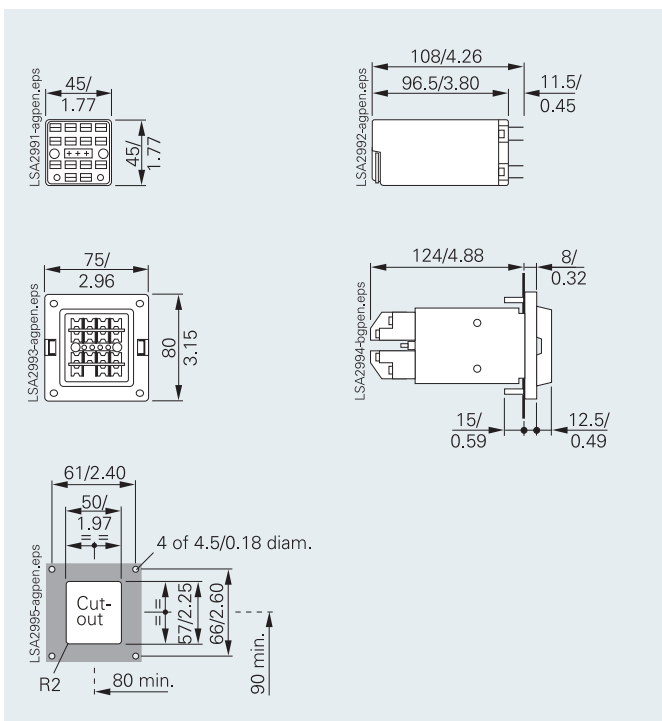


Fig. 14/40 7PA23 auxiliary relay + flush mounting socket 7XP9011-1

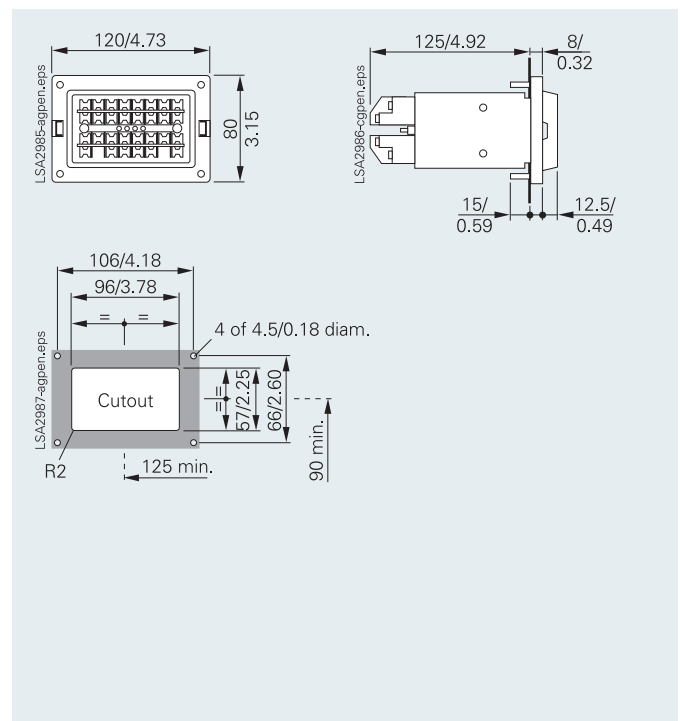


Fig. 14/41 Flush mounting sockets 7XP9010-1, 7XP9010-2, 7XP9010-4 for 7PA22 auxiliary relay, 7TS16 indication relay, 7PA30 three-phase trip circuit supervision

