SIEMENS

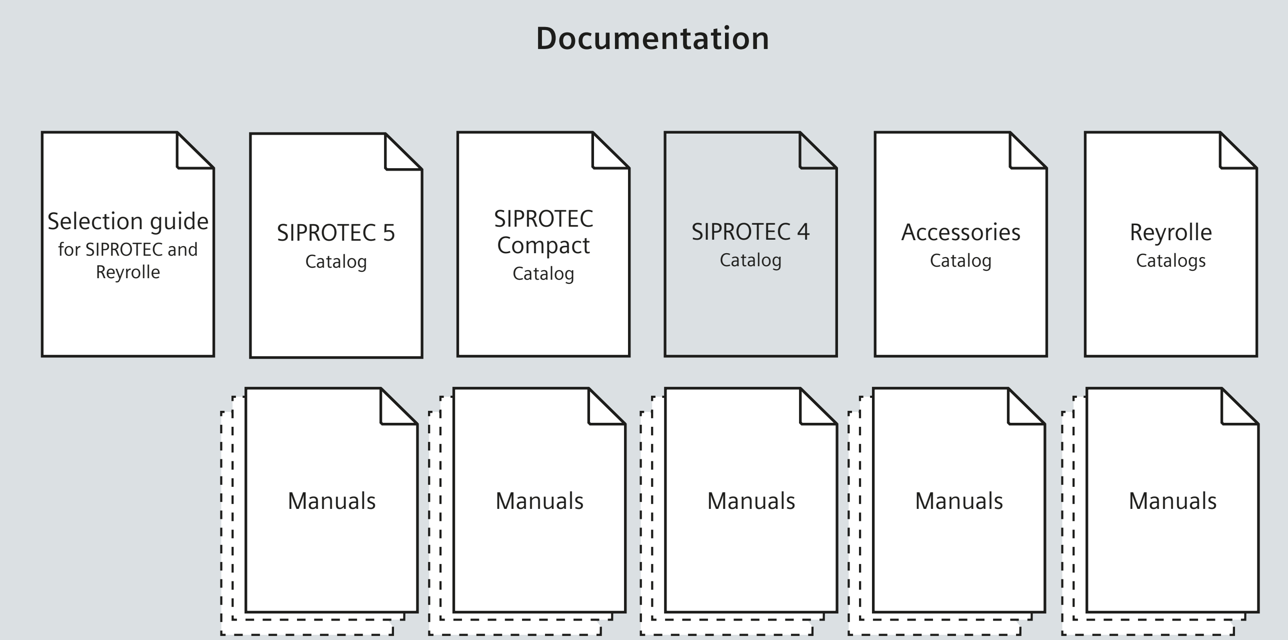
Protection, control, measurement, and automation functions

SIPROTEC 4 – Devices

Catalog SIP · Edition No. 8 / 8.1

siemens.com/siprotec

Overview of Siemens Protection Catalogs



Overview of the Documentation

SIPROTEC 4 Catalog:
This catalog describes the features of the device series SIPROTEC 4.

Selection guide for SIPROTEC and Reyrolle:
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 catalog describes the features of the SIPROTEC 5 system and device-specific features such as scope of functions, hardware and application.

Accessories Catalog:
This catalog describes the accesories for protection, power quality and substation automation devices.

Reyrolle Catalogs:
The Reyrolle catalogs describes the features such as scope of functions, hardware and application.

Manuals:
The manuals describe, among others, the operation, installation, the technical data, of the devices.

Contents

SIPROTEC 4

Catalog SIP · Edition No. 8 / 8.1

Updates Ed8.1:
- Cancellation due to phase out 6MD61, 6MD63, 7SJ63 and 7UM61
- Cancellation SIPROTEC 4 Tutorial
- SIPROTEC 7SJ66 small updates

Invalid: Catalog SIP · Edition No. 8 and No. 7

MANAGEMENT SYSTEM CERTIFICATION
DNV·GL
ISO 9001 ISO 14001
OHSAS 18001

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).

Product Index

Function overview

1

Page

Function overview

SIPROTEC 4 devices series

ANSI	Device application Functions	Abbr.	Type	Distance protection 7SA522	7SA61	7SA63	7SA64	Line differential protection 7SD610	7SD5
	Protection functions for 3-pole tripping	3-pole		■	■	■	■	■	■
	Protection functions for 1-pole tripping	1-pole		●	●	●	●	●	●
14	Locked rotor protection	I> + V<		–	–	–	–	–	–
21/21N	Distance protection	Z<, V< /I>/∠(V,I)		■	■	■	■	–	●
24	Overexcitation protection	V/f		–	–	–	–	–	–
25	Synchrocheck, synchronizing function	Sync		●	●	●	●	–	●
27	Undervoltage protection	V<		●	●	●	●	●	●
27TN/59TN	Stator ground fault 3rd harmonics	$V0<,>_{(3.Harm.)}$		–	–	–	–	–	–
	Undervoltage-controlled reactive power protection	Q>/V<		●	●	●	●	–	–
32	Directional power supervision	P<>, Q<>		■	■	■	■	●	■
37	Undercurrent, underpower	I<, P<		●	●	●	●	–	–
38	Temperature supervision	ϑ>		●	●	●	●	–	–
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		■	■	■	■	■	■
47	Overvoltage protection, negative-sequence system	V>2		●	●	●	●	●	●
48	Starting-time supervision	I^2_{start}		–	–	–	–	–	–
49	Thermal overload protection	ϑ, I^2t		–	●	■	■	■	■
50/50N	Definite time-overcurrent protection	I>		■	■	■	■	■	■
SOFT	Instantaneous tripping at switch onto fault			■	■	■	■	■	■
50Ns	Sensitive ground-current protection	$I_{Ns}>$		●	●	●	●	–	●
	Intermittent ground fault protection	Iie>		●	●	●	●	–	–
50EF	End fault protection			–	–	–	–	–	–
50BF	Circuit-breaker failure protection	CBFP		●	●	●	●	●	■
51/51N	Inverse time-overcurrent protection	I_P, I_{Np}		■	■	■	■	■	■
50L	Load-jam protection	$I>_L$		–	–	–	–	–	–
51C	Cold load pickup			–	–	–	–	–	–
51V	Voltage dependent overcurrent protection	t=f(I)+V<		●	●	●	●	–	–
55	Power factor	cosφ		■ 1)	■ 1)	■ 1)	■ 1)	■ 1)	■ 1)
59	Overvoltage protection	V>		●	●	●	●	●	●
59N	Overvoltage protection, zero-sequence system	V0>		●	●	●	●	●	●
59R, 27R	Rate-of-voltage-change protection	dV/dt		–	–	–	–	–	–
60FL	Fuse-Failure-Monitor			■	■	■	■	●	■
64	Sensitive ground-fault protection (machine)			–	–	–	–	–	–
66	Restart inhibit	I^2t		–	–	–	–	–	–

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

1) via CFC

More functions on page 1/4

You will find the whole function overview of the SIPROTEC devices at:
www.siemens.com/protection

	Device application				Generator and motor protection	Transformer protection			Busbar protection	Bay controller	Breaker management	Synchroniz-ing	High Speed Busbar Transfer
	7SJ61	7SJ62	7SJ64	7SJ66	7UM62	7UT612	7UT613	7UT63	7SS52	6MD66	7VK61	7VE6	7VU683
	■	■	■	■	■	■	■	■	■	–	■	●	■
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Table continued on next page

Function overview

SIPROTEC 4 devices series

	Device application			Distance protection				Line differential protection	
ANSI	Functions	Abbr.	Type	7SA522	7SA61	7SA63	7SA64	7SD610	7SD5
67	Directional time-overcurrent protection, phase	$I>, I_P \angle (V,I)$		■ 1)	■ 1)	■ 1)	■ 1)	●	–
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	ΔZ/Δt		●	●	●	●	–	●
74TC	Trip-circuit supervision	TCS		■	■	■	■	■	■
78	Out-of-step protection	ΔZ/Δt		●	●	●	●	–	●
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
	Changeover of setting group			■	■	■	■	■	■
	Circuit breaker test			■	■	■	■	■	■

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	7SJ61	7SJ62	7SJ64	7SJ66	7UM62	7UT612	7UT613	7UT63	7SS52	6MD66	7VK61	7VE6	7VU683
	–	●	●	●	■	–	–	–	–	–	–	–	–
	–	●	●	●	■	–	–	–	–	–	–	–	–
	–	●	●	●	■	–	–	–	–	–	–	–	–
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	■	■	■	■	■	■	■	■	–	■	■	■	■
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1

Overview/Applications

2

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, you 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 you 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 500,000 devices with IEC 61850 included.

Many users have approved SIPROTEC protection devices for use in their power systems. The devices have also been certified by independent test institutes and universities (KEMA, EPRI, LOYD, UR Laboratories).

Fig. 2/1 SIPROTEC Relay Family

How can system operators benefit from this experience?

- Proven and complete applications
- Easy integration into your system
- Highest quality of hardware and functionality
- 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.

Information about SIPROTEC 5 and SIPROTEC Compact product families can be found in the related catalogs or at: www.siemens.com/siprotec

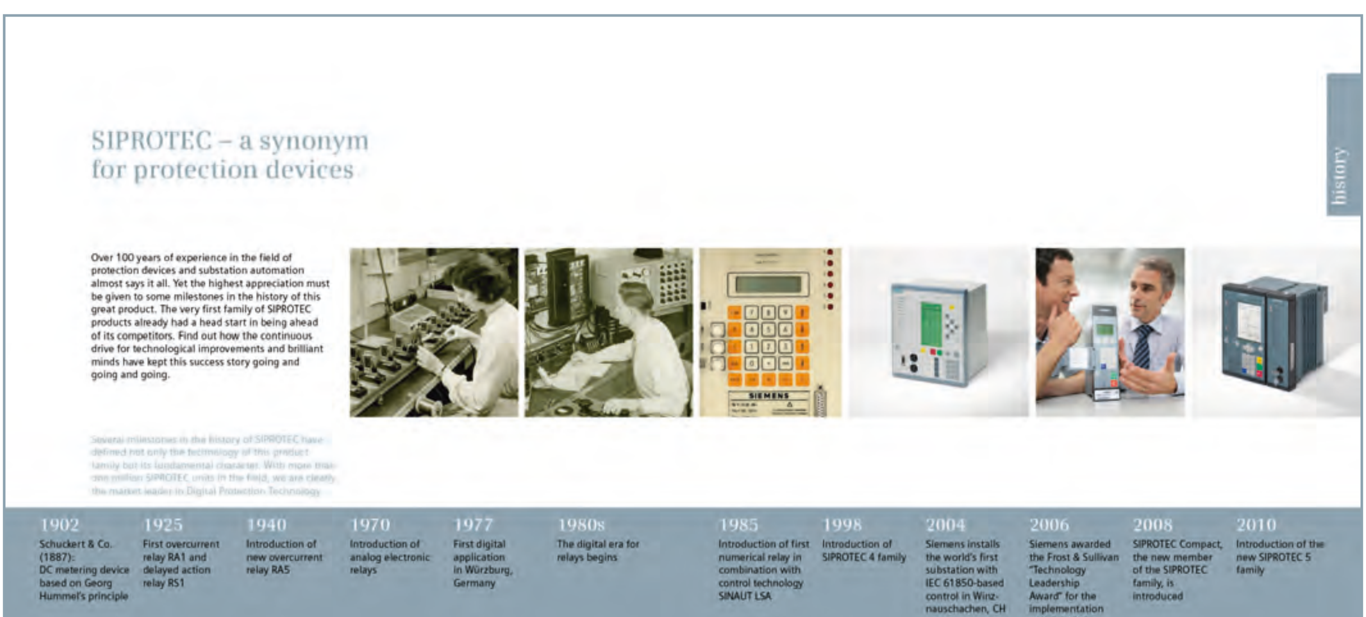


Fig. 2/2 SIPROTEC – Pioneer over generations

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 ⅙ 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. 2/3 SIPROTEC Compact

Fig. 2/4 SIPROTEC Compact – rear view

Fig. 2/5 Feeder protection relay SIPROTEC with HMI

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 of the device types can be tailored to the requested application and adjusted to the ever changing requirements throughout the entire lifecycle.

In addition to 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
- Arc protection, detection of transient ground faults, and process bus can easily be integrated and retrofitted
- 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. 2/6 SIPROTEC 5 – modular hardware

Fig. 2/7 SIPROTEC 5 – rear view

Fig. 2/8 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. 2/9 SIPROTEC 4

Fig. 2/10 SIPROTEC 4 rear view

Fig. 2/11 SIPROTEC 4 in power plant application

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.

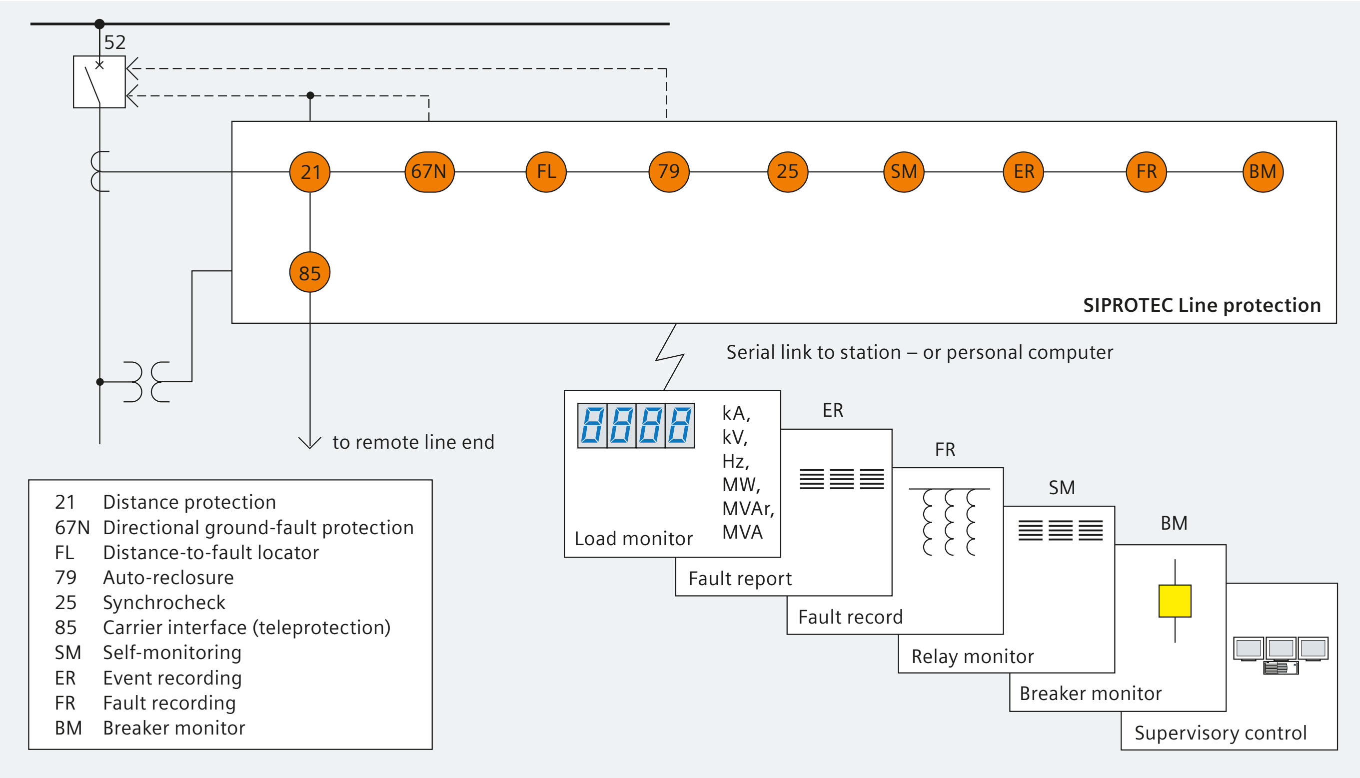


Fig. 2/12 Numerical relays offer increased information availability

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. 2/13).

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. 2/15). 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. 2/14).

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. 2/15).

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.

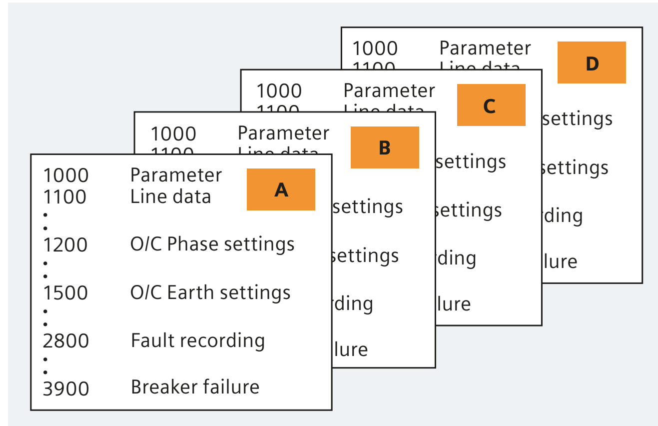


Fig. 2/13 Alternate parameter groups

Fig. 2/14 Left: switchgear with numerical relay (7SJ62) and traditional control; right: switchgear with combined protection and control relay (7SJ64)

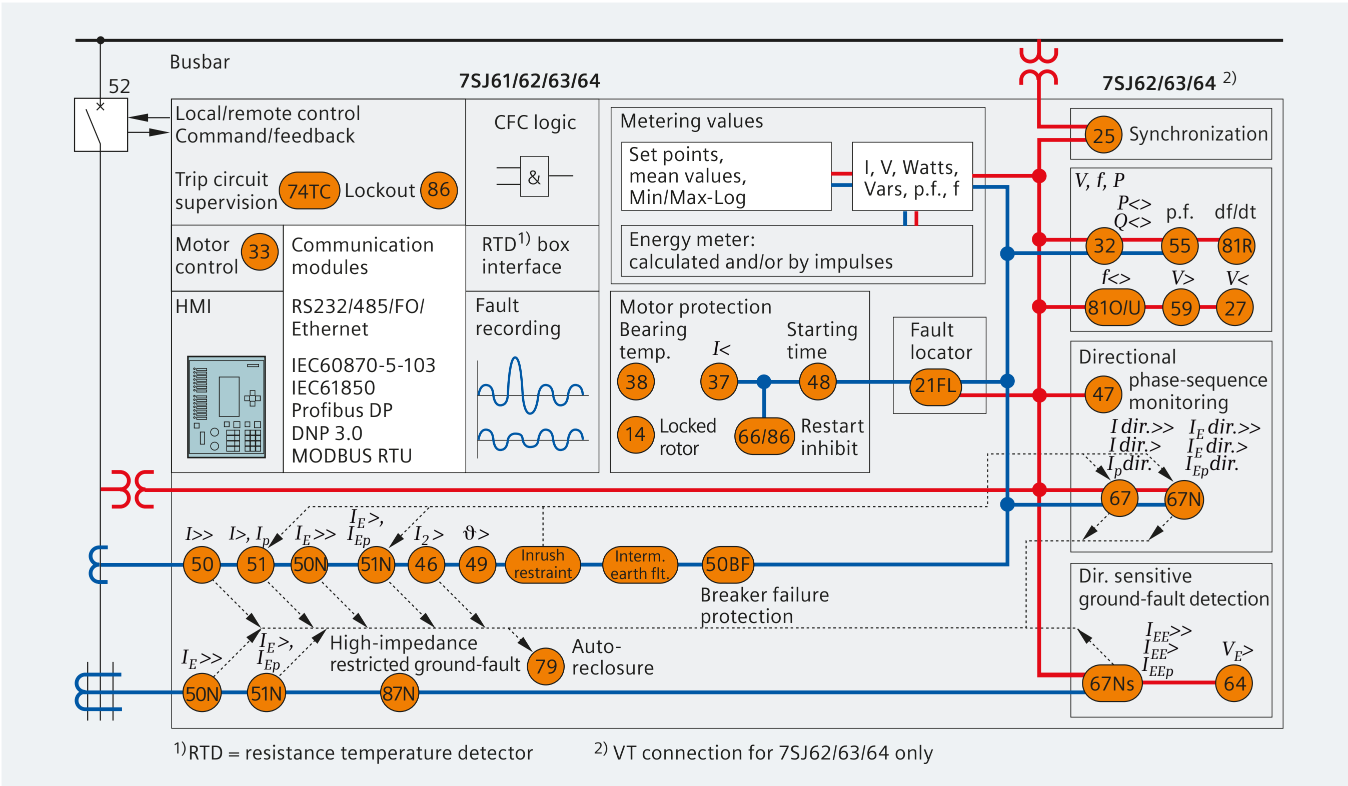


Fig. 2/15 SIPROTEC 4 relays 7SJ61 / 62 / 63, 64 implemented functions

Terminals: Standard relay version with screw-type terminals

Current terminals	
Connection	W_{max} =12 mm
Ring cable lugs	d_1 = 5 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 mm
Ring cable lugs	d_1 = 4 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 ⅓ to ⅟₁ of 19” wide housings with a standard height of 243 mm. Their size is compatible with that of other device series. Therefore, compatible exchange is always possible (Fig. 2/16 to Fig. 2/18).

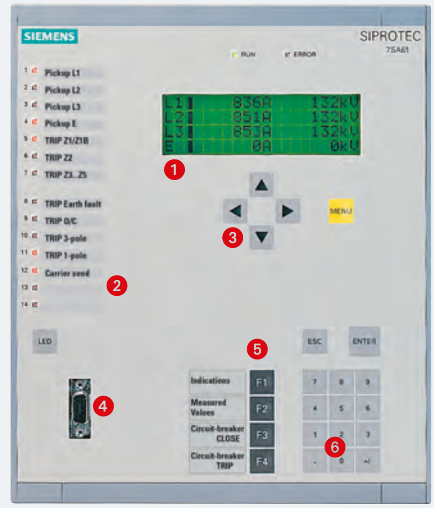
All wires (cables) are connected at the rear side of the relay with or without ring cable lugs. A special relay version with a detached cable-connected operator panel (Fig. 2/19) is also available. It allows, for example, the installation of the relay itself in the low-voltage compartment, and of the operator panel separately in the door of the switchgear.

Fig. 2/16 1/1 of 19" housing

Fig. 2/17 ½ of 19" housing

Fig. 2/18 ⅓ of 19" housing

Fig. 2/19 SIPROTEC 4 combined protection, control and monitoring relay with detached operator panel



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. 2/20 Local operation: All operator actions can be executed and information displayed via an integrated user interface. Two alternatives for this interface are available.

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.

Fig. 2/21 Additional features of the interface with graphic display

2

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 φ)
- Frequency
- Energy ± kWh ± 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. 2/22, Fig. 2/23).

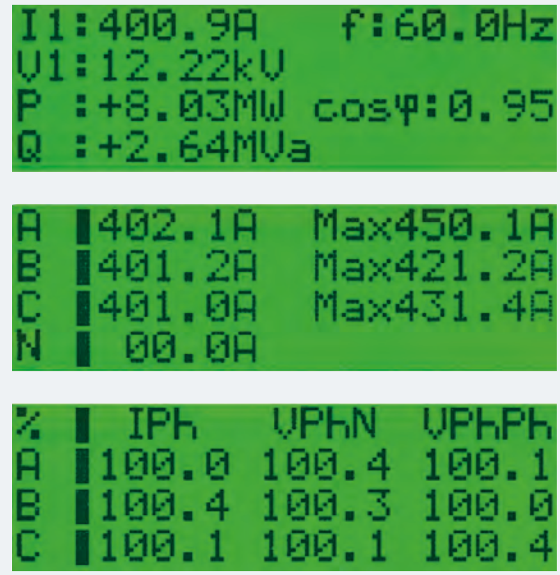


Fig. 2/22 Operational measured values

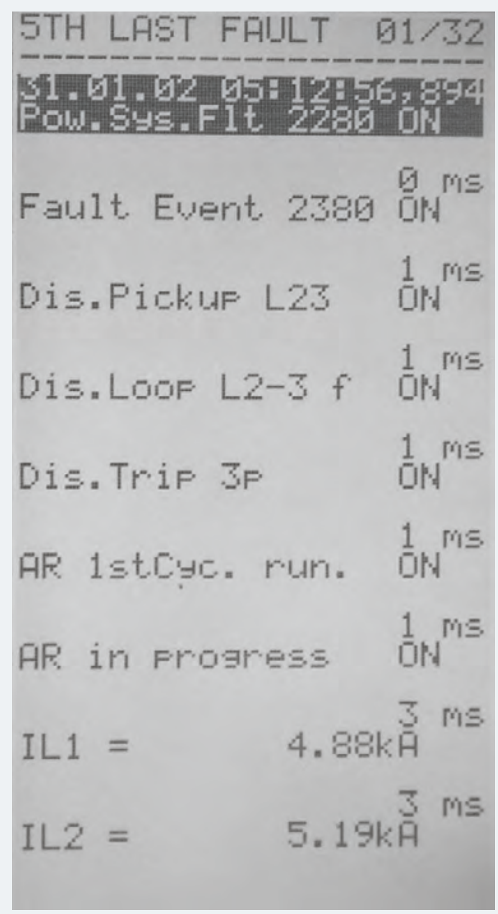


Fig. 2/23 Fault event log on graphical display of the device

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.

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, PROFINET I/O, 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:

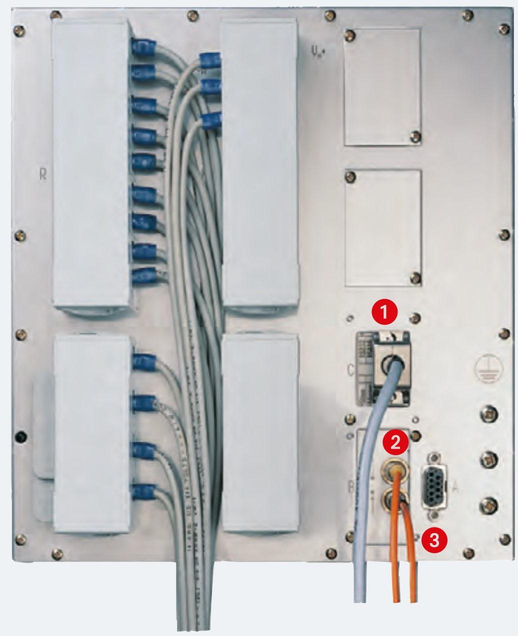
- Every data item is time-stamped at the source, that is, where it originates.
- The communication system automatically handles the transfer of large data blocks (e.g., fault records or parameter data files). The user can apply these features without any additional programming effort.
- For reliable 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. 2/24 Protection relay

Fig. 2/25 Communication module, optical

Fig. 2/26 Communication module RS232,RS485

Fig. 2/27 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. 2/28 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 electromagnetic 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. 2/29).
- RS485 bus
  With this data transmission via copper wires, electromagnetic 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. 2/30).
- 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. 2/31).

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

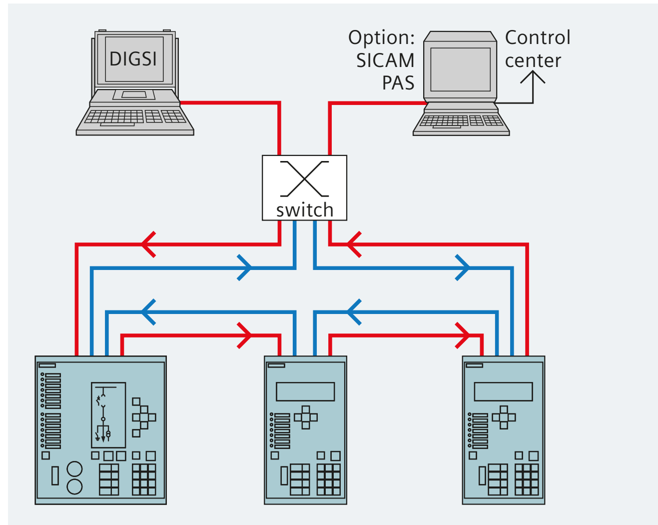


Fig. 2/29 Ring bus structure for station bus with Ethernet and IEC 61850

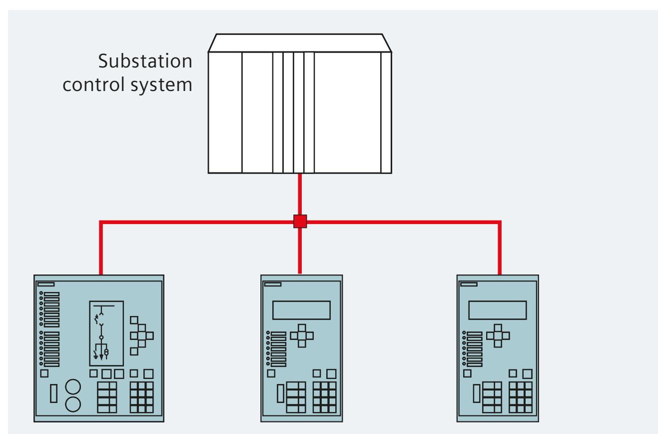


Fig. 2/30 PROFIBUS: Electrical RS485 bus wiring

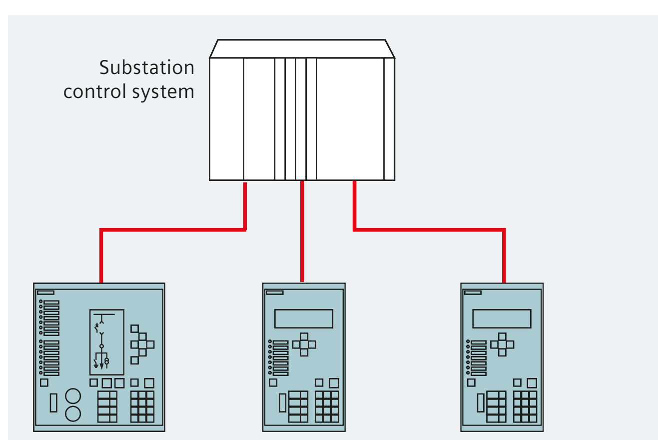


Fig. 2/31 IEC 60870-5-103: Star structure with fiber-optic cables

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.

Fig. 2/32 Protection engineer at work

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.

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. 2/32).

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

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).

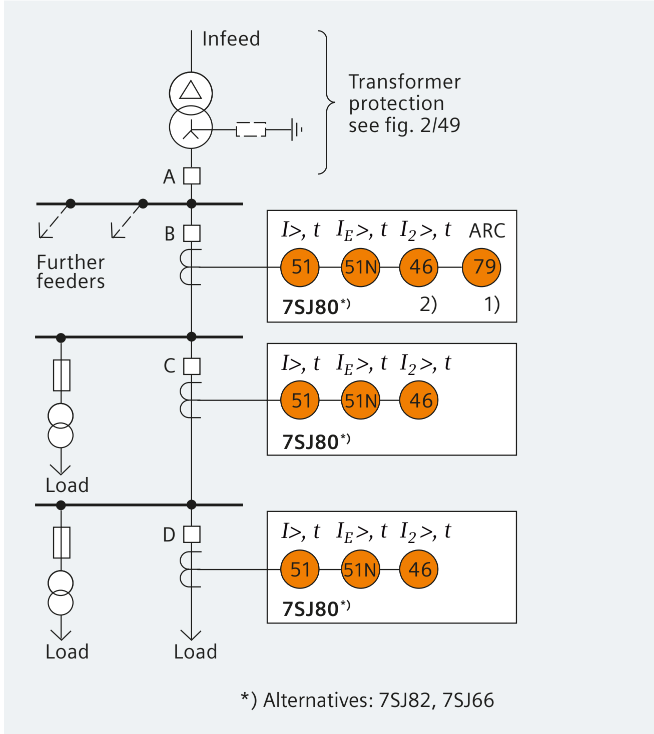


Fig. 2/33 Radial systems

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).

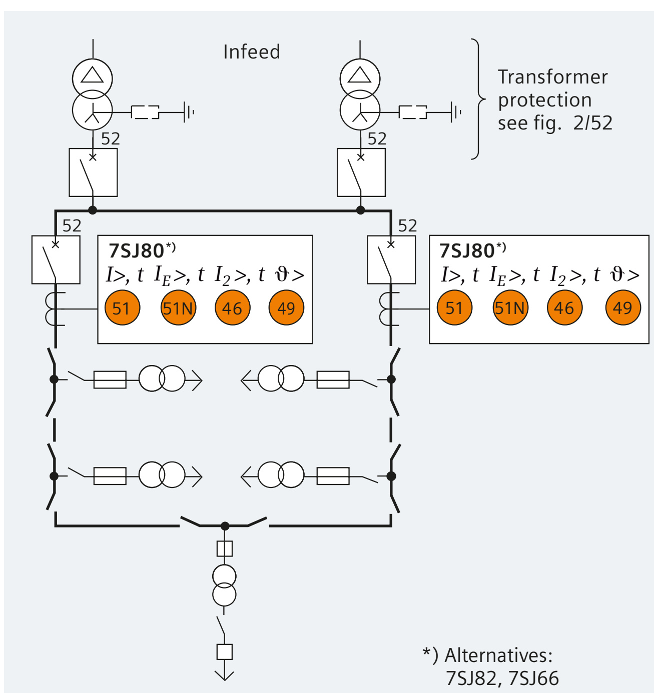


Fig. 2/34 Ring-main circuit

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.

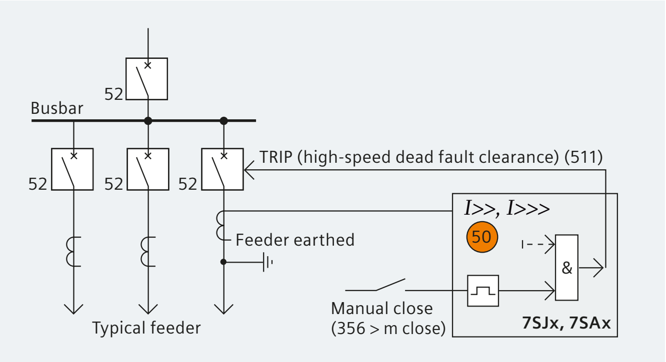


Fig. 2/35 Switch-onto-fault protection

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.

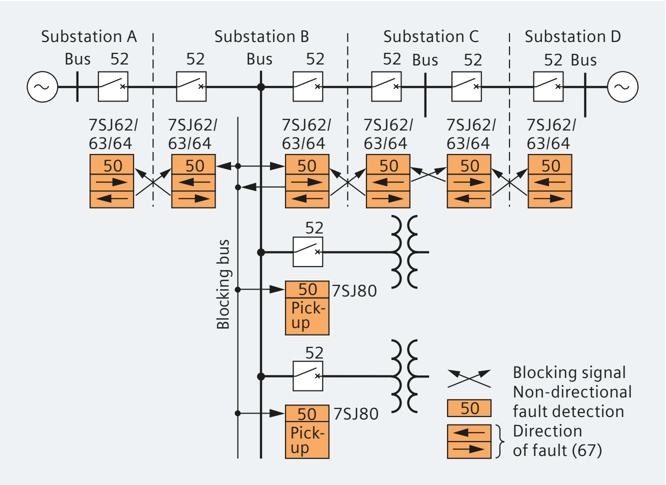


Fig. 2/36 Directional comparison protection

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.

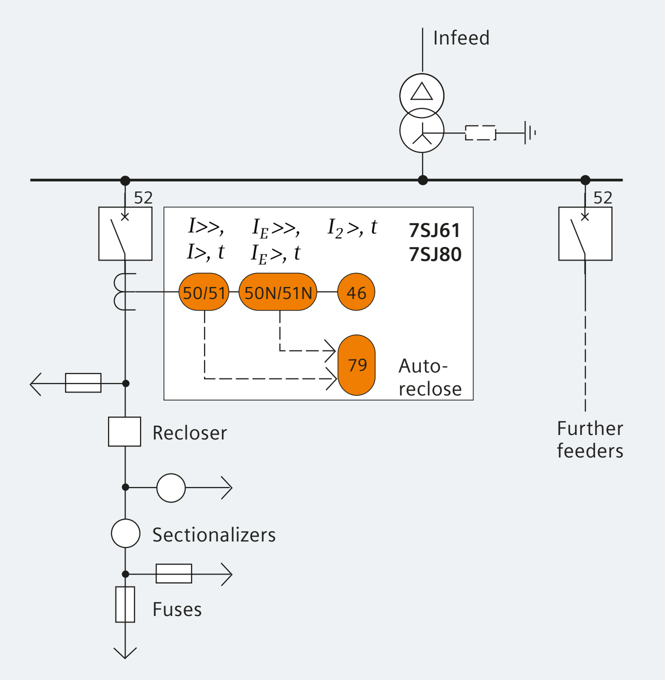


Fig. 2/37 Distribution feeder with reclosers

2

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.

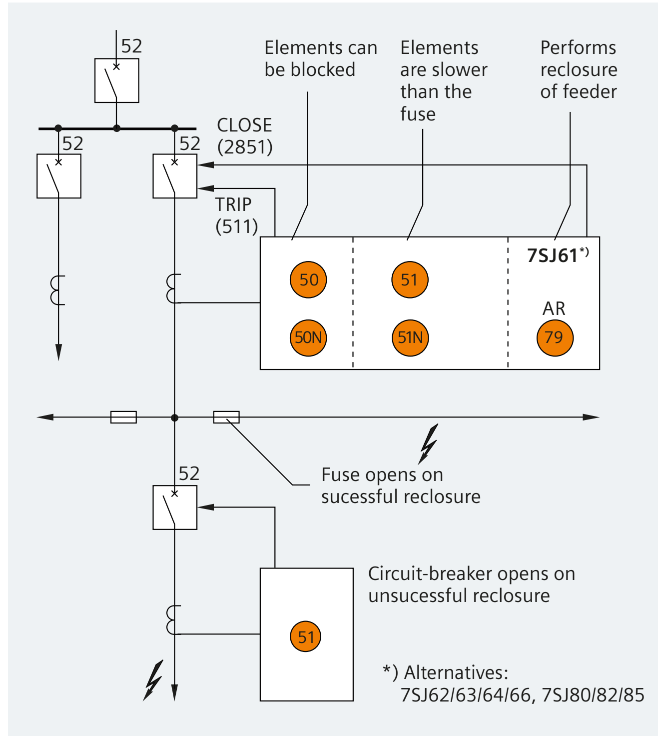


Fig. 2/38 3-pole multishot auto-reclosure (AR, ANSI 79)

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.

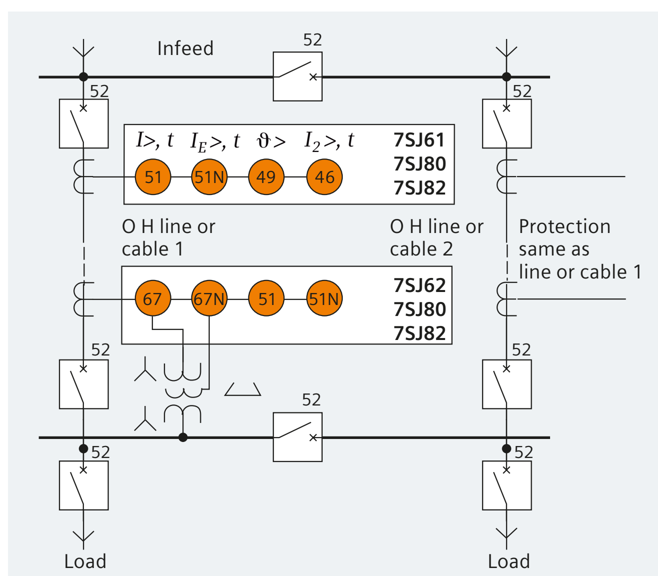


Fig. 2/39 Parallel feeder circuit

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.

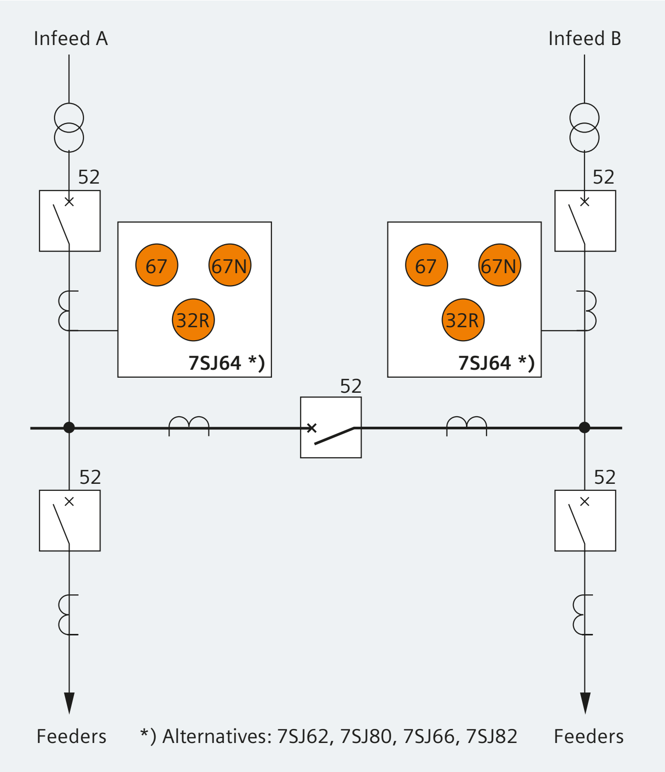


Fig. 2/40 Reverse-power monitoring at double infeed

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).

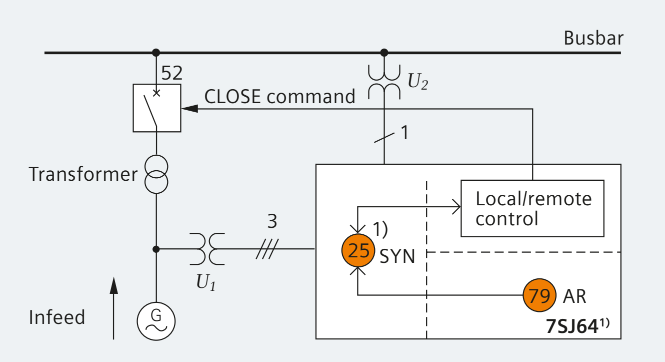


Fig. 2/41 Synchronization function

Overview

Typical protection schemes

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.

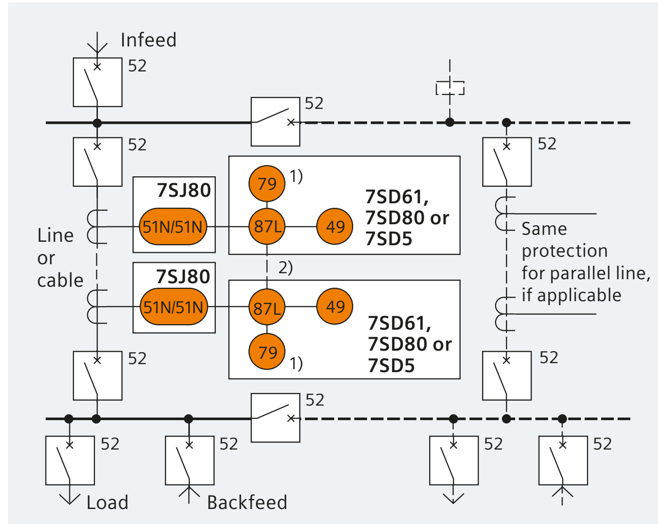


Fig. 2/42 Cables or short overhead lines with infeed from both ends

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.

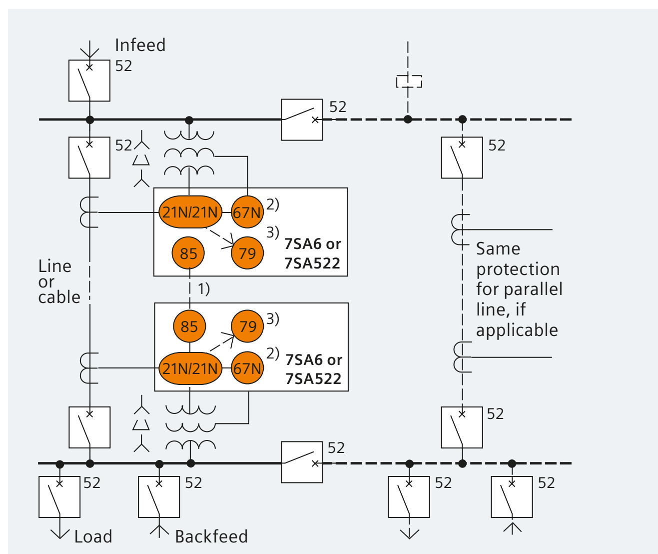


Fig. 2/43 Overhead lines or longer cables with infeed from both ends

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).

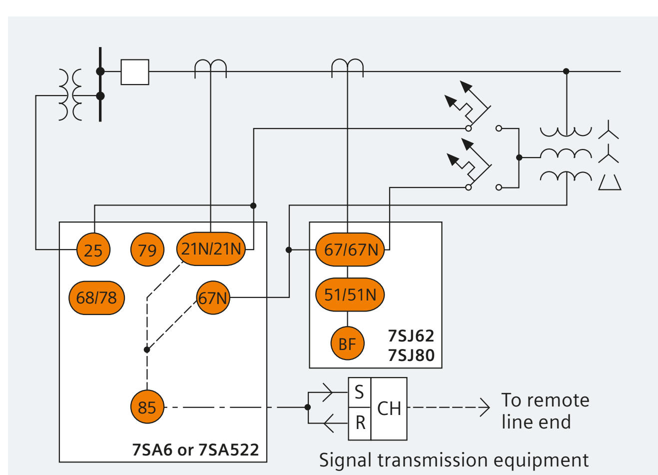


Fig. 2/44 Subtransmission line

		Permissive underreach transfer trip (PUTT)	Permissive overreach transfer trip (POTT)	Blocking	Unblocking
Preferred application	Signal transmission system	Dependable and secure communication channel: • 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		Reliable communication channel (only required during external faults) • Power line carrier with amplitude modulation (ON / OFF). The same frequency may be used on all terminals)	Dedicated channel with continuous signal transfer • Power line carrier with frequency shift keying. Continuous signal transmission must be permitted.
	Characteristic of line	Best suited for longer lines – where the underreach zone provides sufficient resistance coverage	• Excellent coverage on short lines in the presence of fault resistance. • Suitable for the protection of multi-terminal lines with intermediate infeed	All line types – preferred practice in the US	Same as POTT
Advantages		• Simple technique • No coordination of zones and times with the opposite end required. The combination of different relay types therefore presents no problems	• 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)	Same as POTT	Same as POTT but: • If no signal is received (no block and no uncompensated block) then tripping by the overreach zone is released after 20 ms
Drawbacks		• 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	• Zone reach and signal timing coordination with the remote end is necessary (current reversal)	Same as POTT • Slow tripping – all teleprotection trips must be delayed to wait for the eventual blocking signal • Continuous channel monitoring is not possible	Same as POTT

Table 2/1 Application criteria for frequently used teleprotection schemes

Typical protection schemes

Transmission line with reactor (Fig. 2/45)

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 a high-impedance relay (SIPROTEC 7SJ80, Reyrolle 7SR23).

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.

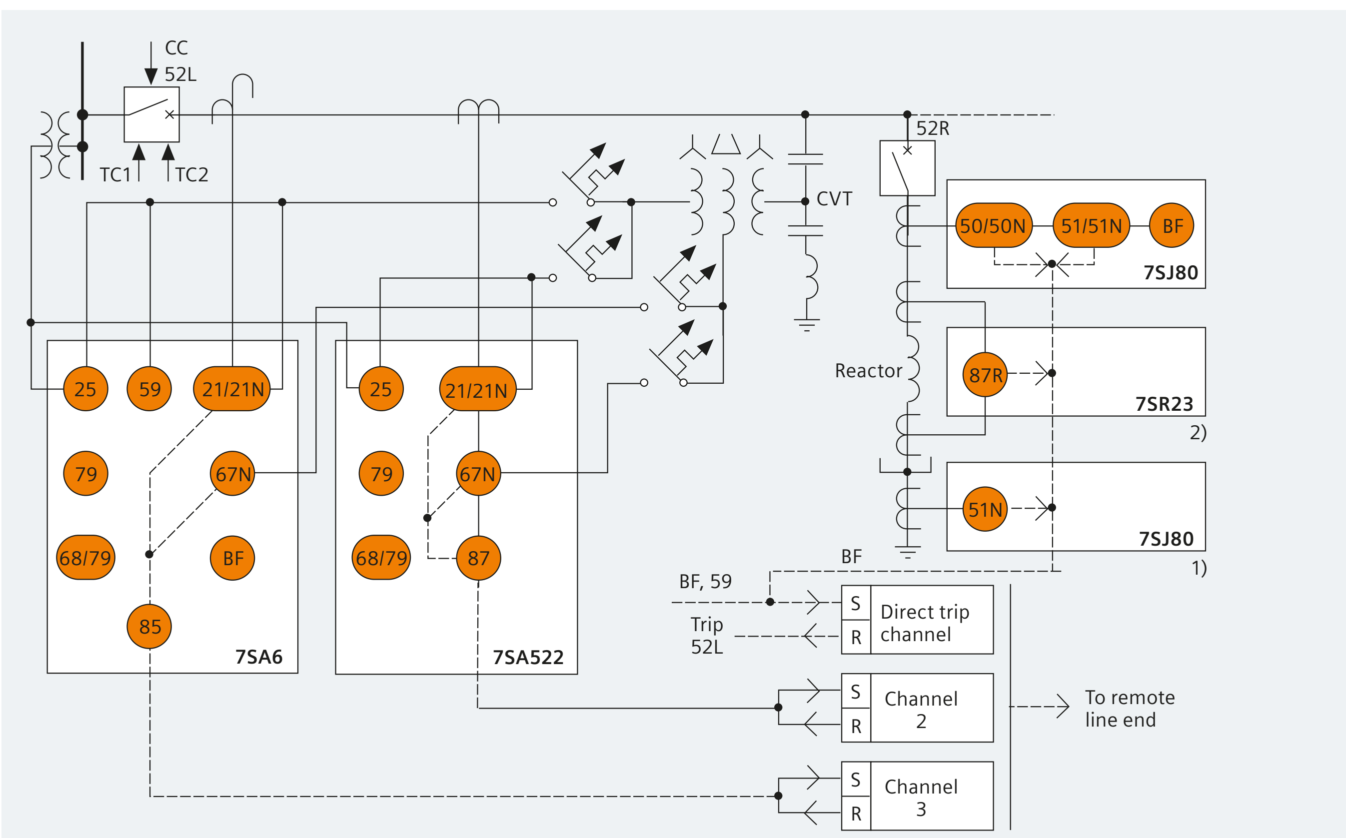


Fig. 2/45 Transmission line with reactor

Transmission line or cable (with wide-band communication)

General notes:

- Digital PCM-coded communication (with n × 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. 2/46). 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. 2/47:

- 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.

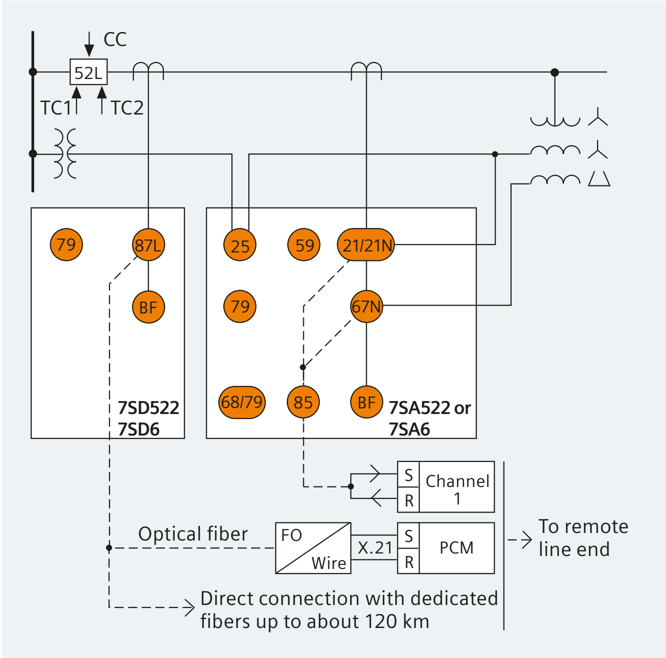


Fig. 2/46 Redundant transmission line protection

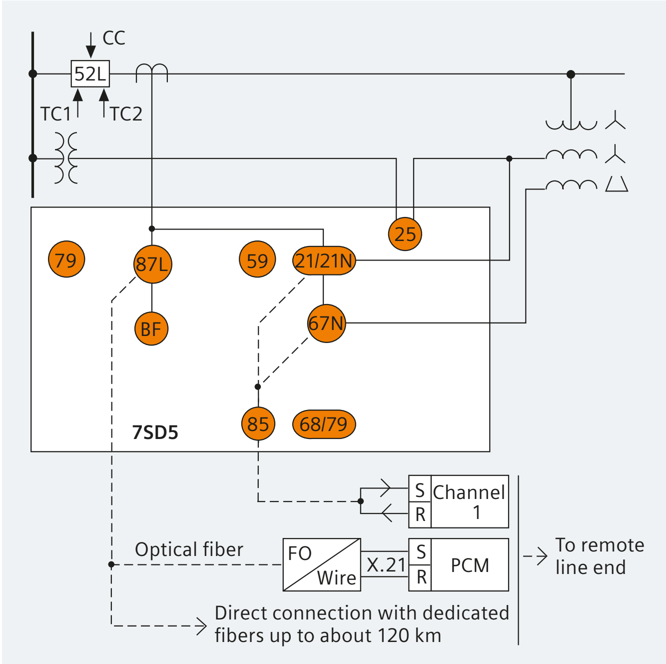


Fig. 2/47 Transmission line protection with redundant algorithm in one device

Typical protection schemes

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.

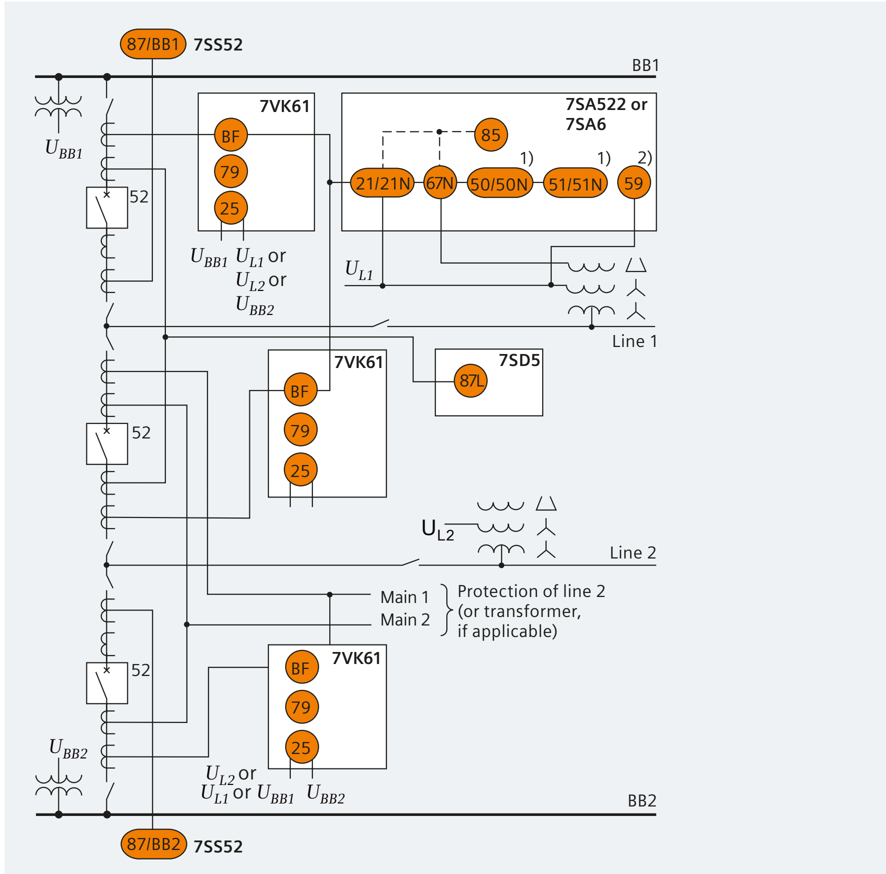


Fig. 2/48 Transmission line, one-breaker-and-a-half terminal, using 3 breaker management relays 7VK61

General notes for Fig. 2/48 *and* Fig. 2/49*:*

- 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. 2/49*:*

- 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.

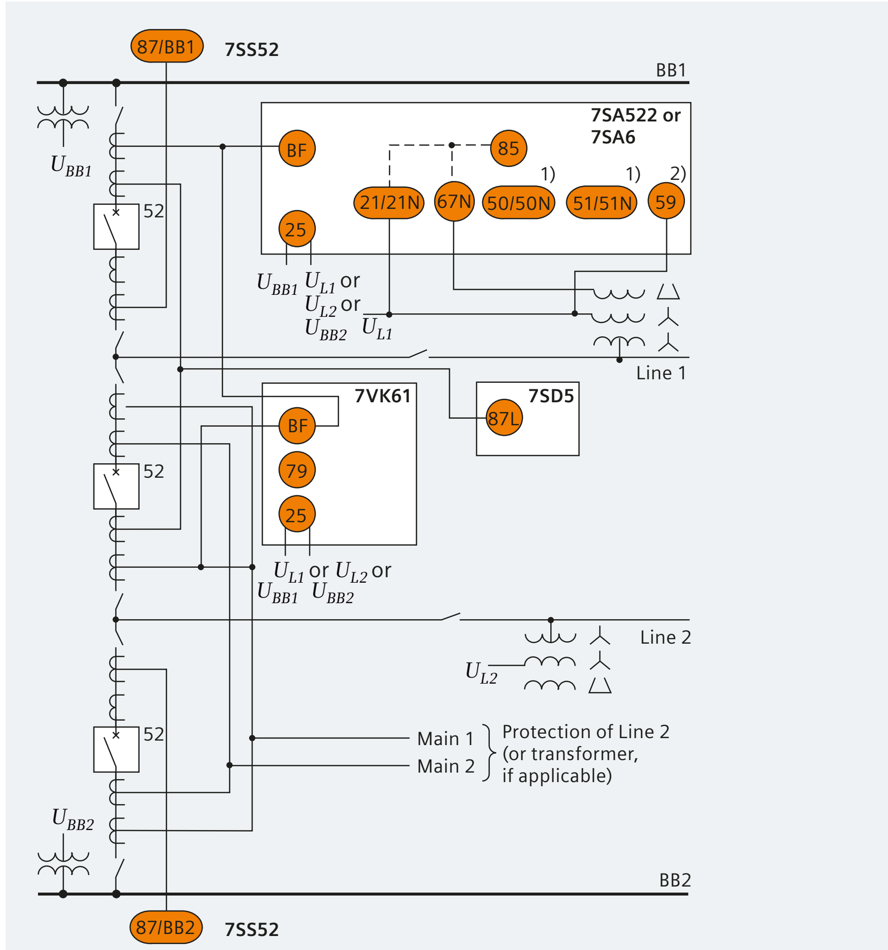


Fig. 2/49 Transmission line, breaker-and-a-half terminal, using 1 breaker management relay 7VK61

2

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.
  SIPROTEC 7SJ80 is of the high-impedance type and requires class × CTs with equal transformation ratios.
- Primary circuit-breaker and relay may be replaced by fuses.

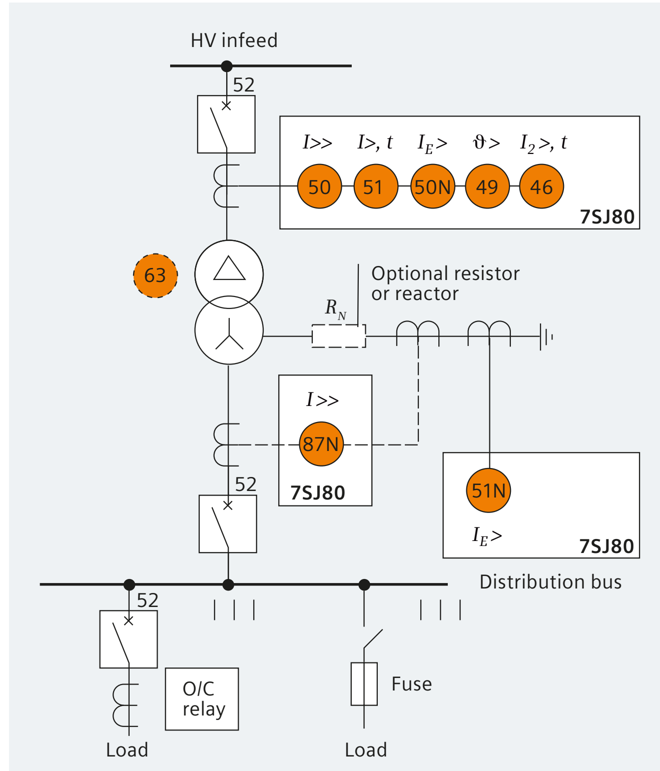


Fig. 2/50 Small transformer infeed

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 7SJ6x or 7SJ80 can be used instead of the 87N inside the 7UT612. However, class × CT cores would also be necessary in this case (see small transformer protection).

2) 51 and 51N may be provided in a separate 7SJ80 or 7SJ61 if required.

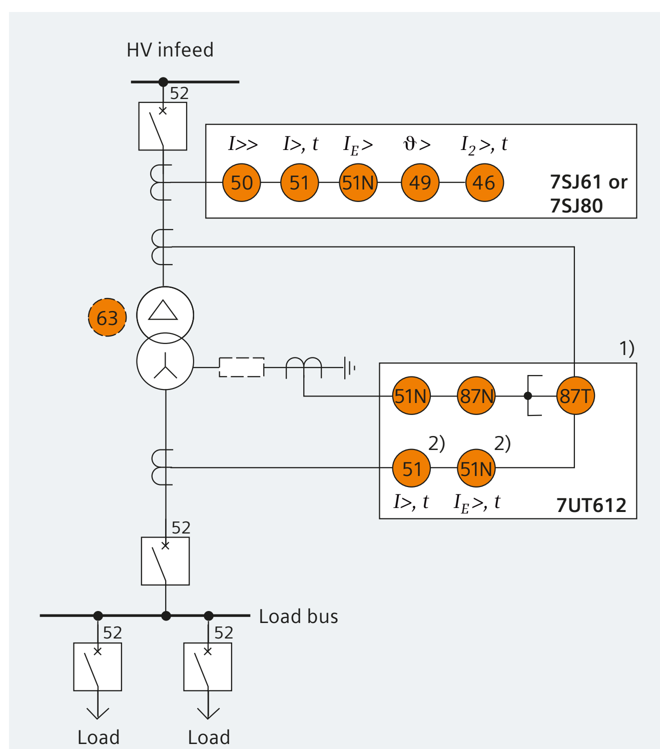


Fig. 2/51 Large or important transformer infeed

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.

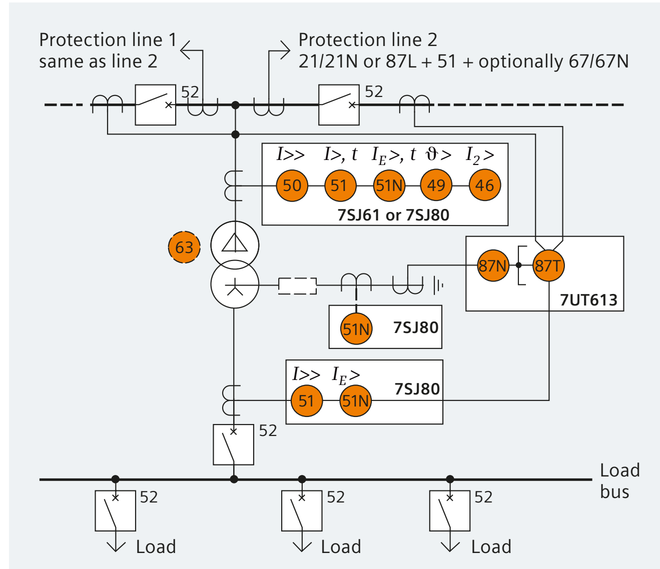


Fig. 2/52 Dual infeed with single transformer

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.

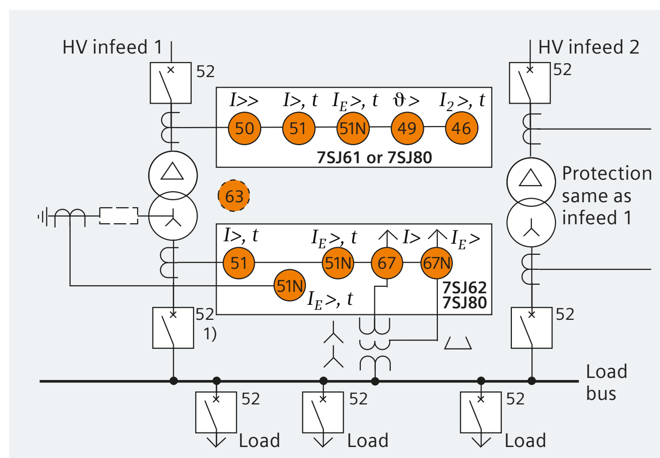


Fig. 2/53 Parallel incoming transformer feeders

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.

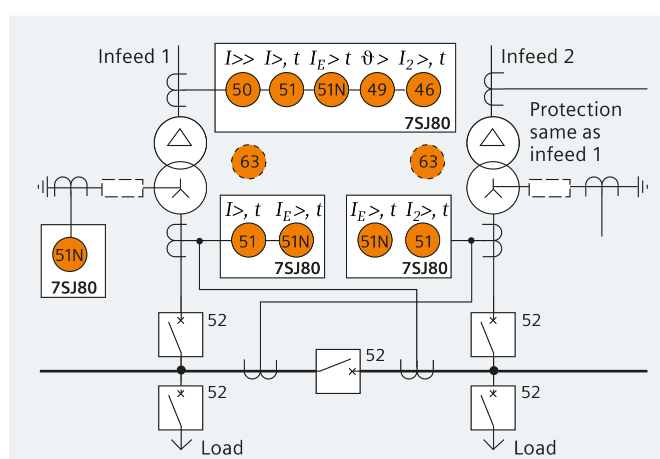


Fig. 2/54 Parallel incoming transformer feeders with bus tie

Overview

Typical protection schemes

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 × 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)

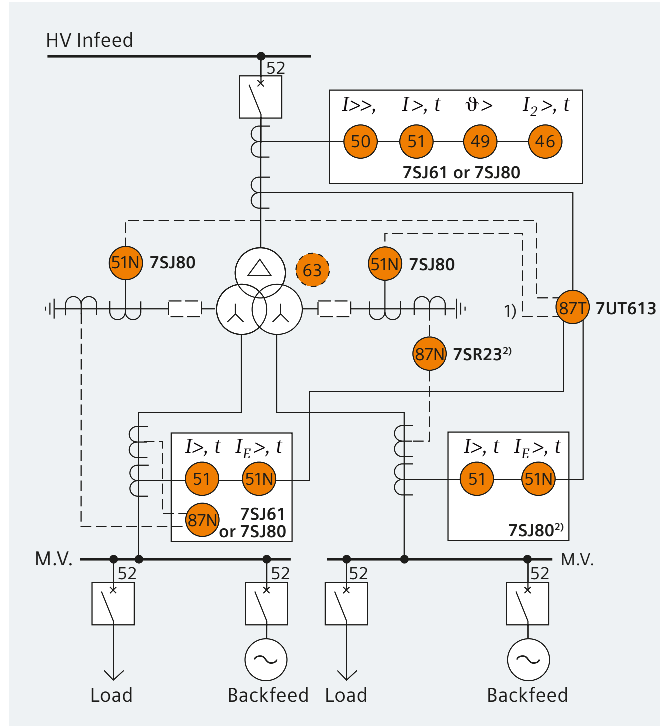


Fig. 2/55 Three-winding transformer

Autotransformer

Notes:

1) 87N high-impedance protection requires special class × current transformer cores with equal transformation ratios.

2) The 7SJ80 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 (Reyrolle 7SR23) 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.).

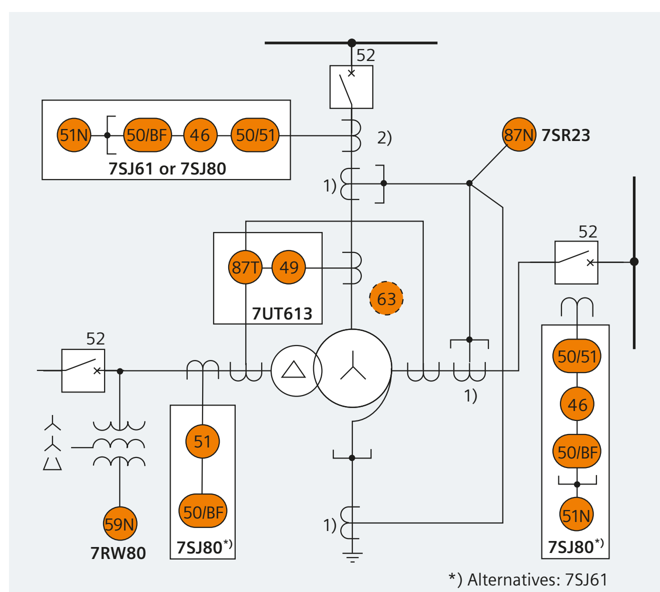


Fig. 2/56 Autotransformer

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 (Reyrolle 7SR23). Separate class × 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.

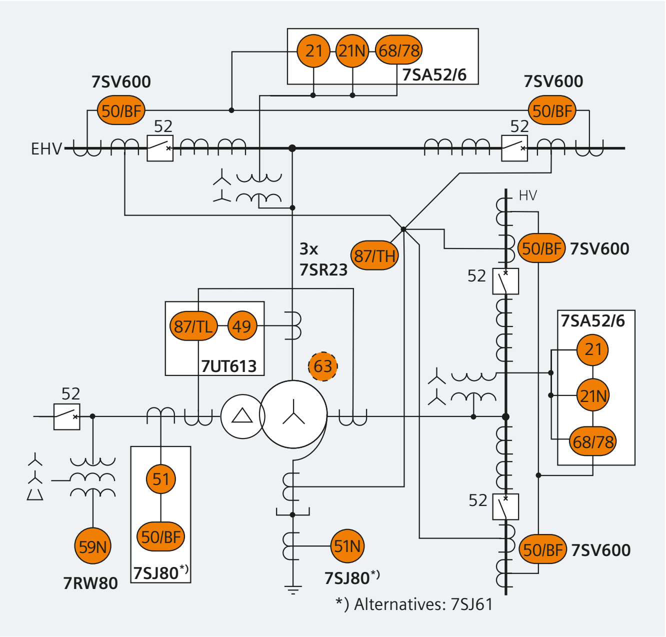


Fig. 2/57 Large autotransformer bank

3. Motors

Small and medium-sized motors < about 1 MW

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

General note:

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

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

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. 2/66)

3) The 7SK80 relay can be applied for isolated and compensated systems.

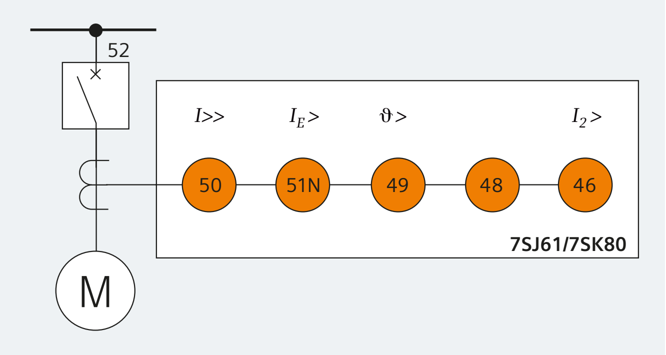


Fig. 2/58 Motor protection with effective or low-resistance grounded infeed

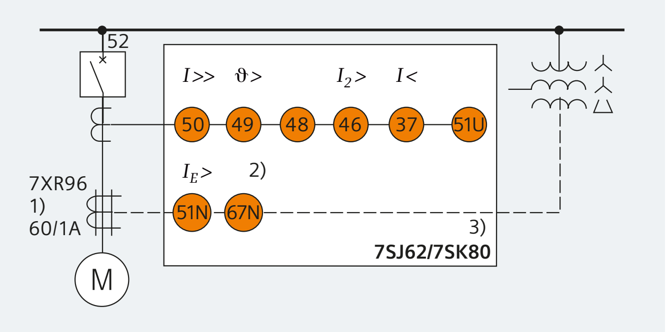


Fig. 2/59 Motor protection with high-resistance grounded infeed

Typical protection schemes

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)

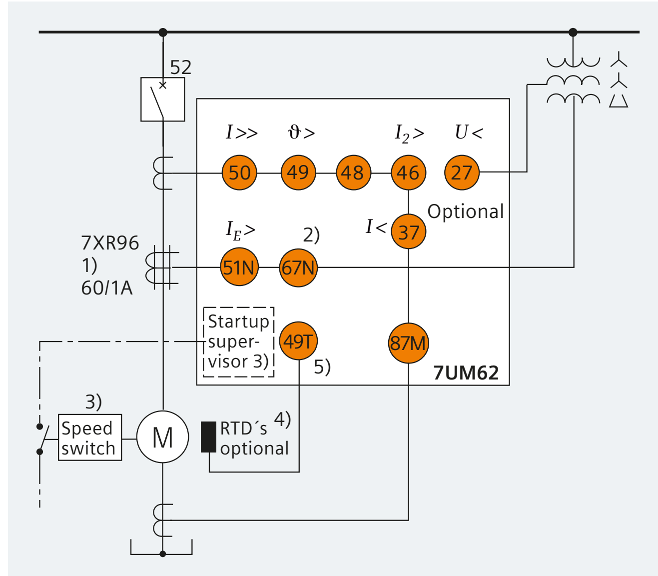


Fig. 2/60 Protection of large HV motors > about 1 MW

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.

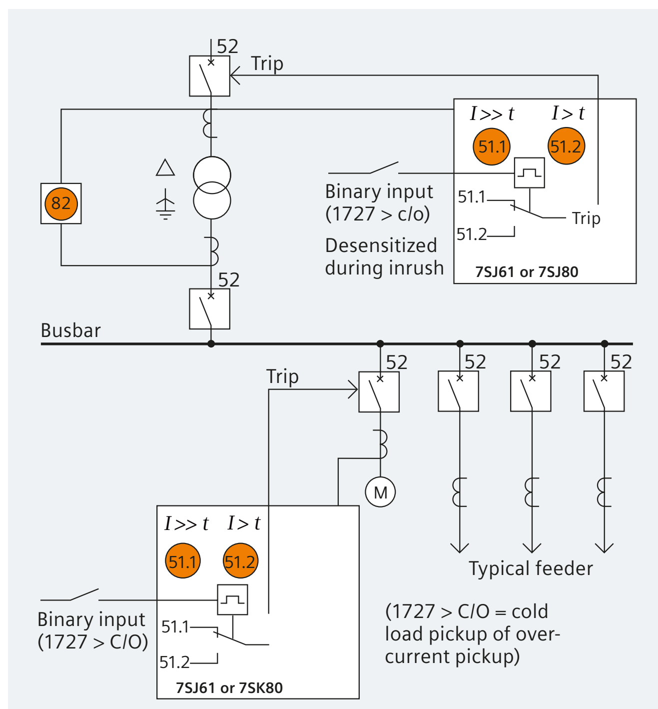


Fig. 2/61 Cold load pickup

2

4. Generators

Generators < 500 kW (Fig. 2/62 and Fig. 2/63)

Note:

If a core-balance CT is provided for sensitive ground-fault protection relay 7SJ80 with separate ground-current input can be used.

Generators, typically 1 – 3 MW

(Fig. 2/64)

Note:

Two VTs in V connection are also sufficient.

Generators > 1 – 3 MW

(Fig. 2/65)

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. 2/64).

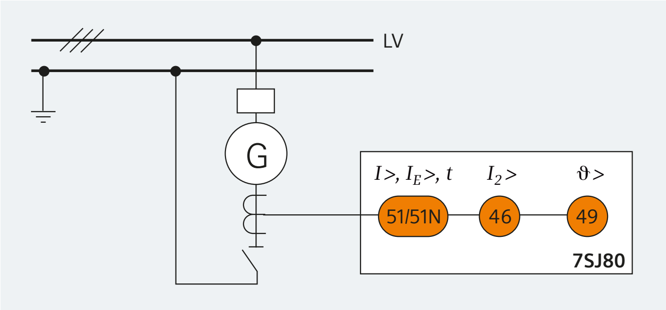


Fig. 2/62 Generator with solidly grounded neutral

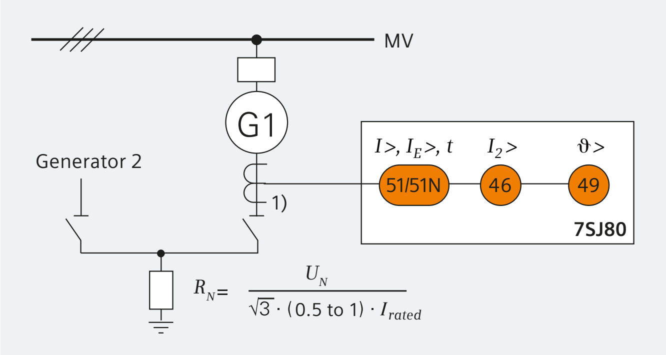


Fig. 2/63 Generator with resistance-grounded neutral

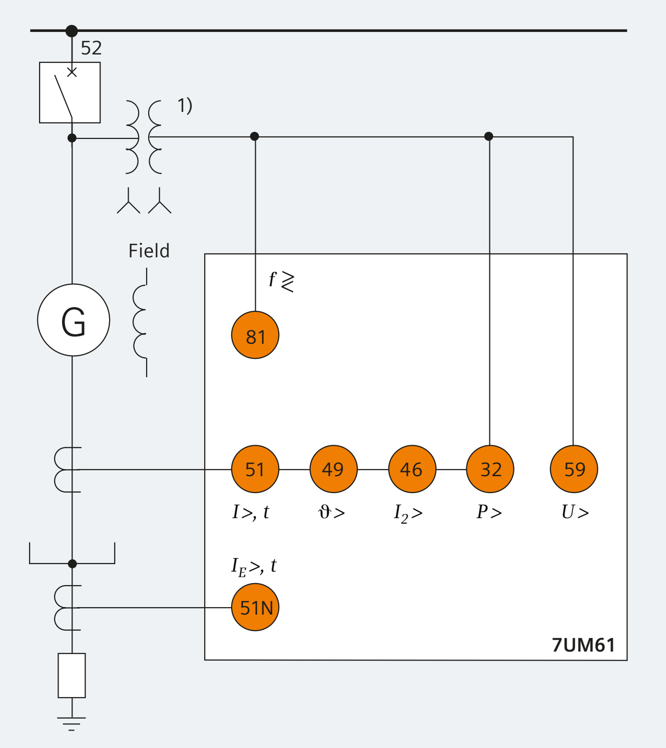


Fig. 2/64 Protection for generators 1 – 3 MW

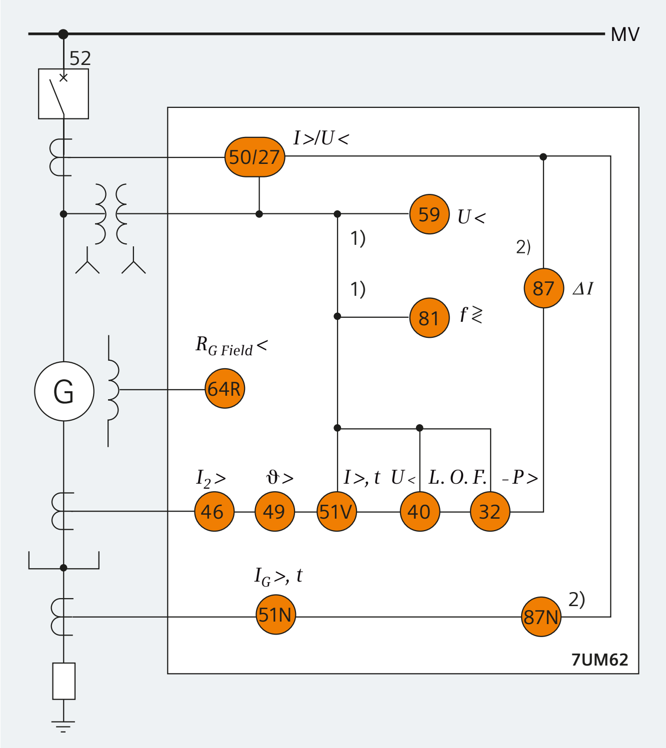


Fig. 2/65 Protection for generators >1 – 3 MW

Typical protection schemes

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

(Fig. 2/66)

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 $I_{n\ SEC}$ 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) × 20 mA = 1.2 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 kVA

In a 5 kV system, it would deliver:

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

corresponding to a relay input current of 9.4 A × 1 / 60 A = 156 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

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

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 $I_{G\ SEC}$ = 9.4 A / (600 / 5) = 78 mA.

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

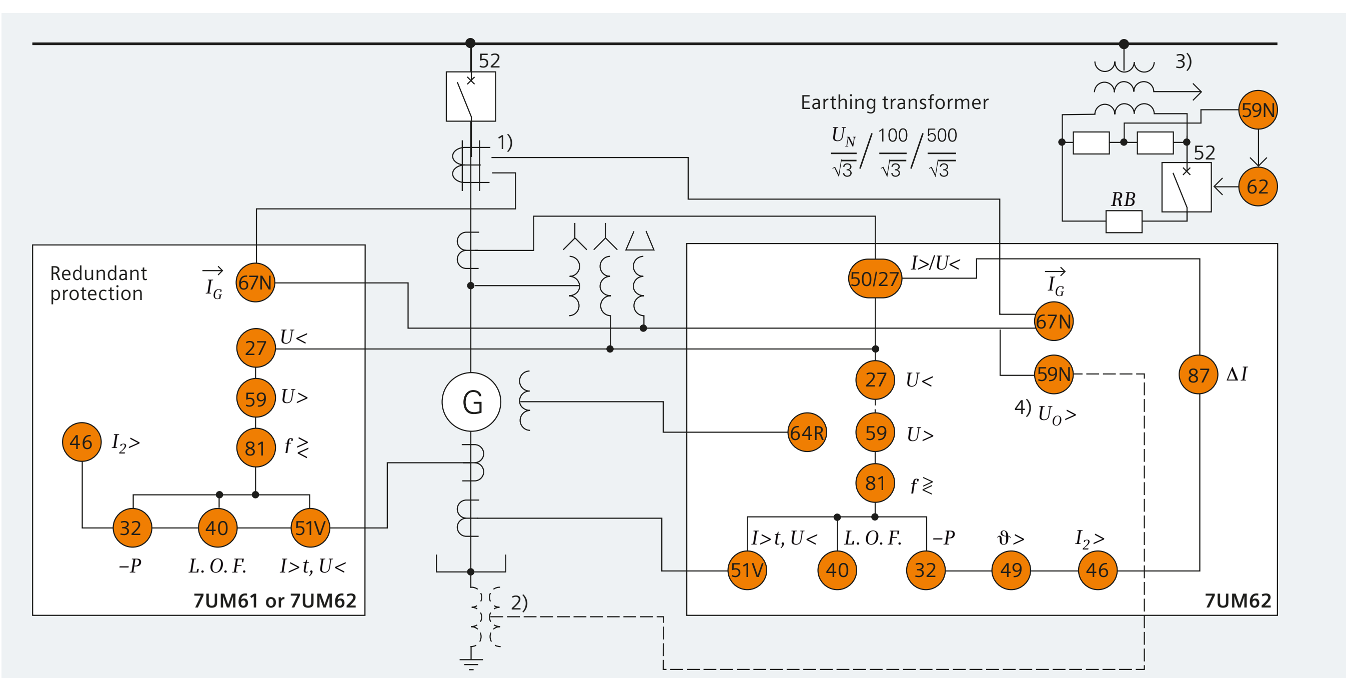


Fig. 2/66 Protection for generators > 5–10 MW

Notes (Fig. 2/66):

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.

Generators > 50 – 100 MW in generator transformer unit connection

(Fig. 2/67)

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.

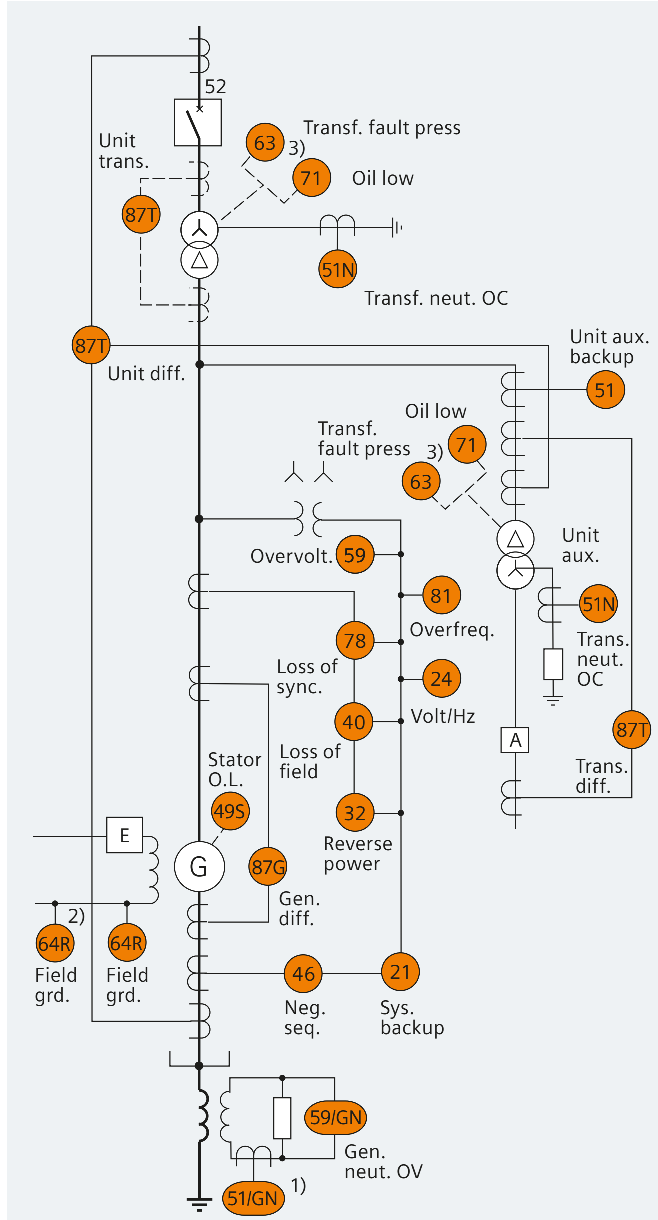


Fig. 2/67 Protections for generators > 50 MW

Relay type	Functions[4]	Number of relays required
7UM62	21, 24, 32, 40, 46, 49, 51GN 1), 59GN, 59, 64R, 64R 2), 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	1 2
7UT613	87T	1

Fig. 2/68 Assignment for functions to relay type

Synchronization of a generator

Fig. 2/69 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.

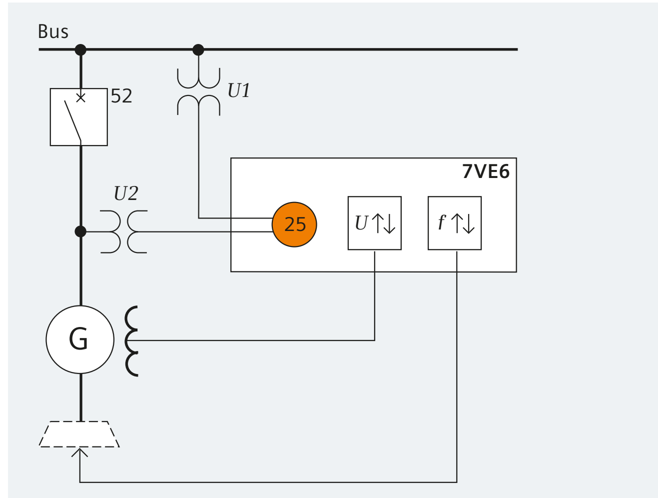


Fig. 2/69 Synchronization of a generator

5. Busbars

Busbar protection by overcurrent relays with reverse interlocking

General note:

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

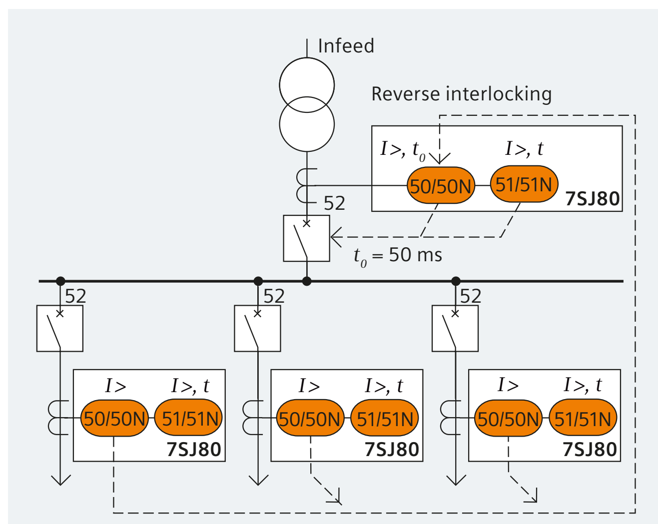


Fig. 2/70 Busbar protection by O / C relays with reverse interlocking

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.

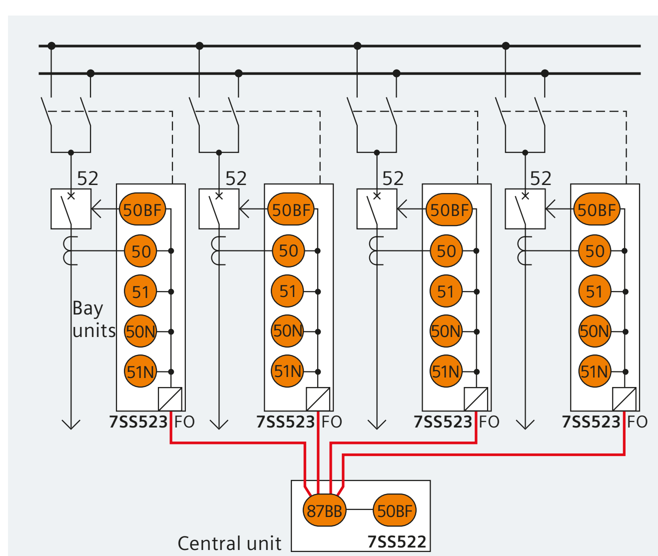


Fig. 2/71 Distributed busbar protection 7SS52

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 7RW80, 7SJ6 and 7SJ8.)

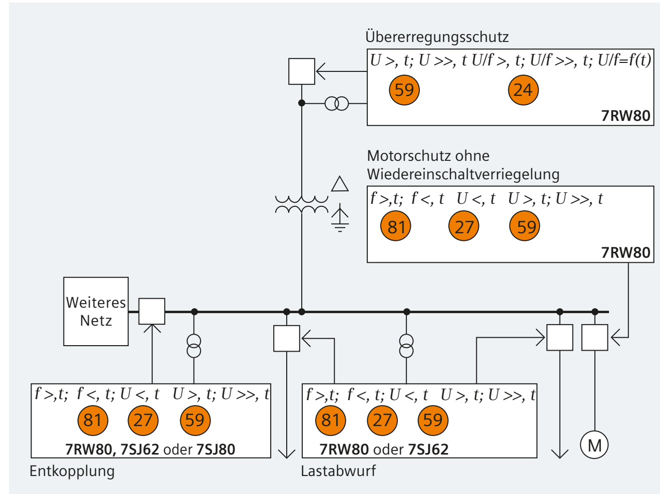


Fig. 2/72 Load shedding

Load shedding with rate-of-frequency-change protection

The rate-of-frequency-change protection calculates, from the measured frequency, the gradient or frequency change d*f* / d*t*. 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.

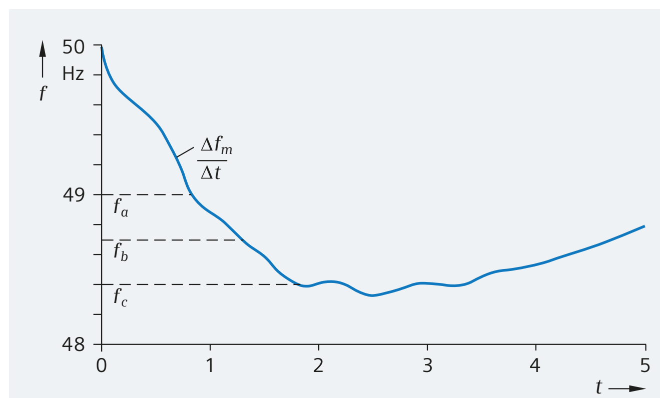


Fig. 2/73 Load shedding with rate-of-frequency-change protection

Trip circuit supervision (ANSI 74TC)

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

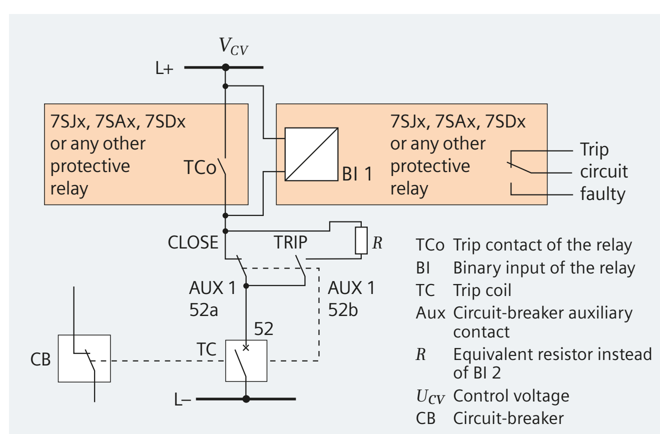


Fig. 2/74 Trip circuit supervision (ANSI 74TC)

Typical protection schemes

2

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.

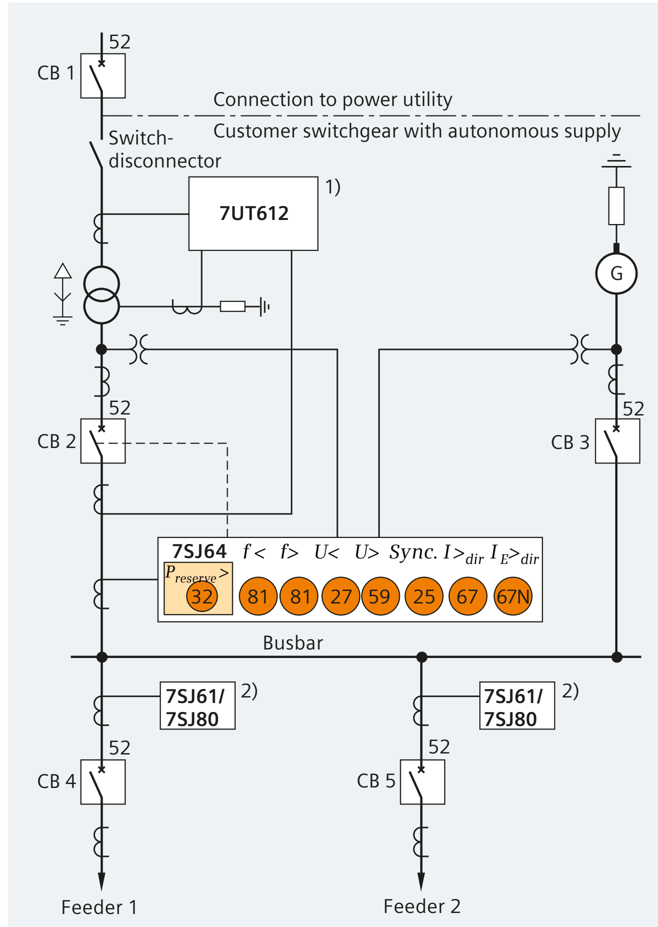


Fig. 2/75 Example of a switchgear with autonomous generator supply

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

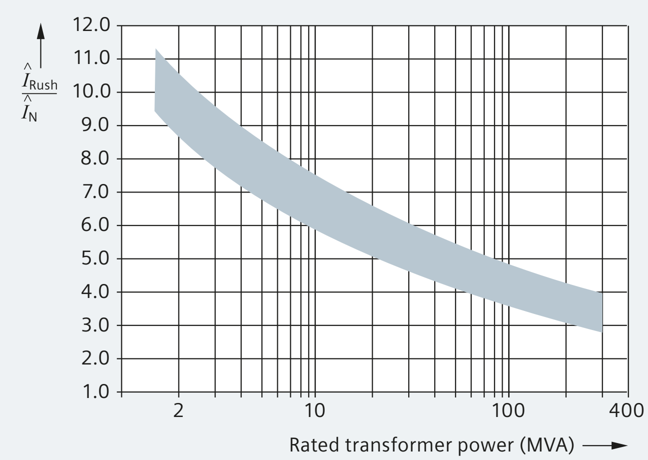
Protection should be as sensitive as possible in order to detect faults at the lowest possible current level. At the same time, however, it should remain stable under all permissible load, overload and through-fault conditions. For more information: http://www.siemens.com/systemplanning. The Siemens engineering programs SINCAL 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. 2/75). 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. 2/76 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. 2/76 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.

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. 2/77.

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. 2/79 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. 2/78).

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.

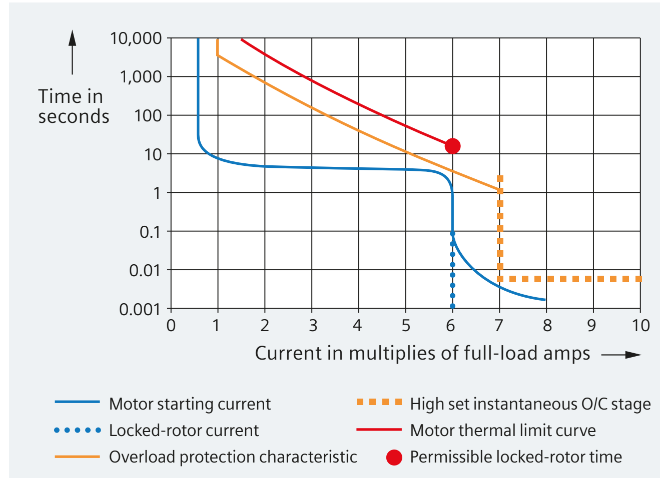


Fig. 2/77 Typical motor current-time characteristics

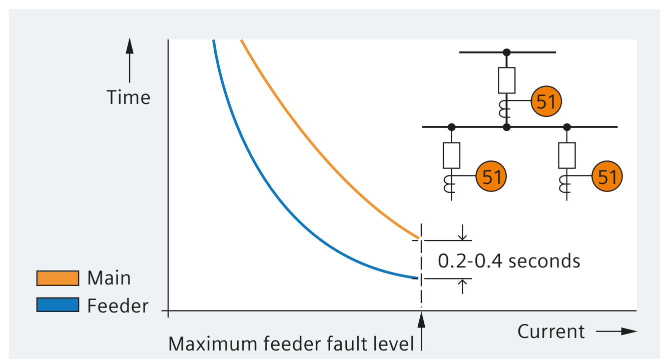


Fig. 2/78 Coordination of inverse-time relays

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. 2/80 and the associated load and short-circuit currents are given. Numerical overcurrent relays 7SJ80 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. 2/81.