Appendix

Dimension drawings in mm/inch

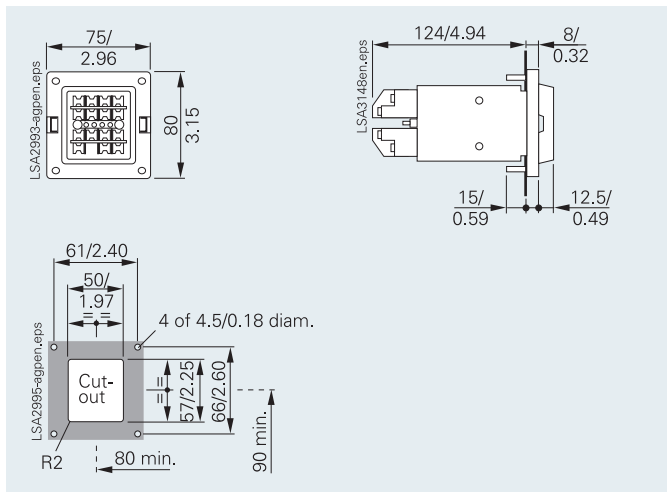


Fig. 14/42 Flush mounting sockets 7XP9011-0, 7XP9011-1 for 7PA23 auxiliary relay
7PA30 trip single-phase circuit supervision

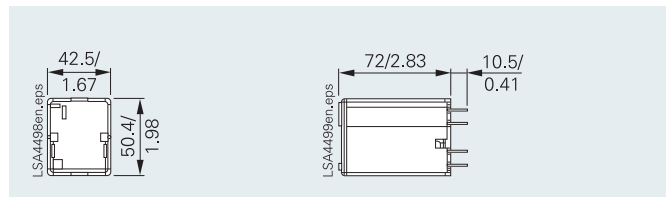


Fig. 14/43 7PA27

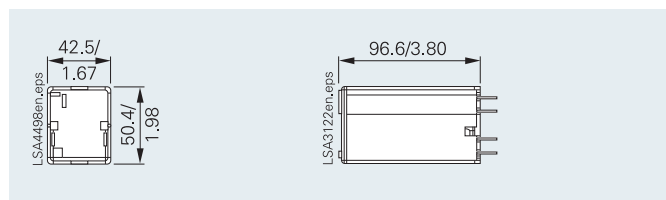


Fig. 14/44 7PA30 single-phase

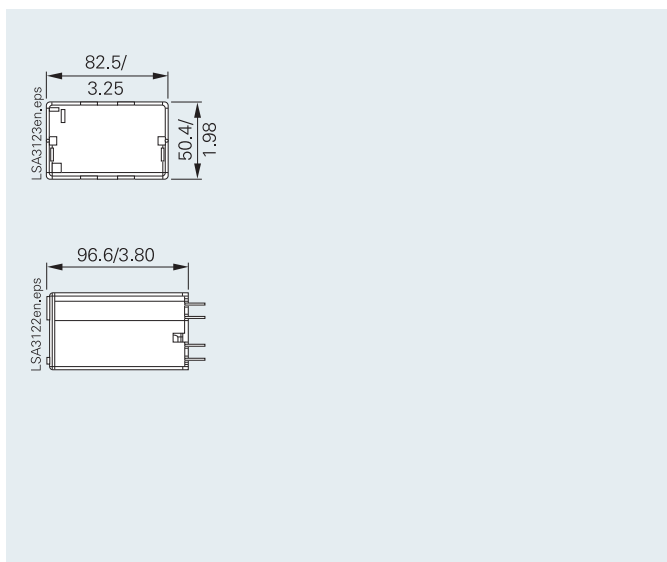


Fig. 14/45 7TS16, 7PA30 three-phase

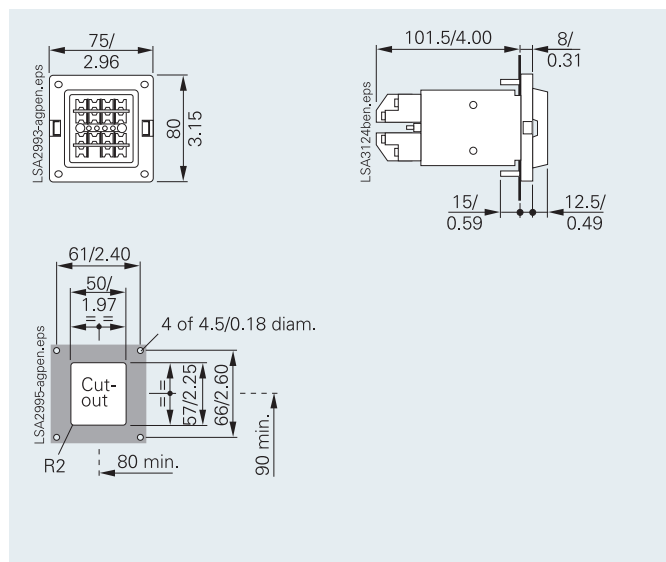


Fig. 14/46 Flush mounting socket 7XP9011-2 for 7PA27 auxiliary relay

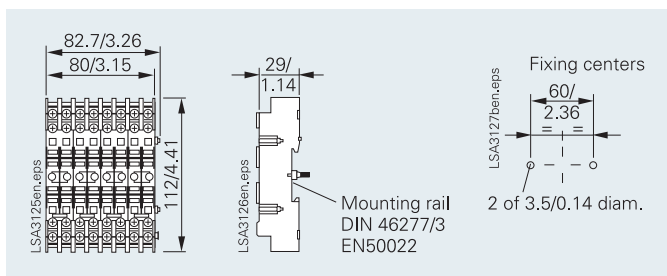


Fig. 14/47 Surface mounting socket 7XP9012 for 7PA22, 7PA26 auxiliary relays
7TS16 indication relay
7PA30 three-phase trip circuit supervision

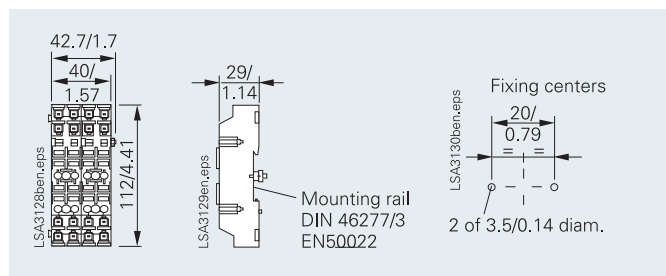


Fig. 14/48 Surface mounting socket 7XP9013 for 7PA23/27 auxiliary relay
7PA30 single-phase trip circuit supervision