The I_p/I_N settings shown in Fig. 2/80 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:

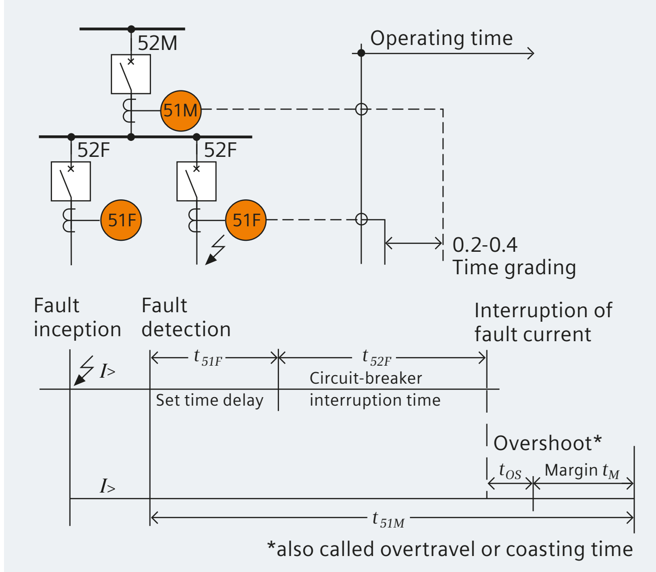
- For coordination with the fuses, we consider the fault in location F1.
  The short-circuit current $I_{scc.}$ max. related to 13.8 kV is 523 A. This results in 7.47 for I/I_p at the overcurrent relay in location C.
- With this value and $T_p = 0.05$, an operating time of $t_A = 0.17$ s can be derived from Fig. 2/81.
- 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.

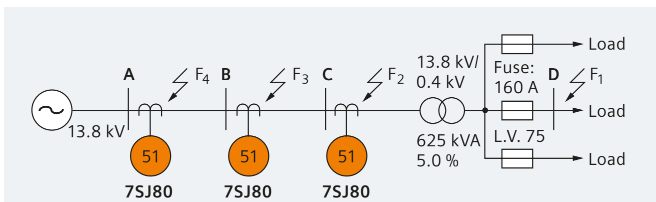
It is assumed that no special requirements for short operating times exist and therefore an average time grading interval of 0.3 s can be chosen. The operating time of the relay in B can then be calculated.

- $t_B = 0.11 + 0.3 = 0.41$ s
- Value of $I_p/I_N = \frac{1{,}395\text{ A}}{220\text{ A}} = 6.34$ (Fig. 2/80)
- With the operating time 0.41 s and $I_p/I_N = 6.34$, $T_p = 0.11$ can be derived from Fig. 2/81.



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

Fig. 2/79 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. 2/80 Time grading of inverse-time relays for a radial feeder

Protection coordination

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. 2/80). 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. 2/81).

Station A:

- Adding the time grading interval of 0.3 s, the desired operating itme 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. 2/82 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 7SJ80 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. 2/83 shows typical examples.

Simple distribution substations use a power fuse on the secondary side of the supply transformers (Fig. 2/83a).

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

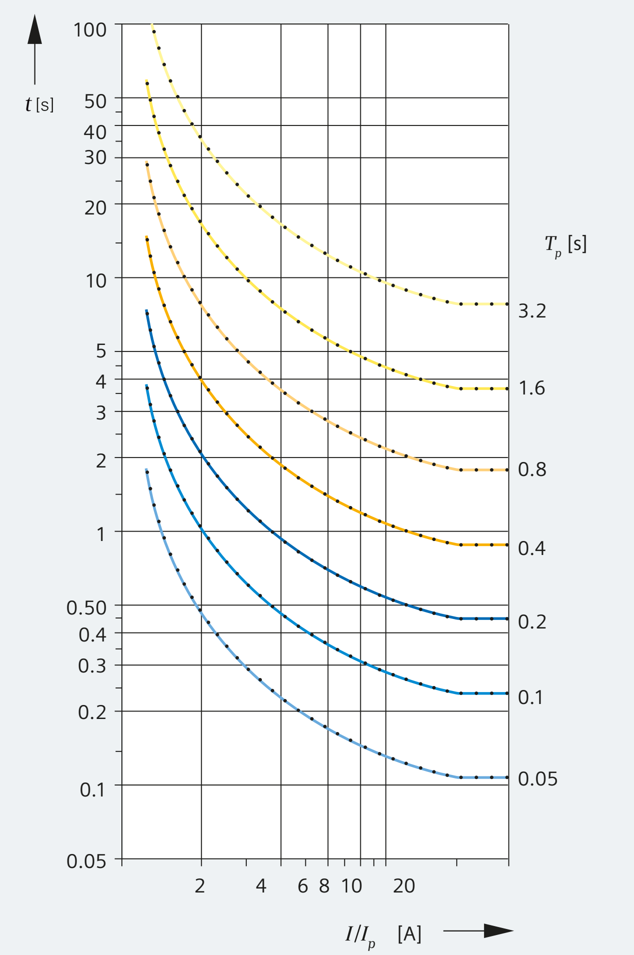


Fig. 2/81 Normal inverse-time characteristic of the 7SJ80 relay

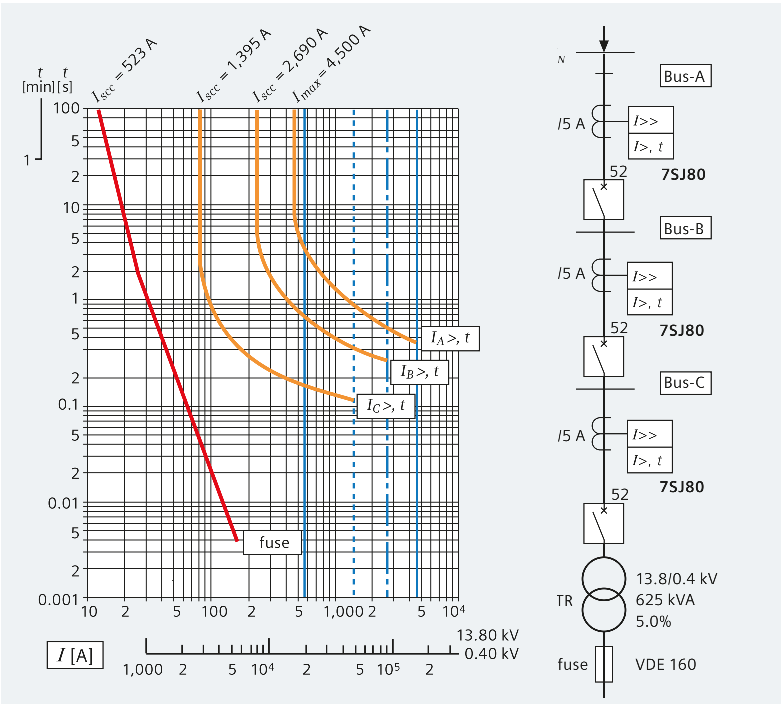
Normal inverse

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

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. 2/83b).



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

Fig. 2/82 Overcurrent-time grading diagram

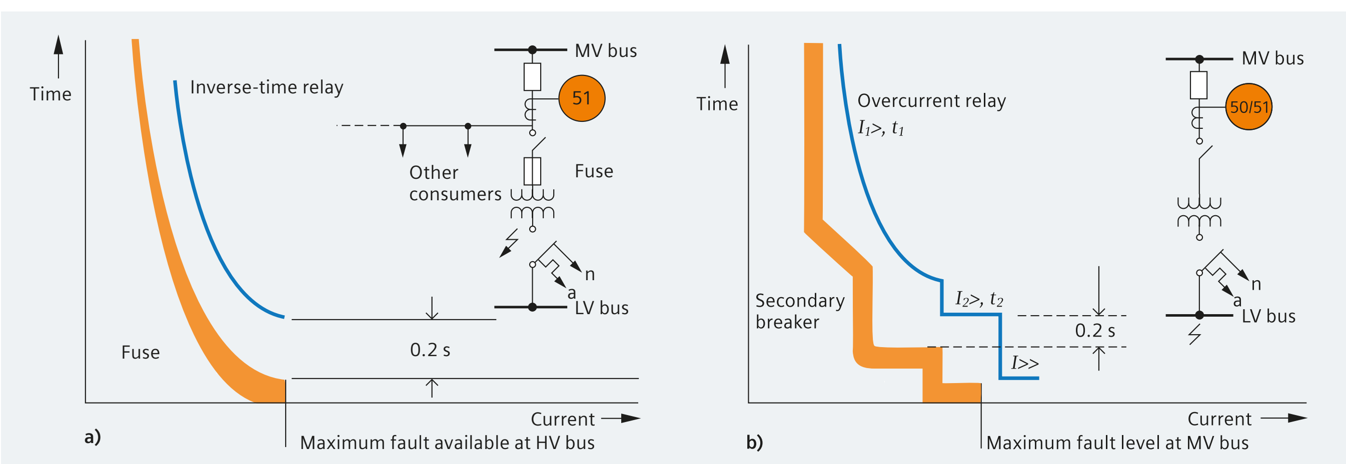


Fig. 2/83 Coordination of an overcurrent relay with an MV fuse and low-voltage breaker trip device

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. 2/84).

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.

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. 2/79, 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:

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

l_{arc} = Arc length in mm

$I_{SCC\,Min}$ = 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.

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

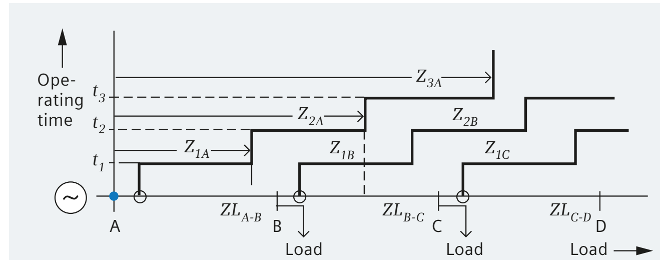
$$l_{min} = \frac{X_{Prim\,Min}}{X'_{Line}}$$

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 (7VK61) is used per breaker (Fig. 2/79, Fig. 2/80).

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).



$Z_{1A} = 0.85 \cdot ZL_{A-B}$

$Z_{2A} = 0.85 \cdot (ZL_{A-B} + Z_{1B})$

$Z_{2A} = 0.85 \cdot (ZL_{A-B} + Z_{2B})$

Fig. 2/84 Grading of distance zones

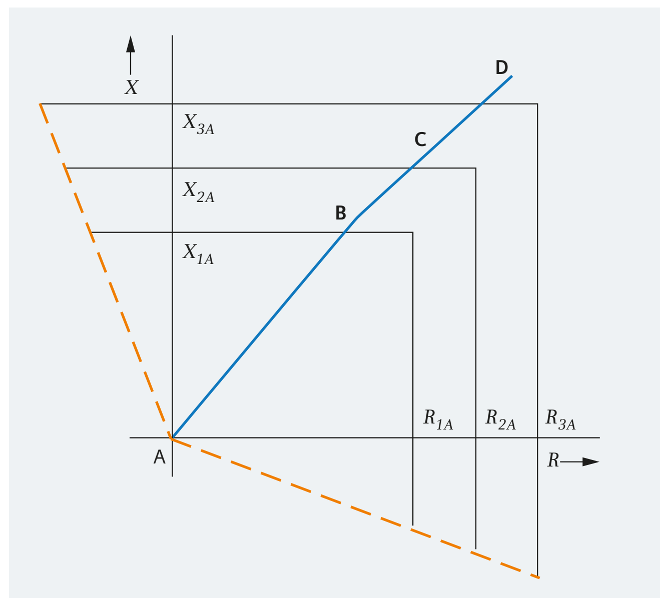


Fig. 2/85 Operating characteristics of Siemens distance relays

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

Fig. 2/87 (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 Reyrolle 7SR23 with external series resistor R_{stab}. If the series resistor is integrated into the relay, the setting values may be directly applied in volts; 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.

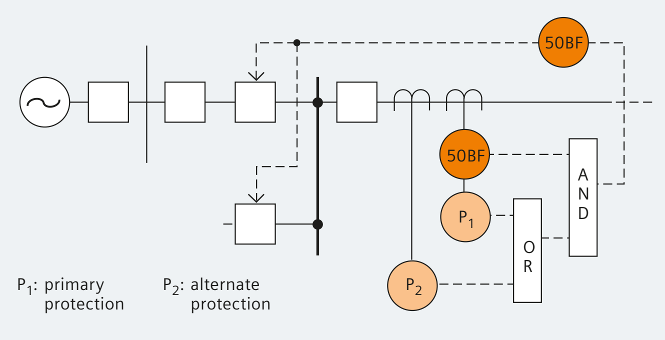


Fig. 2/86 Breaker failure protection, logic circuit

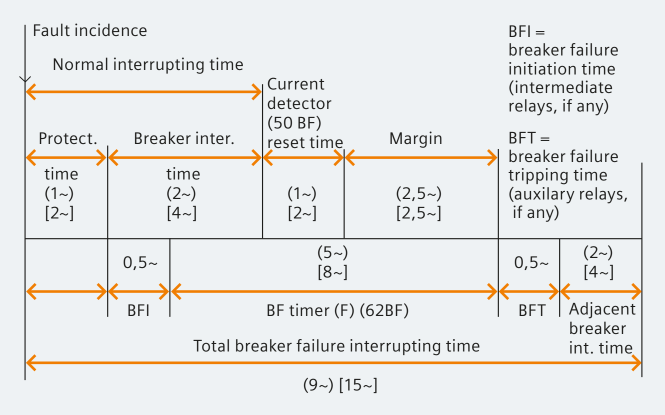


Fig. 2/87 Time coordination of BF time setting

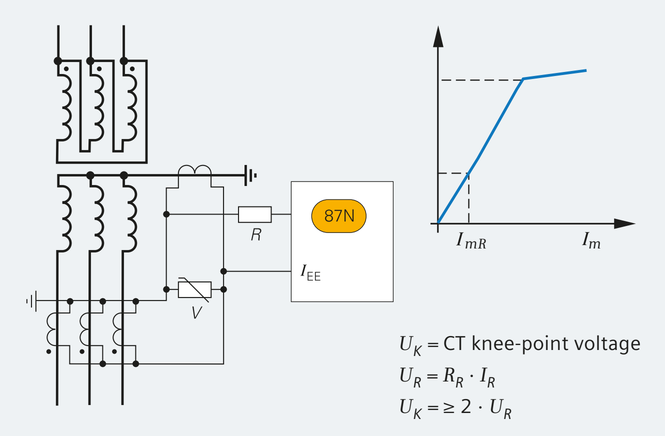


Fig. 2/88 Principle connection diagram for high-impedance restricted ground-fault protection of a winding of the transformer using SIPROTEC digital overcurrent relay (e.g. 7SJ61)

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

2

Calculation example:

Restricted ground fault protection for the 400 kV winding of 400 MVA power transformer with $I_{r,400\,kV} = 577$ 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
$R_{relay} = 50$ mΩ

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 $16 \cdot I_{r,400kV} = 16 \cdot 577$ A = 9,232 A, rounded up to 10 kA.

The actual stability voltage for the scheme U_s can be taken with enough safety margin as $\boldsymbol{U_s} = \mathbf{130\,V}$ (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 $I_{r,400\,kV}$ (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 $\boldsymbol{U_s}$ and $\boldsymbol{I_{set}}$ values calculated above the value of the stabilizing resistor $\boldsymbol{R_{stab}}$ 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}, 0.5 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):

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

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 / √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 $\Omega mm^2/m$ (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 $K'_{ssc} \geq K_{td} \cdot \frac{I_{scc\,max}}{I_{pn}}$ (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 transfered 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: $U_K = \frac{(15 + 4) \cdot 1 \cdot 10}{1.3} = 146$ 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)

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

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

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

* If transformer in protection zone, else 1

$I_{n\text{-}pri}$-CT-Transf-Site ≤ 2 · I_n-Obj-Transf-Site AND

$I_{n\text{-}pri}$-CT-Transf-Site ≥ I_n-Obj-Transf-Site 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)

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 7SJ61, 62, 63, 64 7SJ80, 7SK80	–	$K'_{ssc} \geq \frac{I_{High\ set\ point}}{I_{pn}}$ at least: 20	$U_k \geq \frac{I_{High\ set\ point}}{1.3 \cdot I_{pn}} \cdot (R_{ct} + R'_b) \cdot I_{sn}$ at least: $\frac{20}{1.3} \cdot (R_{ct} + R'_b) \cdot I_{sn}$
Line differential protection (without distance function) 7SD52x, 53x, 610 (50/60 Hz)	Transformer: 1.2 Busbar/Line: 1.2 Gen./Motor: 1.2	$K'_{ssc} \geq$ $K_{td} \cdot \frac{I_{scc\ max\ (ext.\ fault)}}{I_{pn}}$ and (only for 7SS): $\frac{I_{scc\ max\ (ext.\ fault)}}{I_{pn}} \leq 100$ (measuring range)	$U_K \geq$ $K_{td} \cdot \frac{I_{scc\ max\ (ext.\ fault)}}{1.3 \cdot I_{pn}} \cdot (R_{ct} + R'_b) \cdot I_{sn}$ and (only for 7SS): $\frac{I_{scc\ max\ (ext.\ fault)}}{I_{pn}} \leq 100$ (measuring range)
Transformer/generator differential protection 7UT612, 7UT612 V4.0 7UT613, 633, 635, 7UT612 V4.6 7UM62	Transformer / Busbar/Line / Gen./Motor 4 / 4 / 5 3 / 3 / 5 4 / – / 5		
Busbar protection 7SS52	for stabilizing factors k ≥ 0.5 0.5		
Distance protection 7SA522, 7SA6, 7SD5xx (with distance function)	primary DC time constant T_p [ms] ≤ 30 / ≤ 50 / ≤ 100 / ≤ 200 K_{td} (a): 1 / 2 / 4 / 4 K_{td} (b): 4 / 5 / 5 / 5	$K'_{ssc} \geq$ $K_{td}(a) \cdot \frac{I_{scc\ max\ (close-in\ fault)}}{I_{pn}}$ and: $K_{td}(b) \cdot \frac{I_{scc\ max\ (zone\ 1-end\ fault)}}{I_{pn}}$	$U_K \geq$ $K_{td}(a) \cdot \frac{I_{scc\ max\ (close-in\ fault)}}{1.3 \cdot I_{pn}} \cdot (R_{ct} + R'_b) \cdot I_{sn}$ and: $K_{td}(b) \cdot \frac{I_{scc\ max\ (zone\ 1-end\ fault)}}{1.3 \cdot I_{pn}} \cdot (R_{ct} + R'_b) \cdot I_{sn}$

Table 2/2 CT requirements

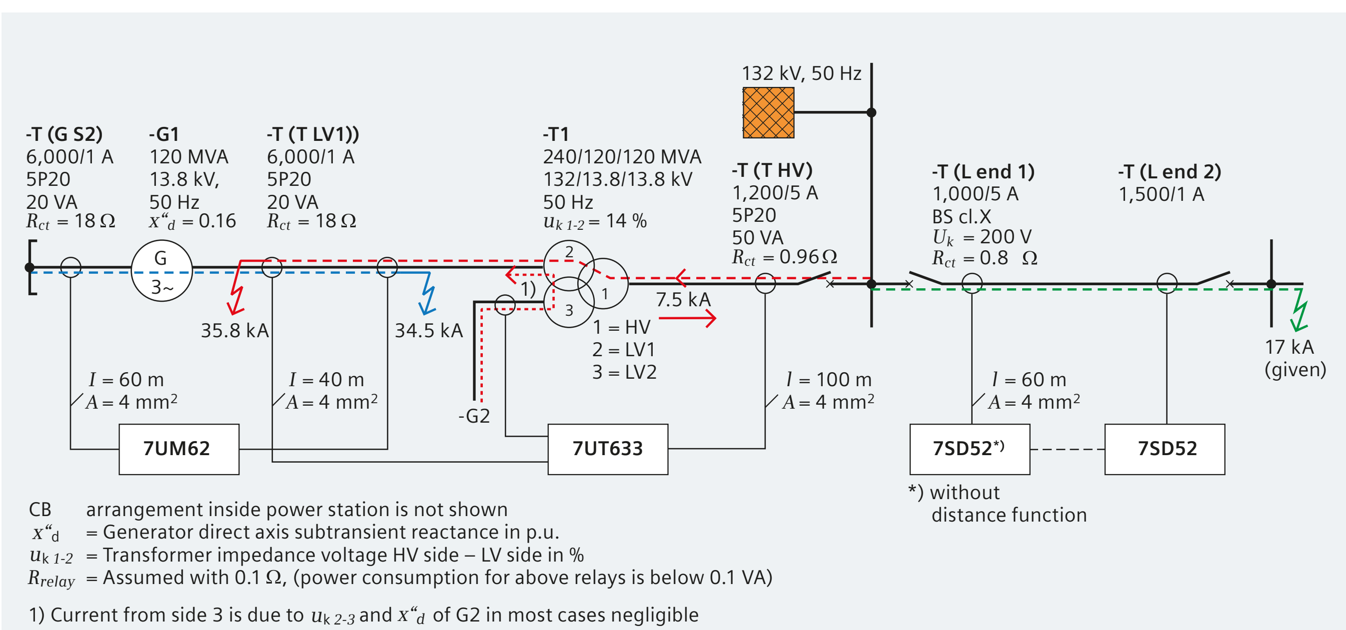


Fig. 2/89 Example 1 – CT verification for 7UM62, 7UT6, 7SD52 (7SD53, 7SD610)

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

$\frac{1}{4} \leq F_{Adap} \leq 4$, (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:

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

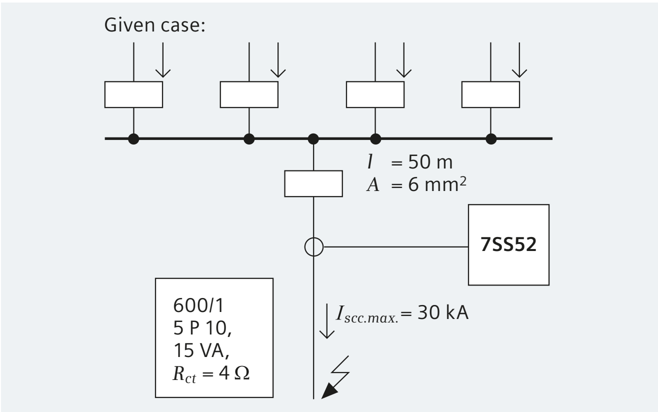


Fig. 2/90 Example 2

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

According to Table 2/2, page 2/48 $K_{td} = ½$

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

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

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

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

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

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

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. Exception is the pilot-wire relay 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_{lead}	$= \frac{2 \cdot \rho \cdot l}{A}$
l	= Single conductor length from the CT to the relay in m
Specific resistance: ρ	$= 0.0175\ \frac{\Omega \cdot \text{mm}^2}{\text{m}}$ (copper wires) at 20 °C/68 °F
A	= Conductor cross-section in mm²

CT design according to ANSI/IEEE C 57.13

Class C of this standard defines the CT by ist 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

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

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

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

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

Software for Engineering and Data Evaluation

Description

The PC operating program DIGSI 4 is the user interface to all Siemens protection devices, up to and including SIPROTEC 4 and SIPROTEC Compact. It has a simple and intuitive user interface. Using DIGSI 4, the parameters for the SIPROTEC devices are set and evaluated – it is the tailor-made program for industrial and energy supply systems.

Functions

- **Simple protection settings**
  The functions actually required can simply be selected from the numerous protection functions. This facilitates increased clarity over the other menus.
- **Setting devices with primary and secondary values**
  The settings can be entered and displayed as primary or secondary values. You can switch between primary and secondary values using the mouse click on the toolbar.

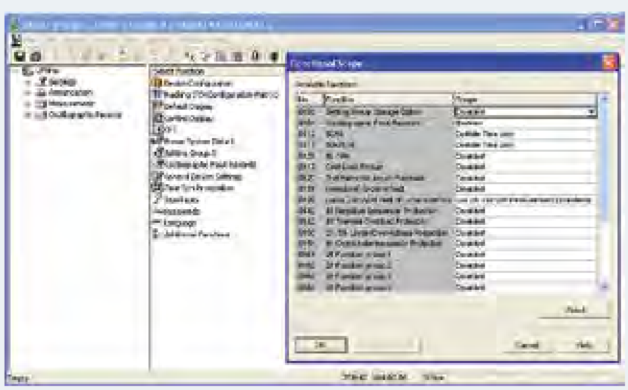


Fig. 3/1 DIGSI 4: Main Menu, Selecting the Protection Functions

- **Routing matrix**
  The DIGSI 4 matrix shows the user the entire device configuration at a glance. For instance, the allocation of LEDs, binary inputs and standard relays is displayed on one screen. The routing can be changed with the click of a mouse.

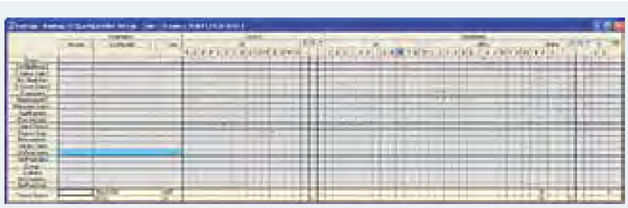


Fig. 3/2 DIGSI 4: Routing Matrix

- **CFC: Configure logic instead of programming it**
  Using CFC (Continuous Function Chart), interlockings and switching sequences can be configured, information linked and derived without software expertise simply by drawing technical processes. Logical elements such as AND, OR and timing elements are available, as are limiting value interrogations of measured values.

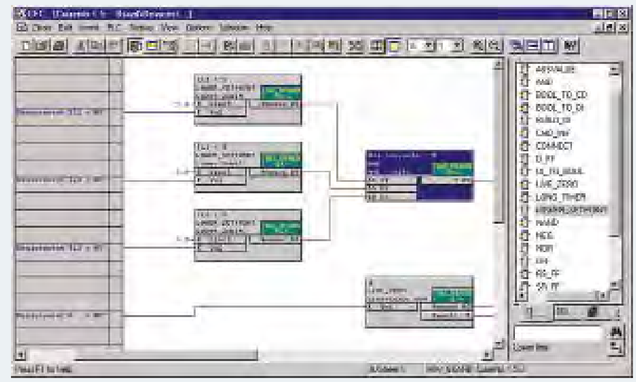


Fig. 3/3 CFC Chart

- **Commissioning**
  Special attention was paid to commissioning. All binary inputs and outputs can be individually tested and read. This enables an extremely simple wiring check. For test purposes, messages can be intentionally sent to the serial interfaces.
- **IEC 61850 System Configurator**
  Using the IEC 61850 system configurator, which is launched from the DIGSI manager, the IEC 61850 network structure and the scope of the data exchange between the participants of an IEC 61850 station can be defined. To do so, subnetworks are added as required to the network working area. These subnetworks are then allocated available participants and the addressing is set. In the GOOSE working area, the data objects between the participants are linked, for example, the pickup indication of the *V/AMZ I>* function of the feeder 1, which is transmitted to the infeed, in order to effect the reverse interlocking of the *V/AMZ I>>* function there. For more information, see "IEC 61850 System Configurator – Description".

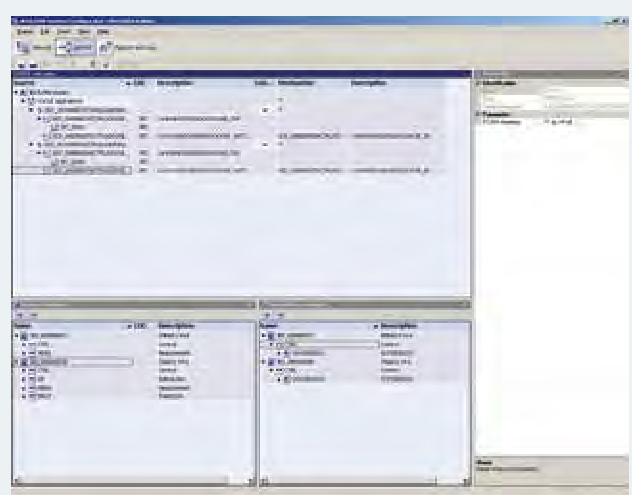


Fig. 3/4 IEC 61850 System Configurator

DIGSI 4 – Selection and Ordering Data

Description	Variants	Order no.
Software for project engineering and operation of Siemens protection devices of the SIPROTEC 4/3/2 and SIPROTEC Compact product families, executable under the following operating systems: - Microsoft Windows 7 Ultimate, Professional and Enterprise (32/64 Bit) - Microsoft Windows 10 Professional and Enterprise (64 Bit) - Microsoft Windows Server 2008/2012 R2 (64 Bit) See product information for details about the supported service packs of the operating systems. Including device templates, Comtrade Viewer, electronic help, DIGSI cables (for all devices) and service (update, hotline). Interface languages: German, English, French, Spanish, Italian, Chinese, Russian, and Turkish (selectable) Delivery is on DVD-ROM	**Basic** Basic version with license for 10 computers (authorization using serial number)	7 X S 5 4 0 0 - 0 A A 0 0
	Professional Basic and in addition SIGRA (fault-record analysis), CFC editor (logic editor), display editor (editor for basic and branch control images) and DIGSI 4 remote (remote control) with license for 10 computers (authorization using serial number)	7 X S 5 4 0 2 - 0 A A 0 0
	DIGSI 4 Professional + IEC 61850 Professional und zusätzlich IEC 61850 System Confi gurator mit Lizenz für 10 Rechner (Autorisierung per Seriennummer)	7 X S 5 4 0 3 - 0 A A 0 0
	Upgrade from DIGSI 4 basic to DIGSI 4 professional	7 X S 5 4 0 7 - 0 A A 0 0
	Upgrade from DIGSI 4 basic to DIGSI 4 professional + IEC 61850	7 X S 5 4 0 8 - 0 A A 0 0
	Upgrade from DIGSI 4 professional to DIGSI 4 professional + IEC 61850	7 X S 5 4 6 0 - 0 A A 0 0
	DIGSI 4 Trial Like DIGSI 4 professional + IEC 61850, but only valid for 30 days (test version, no authorization necessary)	7 X S 5 4 0 1 - 1 A A 0 0
	DIGSI 4 scientific Like DIGSI 4 professional + IEC 61850, only for scientific equipment (university, technical college, research institution) with license for 10 computers (authorization using serial number)	7 X S 5 4 0 2 - 2 A A 0 0
	DIGSI 4 DVD copy Contains latest DIGSI 4, IEC 61850 system configurator and SIGRA, without license	7 X S 5 4 9 0 - 0 A A 0 0

Table 1 DIGSI 4 Selection and Ordering Data

Description

The IEC 61850 system configurator is the manufacturer-independent solution for the interoperable engineering of IEC 61850 products and systems. It supports all devices with IEC 61850, not just Siemens products – like SIPROTEC 5, SIPROTEC 4, SIPROTEC Compact, Reyrolle, SICAM RTUs, SICAM IO/AI/P85x/Q100 – but also devices from other Siemens divisions (such as SITRAS PRO) or from third parties.

The tool supports SCL configuration files (substation configuration language) from the IEC 61850-6 through import or export of all formats (ICD/IID/CID/SCD/SSD/SED). Thus, IEC 61850 devices can be added and a complete IEC 61850 station is available for substation automation technology.

IEDs from the IEC 61850 standard of Edition 1 or Edition 2 are supported. The possible engineering therefore includes not only GOOSE communication and client/server configuration via MMS reporting, but also system topology, process bus communication with SMV (sampled measured values) and IEC 60870-5-104 addresses for the gateway to the network control center via IEC 61850-80-1.

Simple engineering thanks to customer-friendly workflows and universal display of IEC 61850 addresses as well as customer description texts. Users with IEC 61850 basic or expert knowledge find the desired level of detail.

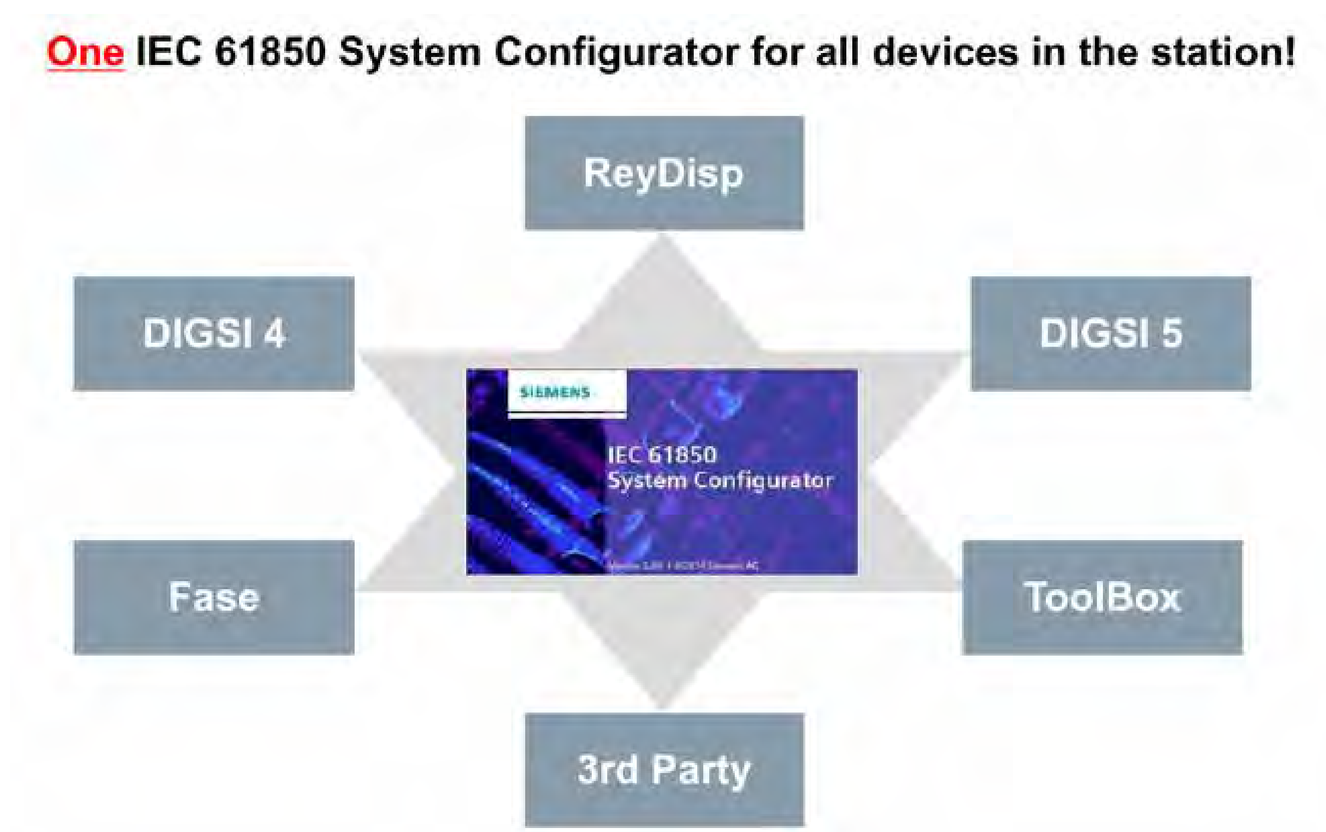


Fig. 3/5 An IEC 61850 System Configurator for All Devices in the Station

IEC 61850 System Configurator – Selection and Ordering Data

Description	Variants	Order no.
IEC 61850 System Configurator Software for configuring stations with IEC 61850 communication Executable under 32-bit and 64-bit MS Windows 7 Ultimate, Enterprise and Professional/MS Windows 8.1/MS Windows Server 2012 R2 64-bit/MS Windows 10 Professional and Enterprise (64 Bit) See product information for supported service packs of the operating systems including electronic help and service (update, hotline) Interface languages: German, English, French, Spanish, Italian, Portuguese, Chinese, Russian and Turkish selectable Supplied on DVD-ROM.	**Stand-alone** For configuration independent from manufacturers of a plant with IEC 61850 devices (SIPROTEC, Reyrolle and devices from the competition), installation independent from DIGSI, with license for 10 computers (authorization using serial number)	7XS5461-0AA00

Table 2 SIGRA – Selection and Ordering Data

Description

The SIGRA user program supports you in analyzing failures in your electrical power system. It graphically analyzes data recorded during the failure and calculates additional supplemental quantities such as impedances, powers or RMS values, from the supplied measured values, making evaluation of the fault record easier for you.

The quantities can be shown as desired in the diagrams of the views

- Time signals
- Phasor diagrams
- Locus diagrams
- Harmonics
- Fault locator

and in the "Table" view.

After a system incident, it is especially important to quickly and completely analyze the error, so that the respective measures can be derived immediately from the cause analysis. This will enable the original network status to be recovered and the down time to be reduced to an absolute minimum.

As well as the usual time signal display of the recorded measured quantity, the current version is also set up to display vector, pie and bar charts to show the harmonics and data tables. From the measured values recorded in the fault records, SIGRA 4 calculates further values, for instance missing quantities in the 3-phase electrical power system, impedances, outputs, symmetrical components, etc. Using two measurement cursors, the fault current can be evaluated easily and conveniently. With the aid of SIGRA however, further fault record can also be added. The signals from another fault record (for example, from the opposite end of the line) are added to the current signal pattern using drag and drop.

SIGRA 4 facilitates the display of signals from various fault records in one diagram as well as a fully automated synchronization of these signals on a common time base. As well as the precise determination of the individual factors of the line fault, the fault location is also of particular interest.

A precise determination of the fault location saves time which the user can use for an on-site inspection of the error. This function is also supported by SIGRA 4 using the "offline fault location" function. SIGRA 4 can be used for all fault records in the COMTRADE file format.

The functions and advantages of SIGRA 4 can often only be optimally displayed directly on the product. For this reason, SIGRA 4 is available as a 30-day test version.

Functions

- 6 diagram types:
  - Time-signal representation (standard)
  - Locus diagram (for example for RX)
  - Vector diagram (reading of angles)
  - Bar chart (for example for visualizing harmonics)
  - Table (with values of several signals at the same point in time)
  - Fault-location determination (display of fault location)

Fig. 3/6 SIGRA 4

- Calculation of additional values, such as positive-sequence impedances, RMS values, symmetrical components and phasors
- 2 measuring cursors that are synchronized in all views
- High-performance panning and zoom functions (for example, section enlargement)
- User-friendly project engineering via drag and drop
- Innovative signal routing in a clearly structured matrix
- Time-saving user profiles, which can be assigned to individual relay types or series
- Addition of further fault records and synchronization of multiple fault records with a common time base
- Simple documentation through copying of the diagrams for example, into MS Office programs
- Offline fault-location determination
- Commenting of fault records, and commenting of individual measuring points in diagrams and free placement of these comments in diagrams
- Application of mathematical operations to signals

Hardware Requirements

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

Software requirements

- MS Windows 7 Ultimate, Enterprise and Professional
- MS Windows 8.1 Enterprise
- MS Windows Server 2008 R2

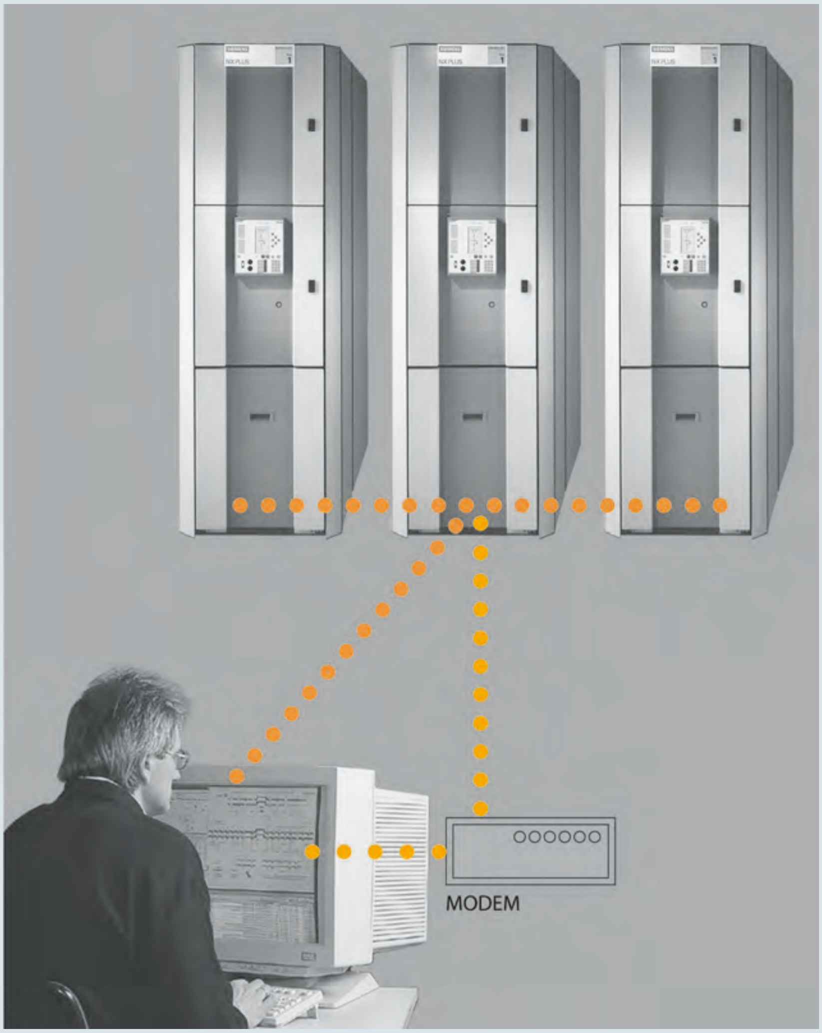
Software for Engineering and Data Evaluation

SIGRA – Selection and Ordering Data

Description	Variants	Order no.
SIGRA Software for graphical visualization, analysis and evaluation of fault records Executable under 32-bit and 64-bit MS Windows 7 Ultimate, Enterprise and Professional/MS Windows 8.1 Enterprise/MS Windows Server 2008 R2 See product information for supported service packs of the operating systems including sample fault record, electronic help and service (update, hotline) Interface languages: German, English, French, Spanish, Italian, Chinese, Russian and Turkish, selectable Incl. Multimedia Tutorial on separate CD-ROM Supplied on DVD-ROM.	**SIGRA for DIGSI** With license for 10 computers (authorization using serial number). The DIGSI 4 license number is required to order.	7XS5410-0AA00
	SIGRA Stand-alone Installation without DIGSI 4 with license for 10 computers (authorization using serial number)	7XS5416-0AA00
	SIGRA Scientific Installation without DIGSI 4 only for scientific equipment (university, technical college, research institution) with license for 10 computers (authorization using serial number)	7XS5416-1AA00
	SIGRA Trial Like SIGRA Stand-alone version but only usable for 30-days (no authorization required)	7XS5411-1AA00
	Upgrade from SIGRA Trial to SIGRA Stand-alone Like SIGRA Stand-alone version for customers who want to activate a trial version with full capabilities and a license for 10 computers	7XS5416-2AA00

Table 3 SIGRA – Selection and Ordering Data

Communication



4

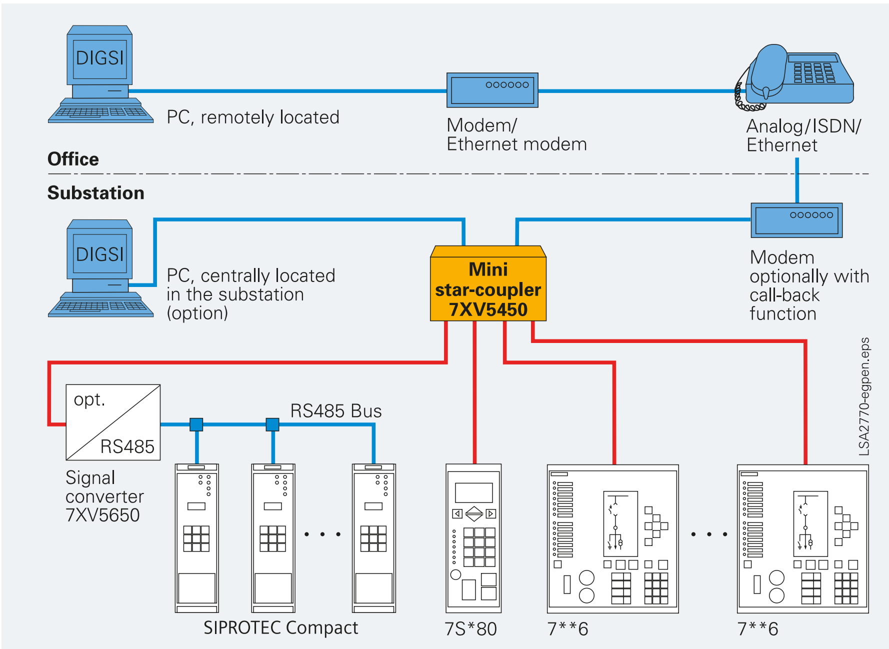


Fig. 4/1 Communication structure

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 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
- Configuration with active star-coupler

Integration into substation control systems

Integration into the SICAM power automation system

Integration into other systems

4

4

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 DP 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 DP.

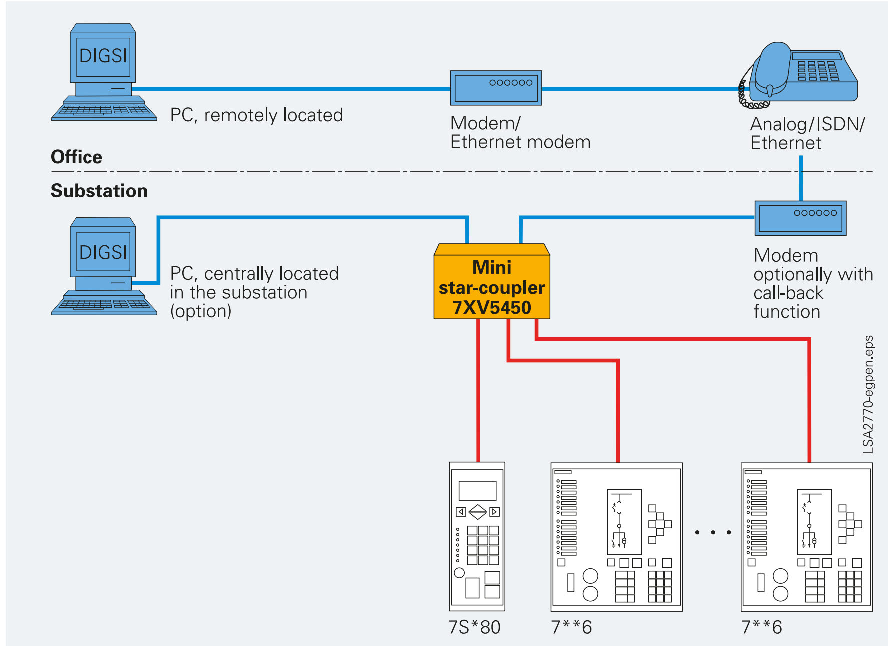


Fig. 4/2 Remote relay communication

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.

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).

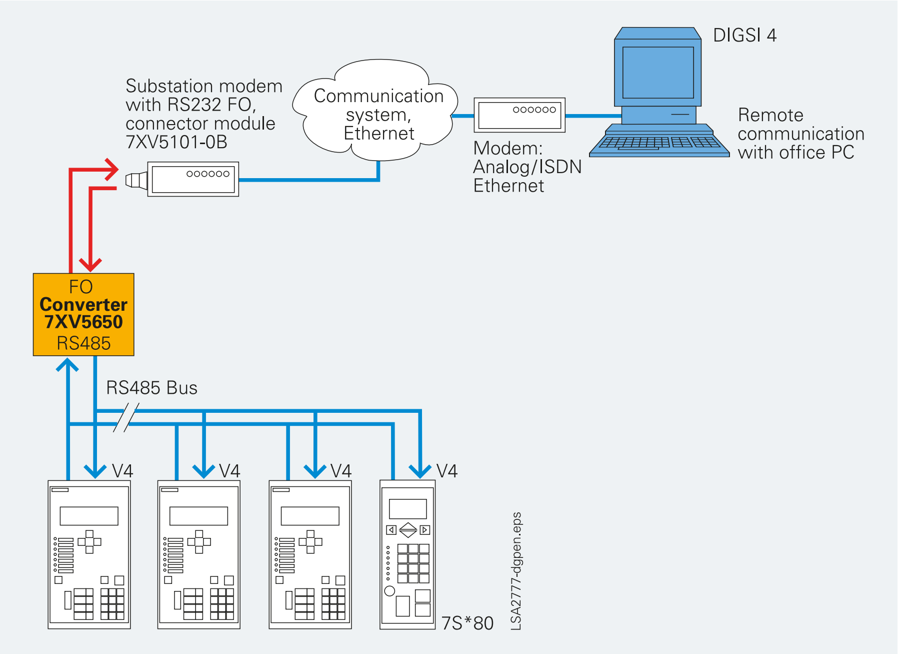


Fig. 4/3 SIPROTEC 4 units on an RS485 bus (Example 1)

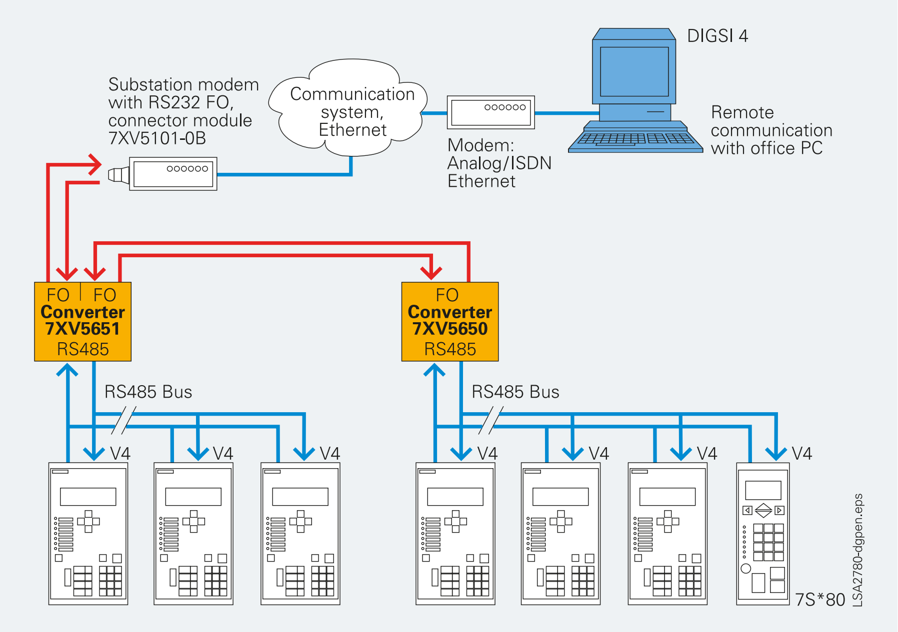


Fig. 4/4 Two groups of SIPROTEC 4 units on an RS485bus (Example 2)

4

Typical applications

Example 3: Mixed system – SIPROTEC 4

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. 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.

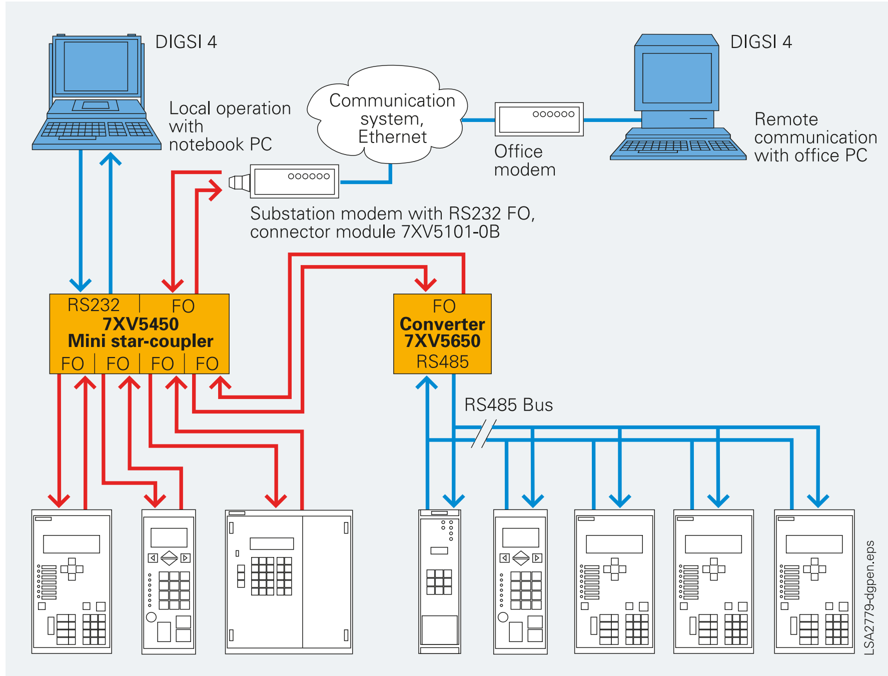


Fig. 4/5 Mixed system, FO/RS485 with units from different families (Example 3)

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.

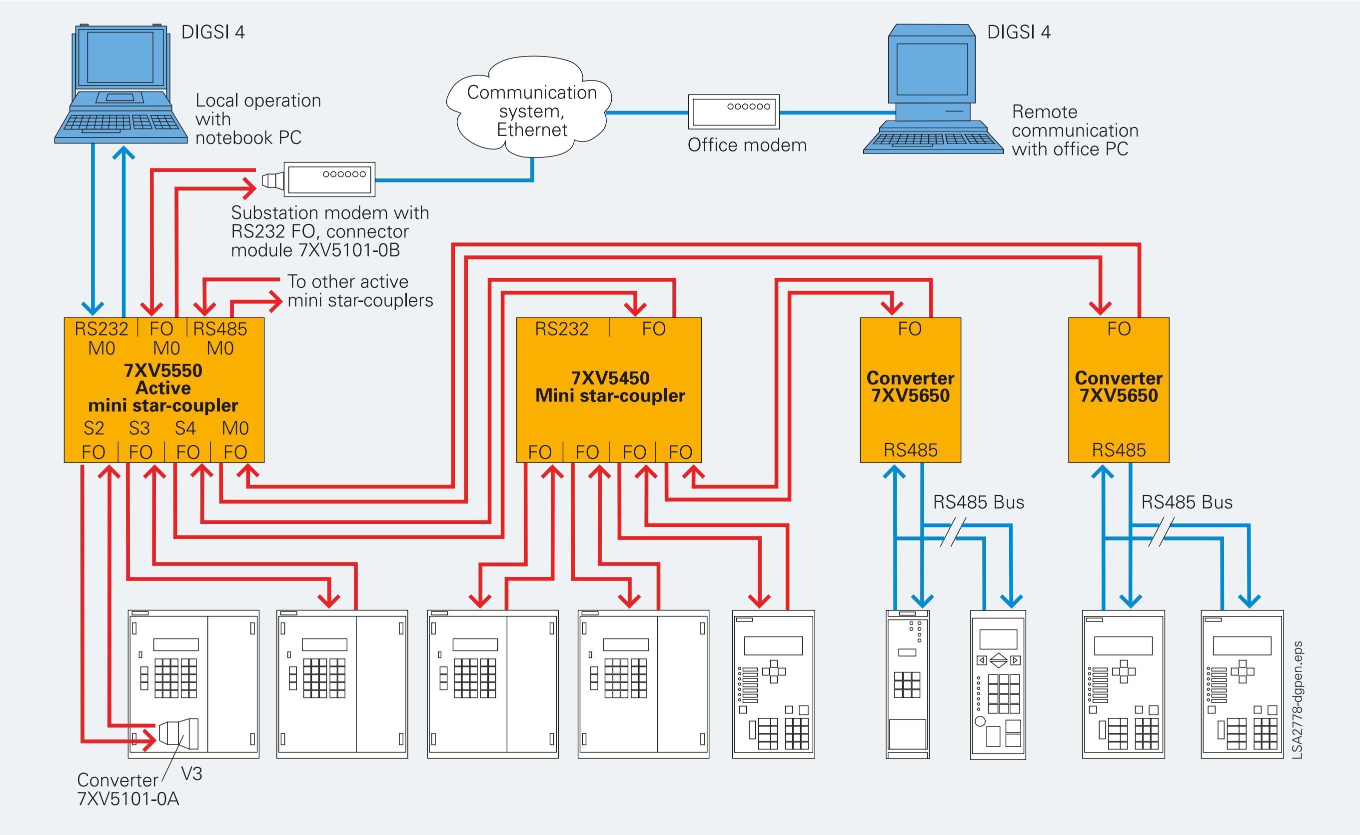


Fig. 4/6 Mixed system with relays from different families, with active star-coupler (Example 4)

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 con-figuration 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. siemen.com/siprotec or in the catalog "Selection Guide for SIPROTEC and Reyrolle"

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.

WebMonitor

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.

IEC 60870-5-104 protocol

The IEC 60870-5-104 substation and power system automation protocol is supported via the electrical and optical Ethernet module. Indications (single and double), measured values, metered values can be transmitted to one or two (redundant) masters. IEC 104 file transfer is also supported and fault recordings can be read out of the device in Comtrade format. In the command direction, secured switching of switching objects is possible via the protocol. Time synchronization can be supported via the T104 master or via SNTP across the network.Redundant time servers are supported. All auxiliary services on Ethernet such as the DIGSI 5 protocol, network redundancy, or SNMP for network monitoring can be activated concurrently with T104. Moreover, GOOSE messages of IEC 61850 can be exchanged between devices.

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.

Protocol Modbus TCP

The Modbus TCP communication protocol is supported by the electrical or optical Ehternet module. Modbus TCP and Modbus RTU are very similar, with Modbus TCP using TCP/IP packets for data transfer.
Modbus TCP can be used to transmit indications (single- and double-point indications), measured values, metered measureands to one or two (redundant) masters. Switchgear can be switched in command direction via the protocol.
Time synchronization can be implemented via SNTP or IEEE1588 via the network, supporting redundant time servers. All additional services on Ethernet like the DIGSI 5 protocol, network redundany or SNMP for network monitoring can be activated at the same time as Modbus TCP and GOOSE messages of IEC 61850 can be sent over the network between the devices.

Serial DNP3 or DNP3 TCP

DNP 3 is supported as a serial protocol via RS485 or an optical 820 nm interface, and as an Ethernet-based TCP variant via the electrical or optical Ethernet module. In conjunction with Ethernet, the switch integrated in the module can be used such that redundant ring structures for DNP 3 can be realized. In this way, for example, connection to a DNP 3 via a redundant optical Ethernet ring can be established. Information about a device, and the fault records of the device, can be routed and transferred using the DNP 3 protocol. Switching commands can be executed in the control direction.

Redundant connection to 2 serial substation controllers can be established via 2 modules or 1 serial double module. With Ethernet, 2 Ethernet modules that can work independently of one another via 1 or 2 networks are to be provided for a redundant connection. Settings values in the device cannot be read or changed via the protocol.

For DNP 3, the network topologies can also be used for Ethernet-based or serial communication.

PROFINET

PROFINET is the ethernet-based successor of Profibus DP and is supported in the variant PROFINET I/O. 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 confi gurable 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.

Integration into the SICAM power automation system

	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 power automation system SICAM. 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 computer 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.

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.

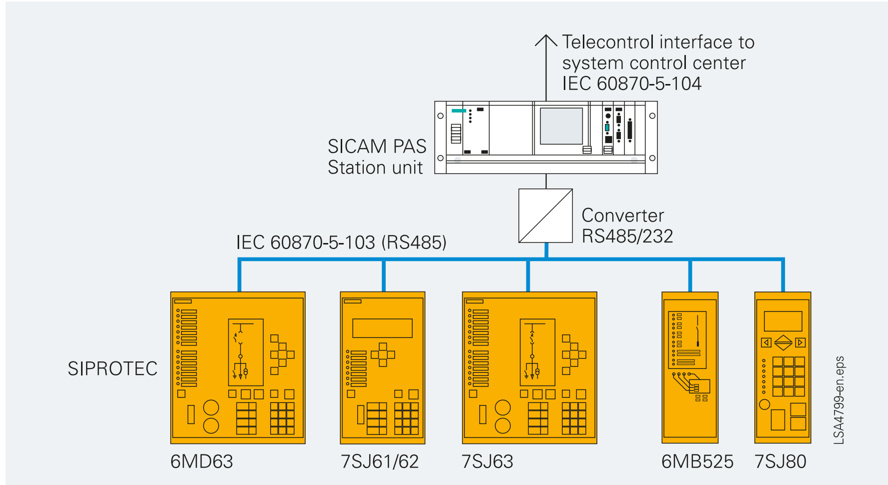


Fig. 4/7 Communication structure with substation automation system

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.

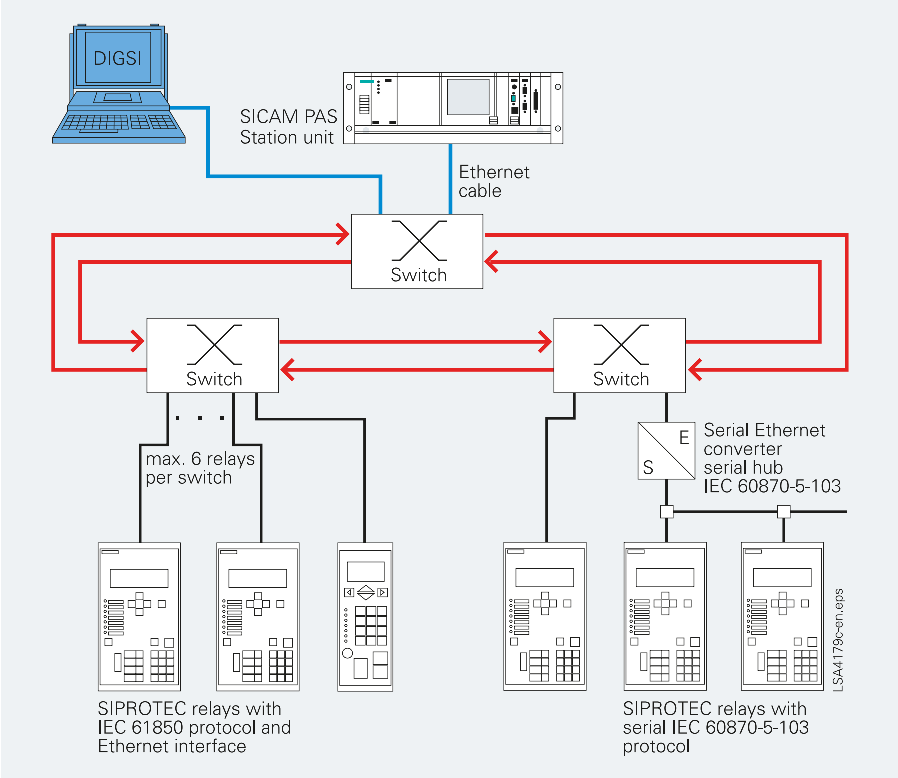


Fig. 4/8 Ethernet-based system with SICAM PAS with electrical Ethernet interface

Integration into a substation automation system, solution without substation control system

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.

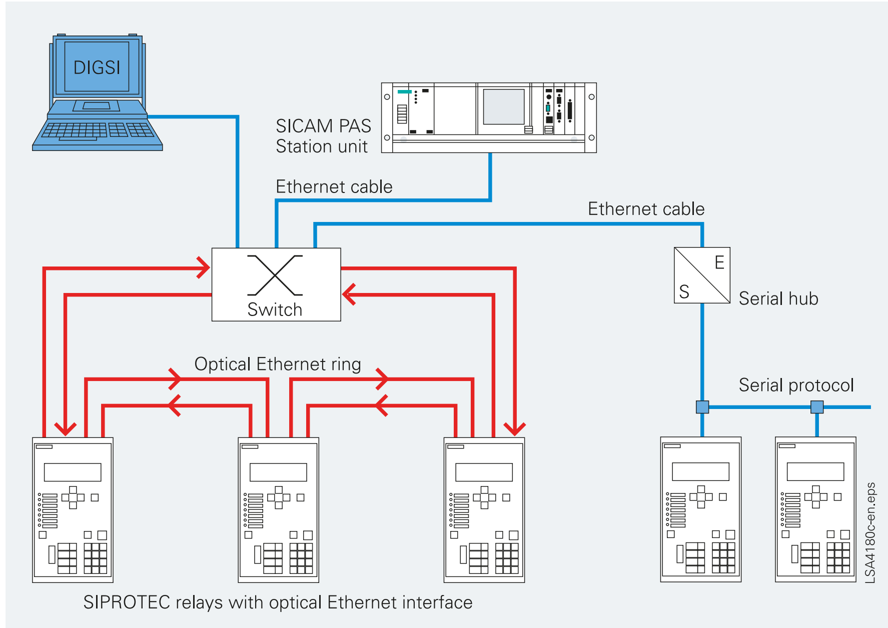


Fig. 4/9 Ethernet-based system with SICAM PAS with optical Ethernet interface

Solution without substation control system

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

- 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.

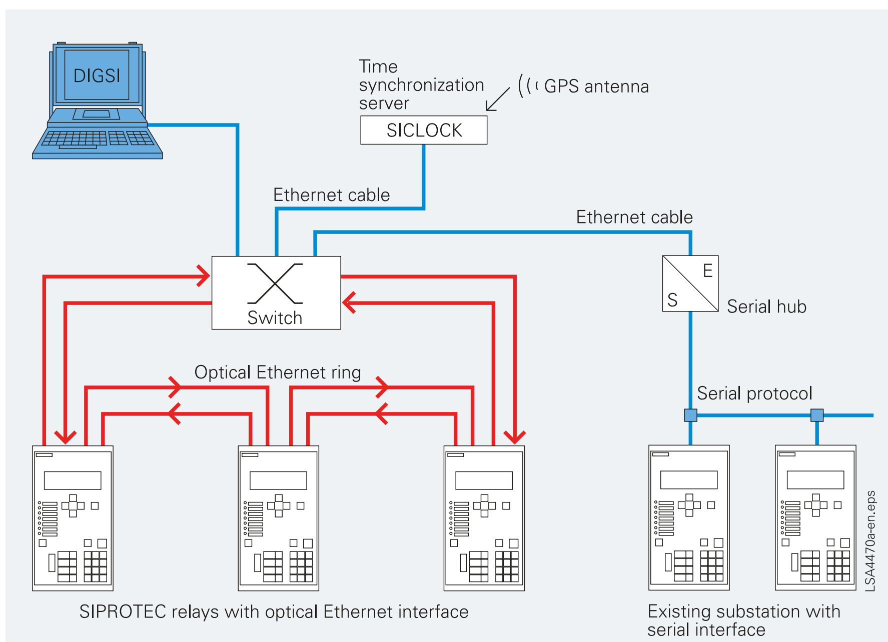


Fig. 4/10 Ethernet-based system with optical Ethernet interface and migration of relays with serial protocol

Overcurrent Protection

5

SIPROTEC 7SJ61 multifunction protection relay

Fig. 5/1 SIPROTEC 7SJ61 multifunction protection relay with text (left) and graphic display

Description

The SIPROTEC 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 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 DP
  – DNP 3/ DNP3 TCP/MODBUS RTU
  – PROFINET
- 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

Application

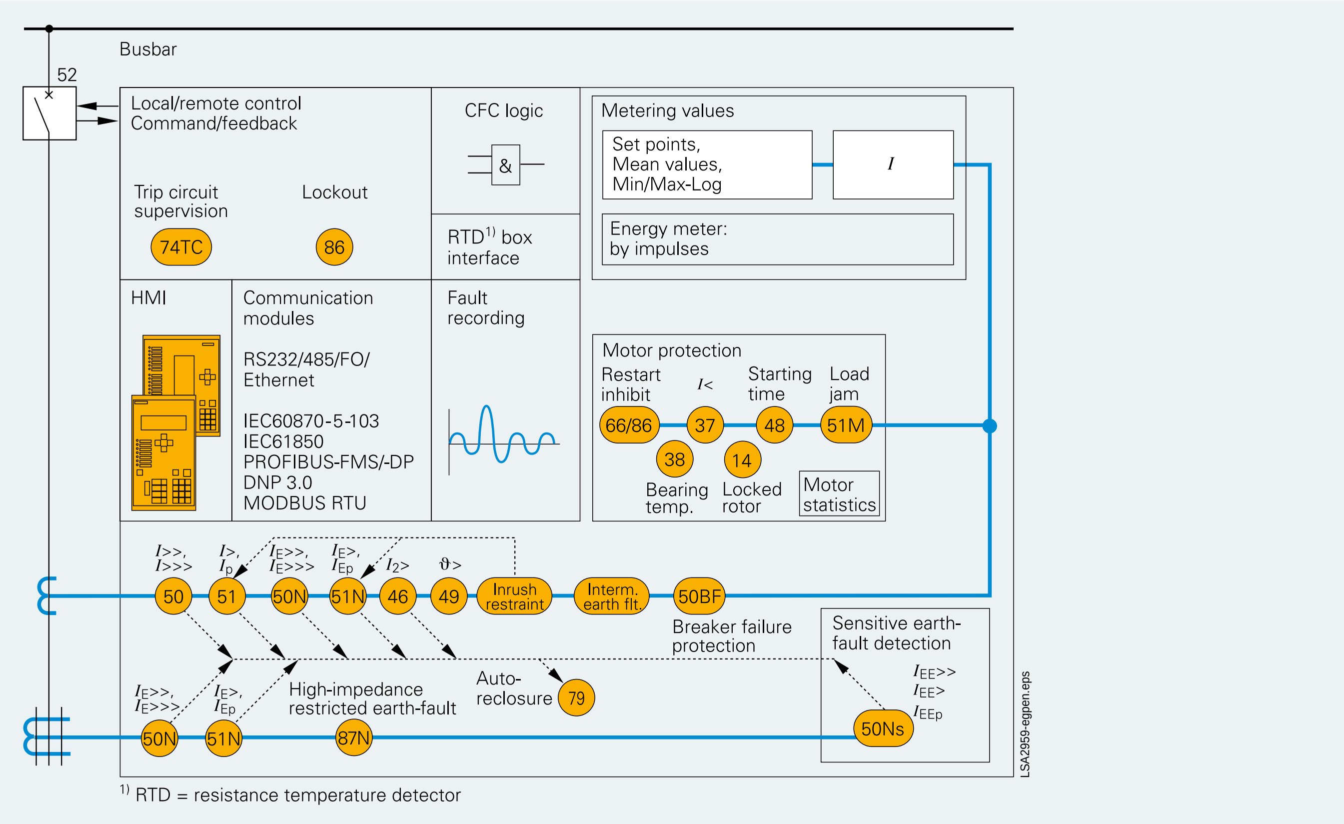


Fig. 5/2 Function diagram

Application

The SIPROTEC 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 7SJ61can 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

⅓-rack size (text display variants) and ½-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. 5/3 Rear view with screw-type, ⅓-rack size

5

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.

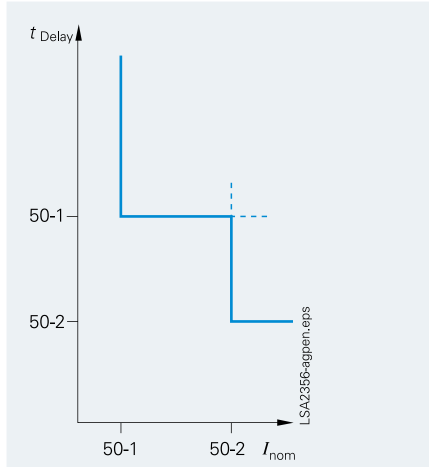


Fig. 5/4 Definite-time overcurrent characteristic

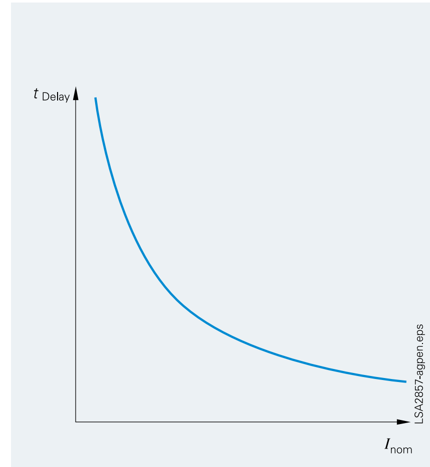


Fig. 5/5 Inverse-time overcurrent characteristic

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 summating 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. 5/6). 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.

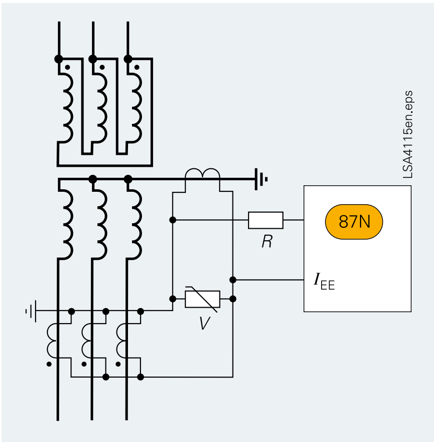


Fig. 5/6 High-impedance restricted ground-fault protection

5

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)

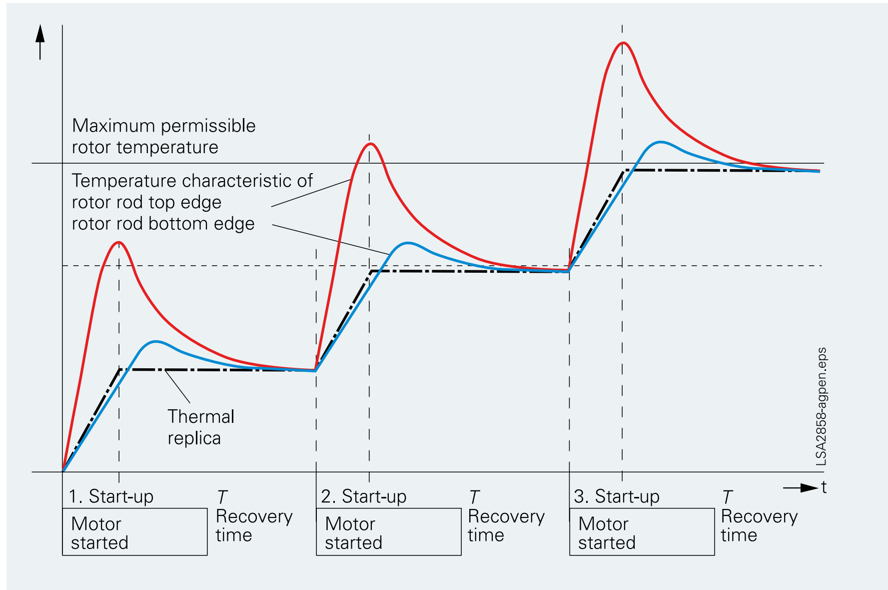


Fig. 5/7

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.

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. 5/7).

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... 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. 5/8) 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

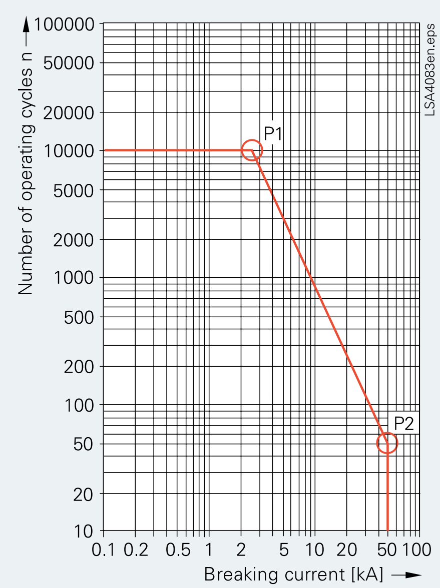


Fig. 5/8 CB switching cycle diagram

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 grounding switches
- Triggering of switching operations, indications or alarm by combination with existing information

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. 5/9 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 interfaces[1)]

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

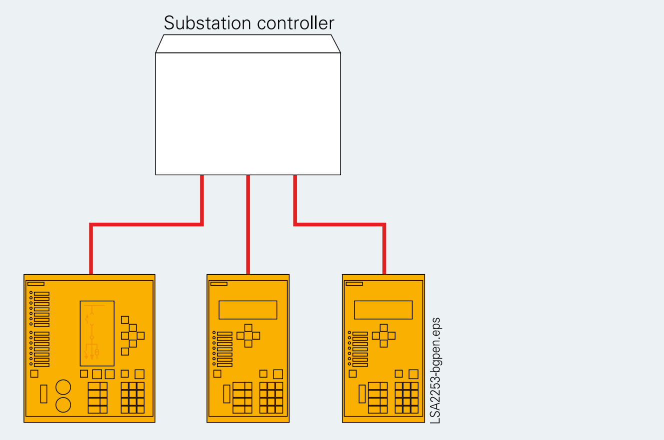


Fig. 5/10 IEC 60870-5-103: Radial fiber-optic connection

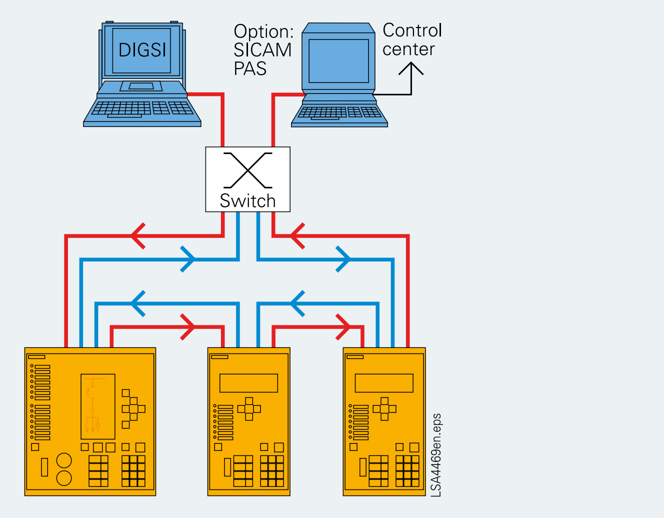


Fig. 5/11 Bus structure for station bus with Ethernet and IEC 61850, fiber-optic ring

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.

1) For units in panel surface-mounting housings please refer to note on page 5/77.

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 certifi ed. 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.

5

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.

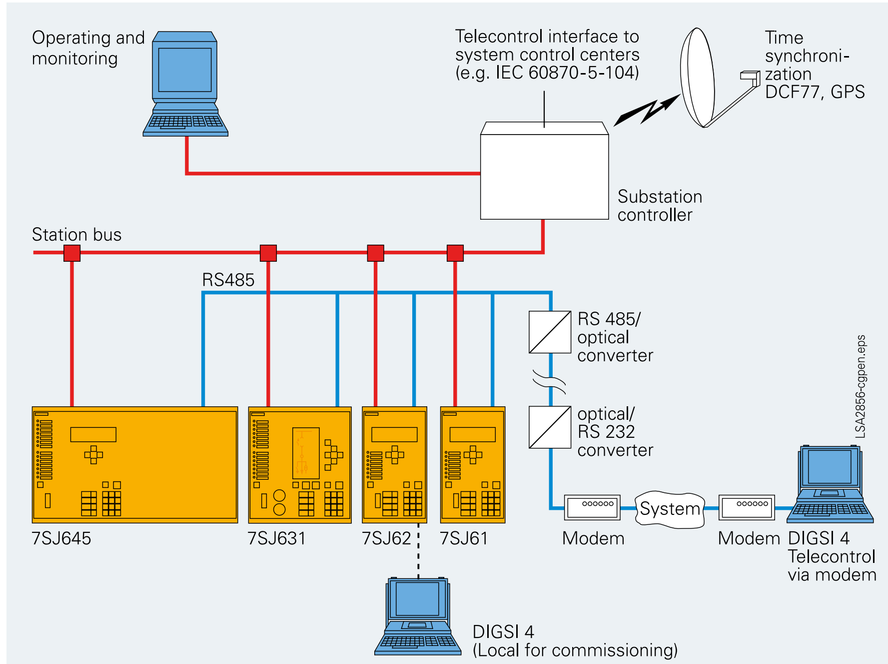


Fig. 5/12 System solution/communication

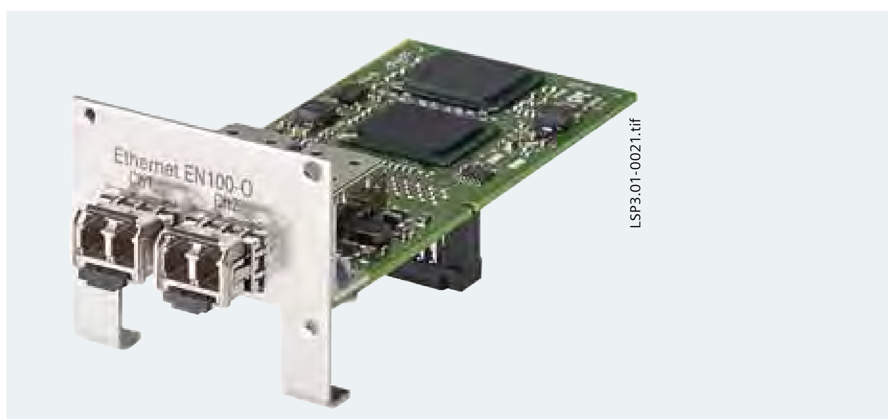


Fig. 5/13 Optical Ethernet communication module for IEC 61850 with integrated Ethernet-switch

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.

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS DP. 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. 5/10).

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. 5/11).

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.

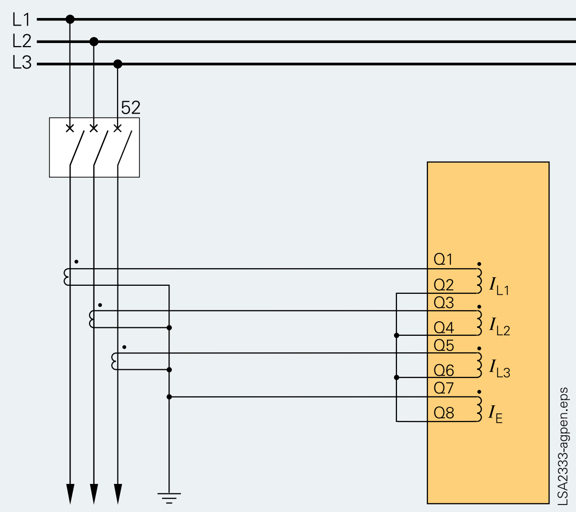


Fig. 5/14 Residual current circuit

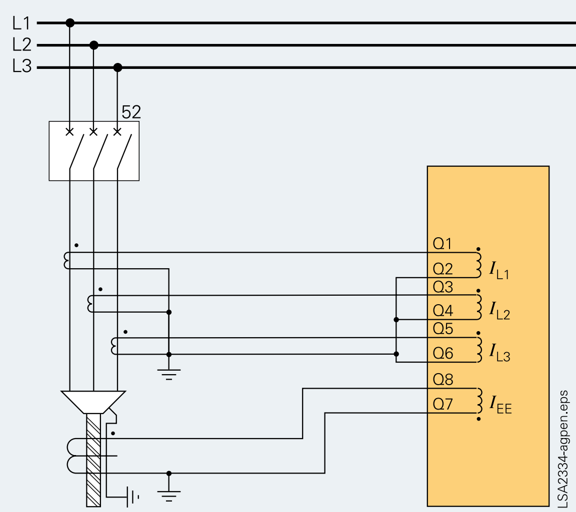


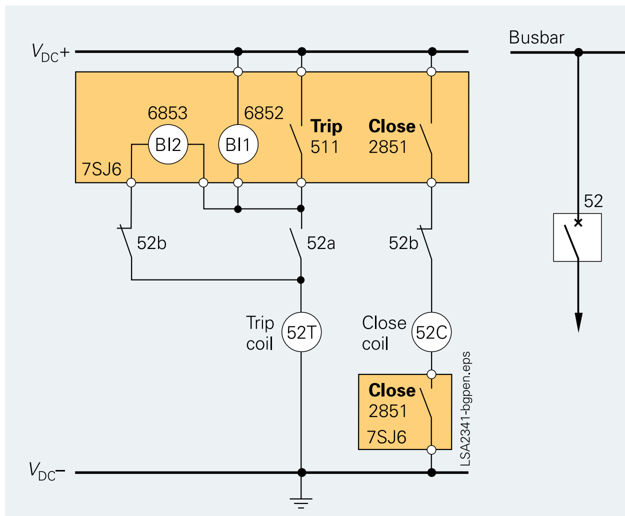
Fig. 5/15 Sensitive ground current detection

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.



TRIP contact	Breaker	BI1	BI2
open	closed	H	L
open	open	H	H
closed	closed	L	L
closed	open	L	H

Fig. 5/16 Trip circuit supervision with 2 binary inputs

General unit data				
Measuring circuits				
System frequency	50 / 60 Hz (settable)			
Current transformer				
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) Dynamic (impulse current)	 500 A for 1 s 150 A for 10 s 20 A continuous 250 x I_{nom} (half cycle)			
Overload capability if equipped with sensitive ground-fault CT Thermal (effective) Dynamic (impulse current)	 300 A for 1 s 100 A for 10 s 15 A continuous 750 A (half cycle)			
Auxiliary voltage (via integrated converter)				
Rated auxiliary voltage V_{aux}	DC AC	24/48 V	60/125 V	110/250 V 115/230 V
Permissible tolerance	DC AC	19-58 V	48-150 V	88-330 V 92-138 V 184-265 V
Ripple voltage, peak-to-peak	≤ 12 %			
Power consumption Quiescent Energized	 Approx. 3 W Approx. 7 W			
Backup time during loss/short-circuit of auxiliary voltage	≥ 50 ms at V ≥ DC 110 V ≥ 20 ms at V ≥ DC 24 V ≥ 200 ms at AC 115 V/230 V			
Binary inputs/indication inputs				
Type	7SJ610	7SJ611, 7SJ613	7SJ612, 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)			

Binary outputs/command outputs				
Type		7SJ610,	7SJ611, 7SJ612,	7SJ613 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 ≤ 50 ms		
Switching voltage	≤ DC 250 V			
Permissible current	5 A continuous, 30 A for 0.5 s making current, 2000 switching cycles			

Electrical tests	
Specification	
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; τ =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 Ω
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 Ω; 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

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

Futher information can be found in the current manual at: www.siemens.com/siprotec

Description	Order No.
7SJ61multifunction protection relay	7SJ61□□-□□□□□-□
Housing, binary inputs (BI) and outputs (BO)	
Housing ▯19", 4 line text display, 3 BI, 4 BO, 1 live status contact	0
Housing ▯19", 4 line text display, 8 BI, 8 BO, 1 live status contact	1
Housing ▯19", 4 line text display, 11 BI, 6 BO, 1 live status contact	2
Housing ½19", graphic display, 8 BI, 8 BO, 1 live status contact [7]	3
Housing ½19", 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

Selection and ordering data

Description	Order No.	Order code
7SJ61 multifunction protection relay	7SJ61□□-□□□□□-□□□□	

	Designation	ANSI No.	Description	Order code
	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 48/14 66/86 51M	Sensitive ground-fault detection (non-directional) High-impedance restricted ground fault Intermittent ground fault Starting time supervision, locked rotor Restart inhibit Load jam protection, motor statistics	R B 2)
■	Motor	50Ns/51Ns 87N 48/14 66/86 51M	Sensitive ground-fault detection (non-directional) High-impedance restricted ground fault Starting time supervision, locked rotor Restart inhibit 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**.

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 DP Slave, RS485	9	L 0 A
PROFIBUS DP Slave, 820 nm wavelength, double ring, ST connector 1)	9	L 0 B
MODBUS, RS485	9	L 0 D
MODBUS, 820 nm wavelength, ST connector 2)	9	L 0 E
DNP 3.0, RS485	9	L 0 G
DNP 3.0, 820 nm wavelength, ST connector 2)	9	L 0 H
IEC 60870-5-103 protocol, redundant, RS485, RJ45 connector 2)	9	L 0 P
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector (EN 100)	9	L 0 R
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector (EN 100) 2)	9	L 0 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

Sample order

Position		Order No. + Order code
		7SJ6125-5EC91-3FA1+L0G
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 L 0 G
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

5

Selection and ordering data

Accessories	Description	Order No.
	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.).

5

Mounting rail

2-pin connector

3-pin connector

Short-circuit links
for current terminals

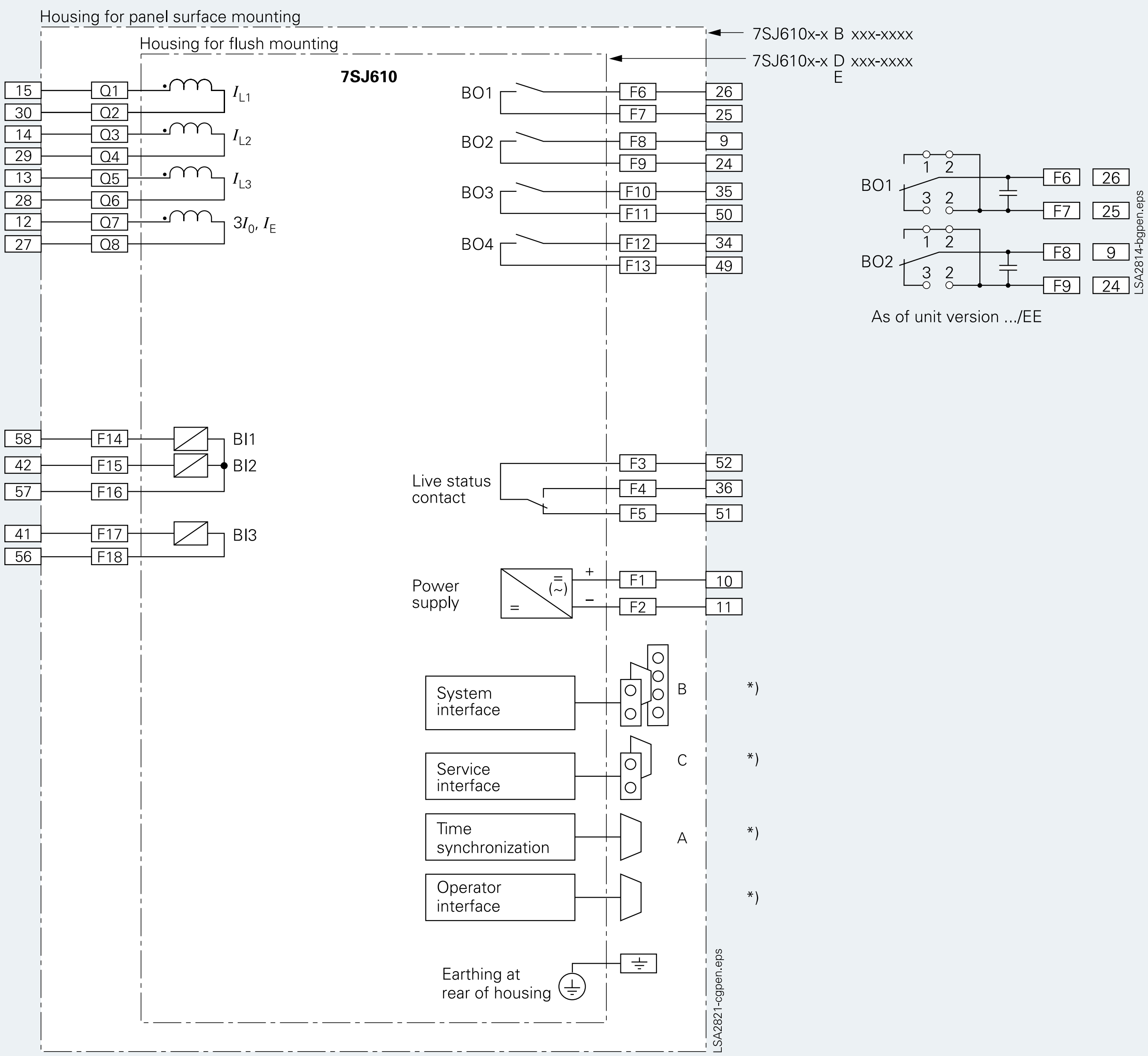
Short-circuit links
for current terminals

Description	Order No.	Size of package	Supplier
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	1)
Crimp connector CI2 0.5 to 1 mm^2	**0-827396-1**	1	1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	**0-163084-2**	1	1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	**0-163083-7**	4000 taped on reel	1)
Crimping tool for Type III+	**0-539635-1**	1	1)
and matching female	**0-539668-2**	1	1)
Crimping tool for CI2	**0-734372-1**	1	1)
and matching female	**1-734387-1**	1	1)
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

1) Your local Siemens representative can inform you on local suppliers.

5

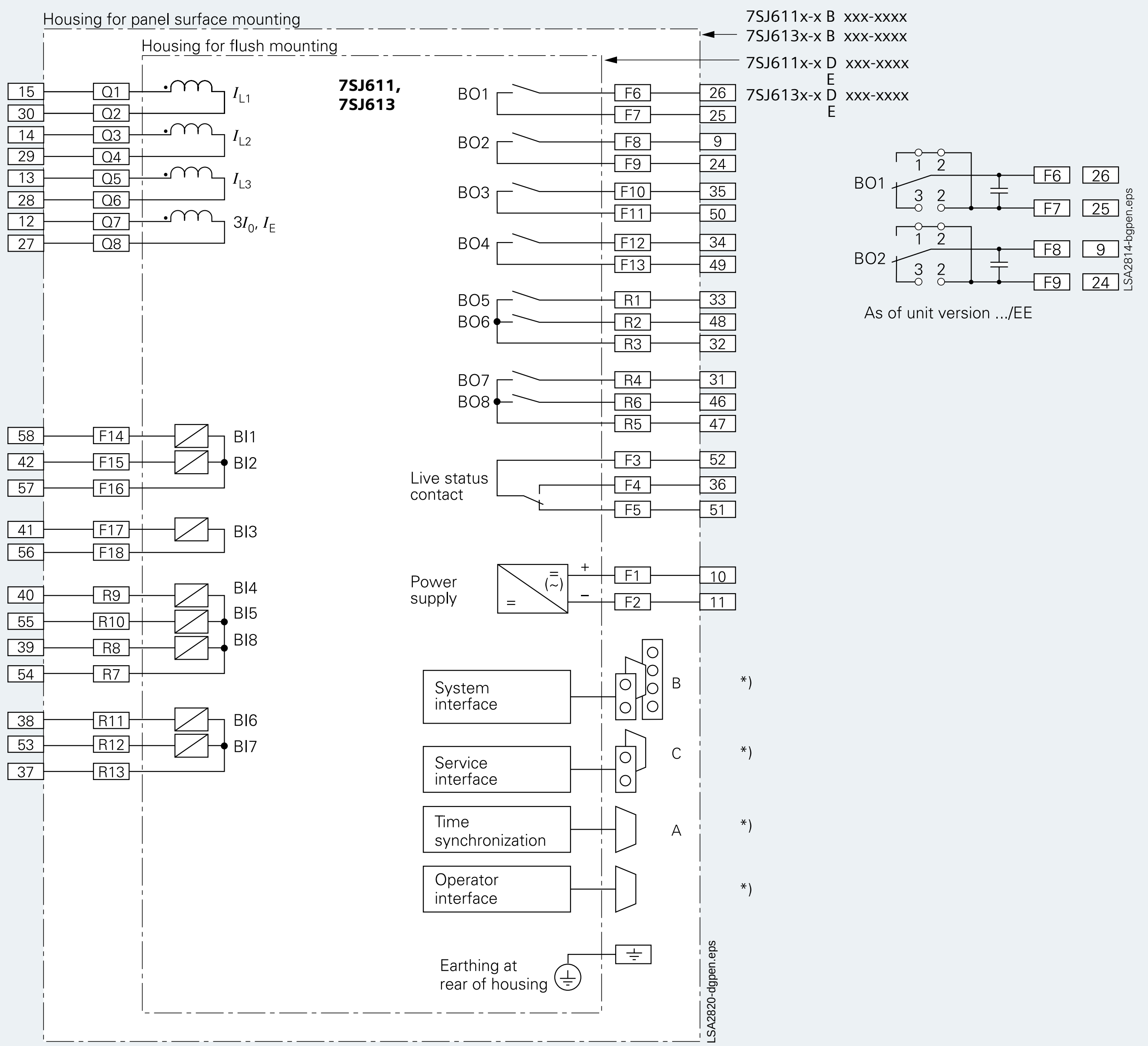
Connection diagram



*) 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. 5/17 7SJ610 connection diagram

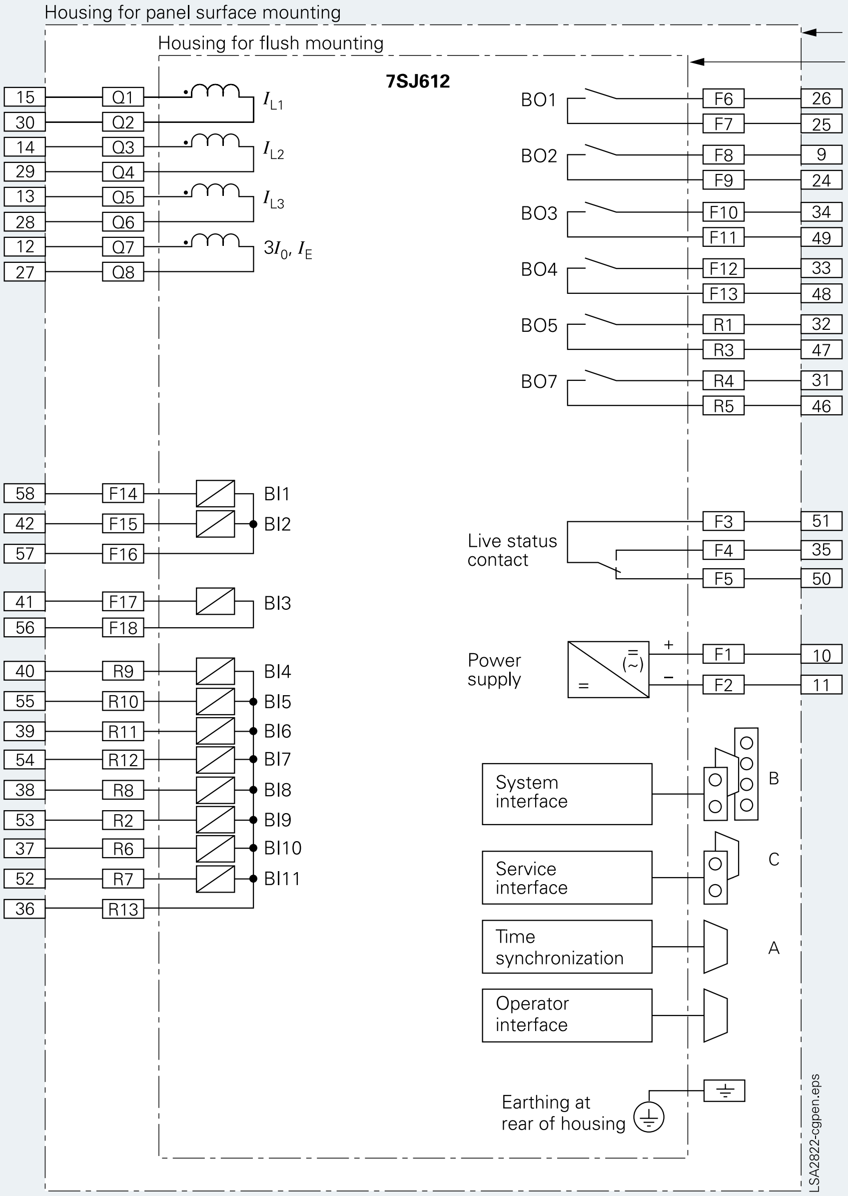
Connection diagram

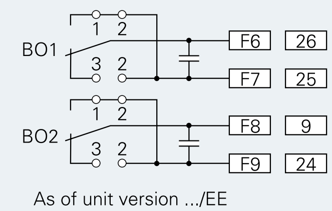


*) For pinout of communication ports see part 14 of this catalog.
For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siemens.com/siprotec).

Fig. 5/18 7SJ611, 7SJ613 connection diagram

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. 5/19 7SJ612, 7SJ614 connection diagram

SIPROTEC 7SJ62 multifunction protection relay

Fig. 5/20 Multifunction protection relay with text (left) and graphic display

Description

The SIPROTEC 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 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

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

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 DP
  – DNP 3/DNP3 TCP/MODBUS RTU
  – PROFINET
- 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

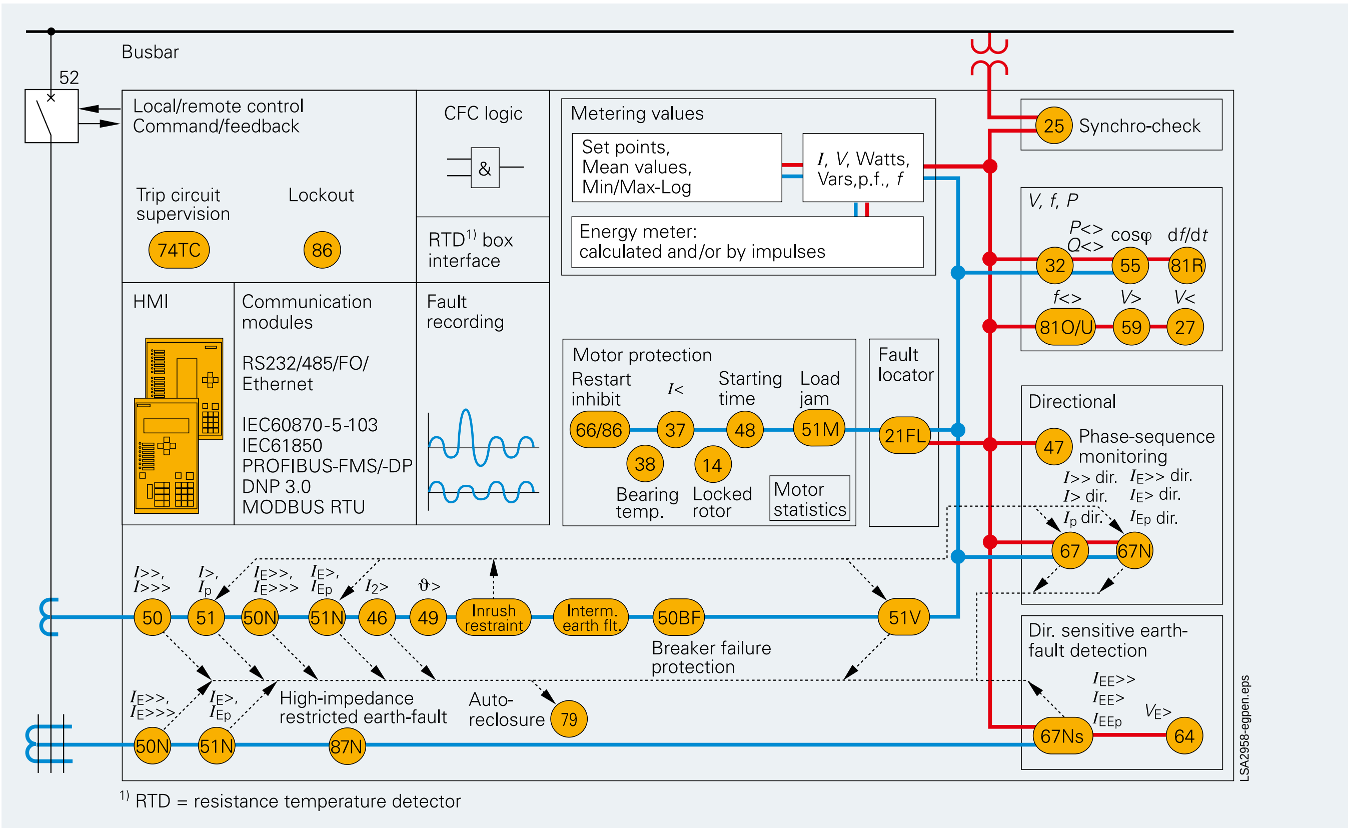


Fig. 5/21 Function diagram

Application

The SIPROTEC 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>, phase-sequence	Unbalance-voltage protection and / or phase-sequence monitoring
49	ϑ>	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 φ	Power factor protection
81O/U	f>, f<	Overfrequency / underfrequency protection
81R	df/dt	Rate-of-frequency-change protection
21FL		Fault locator

Construction, protection functions

Fig. 5/22 Rear view with screw-type terminals, 1/3-rack size

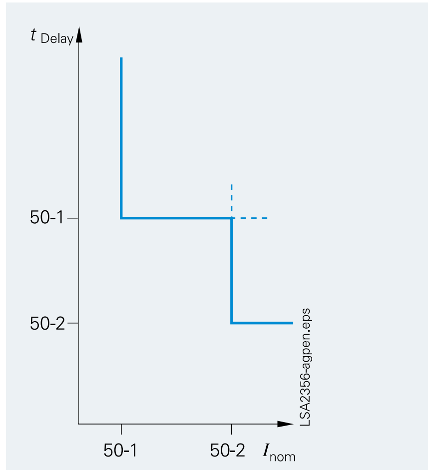


Fig. 5/23 Definite-time overcurrent protection

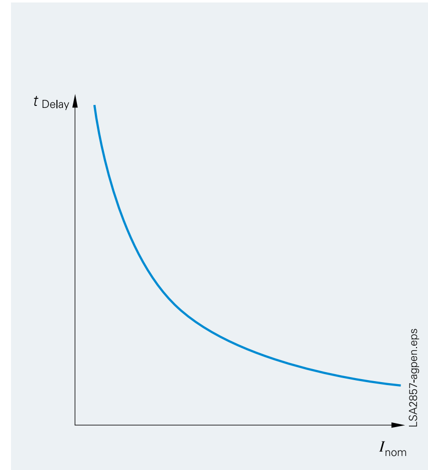


Fig. 5/24 Inverse-time overcurrent protection

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.

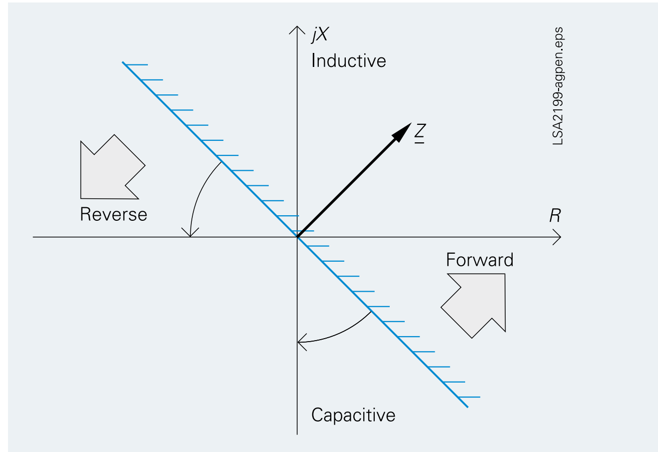


Fig. 5/25 Directional characteristic of the directional overcurrent protection

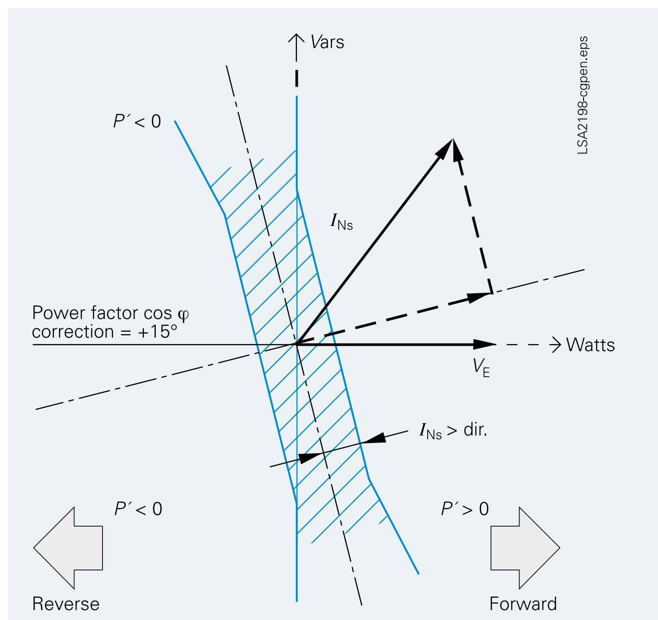


Fig. 5/26 Directional determination using cosine measurements for compensated networks

(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 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 summating 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 specifi cally 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.

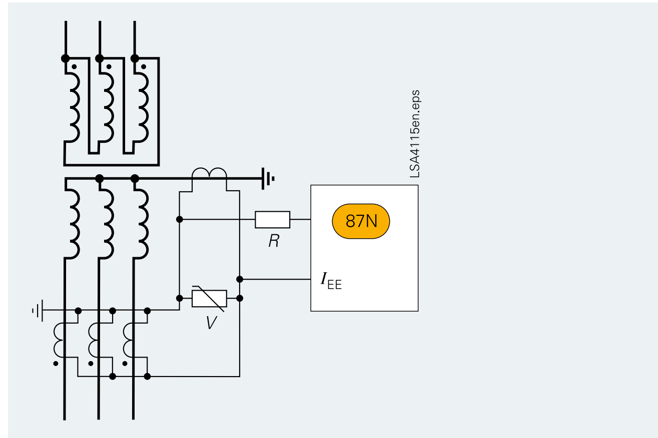


Fig. 5/27 High-impedance restricted ground-fault protection

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 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. 5/27). 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. 5/28). 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 φ (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)

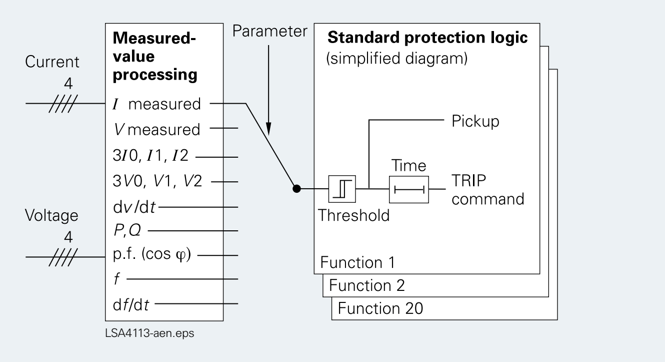


Fig. 5/28 Flexible protection functions

- 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

5

■ 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. 5/29).

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.

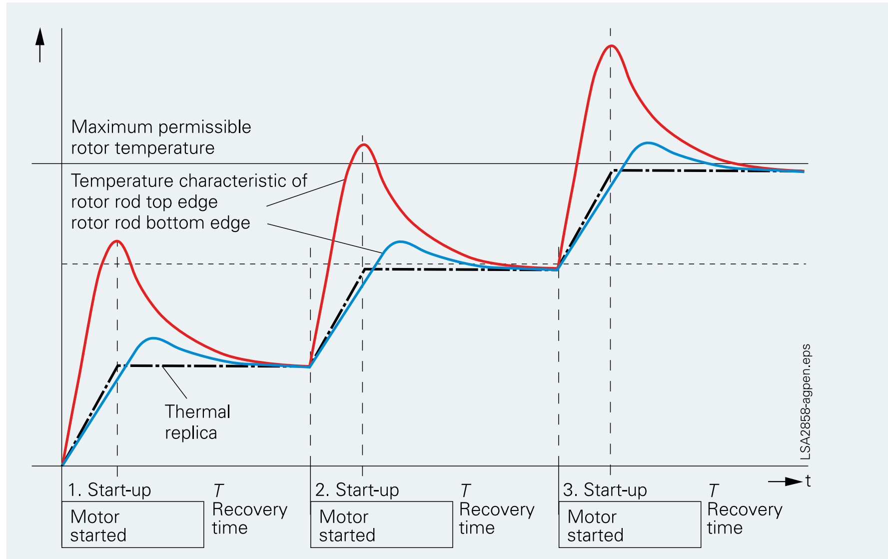


Fig. 5/29

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 (select- able 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... 3
- $\Sigma i^2 t$

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. 5/30) 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.

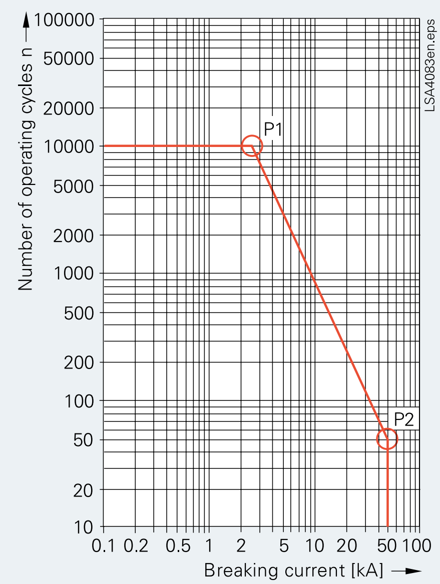


Fig. 5/30 CB switching cycle diagram

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.

5

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. 5/31 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 φ), (total and phase selective)
- Frequency
- Energy ± kWh, ± 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 interfaces[1)]

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.

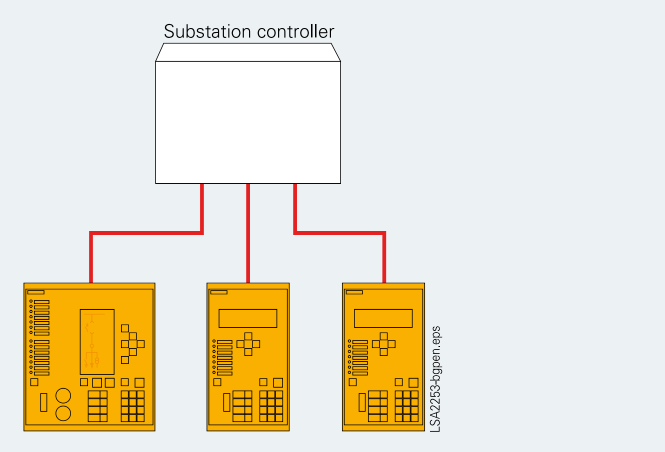


Fig. 5/32 IEC 60870-5-103: Radial fiber-optic connection

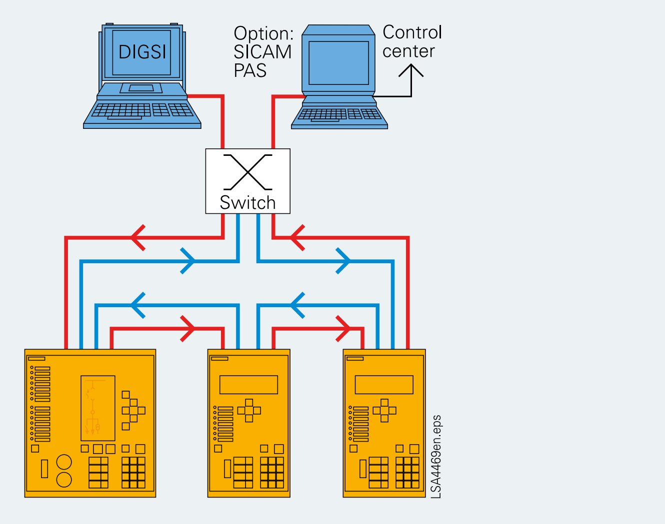


Fig. 5/33 Bus structure for station bus with Ethernet and IEC 61850, fiber-optic ring

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.

5

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 confi gurable 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.

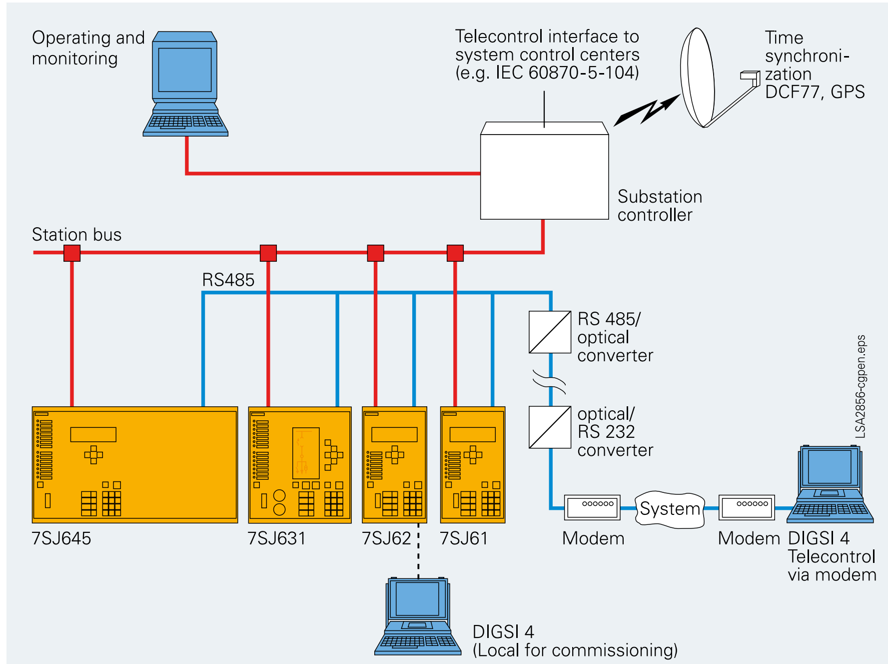


Fig. 5/34 System solution/communication

Fig. 5/35 Optical Ethernet communication module for IEC 61850 with integrated Ethernet-switch

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.

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS DP. 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. 5/32).

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. 5/33).

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.

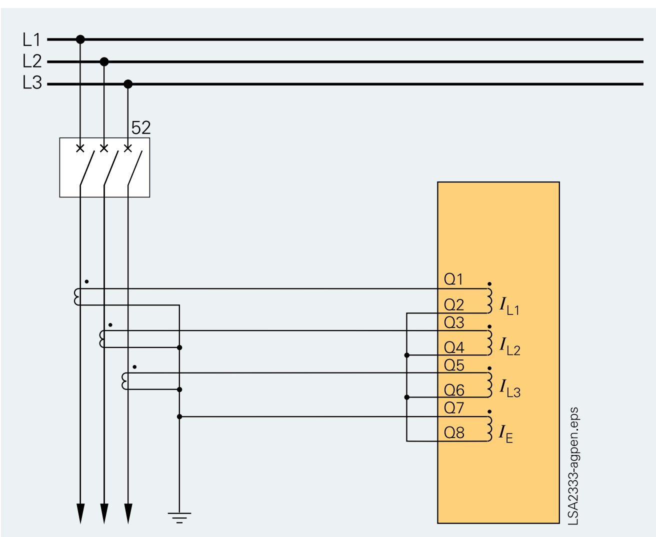


Fig. 5/36 Residual current circuit without directional element

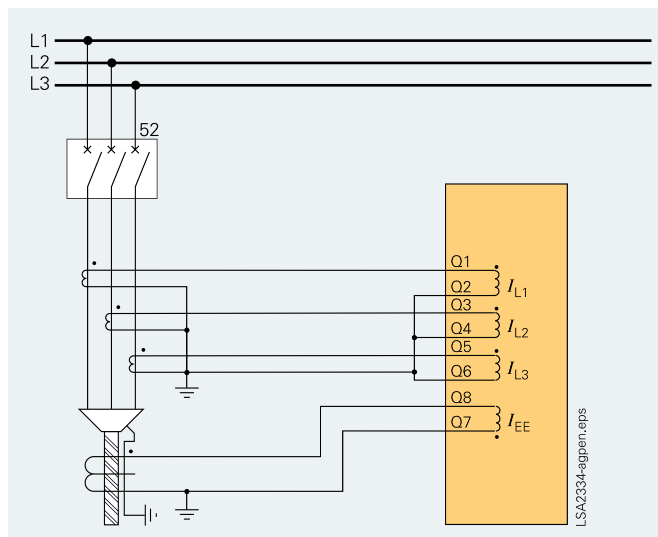


Fig. 5/37 Sensitive ground-current detection without directional element

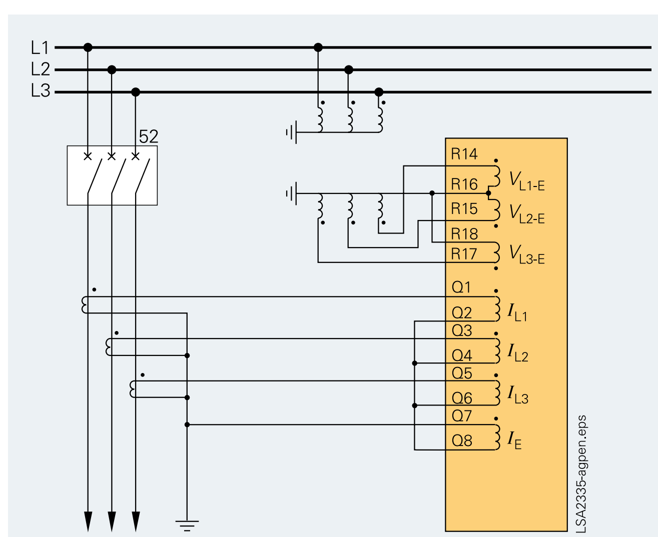


Fig. 5/38 Residual current circuit with directional element

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. 5/39 shows sensitive directional ground-fault detection.

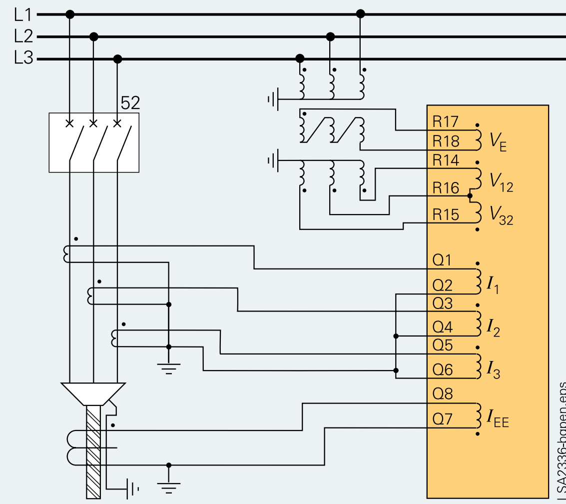


Fig. 5/39 Sensitive directional ground-fault detection with directional element for phases

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.

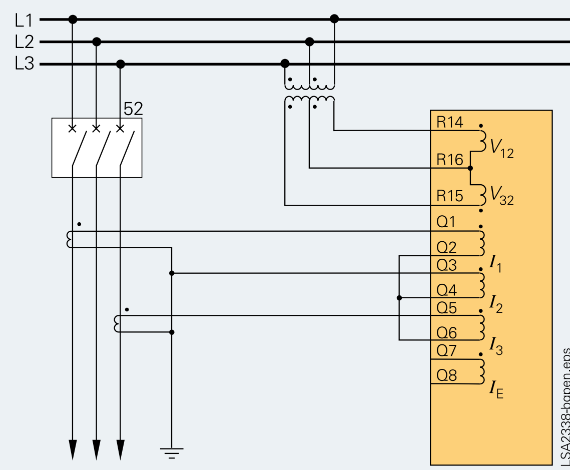


Fig. 5/40 Isolated-neutral or compensated networks

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.

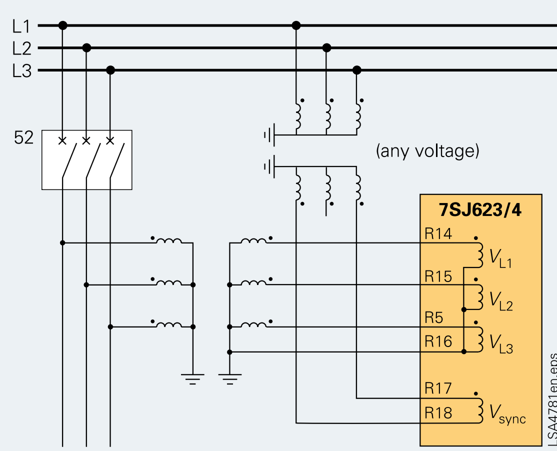


Fig. 5/41 Measuring of the busbar voltage and the outgoing feeder voltage for the synchro-check

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 φ measurement	Phase-balance neutral current transformers required	Phase-to-ground connection with open delta winding required

5

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. 5/42, 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. 5/43 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.

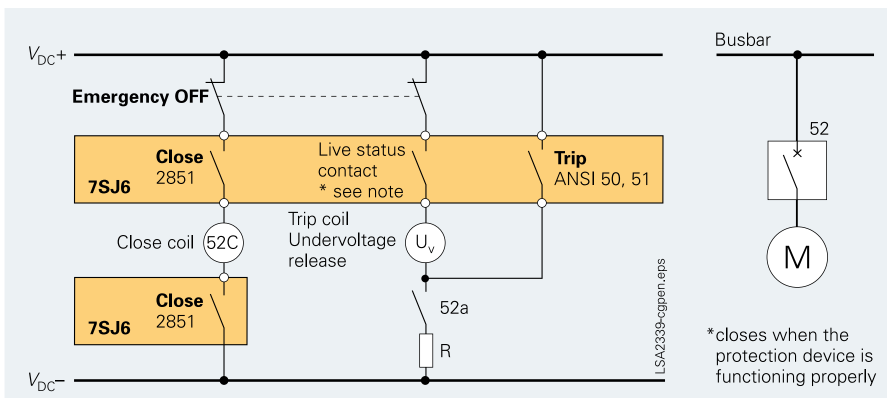


Fig. 5/42 Undervoltage release with make contact (50, 51)

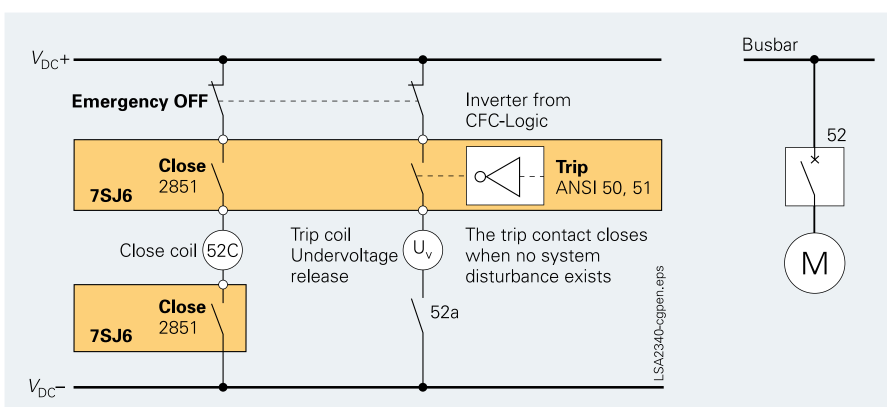


Fig. 5/43 Undervoltage trip with locking contact (trip signal 50 is inverted)

Trip circuit supervision (ANSI 74TC)

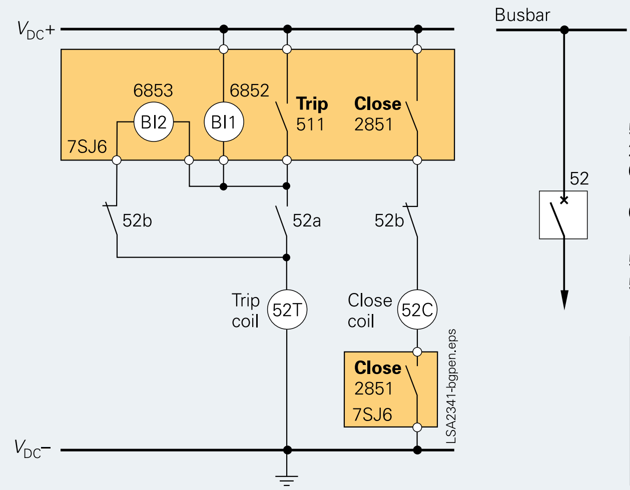
One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal occurs whenever the circuit is interrupted.

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.



Protection indications

511* General trip
2851* CB close command
6852* Trip circuit supervision: Trip relay
6853* Trip circuit supervision: CB aux

52a open, when CB is open
52b open, when CB is closed
BI Binary input

TRIP contact	Breaker	BI1	BI2
open	closed	H	L
open	open	H	H
closed	closed	L	L
closed	open	L	H

Fig. 5/44 Trip circuit supervision with 2 binary inputs

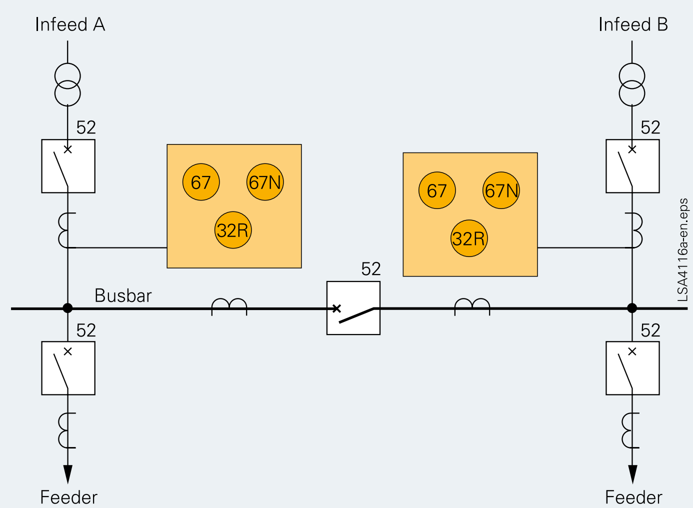


Fig. 5/45 Reverse-power protection for dual supply

General unit data			
Measuring circuits			
System frequency	50 / 60 Hz (settable)		
Current transformer			
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 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)		
Voltage transformer			
Type	7SJ621, 7SJ622,	7SJ623, 7SJ624,	7SJ625 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		

Auxiliary voltage				
Rated auxiliary voltage Vaux	DC 24 / 48 V AC	60 / 125 V	110 / 250 V 115 / 230 V	
Permissible tolerance	DC 19-58 V AC	48–150 V	88–300 V 92–138 V	 184–265 V
Ripple voltage, peak-to-peak	≤ 12 %			
Power consumption Quiescent Energized	 Approx. 4 W Approx. 7 W			
Backup time during loss/short circuit of auxiliary voltage	≥ 50 ms at V ≥ DC 110 V ≥ 20 ms at V ≥ DC 24 V ≥ 200 ms at 115 V / AC 230 V			

Binary inputs/indication inputs		
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, 7SJ623, 7SJ625,	7SJ622 7SJ624 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 ≤ 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	
Specification	
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; τ =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 Ω
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 Ω; test duration 1 min

5

Technical data

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	
<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 axe
<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

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 Flush-mounting housing	 4.5 kg 4.0 kg
Degree of protection acc. to EN 60529 Surface-mounting housing Flush-mounting housing Operator safety	 IP 51 Front: IP 51, rear: IP 20; IP 2x with cover

Futher information can be found in the current manual at:
www.siemens.com/siprotec

Description	Order No.
7SJ62 multifunction protection relay	7SJ62□□-□□□□□-□□□□
Housing, inputs, outputs	
Housing ▯19”, 4 line text display, 3 x U, 4 x I, 8 BI, 8 BO, 1 live status-contact	1
Housing ▯19”, 4 line text display, 3 x U, 4 x I, 11 BI,6 BO, 1 live status-contact	2
Housing ▯19”, 4 line text display, 4 x U, 4 x I, 8 BI, 8 BO, 1 live status-contact	3
Housing ▯19”, 4 line text display, 4 x U, 4 x I, 11 BI,6 BO, 1 live status-contact	4
Housing ½19”, graphic display, 4 x U, 4 x I,8 BI, 8 BO, 1 live status contact 7)	5
Housing ½19”, 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

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 81O/U 27/Q 27/47/59(N) 32/55/81R	Under-/overvoltage Under-/overfrequency Undervoltage-controlled reactive power protection 3) 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 81O/U 27/Q 27/47/59(N) 32/55/81R	Under-/overvoltage Under-/overfrequency Undervoltage-controlled reactive power protection 3) 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 27/59 81O/U 27/Q 27/47/59(N) 32/55/81R	Direction determination for overcurrent, phases and ground Under-/overvoltage Under-/overfrequency Undervoltage-controlled reactive power protection 3) 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 27/59 81U/O 27/Q 27/47/59(N) 32/55/81R	Direction determination for overcurrent, phases and ground Intermittent ground fault protection Under-/overvoltage Under-/overfrequency Undervoltage-controlled reactive power protection 3) Flexible protection functions (quantities derived from current & voltages): Voltage-/power-/p.f.-/rate of freq. change-protection Intermittent ground-fault		P G
Sens.ground-f.det. ■ Dir REF	67/67N 67Ns 67Ns 87N	Direction determination for overcurrent, phases and ground Directional sensitive ground-fault detection Directional intermittent ground fault protection 3) 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

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		
Sens.ground-f.det. *V, P, f*	67Ns	Directional sensitive ground-fault detection		
V,P,f REF	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		
	32/55/81R	current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		F F [2]
Sens.ground-f.det.	67/67N	Direction determination for overcurrent, phases and ground		
Dir IEF REF	67Ns	Directional sensitive ground-fault detection		
■	67Ns	Directional intermittent ground fault protection [3]		
	87N	High-impedance restricted ground fault		
		Intermittent ground faults		P D [2]
Sens.ground-f.det.	67Ns	Directional sensitive ground-fault detection		
REF	67Ns	Directional intermittent ground fault protection [3]		
■	87N	High-impedance restricted ground fault		F B [2]
Sens.ground-f.det. Motor	67Ns	Directional sensitive ground-fault detection		
V,P,f REF	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		
	32/55/81R	current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		H F [2]
Sens.ground-f.det. Motor	67/67N	Direction determination for overcurrent, phases and ground		
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		
	32/55/81R	current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		H H [2]

■ 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

Continued on next page

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	
Sens.ground-f.det. Motor IEF Dir IEF 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 4)	
	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 3)	
	27/47/59(N) 32/55/81R	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 Dir	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	
	81O/U	Under-/overfrequency	
	27/Q	Undervoltage-controlled reactive power protection 3)	
	27/47/59(N) 32/55/81R	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
	25, 79,21FL	With synchro-check 3), auto-reclosure, fault locator	7

■ 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, 7SJ624, 7SJ625 and 7SJ626.

4) with FW V4.90

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 DP Slave, RS485	9	L 0 A
PROFIBUS DP Slave, 820 nm wavelength, double ring, ST connector 1)	9	L 0 B
MODBUS, RS485	9	L 0 D
MODBUS, 820 nm wavelength, ST connector 2)	9	L 0 E
DNP 3.0, RS485	9	L 0 G
DNP 3.0, 820 nm wavelength, ST connector 2)	9	L 0 H
IEC 60870-5-103 protocol, redundant, RS485, RJ45 connector 2)	9	L 0 P
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector (EN 100)	9	L 0 R
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector (EN 100)2)	9	L 0 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

5

Sample order

Position		Order No. + Order code
		7SJ622 5 - 5 E C 9 1 - 3 F A 1 + L 0 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 L 0 G
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

Selection and ordering data

Accessories	Description	Order No.
	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.).


LSP2289-afp.eps

Mounting rail


LSP2090-afp.eps

2-pin connector


LSP2091-afp.eps

3-pin connector


LSP2093-afp.eps

Short-circuit links for current terminals

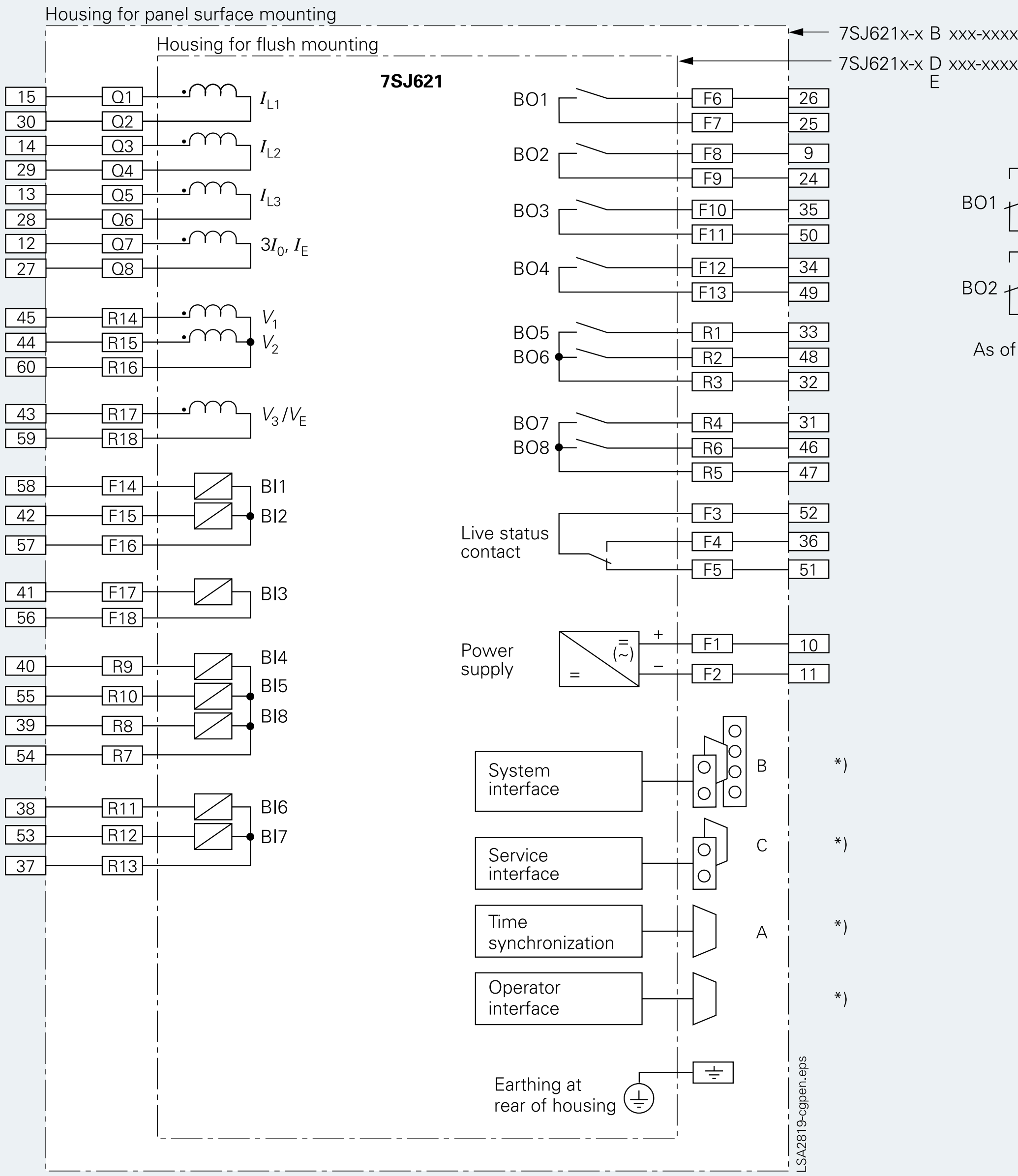

LSP2092-afp.eps

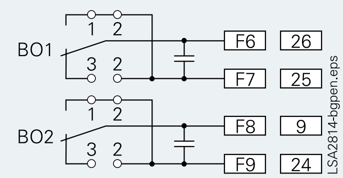
Short-circuit links for current terminals

Description	Order No.	Size of package	Supplier
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	1)
Crimp connector CI2 0.5 to 1 mm^2	**0-827396-1**	1	1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	**0-163084-2**	1	1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	**0-163083-7**	4000 taped on reel	1)
Crimping tool for Type III+	**0-539635-1**	1	1)
and matching female	**0-539668-2**	1	1)
Crimping tool for CI2	**0-734372-1**	1	1)
and matching female	**1-734387-1**	1	1)
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

1) Your local Siemens representative can inform you on local suppliers.

5

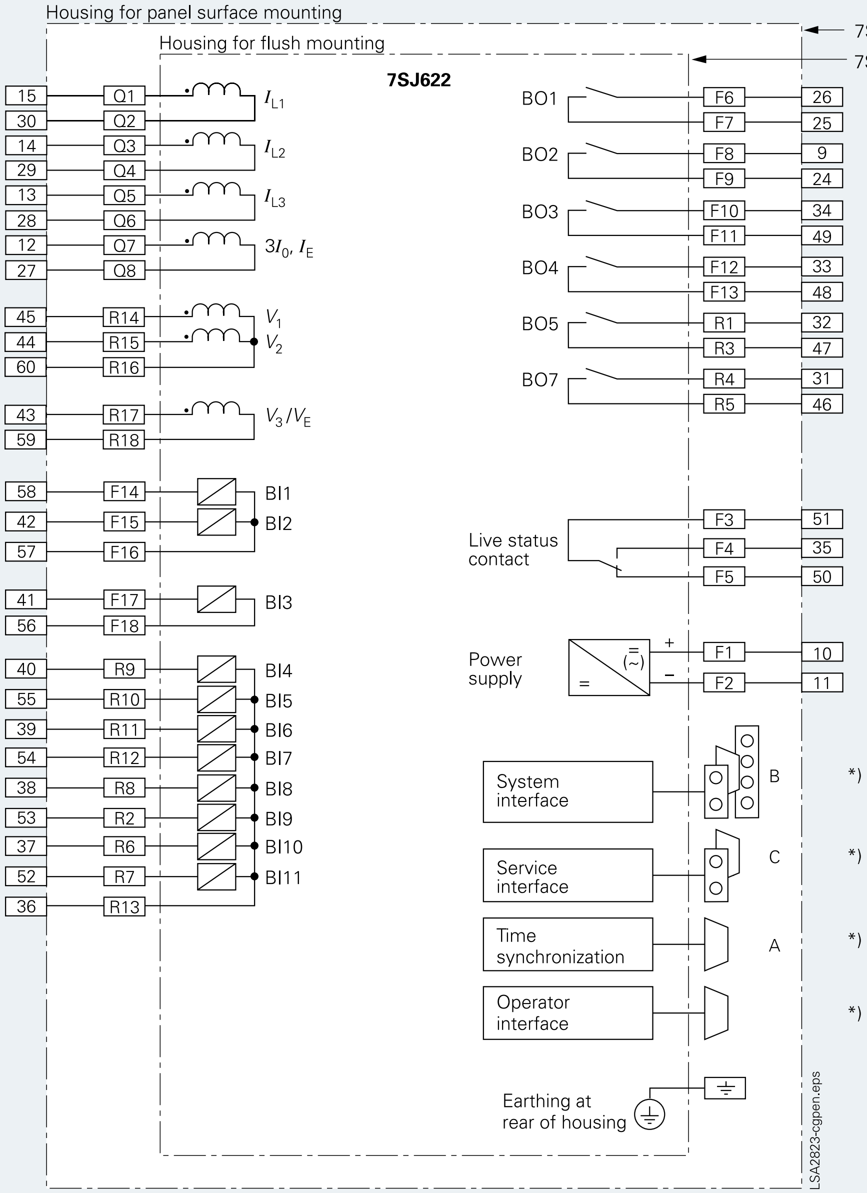


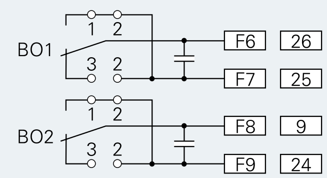


*) For pinout of communication ports see part 14 of this catalog.
For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siemens.com/siprotec).

Fig. 5/46 7SJ621 connection diagram

Connection diagram

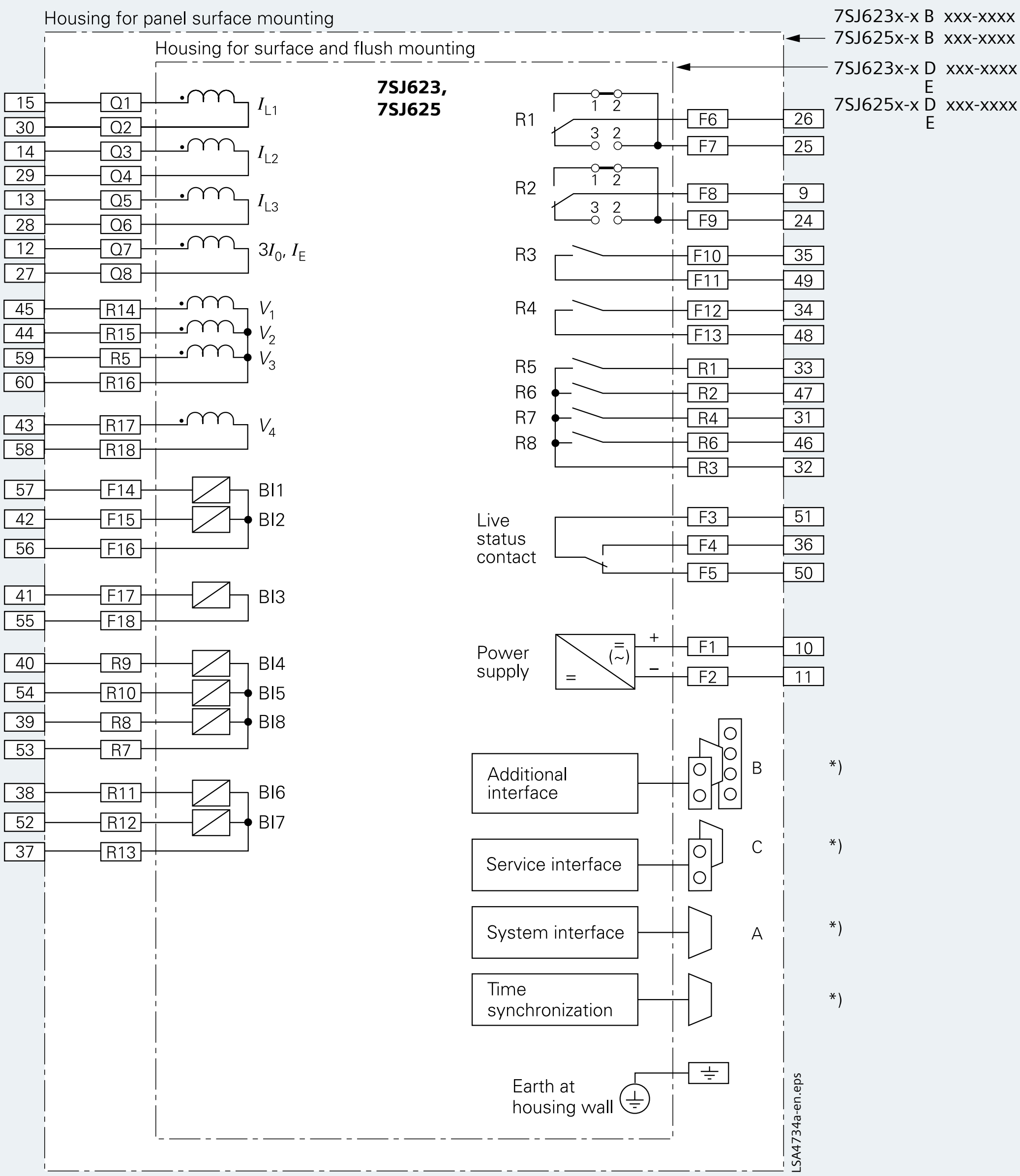




As of unit version .../EE

*) 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).

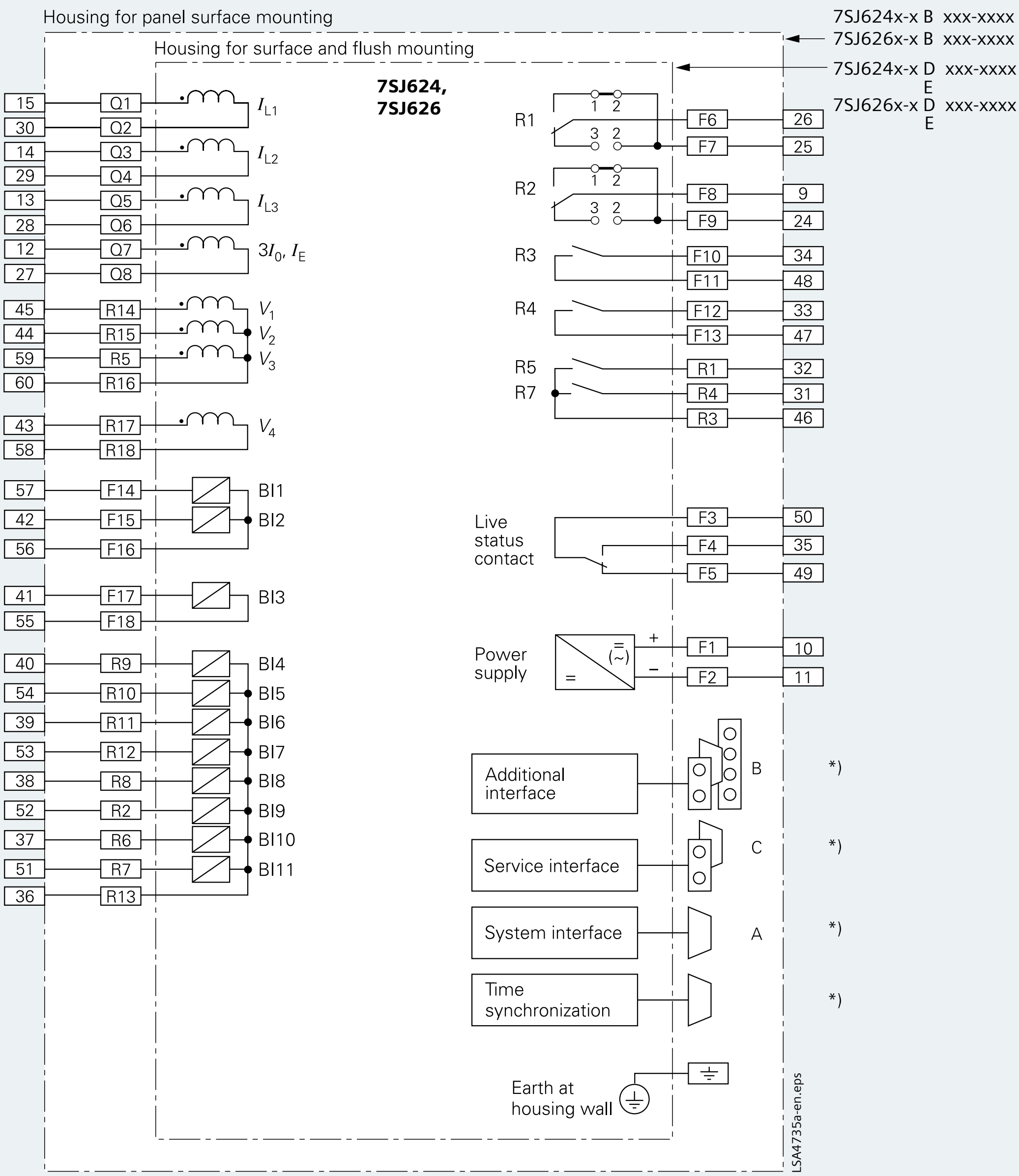
Fig. 5/47 7SJ622 connection diagram



*) 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. 5/48 7SJ623, 7SJ625 connection diagram

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. 5/49 7SJ624, 7SJ626 connection diagram

SIPROTEC 7SJ64 multifunction protection relay with synchronization

Fig. 5/50 SIPROTEC 7SJ64 multifunction protection relay

Description

The SIPROTEC 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 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 $V, I, f, \ldots$
- 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 DP
  – DNP 3 / DNP3 TCP / MODBUS RTU
  – PROFINET
- Service interface for DIGSI 4 (modem)
- Additional interface for temperature detection (RTD-box)
- Front interface for DIGSI 4
- Time synchronization via IRIG B/DCF77

Application

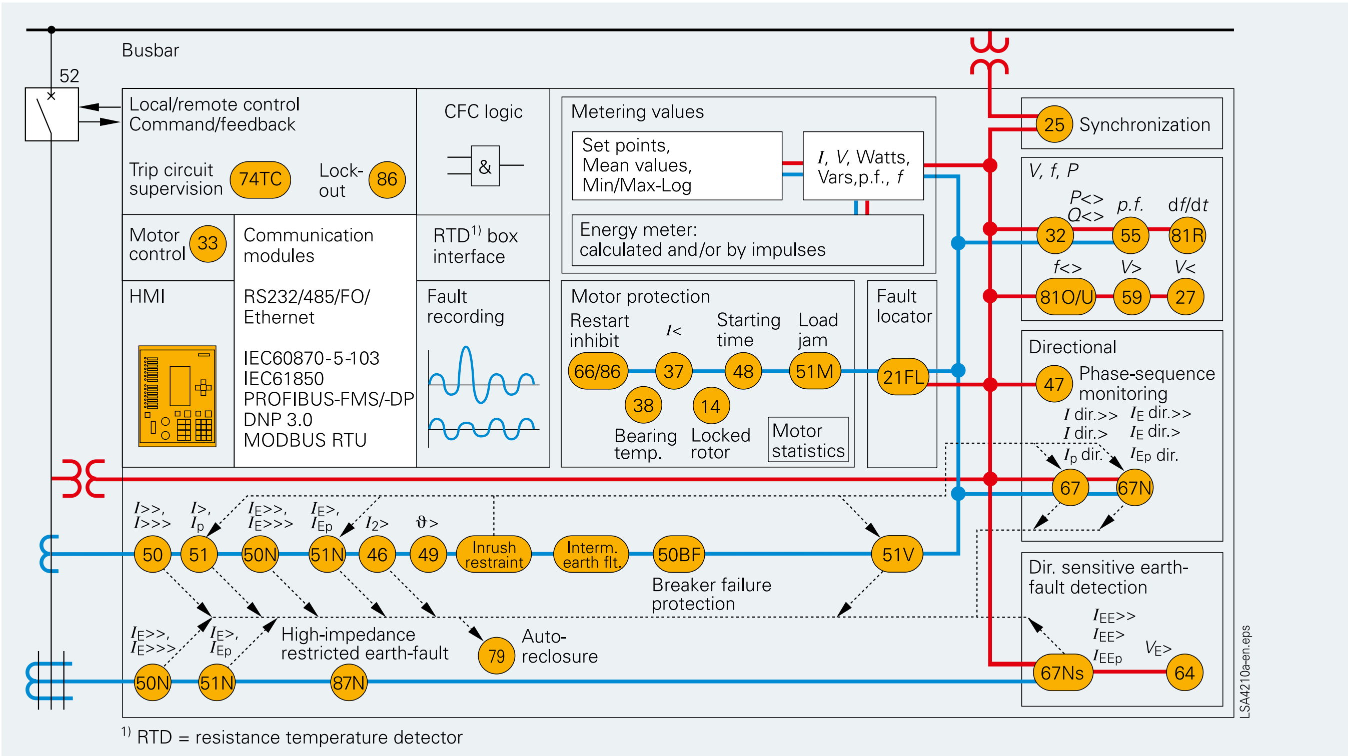


Fig. 5/51 Function diagram

Application

The SIPROTEC 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.

5

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	$I_{dir}>$, $I_{dir}>>$, $I_{p\ dir}$ $I_{Edir}>$, $I_{Edir}>>$, $I_{Ep\ dir}$	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	$V_2>$, 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

Construction

Connection techniques and housing with many advantages

⅓, ½ and 1/1-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 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. 5/91), or without operator panel, in order to allow optimum operation for all types of applications.

Fig. 5/52 Flush-mounting housing with screw-type terminals

Fig. 5/53 Front view of 7SJ64 with ⅓ × 19" housing

Fig. 5/54 Housing with plug-in terminals and detached operator panel

Fig. 5/55 Surface-mounting housing with screw-type terminals

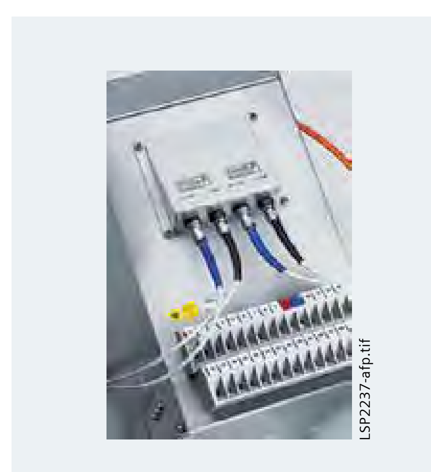


Fig. 5/56 Communication interfaces in a sloped case in a surface-mounting housing

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 over-current 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).

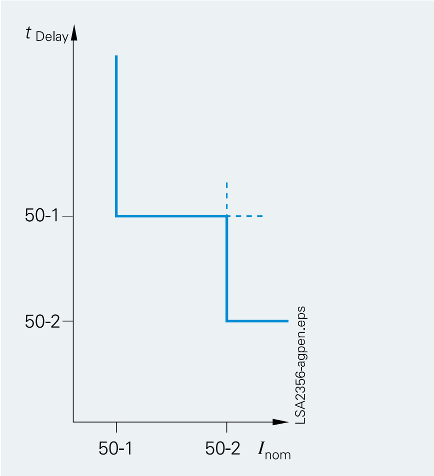


Fig. 5/57 Definite-time overcurrent protection

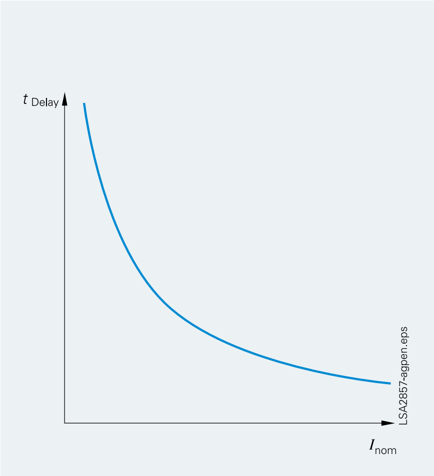


Fig. 5/58 Inverse-time overcurrent protection

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	•	

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.

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).

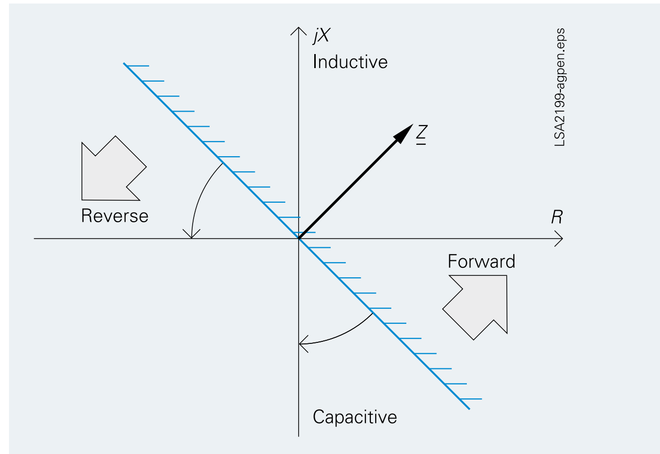


Fig. 5/59 Directional characteristic of the directional overcurrent protection

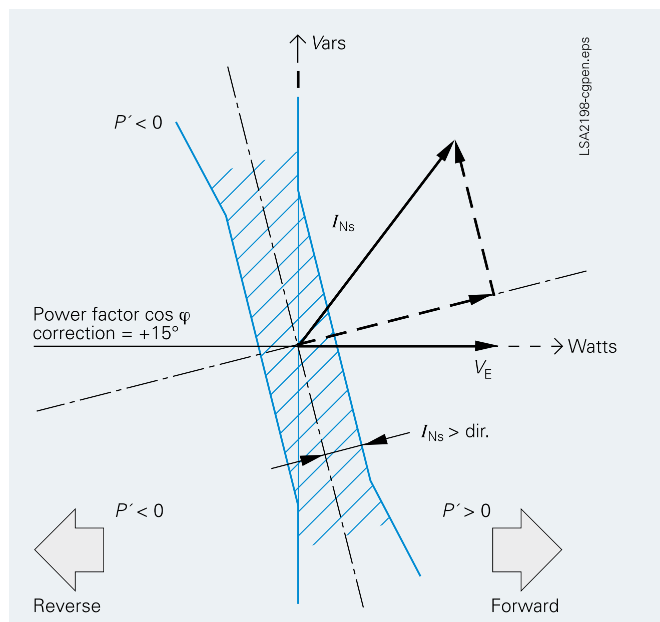


Fig. 5/60 Directional determination using cosine measurements for compensated networks

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 summating 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.

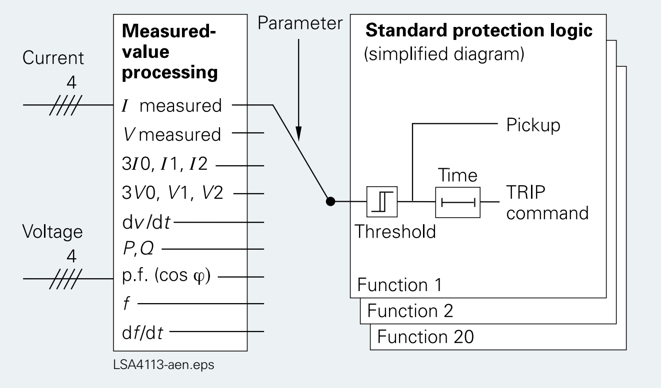


Fig. 5/61 Flexible protection functions

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. 5/98). 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 φ (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.

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-existant. 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.

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. 5/99). 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

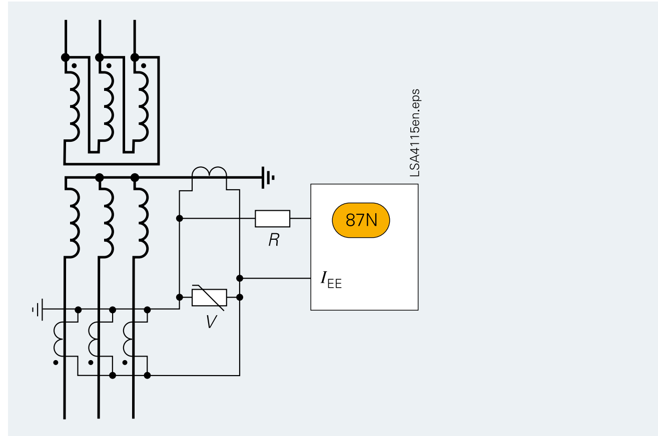


Fig. 5/62 High-impedance restricted ground-fault protection

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. 5/100).

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 $I > I_{MOTOR\ START}$

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

I = Actual current flowing

$I_{MOTOR\ START}$ = 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.

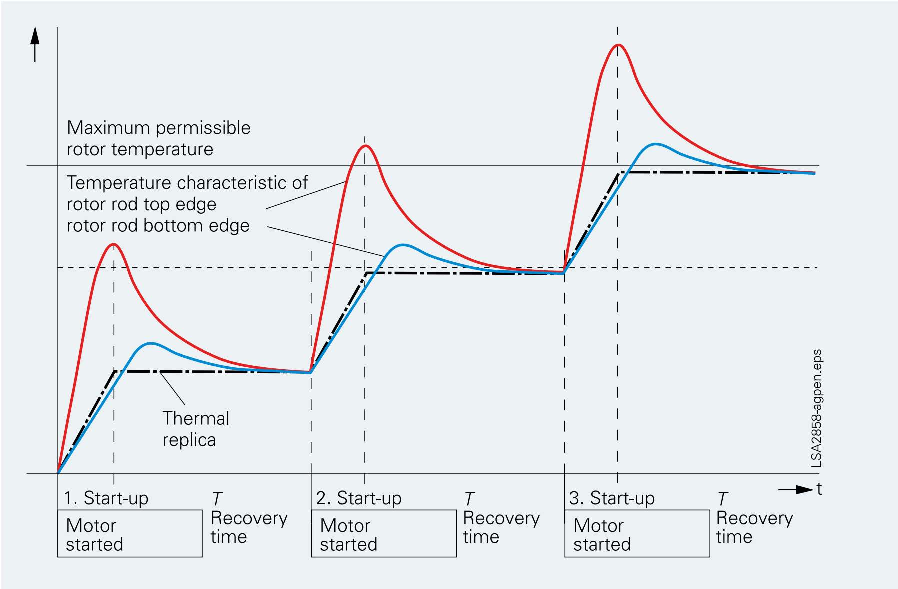


Fig. 5/63

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

5

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... 3
- $\Sigma I^2 t$

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. 5/101) 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.

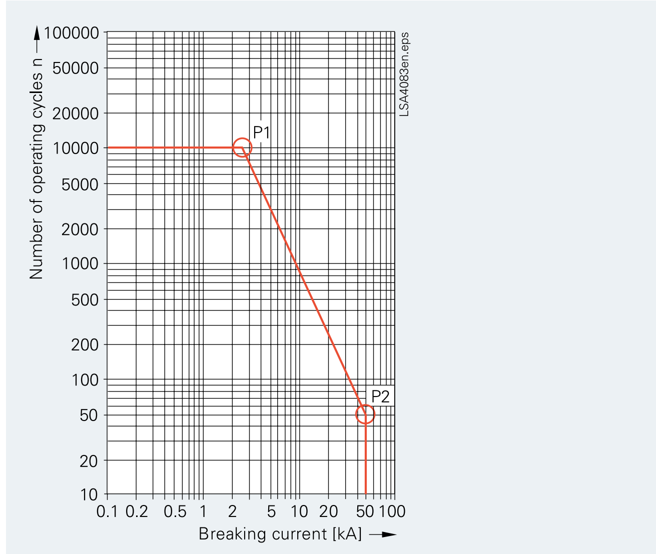


Fig. 5/64 CB switching cycle diagram

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 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

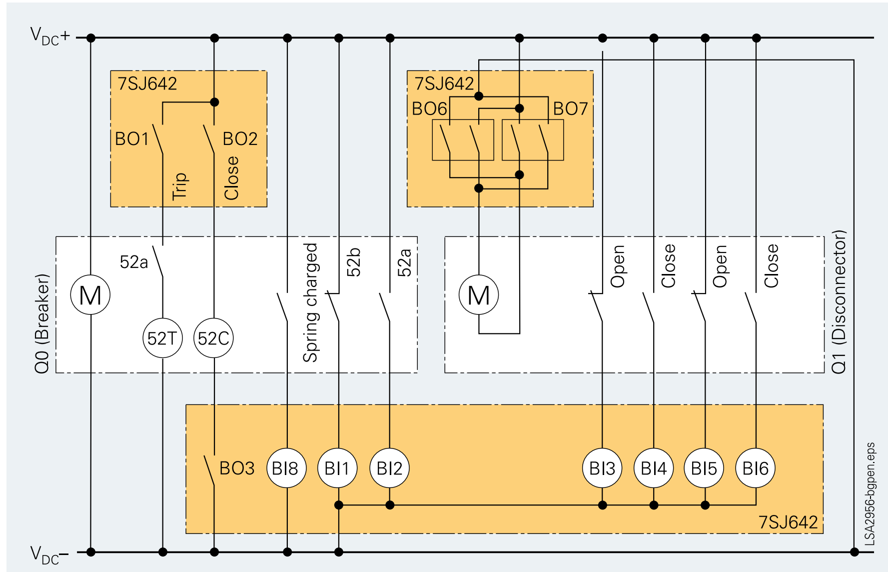


Fig. 5/65 Typical wiring for 7SJ642 motor direct control (simplified representation without fuses). Binary output BO6 and BO7 are interlocked so that only one set of contacts are closed at a time.

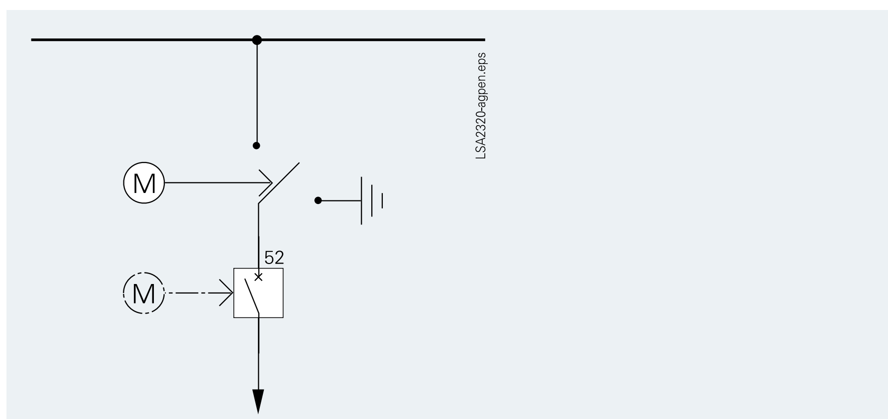


Fig. 5/66 Example: Single busbar with circuit-breaker and motor-controlled three-position switch

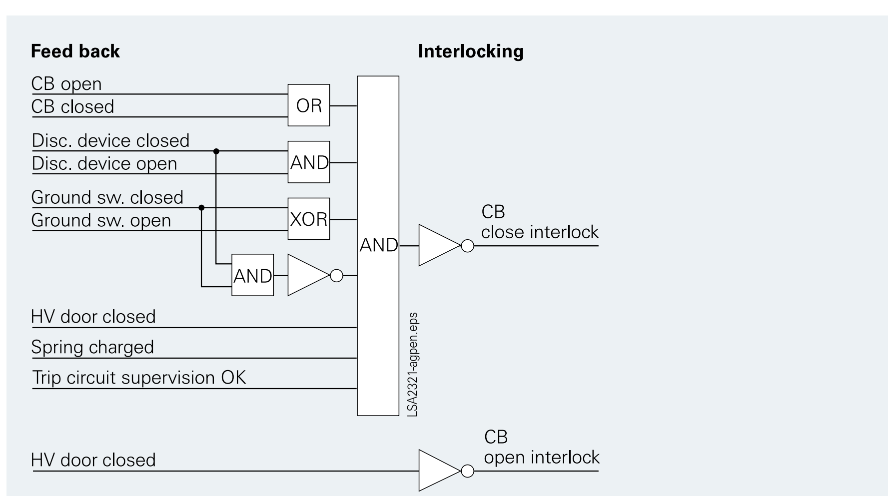


Fig. 5/67 Example: Circuit-breaker interlocking indication is passed on only if the indication voltage is still present after a set period of time.

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 φ), (total and phase selective)
- Frequency
- Energy ± kWh, ± 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. 5/68 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 interfaces[1)]

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.

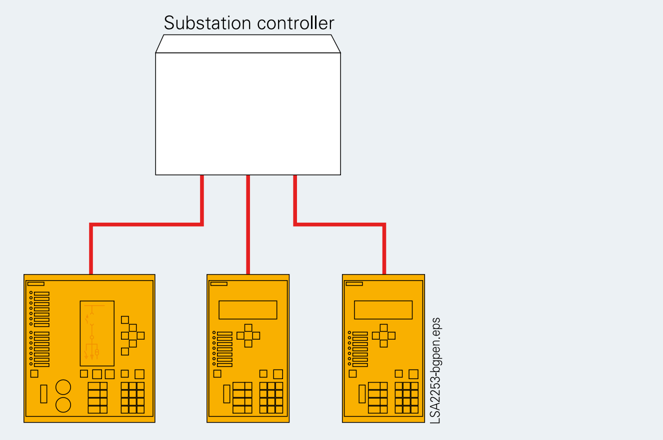


Fig. 5/69 IEC 60870-5-103: Radial fiber-optic connection

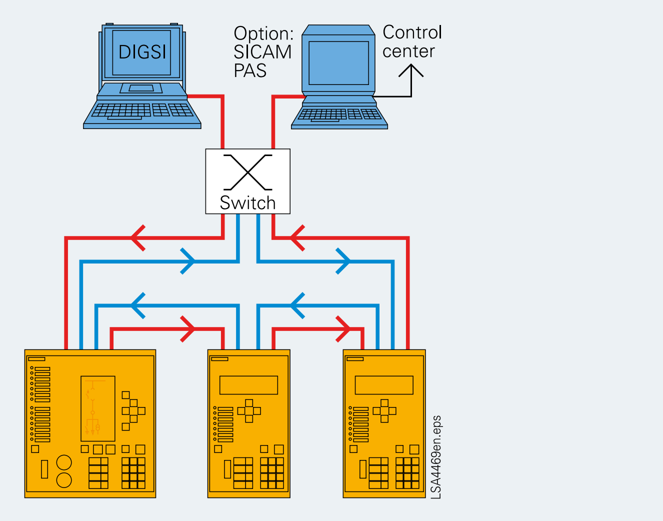


Fig. 5/70 Bus structure for station bus with Ethernet and IEC 61850, fiber-optic ring

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.

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.

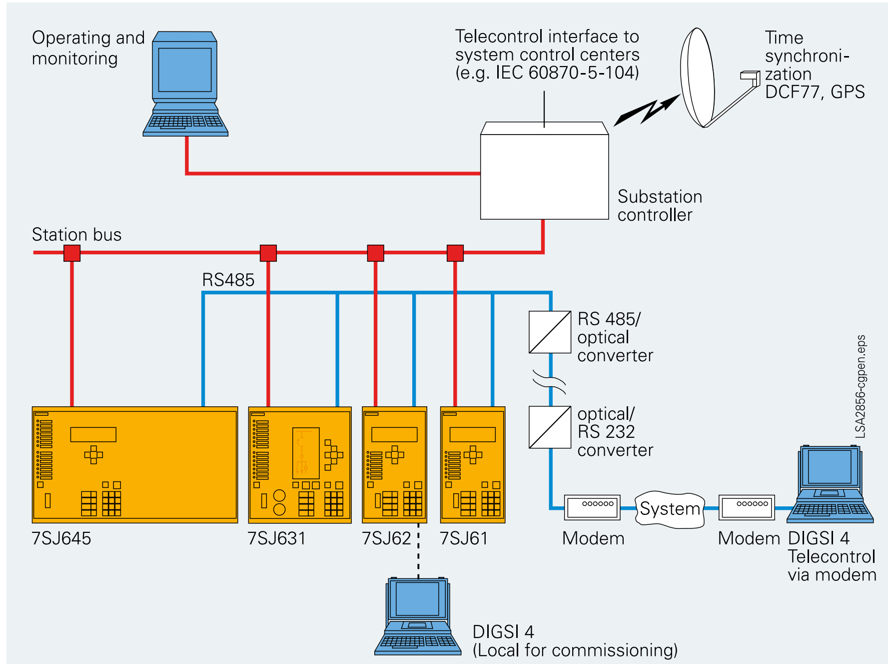


Fig. 5/71 System solution/communication

Fig. 5/72 Optical Ethernet communication module for IEC 61850 with integrated Ethernet-switch

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 confi gured 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 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 DP. 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. 5/106).

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. 5/107).

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.

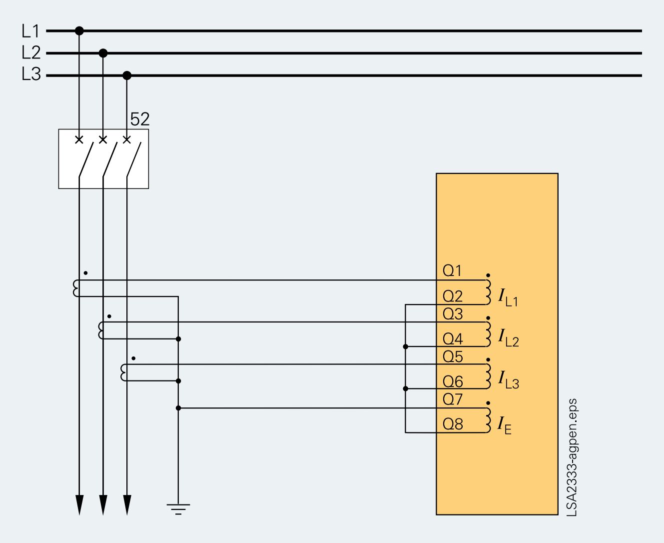


Fig. 5/73 Residual current circuit without directional element

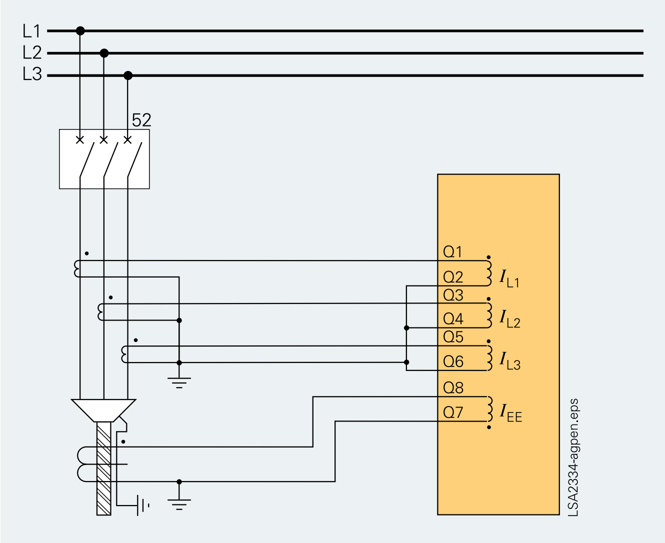


Fig. 5/74 Sensitive ground current detection without directional element

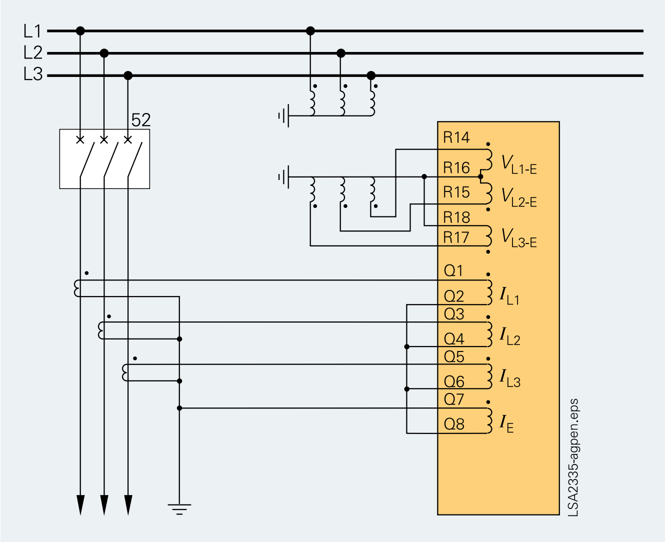


Fig. 5/75 Residual current circuit with directional element

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. 5/113 shows sensitive directional ground-fault detection.

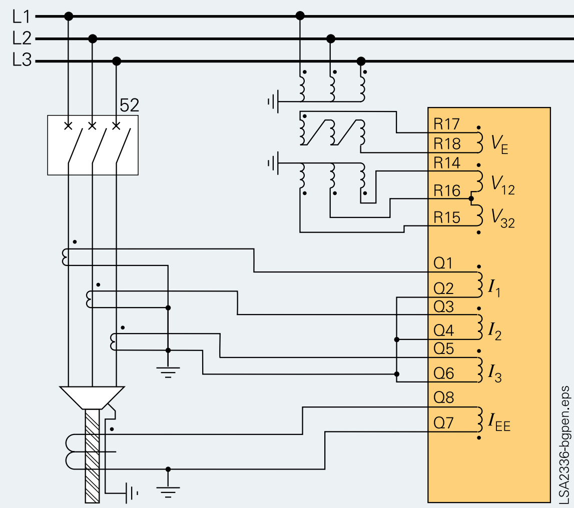


Fig. 5/76 Sensitive directional ground-fault detection with directional element for phases

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.

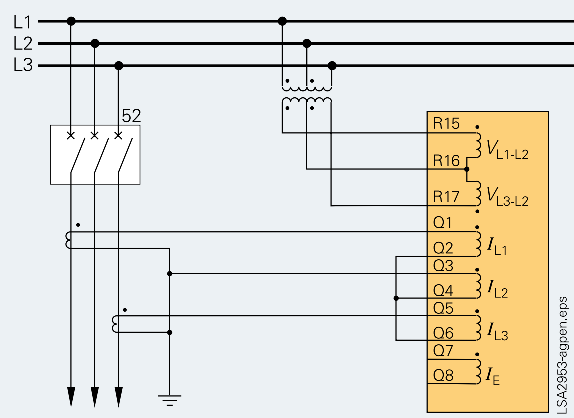


Fig. 5/77 Isolated-neutral or compensated networks

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.

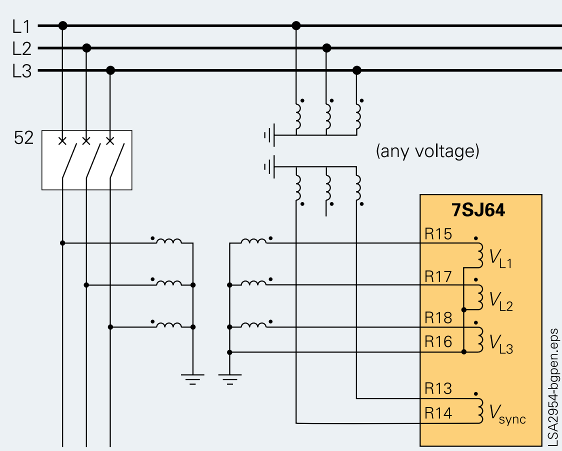


Fig. 5/78 Measuring of the busbar voltage and the outgoing feeder voltage for synchronization

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 φ measurement	Phase-balance neutral current transformers required	Phase-to-ground connection with open delta winding required

Typical applications

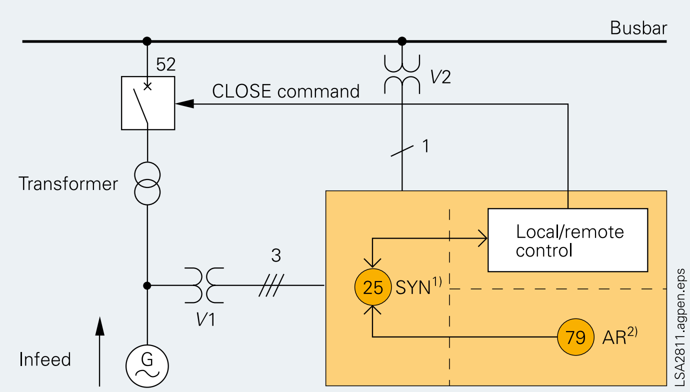
Application examples

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. 5/116, 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.



1) Synchronization function
2) Auto-reclosure function

Fig. 5/79 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).

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.

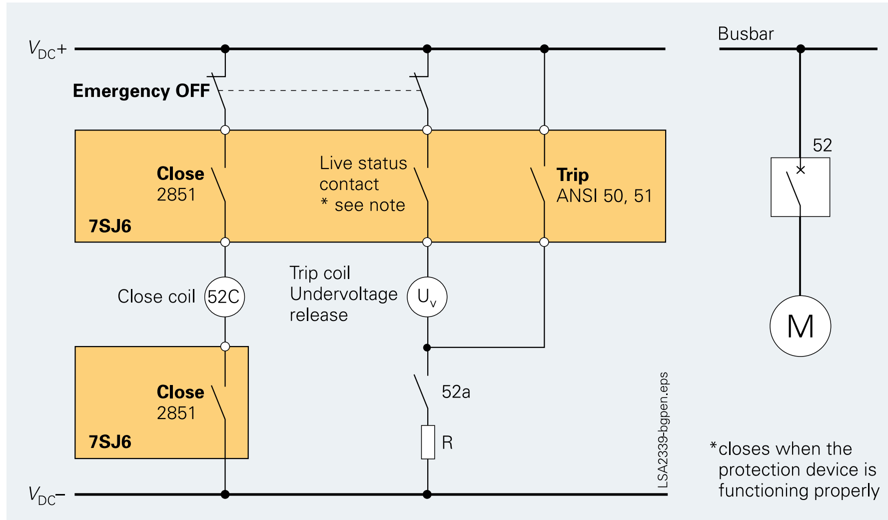


Fig. 5/80 Undervoltage release with make contact 50, 51

In Fig. 5/118 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.

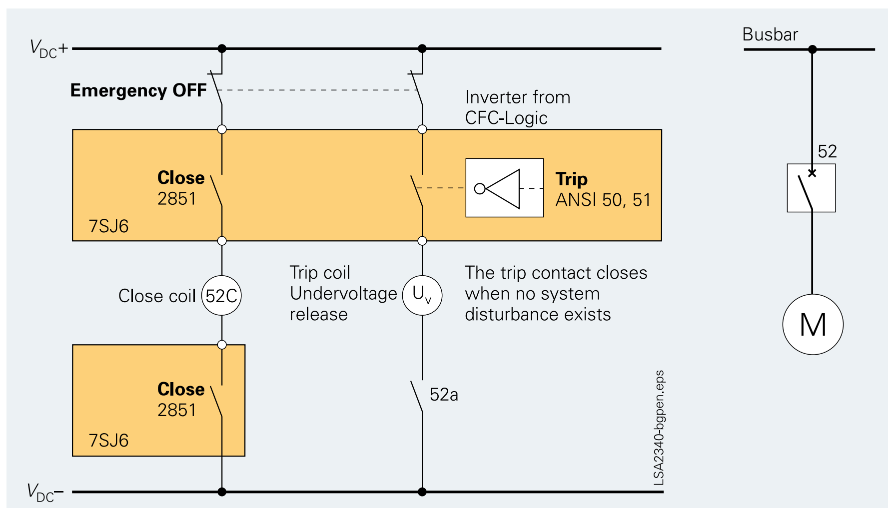


Fig. 5/81 Undervoltage release with locking contact (trip signal 50 is inverted)

Trip circuit supervision (ANSI 74TC)

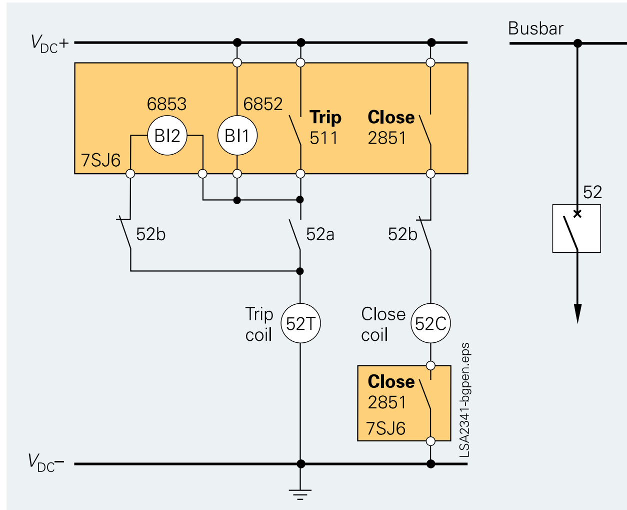
One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal occurs whenever the circuit is interrupted.

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.



Protection indications

511* General trip
2851* CB close command
6852* Trip circuit supervision: Trip relay
6853* Trip circuit supervision: CB aux

52a open, when CB is open
52b open, when CB is closed
BI Binary input

TRIP contact	Breaker	BI1	BI2
open	closed	H	L
open	open	H	H
closed	closed	L	L
closed	open	L	H

Fig. 5/82 Trip circuit supervision with 2 binary inputs

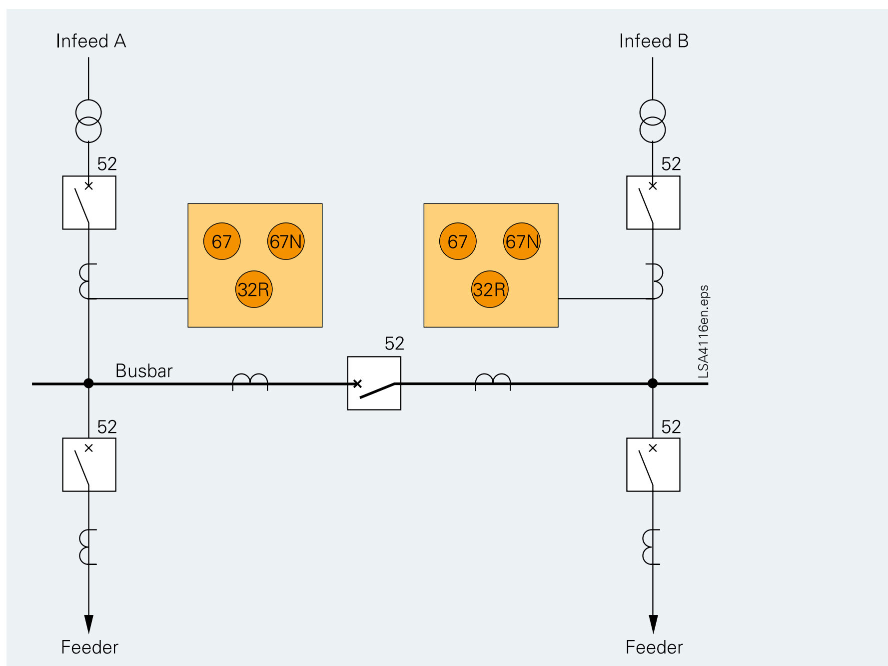


Fig. 5/83 Reverse-power protection for dual supply

General unit data					
Measuring circuits					
System frequency	50 / 60 Hz (settable)				
Current transformer					
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)				
Voltage transformer					
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				
Auxiliary voltage (via integrated converter)					
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 7SJ642	7SJ645	7SJ647
Quiescent Energized	Approx. 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 7SJ642	7SJ645	7SJ647
Quiescent Energized	Approx. 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				
Binary outputs/command outputs					
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				
Power relay (for motor control)					
Type	7SJ640 7SJ641	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	
Specification	
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; τ =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 Ω
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 Ω; 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
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	
<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

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			
Type	7SJ640 7SJ642	7SJ641	7SJ645 7SJ647
Housing	7XP20		
Dimensions	See dimension drawings, part 14 of this catalog		
Weight in kg	Housing width [illegible]	Housing width ½	Housing width [illegible]
Surface-mounting housing	8	11	15
Flush-mounting housing	5	6	10
Housing for detached operator operator panel	–	8	12
Detached operator panel	–	2.5	2.5
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		

Futher information can be found in the current manual at:
www.siemens.com/siprotec

Description	Order No.
7SJ64 multifunction protection relay with synchronization	7SJ64□□-□□□□□-□□□□
Housing, binary inputs and outputs	
Housing 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 ½ 19”, 15 BI, 13 BO (1 NO/NC or 1a/b contact), 1 live status contact, graphic display	1
Housing ½ 19”, 20 BI, 8 BO, 2 power relays (4 contacts), 1 live status contact, graphic display	2
Housing 19”, 33 BI, 11 BO, 4 power relays (8 contacts), 1 live status contact, graphic display	5
Housing 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 = 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, binary inputs)	
DC 24 to 48 V, threshold binary input DC 19 V [3)]	2
DC 60 to 125 V [2)], threshold binary input DC19 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 housingg	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

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.

5

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	
IEC 60870-5-103 protocol, RS485	2	
IEC 60870-5-103 protocol, 820 nm fiber, ST connector	3	
PROFIBUS DP Slave, RS485	9	L 0 A
PROFIBUS DP Slave, 820 nm wavelength, double ring, ST connector 1)	9	L 0 B
MODBUS, RS485	9	L 0 D
MODBUS, 820 nm wavelength, ST connector 2)	9	L 0 E
DNP 3.0, RS485	9	L 0 G
DNP 3.0, 820 nm wavelength, ST connector 2)	9	L 0 H
IEC 60870-5-103 protocol, redundant, RS485, RJ45 connector 2)	9	L 0 P
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector (EN 100)	9	L 0 R
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector (EN 100) 2)	9	L 0 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	

See following pages

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.

Description			Order No. / Order code
7SJ64 multifunction protection relay with synchronization			7SJ64□□-□□□□□-□□□□-□□□□
Designation	ANSI No.	Description	
Basic version	 50/51 50N/51N 50N/51N 50/50N 51 V 49 46 37 47 59N/64 50BF 74TC 86	Control Overcurrent protection $I>$, $I>>$, $I>>>$, I_p Ground-fault protection $I_E>$, $I_E>>$, $I_E>>>$, I_{Ep} Insensitive ground-fault protection through IEE function: $I_{EE}>$, $I_{EE}>>$, I_{EEp} [1] Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I_2>$, $I>>>>$, $I_E>>>>$ Voltage-dependent inverse-time overcurrent protection Overload protection (with 2 time constants) Phase balance current protection (negative-sequence protection) Undercurrent monitoring Phase sequence Displacement voltage Breaker failure protection Trip circuit supervision 4 setting groups, cold-load pickup, Inrush blocking Lockout	F A
■ *V, P, f*	27/59 81O/U 27/Q 27/47/59(N) 32/55/81R	Under-/overvoltage Under-/overfrequency Undervoltage-controlled reactive power protection [3] 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 81O/U 27/Q 27/47/59(N) 32/55/81R	Under-/overvoltage Under-/overfrequency Undervoltage-controlled reactive power protection [3] 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 27/59 81O/U 27/Q 27/47/59(N) 32/55/81R	Direction determination for overcurrent, phases and ground Under-/overvoltage Under-/overfrequency Undervoltage-controlled reactive power protection [3] 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 27/59 81U/O 27/Q 27/47/59(N) 32/55/81R	Direction determination for overcurrent, phases and ground Intermittent ground fault protection Under-/overvoltage Under-/overfrequency Undervoltage-controlled reactive power protection [3] Flexible protection functions (quantities derived from current & voltages) 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 67Ns 67Ns 87N	Direction determination for overcurrent, phases and ground Directional sensitive ground-fault detection Directional intermittent ground fault protection [3] 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) 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

5

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	67Ns	Directional sensitive ground-fault detection	
Dir V,P,f REF	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	
	32/55/81R	current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	F F 2)
Sens.ground-f.det. Motor IEF	67/67N	Directional sensitive ground-fault detection, phases and ground	
Dir V,P,f REF	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	67Ns	Directional sensitive ground-fault detection	
Dir V,P,f REF	67Ns	Directional intermittent ground fault protection 3)	
■	87N	High-impedance restricted ground fault	F B 2)
Sens.ground-f.det. Motor	67Ns	Directional sensitive ground-fault detection	
Dir V,P,f REF	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	
	32/55/81R	current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	H F 2)
Sens.ground-f.det. Motor	67/67N	Direction determination for overcurrent, phases and ground	
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	
	32/55/81R	current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	H H 2)

■ 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

Continued on next page

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	
	81O/U	Underfrequency/overfrequency	
	27/Q	Undervoltage-controlled reactive power protection 3)	
	27/47/59(N) 32/55/81R	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	
	81O/U	Under-/overfrequency	
	27/Q	Undervoltage-controlled reactive power protection 3)	
	27/47/59(N) 32/55/81R	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 variantmight be supplied with a previous firmware version.

3) available with V4.9

Selection and ordering data

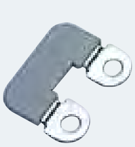
Accessories	Description	Order No.
	Temperature monitoring box	
	AC/DC 24 to 60 V	**7XV5662-2AD10**
	AC/DC 90 to 240 V	**7XV5662-5AD10**
	Varistor/VoltageArrester	
	Voltage arrester for high-impedance REF protection 125 Vrms; 600 A; 1S/S 256	**C53207-A401-D76-1**
	240 Vrms; 600 A; 1S/S 1088	**C53207-A401-D77-1**
	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.).

Mounting rail

2-pin connector

3-pin connector

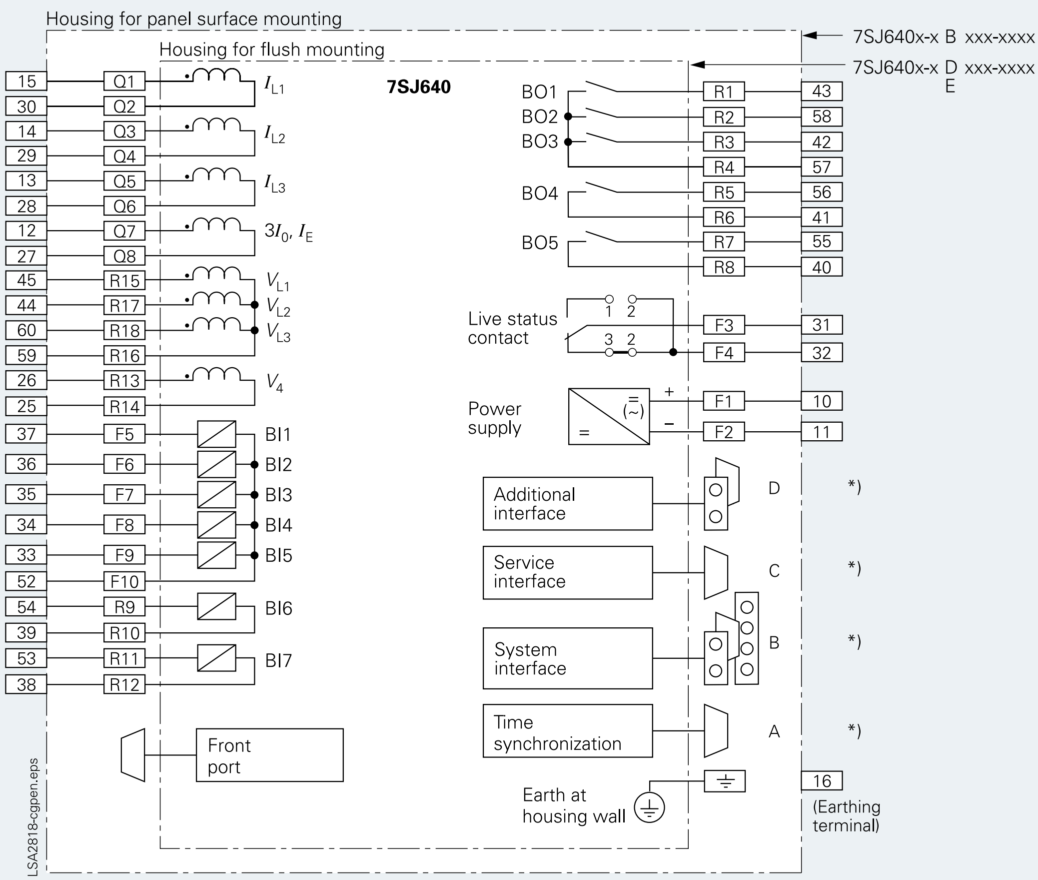


Short-circuit links for current terminals

Short-circuit links for current terminals

Description	Order No.	Size of package	Supplier
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	1)
Crimp connector CI2 0.5 to 1 mm^2	**0-827396-1**	1	1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	**0-163084-2**	1	1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	**0-163083-7**	4000 taped on reel	1)
Crimping tool for Type III+	**0-539635-1**	1	1)
and matching female	**0-539668-2**	1	1)
Crimping tool for CI2	**0-734372-1**	1	1)
and matching female	**1-734387-1**	1	1)
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

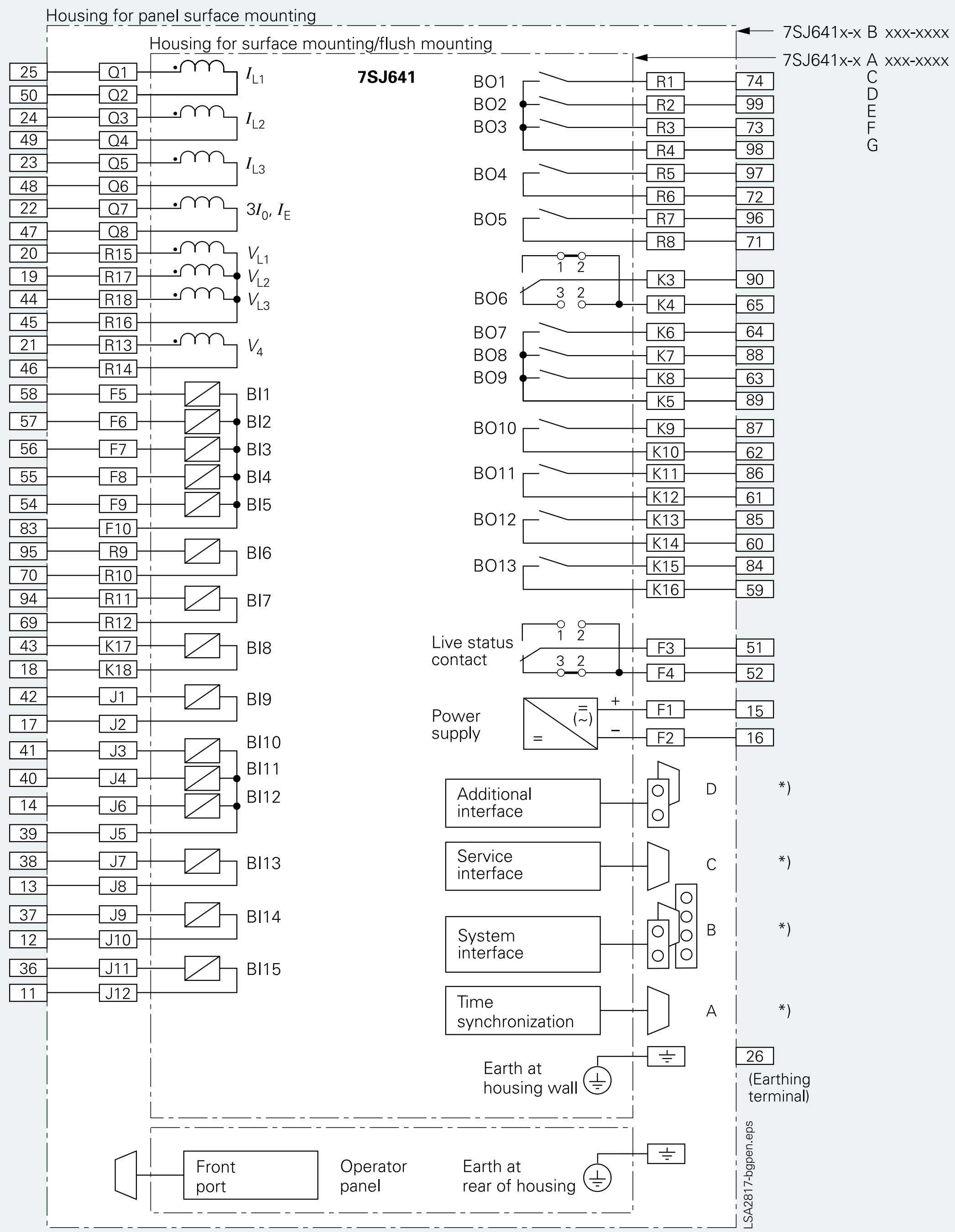
1) Your local Siemens representative can inform you on local suppliers.