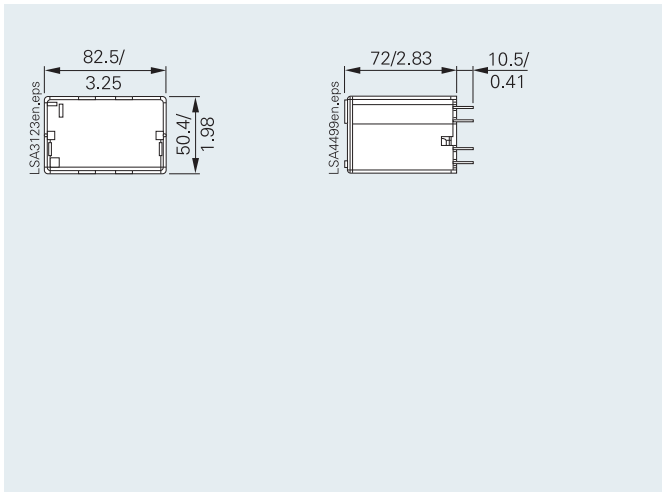


Fig. 14/49 7PA26 auxiliary relay

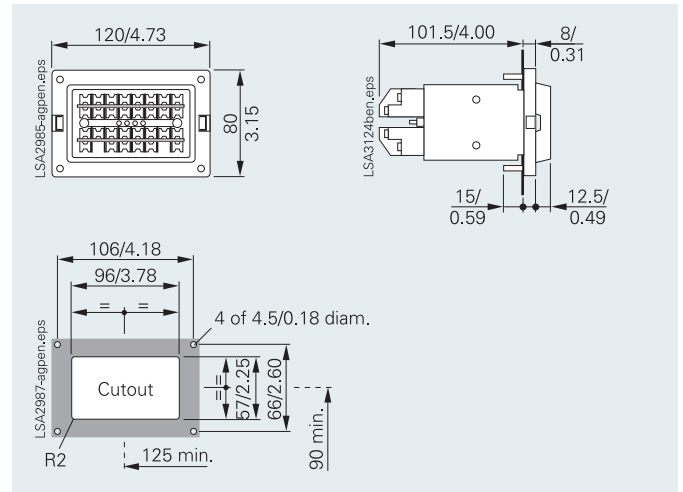


Fig. 14/50 Flush-mounting socket 7XP9010-3 for 7PA26

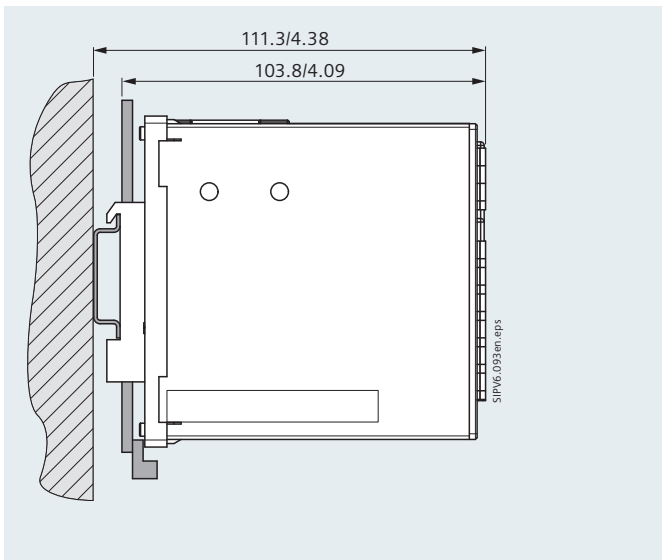


Fig. 14/51 7XV5673 I/O-Unit

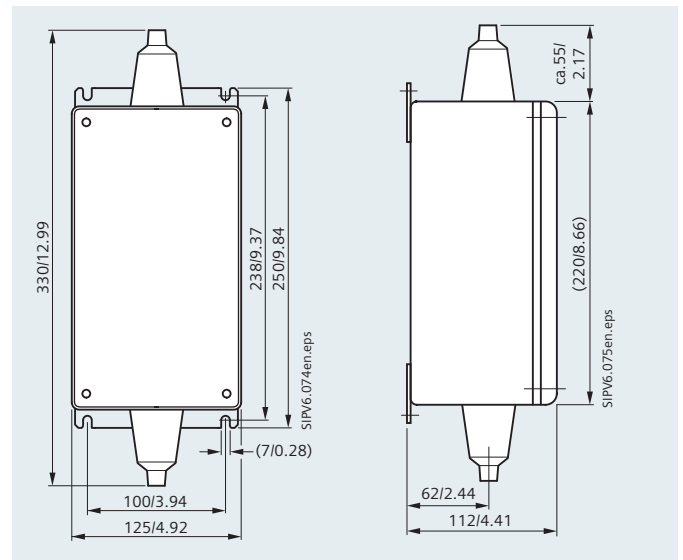


Fig. 14/52 7XR9513 isolating transformer

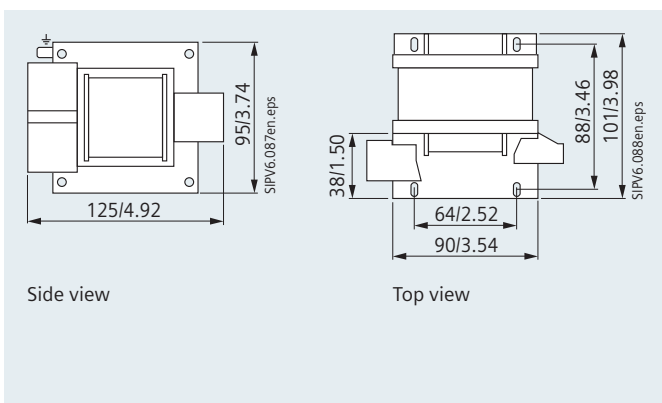


Fig. 14/53 7XR9515 isolating transformer

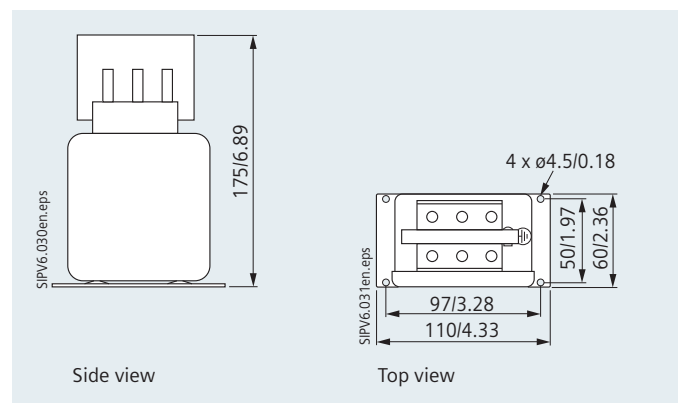