*) 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).

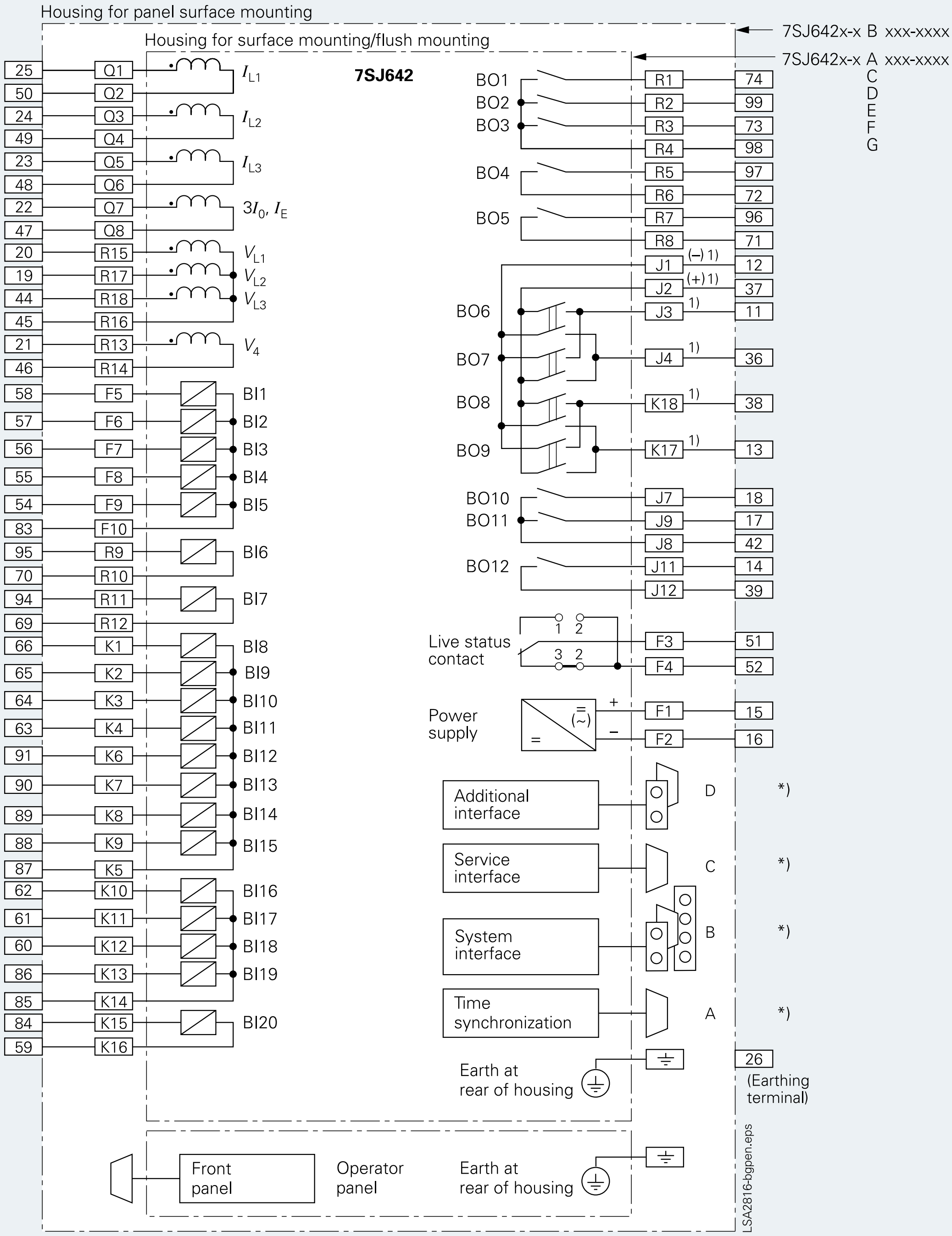
Fig. 5/84 7SJ640 connection diagram

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. 5/85 7SJ641 connection diagram

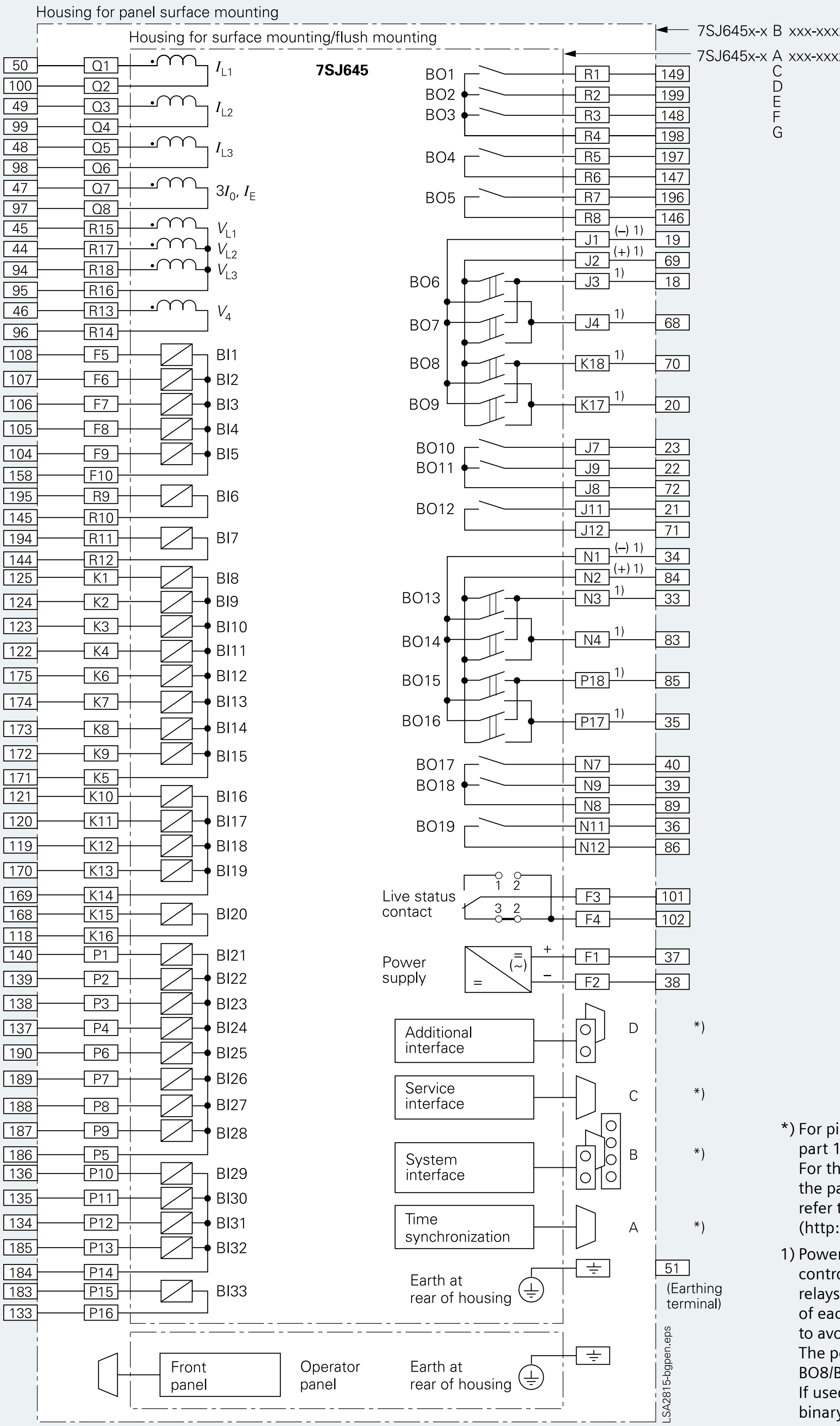


*) For pinout of communication ports see part 14 of this catalog.
For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siemens.com/siprotec).

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 BO6/BO7, BO8/BO9. If used for protection purposes only one binary output of a pair can be used.

Fig. 5/86 7SJ642 connection diagram

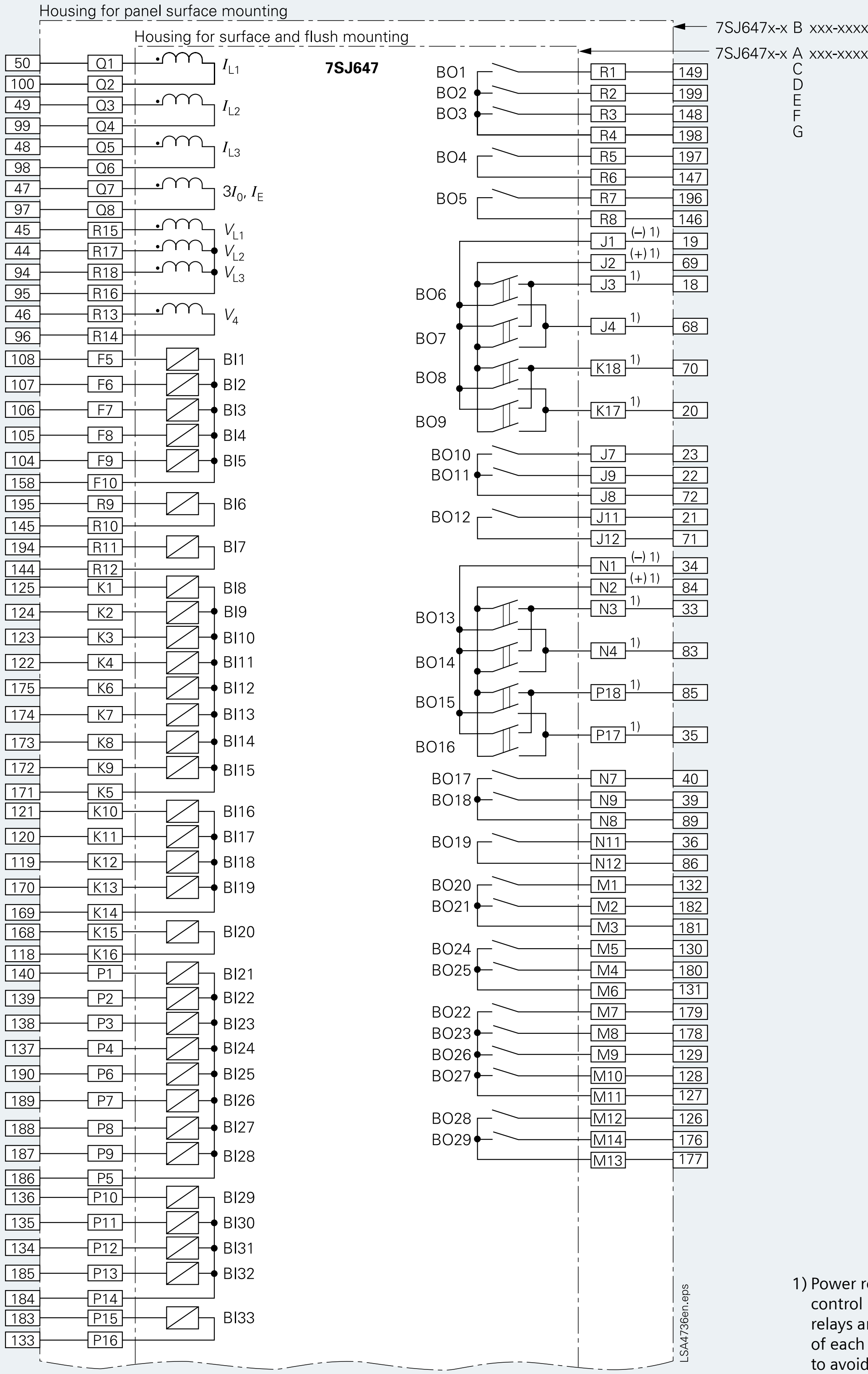
Connection diagram



*) 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 BO6/BO7, BO8/BO9, BO13/BO14, BO15/BO16. If used for protection purposes only one binary output of a pair can be used.

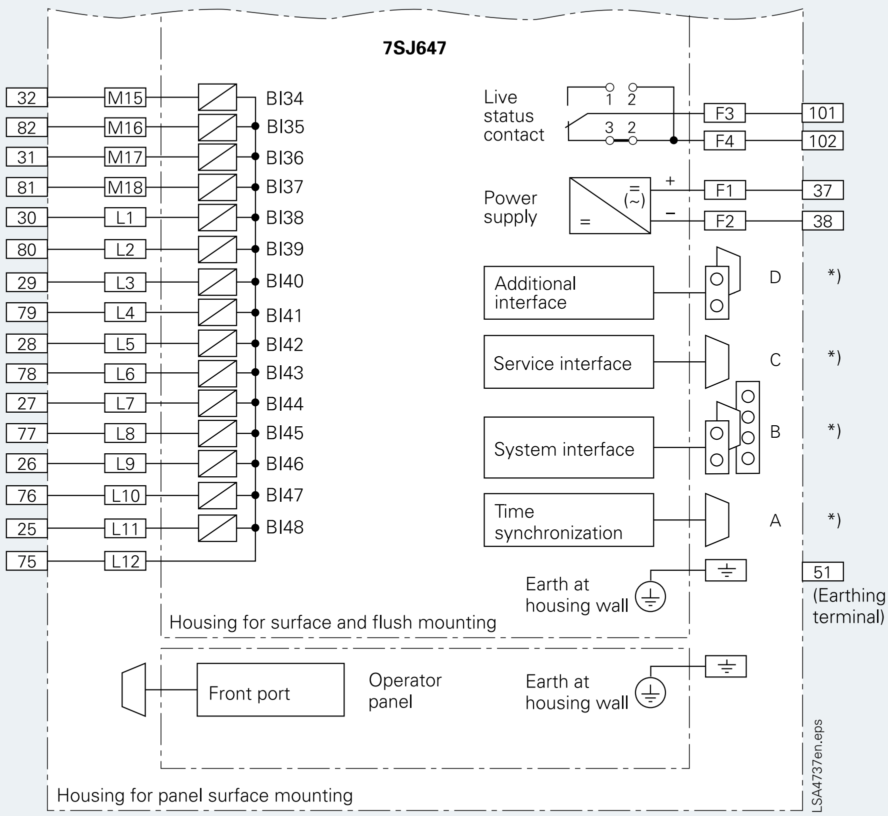
Fig. 5/87 7SJ645 connection diagram



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. 5/88 7SJ647 connection diagram part 1; continued on following page

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. 5/89 7SJ647 connection diagram part 2

Fig. 5/90 SIPROTEC 7SJ66 multifunction protection relay

Description

The SIPROTEC 7SJ66 unit is a numerical protection, control and monitoring device, designed to use in Medium Voltage and Industry applications.

SIPROTEC 7SJ66 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 graphical logic editor (CFC) allows the user to implement its own functions, e. g. for the automation of switchgear (interlocking).

The communication interfaces support the easy integration into modern communication networks.

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
- Inrush restraint
- Motor protection
- Overload protection
- Temperature monitoring

Protection functions (continued)

- 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
- Admittance Earth Fault Protection
- Auto-reclosure

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 with a sampling rate of 1.6 kHz
- Motor statistics
- Security log

Communication (build in interfaces)

- System interface
  IEC 60870-5-103 / IEC 61850 / Modbus RTU / DNP3
- Service interface for DIGSI 4/ RTD-Box
- Electrical and optical interface
- RSTP, PRP (Redundancy Protocol for Ethernet)
- Front USB interface for DIGSI 4
- Time synchronization via IRIG B/DCF77

Hardware

- Screw-type current terminals
- Spring or Screw-type Voltage and Binary I/O terminals
- 4 current and 4 voltage transformers
- 16/22/36 binary inputs
- 7/10/23 output relays
- Graphical or 8 line text display

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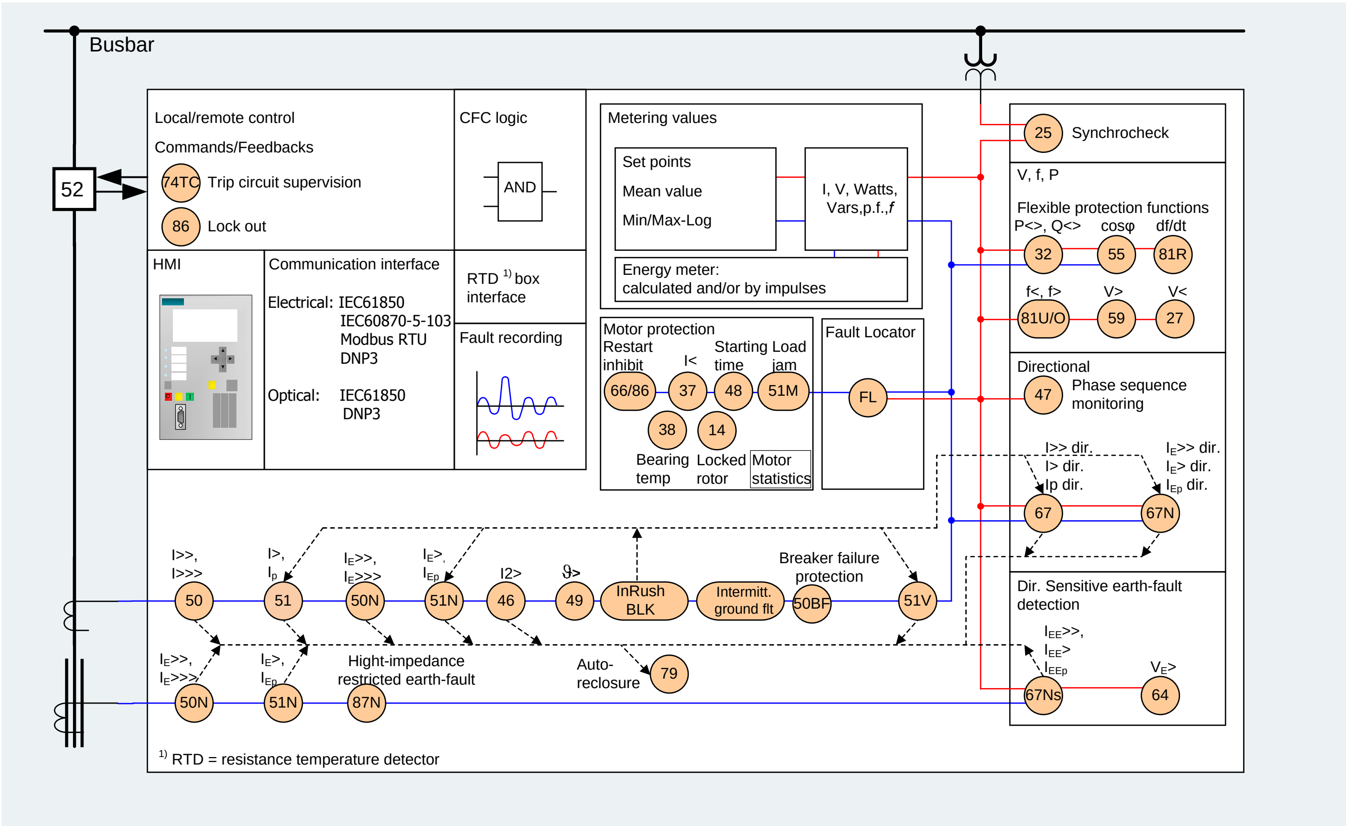

Fig. 5/91 Function diagram

Application

The SIPROTEC 7SJ66 unit is a numerical protection relay that also performs control and monitoring functions and therefore supports the user in cost-effective power system management. The relay 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 SIPROTEC 7SJ66 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 SIPROTEC 7SJ66 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 SIPROTEC 7SJ66 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), Admittance Y0>, 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	$V_2>$, 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

Fig. 5/92 SIPROTEC 7SJ66 rear view with optical Ethernet system interfaces

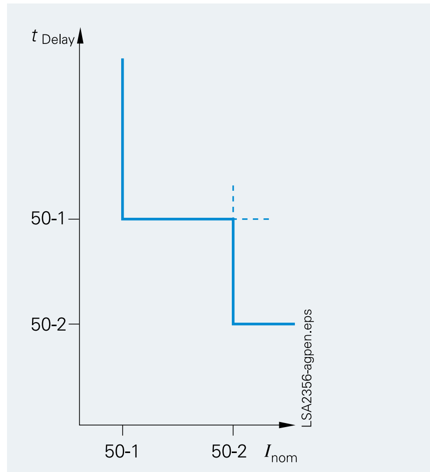

Fig. 5/93 Definite-time overcurrent protection

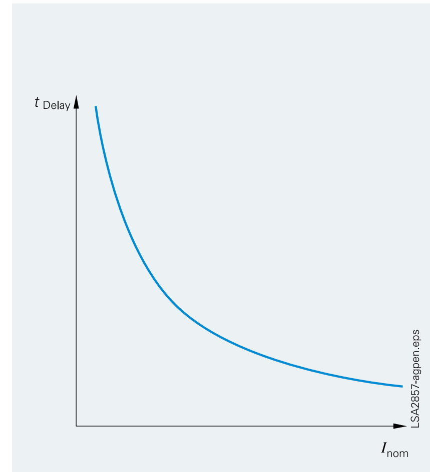

Fig. 5/94 Inverse-time overcurrent protection

Construction

Connection techniques and housing with many advantages

1/3-rack size and 1/2-rack size are the available housing widths of the SIPROTEC 7SJ66 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 housing. All CT-cables can be connected with or without ring lugs.

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.

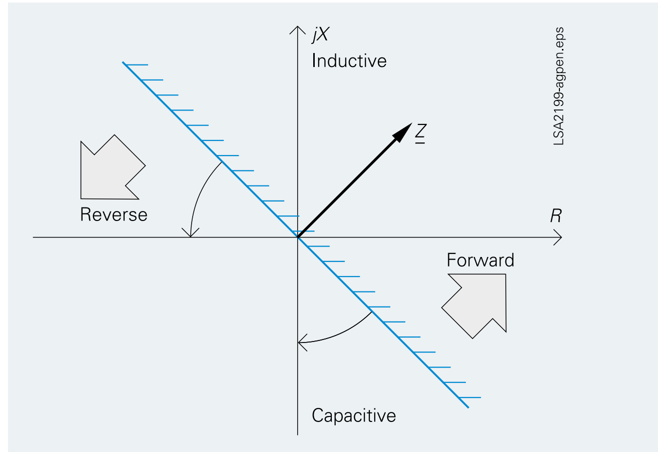

Fig. 5/95 Directional characteristic of the directional overcurrent protection

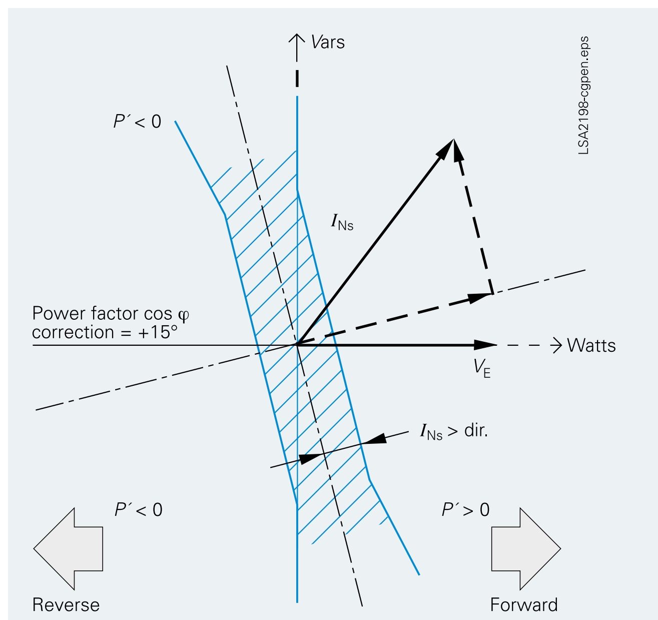

Fig. 5/96 Directional determination using cosine measurements for compensated networks

(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.

It is also possible to detect gound faults with the admittance principle.

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 summating 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 condi tions 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 specifi cally 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.

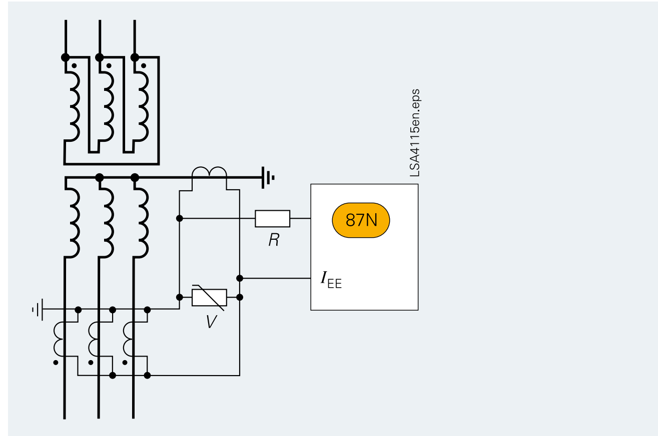

Fig. 5/97 High-impedance restricted ground-fault protection

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 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. 5/134). 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 SIPROTEC 7SJ66 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 stand- ard 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 opera- tion 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 avail- able 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 φ (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 genera- tor, 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)

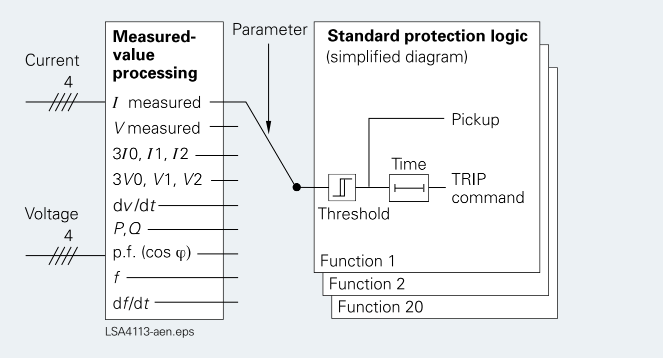

Fig. 5/98 Flexible protection functions

- 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.

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. 5/136).

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.

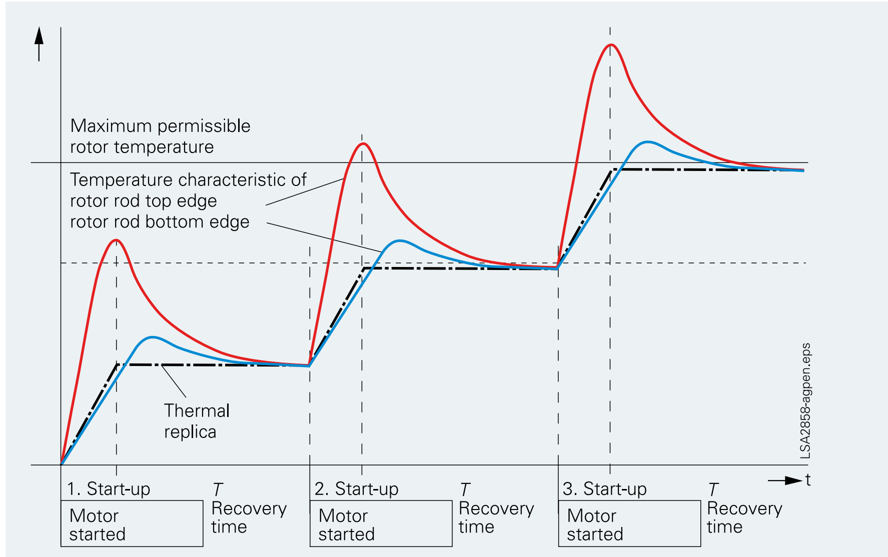

Fig. 5/99

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Temperature monitoring (ANSI 38)

One temperature monitoring box 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.

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 (25 to 70 Hz). 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.

There are four elements (select- able 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... 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. 5/137) 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.

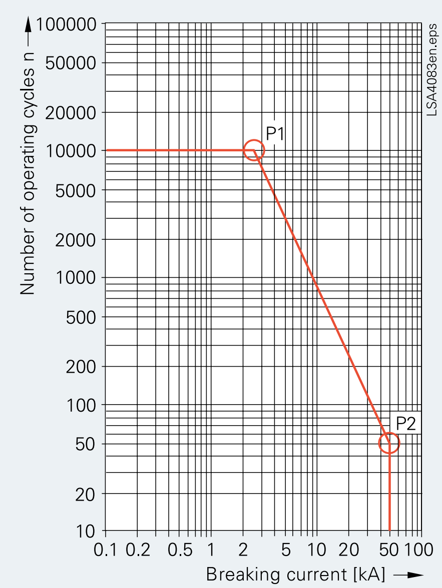

Fig. 5/100 CB switching cycle diagram

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 SIPROTEC 7SJ66 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 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. 5/101 SIPROTEC 7SJ663 rear view with communication ports

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 ϕ), (total and phase selective)
- Frequency
- Energy ± kWh, ± 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.

USB interface

There is a USB interface on the front of the relay. All the relay functions can be parameterized on PC by using DIGSI. Commissioning tools and fault analysis are built into the DIGSI program and are used through this interface.

Rear interfaces

- 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. 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 also allows communication via modem. For special applications, a temperature monitoring box (RTD box) can be connected to this interface.

System interface protocols

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.

Redundant solutions are also possible. Optionally it is possible to read out and alter individual parameters (only possible with the redundant module).

Modbus RTU protocol

This 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.

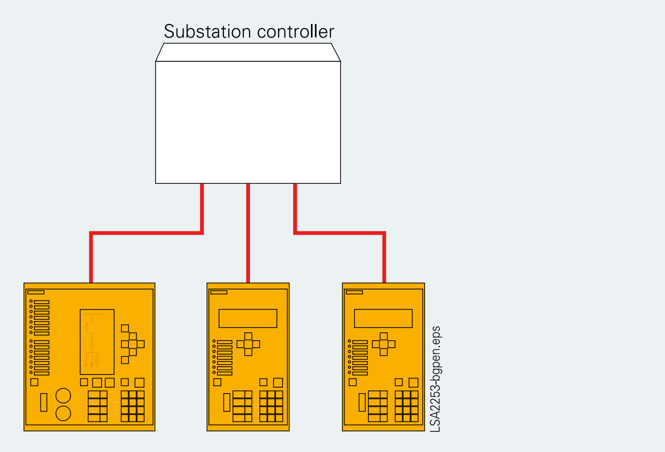

Fig. 5/102 IEC 60870-5-103: Radial electrical connection

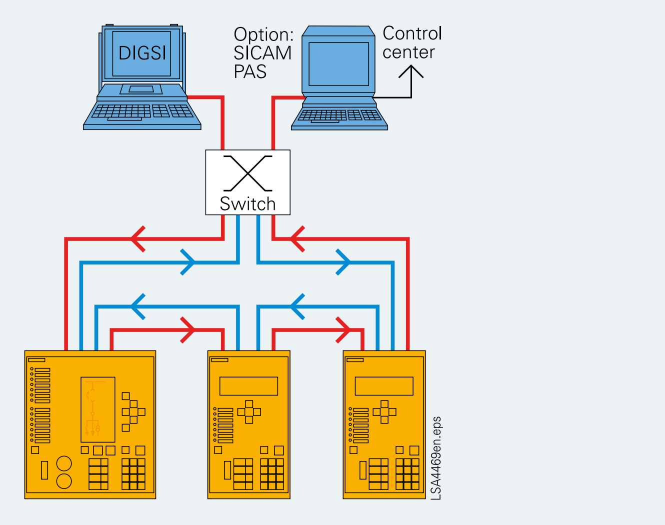

Fig. 5/103 Bus structure for station bus with Ethernet and IEC 61850, electrical and optical ring

DNP3

DNP (Distributed Network Protocol, version 3) is a messaging-based communication protocol. SIPROTEC 7SJ66 is fully Level 1 and Level 2-compliant with DNP3, which is supported by a number of protection units manufactures.

Selection table

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Selection table for multifunctional overcurrent protection devices							
Device	*7SJ80*	*7SJ61*	*7SJ62*	*7SJ63*	*7SJ64*	*7SJ82*	7SJ66
Multifunctional protection functions	✓	✓	✓	✓	✓	✓	✓
CTs	4	4	4	4	4	4	4
VTs	0/3	0	3/4	3	4	0/4	4
Binary inputs incl. Life contact	3 - 11	3 - 11	8 - 11	11 - 37	7 - 48	11 - 23	16 - 36
Binary outputs	5 - 9	4 - 9	6 - 9	8 - 19	5 - 26	8 - 16	7 - 24
Spring-type terminals	-	-	-	-	-	-	✓
Auxiliary voltage	DC 24 - 250 V AC 115 - 230 V	DC 24 - 250 V AC 115 - 230 V	DC 24 - 250 V AC 115 - 230 V	DC 24 - 250 V AC 115 - 230 V	DC 24 - 250 V AC 115 - 230 V	DC 24 - 250 V AC 115 - 230 V	DC 110 - 250 V AC 115 - 230 V
UL listing	✓	✓	✓	✓	✓	✓	-
Surface mounting case	●	●	●	●	●	-	-
Detached on-site operation panel	-	-	-	●	●	-	-
Languages	ge/en/es/fr/it/ru/ch	ge/en/es/fr/it/ru	ge/en/es/fr/it/ru	ge/en/es/fr	ge/en/es/fr/it/ru	ge/en/pt/es/ru	en/es/ru/pl/tr
Front USB	✓	-	-	-	-	✓	✓
Interfaces exchangeable	✓	✓	✓	✓	✓	✓	-
IEC 61850	●	●	●	●	●	●	●
IEC 60870-5-103	●	●	●	●	●	●	● (elec.)
Modbus RTU	●	●	●	●	●	●	● (elec.)
PROFIBUS FMS	-	●	●	●	●	-	-
PROFIBUS DP	●	●	●	●	●	-	-
PROFINET I/O	●	●	●	-	●	-	-
DNP3 serial/TCP	●	●	●	-	●	●	●
RSTP	✓	✓	✓	✓	✓	✓	✓
PRP	✓	✓	✓	✓	✓	✓	✓
HSR	✓	✓	✓	✓	✓	✓	-

✓ basic
- not available
● optional

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.

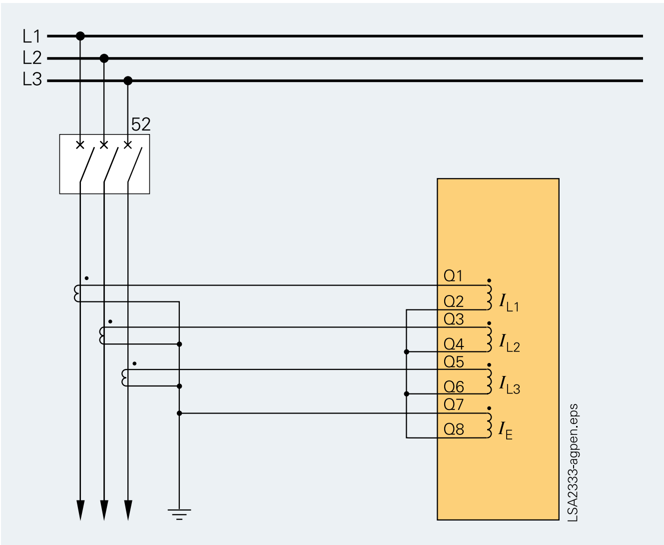

Fig. 5/104 Residual current circuit without directional element

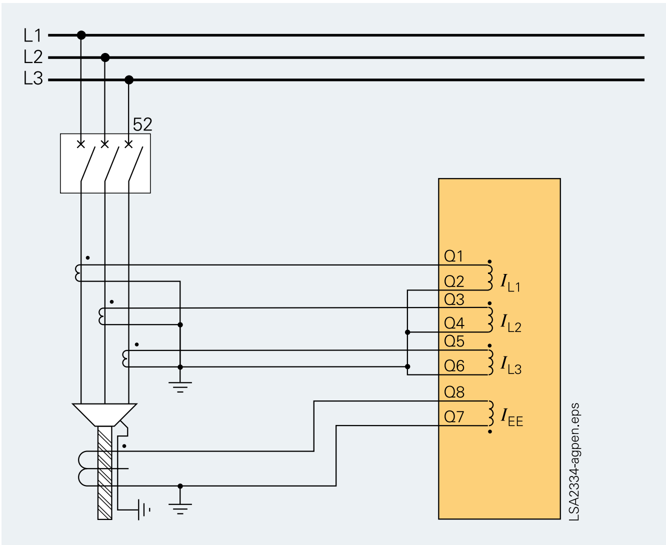

Fig. 5/105 Sensitive ground-current detection without directional element

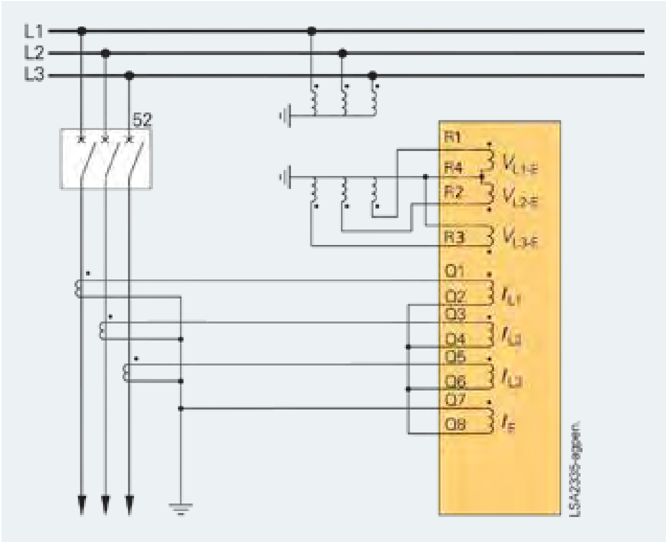

Fig. 5/106 Residual current circuit with directional element

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. 5/144 shows sensitive directional ground-fault detection.

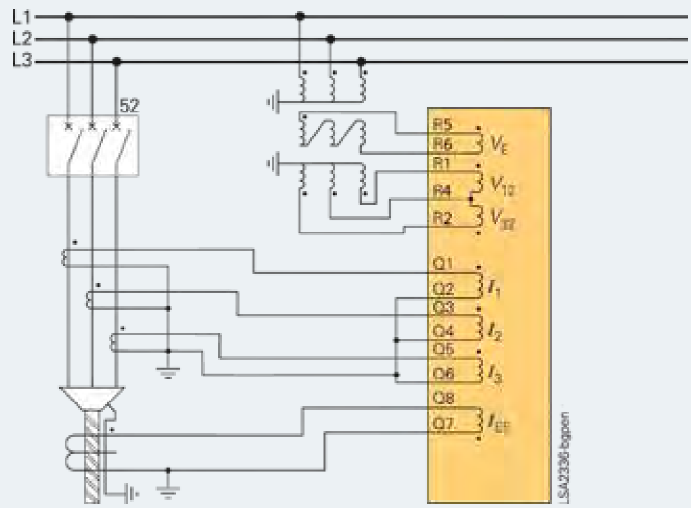

Fig. 5/107 Sensitive directional ground-fault detection with directional element for phases

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.

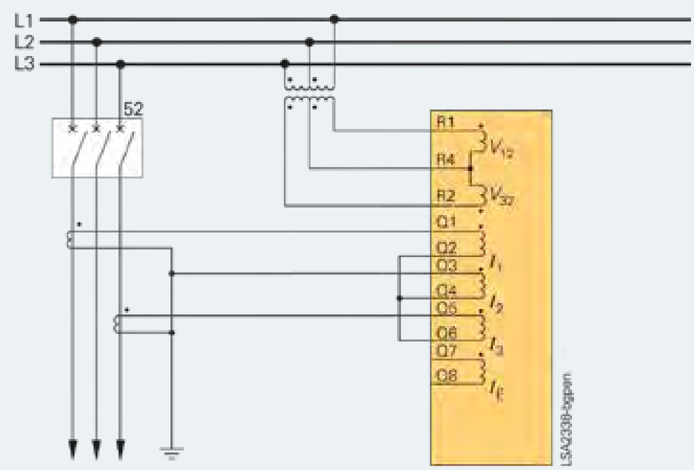

Fig. 5/108 Isolated-neutral or compensated networks

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.

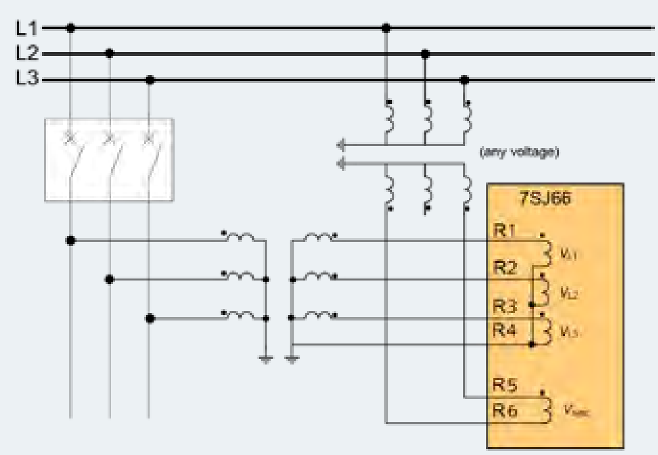

Fig. 5/109 Measuring of the busbar voltage and the outgoing feeder voltage for the synchro-check

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 φ measurement	Phase-balance neutral current transformers required	Phase-to-ground connection with open delta winding required

5

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. 5/147, 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. 5/148 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.

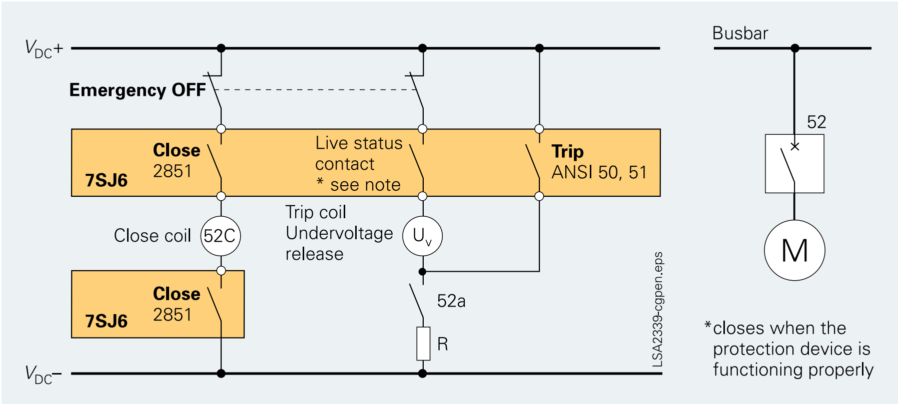

Fig. 5/110 Undervoltage release with make contact (50, 51)

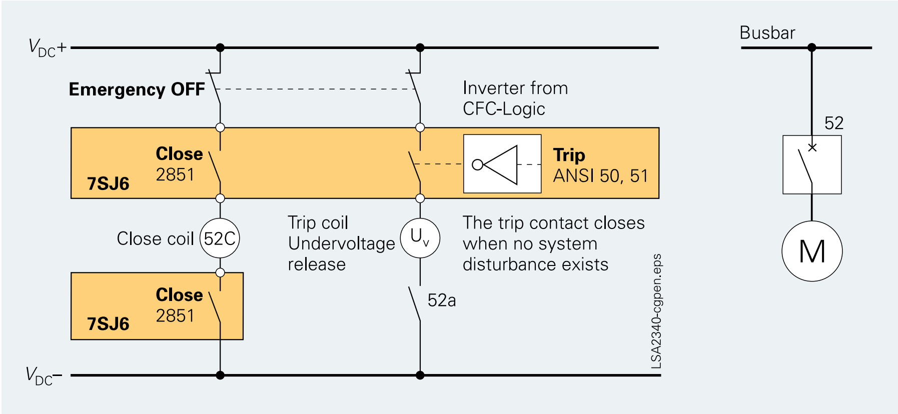

Fig. 5/111 Undervoltage trip with locking contact (trip signal 50 is inverted)

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 SIPROTEC 7SJ66.

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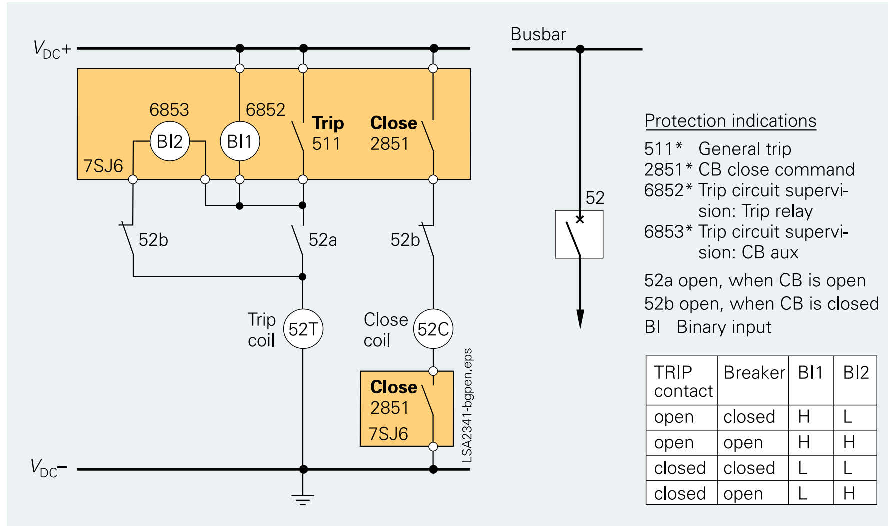


TRIP contact	Breaker	BI1	BI2
open	closed	H	L
open	open	H	H
closed	closed	L	L
closed	open	L	H

Fig. 5/112 Trip circuit supervision with 2 binary inputs

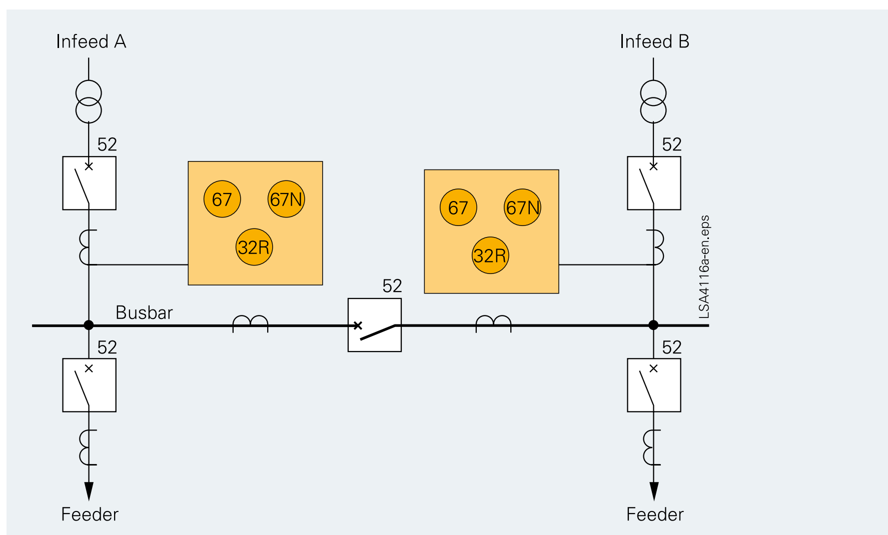


Fig. 5/113 Reverse-power protection for dual supply

Description	Order No.
SIPROTEC 7SJ66 multifunction protection relay and bay controller	12345 6 7 8 9 10 11 12 13 14 15 16 17 18 19 7SJ66□□-□□□□□-□□□□-□□□
Housing, inputs, outputs	
Housing 1/3 19", 4 x *U*, 4 x *I*, 16 BI, 7 BO, 1 life contact	1
Housing 1/3 19", 4 x *U*, 4 x *I*, 22 BI, 10 BO, 1 life contact	2
Housing 1/2 19", 4 x *U*, 4 x *I*, 36 BI, 23 BO, 1 life contact, 4 function keys	3
Measuring inputs	
I_{ph} = 1 A, I_N = 1 A (min. = 0.05 A) Position 15 only with **A, C, E, G**	1
I_{ph} = 1 A, I_N = sensitive (min. = 0.001 A) Position 15 only with **B, D, F, H**	2
I_{ph} = 5 A, I_N = 5 A (min. = 0.25 A) Position 15 only with **A, C, E, G**	5
I_{ph} = 5 A, I_N = sensitive (min. = 0.001 A) Position 15 only with **B, D, F, H**	6
Rated auxiliary voltage (power supply, indication voltage)	
DC 24 to 48 V, threshold binary input DC 19 V [3]	4
DC 110 to 250 V, AC 115 to 230 V, threshold binary input DC 88 V	5
DC 110 to 250 V, AC 115 to 230 V, threshold binary input DC 176V	6
Construction	
Flush-mounting case, screw-type terminals, 8-line text display	D
Flush-mounting case, spring-type terminals (direct connection), screw-type terminals for CT connection (direct connection/ring-type cable lugs), 8-line text display	E
Flush-mounting case, screw-type terminals, graphical display	J
Flush-mounting case, spring-type terminals (direct connection), screw-type terminals for CT connection (direct connection/ring-type cable lugs), graphical display	K
Region-specific default settings/function versions and language settings	
Region World, 50/60 Hz, IEC/ANSI, language: English (language can be changed)	B
Region World, 50/60 Hz, IEC/ANSI, language: Spanish (language can be changed)	E
Region RU, 50/60 Hz, IEC/ANSI, language: Russian (language can be changed)	G
System interface (Port B)	
No system interface	0
IEC 60870-5-103, electrical RS485, RJ45-connector [1]	2
Modbus RTU, electrical RS485, RJ45-connector [1]	9 ... L 0 D
DNP3, RS485 [1]	9 ... L 0 G
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45-connector [2]	9 ... L 0 R
IEC 61850, 100 Mbit Ethernet, optical, double, LC-connector [2]	9 ... L 0 S
DNP3 + IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45-connector [2]	9 ... L 2 R
DNP3 + IEC 61850, 100 Mbit Ethernet, optical, double, LC-connector [2]	9 ... L 2 S
Service interface (Port C)	
No interface	0
DIGSI 4 / Modem / RTD-box, electrical RS485, RJ45-connector	2
Ethernet port (DIGSI port, RTD box connection, not IEC 61850), RJ45-connector	6
Functionality	
See next page	

Continued on next page

1) only available with position **12** = **0** or **2**

2) only available with position **12** = **0** or **6**

3) only available with position **6** = **1**

5

Selection and ordering data

Description			Order No.	Order code
Multifunction protection relay with local control			12345 6 7 8 9 101112 131415 16 171819 7SJ66☐☐-☐☐☐☐☐-☐☐☐☐-☐☐☐	
	ANSI No.			
Basic version		Control	F A	
	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		
Basic+ V,P,f		Basic version (see above), Intermittent earth-fault	F E	
	27/59	Under-/overvoltage		
	81O/U	Under-/overfrequency		
	27Q	Undervoltage-controlled reactive power protection		
	27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		
Basic + V,P,f IEF		Basic version (see above)	P E	
	27/59	Under-/overvoltage		
	81O/U	Under-/overfrequency		
	27Q	Undervoltage-controlled reactive power protection		
	27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		
Basic + Dir		Basic version (see above)	F C	
	67/67N	Direction determination for overcurrent, phases and ground		
Basic + Dir V,P,f		Basic version (see above)	F G	
	67/67N	Direction determination for overcurrent, phases and ground		
	27/59	Under-/overvoltage		
	81O/U	Under-/overfrequency		
	27Q	Undervoltage-controlled reactive power protection		
	27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		
Basic + Dir V,P,f IEF		Basic version (see above)	P G	
	67/67N	Direction determination for overcurrent, phases and ground		
	27/59	Under-/overvoltage		
	81O/U	Under-/overfrequency		
	27Q	Undervoltage-controlled reactive power protection		
	27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		
Basic + Dir IEF		Basic version (see above)	P C	
	67/67N	Direction determination for overcurrent, phases and ground		

Continued on next page

V, P, f = Voltage, power, frequency protection

Dir = Directional overcurrent protection

IEF = Intermittent ground fault

1) only with position 7 = 1 or 5 (non-sensitive ground current input)

5

Description			Order No. / Order code
Multifunction protection relay with local control			1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 7SJ66□□-□□□□□-□□□□-□□□
	ANSI No.		
Basic + Sens.earth-f-det. Dir REF[2)]		Basic version included	F D
	67/67N	Direction determination for overcurrent, phases and ground	
	67Ns	Directional sensitive ground-fault detection	
	67Ns	Directional intermittent ground fault protection	
	87N	High-impedance restricted earth fault	
Basic + Sens.earth-f-det. Dir IEF REF[2)]		Basic version included	P D
	67/67N	Direction determination for overcurrent, phases and ground	
	67Ns	Directional sensitive ground-fault detection	
	67Ns	Directional intermittent ground fault protection	
	87N	High-impedance restricted ground fault	
		Intermittent earth-fault	
Basic + Dir. Sens.earth-f-det. V,P,f REF[2)]		Basic version included	F F
	67Ns	Directional sensitive ground-fault detection	
	67Ns	Directional intermittent ground fault protection	
	87N	High-impedance restricted ground fault	
	27/59	Under-/overvoltage	
	81O/U	Under-/overfrequency	
	27Q	Undervoltage-controlled reactive power protection	
	27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	
Basic + Dir. Sens.earth-f-det. REF[2)]		Basic version included	F B
	67Ns	Directional sensitive ground-fault detection	
	67Ns	Directional intermittent ground fault protection	
	87N	High-impedance restricted ground fault	
Basic + Dir. Sens.earth-f-det. Motor V,P,f REF[2)]		Basic version included	H F
	67Ns	Directional sensitive ground-fault detection	
	67Ns	Directional intermittent ground fault protection	
	87N	High-impedance restricted ground fault	
	48/14	Starting ime supervision, locked rotor	
	66/86	Restart inhibit	
	51M	Motor load jam protection	
		Motor statistics	
	27/59	Under-/overvoltage	
	81O/U	Under-/overfrequency	
	27Q	Undervoltage-controlled reactive power protection	
	27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	
Basic + Sens.earth-f-det. Motor Dir V,P,f REF[2)]		Basic version included	H H
	67/67N	Direction determination for overcurrent, phases and ground	
	67Ns	Directional sensitive ground-fault detection	
	67Ns	Directional intermittent ground fault protection	
	87N	High-impedance restricted ground fault	
	48/14	Starting ime supervision, locked rotor	
	66/86	Restart inhibit	
	51M	Motor load jam protection	
		Motor statistics	
	27/59	Under-/overvoltage	
	81O/U	Under-/overfrequency	
	27Q	Undervoltage-controlled reactive power protection	
	27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	

V, P, f = Voltage, power, frequency protection
Dir = Directional overcurrent protection
IEF = Intermittent ground fault
REF = Restricted earth fault
Motor = Motor protection

2) For isolated/compensated networks, only with postition 7=**2,6** (sensitive earth current input)

Continued on next page

5

Selection and ordering data

Description			Order No.	Order code
SIPROTEC 7SJ66 multifunction protection relay and bay controller			7SJ66□□-□□□□□-□□□□ □□□	
	ANSI No.	Description		
Basic + Dir. S.EF Motor 2)		Basic version included	R H	
	67/67N	Direction determination for overcurrent, phases and ground		
	67Ns	Directional sensitive ground-fault detection		
	67Ns	Directional intermittent ground fault protection		
	87N	High-impedance restricted ground fault		
	48/14	Starting ime supervision, locked rotor		
	66/86	Restart inhibit		
	51M	Motor load jam protection		
		Motor statistics		
	27/59	Under-/overvoltage		
	81O/U	Under-/overfrequency		
	27Q	Undervoltage-controlled reactive power protection		
	27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		
Basic + Motor Dir V,P,f		Basic version included	H G	
	67/67N	Direction determination for overcurrent, phases and ground		
	48/14	Starting ime supervision, locked rotor		
	66/86	Restart inhibit		
	51M	Motor load jam protection		
		Motor statistics		
	27/59	Under-/overvoltage		
	81O/U	Under-/overfrequency		
	27Q	Undervoltage-controlled reactive power protection		
	27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		
Basic + Motor		Basic version included	H A	
	48/14	Starting ime supervision, locked rotor		
	66/86	Restart inhibit		
	51M	Motor load jam protection		
		Motor statistics		
		Measuring/fault recording	13	
		With fault recording	1	
		Slave pointer, average values, min/max-values with fault recording	3	
		ARC, fault locator, synchro-check	16	
		without	0	
	79	with autoreclose	1	
	21FL	with fault locator	2	
	79,21FL	with 79 and fault locator	3	
	25	with synchro-check 3)	4	
	25, 79, 21FL	with synchro-check 3), with auto reclose, with fault recorder	7	
		Conformal Coating		Z Y 1 3

Motor = Motor protection
V, P, f = Voltage, power, frequency protection
Dir = Directional overcurrent protection
IEF = Intermittent ground fault

2) Only with position 7 = 2, 6 (sensitive earth current input).
3) Synchrocheck (no asynchronous switching), one function group

Accessories	Description	Order No.
	RTD-Box (Resistance Temperature Detector)	
	RTD box, VH = 24 to 240 V AC/DC	**7XV5662-6AD10**
	RTD box Eth, VH = 24 to 240 V AC/DC	**7XV5662-8AD10**
	Mounting Rail for 19"-Racks	
	Angle Strip (Mounting Rail)	**53207-A406-D280-1**
	Lithium Battery 3 V/1 Ah, Type CR 1/2 AA	
	VARTA	**6127 101,301**
	Panasonic	**BR-1/2AA**
	Varistor (Voltage-Limiting Resistor for High-Impedance Differential Protection)	
	125 Veff, 600 A, 1S/S256	**W73028-V3125-A1**
	240 Veff, 600 A, 1S/S1088	**W73028-V3300-A2**
	Screw Cover	
	Screw Cover	**C53207-A406-D278-1**
	Front Unit with Display and HMI	
	Front unit with display and HMI 1/3	**C53207-A406-D276-1**
	Front unit with display and HMI 1/2	**C53207-A406-D277-1**
	USB Cover	
	USB Cover	**C53207-A406-D271-1**
	Terminals	
	Terminal voltage,12 pin spring type	**C53207-A406-D272-1**
	Terminal voltage,16 pin spring type	**C53207-A406-D273-1**
	Terminal voltage,12 pin screw type	**C53207-A406-D274-1**
	Terminal voltage,16 pin screw type	**C53207-A406-D275-1**

Connection diagram

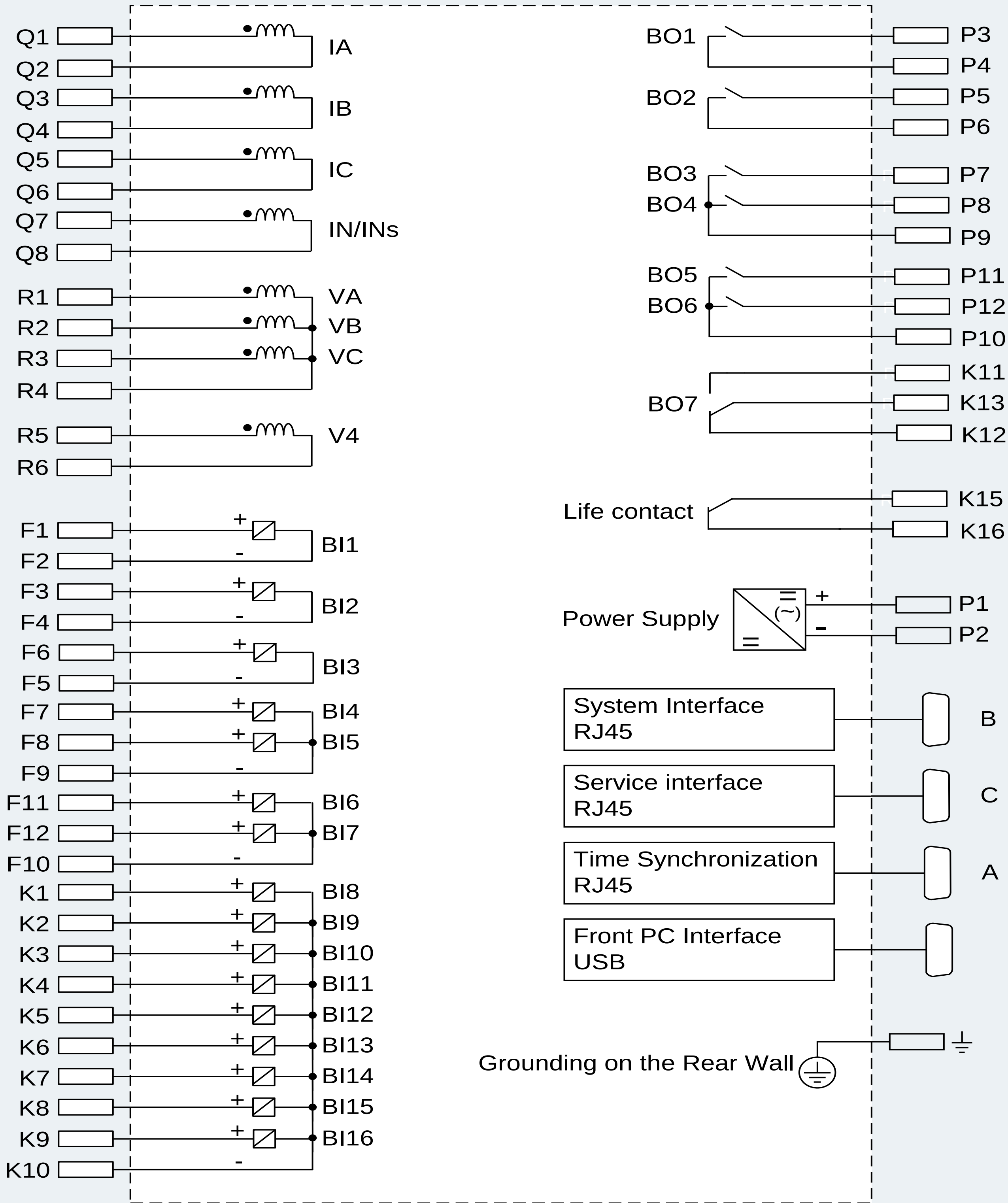


Fig. 5/114 SIPROTEC 7SJ661 connection diagram

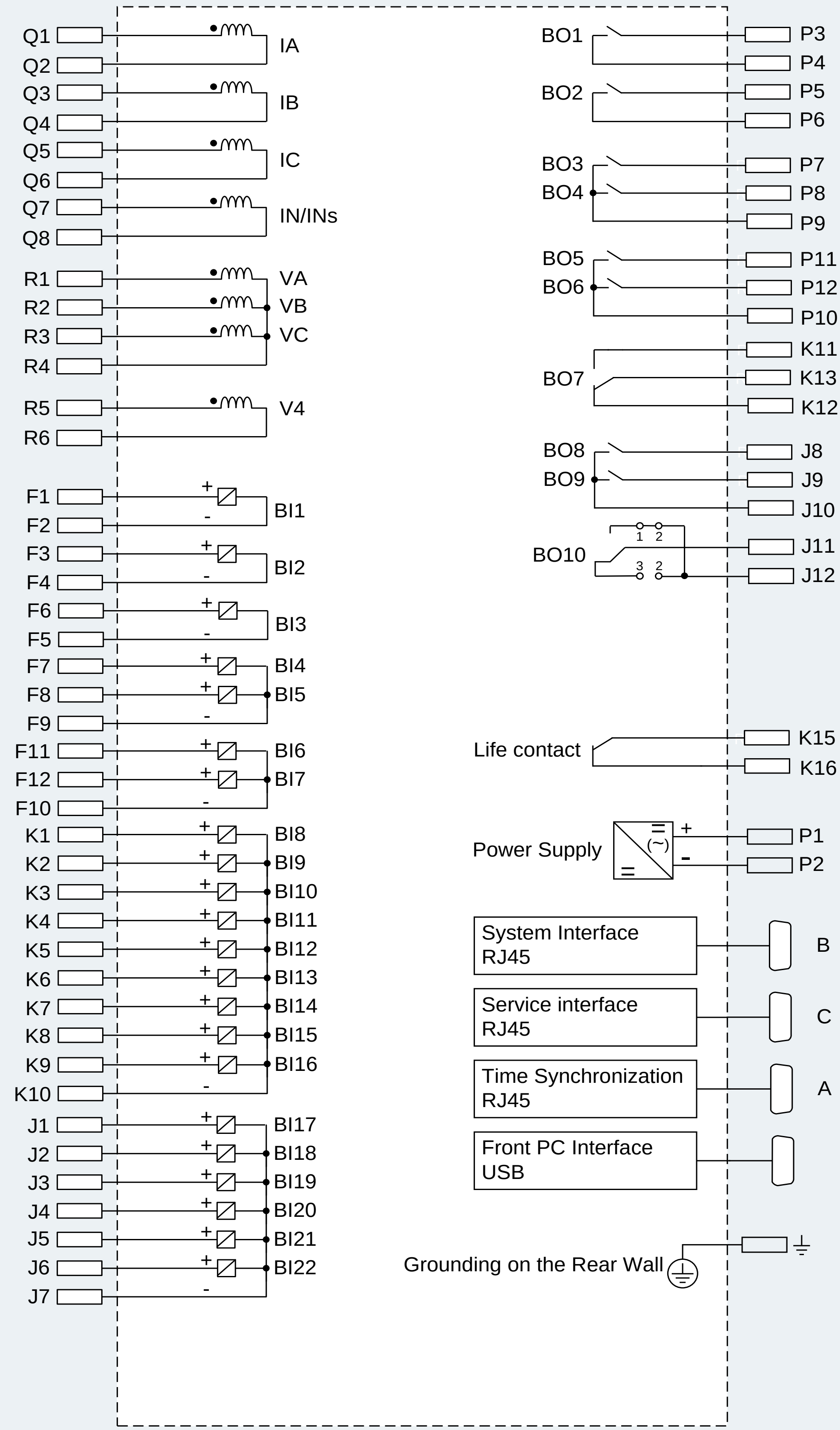


Fig. 5/115 SIPROTEC 7SJ662 connection diagram

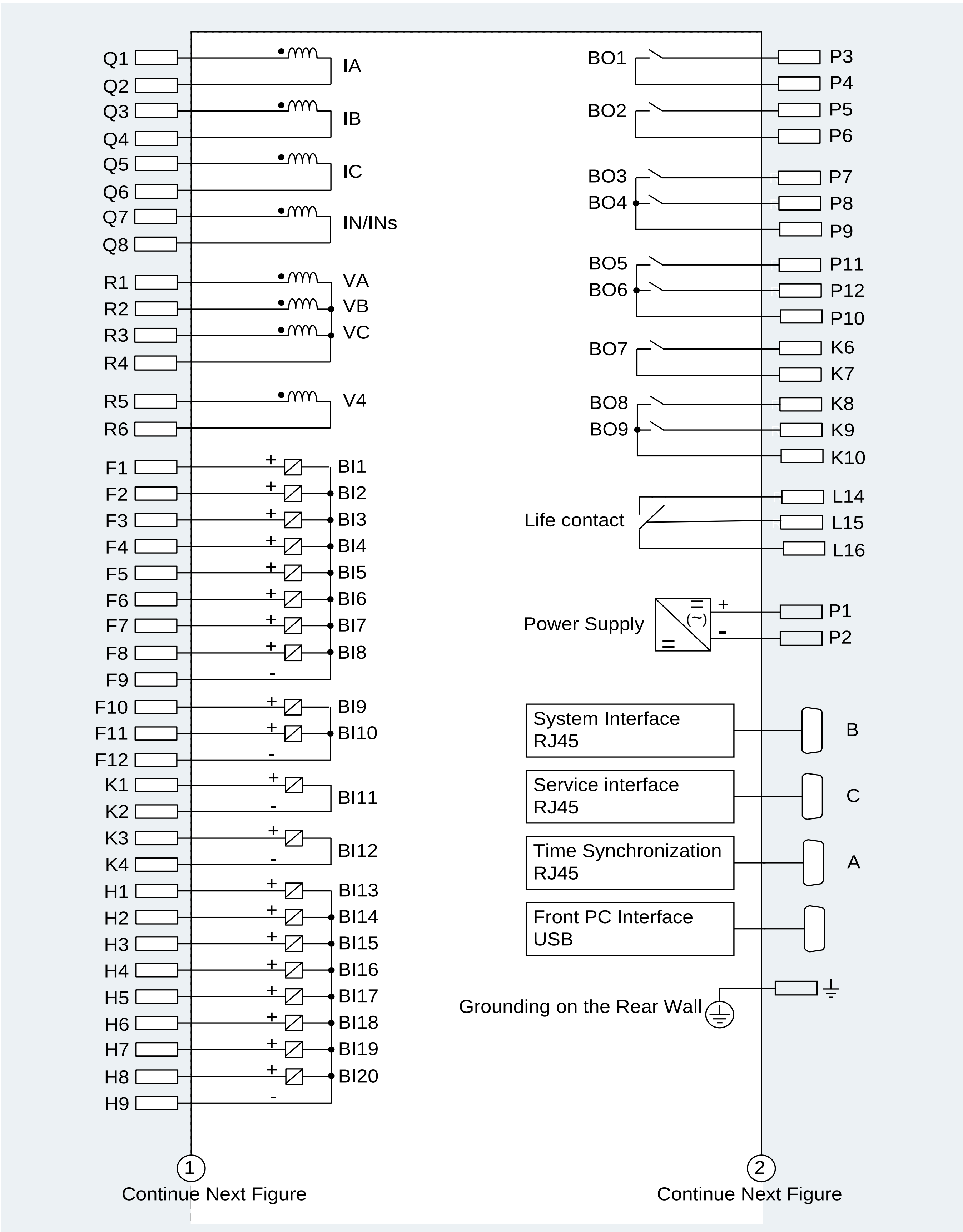


Fig. 5/116 SIPROTEC 7SJ663 connection diagram

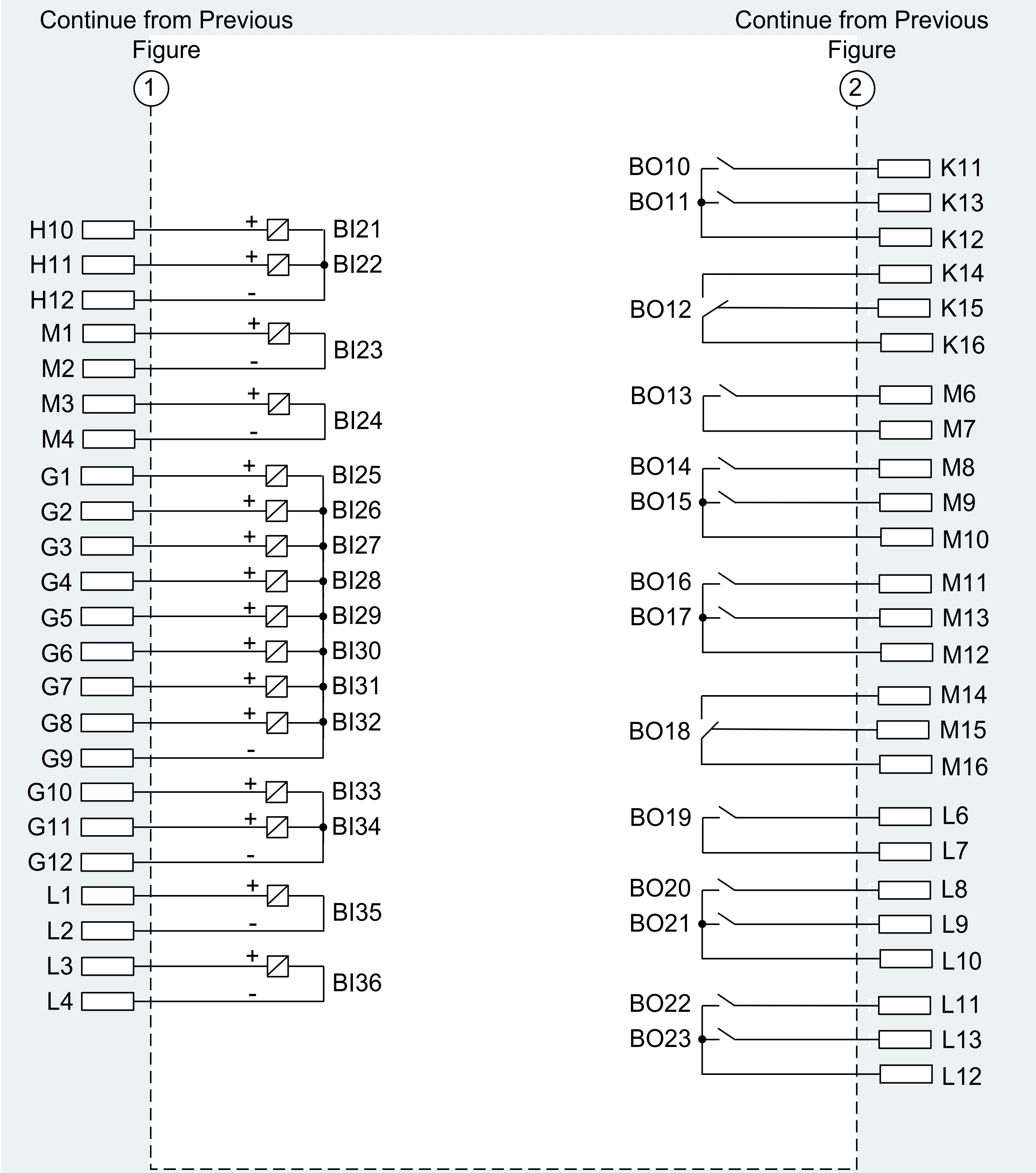


Fig. 5/117 SIPROTEC 7SJ663 connection diagram

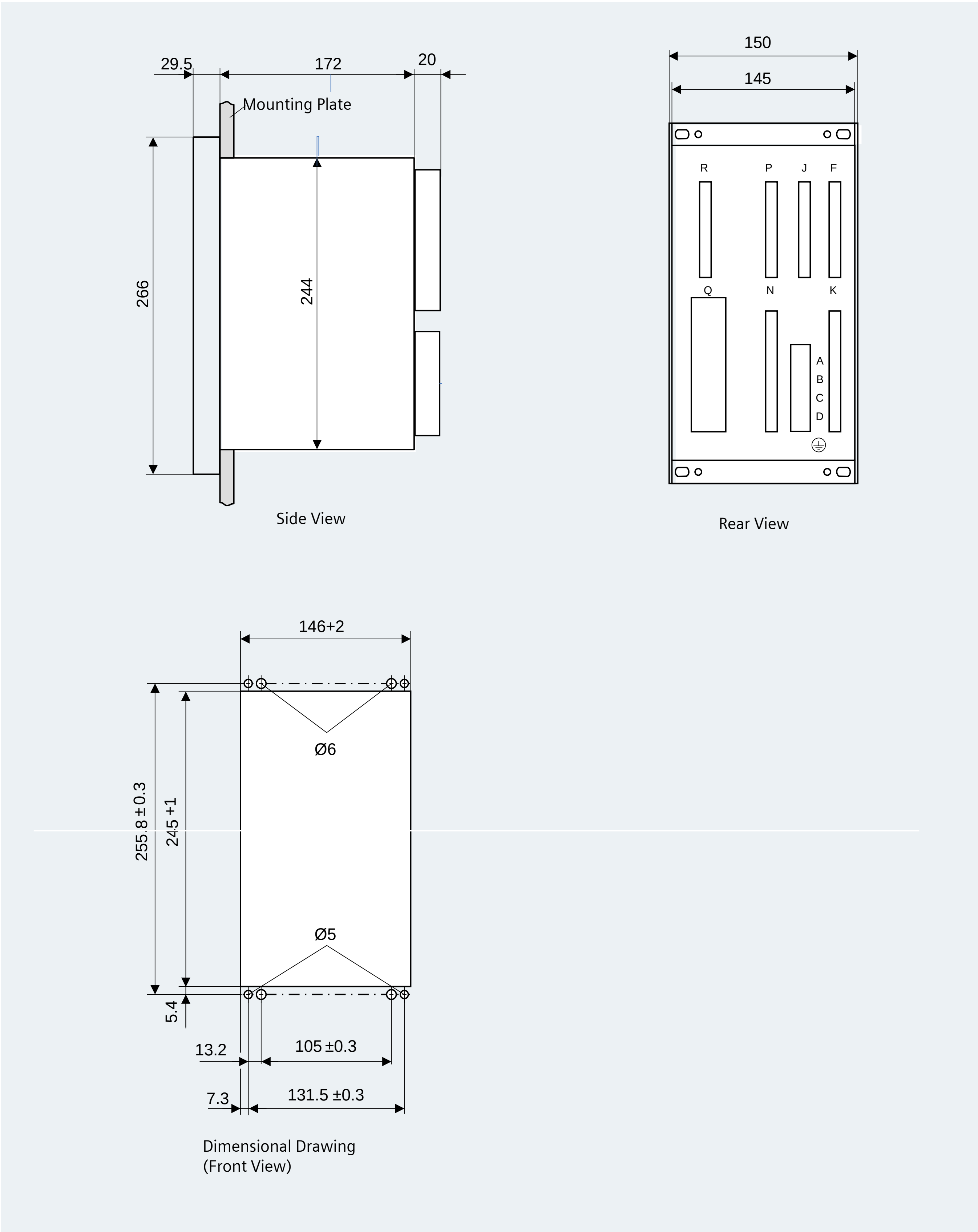


Fig. 5/118 Dimensional drawing for SIPROTEC 7SJ66 (housing size 1/3)

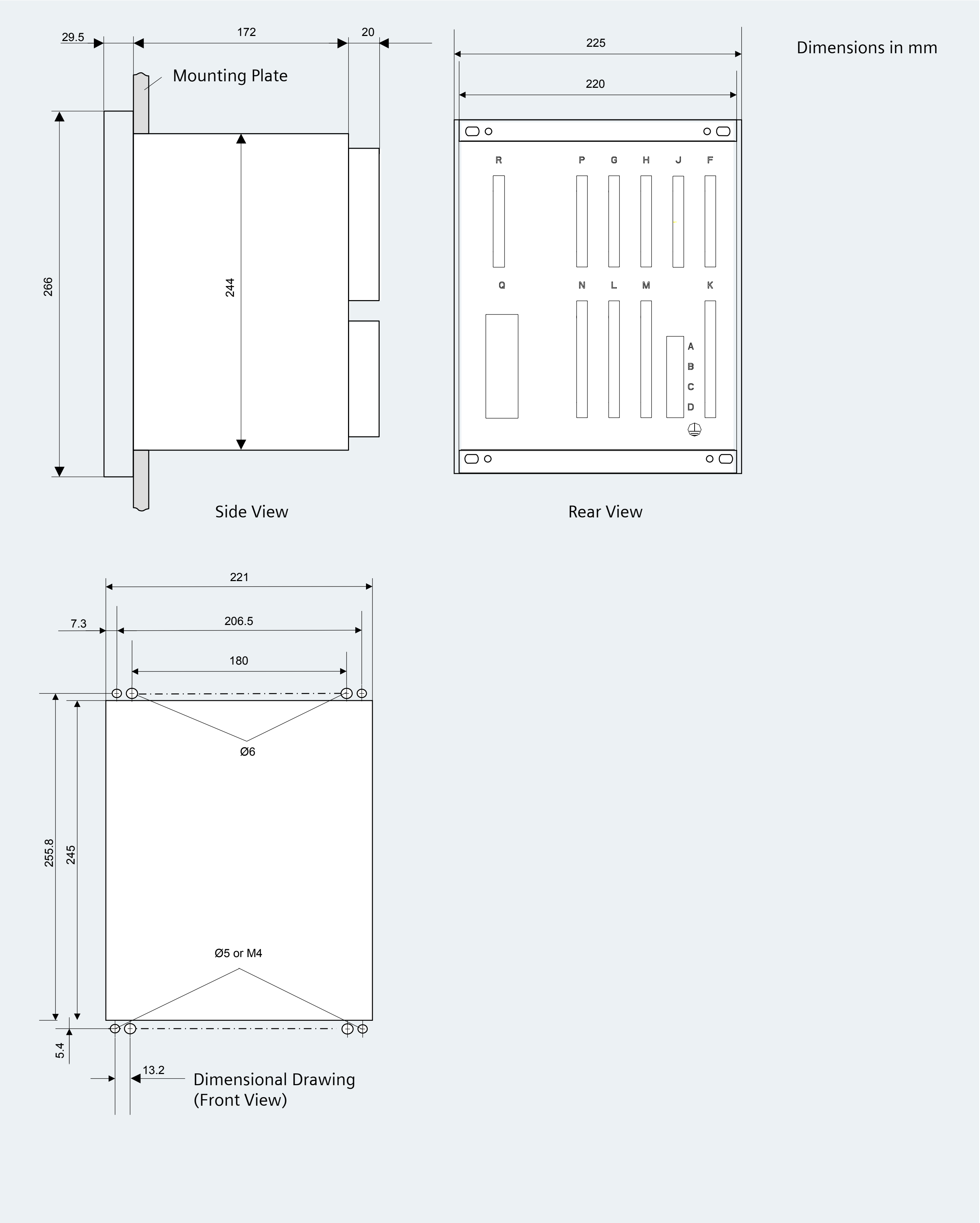


Fig. 5/119 Dimensional drawing of a SIPROTEC 7SJ66 (housing size 1/2)

Distance Protection

6

6

SIPROTEC 7SA6 distance protection relay for all voltage levels

Fig. 6/1 SIPROTEC 7SA6 distance protection relay

Description

The SIPROTEC 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

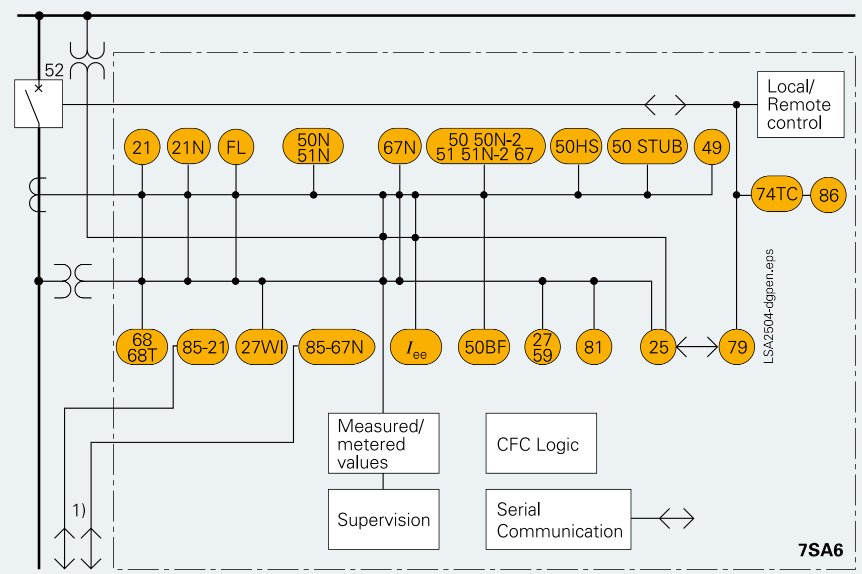
- Front interface for connecting a PC
- System interface for connecting to a control system via various protocols
  – IEC 61850 Ethernet
  – IEC 60870-5-103 protocol
  – PROFIBUS DP
  – DNP 3
- 1 serial protection data interface for teleprotection
- Rear-side service/modem interface
- Time synchronization via
  – IRIG-B or DCF 77 or
  – system interface

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.



1) Teleprotection schemes can use conventional signaling or serial data exchange

Fig. 6/2 Function diagram

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.

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

⅓, ½, ⅔, and 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

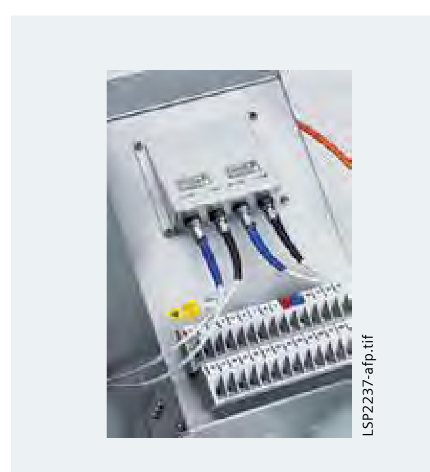


Fig. 6/7 Communication interfaces in a sloped case in a surface-mounting housing

6

6

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.

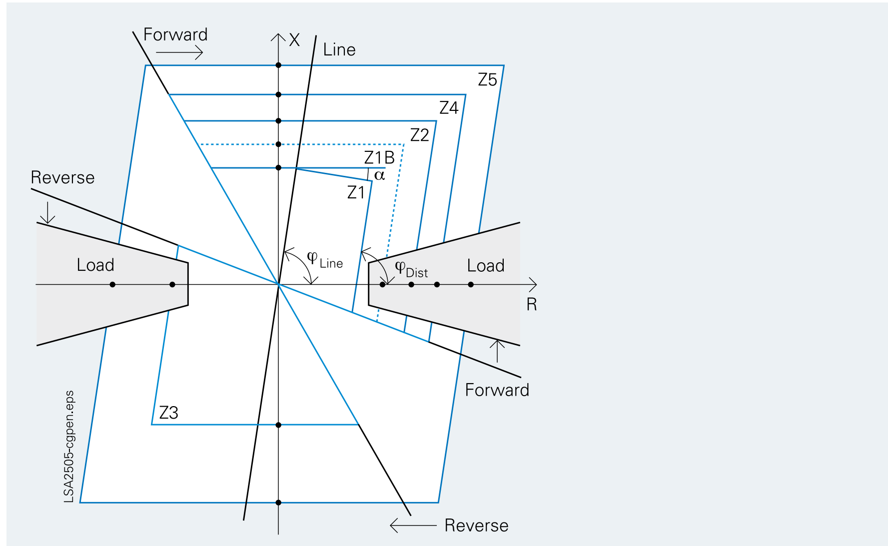


Fig. 6/8 Impedance fault detection $Z<$ with quadrilateral characteristic

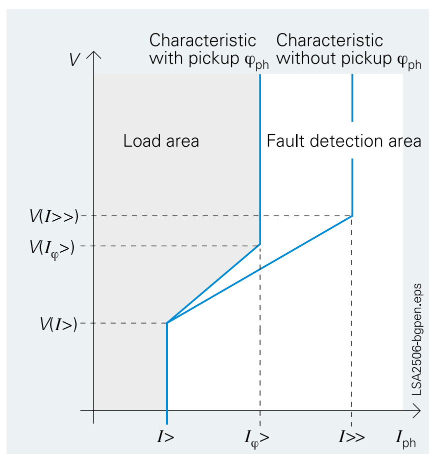


Fig. 6/9 Voltage and angle-dependent overcurrent fault detection $V/I/\varphi$

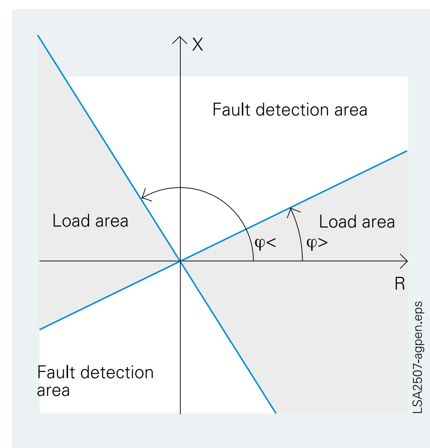


Fig. 6/10 Angle pickup for the $V/I/\varphi$ fault detection

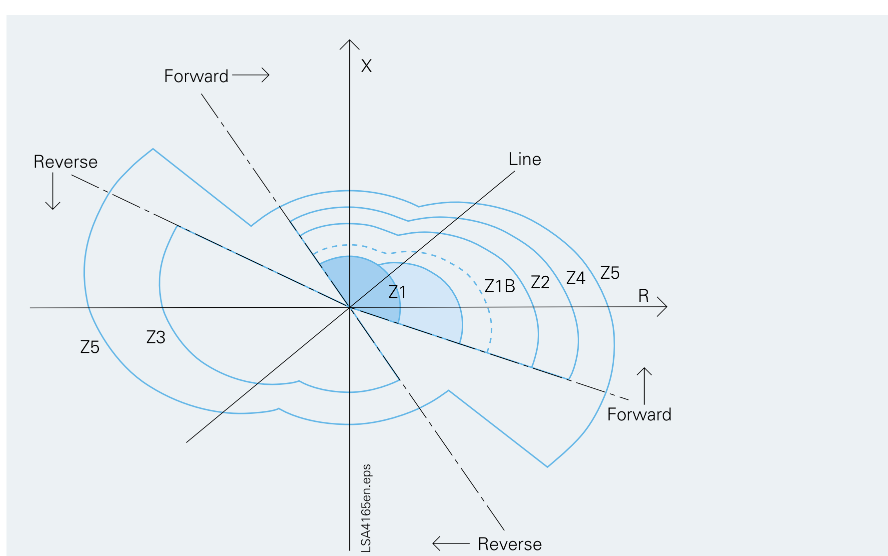


Fig. 6/11 Distance zones with circle characteristic

Seven distance zones
Six independant 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.

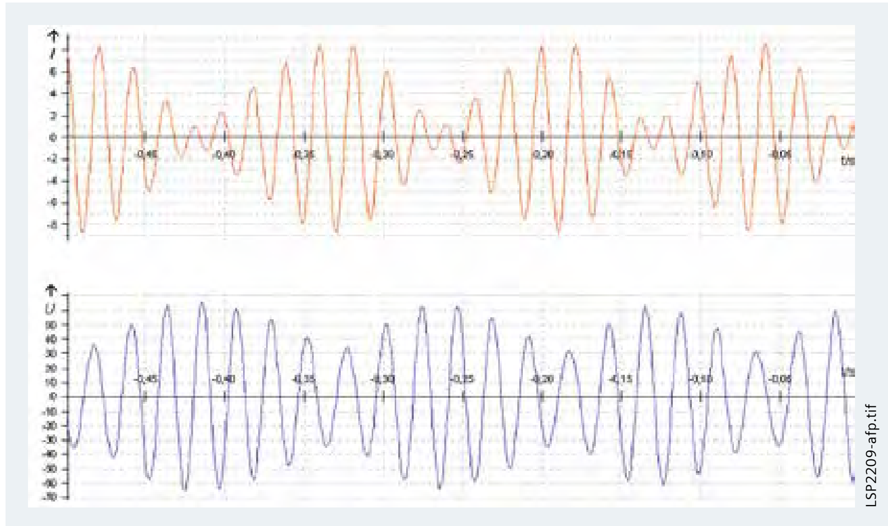


Fig. 6/12 Power swing current and voltage wave forms

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.

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.

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 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.

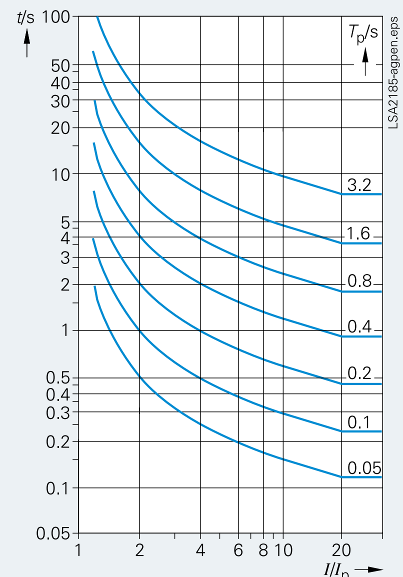
An additional logarithmic inverse-time characteristic is also available.

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.



$$t = \frac{0{,}14}{(I/I_p)^{0{,}02} - 1} T_p$$

Fig. 6/13 Normal inverse

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.

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 (disconnector) 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).

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.

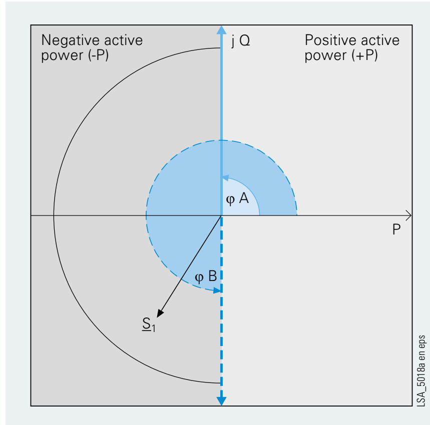


Fig. 6/14 Monitoring of active power direction

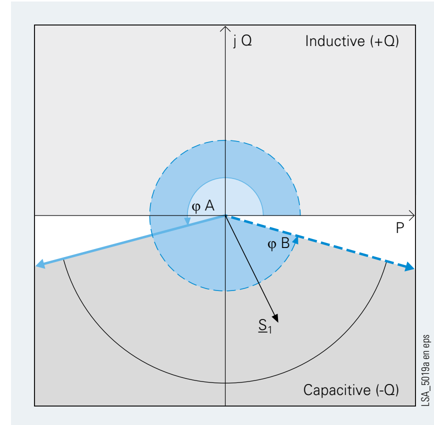


Fig. 6/15 Monitoring of reactive power

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.

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 (S1) of the positive-sequence system power is within the P - Q - level sector. This sector is between angles φ A and φ B. 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.

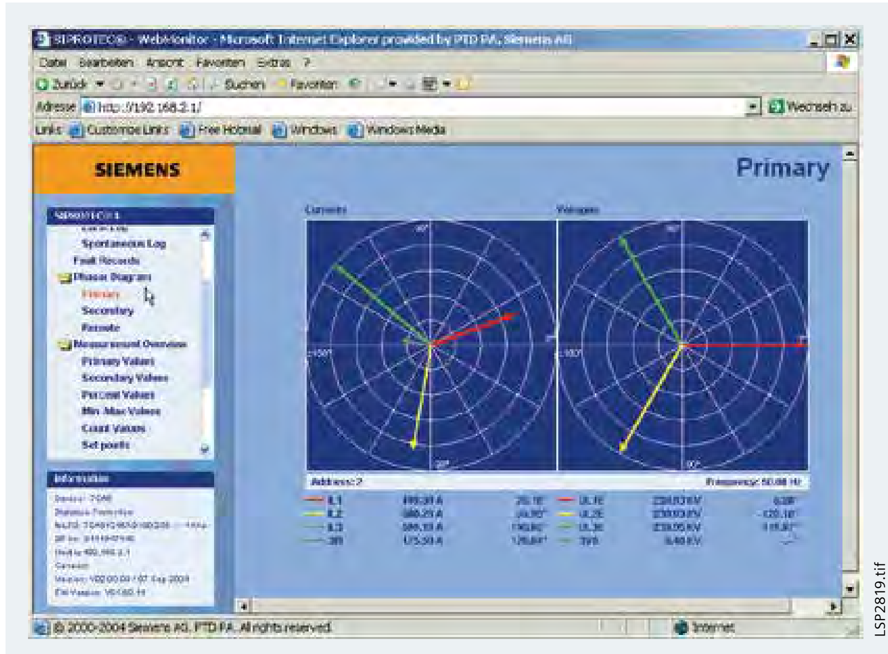


Fig. 6/16 Web Monitor: Supported commissioning by phasor diagram

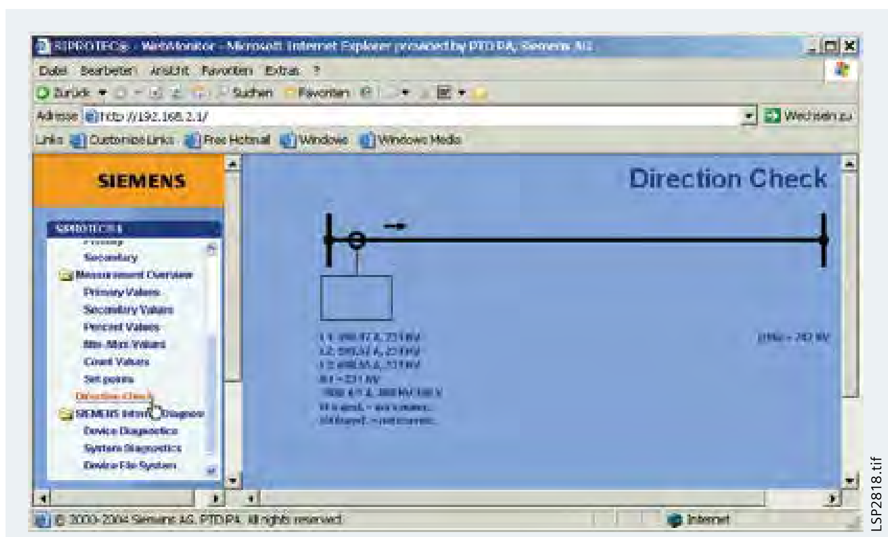


Fig. 6/17 Web Monitor: Display of the protection direction

6

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.

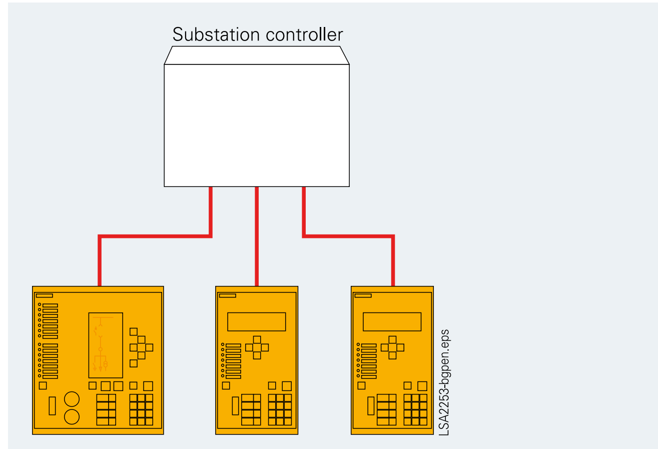


Fig. 6/18 IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

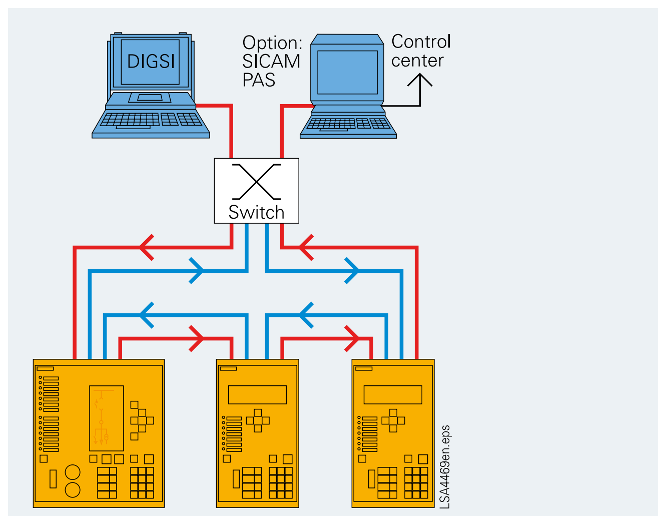


Fig. 6/19 Bus structure for station bus with Ethernet and IEC 61850

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. 6/20 820 nm fiber-optic communication module

Fig. 6/21 Fiber-optic Ethernet communication module for IEC 61850 with integrated Ethernet switch

Fig. 6/22 RS232/RS485 electrical communication module

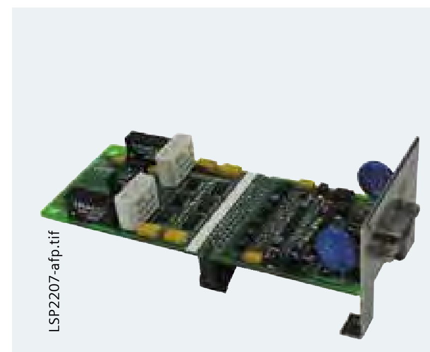


Fig. 6/23 Output module 0 to 20 mA, 2 channels

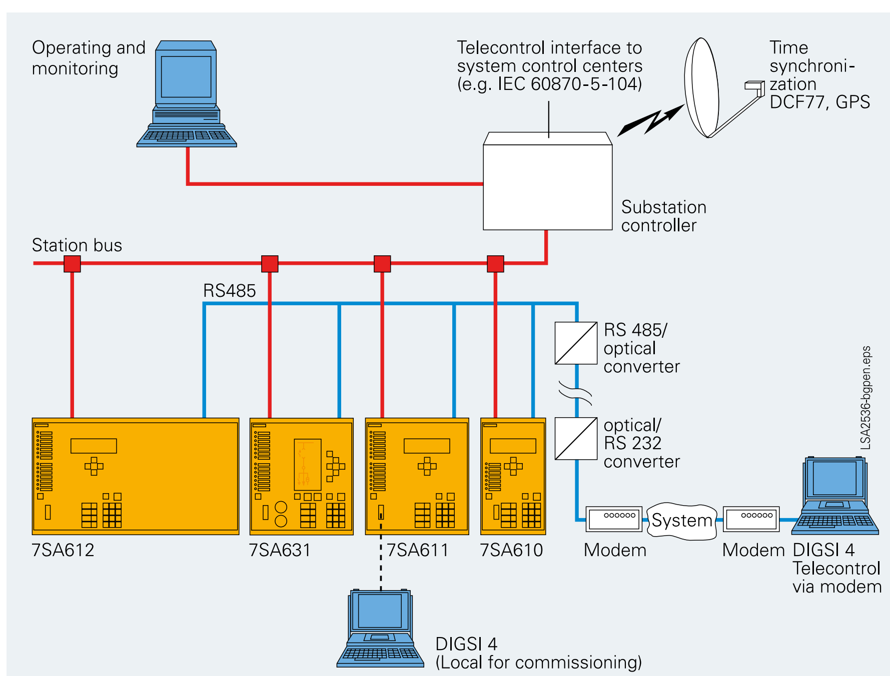


Fig. 6/24 Communication

Communication

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS DP. 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
- Interclose 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:

- FO5[1)], OMA1[2)] 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
- FO6[1)], OMA2[2)] module: Optical 820 nm, 2 ST connectors, FO cable length up to 3.5 km, for direct connection via multimode FO cable
- FO17[1)]: For direct connection up to 24 km[3)], 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO18[1)]: For direct connection up to 60 km[3)] 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO19[1)]: For direct connection up to 100 km[3)] 1550 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO30[1)]: 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.

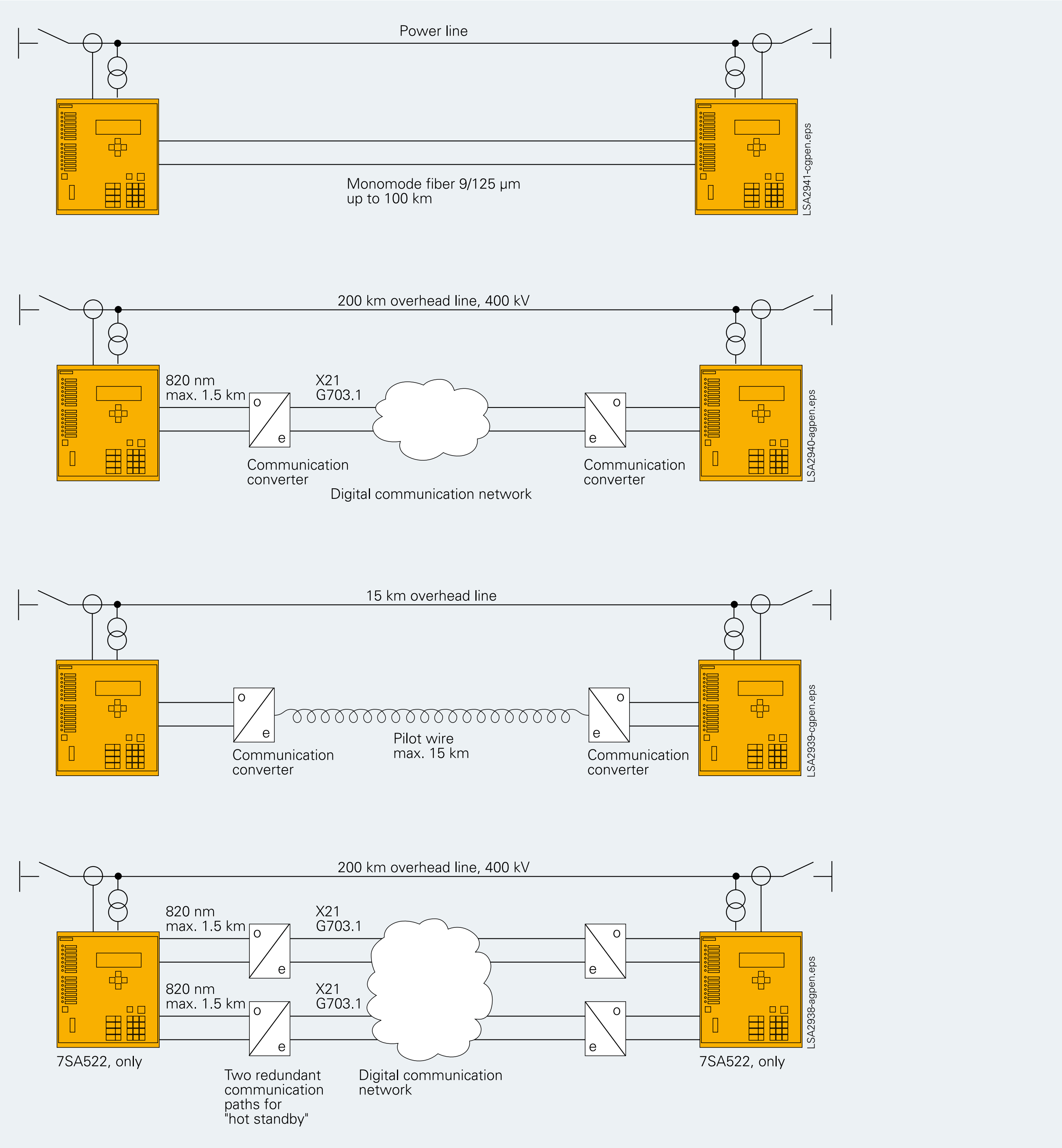


Fig. 6/25 Communication topologies for the serial protection data interface on a two-terminal line

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.

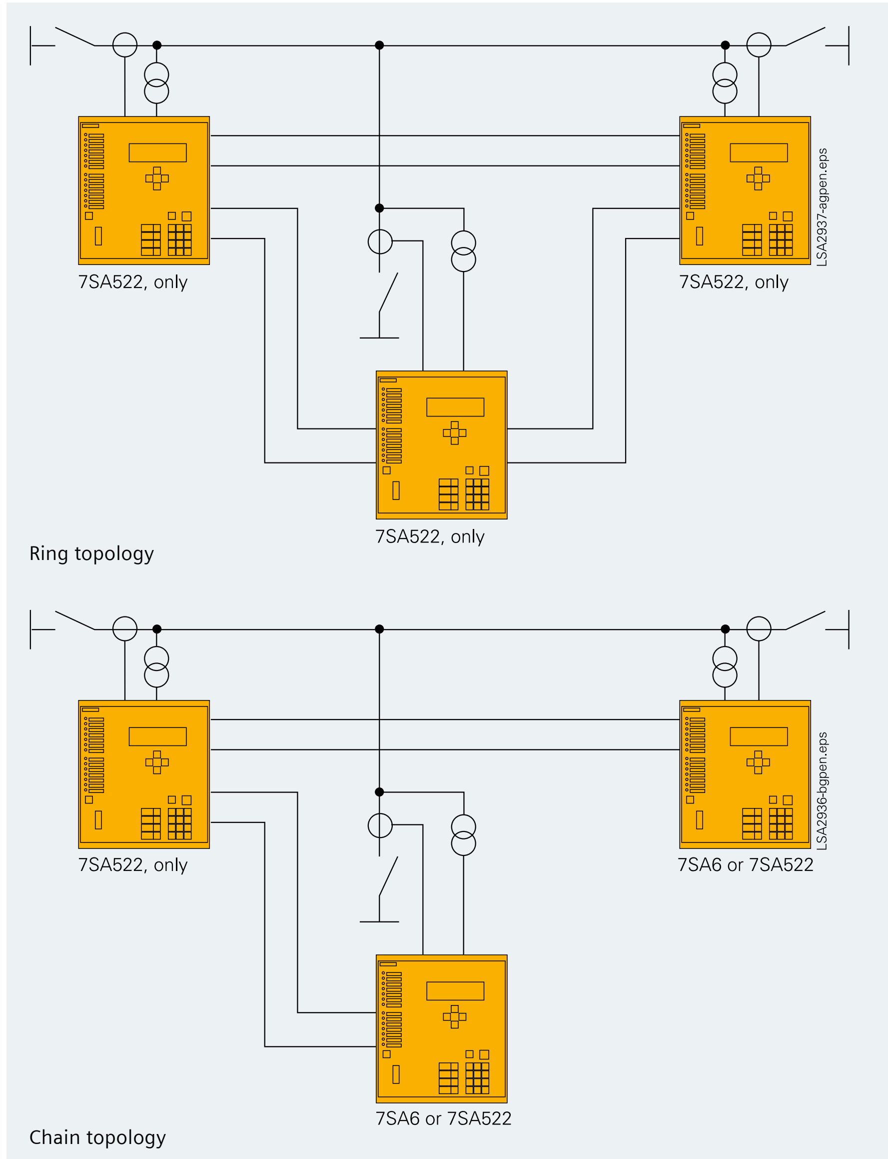


Fig. 6/26 Ring or chain communication topology

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.

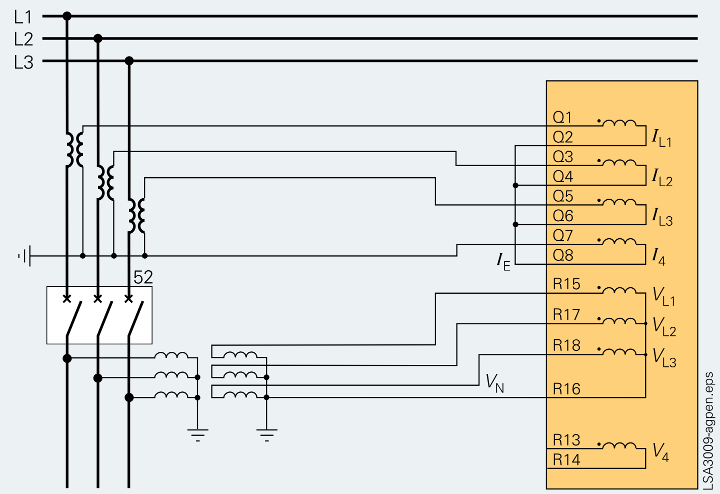


Fig. 6/27 Example of connection for current and voltage transformers

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.

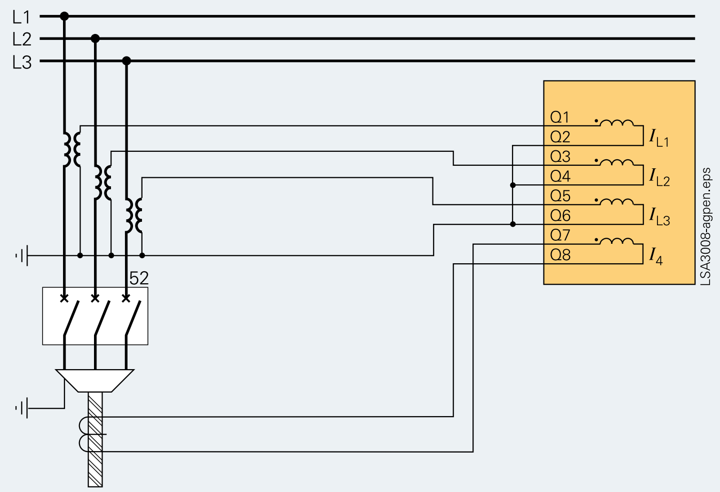


Fig. 6/28 Alternative connection of current transformers for sensitive ground-current measuring with core-balance current transformers

6

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.

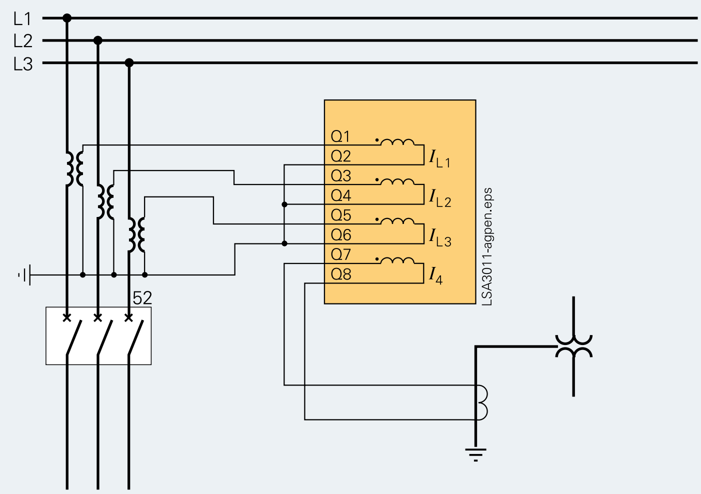


Fig. 6/29 Alternative connection of current transformers for measuring neutral current of an grounded power transformer

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.

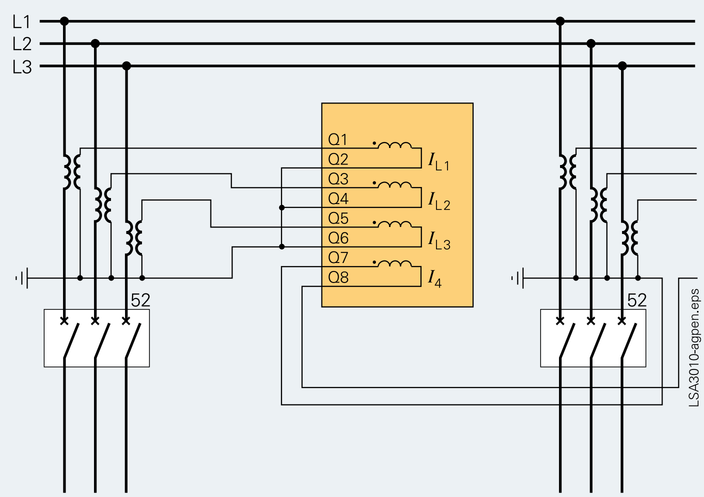


Fig. 6/30 Alternative connection of current transformers for measuring the ground current of a parallel line

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.

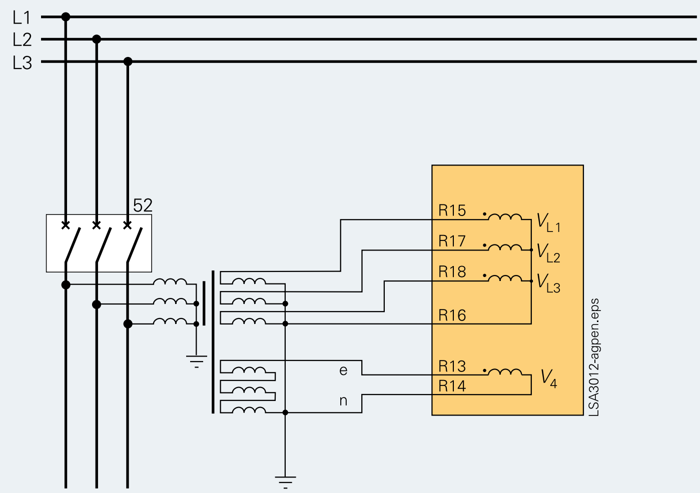


Fig. 6/31 Alternative connection of voltage transformers for measuring the displacement voltage (e-n voltage)

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.

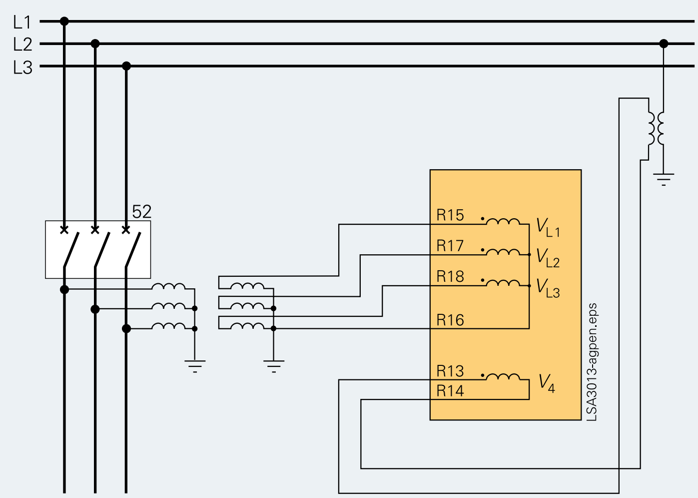


Fig. 6/32 Alternative connection of voltage transformers for measuring the busbar voltage

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 A With I_{nom} = 5 A For I_E, sensitive with 1 A Voltage inputs	 Approx. 0.05 VA Approx. 0.30 VA Approx. 0.05 VA ≤ 0.10 VA
Overload capacity of current circuit (r.m.s.) Thermal Dynamic (peak value)	 500 A for 1 s 150 A for 10 s 20 A continuous 1250 A (half cycle)
Ground current Sensitive Dynamic (peak value)	 300 A for 1 s 100 A for 10 s 15 A continuous 750 A (half cycle)
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 Energized	 Approx. 5 W Approx. 12 W to 18 W, depending on design
Bridging time during failure of the auxiliary voltage For V_{aux} = 48 V and V_{aux} ≥ 110 V For V_{aux} = 24 V and V_{aux} = 60 V	 ≥ 50 ms ≥ 20 ms
Binary inputs	
Quantity 7SA610*-*A/E/J 7SA610*-*B/F/K 7SA6*1*-*A/E/J 7SA6*1*-*B/F/K 7SA6*2*-*A/E/J 7SA6*2*-*B/F/K 7SA6*2*-*C/G/L	 5 7 13 20 21 29 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 Ranges are settable by means of jumpers for each binary input	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)
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 7SA610*-*B/F/K 7SA6*1*-*A/E/J 7SA6*1*-*B/F/K 7SA6*2*-*A/E/J 7SA6*2*-*B/F/K 7SA6*2*-*C/G/L	 5 NO contacts, 3 NC/NO contact[1)] 5 NO contacts, 12 NO contacts, 4 NC/NO contacts[1)] 8 NO contacts, 4 power relays[2)] 19 NO contacts, 5 NC/NO contacts[1)] 26 NO contacts, 6 NC/NO contacts[1)] 11 NO contacts, 8 power relays[2)]
<u>NO/NC contact</u>	
Switching capacity Make Break, high-speed trip outputs Break, contacts Break, contacts (for resistive load) Break, contacts (for τ = L/R ≤ 50 ms)	 1000 W / VA 1000 W / VA 30 VA 40 W 25 VA
Switching voltage	250 V
Permissible total current	30 A for 0.5 seconds 5 A continuous
Operating time, approx. NO contact NO/NC contact (selectable) Fast NO contact High-speed NO trip outputs	 8 ms 8 ms 5 ms < 1 ms
<u>Power relay for direct control of disconnector actuator motors</u>	
Switching capacity Make for 48 to 250 V Break for 48 to 250 V Make for 24 V Break for 24 V	 1000 W/ VA 1000 W/ VA 500 W/ VA 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 7SA6*1/2/3	 7 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	
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
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

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 µs; 0.5 Ws, 3 positive and 3 negative impulses in intervals of 5 s
EMC tests for noise immunity; type tests	
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; τ = 15 ms; 400 surges per s; test duration 2 s, R_i = 200 Ω
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 Ω
Irradiation with HF field, frequency sweep IEC 60255-22-3 (report) class III IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz: 80 % AM; 1 kHz 10 V/m; 800 to 960 MHz: 80 % AM; 1 kHz 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 Ω; test duration 1 min
High-energy surge voltages (SURGE), IEC 61000-4-5 installation class III Auxiliary supply	Impulse: 1.2/50 µs Common mode: 2 kV; 12 Ω; 9 µF Differential mode:1 kV; 2 Ω; 18 µF
Analog measurement inputs, binary inputs, relays output	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
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

6

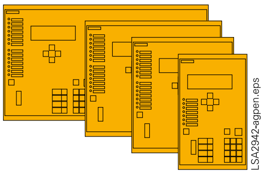
Oscillatory surge withstand capability, IEEE Std C37.90.1	2.5 kV (peak); 1 MHz τ = 50 µs; 400 surges per second, test duration 2 s, R_i = 200 Ω
Fast transient surge withstand capability, IEEE Std C37.90.1	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms repetition rate 300 ms, ; both polarities; test duration 1 min; R_i = 50 Ω
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 Ω
EMC tests for noise emission; type test	
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

6

Mechanical stress test	
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	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
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	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	
Standard	IEC 60255-6
Temperatures	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd	-25 °C to +85 °C / -13 °F to +185 °F
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
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.

Futher information can be found in the current manual at: www.siemens.com/siprotec



Operator panel with:
– 4-line backlit display,
– function keys,
– numerical keys,
– PC interface

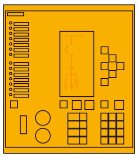
Description	Order No.
7SA61 distance protection relay for all voltage levels	**7SA61 ▯▯-▯▯▯▯▯-▯▯▯▯**
Housing, number of LEDs	
Housing width ▯ 19", 7 LEDs	0
Housing width ½ 19", 14 LEDs	1
Housing width ▯ 19", 14 LEDs	2
Housing width ⅔ 19", 14 LEDs	3
Measuring inputs (4 x V/4 x I)	
I_{ph} = 1 A[1], I_e = 1 A[1] (min. = 0.05 A)	1
I_{ph} = 1 A[1], I_e = 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 = 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

see pages 6/32 to 6/35

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	Order No.
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

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.

Selection and ordering data



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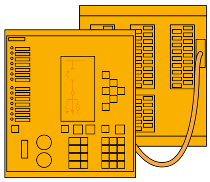
Operator panel with:
– backlit graphic display for single-line diagram
– control keys,
– key-operated switches,
– function keys,
– numerical keys,
– PC interface

Description	Order No.
7SA63 distance protection relay for all voltage levels	7SA63□□-□□□□□-□□□□
Housing, number of LEDs	
Housing width ½ 19", 14 LEDs	1
Housing width □ 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 = 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 = 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

see pages 6/32 to 6/35

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	Order No.
For 7SA631								
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

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.



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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 ▯ 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 = 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 = 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**

see pages 6/32 to 6/35

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	Order No.
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**

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.

6

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]		see pages 6/33 to 6/35
Region DE, language: German	A	
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	
2 analog outputs, each 0.....20 mA	7	
System interface, PROFIBUS DP, electrical RS485	9	L 0 A
System interface, PROFIBUS DP, optical 820 nm, double ring [2], ST connector	9	L 0 B
System interface, DNP 3.0, electrical RS485	9	L 0 G
System interface, DNP 3.0, optical 820 nm, ST connector[2]	9	L 0 H
System interface, IEC 61850, 100 Mbit/s Ethernet, electrical, duplicate, RJ45 plug connectors	9	L 0 R
System interface, IEC 61850, 100 Mbit/s Ethernet, optical, double, LC connector[3]	9	L 0 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) Optical double ring interfaces are not available with surface mounting housings.

3) For surface mounting housing applications please order the relay with electrical Ethernet interface and use a separate fiber-optic switch.

Description	Order No.	Order code
7SA6 distance protection relay for all voltage levels	7SA6□□□-□□□□□-□□□□	□□□
Port C and port D		see pages 6/34 and 6/35
Port C: DIGSI/modem, electrical RS232, Port D: empty	1	
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

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.

6

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		Order No.
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	Order No.
I>			**A**
V< / *I*>			**B**
Quadrilateral (*Z*<)			**C**
Quadrilateral (*Z*<), *V*< / *I*> / *φ*			**D**
Quadrilateral (*Z*<)	■		**F**
Quadrilateral (*Z*<), *V*< / *I*> / *φ*	■		**G**
V< / *I*>		■ 1)	**J**
Quadrilateral (*Z*<)		■ 1)	**K**
Quadrilateral (*Z*<), *V*< / *I*> / *φ*		■ 1)	**L**
Quadrilateral (*Z*<)	■	■ 1)	**N**
Quadrilateral (*Z*<), *V*< / *I*> / *φ*	■	■ 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)	Order No.
				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		Order No.
				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**.

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 $V</I>$	$Z<$ (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	
Basic version															
■		■								■					1 A B 0
■		■								■				■	1 A B 1
Medium voltage, cables															
■		■	■						■	■	■	■ 1)	■		3 B D 6
■		■	■						■	■	■	■ 1)	■	■	1 B D 7
Medium voltage, overhead lines															
■		■	■				■		■	■	■	■ 1)	■		3 B M 6
■		■	■				■		■	■	■	■ 1)	■	■	3 B M 7
High voltage, cables															
■		■	■	■	■			■	■	■	■		■		3 G H 4
■		■	■	■	■			■	■	■	■		■	■	3 G H 5
High voltage, overhead lines															
■	■	■	■	■	■	■ 2)	■	■	■	■	■		■		7 P R 4
■	■	■	■	■	■	■ 2)	■	■	■	■	■		■	■	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**.

6

Selection and ordering data

Accessories	Description	Order No.
	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 FO5, OMA1, 820 nm, multi-mode FO cable, ST connector, 1.5 km	**C53207-A351-D651-1**
	Protection data interface FO6, OMA2, 820 nm, multi-mode FO cable, ST connector, 3.5 km	**C53207-A351-D652-1**
	Protection data interface FO17, 1300 nm, mono-mode FO cable, LC-Duplex connector, 24 km	**C53207-A351-D655-1**
	Protection data interface FO18, 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	**C53207-A351-D656-1**
	Protection data interface FO19, 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	**C53207-A351-D657-1**
	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**

6

Accessories


LSP2289-afp.eps

Fig. 6/33 Mounting rail for 19" rack


LSP2090-afp.eps

Fig. 6/34
2-pin connector


LSP2091-afp.eps

Fig. 6/35
3-pin connector


LSP2093-afp.eps

Fig. 6/36
Short-circuit link for current contacts


LSP2092-afp.eps

Fig. 6/37
Short-circuit link for voltage contacts/ indications contacts

Description		Order No.	Size of package	Supplier	Fig.
Connector	2-pin	**C73334-A1-C35-1**	1	Siemens	6/35
	3-pin	**C73334-A1-C36-1**	1	Siemens	6/36
Crimp connector	CI2 0.5 to 1 mm^2	**0-827039-1**	4000	1)	
		0-827396-1	1	1)	
	CI2 0.5 to 2.5 mm^2	**0-827040-1**	4000	1)	
		0-827397-1	1	1)	
	Type III+ 0.75 to 1.5 mm^2	**0-163083-7**	4000	1)	
		0-163084-2	1	1)	
Crimping tool	For type III+	**0-539635-1**	1	1)	
	and matching female	**0-539668-2**		1)	
	For CI2	**0-734372-1**	1	1)	
	and matching female	**1-734387-1**		1)	
19"-mounting rail		**C73165-A63-D200-1**	1	Siemens	6/34
Short-circuit links	For current terminals	**C73334-A1-C33-1**	1	Siemens	6/37
	For other terminals	**C73334-A1-C34-1**	1	Siemens	6/38
Safety cover for terminals	large	**C73334-A1-C31-1**	1	Siemens	6/4
	small	**C73334-A1-C32-1**	1	Siemens	6/4

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram

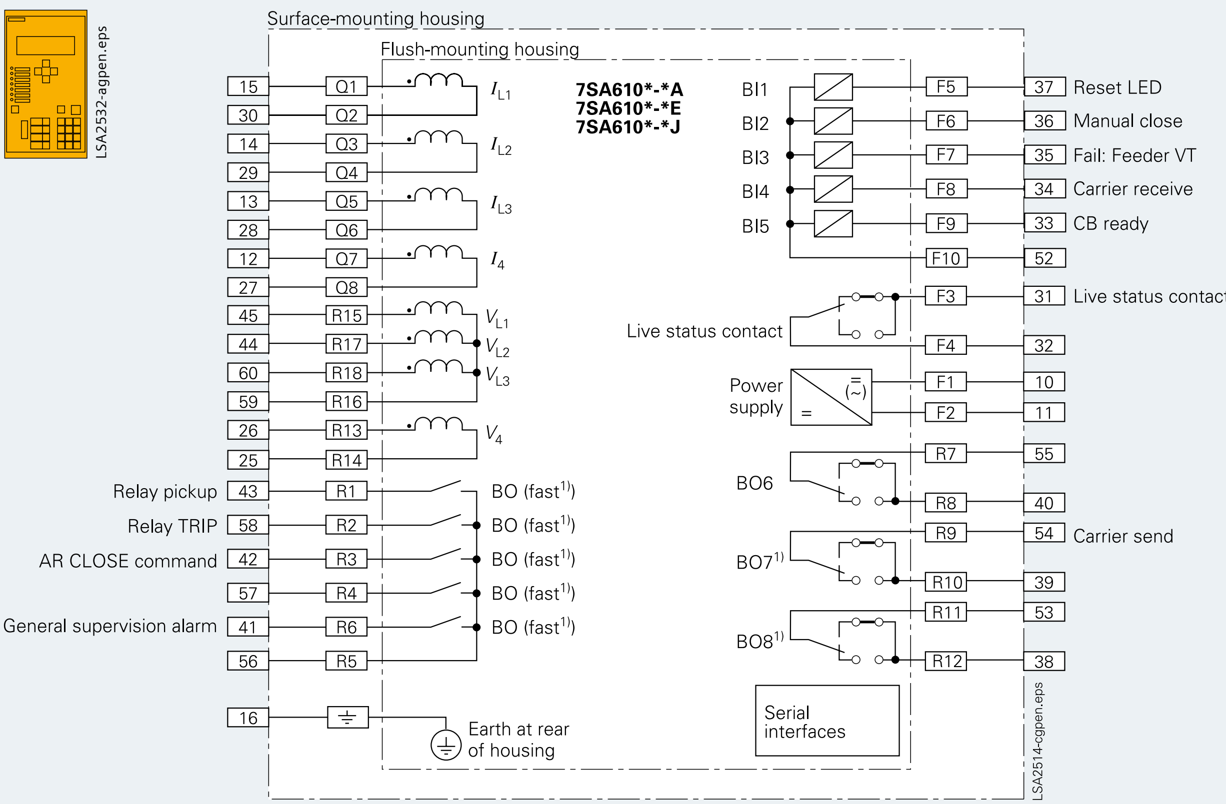
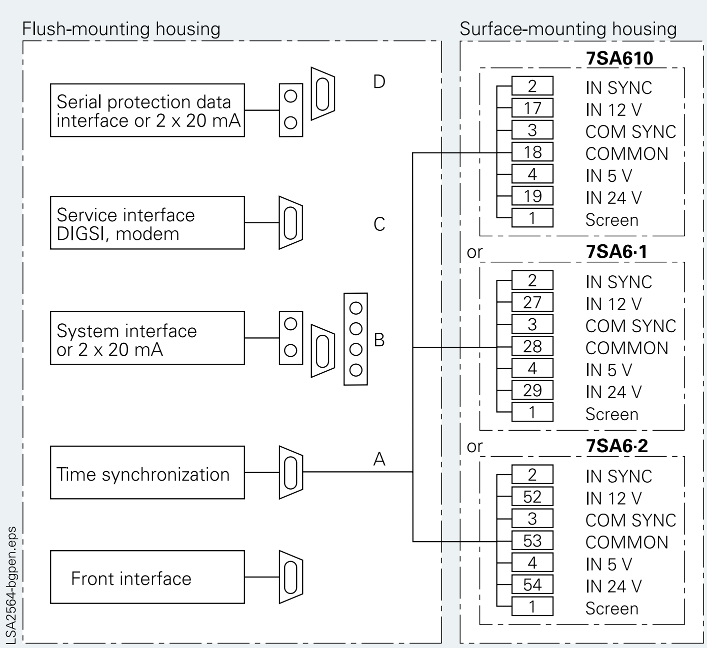


Fig. 6/38 Connection diagram



1) Starting from unit version ..../EE.

Fig. 6/39 Serial interfaces

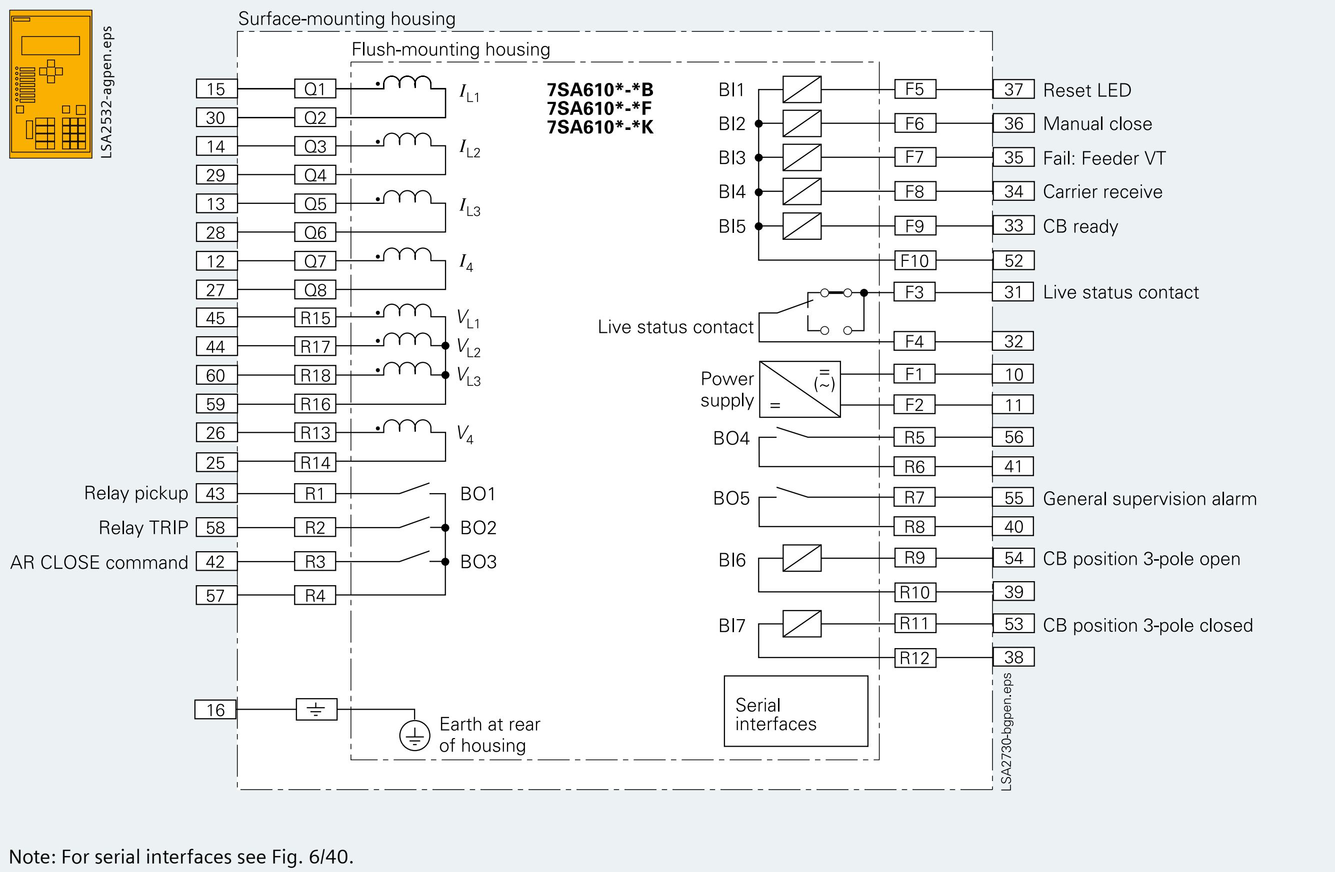
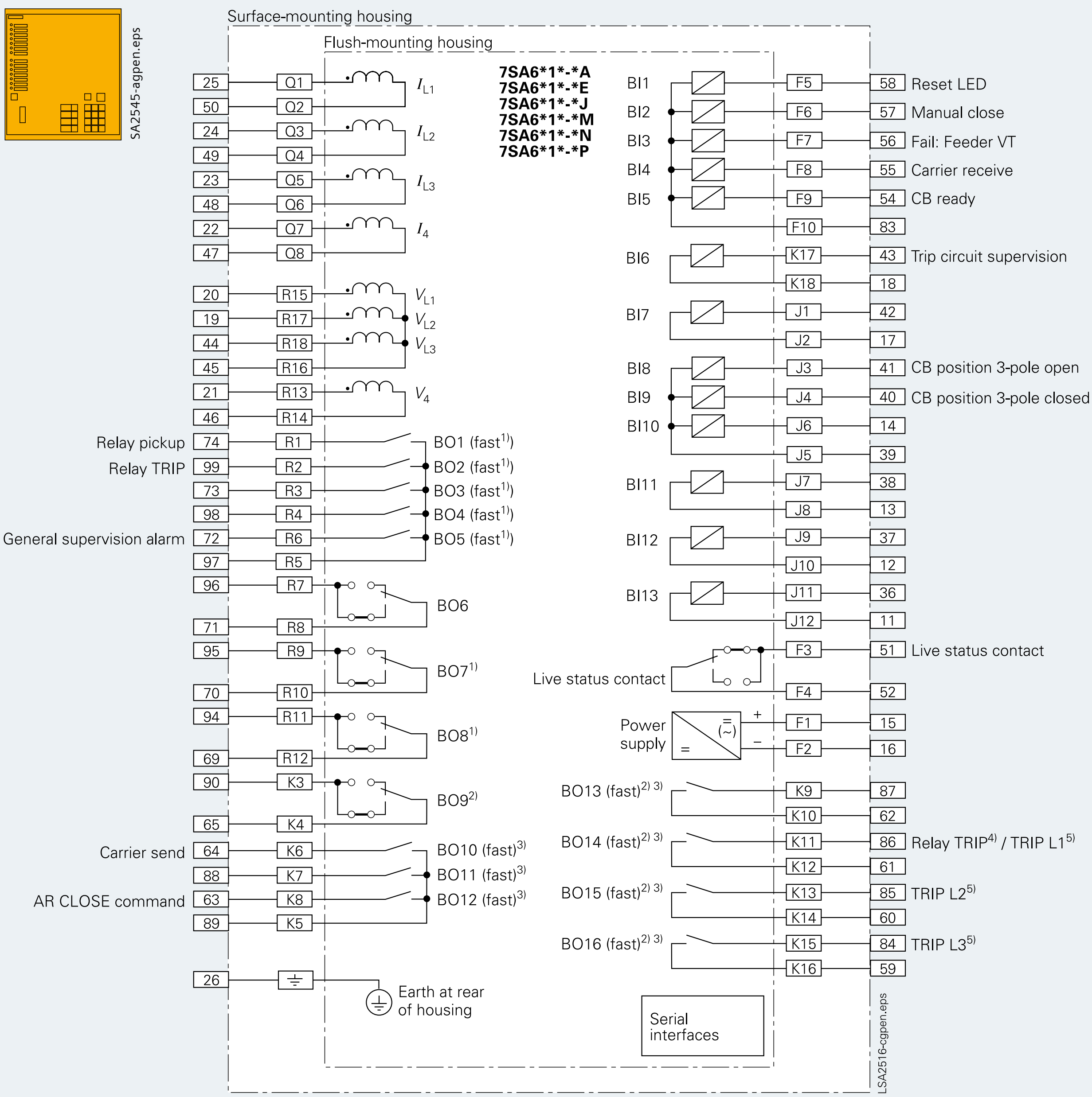


Fig. 6/40 Connection diagram

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

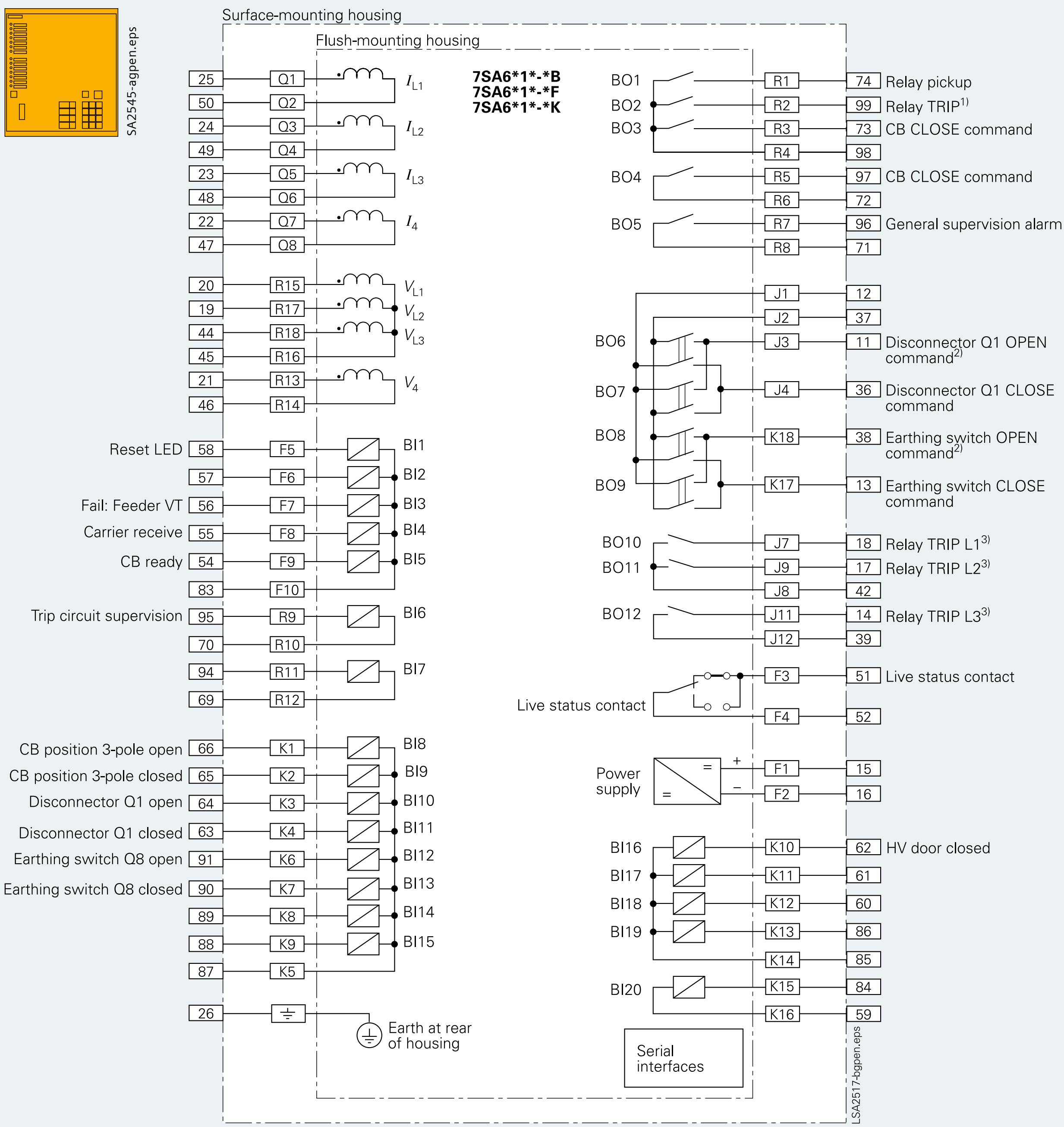
3) Time advantage with fast relay approx. 3 ms.

4) Version with 3-pole tripping.

5) Version with 1/3-pole tripping.

Note: For serial interfaces see Fig. 6/40.

Fig. 6/41 Connection diagram



1) Version with 3-pole tripping.

2) Each pair of contacts is mechanically interlocked to prevent simultaneous closure.

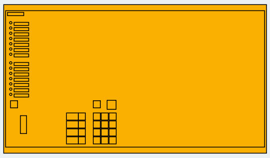
3) Version with 1/3-pole tripping.

Note: For serial interfaces see Fig. 6/40.

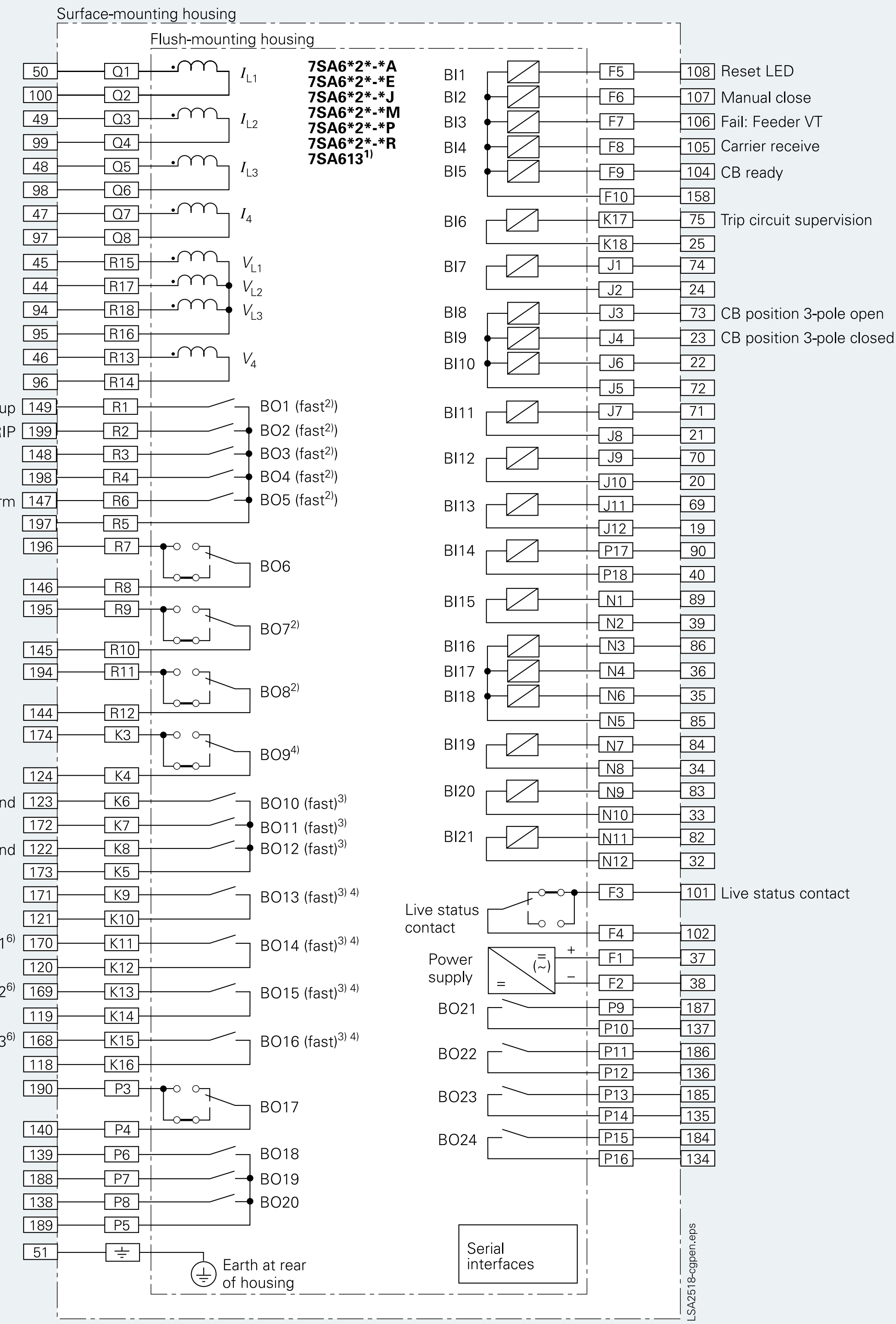
Fig. 6/42 Connection diagram

6

Connection diagram



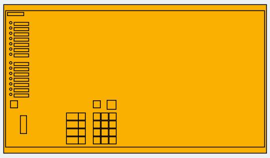
SA2546-agpen.eps

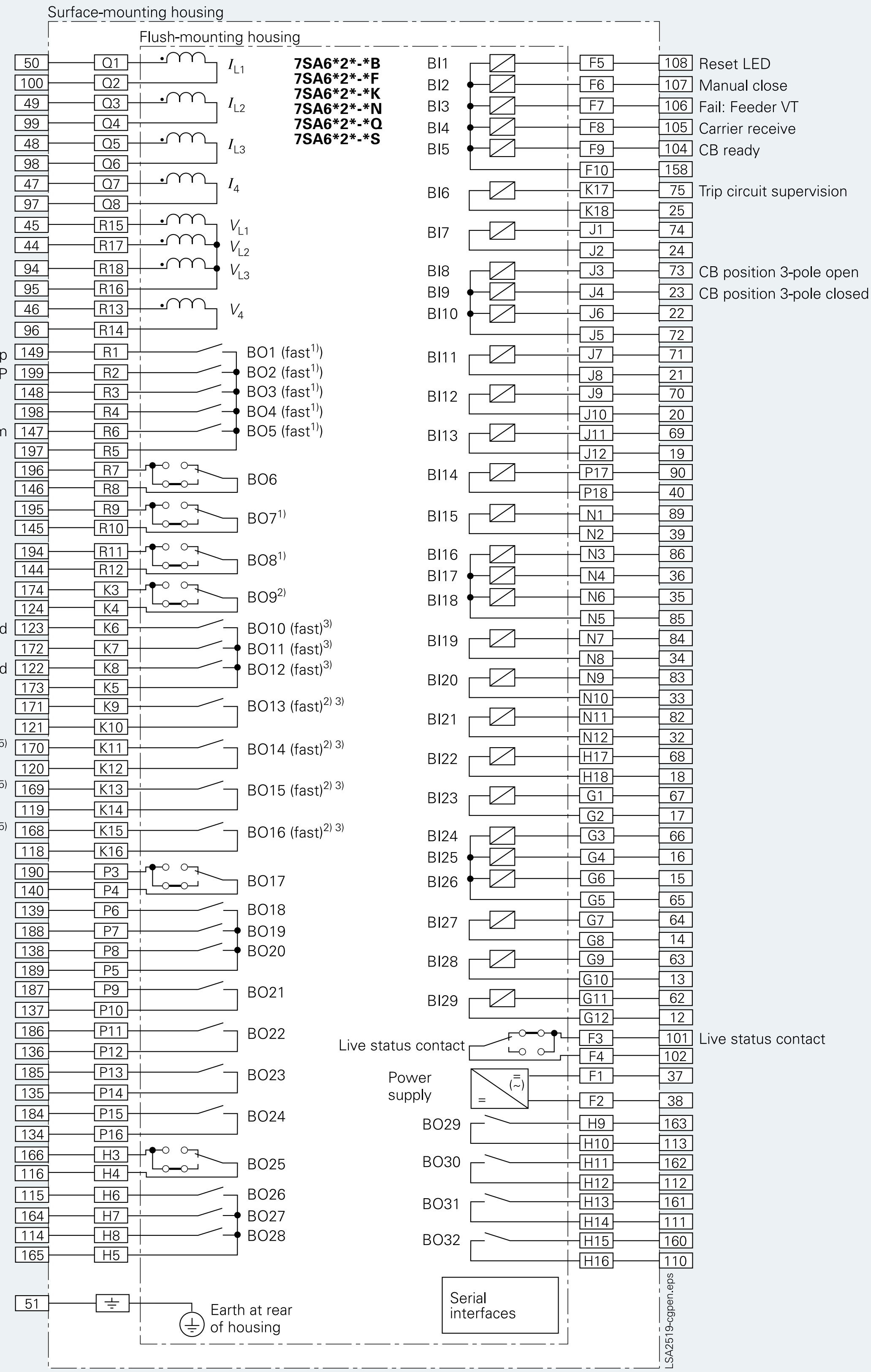


1) 7SA613 is only available in a 2/3 x 19" flush-mounting housing.
2) Starting from unit version .../EE
3) Time advantage with fast relay approx. 3 ms.
4) High-speed trip outputs in versions 7SA6*2*-*M, 7SA6*2*-*P, 7SA6*2*-*R.
Time advantage of high-speed relays over fast relays: approx. 5 ms
5) Version with 3-pole tripping.
6) Version with 1/3-pole tripping.

Note: For serial interfaces see Fig. 6/40.

Fig. 6/43 Connection diagram





1) Starting from unit version .../EE.

2) High-speed trip outputs in versions 7SA6*2*-*N, 7SA6*2*-*Q, 7SA6*2*-*S.

3) Time advantage with fast relay approx. 3 ms.

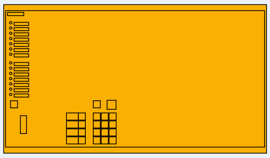
4) Version with 3-pole tripping.

5) Version with 1/3-pole tripping. Time advantage of high-speed relays over fast relays: approx. 5 ms.

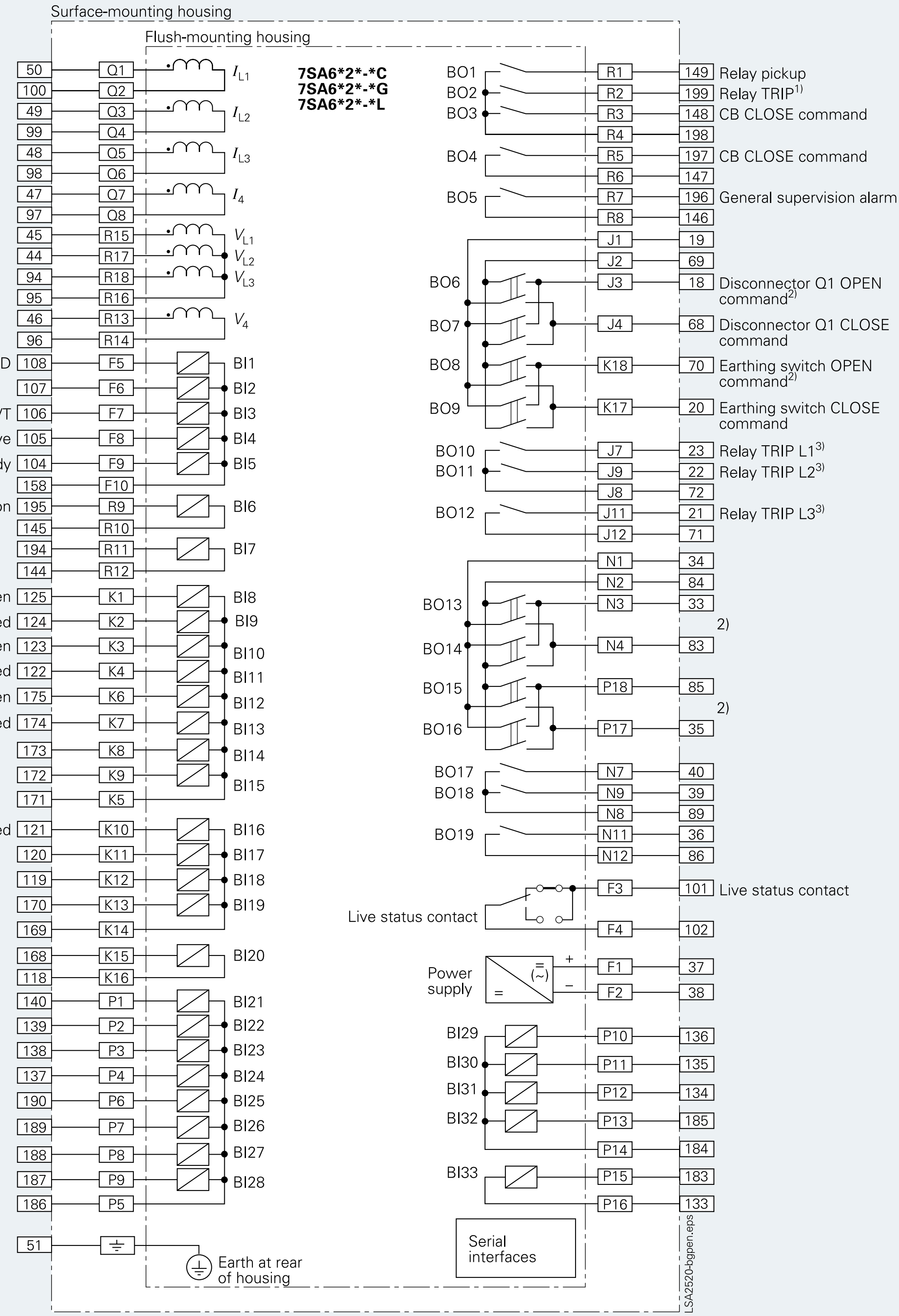
Note: For serial interfaces see Fig. 6/40.

Fig. 6/44 Connection diagram

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. 6/45 Connection diagram

SIPROTEC 7SA522 distance protection relay for transmission lines

Fig. 6/46 SIPROTEC 7SA522 distance protection relay

Description

The SIPROTEC 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 DP
  - DNP 3
- 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)

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.

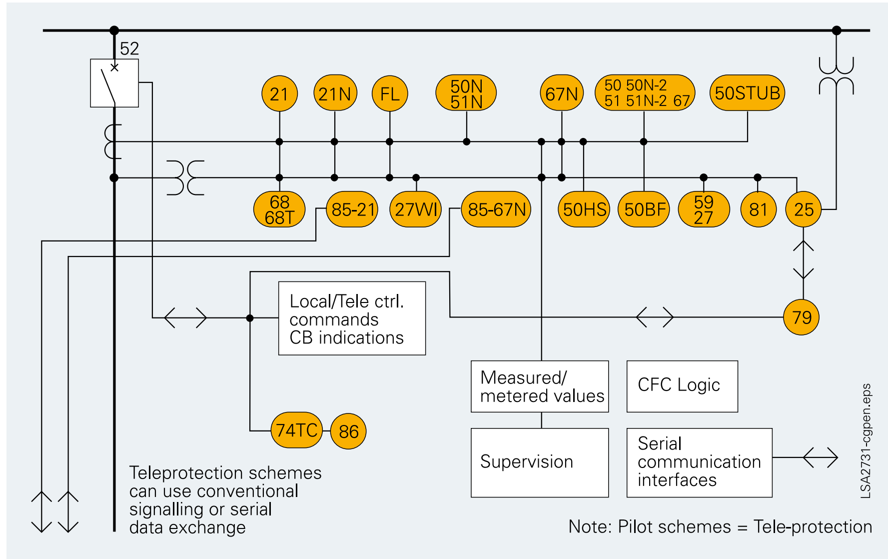


Fig. 6/47 Single-line diagram

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.

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	Overvoltage/undervoltage protection
81O/U	Over/underfrequency protection
25	Synchro-check
79	Auto-reclosure
74TC	Trip circuit supervision
86	Lockout (CLOSE command interlocking)

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 fo frequencies up to 7 Hz
- Digital relay-to-relay communication for two and three terminal topologies
- Adaptive auto-reclosure (ADT)

Construction

Connection techniques and housing with many advantages

½ and 1/1-rack sizes

These are the available housing widths of the SIPROTEC 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. 6/48 Housing widths ½ × 19" and 1/1 × 19"

Fig. 6/49 Rear view with screw-type terminals and serial interfaces

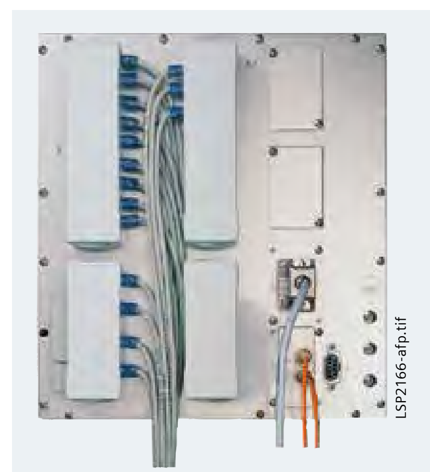


Fig. 6/50 Rear view with terminal covers and wiring

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 independant 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.

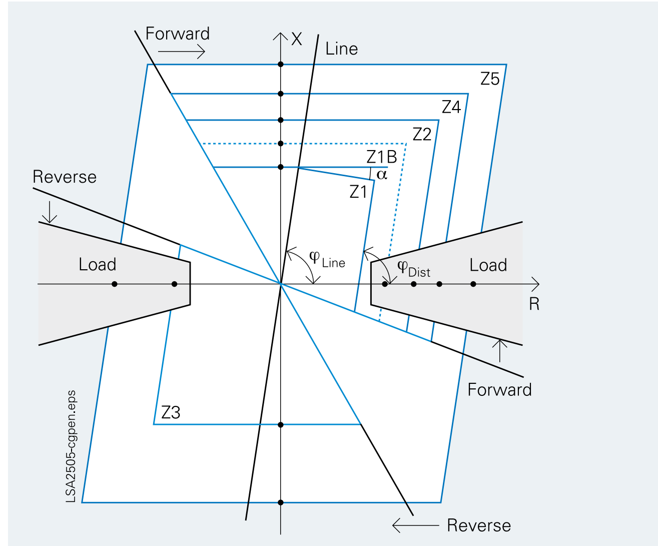


Fig. 6/51 Distance protection: quadrilateral characteristic

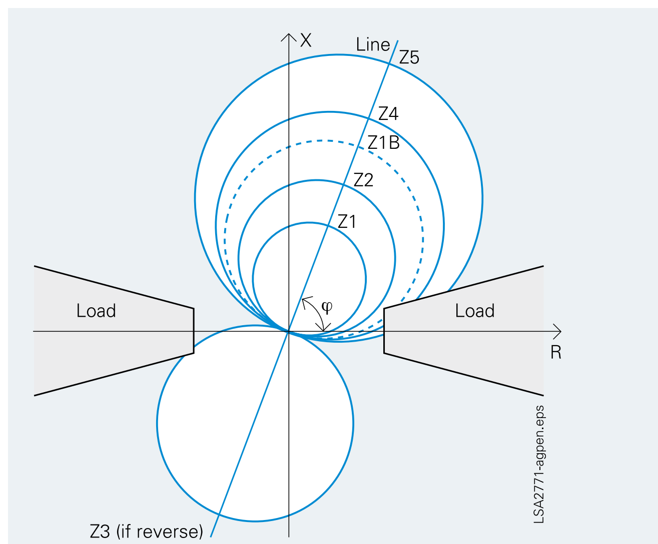


Fig. 6/52 Distance protection: mho characteristic

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)

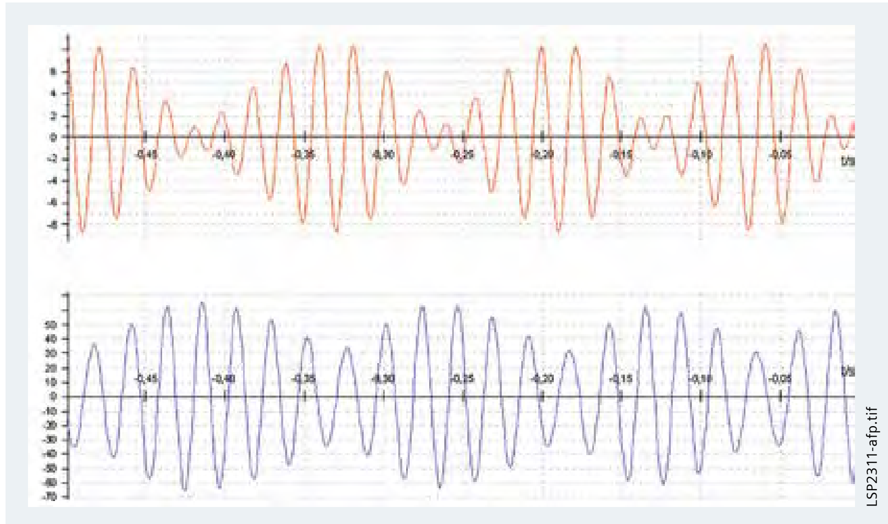


Fig. 6/53 Power swing current and voltage wave forms

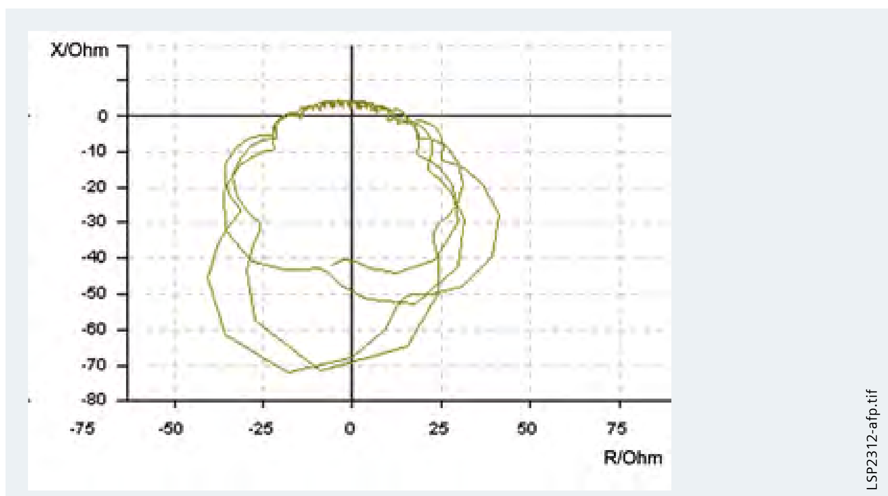


Fig. 6/54 Power swing circle diagram

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).

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.

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 an 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.

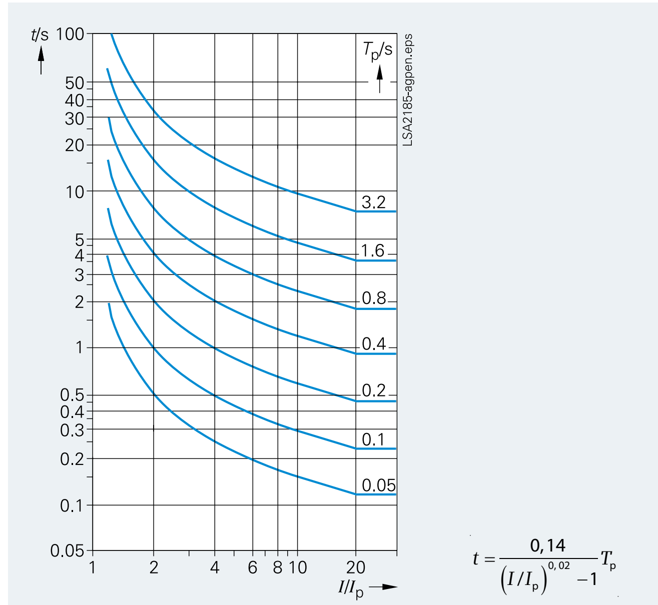


Fig. 6/55 Normal inverse

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.

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").

6

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 signalling that the line isolator (disconnector) 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 4^{th} 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.

6

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 (S1) of the positive-sequence system power is within the P - Q - level sector. This sector is between angles φ A and φ B.
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.

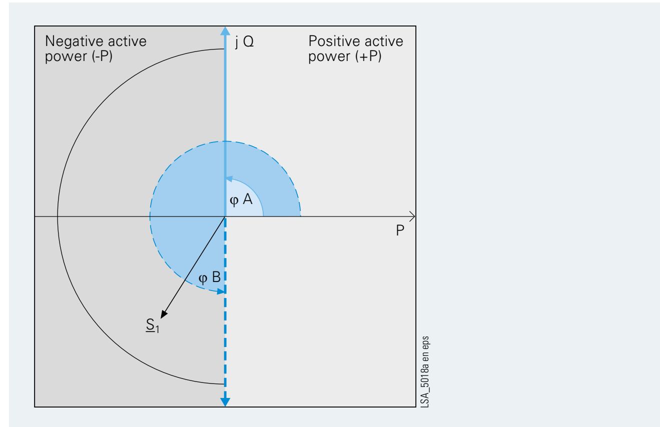


Fig. 6/56 Monitoring of active power direction

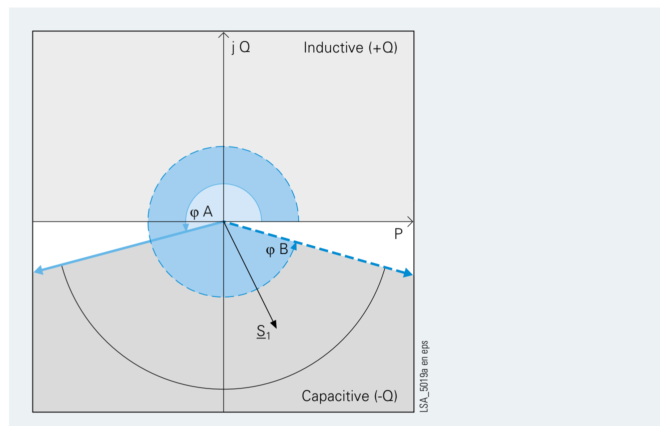


Fig. 6/57 Monitoring of reactive power

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.

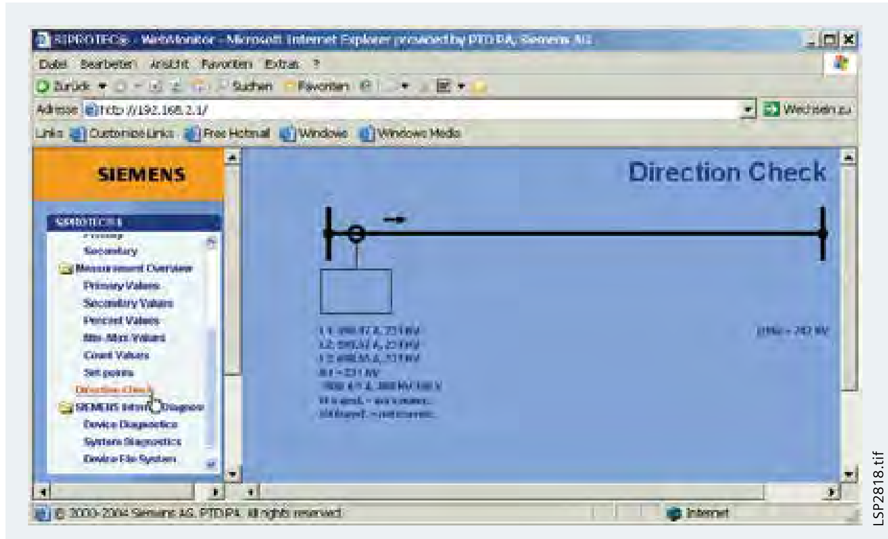


Fig. 6/58 Web Monitor: Display of the protection direction

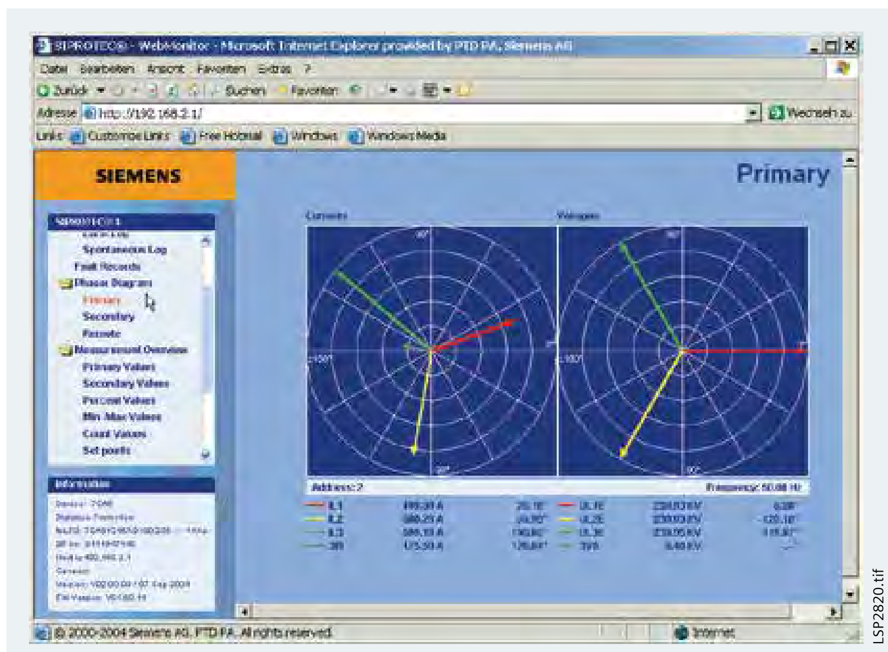


Fig. 6/59 Web monitor: Supported commissioning by phasor diagram

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.

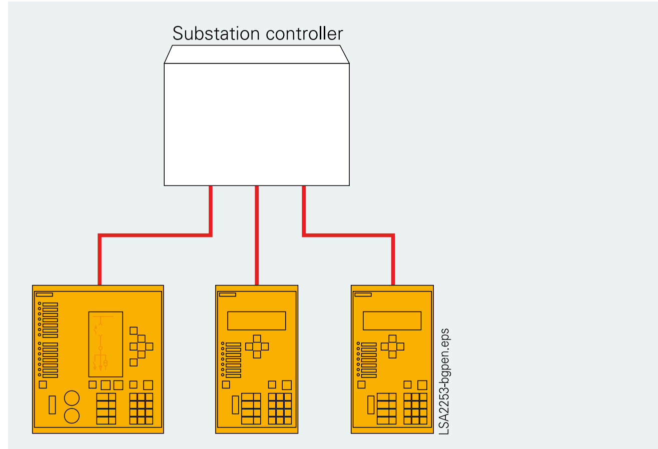


Fig. 6/60 IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

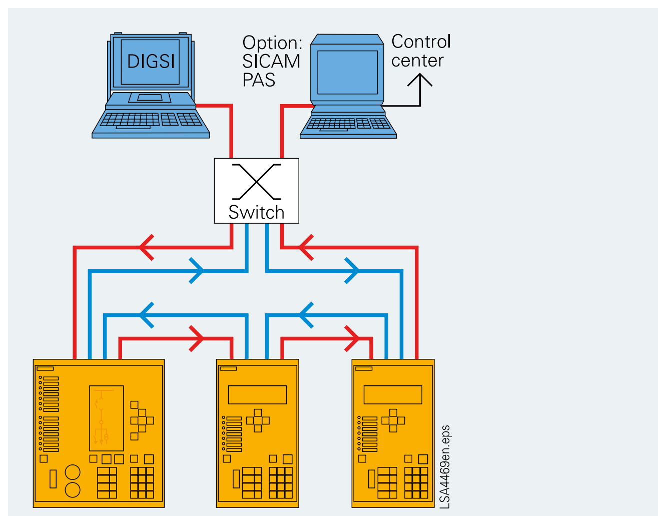


Fig. 6/61 Bus structure for station bus with Ethernet and IEC 61850

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 communcation 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 DP. 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. 6/62 820 nm fiber-optic communication module

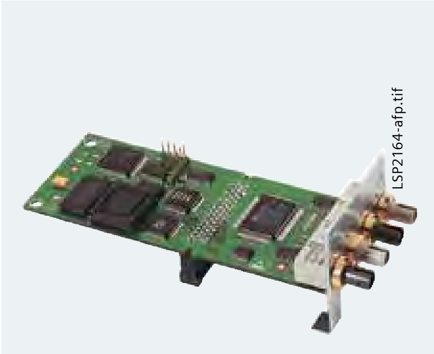


Fig. 6/63 PROFIBUS fiber-optic double ring communication module

Fig. 6/64 RS232/RS485 electrical communication module

Fig. 6/65 Fiber-optic Ethernet communication module for IEC 61850 with integrated Ethernet switch

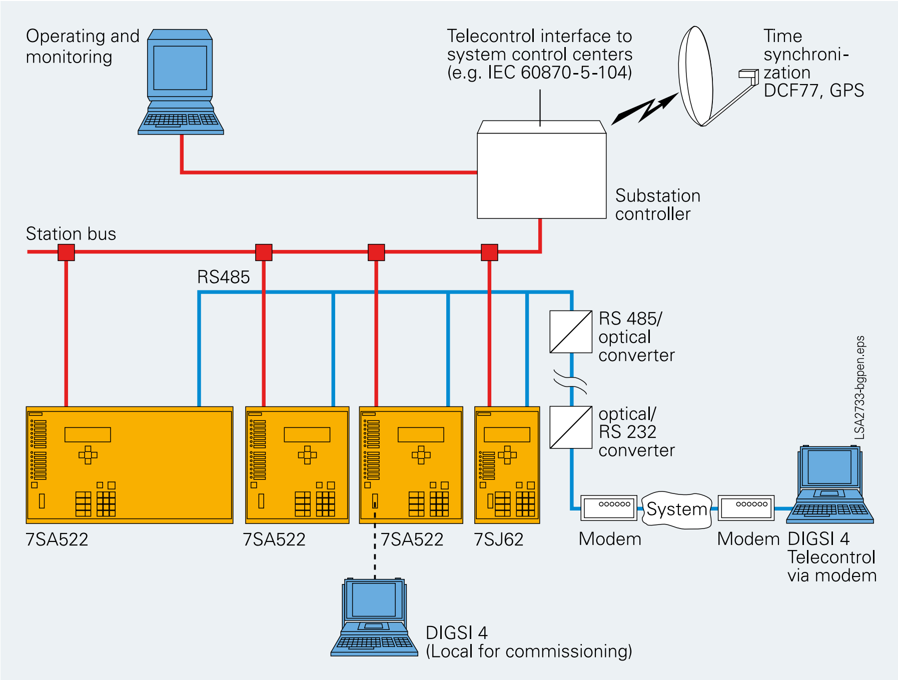


Fig. 6/66 Communication

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
- Interclose 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:

- FO5[1)], OMA1[2)] 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
- FO6[1)], OMA2[2)] module: Optical 820 nm, 2 ST connectors, FO cable length up to 3.5 km, for direct connection via multi-mode FO cable
- FO17[1)]: for direct connection up to 24 km[3)], 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO18[1)]: for direct connection up to 60 km[3)], 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO19[1)]: for direct connection up to 100 km[3)], 1550 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO30[1)]: 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.

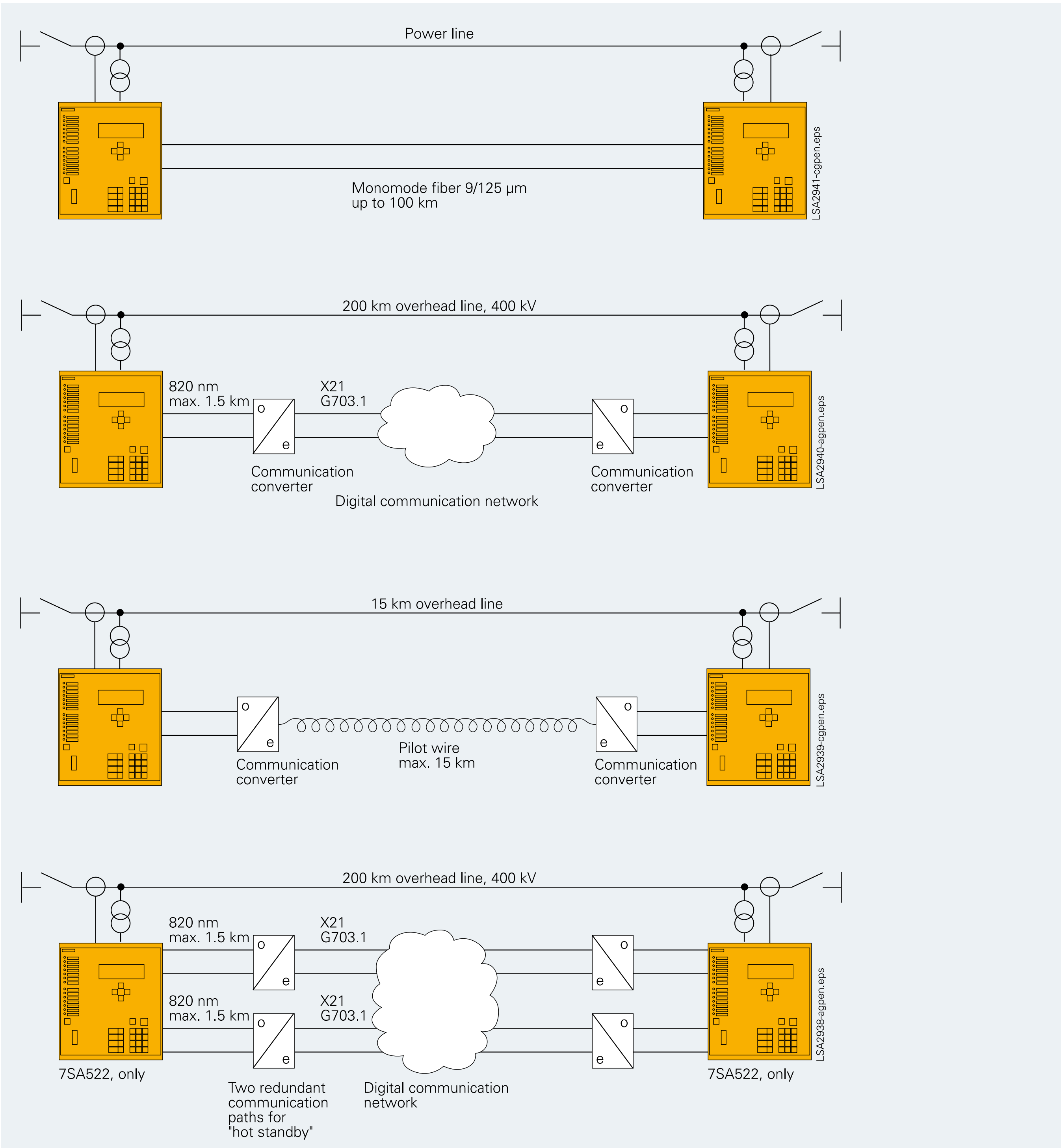


Fig. 6/67 Communication topologies for the serial protection data interface on a two-terminal line

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.

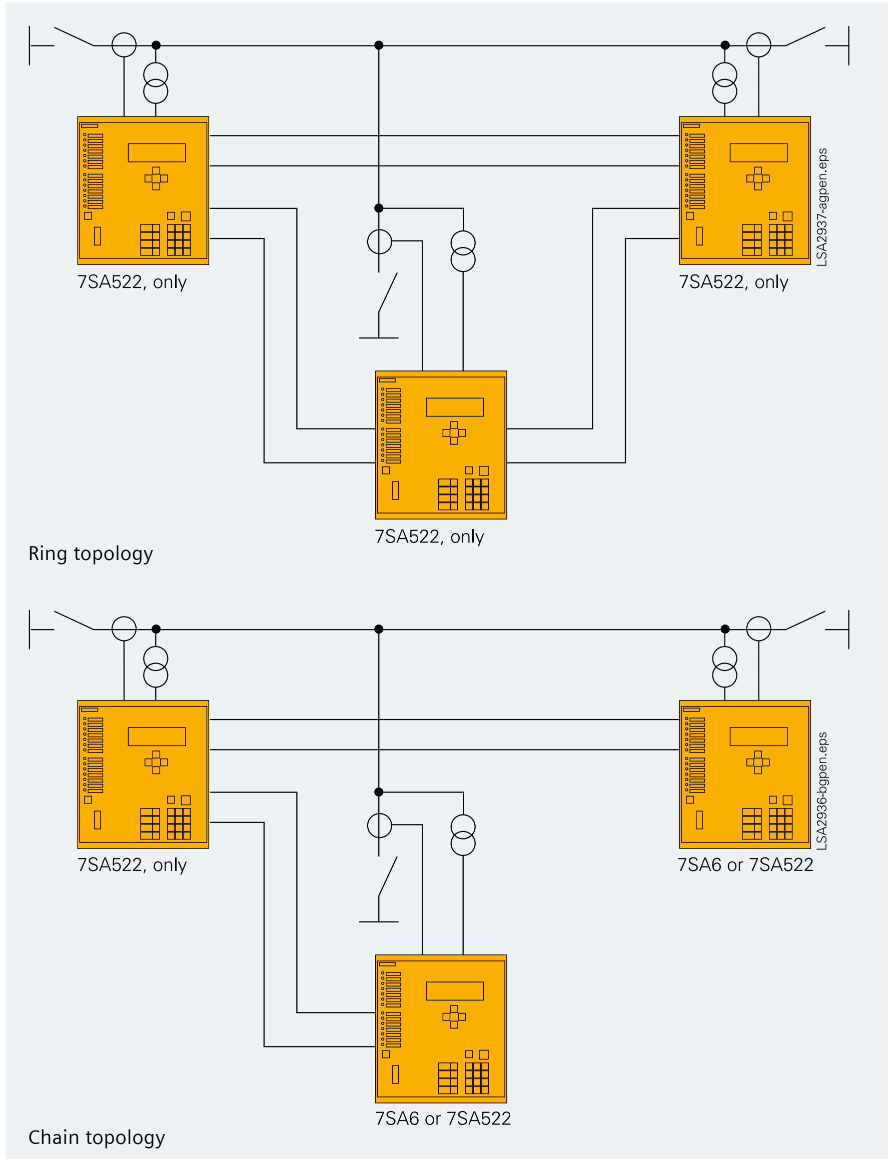


Fig. 6/68 Ring or chain communication topology

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.

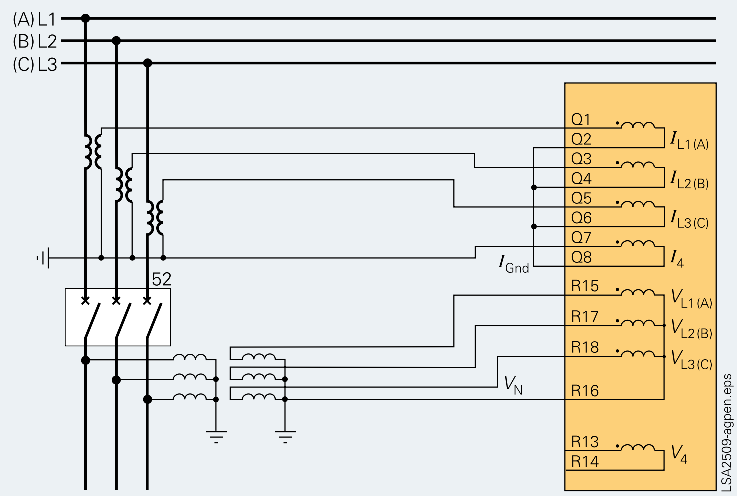


Fig. 6/69 Example of connection for current and voltage transformers

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.

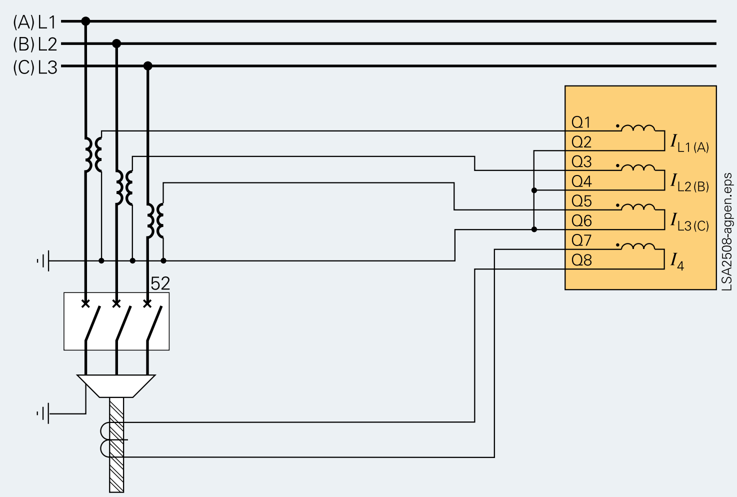


Fig. 6/70 Alternative connection of current transformers for sensitive ground-current measuring with core-balance current transformers

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. 6/70, 6/74 or 6/75.

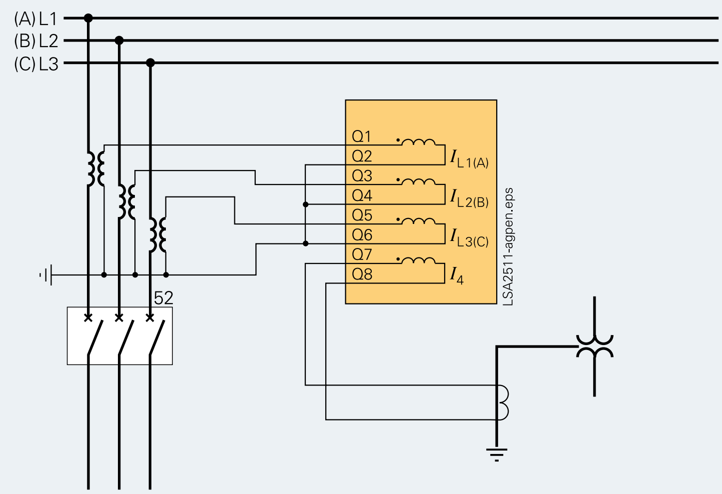


Fig. 6/71 Alternative connection of current transformers for measuring neutral current of a grounded (earthed) power transformer

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.

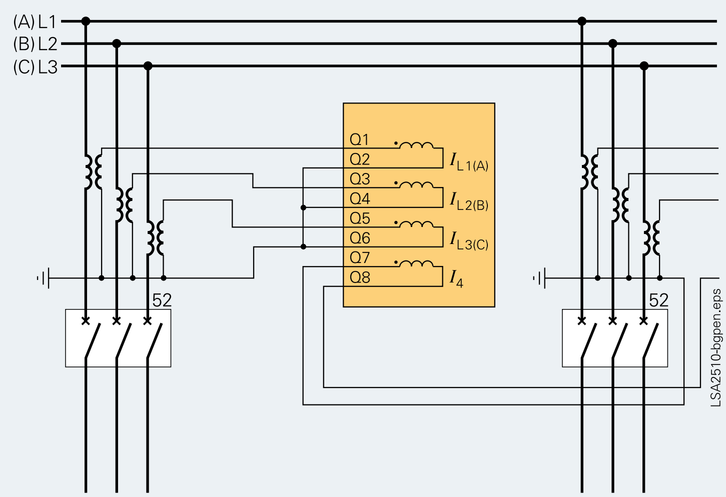


Fig. 6/72 Alternative connection of current transformers for measuring the ground (earth) current of a parallel line

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.

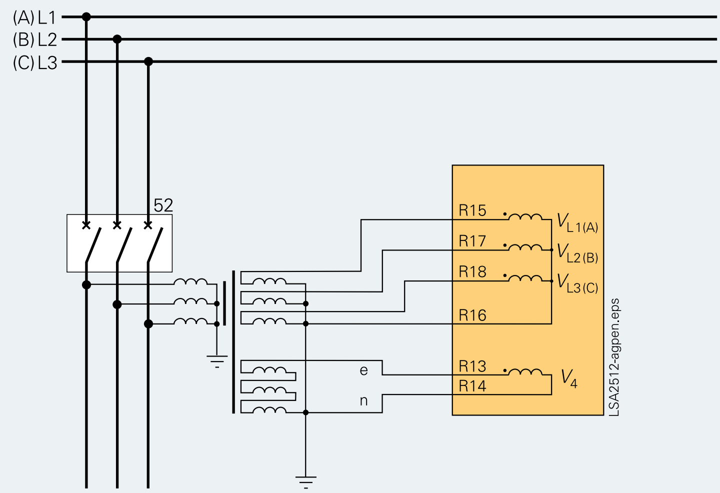


Fig. 6/73 Alternative connection of voltage transformers for measuring the displacement voltage (e-n voltage)

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.

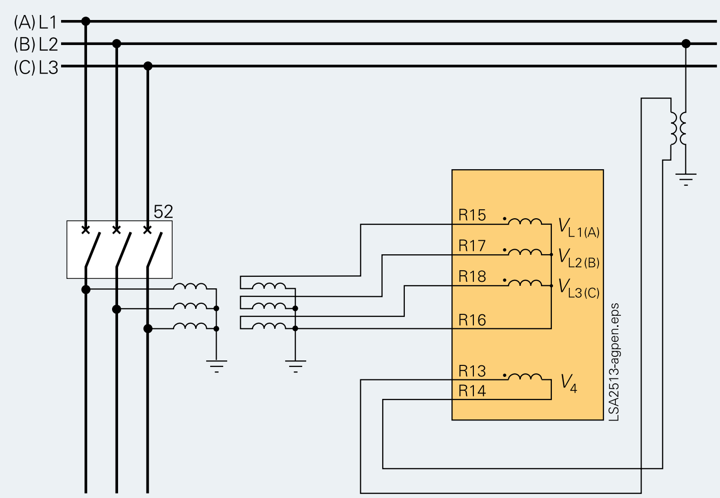


Fig. 6/74 Alternative connection of voltage transformers for measuring the busbar voltage

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	80 to 125 V (selectable)
Power consumption In CT circuits with I_{nom} = 1 A In CT circuits with I_{nom} = 5 A In the CT circuit for high sensitive ground(earth)-fault protection (refer to ordering code) at 1 A	 Approx. 0.05 VA Approx. 0.30 VA Approx. 0.05 VA
In VT circuits	Approx. 0.10 VA
Thermal overload capacity In CT circuits	 500 A for 1 s 150 A for 10 s 20 A continuous
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
In VT circuits	230 V continuous per phase
Dynamic overload capacity In CT circuits In the CT circuit for high sensitive ground(earth)-fault protection (refer to ordering code)	 1250 A (one half cycle) 750 A (one half cycle)
Auxiliary voltage	
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
Permissible tolerance of the rated auxiliary voltage	-20 % to +20 %
Max. superimposed AC voltage (peak-to-peak)	≤ 15 %
Power consumption During normal operation During pickup with all inputs and outputs activated	 Approx. 8 W Approx. 18 W
Bridging time during auxiliary voltage failure V_{aux} = 48 V and V_{aux} ≥ 110 V	 ≥ 50 ms
Binary inputs	
Quantity Functions are freely assignable	8 or 16 or 24 (refer to ordering code)
Pickup/Reset voltage thresholds Ranges are settable by means of jumpers for each binary input	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)
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	
Quantity Function can be assigned	8 or 16 or 24 (refer to ordering code)
Switching capacity Make Break, high-speed trip outputs Break, contacts Break, contacts (for resistive load)	 1000 W/VA 1000 W/VA 30 VA 40 W
Break, contacts (for τ = L/R ≤ 50 ms)	25 VA
Switching voltage	250 V
Permissible current	30 A for 0.5 s 5 A continuous
Operating time, approx. NO contact NO/NC contact (selectable) Fast NO contact High-speed NO trip outputs	 8 ms 8 ms 5 ms < 1 ms
LEDs	
	Quantity
RUN (green) ERROR (red) Indication (red), function can be assigned	1 1 14
Unit design	
Housing	7XP20
Dimension	1/2 x 19" or 1/1 x 19" Refer to ordering code, and see dimension drawings, part 14
Degree of protection acc. to EN 60529	
Surface-mounting housing Flush-mounting housing Front Rear For the terminals	IP 51 IP 51 IP 50 IP 20 with terminal cover put on
Weight Flush-mounting housing ½ x 19" 1/1 x 19" Surface-mounting housing ½x 19" 1/1 x 19"	 6 kg 10 kg 11 kg 19 kg

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 µs; 0.5 Ws, 3 positive and 3 negative impulses in intervals of 5 s

EMC tests for noise immunity; type tests	
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; τ = 15 ms; 400 surges per s; test duration 2 s, R_i = 200 Ω
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 Ω
Irradiation with HF field, frequency sweep IEC 60255-22-3 (report) class III IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz: 80 % AM; 1 kHz 10 V/m; 800 to 960 MHz: 80 % AM; 1 kHz 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 Ω;
	test duration 1 min

High-energy surge voltages (SURGE), IEC 61000-4-5 installation class III Auxiliary supply	Impulse: 1.2/50 µs Common mode: 2 kV; 12 Ω; 9 µF Differential mode:1 kV; 2 Ω; 18 µF
Analog measurement inputs, binary inputs, relays output	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
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 τ = 50 µs; 400 surges per second, test duration 2 s, R_i = 200 Ω
Fast transient surge withstand capability, IEEE Std C37.90.1	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms repition rate 300 ms, ; both polarities; test duration 1 min; R_i = 50 Ω
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 Ω
EMC tests for noise emission; type test	
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

6

Mechanical stress test	
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	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
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	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	
Standard	IEC 60255-6
Temperatures	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd	-25 °C to +85 °C / -13 °F to +185 °F
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
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.

Futher information can be found in the current manual at:
www.siemens.com/siprotec

6

Description	Order No.
7SA522 distance protection relay or transmission lines	**7SA522□-□□□□□-□□□□ □□□**

Current transformer

I_{ph} = 1 A[1)], I_{Gnd} = 1 A[1)] (min. = 0.05 A)	**1**
I_{ph} = 1 A[1)], I_{Gnd} = high sensitive (min. = 0.003 A)	**2**
I_{ph} = 5 A[1)], I_{Gnd} = 5 A (min. = 0.25 A)	**5**
I_{ph} = 5 A[1)], I_{Gnd} = high sensitive (min. = 0.003 A)	**6**

see following pages

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	–	▯	■			**C**
16	12	12	–	▯			■	**G**
16	12	12	–	▯		■		**L**
16	4	15	5	▯	■			**N**
16	4	15	5	▯			■	**Q**
16	4	15	5	▯		■		**S**
24	20	12	–	▯	■			**D**
24	20	12	–	▯			■	**H**
24	20	12	–	▯		■		**M**
24	12	15	5	▯	■			**P**
24	12	15	5	▯			■	**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 presettings and function versions:

Region DE: preset to f = 50 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 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 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 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.

1) Rated current can be selected by means of jumpers.

2) Transition between the three auxiliary voltage ranges can be selected by means of jumpers.

3) The binary input thresholds can be selected by means of jumpers.

6

Selection and ordering data

Description	Order No.	Order Code
7SA522 distance protection relay for transmission lines	7SA522□□□-□□□□□-□□□□	□□□
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 DP, electrical RS485	9	L 0 A
System interface, PROFIBUS DP, optical 820 nm, double ring, ST connector[1)]	9	L 0 B
System interface, DNP 3.0, electrical RS485	9	L 0 G
System interface, DNP 3.0, optical 820 nm, ST connector[1)]	9	L 0 H
System interface, IEC 61850, 100 Mbit/s Ethernet, electrical, duplicate,RJ45 plug connectors	9	L 0 R
System interface, IEC 61850, 100 Mbit/s Ethernet, optical, double, LC connector[4)]	9	L 0 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[2)]		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[3)]		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[3) 5)]		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[3) 6)]		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

see following pages

1) Optical double ring interfaces are not available with surface-mounting housings. Please, order the version with RS485 interface and a separate electrical/ optical converter.
2) Suitable communication converters 7XV5662 (optical to G703.1/X21/RS422 or optical to pilot wire or optical to ISDN) see “Accessories”.
3) For surface-mounting housing applications an internal fiber-optic module 820 nm will be delivered in combination with an external repeater.
4) For surface-mounting housing applications please order the relay with electrical Ethernet interface and use a separate fiber-optic switch.
5) For distances less than 25 km, two optical attenuators 7XV5107-0AA00 are required to avoid optical saturation of the receiver element.
6) For distances less than 50 km, two optical attenuators 7XV5107-0AA00 are required to avoid optical saturation of the receiver element.