Fig. 14/54 7XR9516 isolating transformer

Dimension drawings in mm/inch

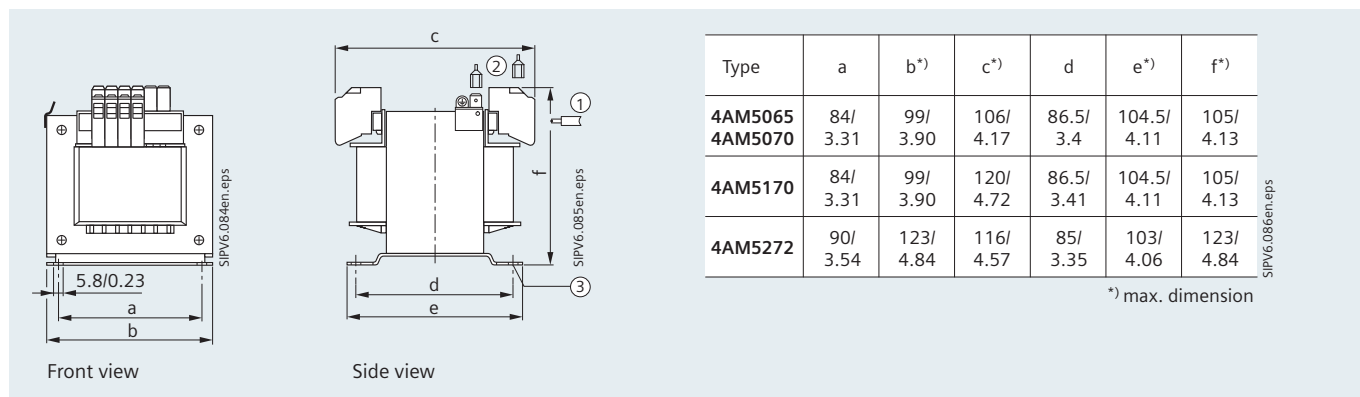


Fig. 14/55 4AM50, 4AM5170, 4AM52 auxiliary current transformer without varistor

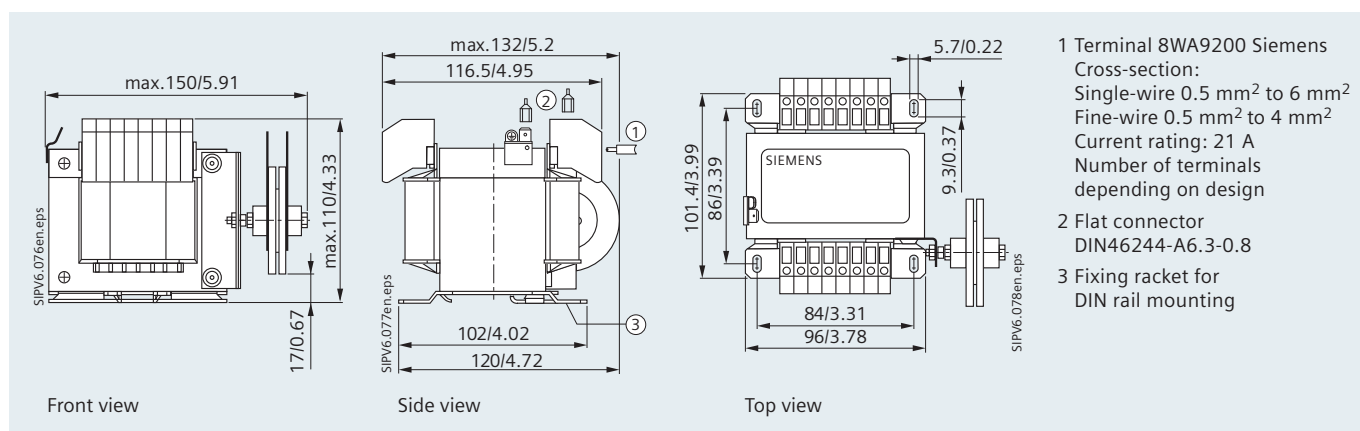


Fig. 14/56 4AM5120 auxiliary current transformer with varistor

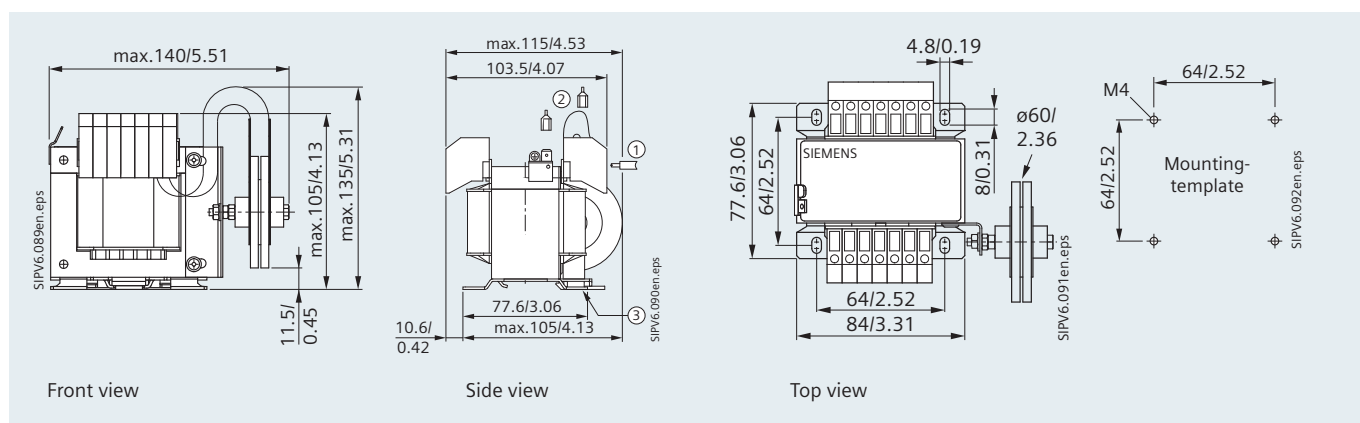


Fig. 14/57 4AM4930 auxiliary current transformer

Products applied until now	Function	Recommended new products
7PA10	Auxiliary relay	7PA26/27