Description	Order No.	Order code
7SA522 distance protection relay for transmission lines	**7SA522□-□□□□□-□□□□ □□□**	
Functions 1 and Port E		see next page
Trip mode 3-pole; Port E: empty	0	
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	N □□
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

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.

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	Order code
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)	Order code
				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	Order code
		0
	■	1
■		4
■	■	5

1) Only with position 7 of Order No. = **1** or **5**.

Accessories	Description	Order No.
	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**

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 FO5, OMA1, 820 nm, multi-mode FO cable, ST connector, 1.5 km	**C53207-A351-D651-1**
	Protection data interface FO6, OMA2, 820 nm, multi-mode FO cable, ST connector, 3.5 km	**C53207-A351-D652-1**
	Protection data interface FO17, 1300 nm, mono-mode FO cable, LC-Duplex connector, 25 km	**C53207-A351-D655-1**
	Protection data interface FO18, 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	**C53207-A351-D656-1**
	Protection data interface FO19, 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	**C53207-A351-D657-1**
	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

LSP2289-afp.eps

Fig. 6/75 Mounting rail for 19" rack

LSP2090-afp.eps

Fig. 6/76
2-pin connector

LSP2091-afp.eps

Fig. 6/77
3-pin connector

LSP2093-afp.eps

Fig. 6/78
Short-circuit link for current contacts

LSP2092-afp.eps

Fig. 6/79
Short-circuit link for voltage contacts/ indications contacts

Description		Order No.	Size of package	Supplier	Fig.
Connector	2-pin	**C73334-A1-C35-1**	1	Siemens	6/77
	3-pin	**C73334-A1-C36-1**	1	Siemens	6/78
Crimp connector	CI2 0.5 to 1 mm^2	**0-827039-1**	4000	1)	
		0-827396-1	1	1)	
	CI2 0.5 to 2.5 mm^2	**0-827040-1**	4000	1)	
		0-827397-1	1	1)	
	Type III+ 0.75 to 1.5 mm^2	**0-163083-7**	4000	1)	
		0-163084-2	1	1)	
Crimping tool	For type III+	**0-539635-1**	1	1)	
	and matching female	**0-539668-2**		1)	
	For CI2	**0-734372-1**	1	1)	
	and matching female	**1-734387-1**		1)	
19"-mounting rail		**C73165-A63-D200-1**	1	Siemens	6/76
Short-circuit links	For current terminals	**C73334-A1-C33-1**	1	Siemens	6/79
	For other terminals	**C73334-A1-C34-1**	1	Siemens	6/80
Safety cover for terminals	large	**C73334-A1-C31-1**	1	Siemens	6/51
	small	**C73334-A1-C32-1**	1	Siemens	6/51

1) Your local Siemens representative can inform you on local suppliers.

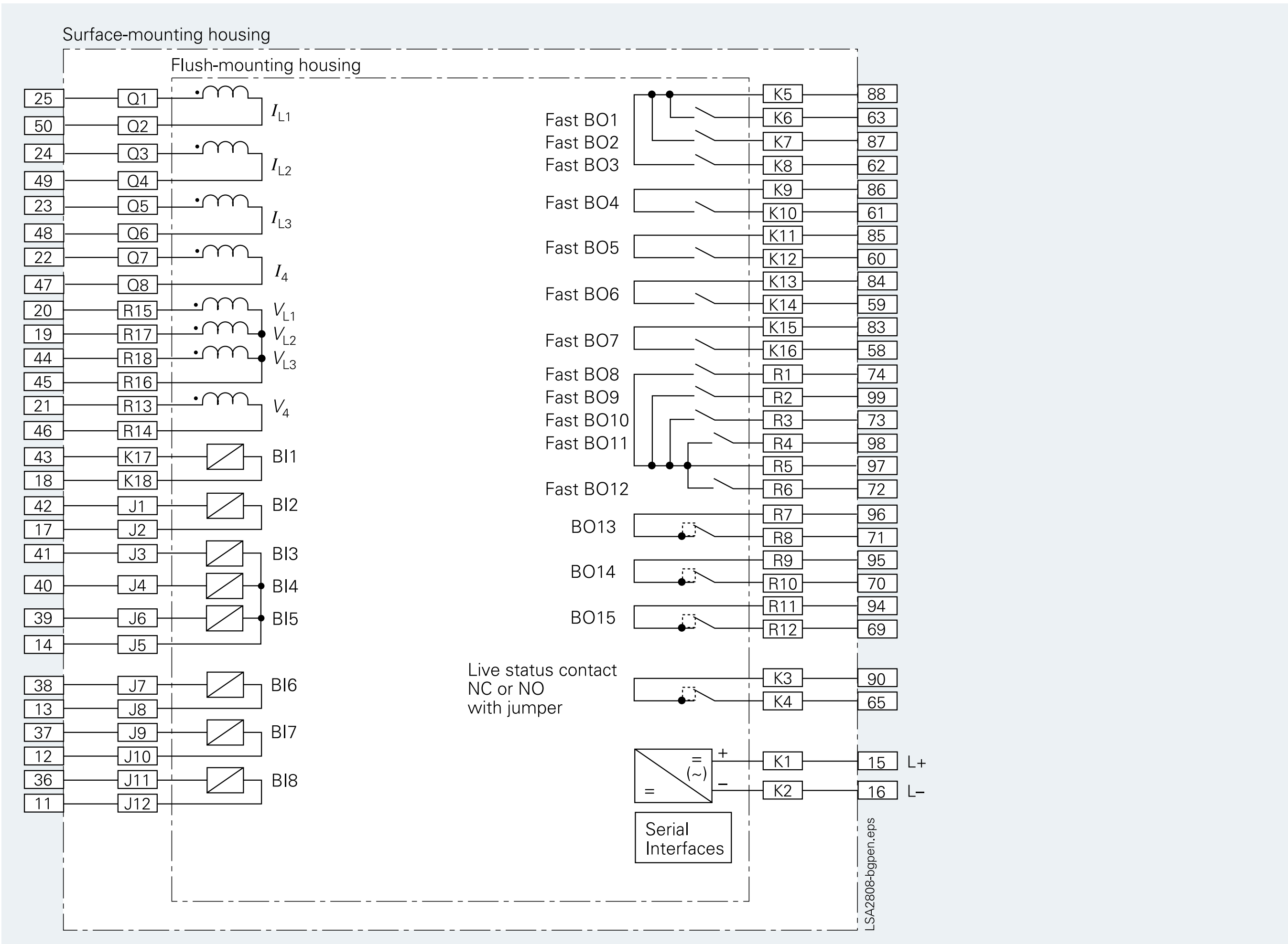


Fig. 6/80 Housing 1/2 x 19”, basic version 7SA522x-xA, 7SA522x-xE and 7SA522x-xJ with 8 binary inputs and 16 binary outputs, hardware version .../FF

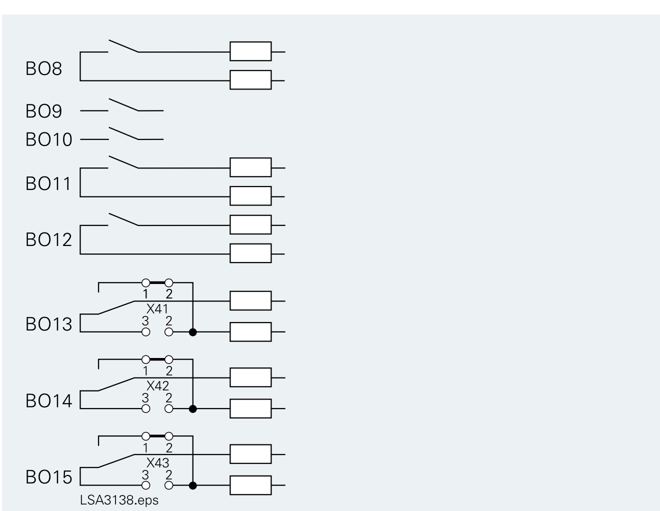


Fig. 6/81a Additional setting by jumpers: Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82. Switching of BO13, BO14, BO15 as NO contact or NC contact with jumpers.

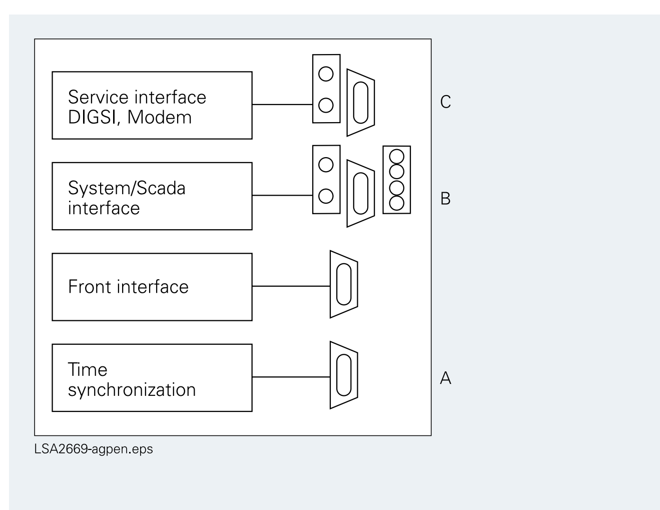


Fig. 6/81 Serial interfaces

Connection diagram, IEC

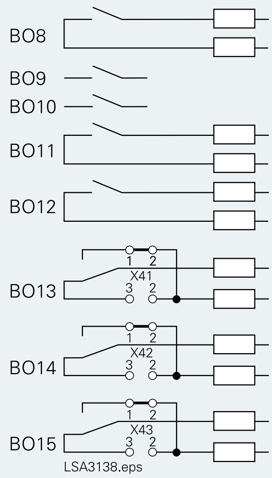
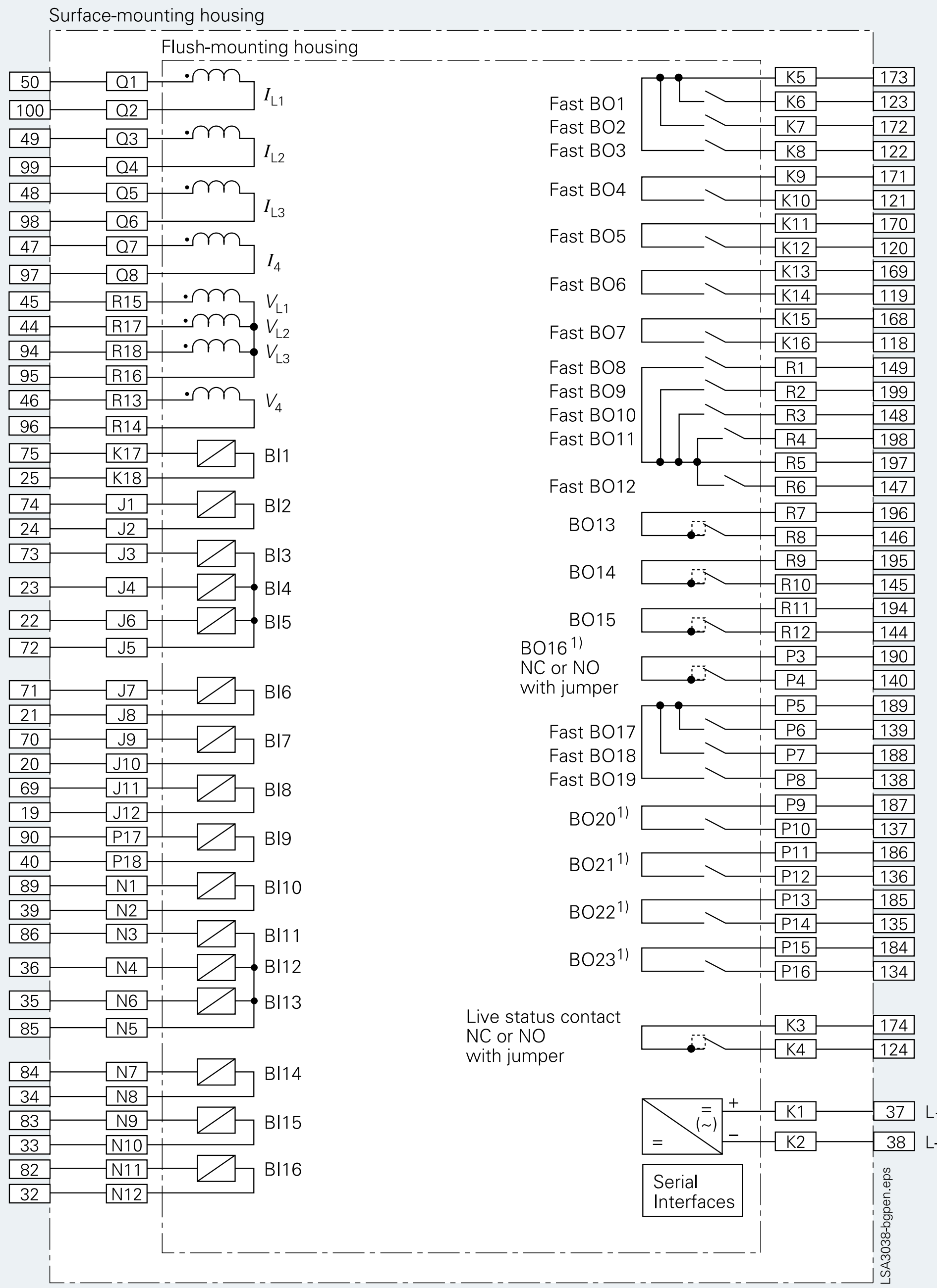


Fig. 6/83a
Additional setting by jumpers: Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82. Switching of BO13, BO14, BO15 as NO contact or NC contact with jumpers.



1) High-speed trip outputs in versions 7SA522x-xN, 7SA522x-xQ, 7SA522x-xS.

Note: For serial interfaces see Figure 6/82.

Fig. 6/82 Housing ▯ 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

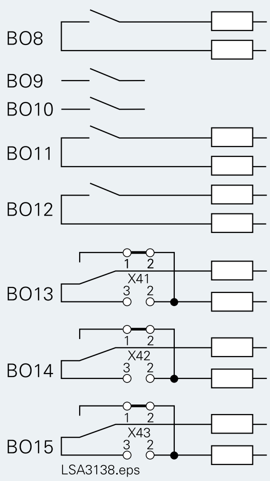
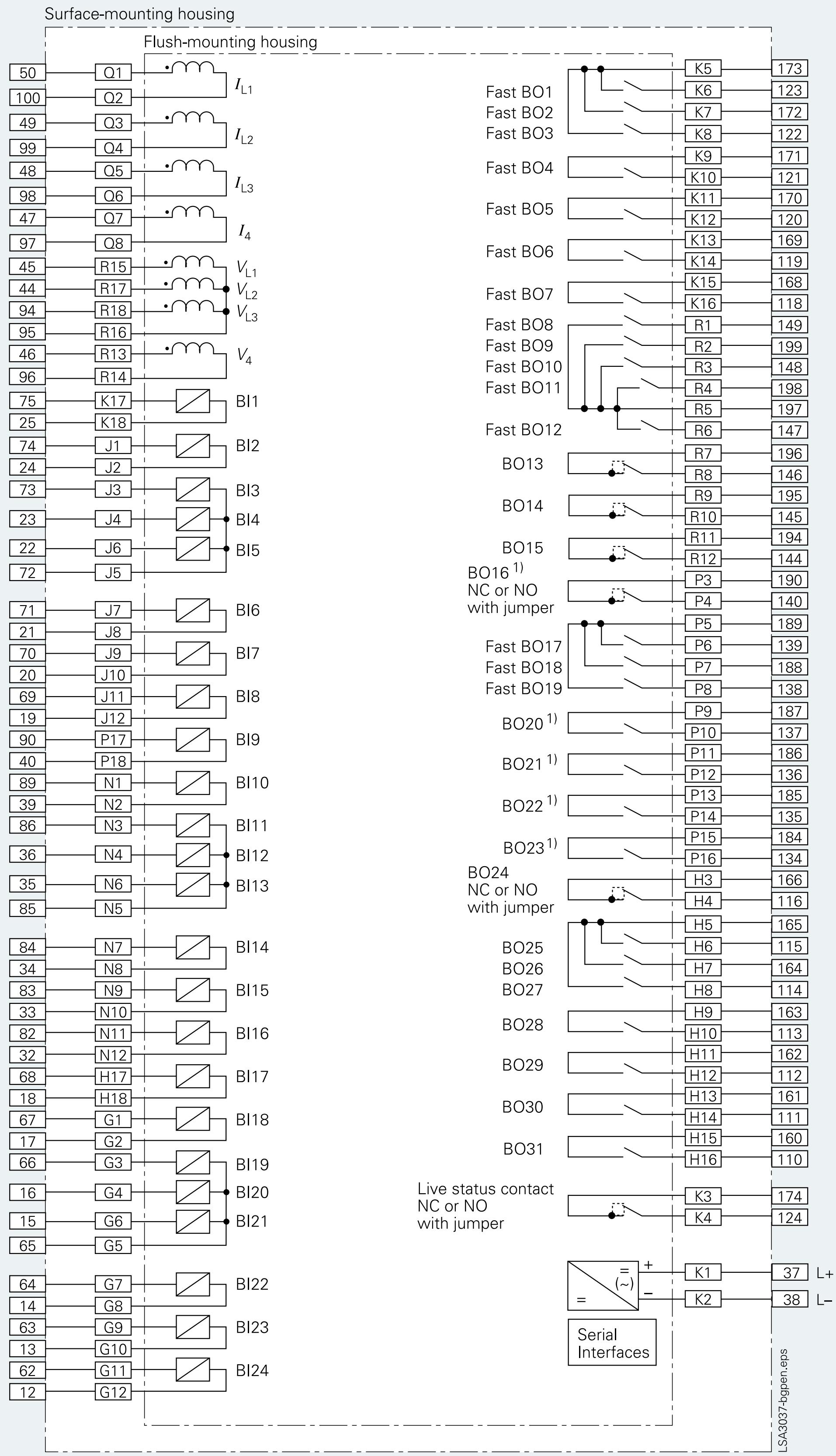


Fig. 6/84a
Additional setting by jumpers: Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82. Switching of BO13, BO14, BO15 as NO contact or NC contact with jumpers.



1) High-speed trip outputs in versions 7SA522x-xP, 7SA522x-xR, 7SA522x-xT.

Note: For serial interfaces see Figure 6/82.

Fig. 6/83 Housing ▯ 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

Connection diagram, ANSI

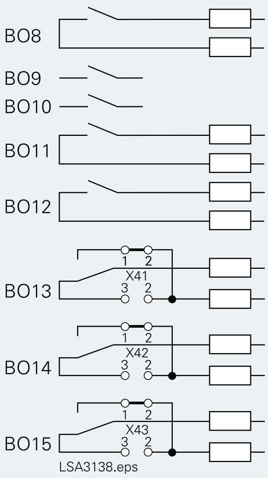
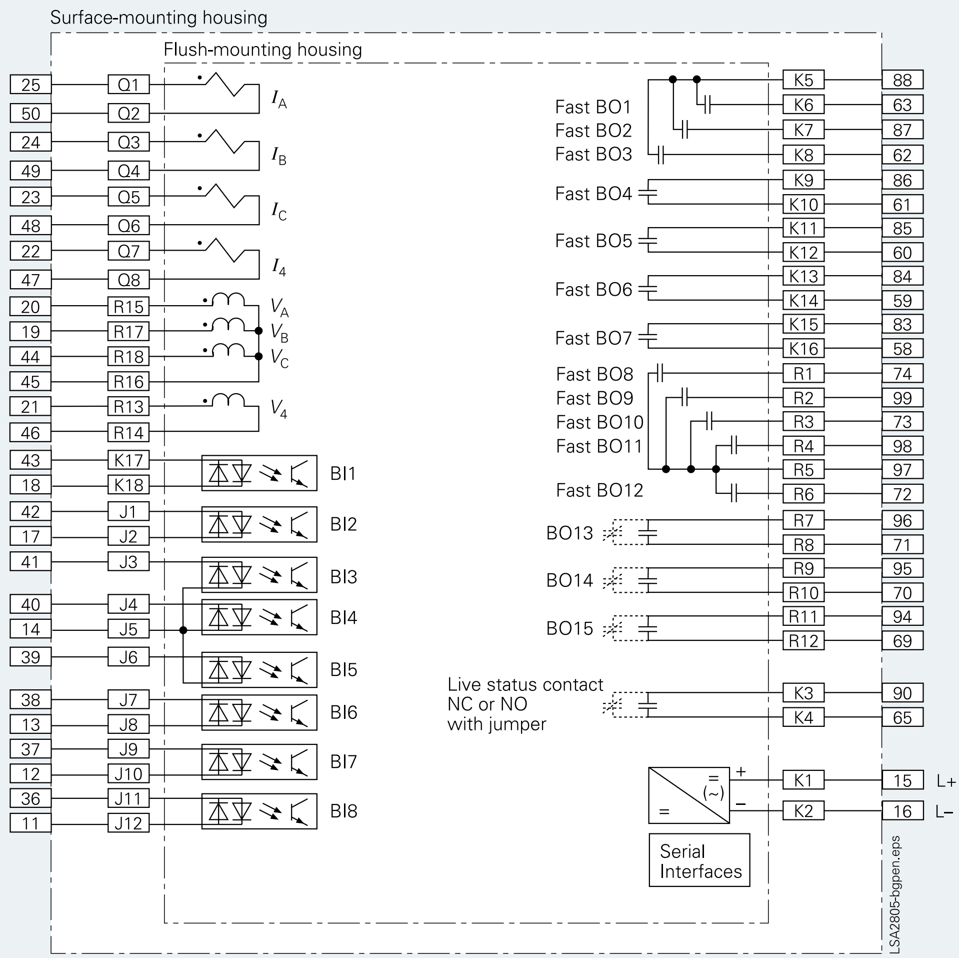


Fig. 6/85a
Additional setting by jumpers: Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82. Switching of BO13, BO14, BO15 as NO contact or NC contact with jumpers.



Note: For serial interfaces see Figure 6/82.

Fig. 6/84 Housing ½ x 19", basic version 7SA522x-xA, 7SA522x-xE and 7SA522x-xJ with 8 binary inputs and 16 binary outputs, hardware version .../FF

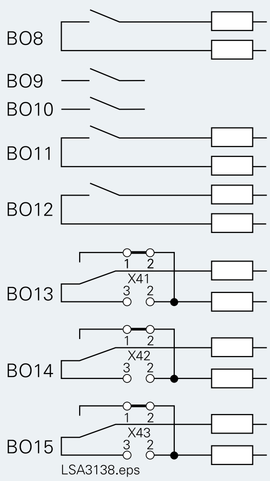
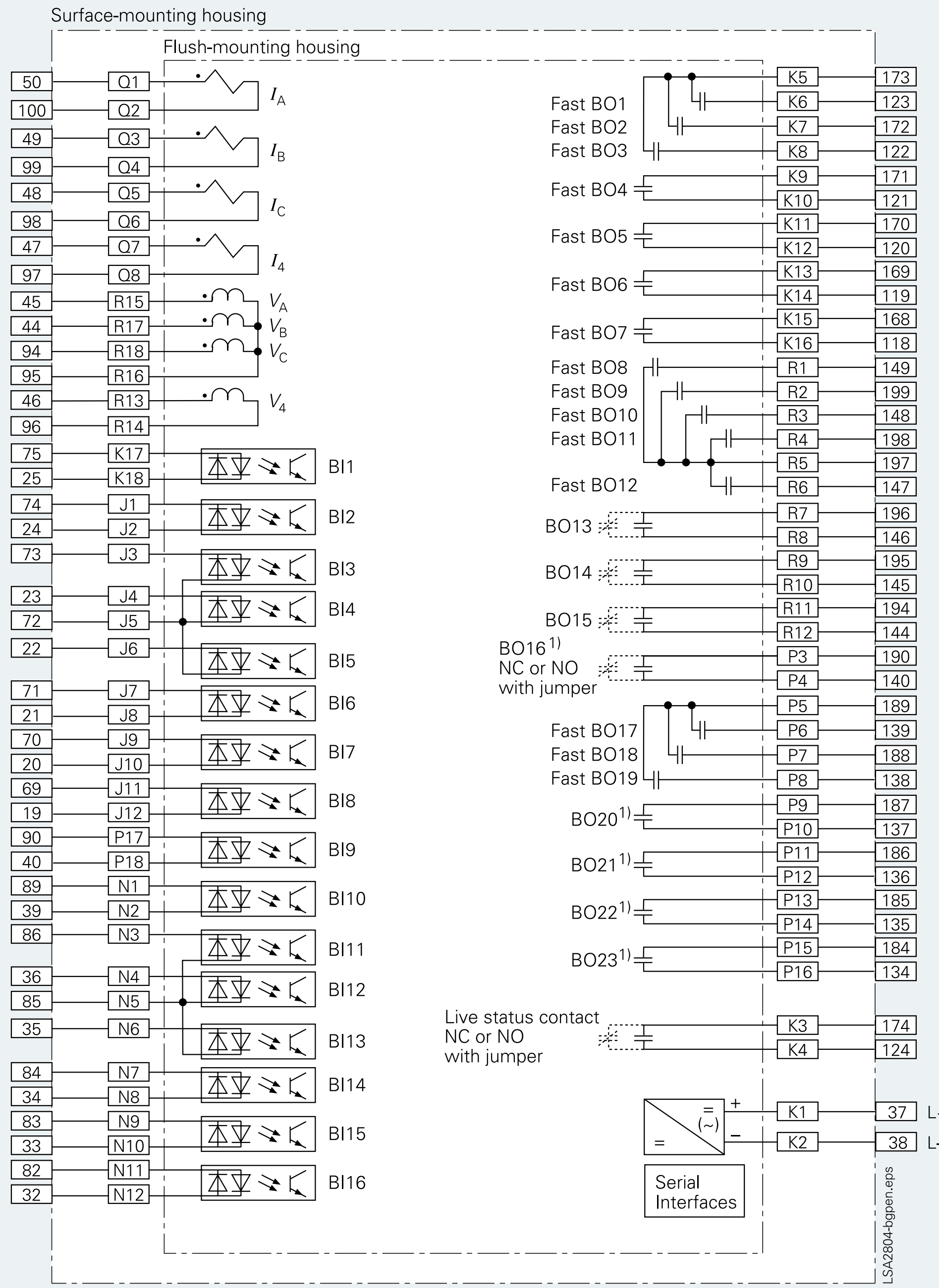


Fig. 6/86a
Additional setting by jumpers: Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82. Switching of BO13, BO14, BO15 as NO contact or NC contact with jumpers.



1) High-speed trip outputs in versions 7SA522x-xN, 7SA522x-xQ, 7SA522x-xS.

Note: For serial interfaces see Figure 6/82.

Fig. 6/85 Housing ▯ 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

Connection diagram, ANSI

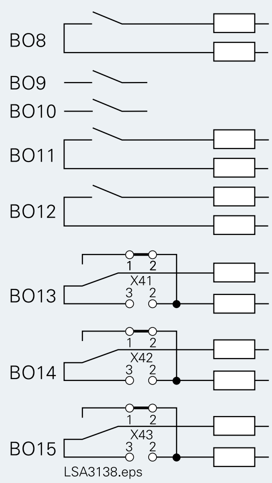


Fig. 6/87a
Additional setting by jumpers: Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82. Switching of BO13, BO14, BO15 as NO contact or NC contact with jumpers.

1) High-speed trip outputs in versions 7SA522x-xP, 7SA522x-xR, 7SA522x-xT.

Note: For serial interfaces see Figure 6/82.

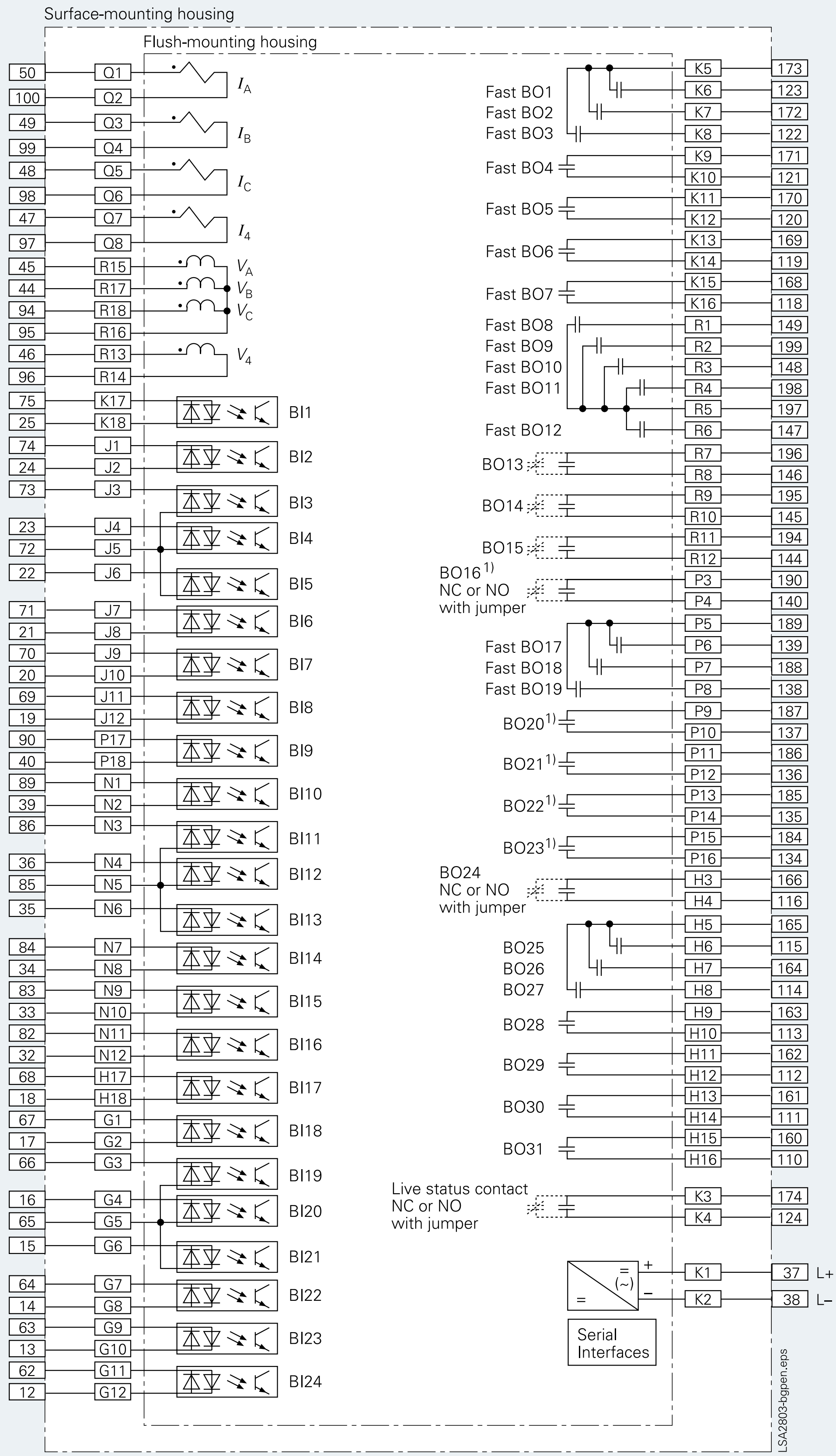


Fig. 6/86 Housing ▯ x 19”, maximum version 7SA522x-xD, 7SA522x-xH and 7SA522x-xM with 24 binary inputs and 32 binary outputs, hardware version ../FF

Line Differential Protection

7

SIPROTEC 7SD61 differential protection relay for two line ends

Fig. 7/1 SIPROTEC 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 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

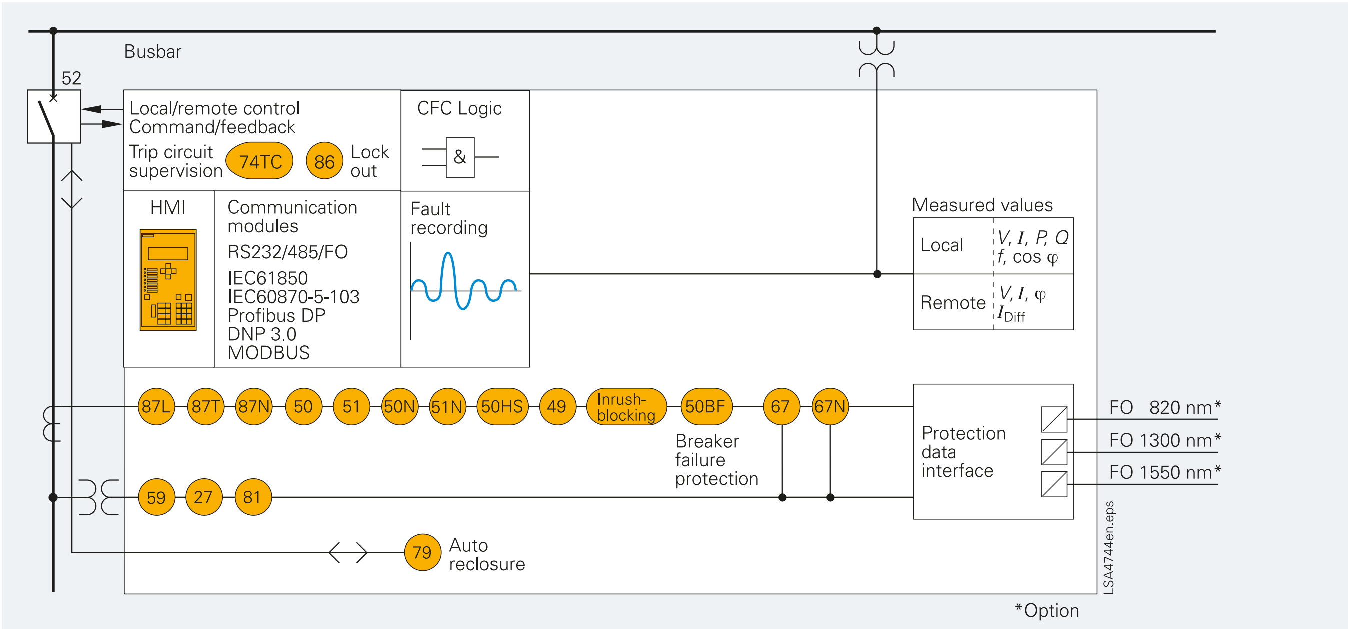


Fig. 7/2

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 51/51N/67/67N	Overcurrent protection with directional elements
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. 7/3. 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.

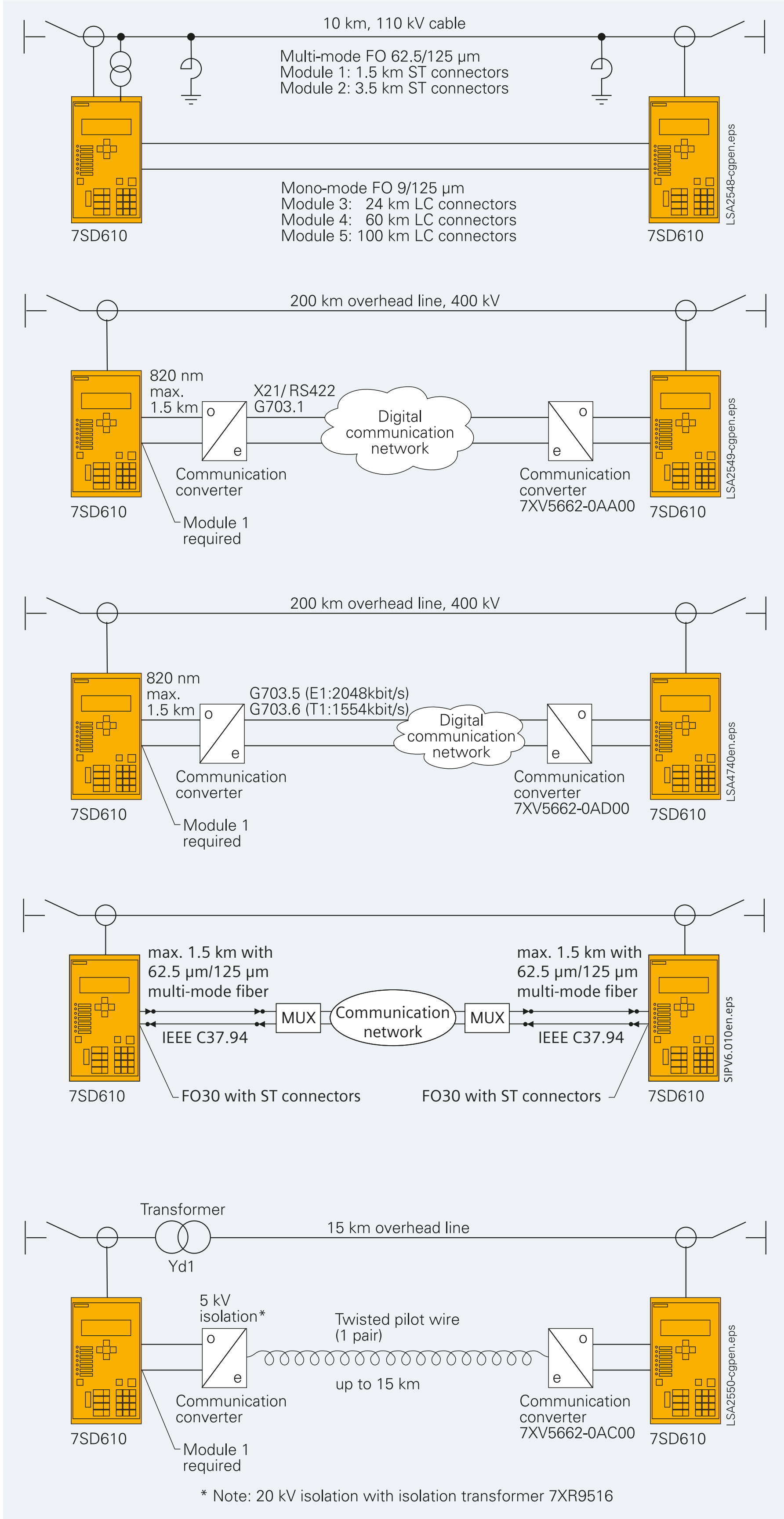


Fig. 7/3 Typical applications

Construction, protection functions

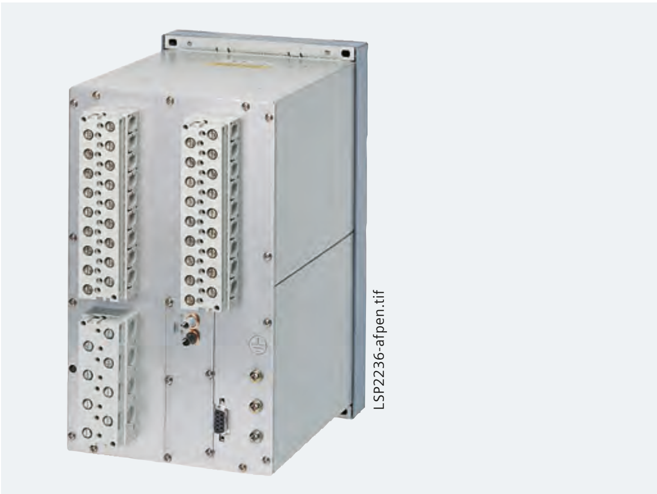


Fig. 7/4

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 communciation 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 syncronized 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 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.

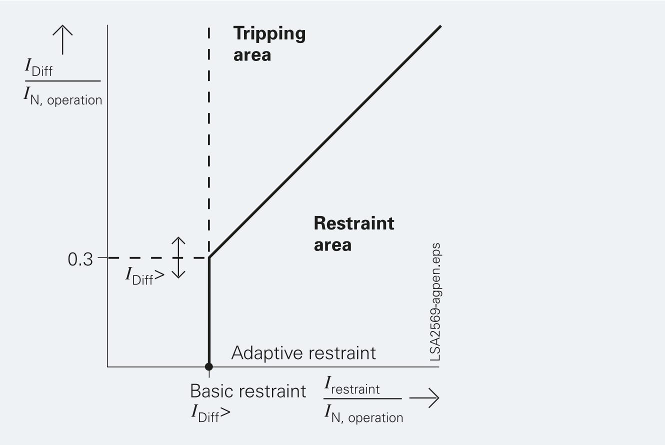


Fig. 7/5 Tripping characteristic

- 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.

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

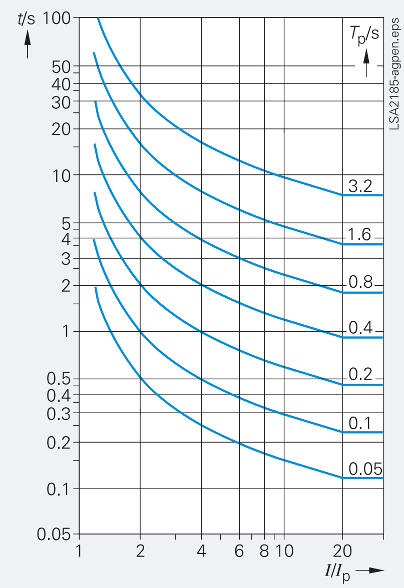
If VTs are connected, separate stages with directional measurement are available, two definite-time and two inverse-time stages (each for phase and ground). Using the forward pickup indication as a signal to the remote end, a 100 % protection coverage of the line can be operated in parallel to the differential 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.



$$t = \frac{0{,}14}{(I/I_p)^{0{,}02} - 1} T_p$$

Fig. 7/6 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

7

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.

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 malopera- tion of a differential relay if the load current exceeds the differential setpoint. The 7SD610 provides fast broken wire supervision which immediatelly 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 φ), 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 x I_{Phase}, $3I_0$, I_{E}, $I_{\text{E sensitive}}$
- Voltages 3 x $V_{\text{Phase-Ground}}$, 3 x $V_{\text{Phase-Phase}}$,
- $3V_0$,V_{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 PF (= cos φ)
- 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 freezed 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.

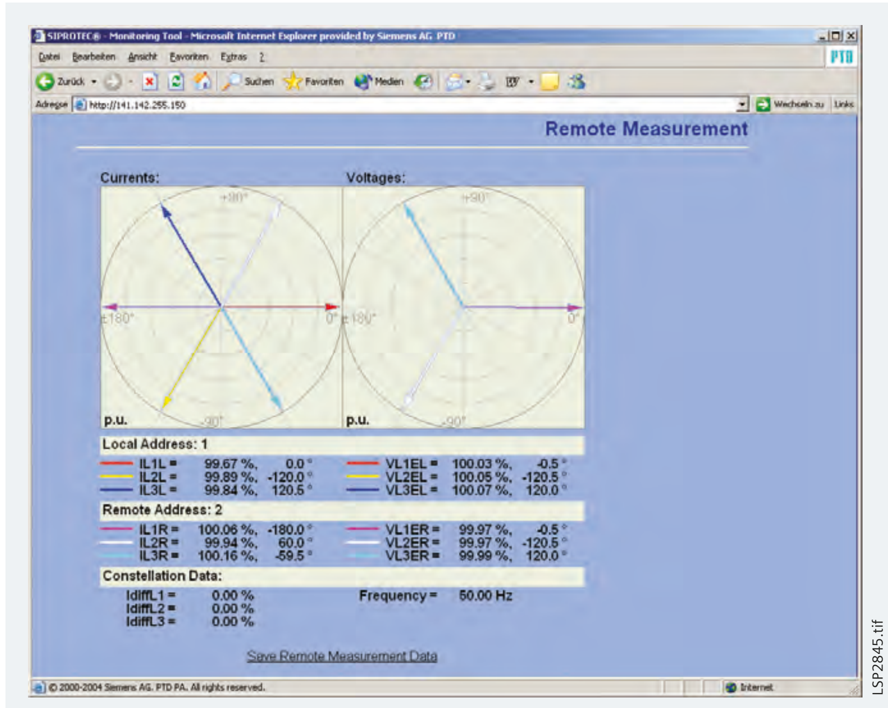


Fig. 7/7 Browser-aided commissioning: Phasor diagram

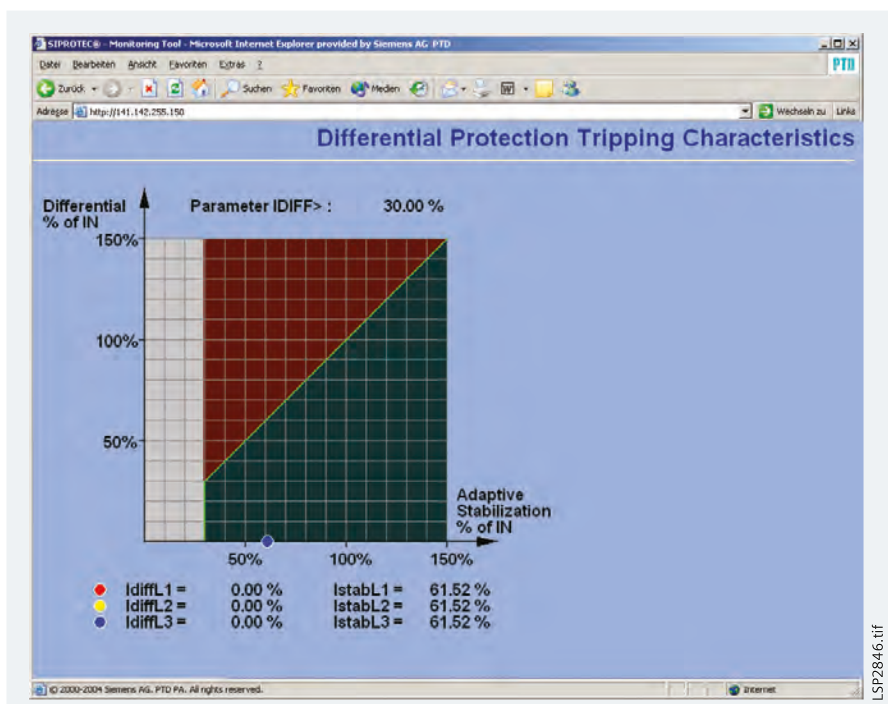


Fig. 7/8 Browser-aided commissioning: Differential protection tripping characteristic

7

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 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.

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.

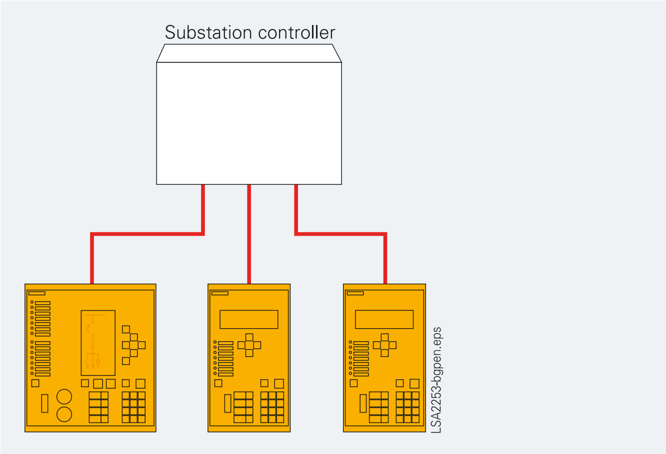


Fig. 7/9 IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

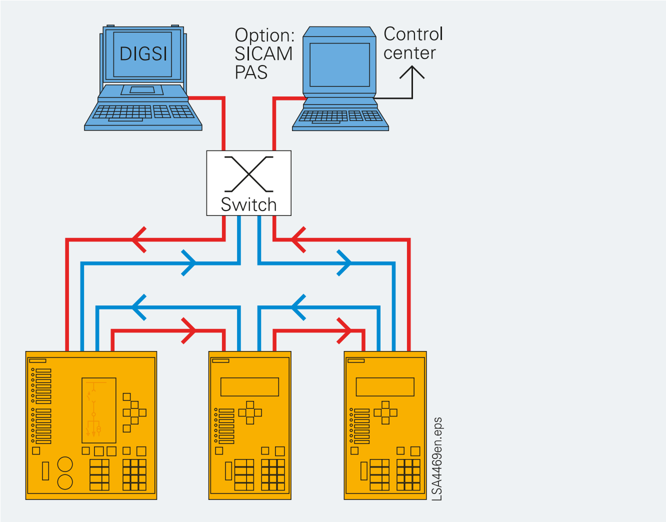


Fig. 7/10 Bus structure for station bus with Ethernet and IEC 61850

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.

7

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.

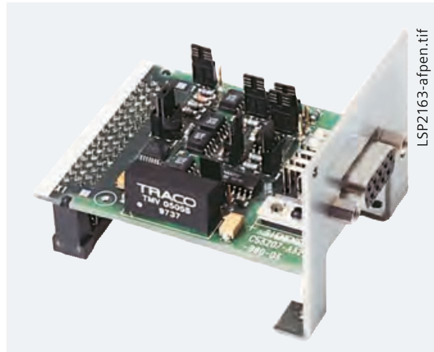


Fig. 7/11 RS232/RS485 electrical communication module

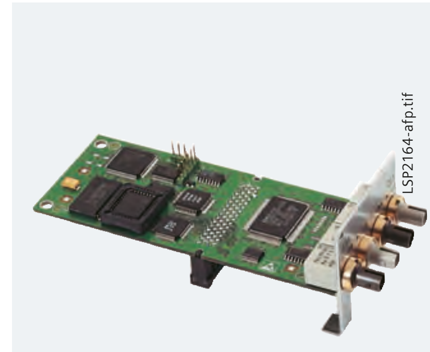


Fig. 7/12 PROFIBUS fiber-optic double ring communication module

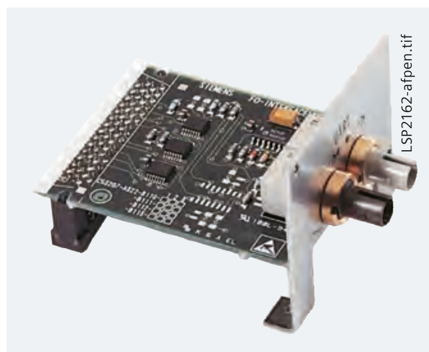


Fig. 7/13 820 nm fiber-optic communication module

Fig. 7/14 Fiber-optic Ethernet communication module for IEC 61850 with integrated Ethernet switch

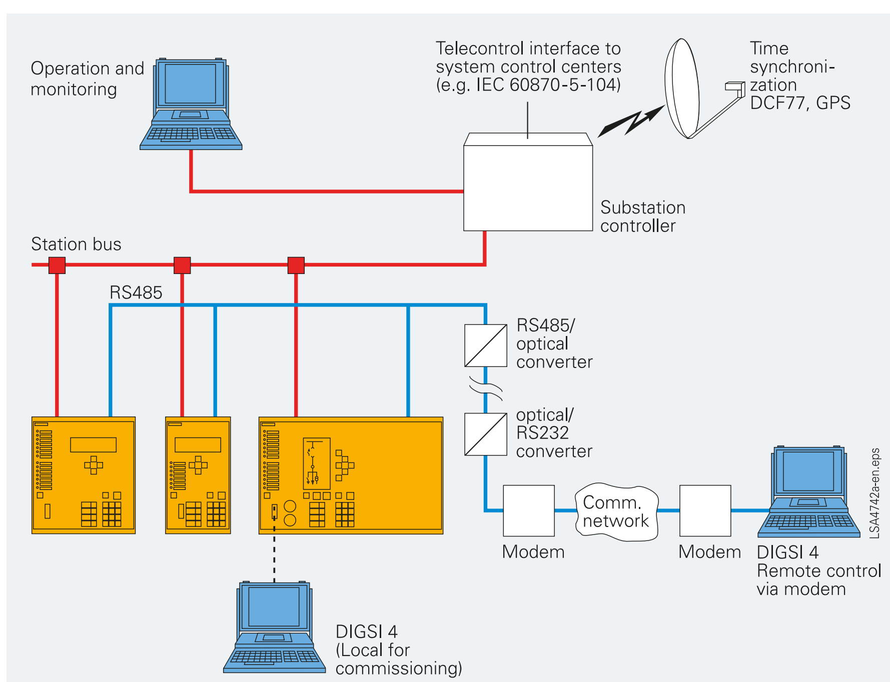


Fig. 7/15 System solution: Communications

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS DP. 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. 7/9).

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. 7/10).

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
- Interclose 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.

- FO5[1)], OMA1[2)] 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.
- FO6[1)], OMA2[2)] 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

FO17[1)]:
For direct connection up to 24 km[3)], 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector

FO18[1)]:
For direct connection up to 60 km[3)], 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector

FO19[1)]:
For direct connection up to 100 km[3)], 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.

7

Communication

Communication possibilities between relays

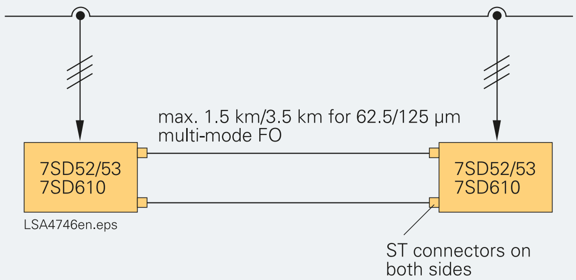


Fig. 7/16 Direct optical link up to 1.5 km/3.5 km, 820nm

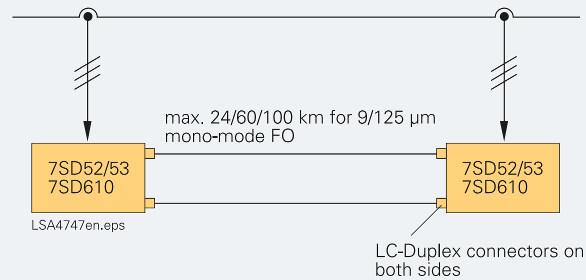


Fig. 7/17 Direct optical link up to 25/60 km with 1300 nm or up to 100 km with 1550 nm

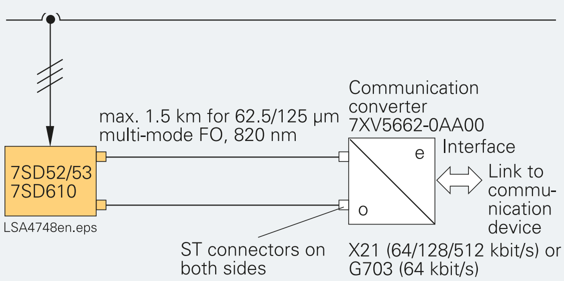


Fig. 7/18 Connection to a communication network CC-XG

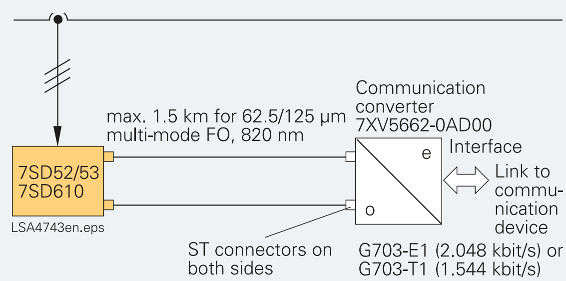


Fig. 7/19 Connection to a communication network CC-2M

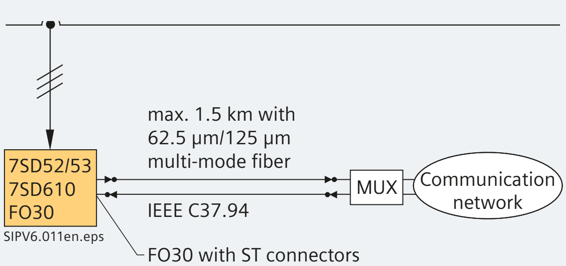


Fig. 7/20 Connection to a communication network via IEEE C37.94

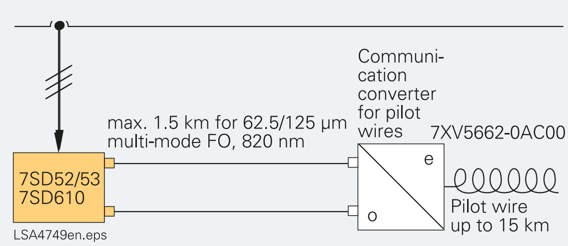


Fig. 7/21 Connection to a pilot wire

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.

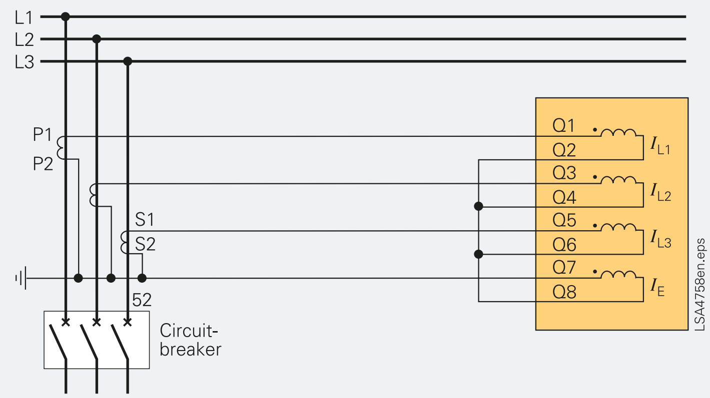


Fig. 7/22 Typical connection to current transformers

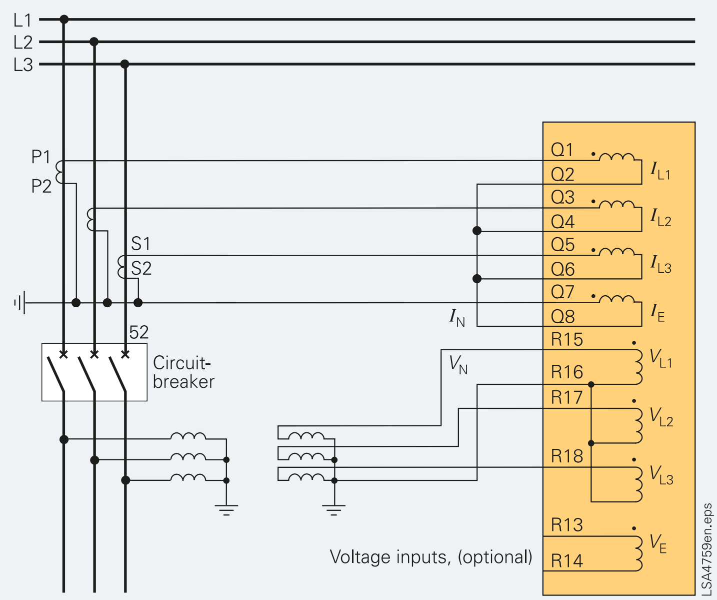


Fig. 7/23 Typical connection to current transformers with optional voltage inputs

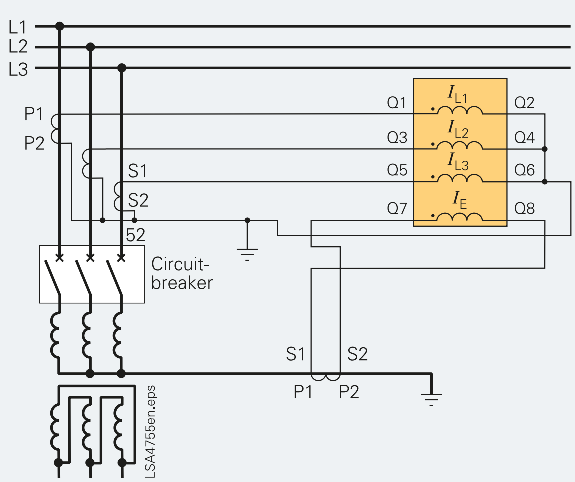


Fig. 7/24 Connection for transformer with restricted ground-fault protection (REF)

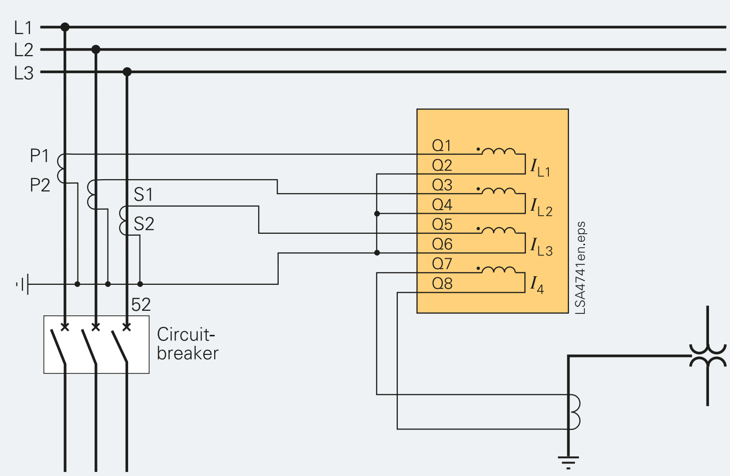


Fig. 7/25 Alternative connection of current transformers for measuring neutral current of a grounded (earthed) power transformer

Technical data

General unit data	
Analog inputs	
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 with I_N = 5 A in VT circuits	 Approx. 0.05 VA Approx. 0.3 VA Approx. 0.1 VA
Thermal overload capacity in CT circuits (for I_N = 5 A) Dynamic (peak value)	I_N 100 A for 1 s 30 I_N for 10 s 4 I_N continuous 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
Auxiliary voltage	
Rated voltages Ranges are settable by means of jumpers	DC 24 to 48 V 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 During pickup with all inputs and outputs activated	 Approx. 8 W Approx. 18 W
Bridging time during failure of the auxiliary voltage V_{aux} ≥ 110 V	 ≥ 50 ms
Binary inputs	
Number	7 (marshallable)
Rated voltage range Pickup threshold	24 to 250 V, bipolar 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
Output relay	
Command / indication relay	
Number	5 (marshallable) 1 alarm contact (not marshallable)
Switching capacity Make Break Break (with resistive load) Break (with L/R ≤ 50 ms)	1000 W/VA 30 VA 40 W 25 W 250 V
Switching voltage Permissible total current	30 A for 0.5 seconds 5 A continuous
LEDs	
Number RUN (green) ERROR (red) LED (red), function can be assigned	 1 1 7

Unit design	
Housing 7XP20	For dimensions refer to dimension drawings, part 14
Degree of protection acc. to EN 60529 Surface-mounting housing Flush-mounting housing front rear for the terminals	 IP 51 IP 51 IP 50 IP 20 with terminal cover put on
Weight Flush-mounting housing 1/3 x 19" Surface-mounting housing 1/3 x 19"	 4 kg 6 kg
Electrical tests	
Specification	
Standards	EC 60255 (product standards) ANSI/IEEE C37.90.0/.1/.2 UL 508 For further standards see “Individual functions”
Insulation tests	
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; τ = 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 Ω
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.

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 Ω; test duration 1 min
High-energy surge voltages (SURGE), IEC 61000-4-5 installation, class III	Impulse: 1.2/50 µs
Auxiliary supply	Common (longitudinal) mode: 2 kV; 12 Ω; 9 µF Differential (transversal) mode: 1 kV; 2 Ω; 18 µF
Measurement inputs, binary inputs, binary output relays	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 impulses per second; both polarities; duration 2 s; R_i = 80 Ω
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 Ω

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 Limit class B
Radio interference field strength IEC-CISPR 22	30 to 1000 MHz Limit class B

Mechanical dynamic tests	
Vibration, shock stress and seismic vibration	
<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 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
<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 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

Futher information can be found in the current manual at: www.siemens.com/siprotec

7

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 ⅓ 19", 7 BI, 5 BO, 1 live-status contact	B	
Surface-mounting housing with screw-type terminals ⅓ 19", 7 BI, 5 BO, 1 live-status contact	F	
Flush-mounting housing with plug-in terminals, ⅓ 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, RJ45 connector (EN 100)		R
IEC 61850, 100 Mbit Ethernet, with integrated switch optical, double, LC connector[5)]		S

see next page

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

7

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) DIGSI 4, electrical RS232		1
DIGSI 4, electrical RS485		2
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	
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-/frequence protection	Restricted earth fault (low impedance)	Order No.
				A
		■		B
	■			E
	■	■		F
■				J
■		■		K
■	■			N
■	■	■		P
■	■		■	S
■	■	■	■	T

Description	Order No.
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**).

Selection and ordering data

Accessories	Description	Order No.
	Opto-electric communication converter CC-XG (connection to communication network) 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	**7XV5662-0AA00**
	Opto-electric communication converter CC-2M to G703-E1/-T1 communication networks with 2,048 / 1,554 kbit/s 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	**7XV5662-0AD00**
	Opto-electric communication converter (connection to pilot wire) Converter to interface to a pilot wire or twisted telephone pair (typical 15 km length) Connection via FO cable for 62.5/125 µmor 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	**7XV5662-0AC00**
	Additional interface modules	
	Protection interface module, optical 820 nm, multi-mode FO cable, ST connector, 1.5 km	**C53207-A351-D651-1**
	Protection interface module, optical 820 nm, multi-mode FO cable, ST connector, 3.5 km	**C53207-A351-D652-1**
	Further modules	
	Protection interface module, optical 1300 nm, mono-mode FO cable, LC-Duplex connector, 24 km	**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**
	Optical repeaters	
	Serial repeater (2-channel), optical 1300 nm,mono-mode FO cable, LC-Duplex connector, 24 km	**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**
	Time synchronizing unit with GPS output GPS 1 sec pulse and time telegram IRIG B/DCF 77	**7XV5664-0AA00**
	Isolation transformer (20 kV) for pilot wire communication	**7XR9516**
	Voltage transformer miniature circuit-breaker Rated current 1.6 A; thermal overload release 1.6 A; overcurrent trip 6 A	**3RV1611-1AG14**

Accessories	Description	Order No.
	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**

7

Fig. 7/26 Mounting rail for 19" rack

Fig. 7/27
2-pin connector

Fig. 7/28
3-pin connector

Fig. 7/29
Short-circuit link for current contacts

Fig. 7/30
Short-circuit link for voltage contacts/ indications contacts

Description		Order No.	Size of package	Supplier	Fig.
Connector	2-pin	**C73334-A1-C35-1**	1	Siemens	7/27
	3-pin	**C73334-A1-C36-1**	1	Siemens	7/28
Crimp connector	CI2 0.5 to 1 mm^2	**0-827039-1**	4000	1)	
		0-827396-1	1	1)	
	CI2 0.5 to 2.5 mm^2	**0-827040-1**	4000	1)	
		0-827397-1	1	1)	
	Type III+ 0.75 to 1.5 mm^2	**0-163083-7**	4000	1)	
		0-163084-2	1	1)	
Crimping tool	For type III+	**0-539635-1**	1	1)	
	and matching female	**0-539668-2**		1)	
	For CI2	**0-734372-1**	1	1)	
	and matching female	**1-734387-1**		1)	
19"-mounting rail		**C73165-A63-D200-1**	1	Siemens	7/26
Short-circuit links	For current terminals	**C73334-A1-C33-1**	1	Siemens	7/29
	For other terminals	**C73334-A1-C34-1**	1	Siemens	7/30
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.

Connection diagram

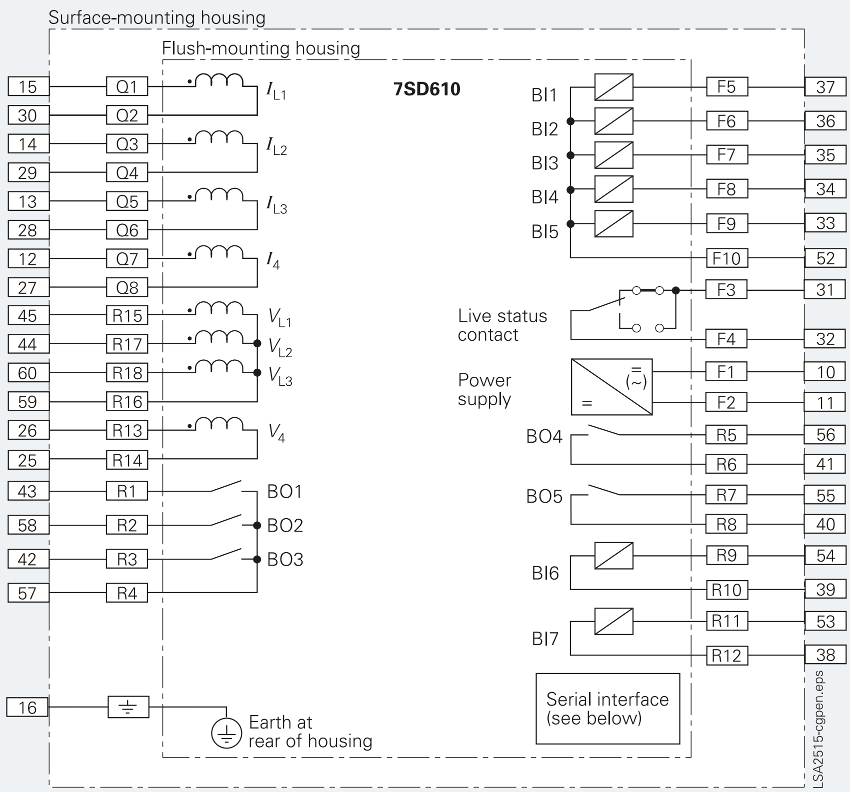


Fig. 7/31 Connection diagram

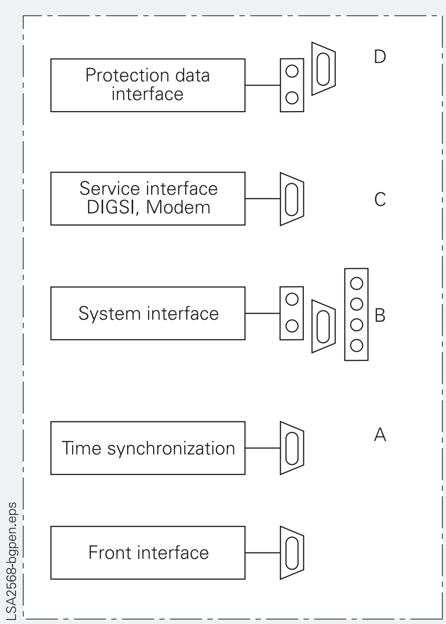


Fig. 6/32 Serial interfaces

SIPROTEC 7SD52/53 multi-end differential and distance protection in one relay

Fig. 7/33 SIPROTEC 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 DP and DNP 3
- Rear-side service/modem interface
- Time synchronization via IRIG-B or DCF77 or system interface

7

Application

ANSI	Protection functions
87L	ΔI for lines / cables
87T	ΔI for lines / cables with transformers
87N	Low impedance restricted ground-fault protection for transformers
85	Phase-selective intertrip, remote trip
86	Lockout function
21/21N	Distance protection
FL	Fault locator
68/68T	Power swing detection/tripping
85/21	Teleprotection for distance protection
27WI	Weak-infeed protection
50N/51N/67N	Directional earth(ground)-fault protection

ANSI	Protection functions
85/67N	Teleprotection for earth(ground)-fault protection
50/50N/51/51N	Overcurrent protection
50HS	Instantaneous high-current tripping (switch-onto-fault)
59/27	Overvoltage/undervoltage protection
81O/U	Over/underfrequency protection
25	Synchro-check
79	Single or three-pole auto-reclosure with new adaptive technology
49	Overload protection
50BF	Breaker-failure protection
74TC	Trip circuit supervision
50 STUB	STUB-bus overcurrent stage

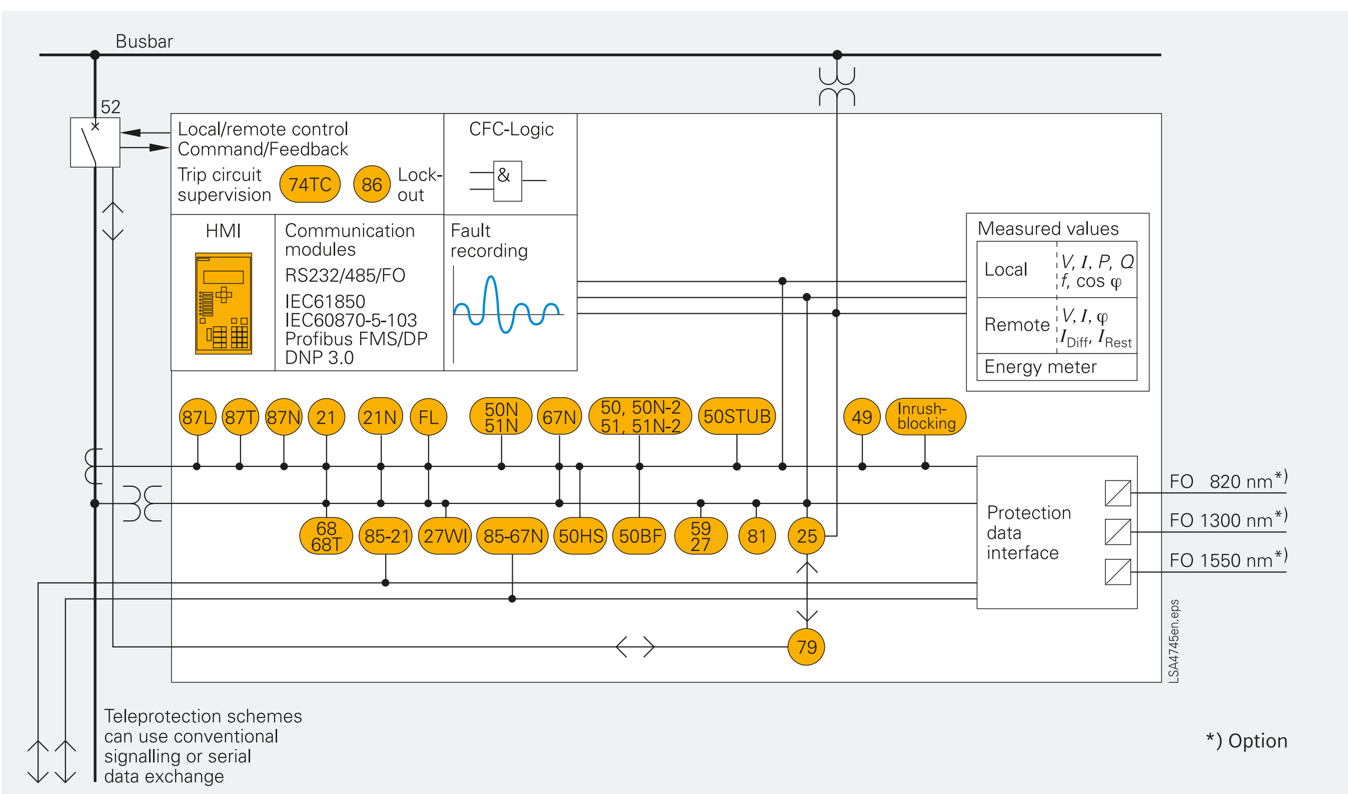


Fig. 7/34

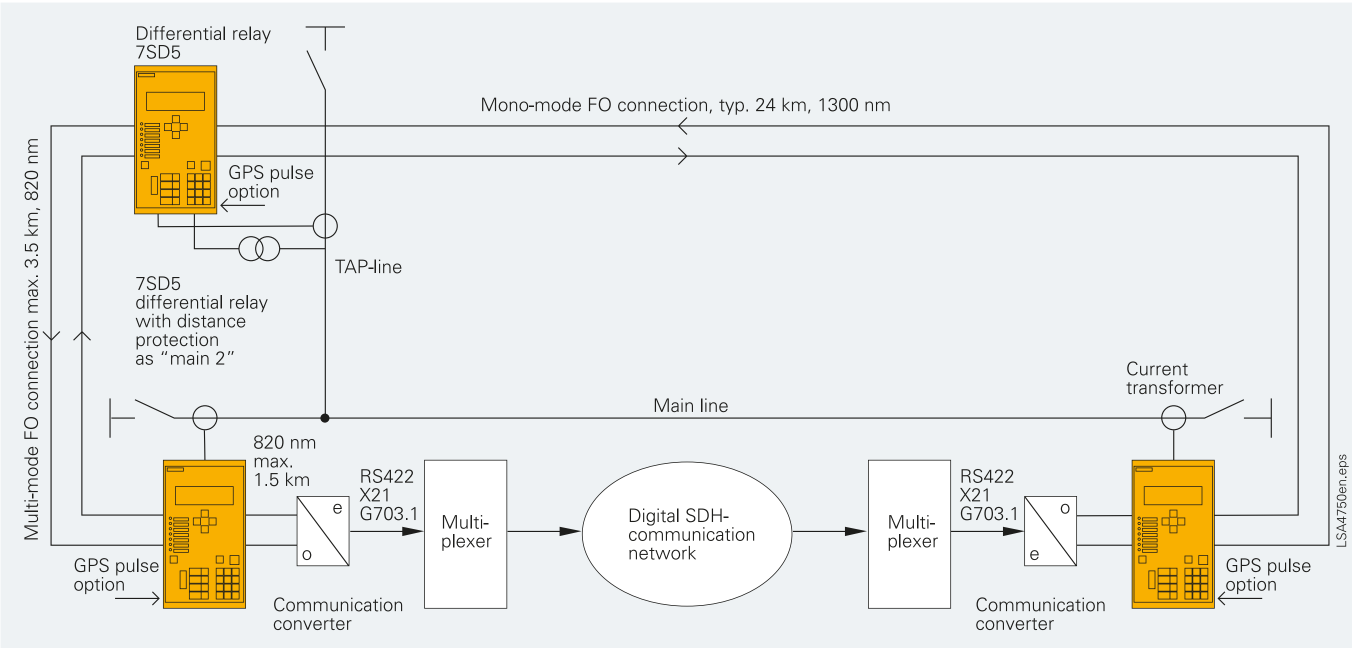


Fig. 7/35 Application for three line ends (Ring topology)

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.

Construction

Connection techniques and housing with many advantages

⅓, ½, ⅔, and ⅟₁-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. 7/36 Flush-mounting housing with screw-type terminals

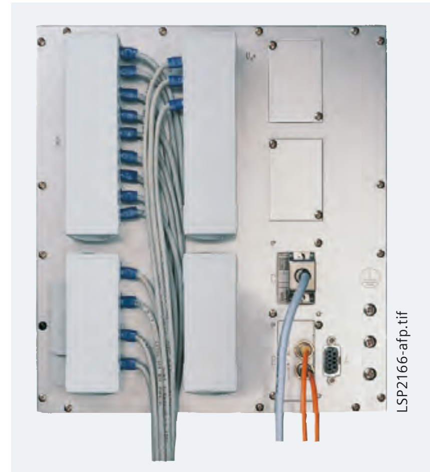


Fig. 7/37 Rear view with screw-type terminals and serial interfaces

Fig. 7/38 Surface-mounting housing with screw-type terminals

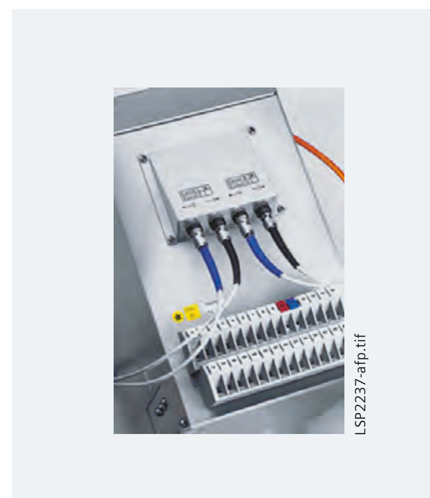


Fig. 7/39 Communication interfaces in a sloped case in a surfacemounting housing

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 clearence 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.

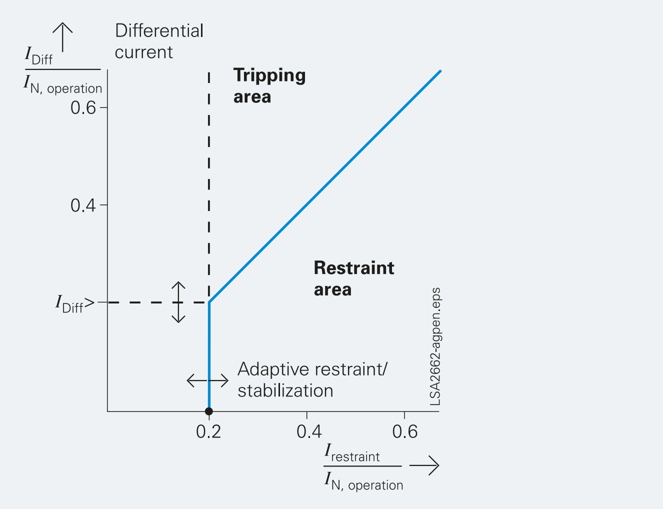


Fig. 7/40 Tripping characteristic

- 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)

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.

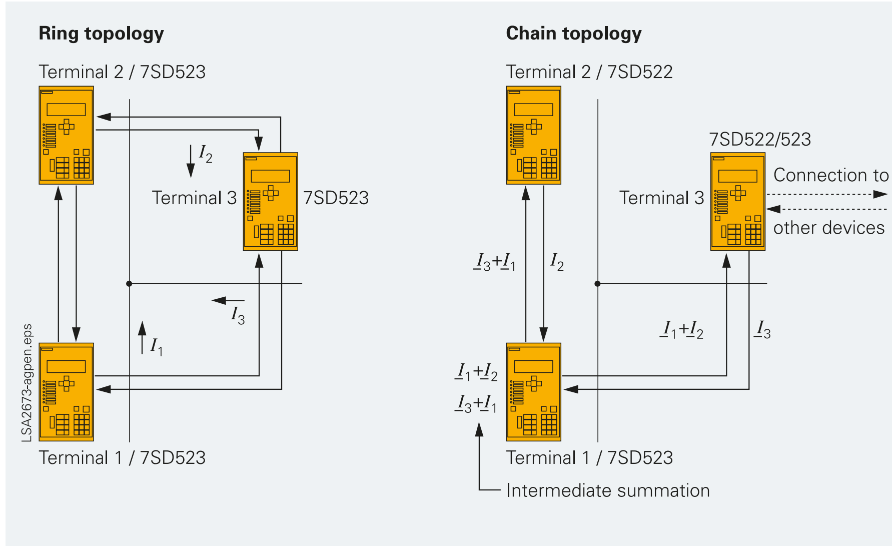


Fig. 7/41 Differential protection in ring or chain topology

- 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.
- 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 algogrithms 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 V/I
- Voltage-dependent and phase angle-dependent overcurrent pickup $V/I/\varphi$
- 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

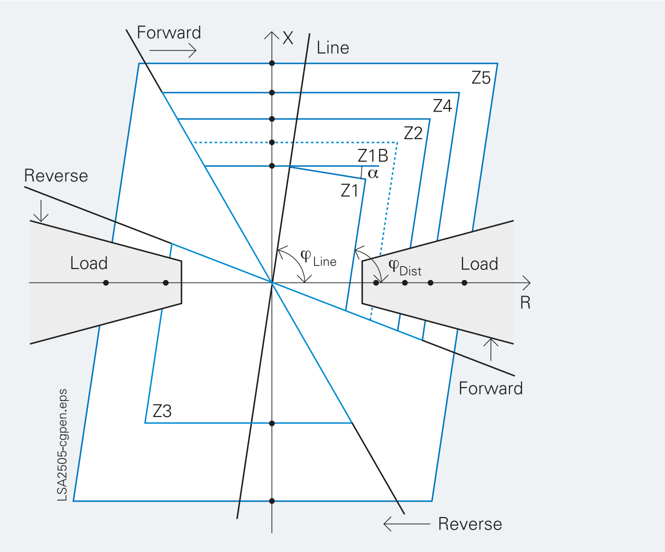


Fig. 7/42 Distance protection: quadrilateral characteristic

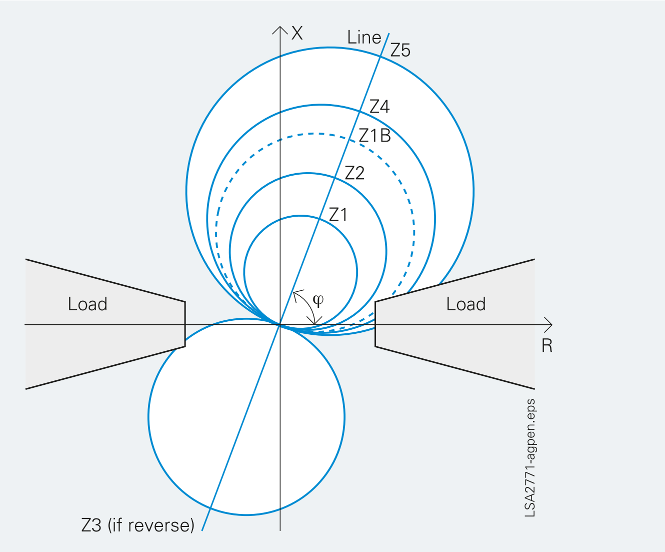


Fig. 7/43 Distance protection: mho characteristic

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.

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.

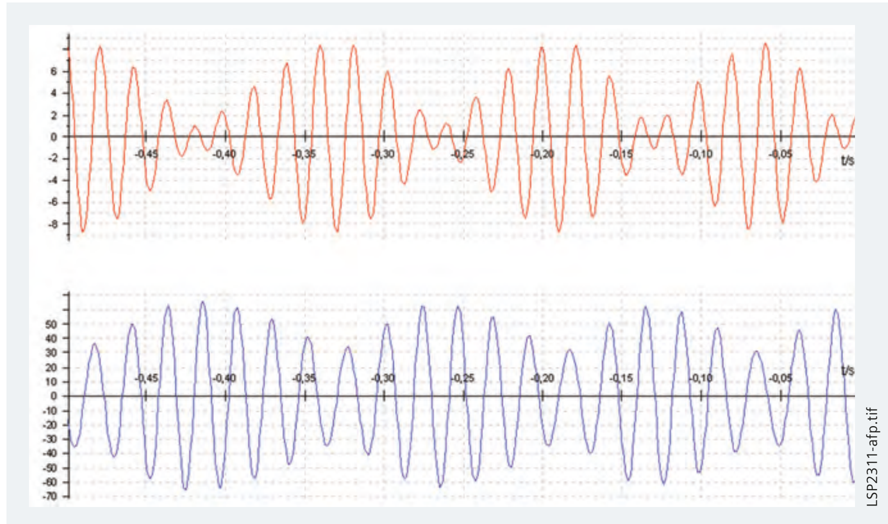


Fig. 7/44 Power swing current and voltage wave forms

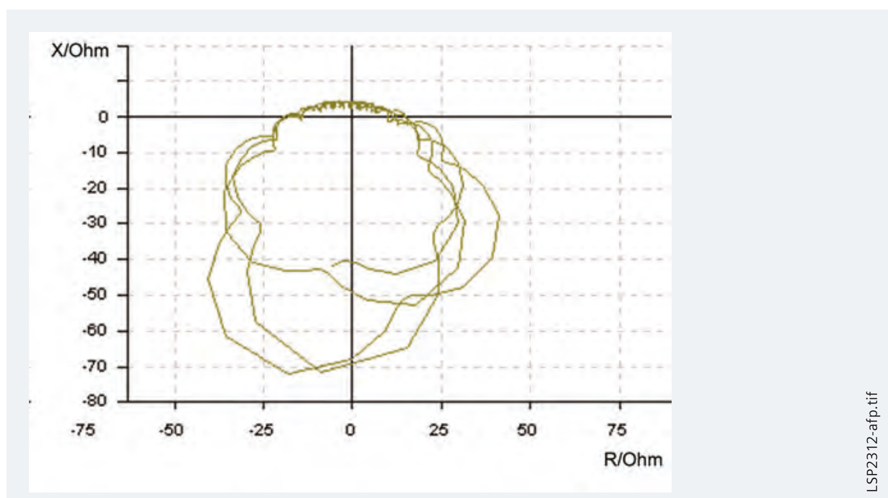


Fig. 7/45 Power swing circle diagram

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.

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.

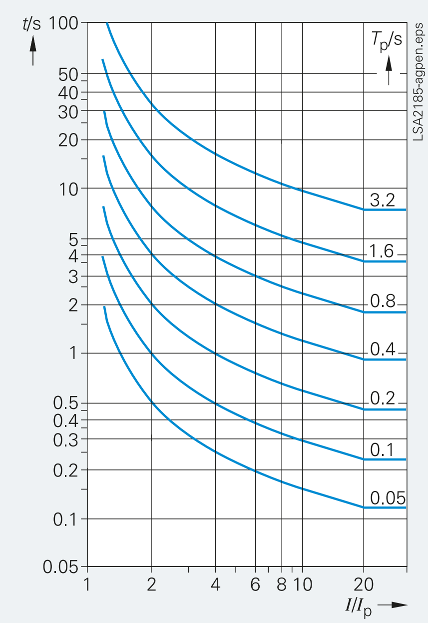
Inverse-time characteristics according to IEC 60255-3 and ANSI/IEEE are provided (see “Technical data”). An additional logarithmic inverse-time characteristic is also available.

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.



$$t = \frac{0{,}14}{\left(I/I_p\right)^{0{,}02} - 1} T_p$$

Fig. 7/46 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

7

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 (disconnector) 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 ciruit-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 malopera- tion of a differential relay if the load current exceeds the differential setpoint. The 7SD52/53 provides fast broken wire supervision which immediatelly 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 φ), 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 x I_{Phase}, $3I_0$, I_E, $I_{\text{E sensitive}}$
- Voltages 3 x $V_{\text{Phase-Ground}}$, 3 x $V_{\text{Phase-Phase}}$, $3V_0$, 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 φ)
- Frequency f
- Differential and restraint current per phase
- Load impedances with directional indication
  3 x $R_{\text{Phase-Ground}}$, $X_{\text{Phase-Ground}}$
  3 x $R_{\text{Phase-Phase}}$, $X_{\text{Phase-Phase}}$
- Long term mean values
  3 x I_{Phase}; I_1; P; P+; P-; Q; Q+; Q-; S
- Minimum/maximum memory
  3 x I_{Phase}; I_1; 3 x $V_{\text{Phase-Ground}}$
  3 x $V_{\text{Phase-Phase}}$, $3V_0$; V_1; P+; P-; Q+; Q-; S; f;
  power factor (+); power factor (-);
  from mean values 3 x I_{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.

7

Measured values at remote line ends

Every two seconds the currents and voltages are freezed 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.

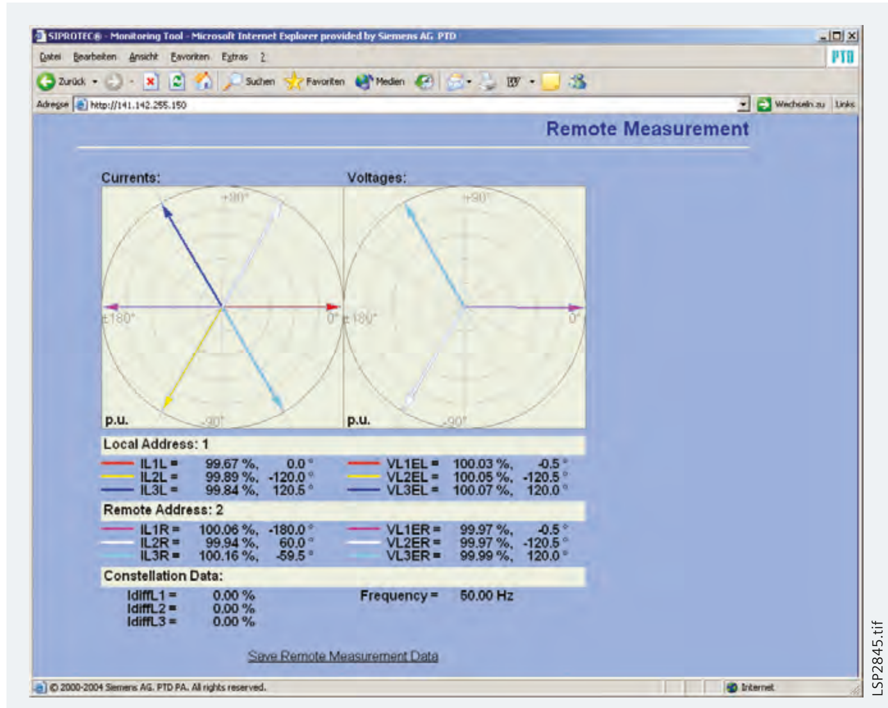


Fig. 7/47 Browser-aided commissioning: Phasor diagram

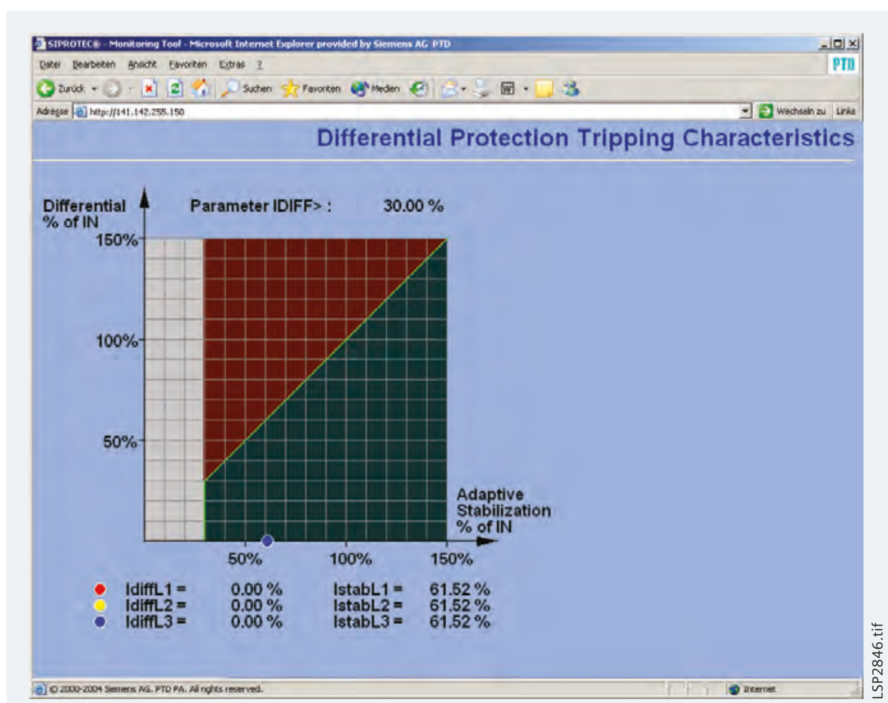


Fig. 7/48 Browser-aided commissioning: Differential protection tripping characteristic

Stability can be checked by using the operating characteristic as well as the calculated differential and restraint values in the browser windows.

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.

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 DP, DNP 3, DIGSI, etc.) are required, such demands can be met.

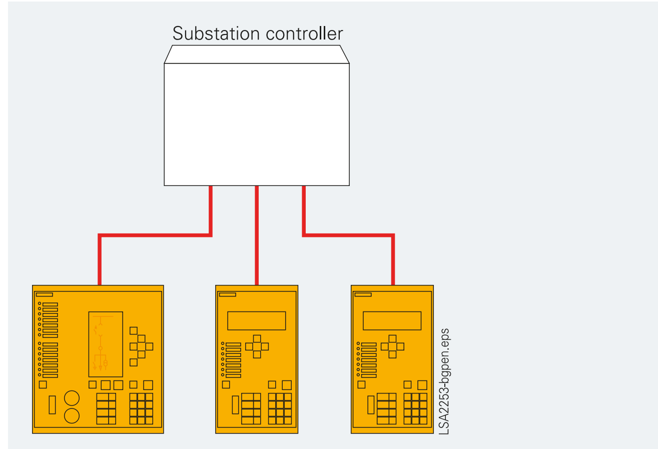


Fig. 7/49 IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

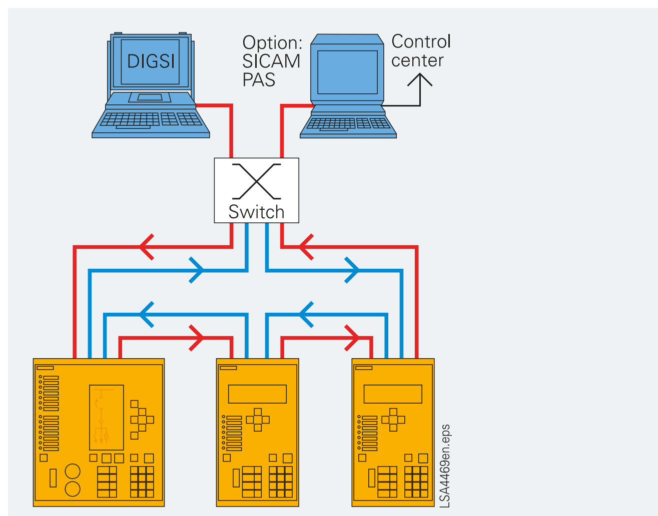


Fig. 7/50 Bus structure for station bus with Ethernet and IEC 61850

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.

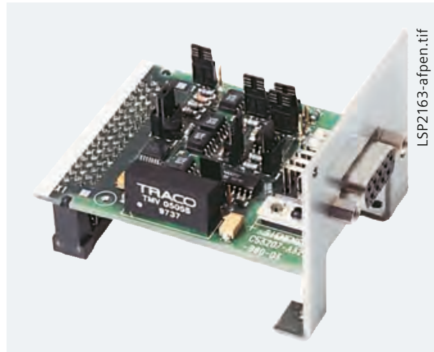


Fig. 7/51 RS232/RS485 electrical communication module

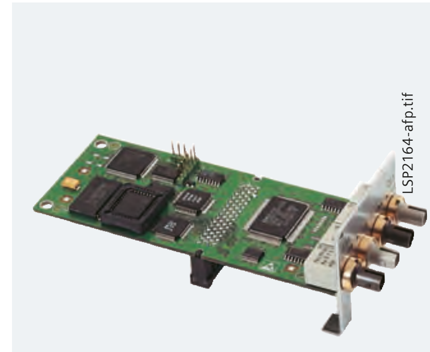


Fig. 7/52 PROFIBUS communication module, optical double-ring

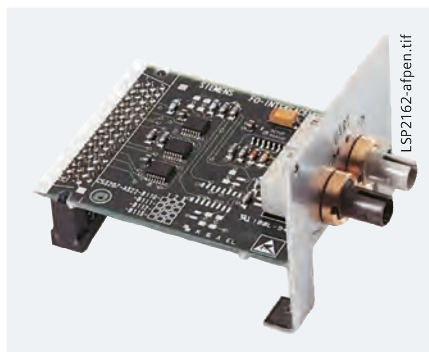


Fig. 7/53 820 nm fiber-optic communication module

Fig. 7/54 Fiber-optic Ethernet communication module for IEC 61850 with integrated Ethernet switch

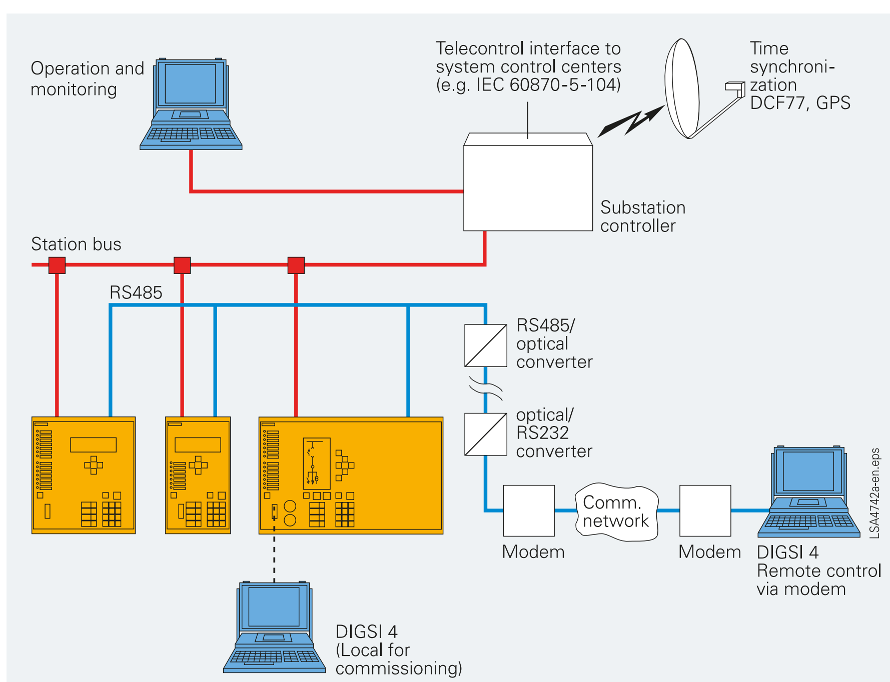


Fig. 7/55 System solution: Communications

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System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS DP. 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. 7/49).

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. 7/50).

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.

- FO5[1)], OMA1[2)] 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.
- FO6[1)], OMA2[2)] 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

- FO17[1)]: For direct connection up to 24 km[3)], 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO18[1)]: For direct connection up to 60 km[3)], 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO19[1)]: For direct connection up to 100 km[3)], 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

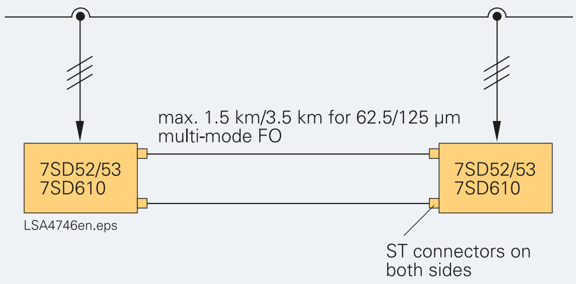


Fig. 7/56 Direct optical link up to 1.5 km/3.5 km, 820nm

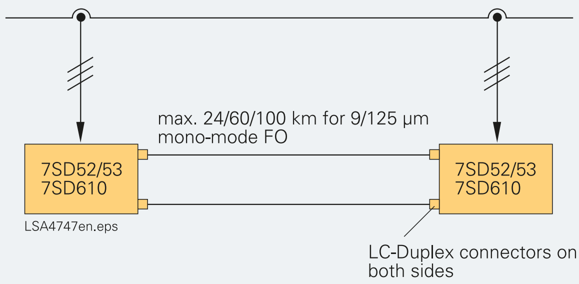


Fig. 7/57 Direct optical link up to 25/60 km with 1300 nm or up to 100 km with 1550 nm

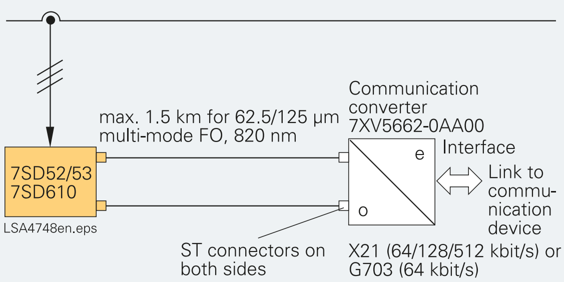


Fig. 7/58 Connection to a communication network CC-XG

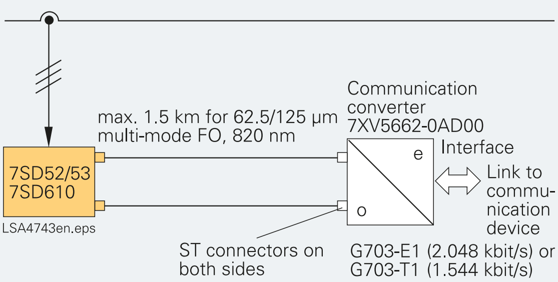


Fig. 7/60 Connection to a communication network CC-2M

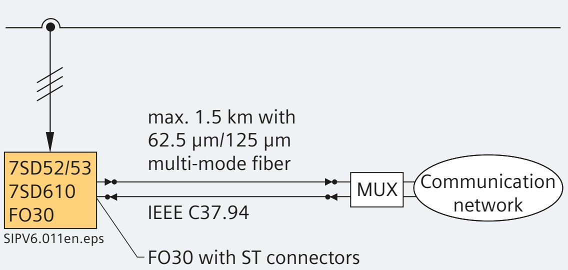


Fig. 7/59 Connection to a communication network via IEEE C37.94

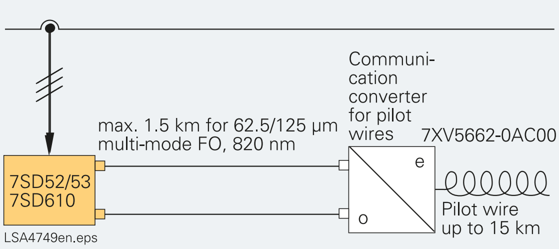


Fig. 7/61 Connection to a pilot wire

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.

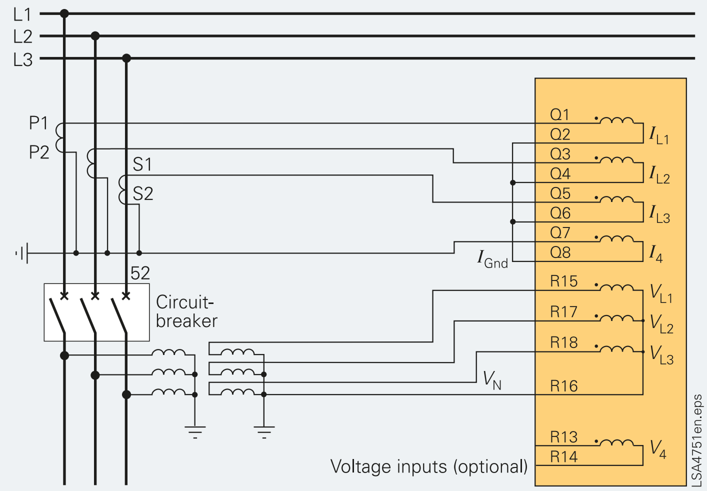


Fig. 7/62 Example of connection for current and voltage transformers

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. 7/62, 7/67 or 7/68.

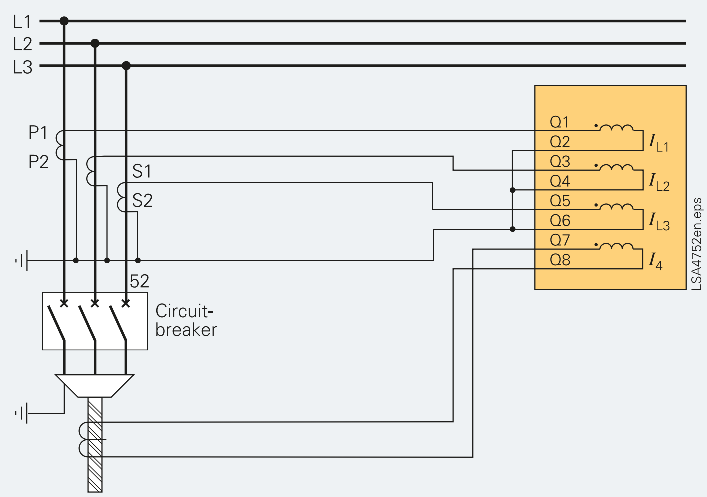


Fig. 7/63 Alternative connection of current transformers for sensitive ground(earth)-current measuring with core-balance current transformers

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. 7/71, 7/76 or 7/77.

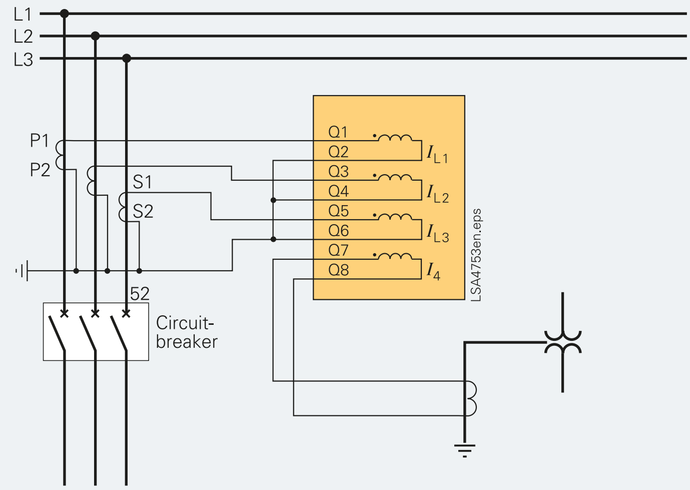


Fig. 7/64 Alternative connection of current transformers for measuring neutral current of a grounded (earthed) power transformer

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. 7/71, 7/76 or 7/77.

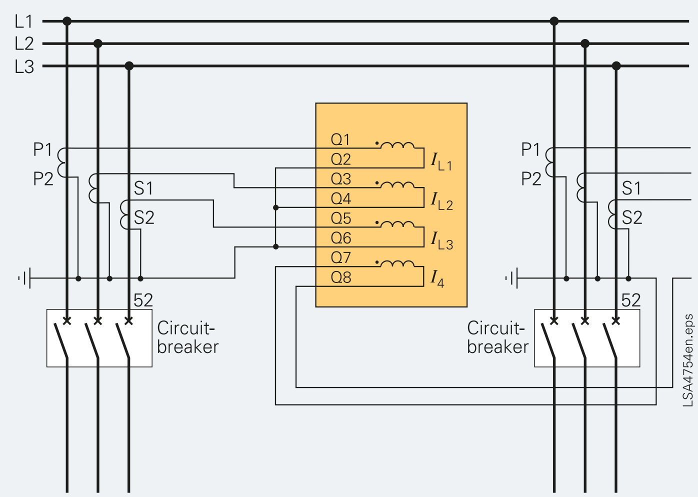


Fig. 7/65 Alternative connection of current transformers for measuring the ground (earth) current of a parallel line

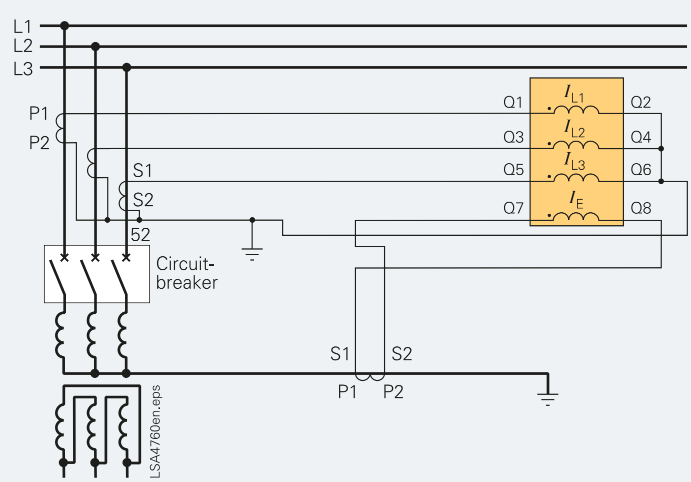


Fig. 7/66 Connection of current transformer with restricted ground-fault protection (REF)

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. 7/62, 7/63, 7/64 and 7/65.

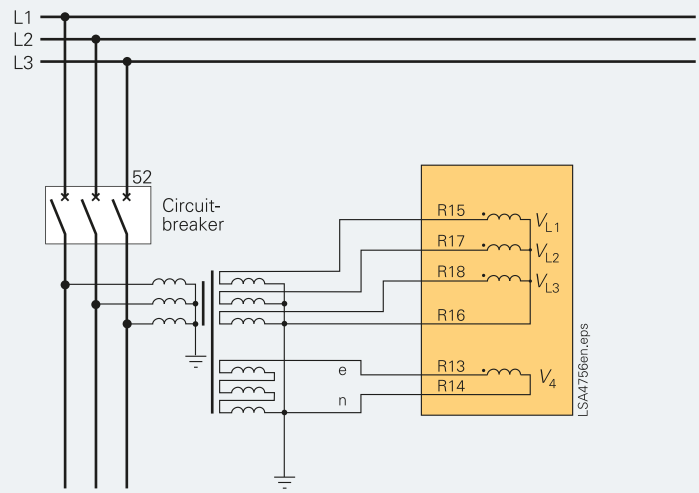


Fig. 6/67 Alternative connection of voltage transformers for measuring the displacement voltage (e-n voltage)

Alternative voltage connection

3 phase voltage transformers, V_4 connected to busbar voltage transformer for synchrocheck.

Note:
Any phase-to-phase or phase-toground (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. 7/62, 7/63, 7/64 and 7/65.

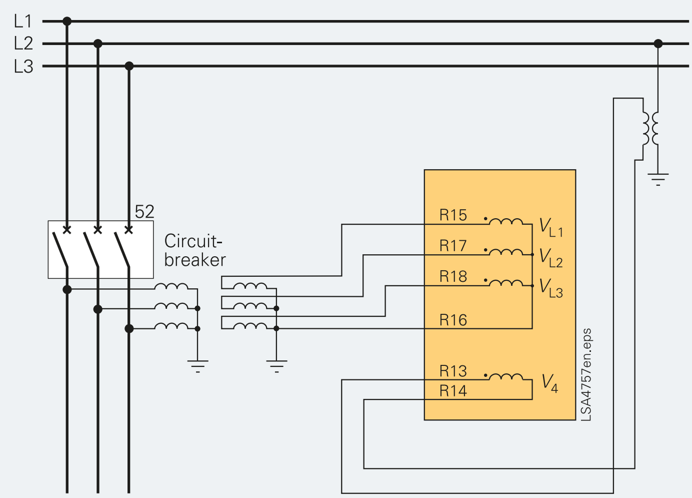


Fig. 6/68 Alternative connection of voltage transformers for measuring the busbar voltage

7

General unit data	
Analog inputs	
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 In CT circuits with I_N = 5 A In VT circuits	 Approx. 0.05 VA Approx. 0.30 VA 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 In the CT circuit for high sensitive ground-fault protection (refer to ordering code)	 1250 A (half cycle)
Auxiliary voltage	
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 Hz1)
Permissible tolerance	-20 % to +20 %
Max. superimposed AC voltage (peak-to-peak)	≤ 15 %
Power consumption During normal operation During pickup with all inputs and outputs activated	 Approx. 8 W Approx. 18 W
Bridging time during auxiliary voltage failure V_{aux} AC/DC 110 V	≥ 50 ms
Binary inputs	
Quantity Function can be assigned	8 or 16 or 24
Minimum permissible voltage Range is selectable with jumpers for each binary input	DC 19 or 88 or 176 V, bipolar (3 operating ranges)
Maximum permissible voltage	DC 300 V
Current consumption, energized	Approx. 1.8 mA
Output relays	
Quantity Function can be assigned	16 or 24 or 32
Switching capacity Make Break Break (for resistive load) Break (for τ = L/R ≤ 50 ms)	 1000 W /VA 30 VA 40 W 25 VA
Switching voltage	250 V
Permissible current	30 A for 0.5 s 5 A continuous
LEDs	
	Quantity
RUN (green)	1
ERROR (red)	1
Indication (red), function can be assigned	14

1) Ranges are settable by means of jumpers.

Unit design	
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 Flush-mounting housing Rear Front	 IP 51 IP 50 IP 51
For the terminals	IP 2x with cover cap
Weight Flush-mounting housing 1/2 x 19" 1/1 x 19"	 6 kg 10 kg
Surface-mounting housing 1/2 x 19" 1/1 x 19"	 11 kg 19 kg
Electrical tests	
Specifications	
Standards	IEC 60255 (product standards) ANSI/IEEE C37.90.0/.1/.2 UL 508 For further standards see "Individual functions"
Insulation tests	
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 µs; 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; τ = 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 Ω
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.

7

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 Ω; 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 Ω 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 Ω
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 Ω
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	
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 othogonal 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	
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.	Yearly average ≤ 75 % relative humidity; on 56 days in the year up to 93 % relative humidity; condensation is not permitted

Futher information can be found in the current manual at: www.siemens.com/siprotec

Description	Order No.	Short code
7SD5 combined multi-end line differential protection with distance protection	7SD5□□□-□□□□□-□□□□-□□□	
Device type[1]		
Two-terminal differential relay with 4-line display	2 2	
Two-terminal differential relay with grapical 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 A[2], I_e = 1 A[2]	1	
I_{ph} = 1 A[2], I_e = high (min. = 0.005 A)	2	
I_{ph} = 5 A[2], I_e = 5 A[2]	5	
I_{ph} = 5 A[2], I_e = 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	

see next page

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	Order No.
8	4	12	–	½	■			A
8	4	12	–	½			■	E
8	4	12	–	½		■		J
16	12	12	–	1/1	■			C
16	12	12	–	1/1			■	G
16	12	12	–	1/1		■		L
16	4	15	5	1/1	■			N
16	4	15	5	1/1			■	Q
16	4	15	5	1/1		■		S
24	20	12	–	1/1	■			D
24	20	12	–	1/1			■	H
24	20	12	–	1/1		■		M
24	12	15	5	1/1	■			P
24	12	15	5	1/1			■	R
24	12	15	5	1/1		■		T
24	4	18	10	1/1	■			W

Description	Order No.
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

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 indentified 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

7

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	
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
DNP 3.0, optical 820 nm, ST connector 1)		H
IEC 61850, 100 Mbit Etherrnet, electrical, double, RJ45 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

Order positions 8 to 11 (middle block): see next page

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**).

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).

7

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 ($I_{pick-up}$ $I>$,-VI/φ, -$Z<$), polygon, parallel line comp. 2), power swing det. (ANSI 21, 21N, 68, 68T)	Ground fault detection for isolated/ compensated networks 1)	Order code
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, frequence protection (ANSI 27, 50)	Restricted ground fault low impedance (ANSI 87N) 2)	Order code
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	Order code
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**

Accessories	Description	Order No.
	Opto-electric communication converter CC-XG (connection to communication network)	
	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	**7XV5662-0AA00**
	Opto-electric communication converter CC-2M to G703-E1 / -T1 communication networks with 2,048 / 1,554 kbit/s	
	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	**7XV5662-0AD00**
	Opto-electric communication converter (connection to pilot wire)	
	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	**7XV5662-0AC00**
	Additional interface modules	
	Protection interface mod. opt. 820 nm, multi-mode FO cable, ST connector, 1.5 km	**C53207-A351-D651-1**
	Protection interface mod. opt. 820 nm, multi-mode FO cable, ST connector, 3.5 km	**C53207-A351-D652-1**
	Further modules	
	Protection interface mod. opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 24 km	**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**
	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**
	Time synchronizing unit with GPS output	
	GPS 1 sec pulse and time telegram IRIG B / DCF 77	**7XV5664-0AA00**
	Isolation transformer (20 kV) for pilot wire communication	**7XR9516**
	Voltage transformer miniature circuit-breaker	
	Rated current 1.6 A; thermal overload release 1.6 A; overcurrent trip 6 A	**3RV1611-1AG14**

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**
	Manual for 7SD522/523 V4.6 English	**C53000-G1176-C169**

Fig. 7/69 Mounting rail for 19" rack

Fig. 7/70
2-pin connector

Fig. 7/71
3-pin connector

Fig. 7/72
Short-circuit link for current contacts

Fig. 7/73
Short-circuit link for voltage contacts/ indications contacts

Description		Order No.	Size of package	Supplier	Fig.
Connector	2-pin	**C73334-A1-C35-1**	1	Siemens	7/70
	3-pin	**C73334-A1-C36-1**	1	Siemens	7/71
Crimp connector	CI2 0.5 to 1 mm^2	**0-827039-1**	4000	1)	
		0-827396-1	1	1)	
	CI2 0.5 to 2.5 mm^2	**0-827040-1**	4000	1)	
		0-827397-1	1	1)	
	Type III+ 0.75 to 1.5 mm^2	**0-163083-7**	4000	1)	
		0-163084-2	1	1)	
Crimping tool	For type III+	**0-539635-1**	1	1)	
	and matching female	**0-539668-2**		1)	
	For CI2	**0-734372-1**	1	1)	
	and matching female	**1-734387-1**		1)	
19"-mounting rail		**C73165-A63-D200-1**	1	Siemens	7/69
Short-circuit links	For current terminals	**C73334-A1-C33-1**	1	Siemens	7/72
	For other terminals	**C73334-A1-C34-1**	1	Siemens	7/73
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.

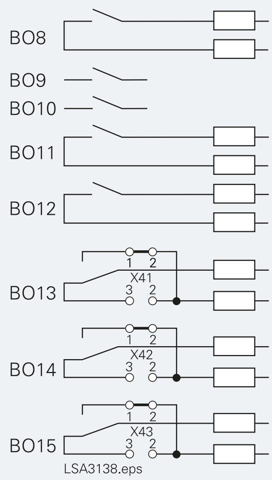
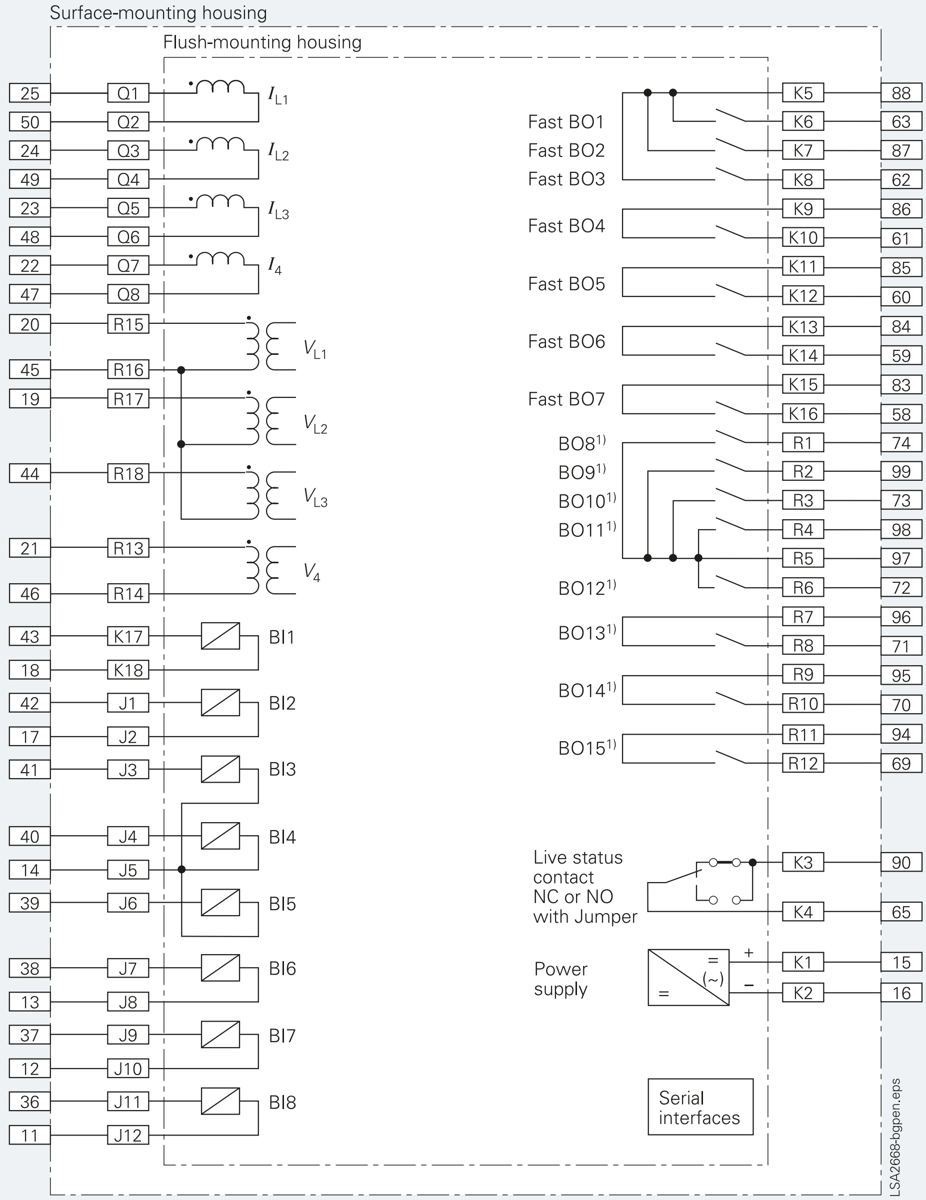


Fig. 7/76
Additional setting by jumpers: Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82. Switching of BO14, BO15 as NO contact or NC contact with jumpers X41, X42, X43.



1) Configuration of binary outputs until Hardware-version /EE. For advanced flexibility see Fig. 7/76.

Fig. 7/74 Basic version in housing ½ x 19" with 8 binary inputs and 16 binary outputs

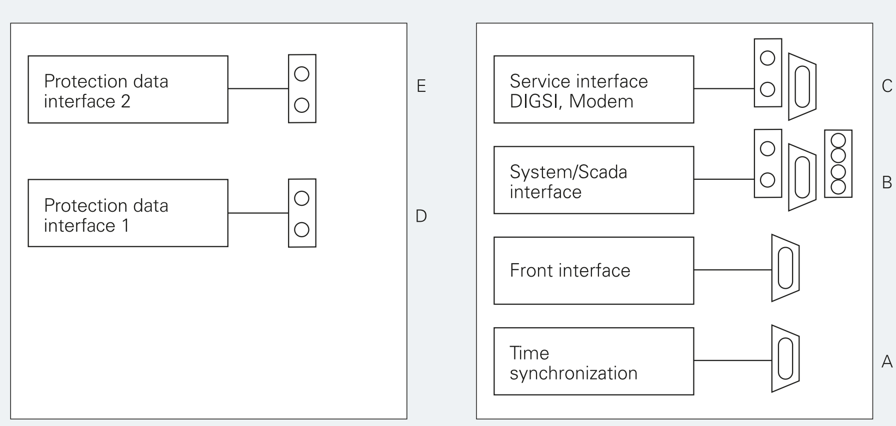


Fig. 7/75 Serial interfaces

Connection diagram

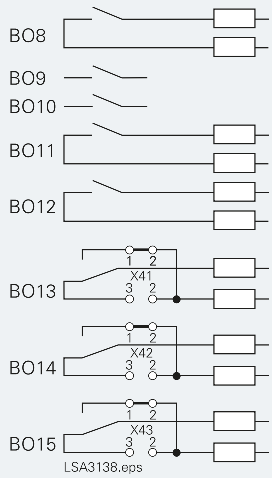
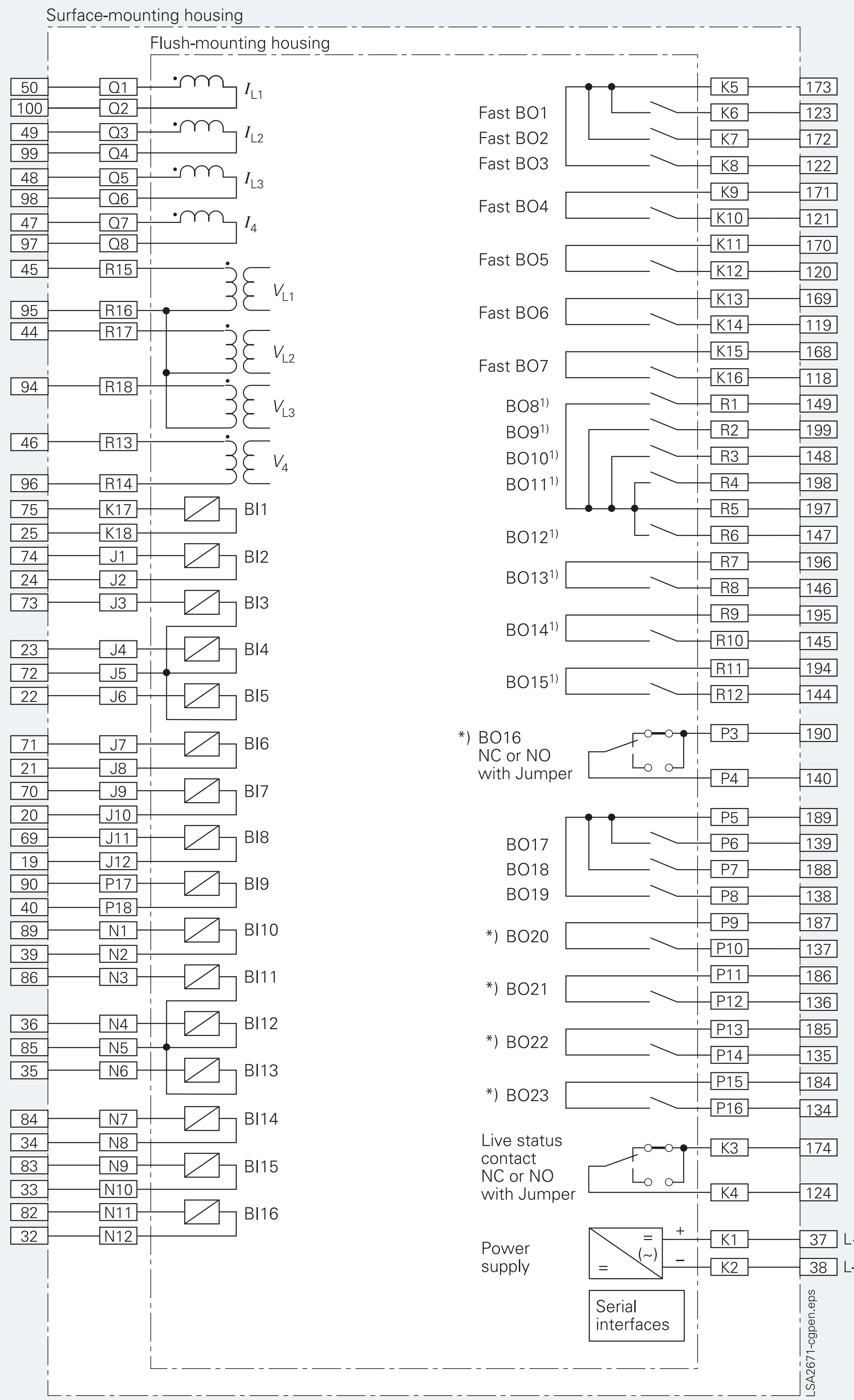


Fig. 7/78
Additional setting by jumpers: Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82. Switching of BO14, BO15 as NO contact or NC contact with jumpers X41, X42, X43.



*) For unit version 7SD52xx-xN/S/Q high-speed contacts

1) Configuration of binary outputs until Hardware-version /EE.
For advanced flexibility see Fig. 7/78.

Fig. 7/77 Medium version in housing 1/1 x 19"

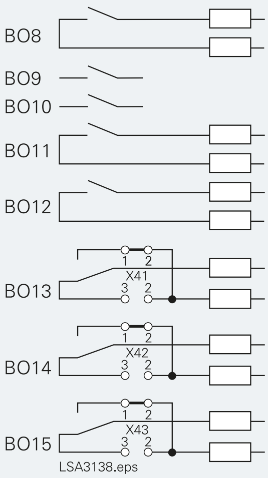
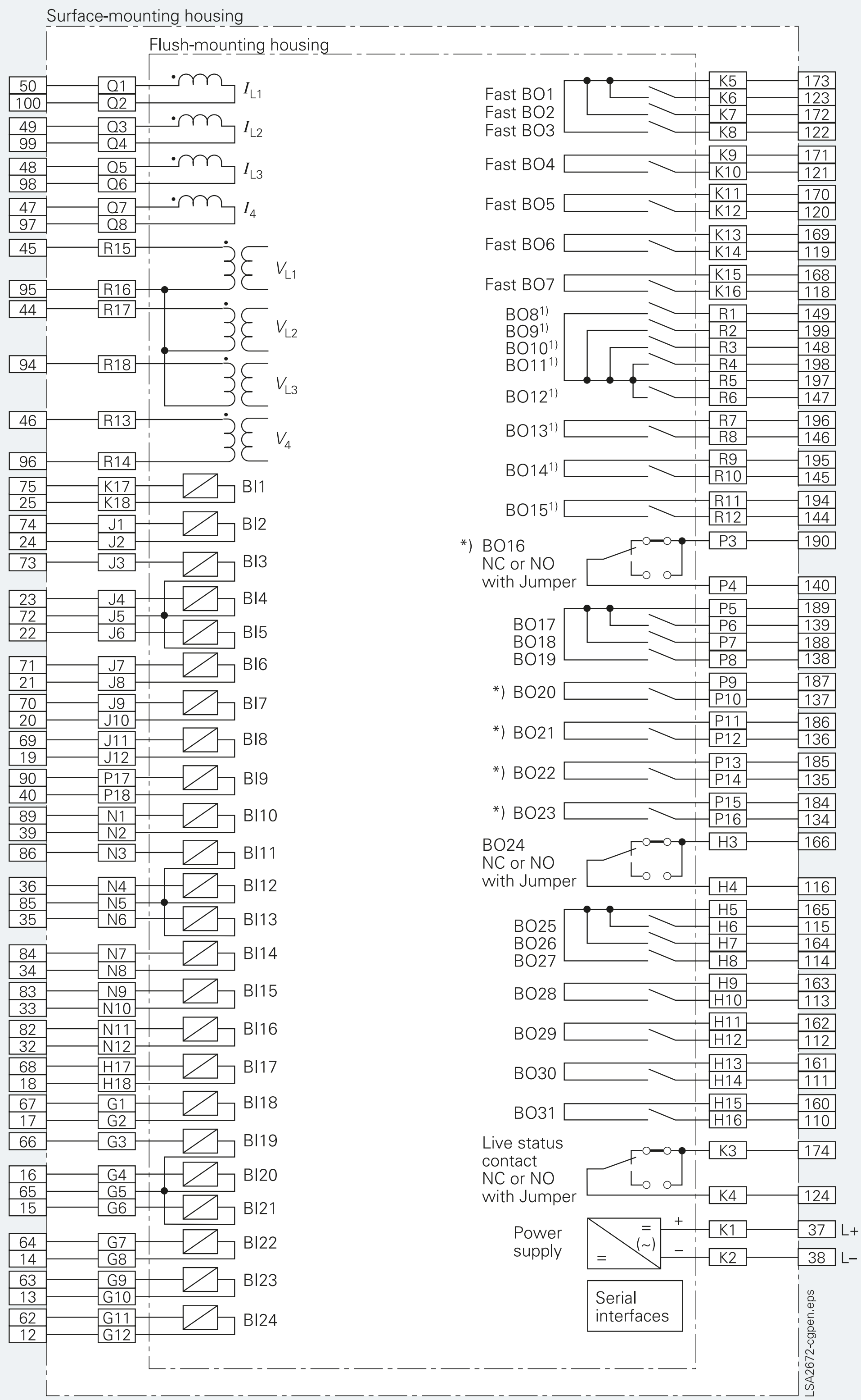


Fig. 7/80
Additional setting by jumpers: Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82. Switching of BO14, BO15 as NO contact or NC contact with jumpers X41, X42, X43.



*) For unit version 7SD52xx-xR/P/T high-speed contacts

1) Configuration of binary outputs until Hardware-version /EE.
For advanced flexibility see Fig. 7/80.

Fig. 7/79 Medium version in housing ⅓ x 19"

7

Transformer Differential Protection

8

8

SIPROTEC 4 7UT6 differential protection relay for transformers, generators, motors and busbars

Fig. 8/1 SIPROTEC 7UT6 differential protection relay for ransformers, 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 DP,
  MODBUS or DNP 3
- Service interface for DIGSI 4 (modem)/ temperature monitoring (thermo-box)
- Time synchronization via IRIG-B/DCF 77

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.

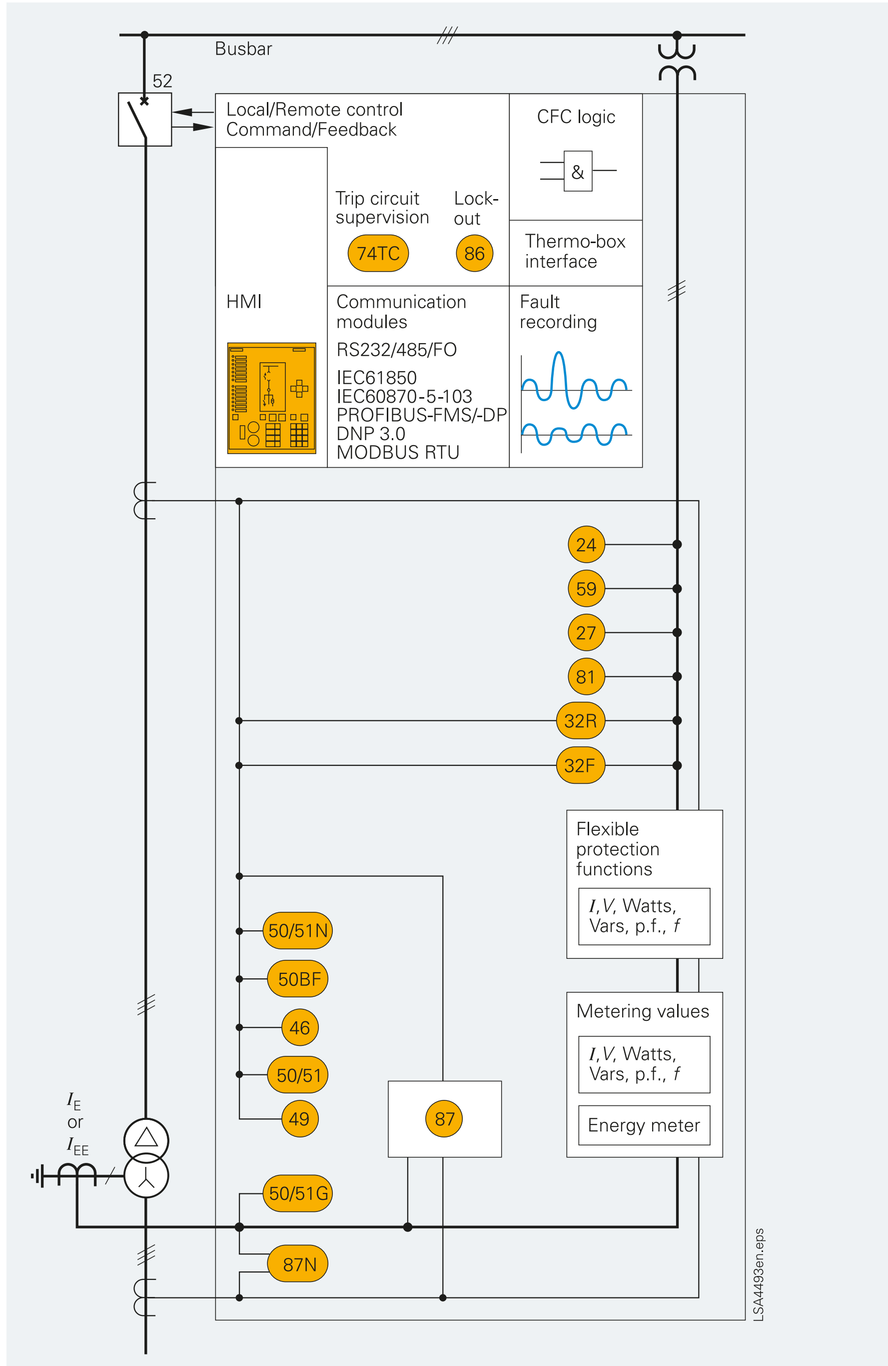


Fig. 8/2 Function diagram

Application

Protection functions	ANSI No.	7UT612	7UT613/33	7UT635	Three-phase transformer	Single-phase transformer	Auto-transformer	Generator/ Motor	Busbar, 3-phase	Busbar, 1-phase
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.

– ⅓ (7UT612),
– ½ (7UT613),
– ⁄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).

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Fig. 8/3 Rear view flush-mountig housing

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.

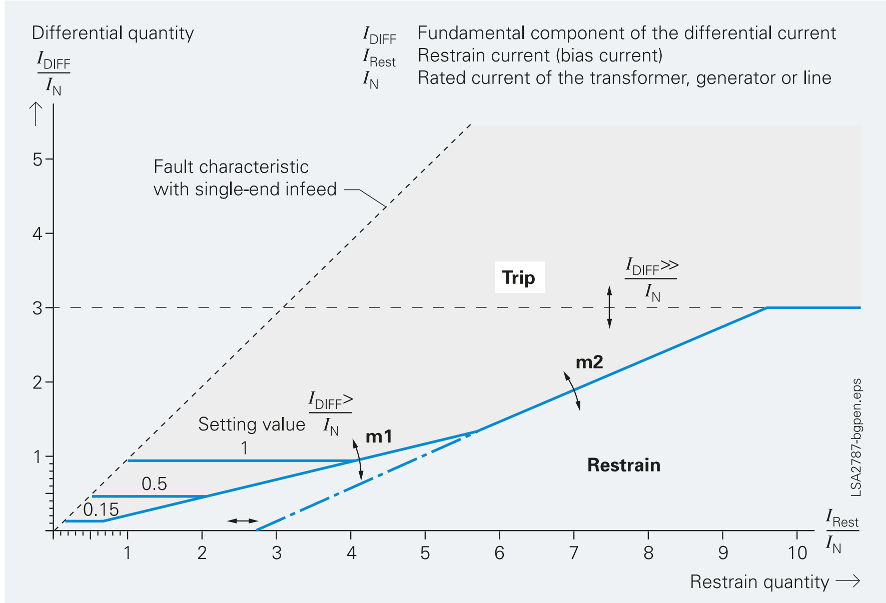

Fig. 8/4 Tripping characteristic with preset transformer parameters for three-phase faults

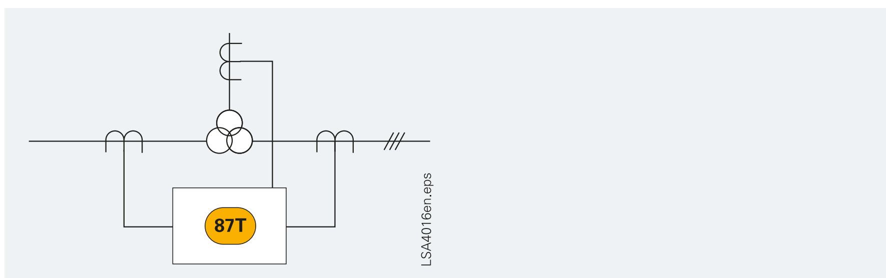

Fig. 8/5 3-winding transformers (1 or 3-phase)

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.

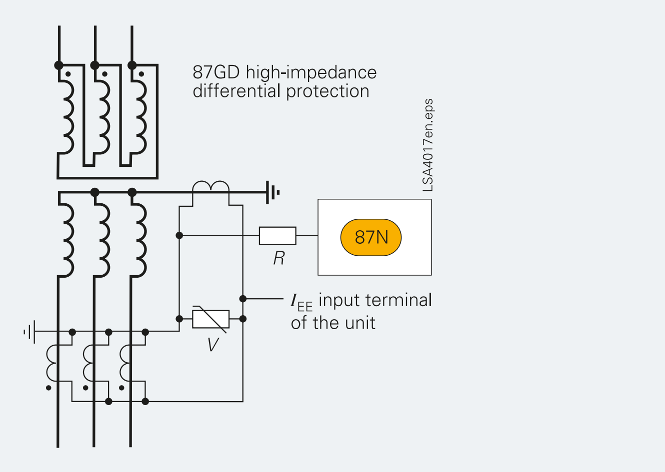

Fig. 8/6 High-impedance differential protection

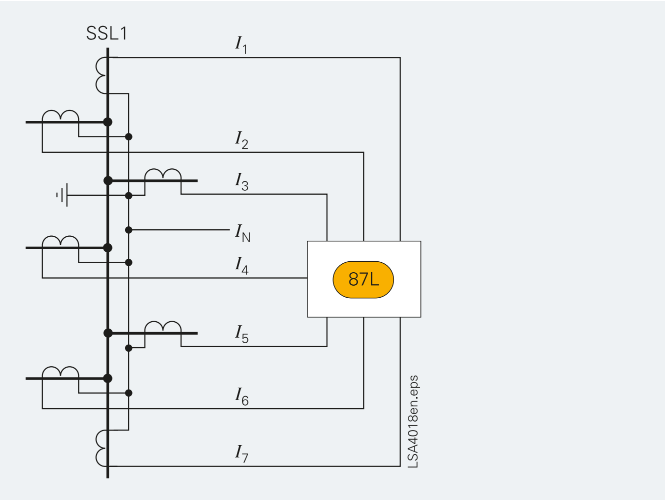

Fig. 8/7 Simple busbar protection with phase-selective configuration 7UT612: 7 feeders; 7UT613/633: 9 feeders; 7UT635: 12 feeders

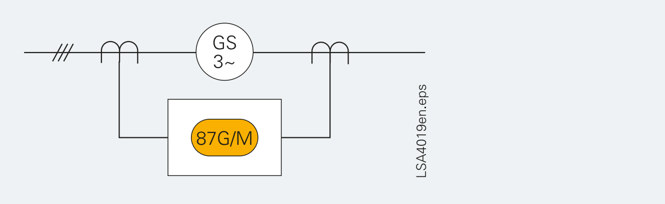

Fig. 8/8 Generator/motor differential protection

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 transfomers at each side of the protected object.

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 (±) of the active power can be reversed via parameters.

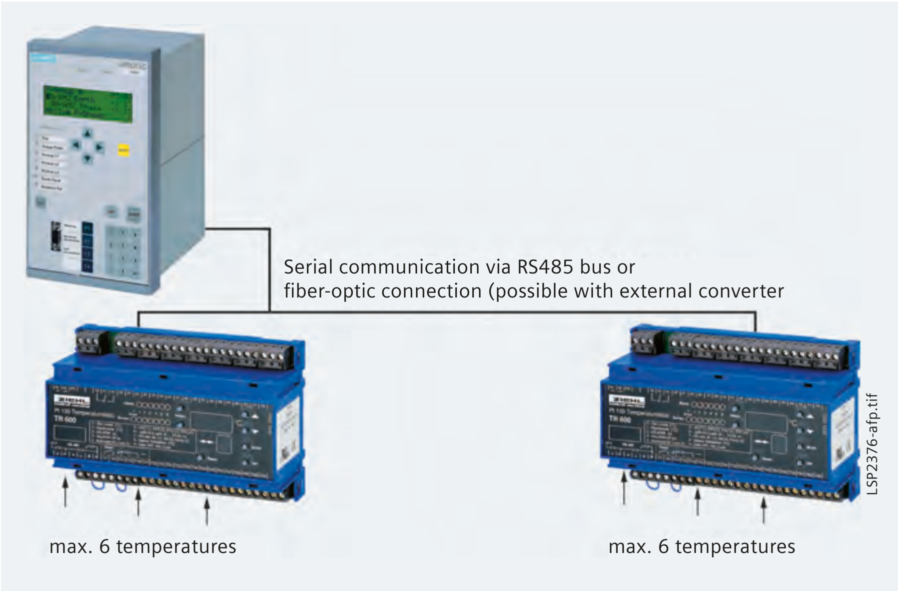

Fig. 8/9 Temperature measurement and monitoring with external thermo-boxes

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.

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.

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 φ),
- 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 φ, 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.

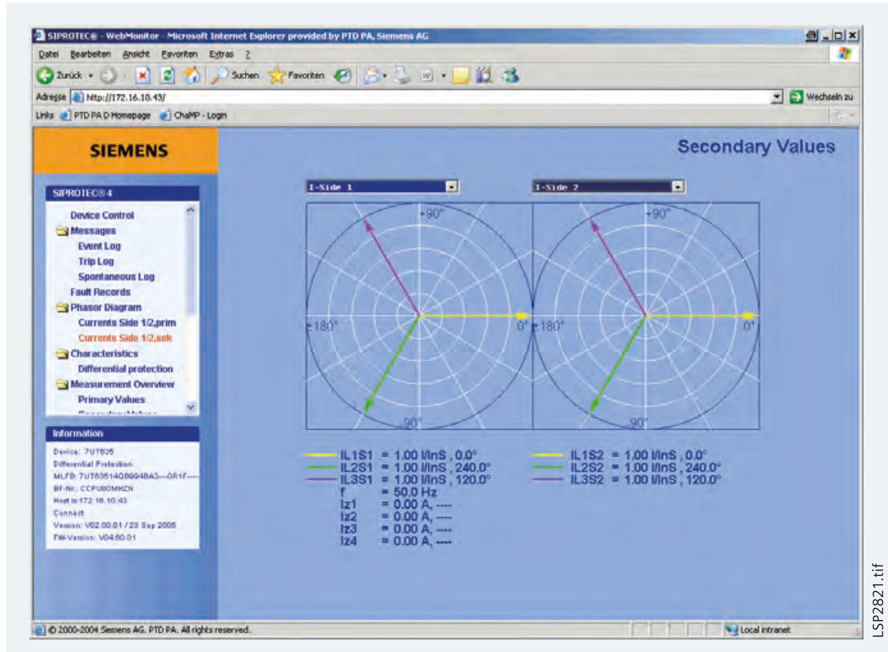

Fig. 8/10 Commissioning via a standard Web browser: Phasor diagram

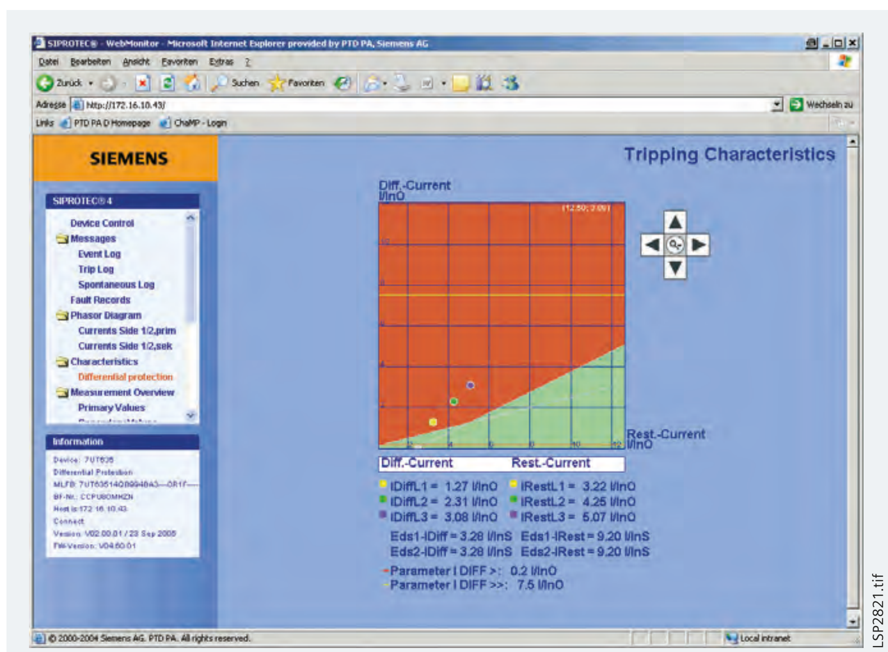

Fig. 8/11 Commissioning via a standard Web browser:Operating characteristic

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.

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 transfomers 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.

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 DP, MODBUS RTU, DNP 3, DIGSI, etc.) are required, such demands can be met.

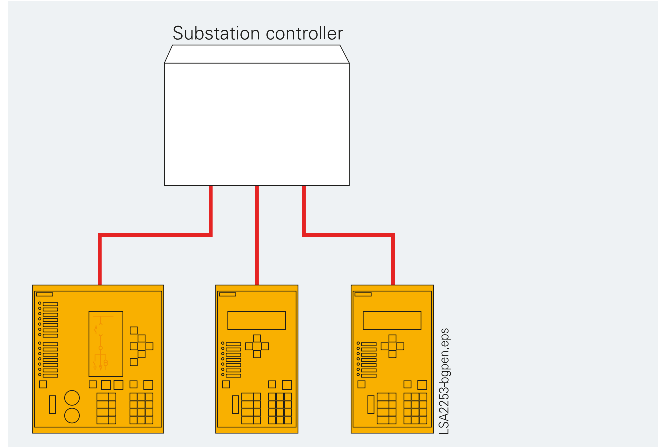

Fig. 8/12 IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

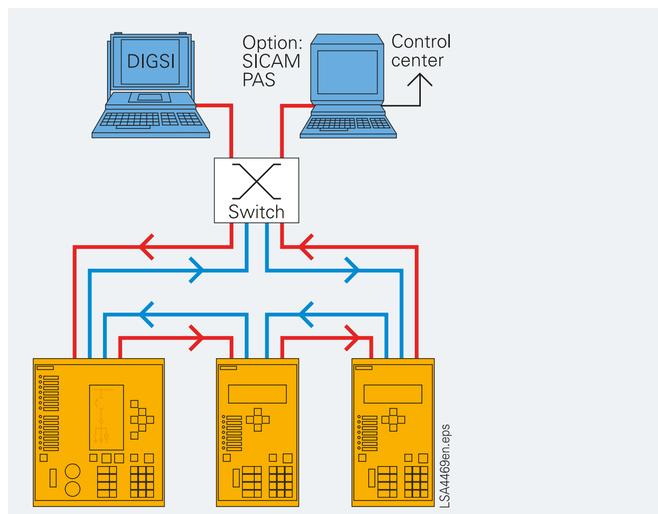

Fig. 8/13 Bus structure for station buswith Ethernet und IEC 61850, fiber-optic ring

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.

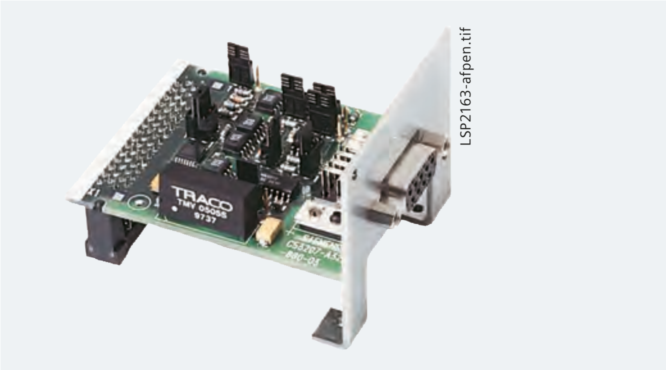

Fig. 8/14 RS232 / RS485 electrical communication module

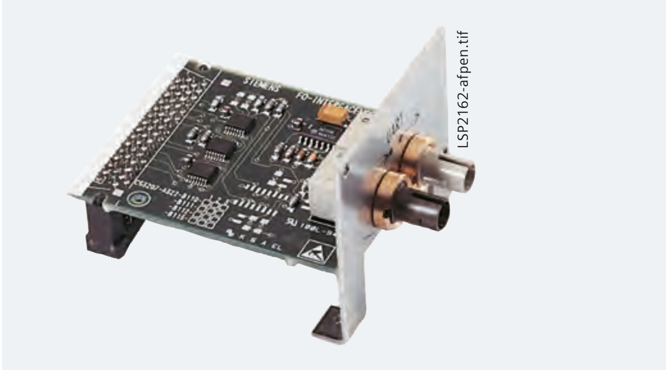

Fig. 8/15 820 nm fiber-optic communication module

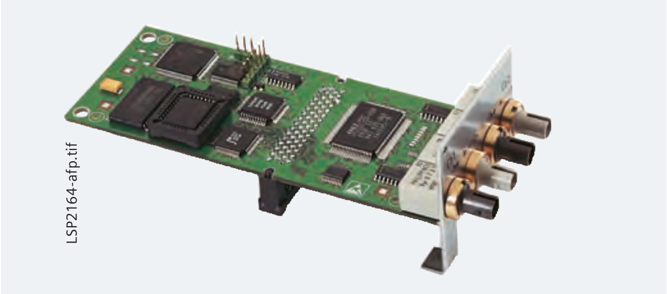

Fig. 8/16 PROFIBUS communication module, optical double-ring

Fig. 8/17 Optical Ethernet communication module for IEC 61850 with integrated Ethernet switch

Communication

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS DP. 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.

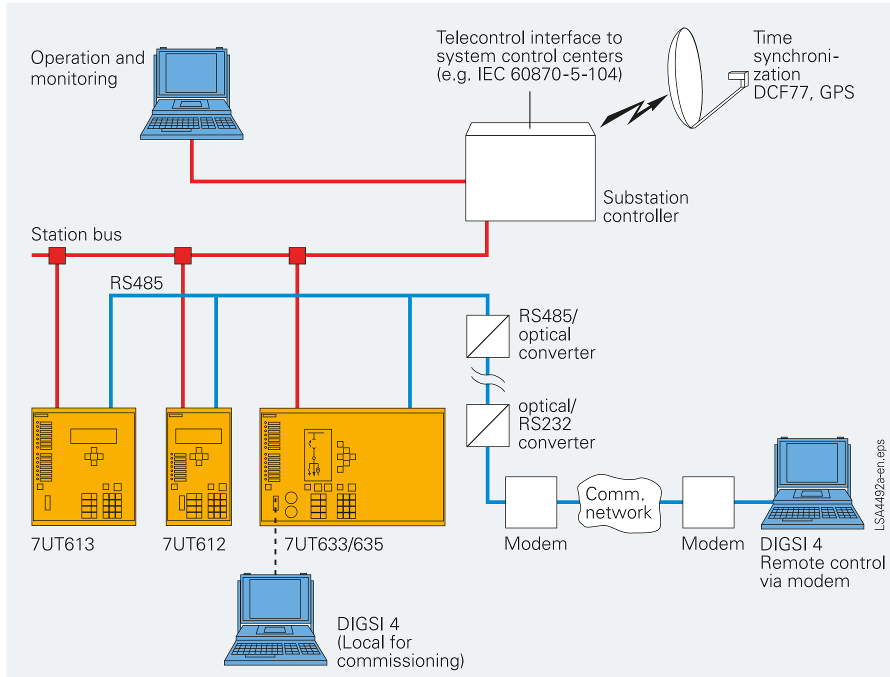

Fig. 8/18 System solution: Communications

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).

8

Typical connections

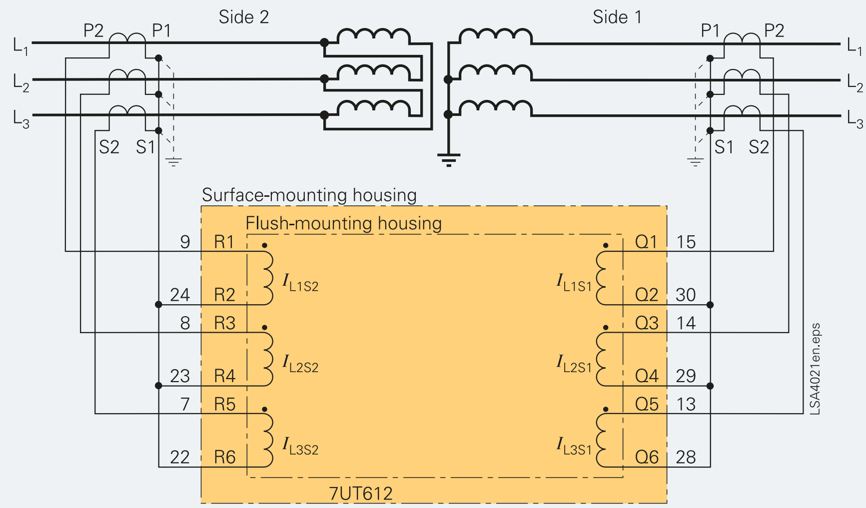

Fig. 8/19 Standard connection to a transformer without neutral current measurement

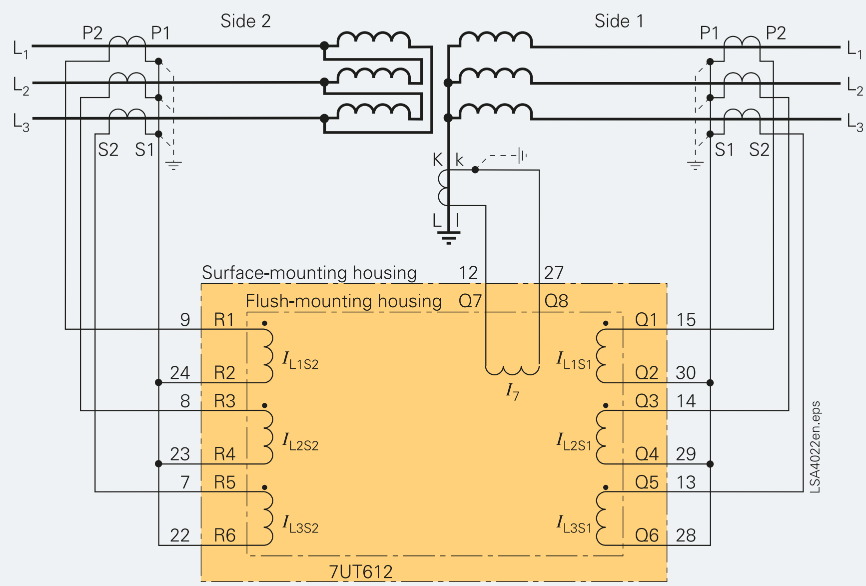

Fig. 8/20 Connection to a transformer with neutral current measurement

8

Typical connections

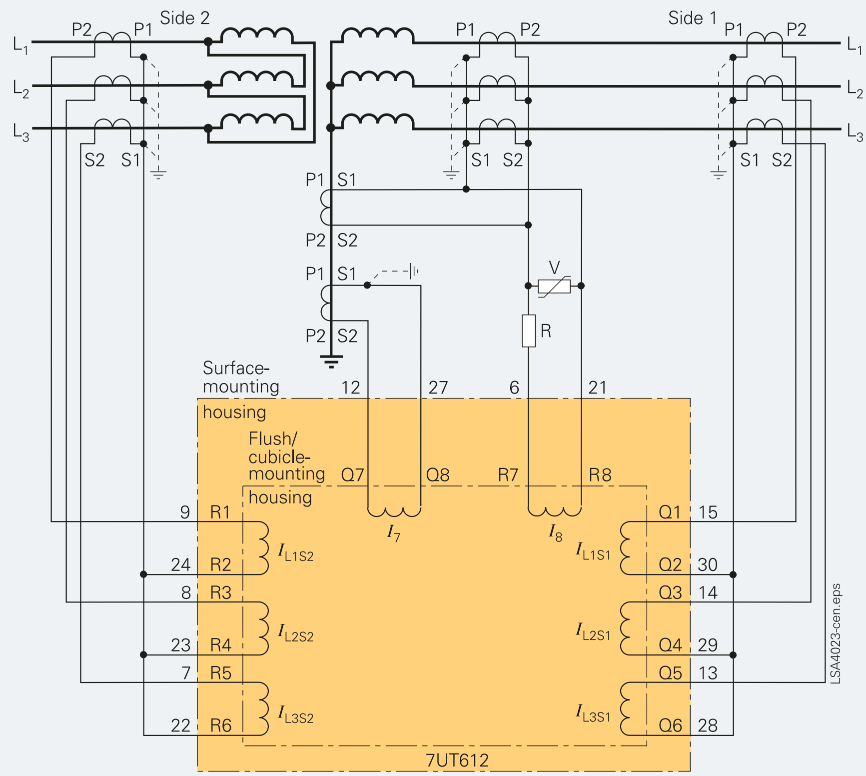

Fig. 8/21 Connection of transformer differential protection with high impedance REF (I_8) and neutral current measurement at I_7

8

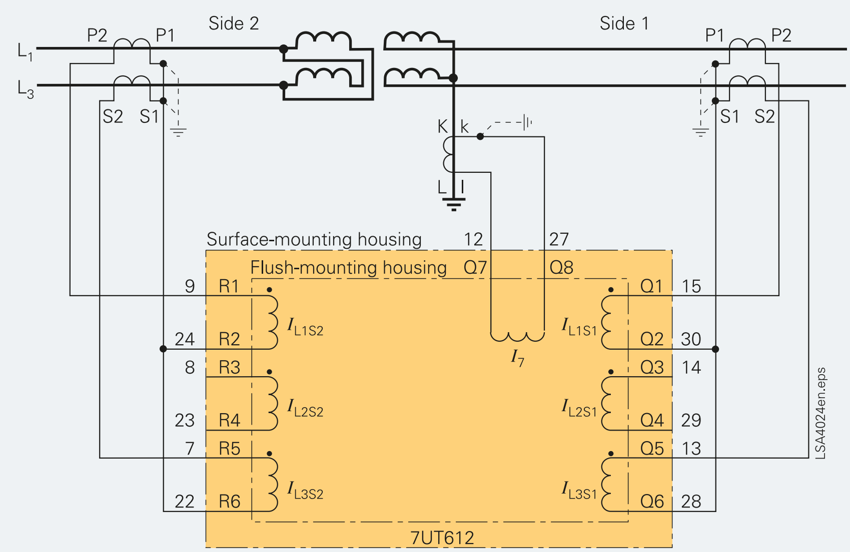

Fig. 8/22 Connection example to a single-phase power transformer with current transformer between starpoint and grounding point

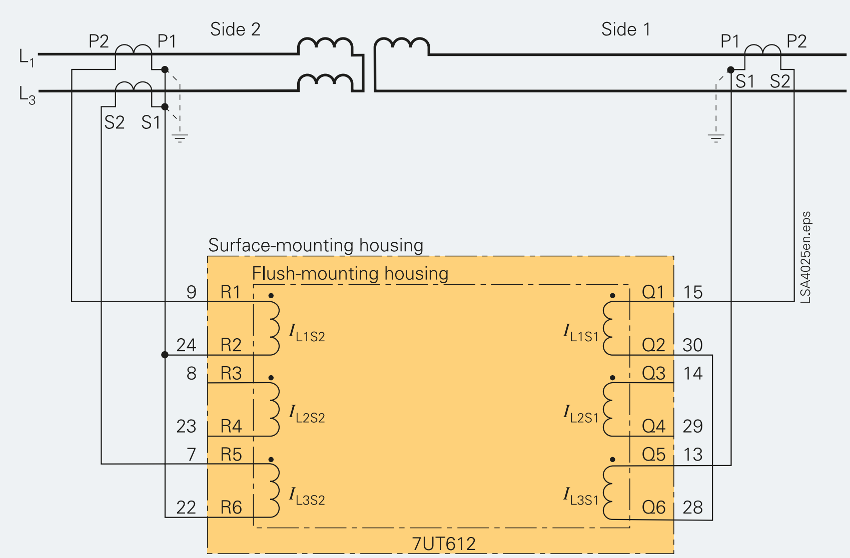

Fig. 8/23 Connection example to a single-phase power transformer with only one current transformer (right side)

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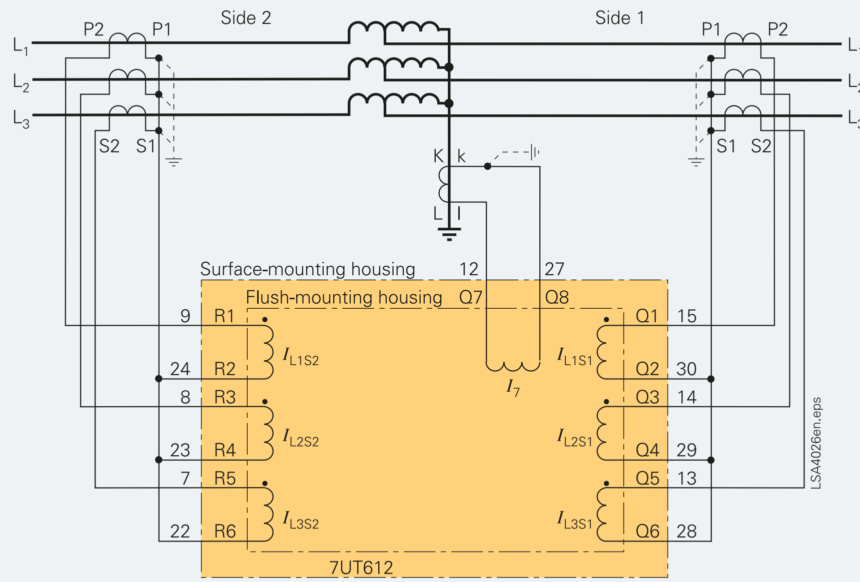

Fig. 8/24 Connection to a three-phase auto-transformer with current transformer between starpoint and grounding point

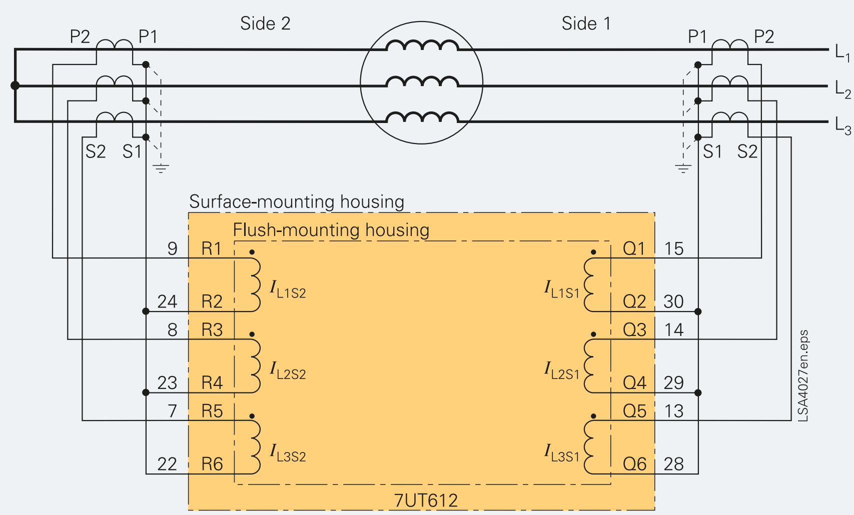

Fig. 8/25 Generator or motor protection

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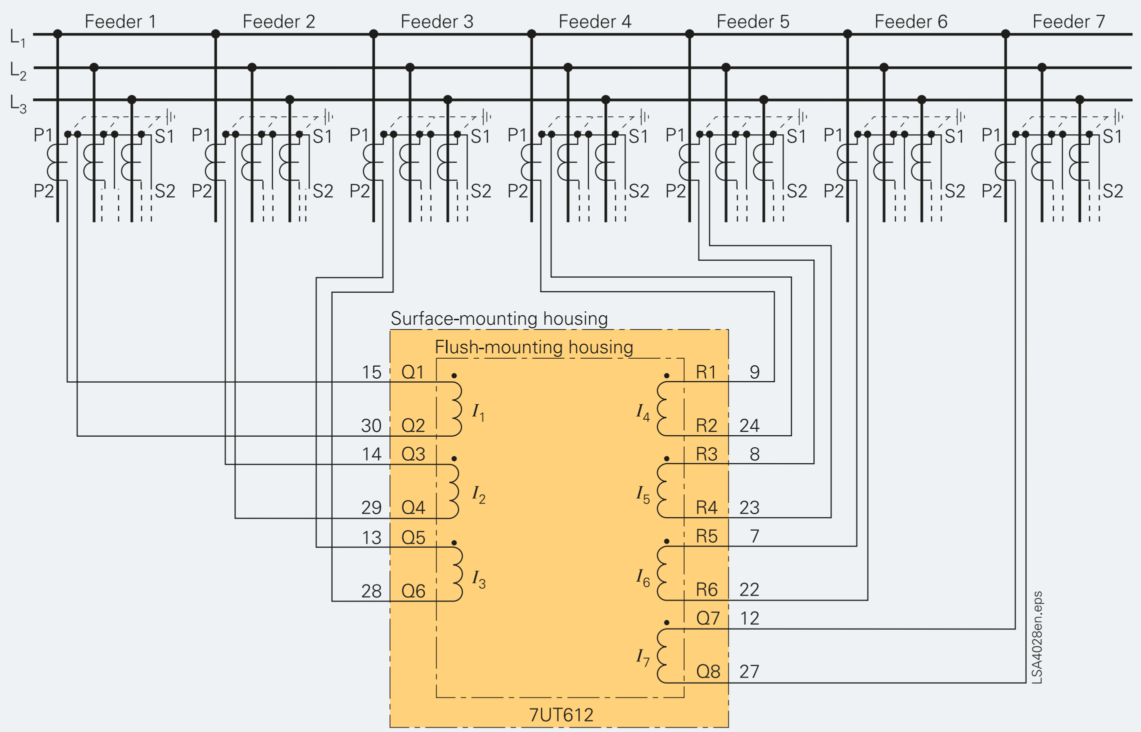

Fig. 8/26 Connection 7UT612 as single-phase busbar protection for 7 feeders, illustrated for phase L1

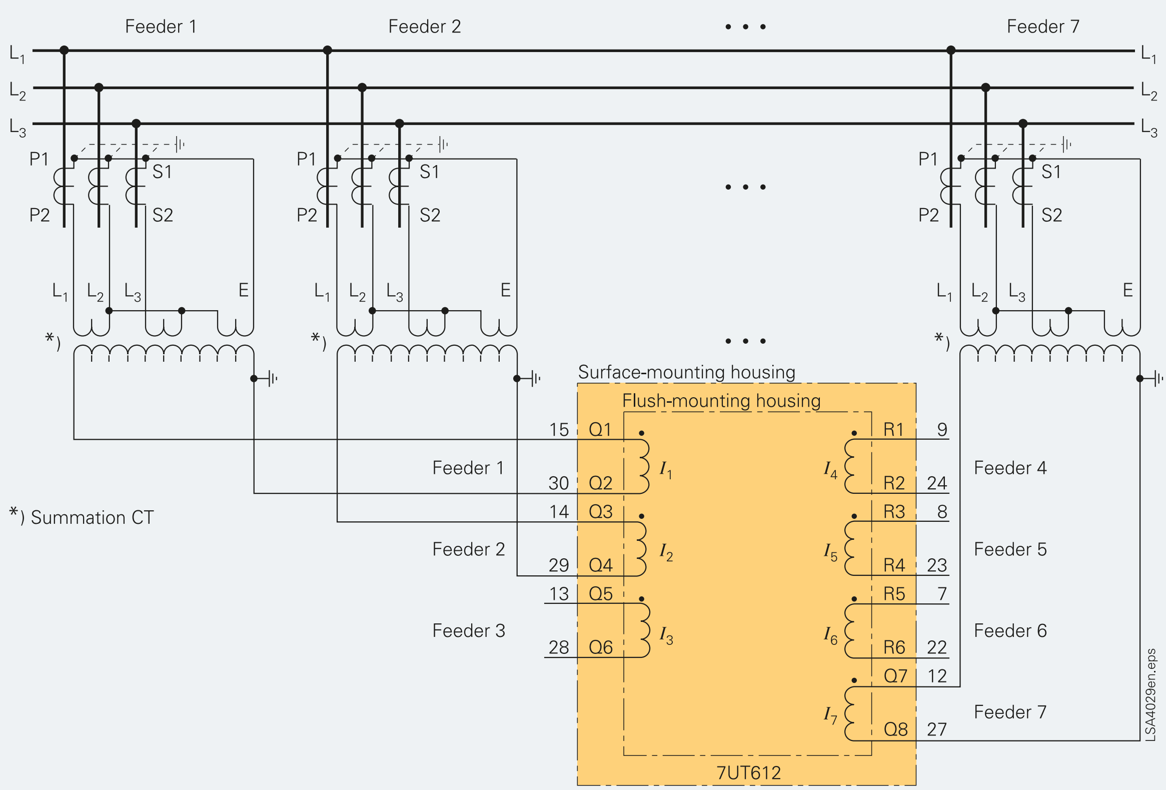

Fig. 8/27 Connection 7UT612 as busbar protection for feeders, connected via external summation current transformers (SCT) – partial illustration for feeders 1, 2 and 7

8

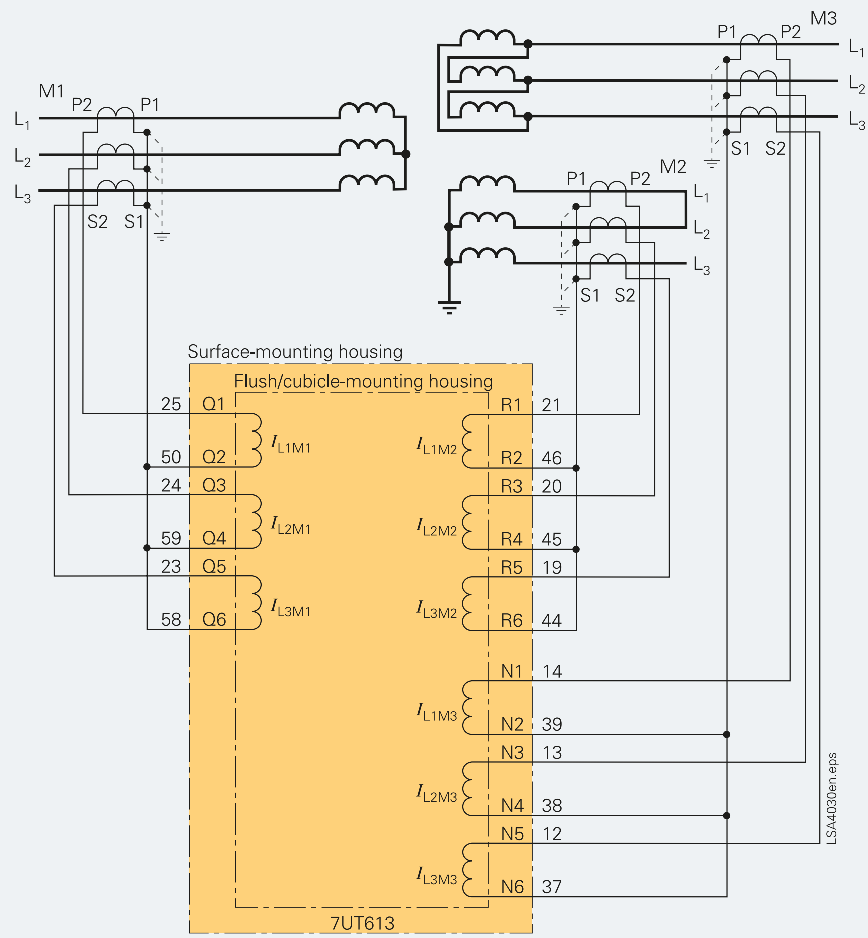

Fig. 8/28 Connection example 7UT613 for a three-winding power transformer

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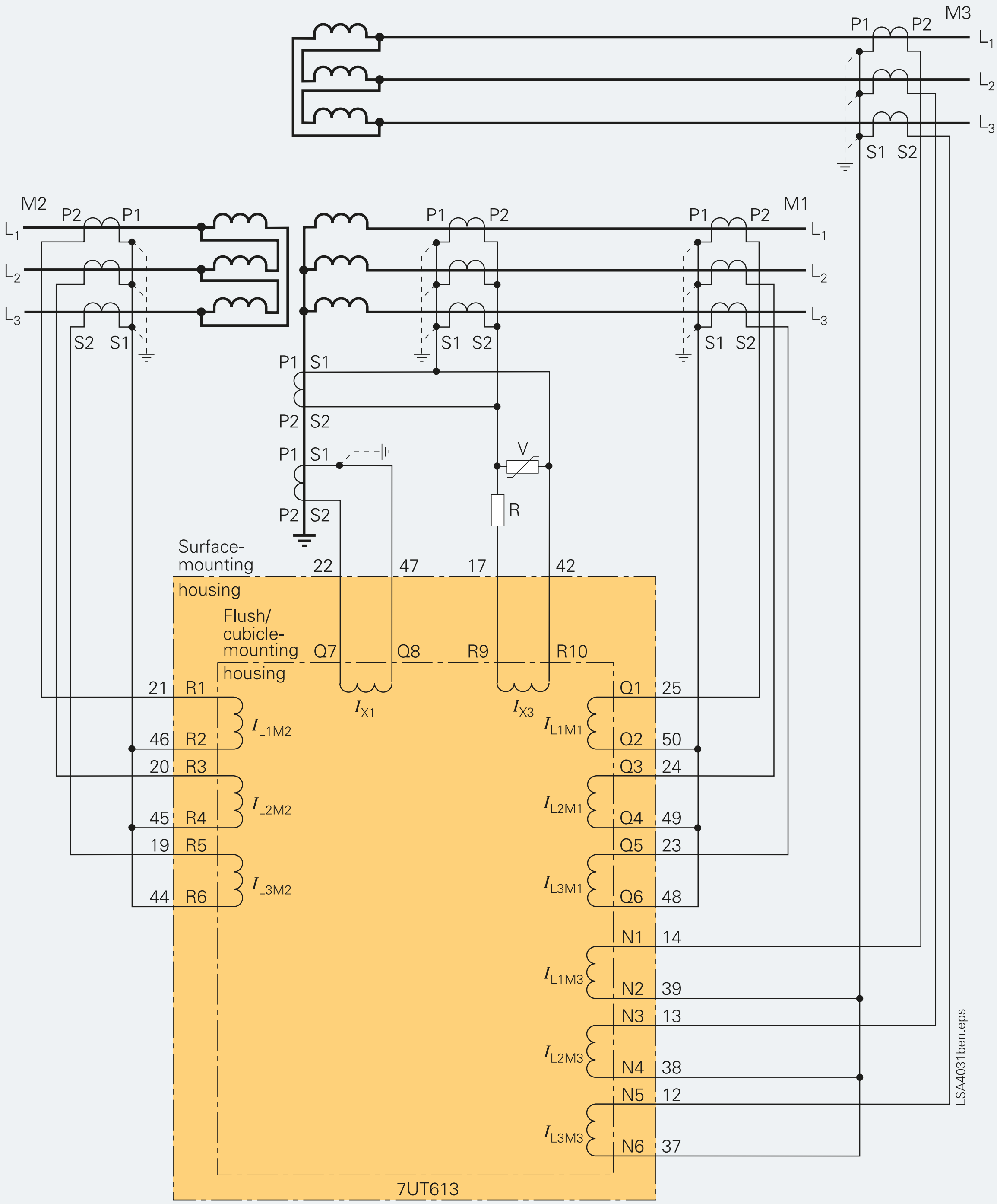


Fig. 8/29 Connection example 7UT613 for a three-winding power transformer with current transformers between starpoint and grounding point, additional connection for high-impedance protection; I_{X3} connected as high-sensitivity input

Typical connections

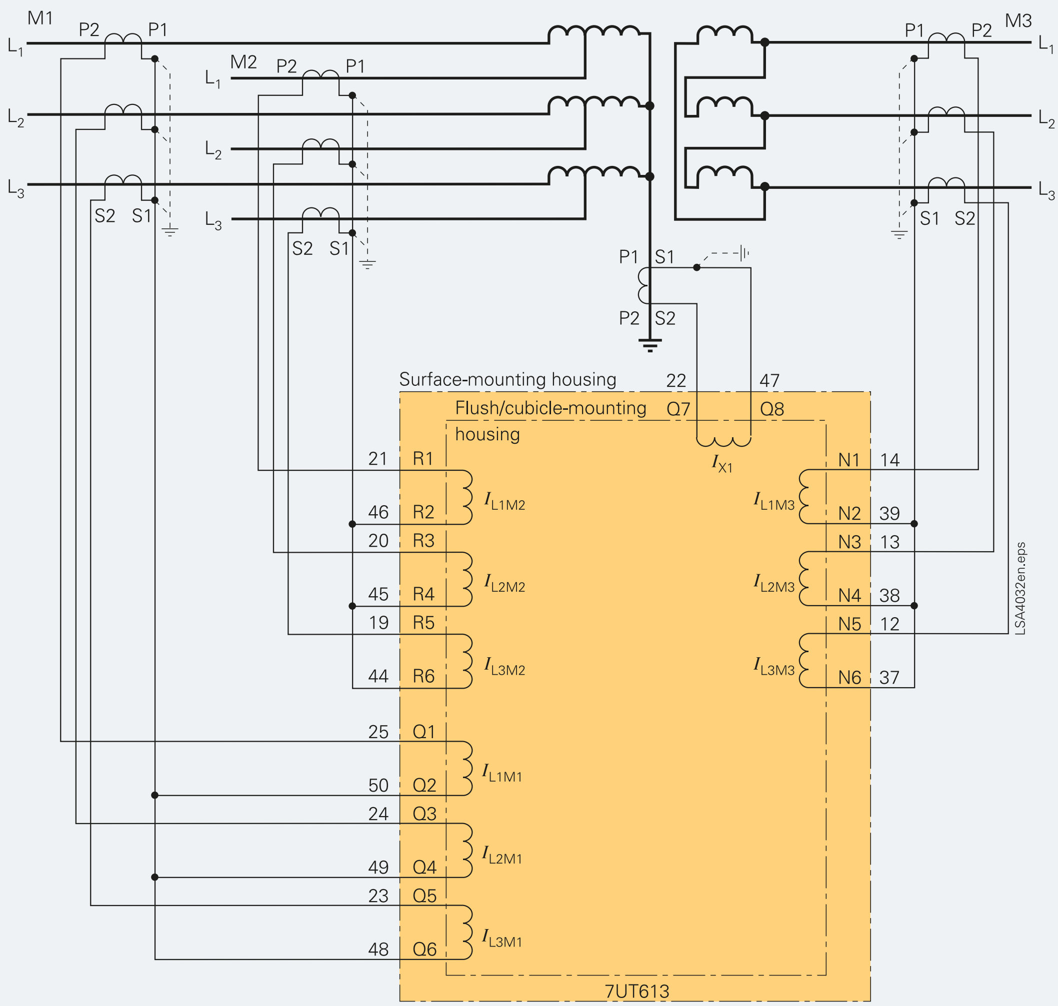


Fig. 8/30 Connection example 7UT613 for a three-phase auto-transformer with three-winding and current transformer between starpoint and grounding point

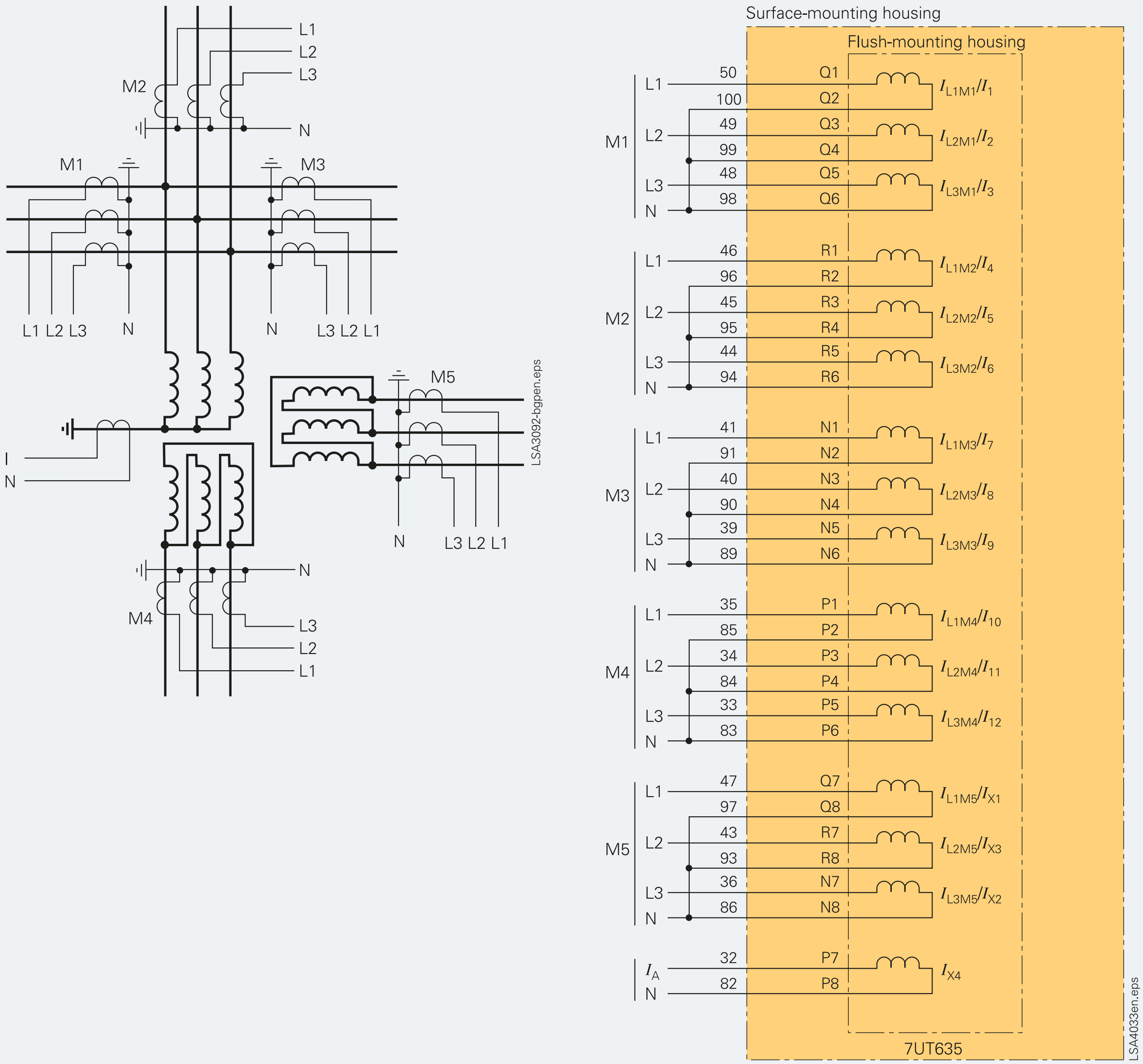


Fig. 8/31 Connection example 7UT635 for a three-winding power transformer with 5 measurement locations (3-phase) and neutral current measurement

8

Typical connections

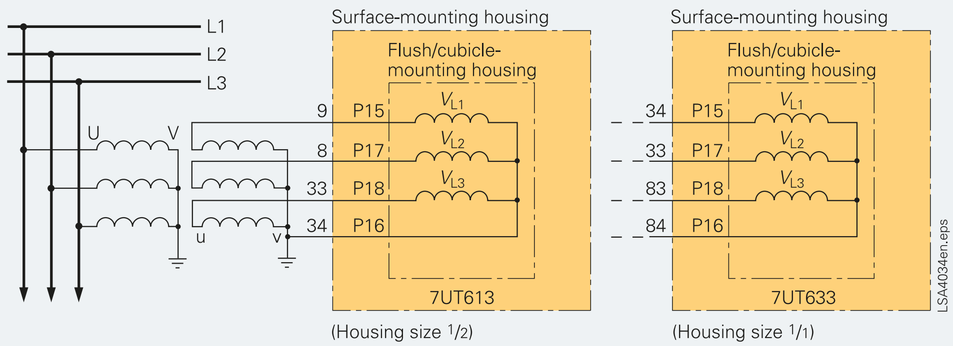


Fig. 8/32 Voltage transformer connection to 3 star-connected voltage transformers (7UT613 and 7UT633 only)

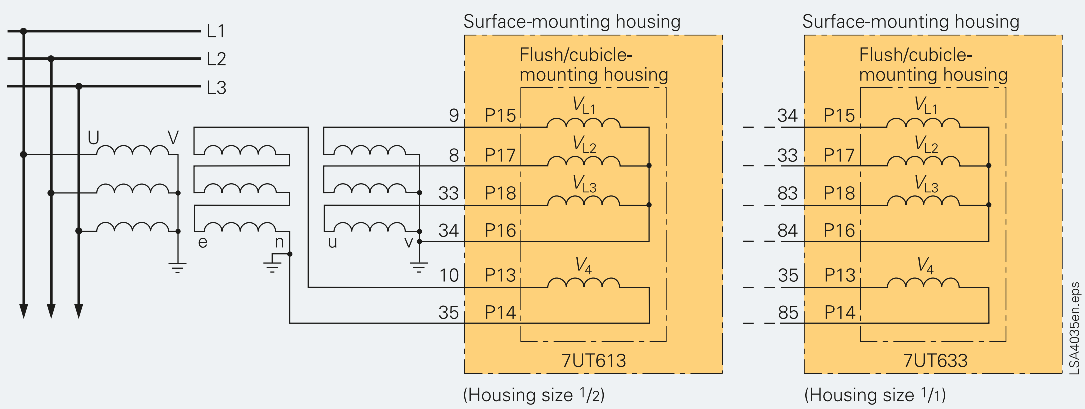


Fig. 8/33 Voltage transformer connection to 3 star-connected voltage transformers with additional delta winding (e-n-winding) (7UT613 and 7UT633 only)

8

General unit data				
Analog inputs				
Rated frequency	50 or 60 Hz (selectable)			
Rated current	0.1 or 1 or 5 A (selectable by jumper, 0.1 A)			
Power consumption In CT circuits	7UT 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 In CT circuits Thermal (r.m.s.)	I_N 100 I_N for 1 s 30 I_N for 10 s 4 I_N continuous			
Dynamic (peak value)	250 I_N (half cycle)			
In CT circuits for highly sensitive input I_{EE} Thermal Dynamic	 300 A for 1 s 100 A for 10 s 15 A continuous 750 A (half cycle)			
Rated voltage (7UT613/633 only) Power consumption per phase at 100 V	80 to 125 V ≤ 0.1 VA			
Overload capacity Thermal (r.m.s.)	 230 V continuous			
Auxiliary voltage				
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} ≥ 110 V	≥ 50 ms			
Binary inputs				
Functions are freely assignable				
Quantity marshallable	7UT 612	613	633	635
	3	5	21	29
Rated voltage range	24 to 250 V, bipolar			
Minimum pickup threshold 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			
Output relay				
Command / indication / alarm relay				
Quantity each with 1 NO contact	7UT 612	613	633	635
(marshallable) 1 alarm contact, with 1 NO or NC contact (not marshallable)	4	8	24	24

Switching capacity Make Break Break (with resistive load) Break (with L/R w 50 ms)	 1000 W / VA 30 VA 40 W 25 W			
Switching voltage	250 V			
Permissible total current	30 A for 0.5 seconds 5 A continuous			
Operating time, approx. NO contact NO/NC contact (selectable) Fast NO contact High-speed*) NO trip outputs	 8 ms 8 ms 5 ms < 1 ms			
LEDs				
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
Unit design				
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 in flush-mounting housing front rear	 IP 51 IP 51 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 Surface-mounting housing	 5.1 9.6	 8.7 13.5	 13.8 22.0	 14.5 22.7

Electrical tests	
Specifications	
Standards	IEC 60255 (Product standards) ANSI/IEEE C37.90.0/.1/.2 UL 508
Insulation tests	
Standards	EC 60255-5 and 60870-2-1
Voltage test (100 % test) All circuits except for auxiliary supply, binary inputs and communication interfaces	 2.5 kV (r.m.s.), 50 Hz / 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 Hz / 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

*) With high-speed contacts all operating times are reduced by 4.5 ms.

8

Technical data

Electrical tests (cont'd)	
EMC tests for interference immunity	
Standards	IEC 60255-6, 60255-22 (product standards) EN 6100-6-2 (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); 1 MHz; τ = 15 ms; 400 surges per s; test duration 2 s; R_i = 200 Ω
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
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
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
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
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 Ω; test duration 1 min
High-energy surge voltages (SURGE), IEC 61000-4-5, installation class III	Impulse: 1.2/50 ms
Auxiliary supply	Common (longitudinal) mode: 2kV; 12 Ω, 9 µF Differential (transversal) mode: 1kV; 2 Ω, 18 µF
Analog inputs, binary inputs, binary outputs	Common (longitude) mode: 2kV; 42 Ω, 0.5 µF Differential (transversal) mode: 1kV; 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
EMC tests for interference immunity (cont'd)	
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; τ = 15 µs; Damped wave; 400 surges per second; duration 2 s; R_i = 200 Ω
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 Ω
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 Ω
EMC tests for interference emission (type test)	
Standard	EN 50081-* (generic standard)
Conducted interference, only auxiliary supply IEC-CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strenght IEC-CISPR 22	30 to 1000 MHz Limit class B

Mechanical stress tests	
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
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 on each of the 3 axes in both directions

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 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; ondensation not permitted

Futher information can be found in the current manual at:
www.siemens.com/siprotec

8

Description	Order No.	Order code
7UT612 differential protection relay for transformers, generators, motors and busbars Housing ⅓ x 19"; 3 BI, 4 BO, 1 live status contact, 7 I, I_{EE}	7UT612□-□□□□□-□□A0	-□□□
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 V2)	2	
DC 60 to 125 V1), binary input threshold 19 V2)	4	
DC 110 to 250 V1), AC 115/230 V, binary input threshold 88 V2)	5	
DC 220 to 250 V1), AC 115/230 V, binary input threshold 176 V1,2,3)	6	
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 DP Slave, electrical RS485	9	L 0 A
PROFIBUS DP Slave, optical 820 nm, double loop, ST connector4)	9	L 0 B
MODBUS, electrical RS485	9	L 0 D
MODBUS, optical 820 nm, ST connector4)	9	L 0 E
DNP 3.0, electrical RS485	9	L 0 G
DNP 3.0, optical 820 nm, ST connector4)	9	L 0 H
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector (EN 100)	9	L 0 R
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector (EN 100)5)	9	L 0 S

see next page

1) With plug-in jumper one of the 2 voltage ranges can be selected

2) For each binary input one of 2 pick-up threshold ranges can be selected with plug-in jumper

3) Ordering option 6 only for V4.6 and higher

4) Not possible with surface mounting housing (position 9 = B). For the surface mounted version, please order a device with the appropriate electrical RS485 interface and accessories as stated in A.1under „External converters"

5) Cannot be delivered in connection with 9th digit = B.

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, electrical RS485	2	
DIGSI 4 / browser or temperature monitoring box, 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)[1]	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): $3I_0$>, $3I_0$>>, $3I_{0P}$ (inrush stabilization) Overcurrent-time protection ground (50G/51G): I_E>, I_E>>, I_{EP} (inrush stabilization)	A	
Differential protection + basic functions + additional 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) Only in connection with position 12 = 2 or 3

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 1), 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 220 to 250 V 1), AC 115/230 V, binary input threshold 176 V 1,2)	6	
Unit design		
Surface mounting housing with two-tier terminals, ½ x 19", 5 BI, 8 BO, 1 live status contact	B	
Flush mounting housing, ½ x 19", with plug-in terminals, 5 BI, 8 BO, 1 live status contact	D	
Flush mounting housing with screwed terminals, ½ x 19", 5 BI, 8 BO, 1 live status contact	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 DP Slave, electrical RS485	9	L 0 A
PROFIBUS DP Slave, optical 820 nm, double ring, ST connector 3)	9	L 0 B
MODBUS, electrical RS485	9	L 0 D
MODBUS, optical 820 nm, ST connector 4)	9	L 0 E
DNP 3.0, electrical RS485	9	L 0 G
DNP 3.0, optical 820 nm, ST connector 4)	9	L 0 H
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector	9	L 0 R
IEC 61850, 100 Mbit Etherent, optical, ST-connector 4)	9	L 0 S

1) One of the 2 voltage ranges can be selected with plug-in jumper

2) For each binary input one of 2 pick-up threshold ranges can be selected with plug-in jumper.

3) Not possible with surface mounting housing (position 9 = B). For the surface mounted version, please order a device with the appropriate electrical RS485 interface and accessories in accordance with A.1 under „External Converters"

4) Cannot be delivered in connection with 9th digit = B.

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[1)]		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)[2)]	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) In case of a connection to a RTD box 7XV5662-xAD10, a RS485-LWL converter 7XV5650-0xA00 is required.