7PA20	Lockout relay	7PA22/23
7PA21	Trip circuit monitoring	7PA30
7RP72	Frequency relay	7RW600
7SD24	Line differential relay	7SD600
7SD510/511	Line differential relay via FO	7SD610
7SD512	Line differential relay via FO	7SD5
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Appendix

Training

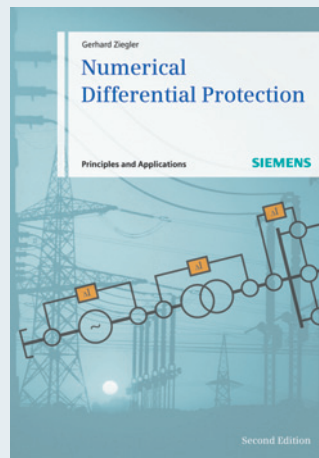
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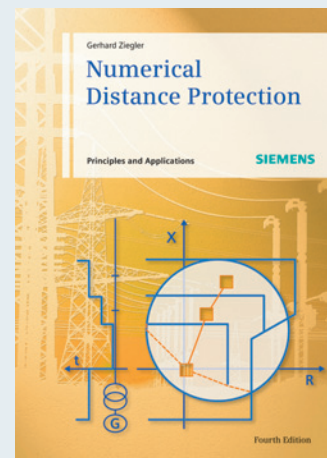
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