2) Only in connection with position 12 = 2 or 9 and Mxx (supplementary)

8

Description	Order No.	Order code
7UT63□ differential protection relay for transformers, generators,motors and busbars, graphic display	7UT63□□-□□□□□-□□□□-□□□	
Housing, inputs and outputs		
Housing 1/1 x 19", 21 BI, 24 BO, 1 live status contact, 12 current inputs (11 I, I_{EE}); 4 voltage inputs (1 x 3-phase + 1 x 1-phase)	3	
Housing 1/1 x 19", 29 BI, 24 BO, 1 live status contact, 16 current inputs (14 I, 2 I_{EE})	5	
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 1), 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 220 to 250 V 1), AC 115/230 V, binary input threshold 176 V 2)	6	
Unit design		
Surface-mounting with two-tier terminals	B	
Flush-mounting with plug-in terminals	D	
Flush-mounting with screw-type terminals	E	
Surface-mounting with two-tier terminals, with 5 high-speed trip contacts	N	
Flush-mounting with plug-in terminals, with 5 high-speed trip contacts	P	
Flush-mounting with screw-type terminals, with 5 high-speed trip contacts	Q	
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 DP Slave, electrical RS485	9	L 0 A
PROFIBUS DP Slave, optical 820, double ring, ST connector 3)	9	L 0 B
MODBUS, electrical RS485	9	L 0 D
MODBUS, optical 820 nm, ST connector 4)	9	L 0 E
DNP 3.0, electrical RS485	9	L 0 G
DNP 3.0, optical 820 nm, ST connector 4)	9	L 0 H
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector (EN 100)	9	L 0 R
IEC 61850, 100 Mbit Ethernet, optical, LC-connector 4)	9	L 0 S

see next page

1) One of the 2 voltage ranges can be selected with plug-in jumper

2) For each binary input one of 2 pick-up threshold ranges can be selected with plug-in jumper

3) Not possible with surface mounting housing (position 9 = B). For the surface mounted version, please order a device with the appropriate electrical RS485 interface and accessories in accordance with A. under „External Converters“

4) Cannot be delivered in connection with 9th digit = B.

8

Selection and ordering data

Description	Order No.	Order code
7UT63□ differential protection relay **for transformers, generators,motors and busbars, graphic display**	7UT63□□-□□□□□-□□□□-□□□	
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[1)]		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. values, mean values, transformer monitoring functions (connection to thermo-box/hot spot, overload factor)[2)]	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 (only with 7UT633)		
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 (6FL)	C	
Additional functions (general)		
Without	0	
Multiple protection functions (50, 51, 50N/G, 87N, 50BF, 49)[3)]	1	
Flexible protection functions	2	
Multiple + flexible protection functions	3	

1) In case of a connection to a RTD box 7XV5662-xAD10, a RS485-LWL converter 7XV5650-0xA00 is required.

2) Only in connection with position 12 = 2 or 9 and Mxx (supplementary)

3) Available if selected on position 14.

8

Accessories

Description		Order No.
Connecting 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**
Cable between thermo-box and relay		
- length 5 m / 16.4 ft		**7XV5103-7AA05**
- length 25 m / 82 ft		**7XV5103-7AA25**
- length 50 m / 164 ft		**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	AC/DC 24 to 60 V	**7XV5662-2AD10**
RS485 interface	AC/DC 90 to 240 V	**7XV5662-5AD10**
Manual for 7UT6x		
English V4.6		**C53000-G1176-C230-2**
German V4.6		**C53000-G1100-C230-3**
Turkey V4.6		**C53000-G115A-C230-1**
Manual for 7UT612		
English		**C53000-G1176-C148-1**
Manual for 7UT6		
English V4.0		**C53000-G1176-C160-1**
English V4.6		**C53000-G1176-C160-2**

Accessories

Fig. 8/34 Mounting rail for 19" rack

Fig. 8/35
2-pin connector

Fig. 8/36
3-pin connector

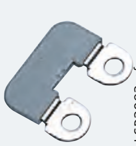


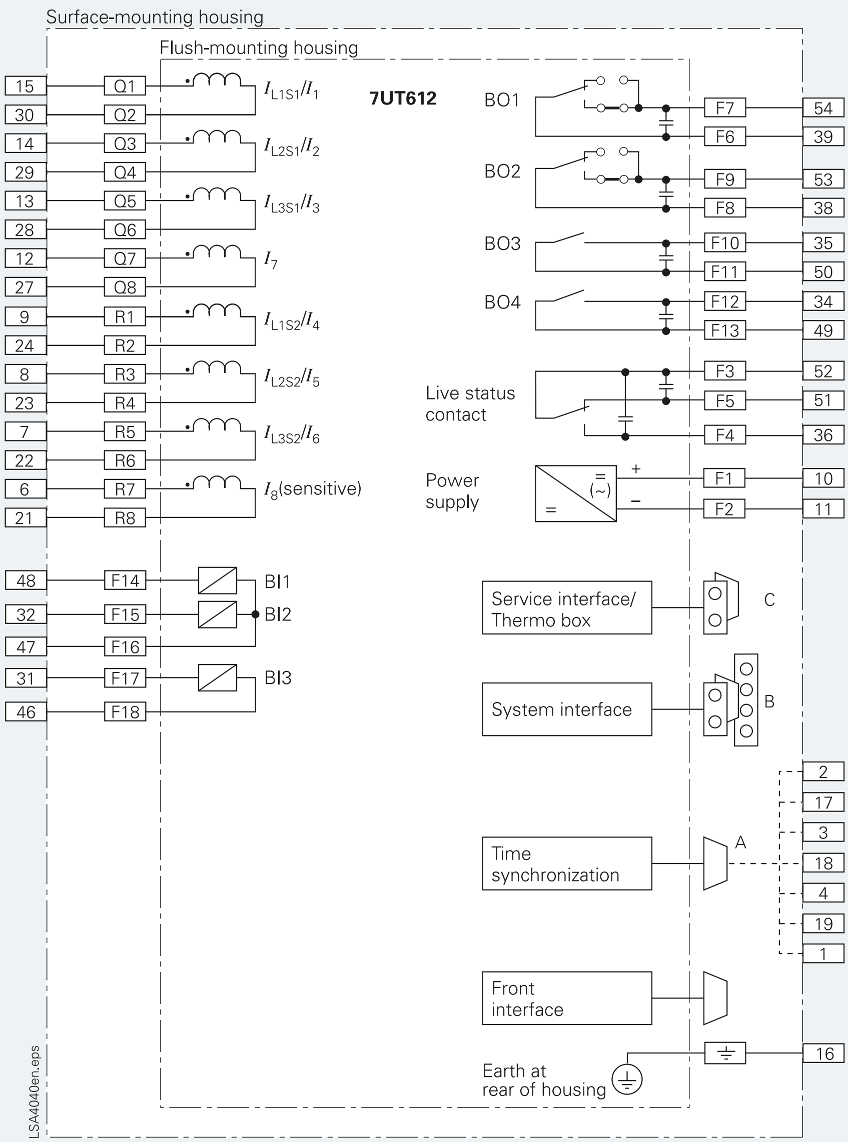
Fig. 8/37
Short-circuit link for current contacts

Fig. 8/38
Short-circuit link for voltage contacts/ indications contacts

Description		Order No.	Size of package	Supplier	Fig.
Connector	2-pin	**C73334-A1-C35-1**	1	Siemens	8/35
	3-pin	**C73334-A1-C36-1**	1	Siemens	8/36
Crimp connector	CI2 0.5 to 1 mm^2	**0-827039-1**	4000	1)	
		0-827396-1	1	1)	
	CI2 0.5 to 2.5 mm^2	**0-827040-1**	4000	1)	
		0-827397-1	1	1)	
	Type III+ 0.75 to 1.5 mm^2	**0-163083-7**	4000	1)	
		0-163084-2	1	1)	
Crimping tool	For type III+	**0-539635-1**	1	1)	
	and matching female	**0-539668-2**		1)	
	For CI2	**0-734372-1**	1	1)	
	and matching female	**1-734387-1**		1)	
19"-mounting rail		**C73165-A63-D200-1**	1	Siemens	8/34
Short-circuit links	For current terminals	**C73334-A1-C33-1**	1	Siemens	8/37
	For other terminals	**C73334-A1-C34-1**	1	Siemens	8/38
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.

Connection diagram



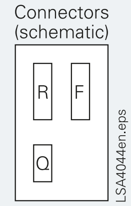
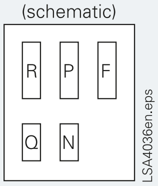


Fig. 8/39 Connection diagram



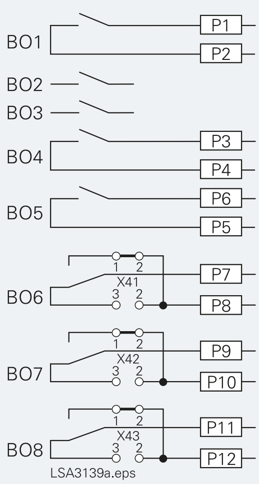
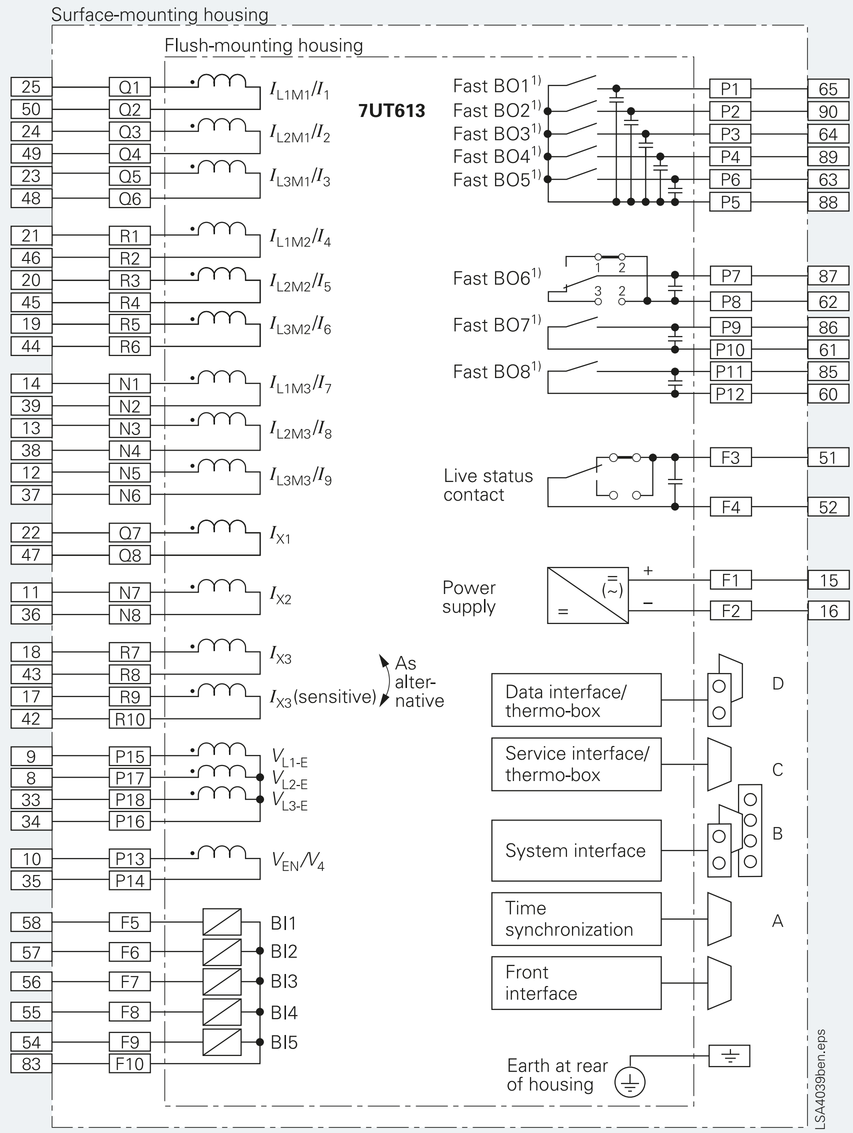


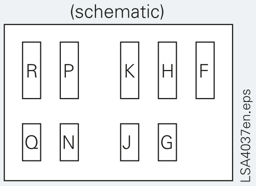
Fig. 8/40a
Additional setting by jumpers:
Separation of common circuit of fast BO1 to BO5 with jumpers X80, X81, X82. Switching of fast BO7, BO8 as NO contact or NC contact with jumpers X41, X42, X43.



1) Configuration of binary outputs up to hardware-version .../CC
For advanced flexibility see Fig. 8/40a.

Fig. 8/40 Connection diagram 7UT613

Connection diagram



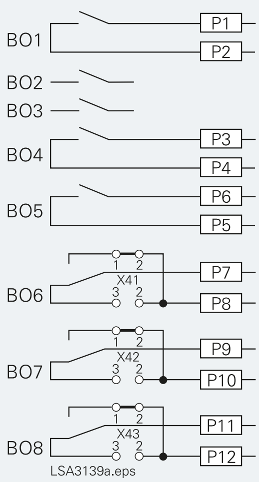
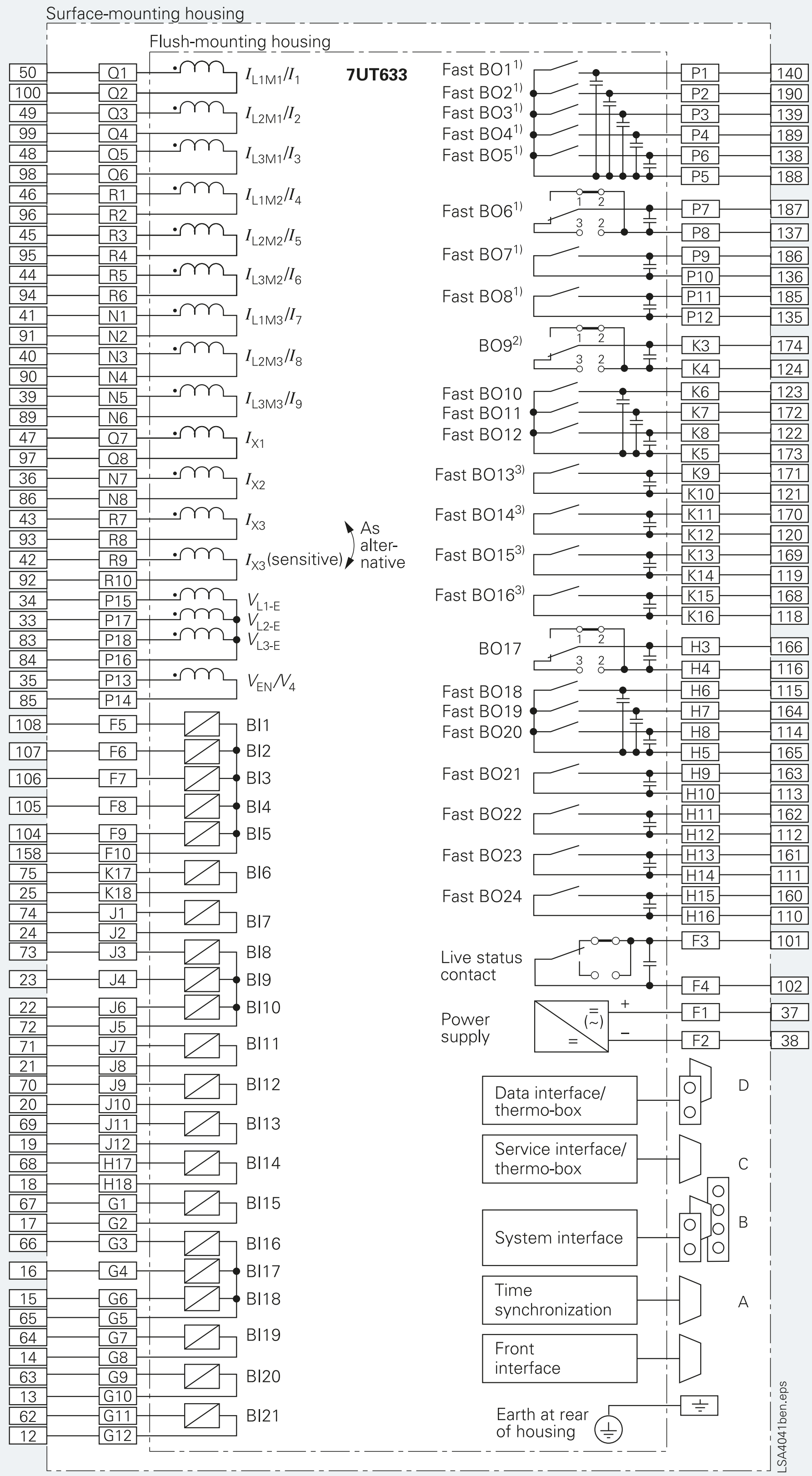
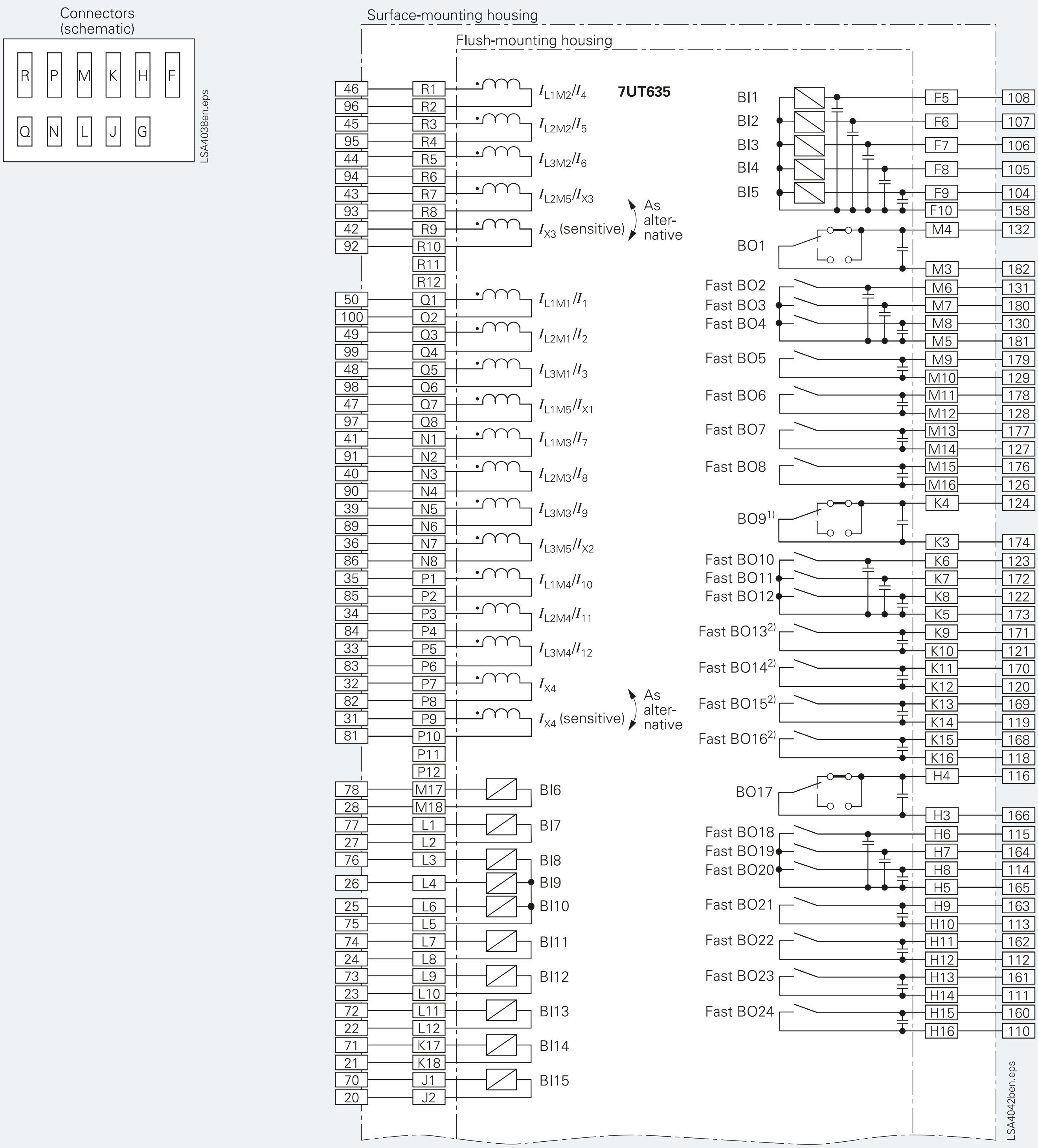


Fig. 8/41a
Additional setting by jumpers: Separation of common circuit of fast BO1 to BO5 with jumpers X80, X81, X82. Switching of fast BO7, BO8 as NO contact or NC contact with jumpers X41, X42, X43



1) Configuration of binary outputs up to hardware-version .../CC
For advanced flexibility see Fig. 8/41a.
2) High-speed contacts (option), NO only
3) High-speed contacts (option)

Fig. 8/41 Connection diagram 7UT63



1) High-speed contacts (option), NO only
2) High-speed contacts (option)

Fig. 8/42 Connection diagram 7UT635 part 1; continued on following page

Connection diagram

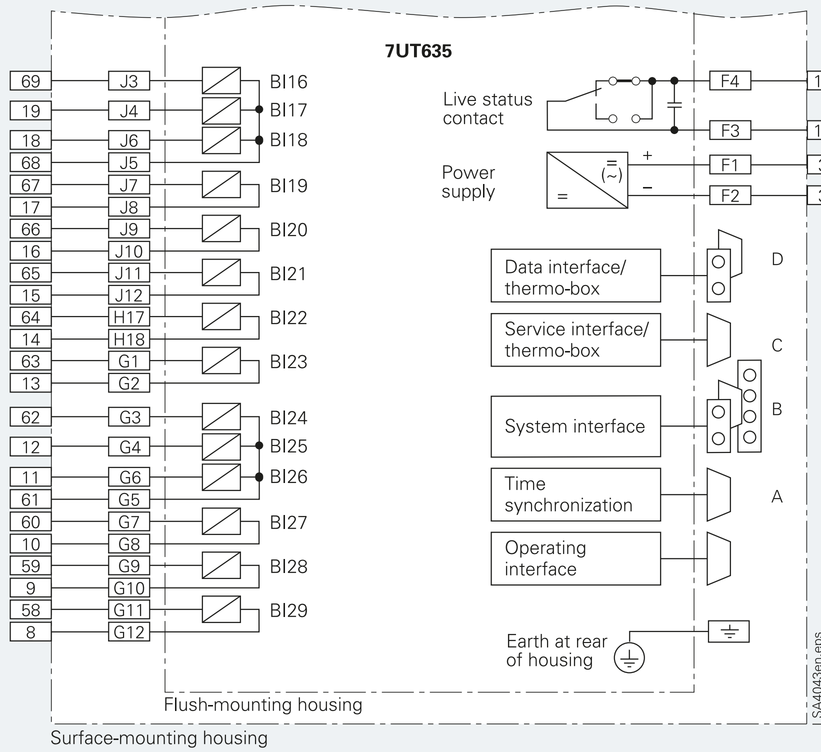


Fig. 8/43 Connection diagram 7UT635 part 2

Busbar Differential Protection

9

SIPROTEC 7SS52 distributed numerical busbar and breaker failure protection

Fig. 9/1 SIPROTEC 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.

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
- 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)

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

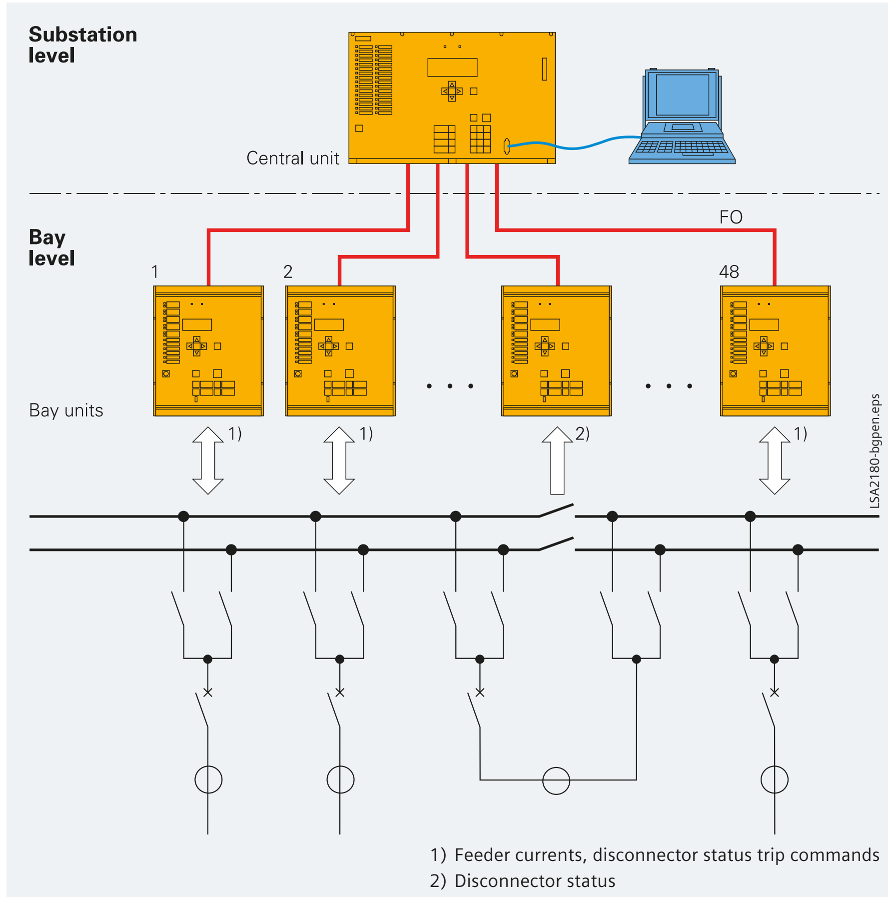


Fig. 9/2 Distributed system structure

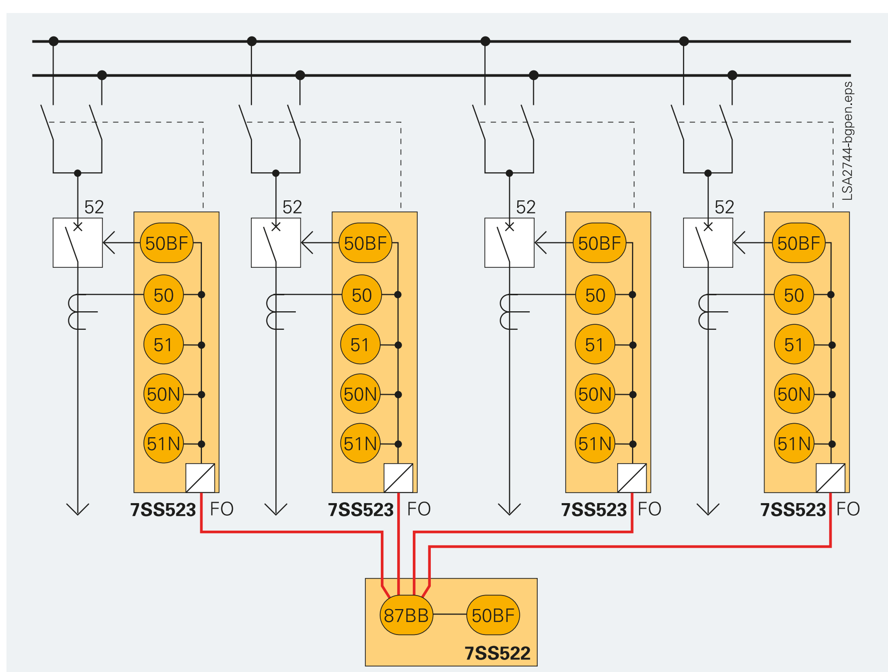


Fig. 9/3 Protection functions of the central unit and the bay units

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 disconnector 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. 9/4 7SS522 central unit – front view of SIPAC subrack version

Fig. 9/5 7SS522 central unit – rear view

Fig. 9/6 7SS523 bay unit – front view of panel / flush / cubicle mounting unit

Fig. 9/7 7SS525 bay unit – front view of panel/flush/cubicle mounting unit

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.

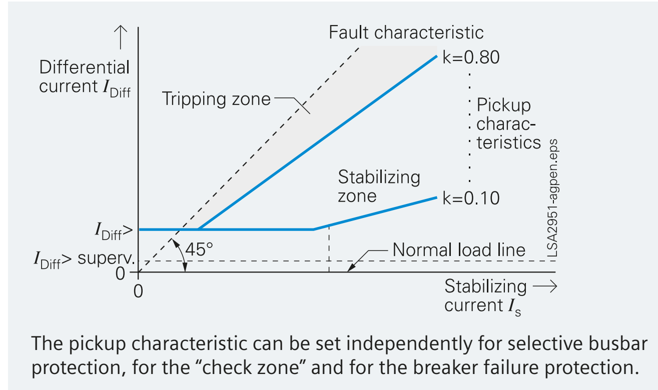


Fig. 9/8 Standard characteristic

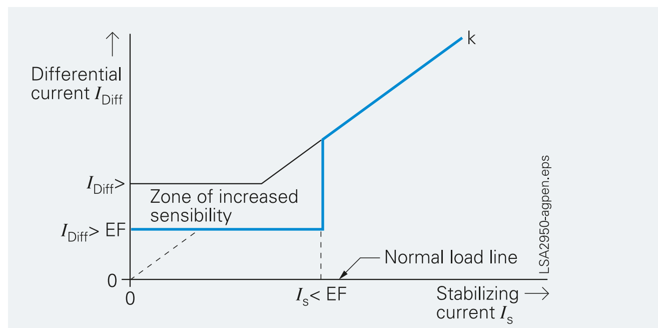


Fig. 9/9 Ground-fault characteristic

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.

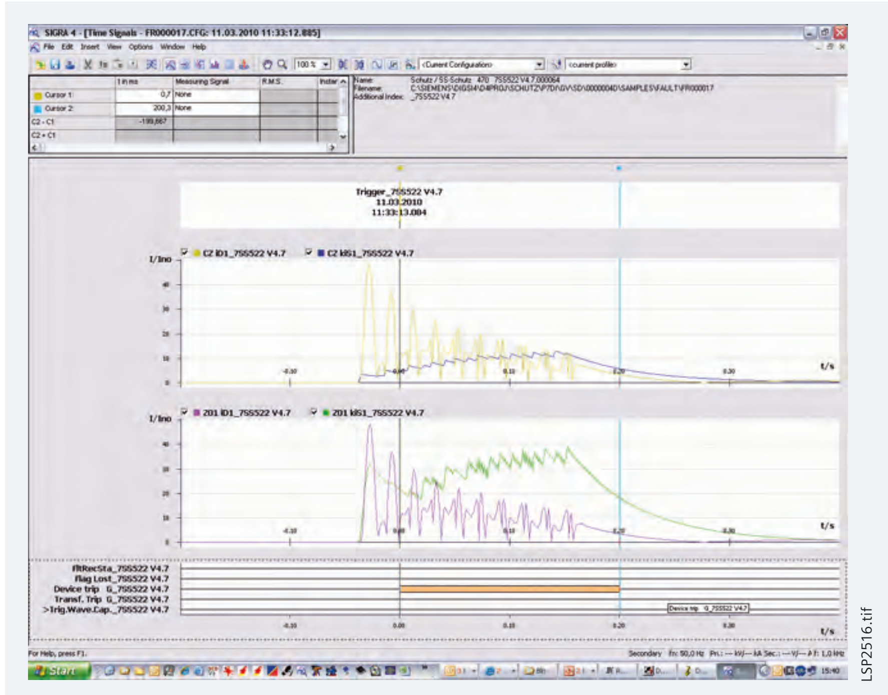


Fig. 9/10 Fault record

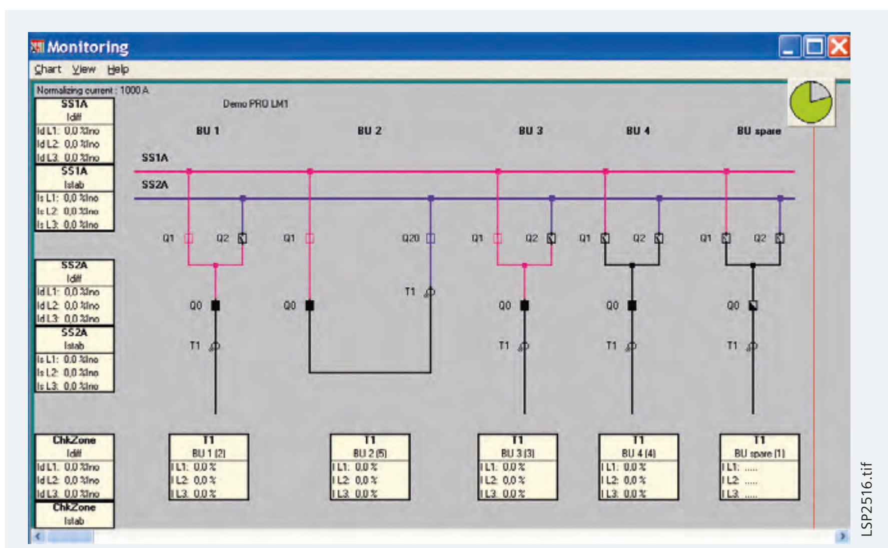


Fig. 9/11 DIGSI plant monitoring

Disconnector 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).
- Disconnector 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.

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

9

The bay units have marshallable binary inputs:

- Disconnector 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.
- Disconnector replica freezing (maintenance) with alarm indication ("Disconnector 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 disconnector switching, disconnector 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 disconnector 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 disconnector 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 modern
- 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.

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.

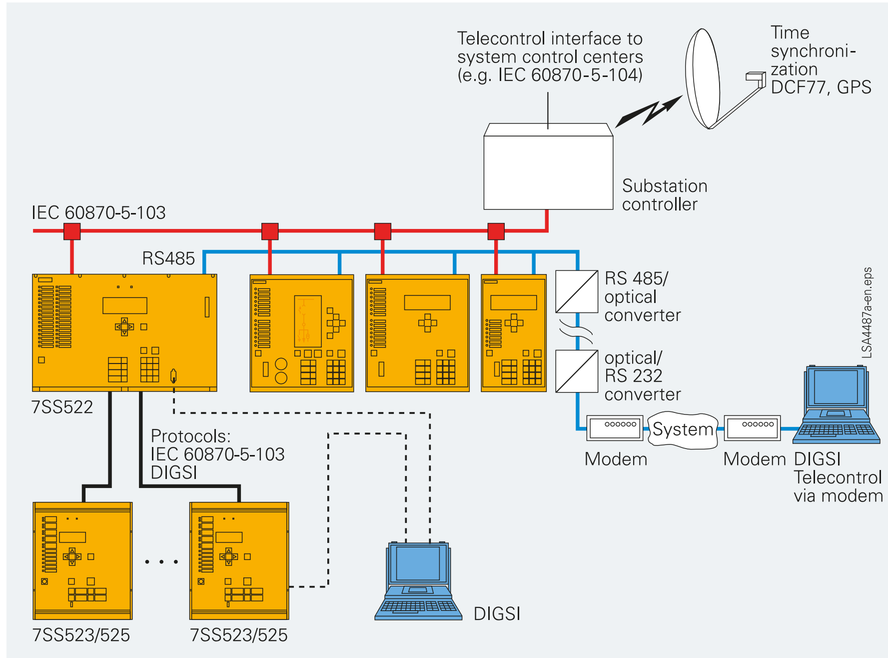


Fig. 9/12 Communication structure with DIGSI and IEC 60870-5-103

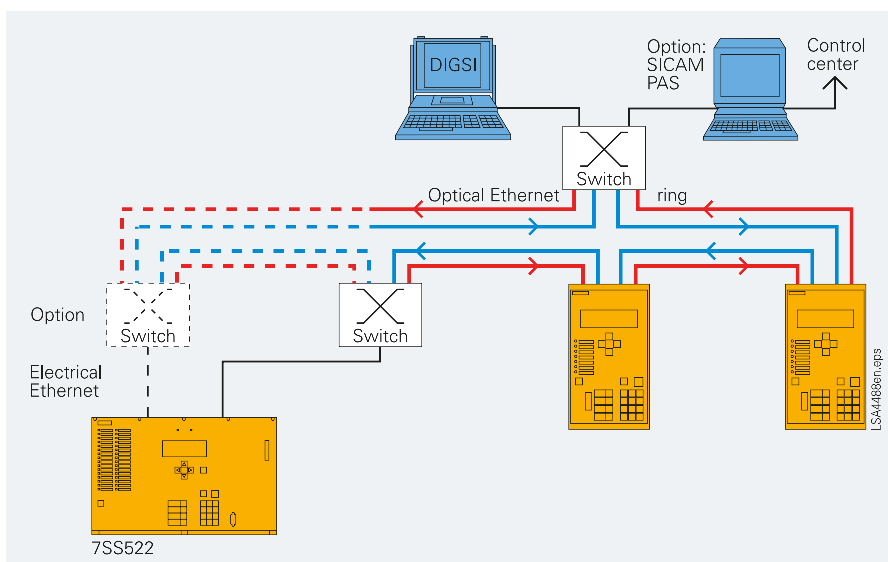


Fig. 9/13 Communication structure for station bus with Ethernet and IEC 61850, FO ring

9

General unit data			
Input circuits			
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	
Auxiliary voltage			
Rated auxiliary voltage V_{aux}	Central unit	DC 48 V to 250 V	
Rated auxiliary voltage V_{aux}	Bay unit	DC 48 V to 250 V	
Permissible tolerance V_{aux}		–20 to +20 %	
Maximum ripple		≤ 15 %	
Power consumption		Configuration dependent	
Central unit	Quiescent Energized	35 to 55 W < 70 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	
Binary inputs			
		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	
Alarm/event contacts			
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	
Command contacts			
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)	
Control, displays			
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	
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	

Technical data

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, τ = 15 µs, 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 Ω
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 Ω, 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!

Futher information can be found in the current manual at: www.siemens.com/siprotec

9

Description	Order No.	Order code
7SS522 distributed busbar/breaker failure protection	7SS52□0-□□□□□-□□A0-□□□	
Central unit		
Central unit 50/60 Hz	2	
Rated auxiliary voltage		
DC 48 to 250 V	6	
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 0 R
IEC 61850, 100 Mbit Ethernet, with integrated switch optical, double	9	L 0 S
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□□-□□A01-□AA1	
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		
DC 48 to 250 V	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	

9

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 0 1-□A A 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.
	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**

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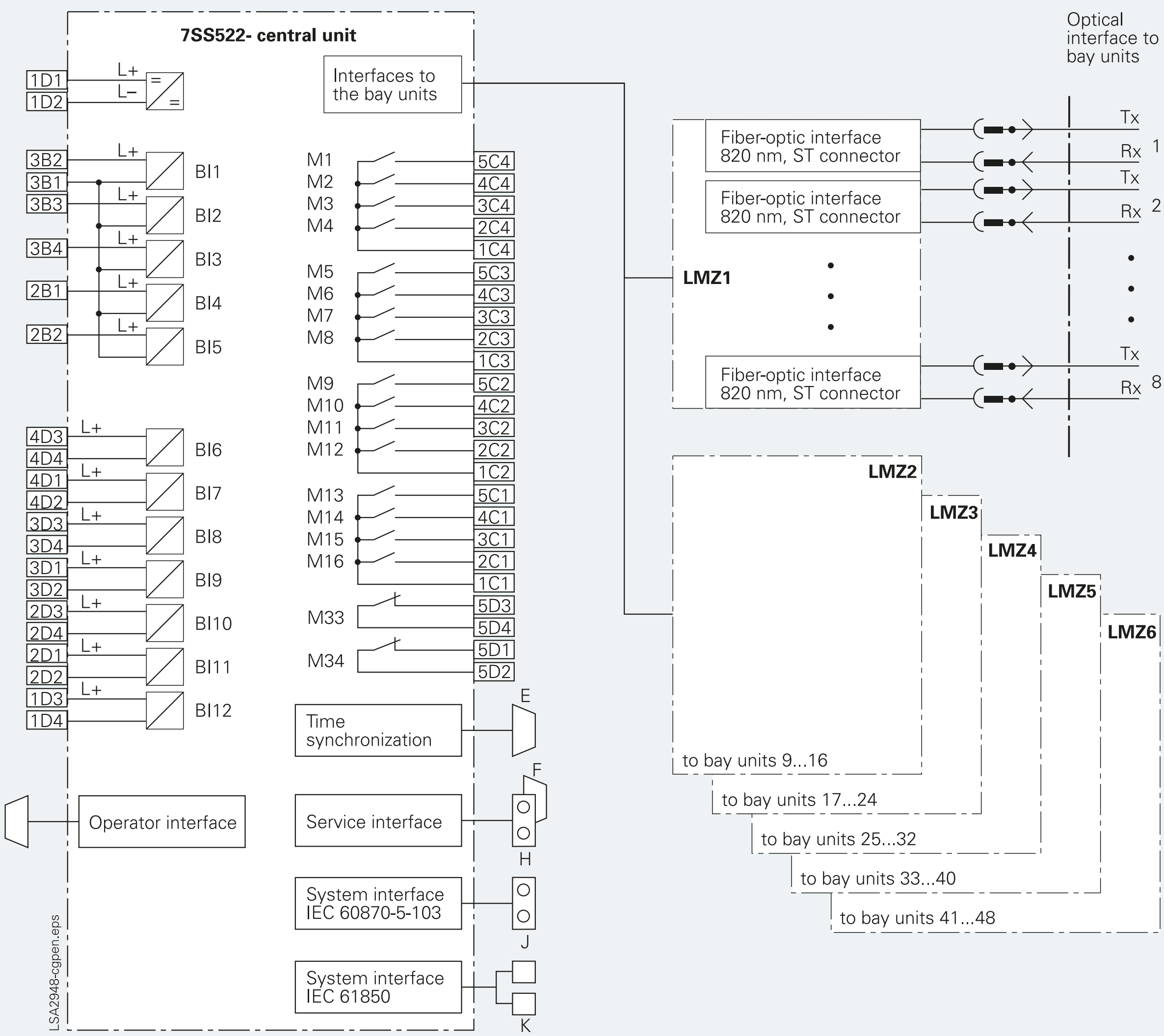


Fig. 9/14 Connection diagram 7SS522

Connection diagram

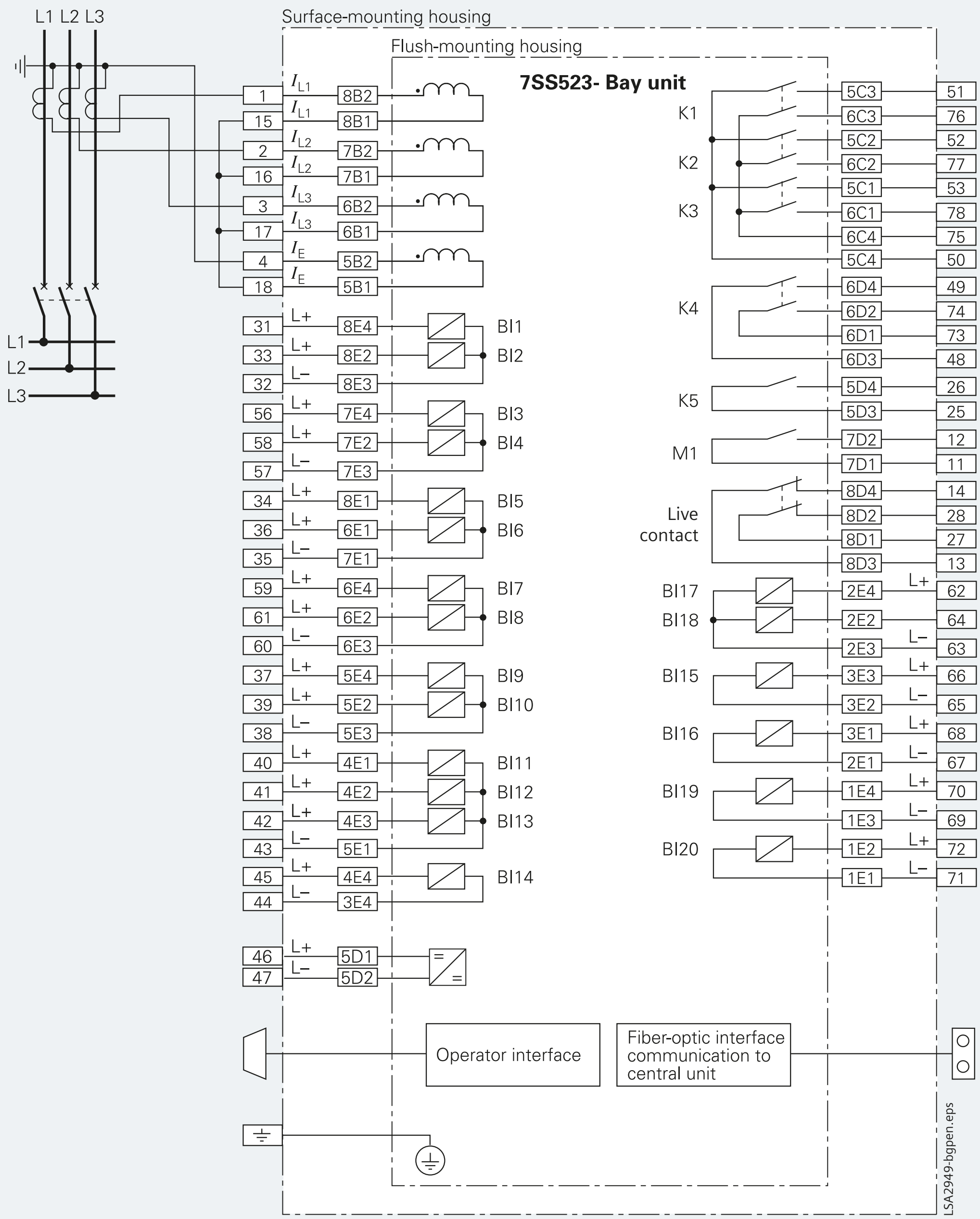


Fig. 9/15 Connection diagram 7SS523

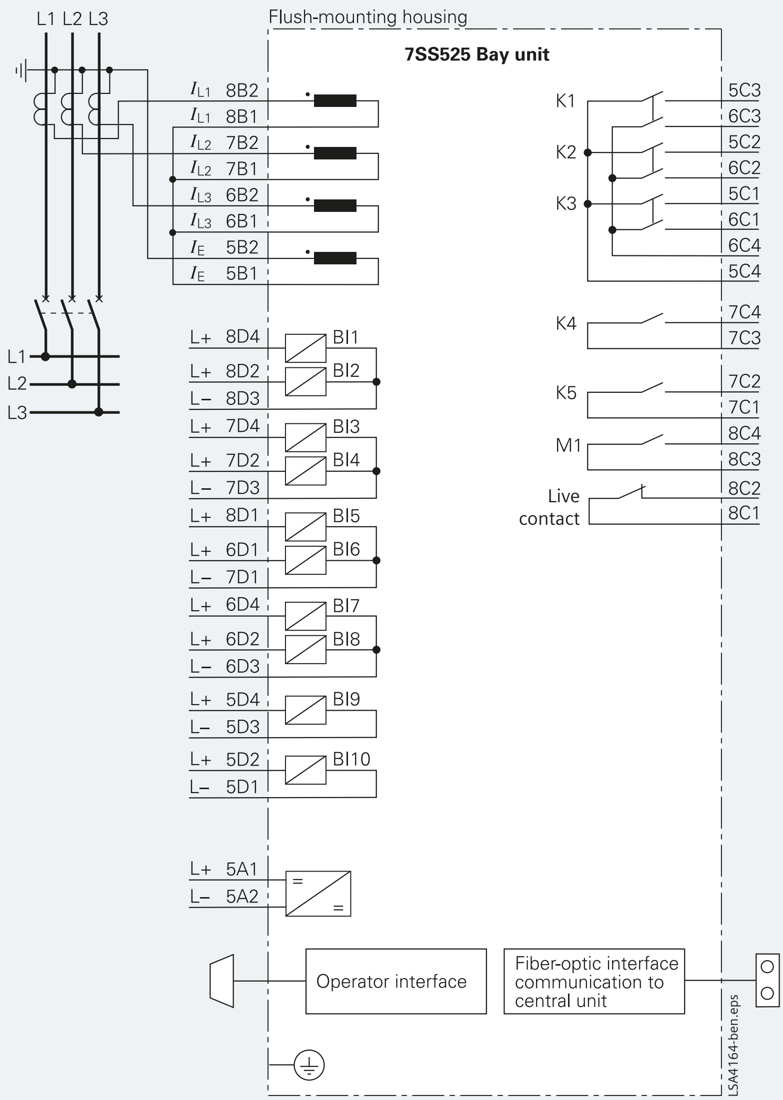


Fig. 9/16 Connection diagram 7SS525

Relays for Various Protection Applications

Page

10

SIPROTEC 7VK61 breaker management relay

Fig. 10/1 SIPROTEC 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

Communicatlon 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 DP
  – DNP 3
- Rear-side service/modem interface
- Time synchronization via
  – IRIG-B or DCF77 or system interface

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.

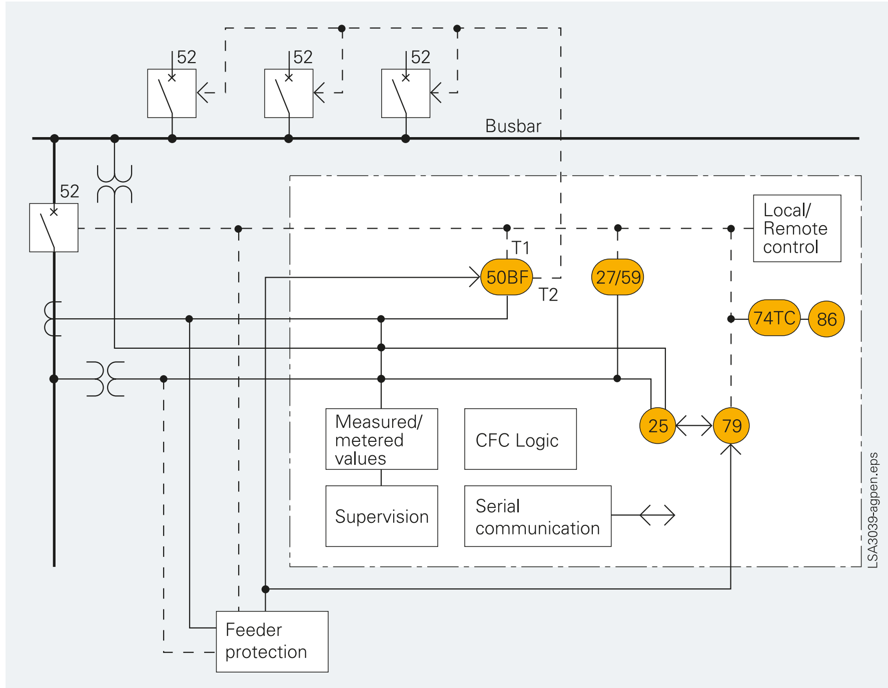


Fig. 10/2 Application and function diagram

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.

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	Overvoltage/undervoltage protection
25	Synchro-check
79	Auto-reclosure
74TC	Trip circuit supervision
86	Lockout (CLOSE command interlocking)

10

Construction

Connection technique and housing with many advantages

⅓ and ½-rack sizes are available as housing widths of the SIPROTEC 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

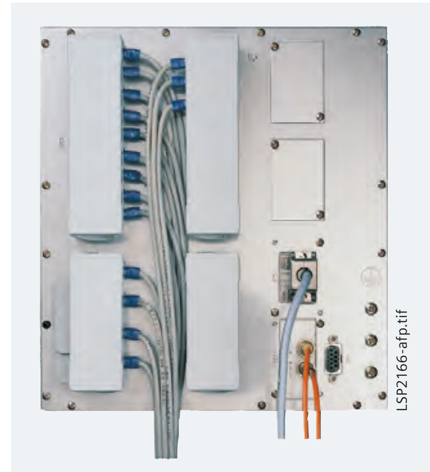


Fig. 10/4 Rear view of flush-mounting housing with covered connection terminals andwirings

Fig. 10/5 Surface-mounting housing with screw-type terminals, example 7SA63

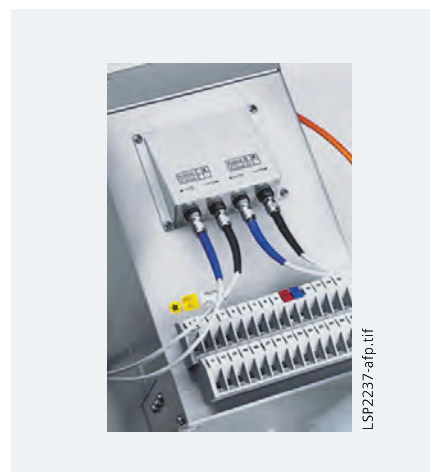


Fig. 10/6 Communication interfaces in a sloped case in a surface-mounting housing

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.

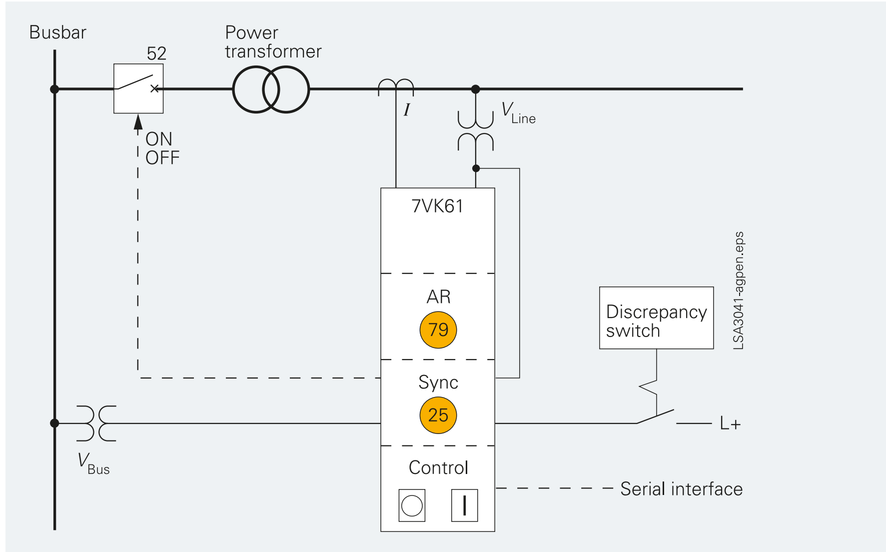


Fig. 10/7 Auto-reclosure and synchro-check with voltage measurement across a power transformer

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.

10

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.

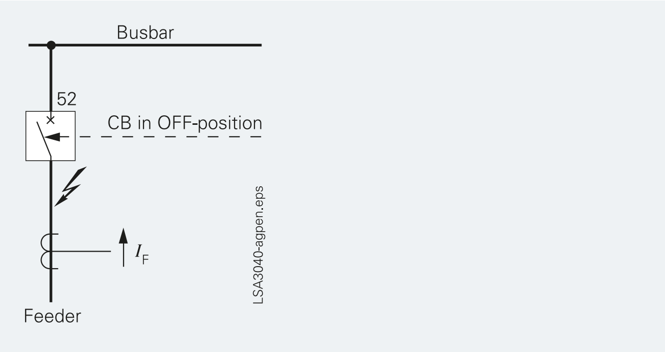


Fig. 10/8 End-fault between circuit-breaker and current transformer

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

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.

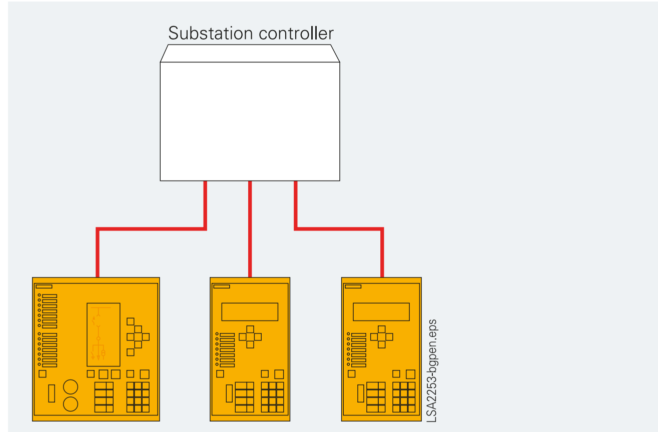


Fig. 10/9 IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

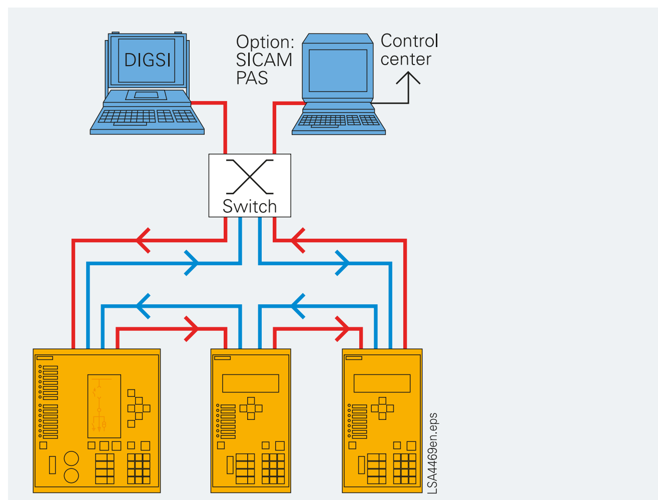


Fig. 10/10 Bus structure for station bus with Ethernet and IEC 61850 with fiber-optic ring

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 be 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 DP. 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.

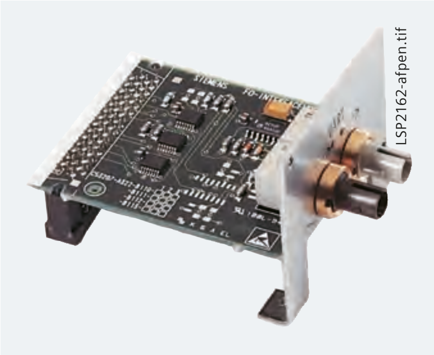


Fig. 10/11 820 nm fiber-optic communication module

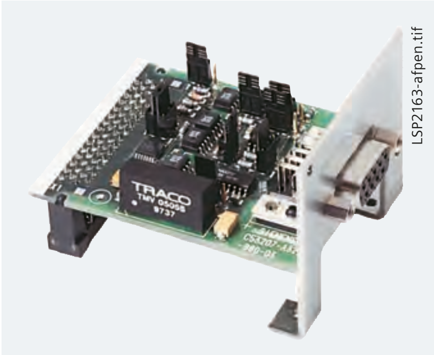


Fig. 10/12 RS232/RS485 electrical communication module

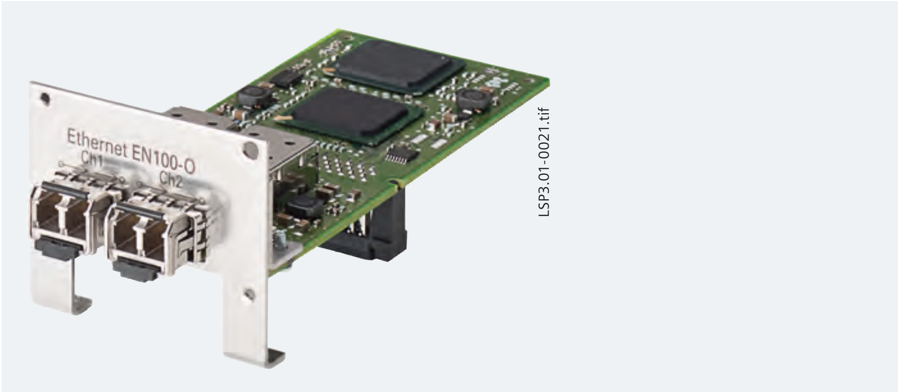


Fig. 10/13 Fiber-optic Ethernet communication module for IEC 61850 with integrated Ethernet switch

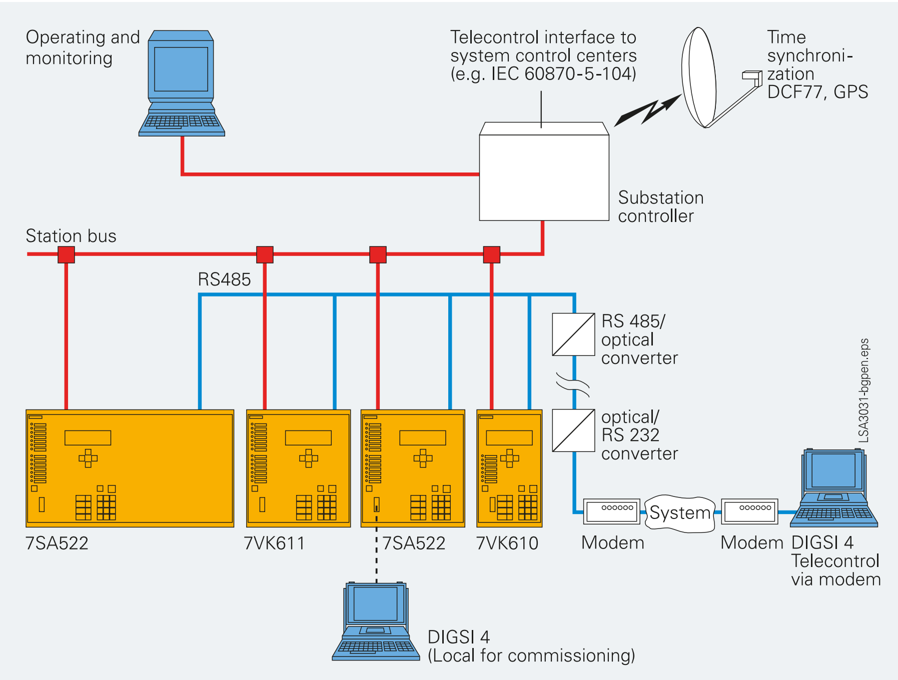


Fig. 10/14 Communication

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.

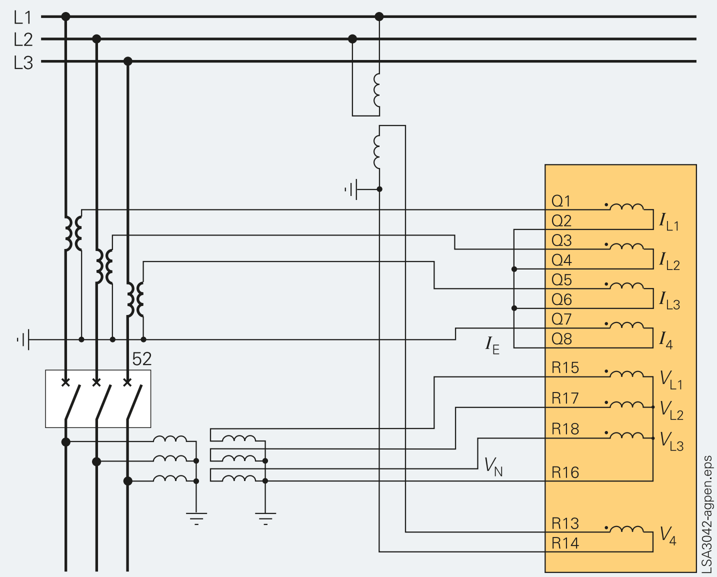


Fig. 10/15 Complete connection of all current and voltage transformers

Alternative: Connection for current transformers only

The connection for current transformers only provides breaker failure protection and current operational measured values.

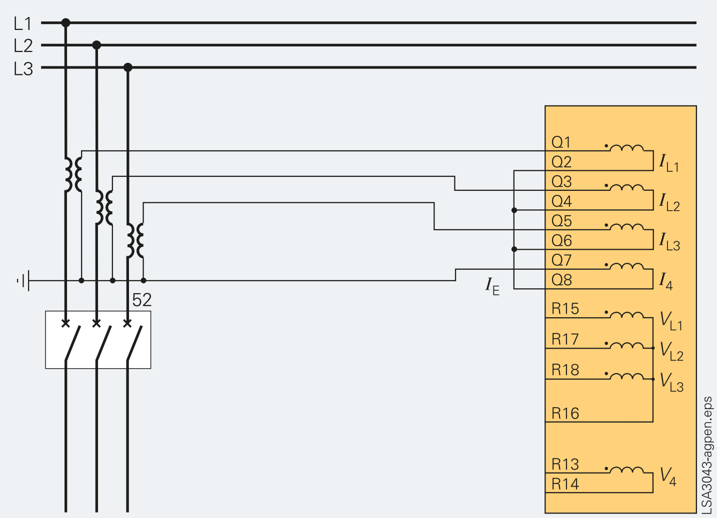


Fig. 10/16 Typical current transformer connection for breaker failure protection

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.

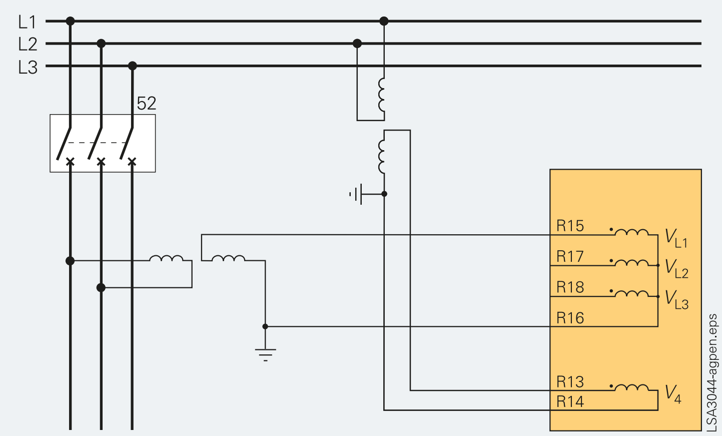


Fig. 10/17 Typical voltage transformer connection for synchro-check with single voltage dead line check

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 A With I_{nom} = 5 A Voltage inputs	 Approx. 0.05 VA Approx. 0.30 VA ≤ 0.10 VA
Overload capacity of current circuit Thermal (r.m.s.) Dynamic (peak value)	 500 A for 1 s 150 A for 10 s 20 A continuous 1250 A (half cycle)
Thermal overload capacity of voltage circuit	230 V continuous
Auxiliary voltage	
Rated voltages	DC 24, 48 V DC 60, 125 V DC 110, 250 V and AC 115, 230 V (50/60 Hz)
Permissible tolerance	-20 % to +20 %
Superimposed AC voltage (peak-to-peak)	≤ 15 %
Power consumption Quiescent Energized	 Approx. 5 W Approx. 8 W to 14 W, depending on design
Bridging time during failure of the auxiliary voltage For V_{aux} = 48 V and V_{aux} ≥ 110 V For V_{aux} = 24 V and V_{aux} = 60 V	 ≥ 50 ms ≥ 20 ms
Binary inputs	
Quantity 7VK610 7VK611	 7 20
Rated voltage range Pickup threshold	24 to 250 V, bipolar DC 19 or 88 V or 176 V, bipolar
Functions are freely assignable	
Minimum pickup voltage Ranges are settable by means of jumpers for each binary input	DC 19 or 88 V or 176 V, bipolar (3 operating ranges)
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

1) Can be set via jumpers.

Output contacts	
"Unit ready" contact (live status contact)	1 NC/NO contact[1)]
Command/indication relay	
Quantity 7VK610 7VK611	 5 NO contacts, 14 NO contacts, 4 NC/NO contacts[1)]
NO/NC contact	
Switching capacity Make Break, contacts Break, contacts (for resistive load) Break, contacts (for τ = L/R ≤ 50 ms)	 1000 W/VA 30 VA 40 W 25 VA
Switching voltage	250 V
Permissible total current	30 A for 0.5 seconds 5 A continuous
Operating time, approx. NO contact NO/NC contact (selectable) Fast NO contact	 8 ms 8 ms 5 ms
LEDs	
Quantity RUN (green) ERROR (red) LED (red), function can be assigned 7VK610 7VK611	 1 1 7 14
Unit design	
Housing	7XP20
Dimensions	Refer to part 14 for dimension drawings
Degree of protection acc. to EN 60529 Surface-mounting housing Flush-mounting housing Front Rear For the terminals	 IP 51 IP 51 IP 50 IP 20 with terminal cover put on
Weight Flush-mounting housing ⅓ x 19" ½ x 19" Surface-mounting housing ⅓ x 19" ½ x 19"	 5 kg 6 kg 9.5 kg 11 kg

10

Electrical tests	
Specifications	
Standards	IEC 60255 (product standards) IEEE C37.90.0/.1/.2 VDE 0435 For further standards see "Individual tests"
Insulation tests	
Standards	IEC 60255-5 and 60870-2-1
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
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 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 in intervals of 5 s
EMC tests for noise immunity; type tests	
Standards	IEC 60255-6; IEC 60255-22 (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 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
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
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
Irradiation with HF field, IEC 60255-22-31, IEC 61000-4-3	Class III, 10 V/m
Amplitude-modulated	80; 160; 450; 900 MHz; 80 % AM 1kHz; duration >10 s
Pulse-modulated	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 Ω; test duration 1 min

1) Conversion with external OLM
Fiber-optic interface please complete order number at 11th position with **9** and Order Code **L0A** (DP RS485) or **9** and Order Code **L0G** (DNP 3.0) and additionally a suitable external repeater.

EMC tests for noise immunity; type tests	
High-energy surge voltages (SURGE), IEC 61000-4-5 installation class III	Impulse: 1.2/50 µs
Auxiliary supply	Common (longitudinal) mode: 2 kV; 12 Ω; 9 µF Differential (transversal) mode: 1 kV; 2 Ω; 18 µF
Measurement inputs, binary inputs,	Common (longitudinal) mode: 2 kV; 42 Ω; 0.5 µF
binary output relays	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, IEEE C37.90.1	2.5 kV (peak); 1 MHz; τ = 50 µs; 400 surges per second, duration 2 s, R_i = 200 Ω
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
Radiated electromagnetic interference 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 Ω
EMC tests for interference emission; type tests	
Standard	EN 61000-6-3 (generic standard)
Conducted interference voltage on 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	
Vibration, shock stress and seismic vibration	
<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 on each of the 3 axes in both directions

Vibration, shock stress and seismic vibration (continued)	
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 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	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	
Standard	IEC 60255-6
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 (Legibility of display may be impaired above +55 °C / +131 °F)	-20 °C to +70 °C / -4 °F to +158 °F
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 proounced temperature changes that could cause condensation.	Annual average on ≤ 75 % relative humidity; on 56 days per year up t o 93 % relative humidity; condensation is not permitted.

Futher information can be found in the current manual at: www.siemens.com/siprotec

10

Selection and ordering data

Description	Order No.	Order code
7VK61 breaker management relay	7VK61□□-□□□□□-4Y□0	-□□□
Housing, binary inputs (BI) and outputs (BO)		
Housing ⅓ 19", 7 BI, 6 BO incl. 1 live-status contact,	0	
Housing ½ 19", 20 BI, 19 BO incl. 1 live-status contact	1	
Measuring inputs (4 x V, 4 x I)		
I_{ph} = 1 A, I_e = 1 A (min. = 0.05 A)1)	1	
I_{ph} = 5 A, I_e = 5 A (min. = 0.25 A)1)	5	
Rated auxiliary voltage (power supply, threshold of binary inputs)		
DC 24 to 48 V, binary input threshold 19 V3)	2	
DC 60 to 125 V 2), binary input threshold 19 V3)	4	
DC 110 to 250 V 2), AC 115 to 230 V, binary input threshold 88 V3)	5	
DC 220 to 250 V 2), AC 115 to 230 V, binary input threshold 176 V3)	6	
Unit version		
For panel flush mounting	A	
For panel surface mounting	E	
Region-specific default settings / language settings and functions versions		
Region DE, language: German, selectable	A	
Region World, language: English, selectable	B	
Region US, language:US-English, selectable	C	
Region FR, language: French, selectable	D	
Region World, language: Spanish, selectable	E	
Region World, language: Italian, selectable	F	
Port B system interface		
Empty	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, RS485	9	L 0 A
PROFIBUS DP Slave, optical 820 nm, double ring, ST connector 4)	9	L 0 B
DNP 3.0, RS485	9	L 0 G
DNP 3.0, optical 820 nm, ST connector 4)	9	L 0 H
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector	9	L 0 R
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector 5)	9	L 0 S
Port C service interface		
DIGSI 4 / modem, electrical RS232	1	
DIGSI 4 / modem, electrical RS485	2	

Functions

Breaker failure protection 1-/3-pole or 3-pole only	Auto-reclosure 1-/3-pole or 3-pole only and synchro-check	Over/Undervoltage protection	Order No.
■			C
■		■	D
	■		N
	■	■	P
■	■		Q
■	■	■	R

1) Rated current can be selected by means of jumpers.

2) Transition between the 3 auxiliary ranges can be selected by means of jumpers.

3) The binary input thresholds are selectable in 3 steps by means of jumpers.

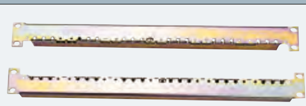
4) Optical interfaces are not available with surface mounting housings (position **9** = E). Please order the version with RS485 interface and a separate electrical/optical converter.

5) For surface-mounting housing applications please order the relay with electrical Ethernet interface and use a separate fiber-optic switch.

10

Selection and ordering data

Accessories	Description	Order No.
	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**



LSP2289-afp.eps

Fig. 10/18 Mounting rail for 19" rack

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Fig. 10/19 2-pin connector

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Fig. 10/20 3-pin connector

LSP2093-afp.eps

Fig. 10/21 Short-circuit link for current contacts

LSP2092-afp.eps

Fig. 10/22 Short-circuit link for voltage contacts/ indications contacts

Description		Order No.	Size of package	Supplier	Fig.
Connector	2-pin	**C73334-A1-C35-1**	1	Siemens	10/19
	3-pin	**C73334-A1-C36-1**	1	Siemens	10/20
Crimp connector	CI2 0.5 to 1 mm^2	**0-827039-1**	4000	1)	
		0-827396-1	1	1)	
	CI2 0.5 to 2.5 mm^2	**0-827040-1**	4000	1)	
		0-827397-1	1	1)	
	Type III+ 0.75 to 1.5 mm^2	**0-163084-7**	4000	1)	
		0-163083-2	1	1)	
Crimping tool	For type III+	**0-539635-1**	1	1)	
	and matching female	**0-539668-2**		1)	
	for CI2	**0-734372-1**	1	1)	
	and matching female	**1-734387-1**		1)	
19"-mounting rail		**C73165-A63-D200-1**	1	Siemens	10/18
Short-circuit links	For current terminals	**C73334-A1-C33-1**	1	Siemens	10/21
	For other terminals	**C73334-A1-C34-1**	1	Siemens	10/22
Safety cover for terminals	large	**C73334-A1-C31-1**	1	Siemens	10/4
	small	**C73334-A1-C32-1**	1	Siemens	10/4

1) Your local Siemens representative can inform you on local suppliers.

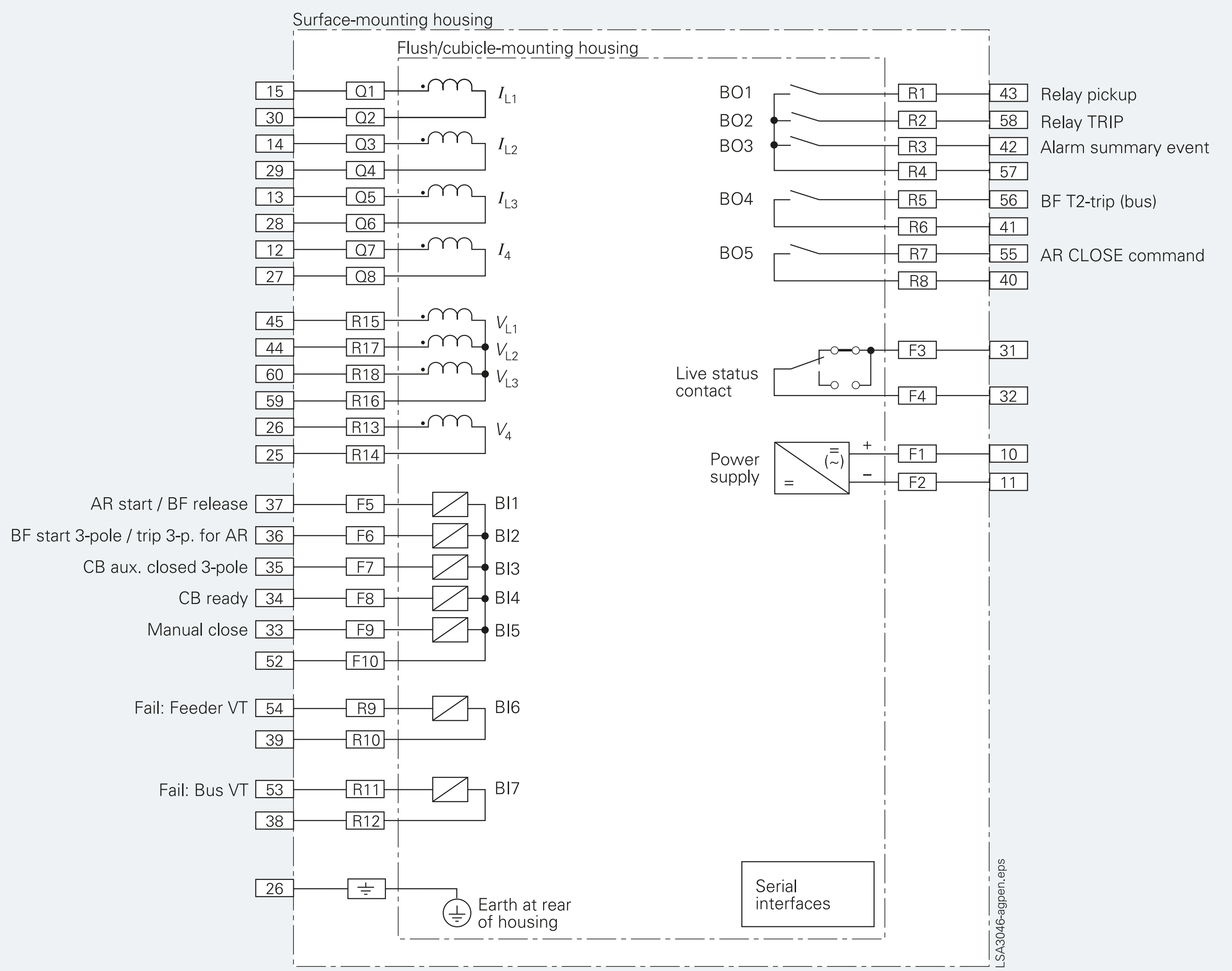

Fig. 10/23 Connection diagram 7VK610, ⅓ x 19" housing

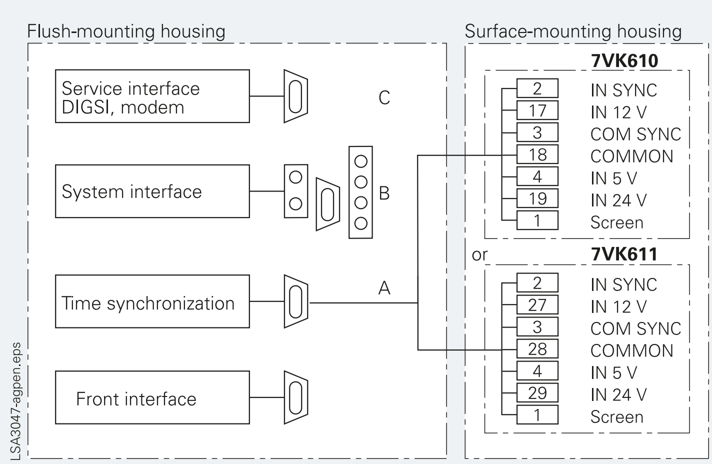

Fig. 10/24 Serial interfaces

Connection diagrams

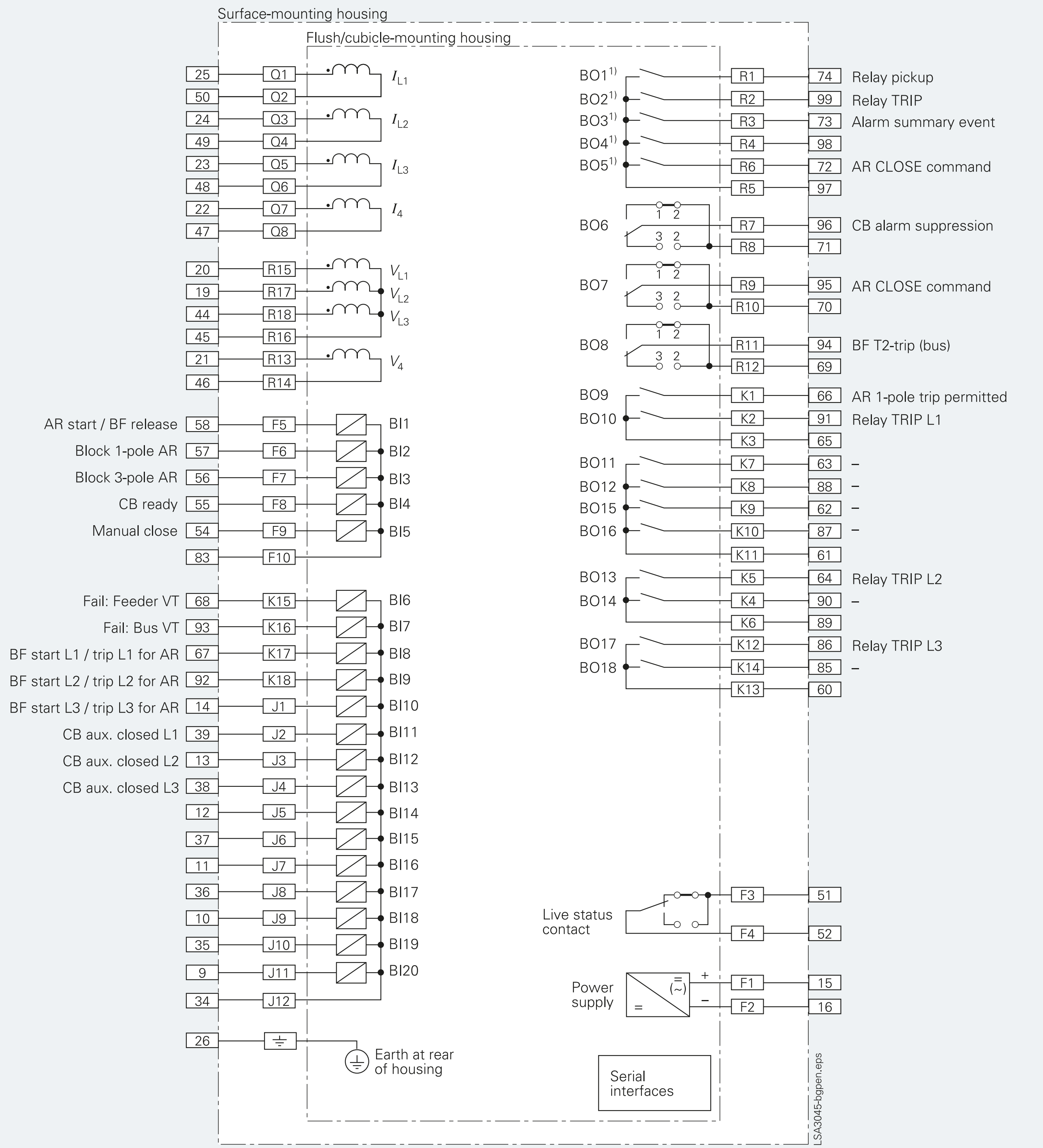

Fig. 10/25 Connection diagram 7VK611, ½ x 19" housing

Generator Protection

11

SIPROTEC 7UM62 multifunction generator, motor and transformer protection relay

Fig. 11/1 SIPROTEC 7UM62 multifunction protection relay for generators, motors and transformers

Description

The SIPROTEC 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 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 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
  – PROFINET

11

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

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.

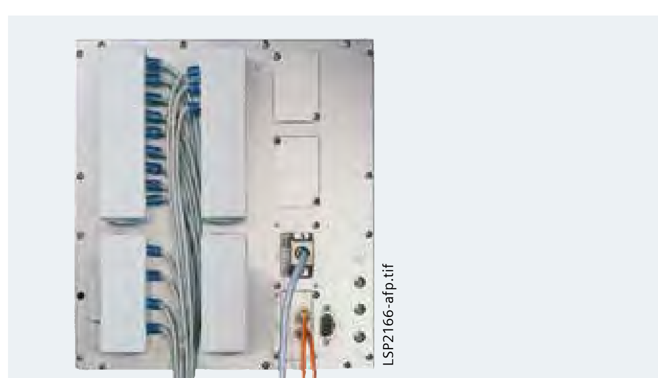

Fig. 11/2 Rear view with wiring terminal safety cover and serial interface

Protection functions

Protection functions	Abbreviation	ANSI No.	Gene-rator Basic	Gene-rator Standard	Gene-rator Full	Motor Asyn-chronous	Trans-former
Current differential protection	ΔI	87G/87T/87M	■	■	■	■	■
Stator ground-fault protection non-directional, directional	$V_0>$, $3I_0>$ \(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^2t	49	■	■	■	■	■
Definite-time overcurrent prot. with undervolt. seal-in	$I> +V<$	51	■	■	■	■	■
Definite-time overcurrent protection, directional	$I>>$, 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/xd	40	■	■	■		
Negative-sequence protection	$I_2>$, $t = f(I_2)$	46	■	■	■	■	
Breaker failure protection	$I_{min}>$	50BF	■	■	■	■	■
Motor starting time supervision	$I_{start}{}^2t$	48	■	■	■	■	
Restart inhibit for motors	I^2t	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 3rd harmonics	V_0 (3rd harm.)	59TN, 27TN 3rd h		■	■		
Impedance protection with ($I>+V<$) pickup	$Z<$	21		■	■		
Interturn protection	$U_{Interturn}>$	59N(IT)		■	■		
DC voltage / DC current time protection	$V_{dc} >$ $I_{dc} >$	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)	$R_{REF}<$	64R (1 – 3 Hz)	■ 1)	■ 1)	■ 1)		
100 % stator ground-fault protection with 20 Hz voltage	$R_{SEF}<$	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

11

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}>>), 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.

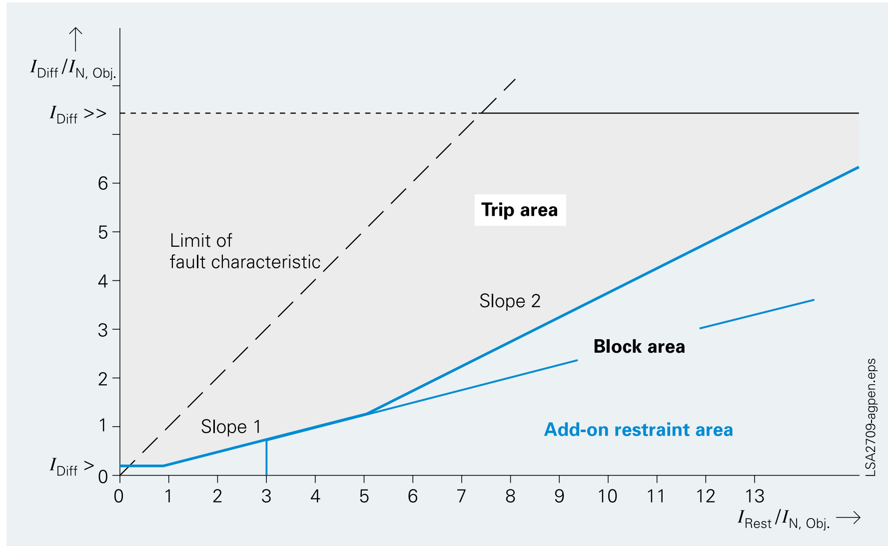

Fig. 11/3 Restraint characteristic of current differential protection

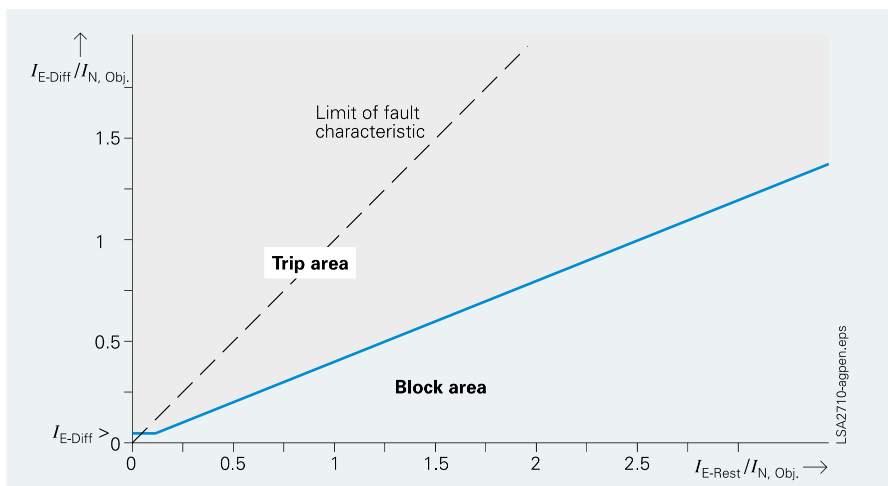

Fig. 11/4 Restraint characteristic of ground-current differential protection

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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).

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.

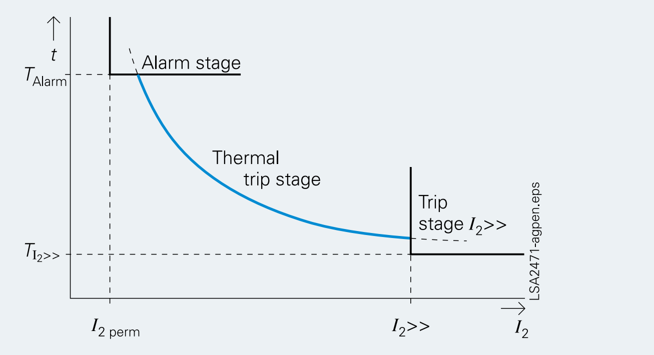

Fig. 11/5 Characteristic of negative-sequence protection

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.

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 (±) 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.

11

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.

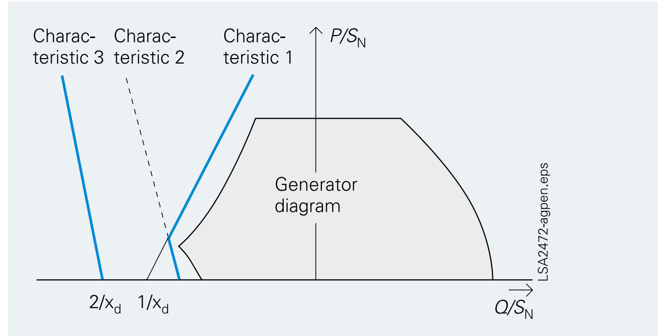

Fig. 11/6 Characteristic of underexcitation protection

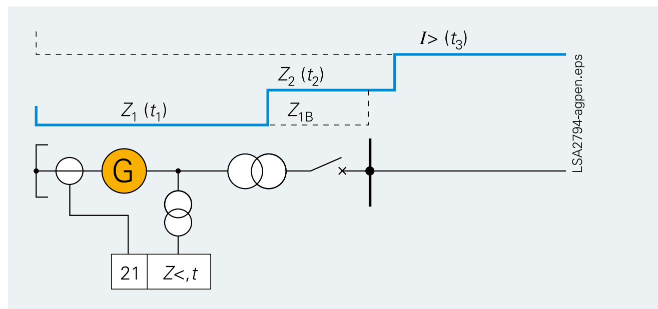

Fig. 11/7 Grading of impedance protection

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 occurence 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.

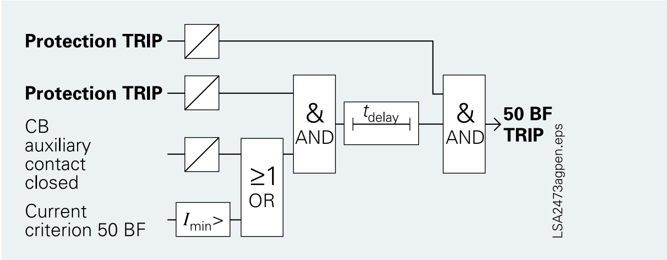

Fig. 11/8 Logic diagram of breaker failure protection

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.

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:

$$t_{Trip} = \left(\frac{I_{start}}{I_{rms}}\right)^2 \cdot t_{start\,max}$$

t_{Trip}	Tripping time
I_{start}	Permissible start-up current
$t_{start\,max}$	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 $I_{N,\,MOTOR}$).

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

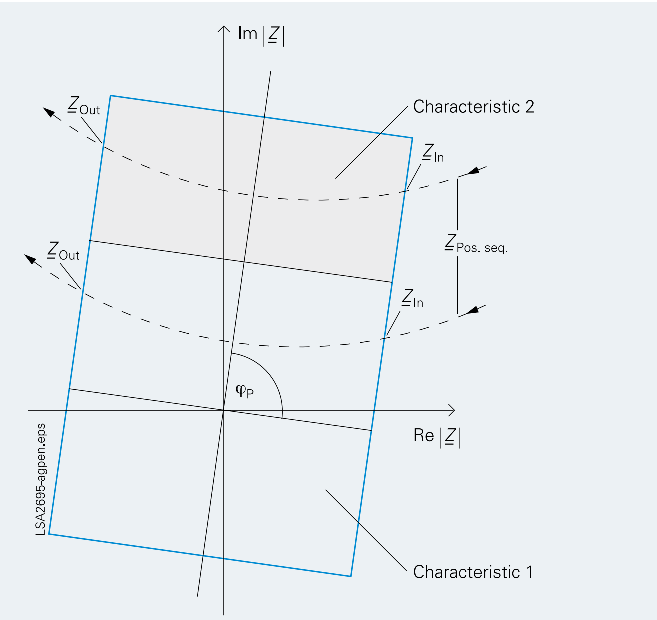

Fig. 11/9 Ranges of the characteristic and possible oscillation profiles

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.

$$t_{TRIP} = \frac{I}{I - \frac{V}{V_P}} \cdot T_M$$

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 $I_{EE\text{-}B}$ 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 $I_{EE\text{-}B}$ 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 inducted 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).

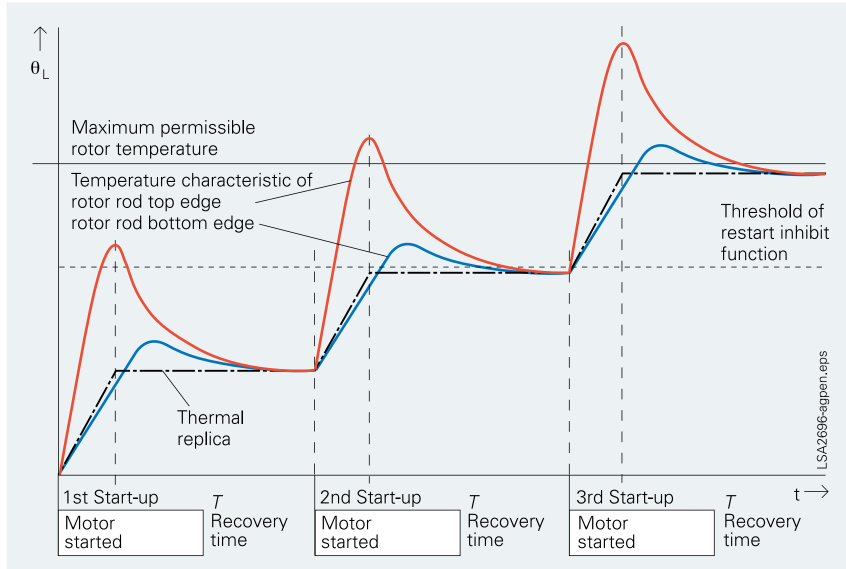

Fig. 11/10 Temperature characteristic at rotor and thermal replica of the rotor (multiple start-ups)

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 an 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.

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.

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 confi gurable 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.

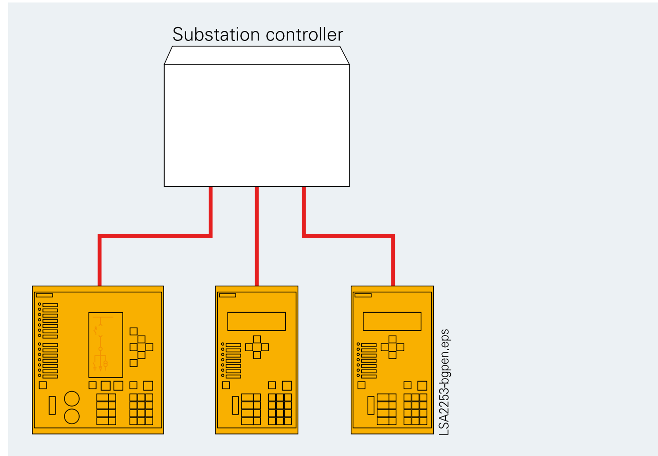

Fig. 11/11 IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

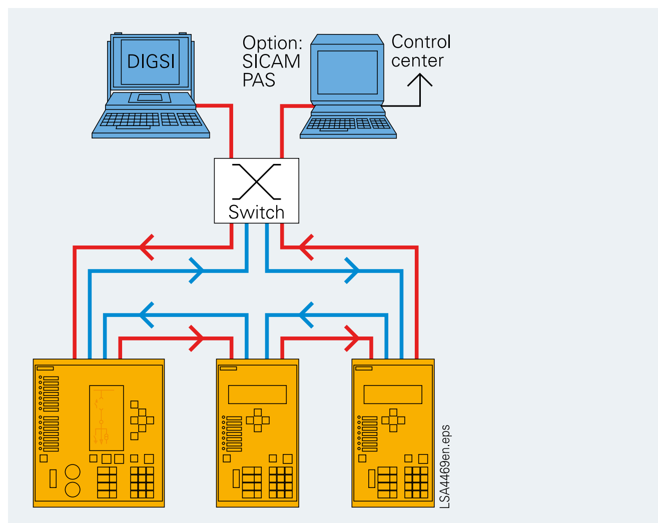

Fig. 11/12 Bus structure for station bus with Ethernet and IEC 61850, fiber-optic ring

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.

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

Fig. 11/13 RS232/RS485 Electrical communication module

Fig. 11/14 820 nm fiber-optic communication module

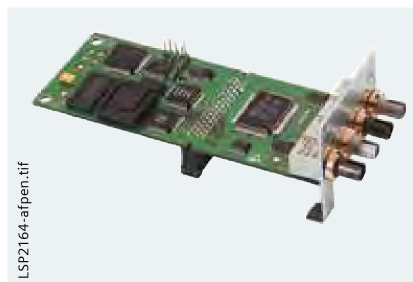

Fig. 11/15 PROFIBUS communication module optical, double-ring

Fig. 11/16 Optical Ethernet communication module for IEC 61850 with integrated Ethernet switch

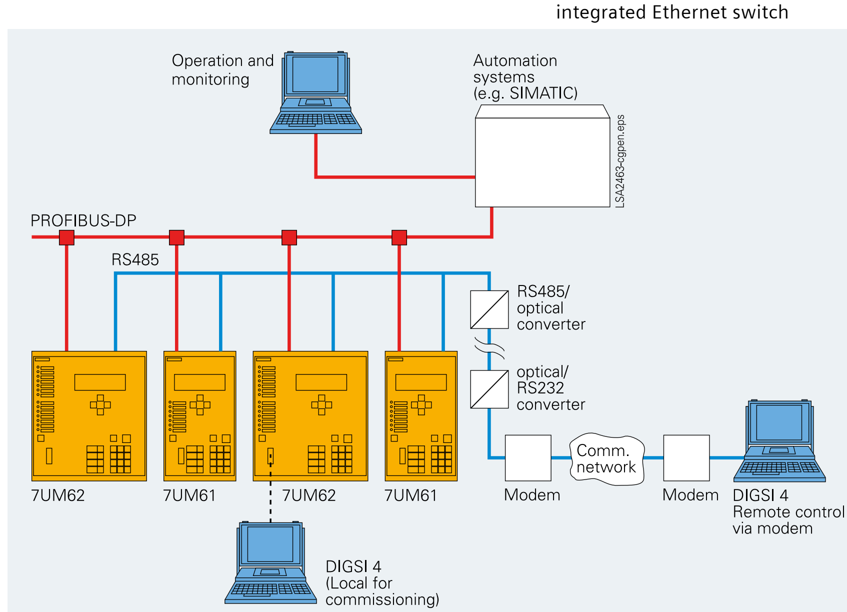

Fig. 11/17 System solution: Communications

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 φ), □$_{stator}$, □$_{rotor}$) can be selected and transmitted via the 0 to 20 mA interfaces.

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.

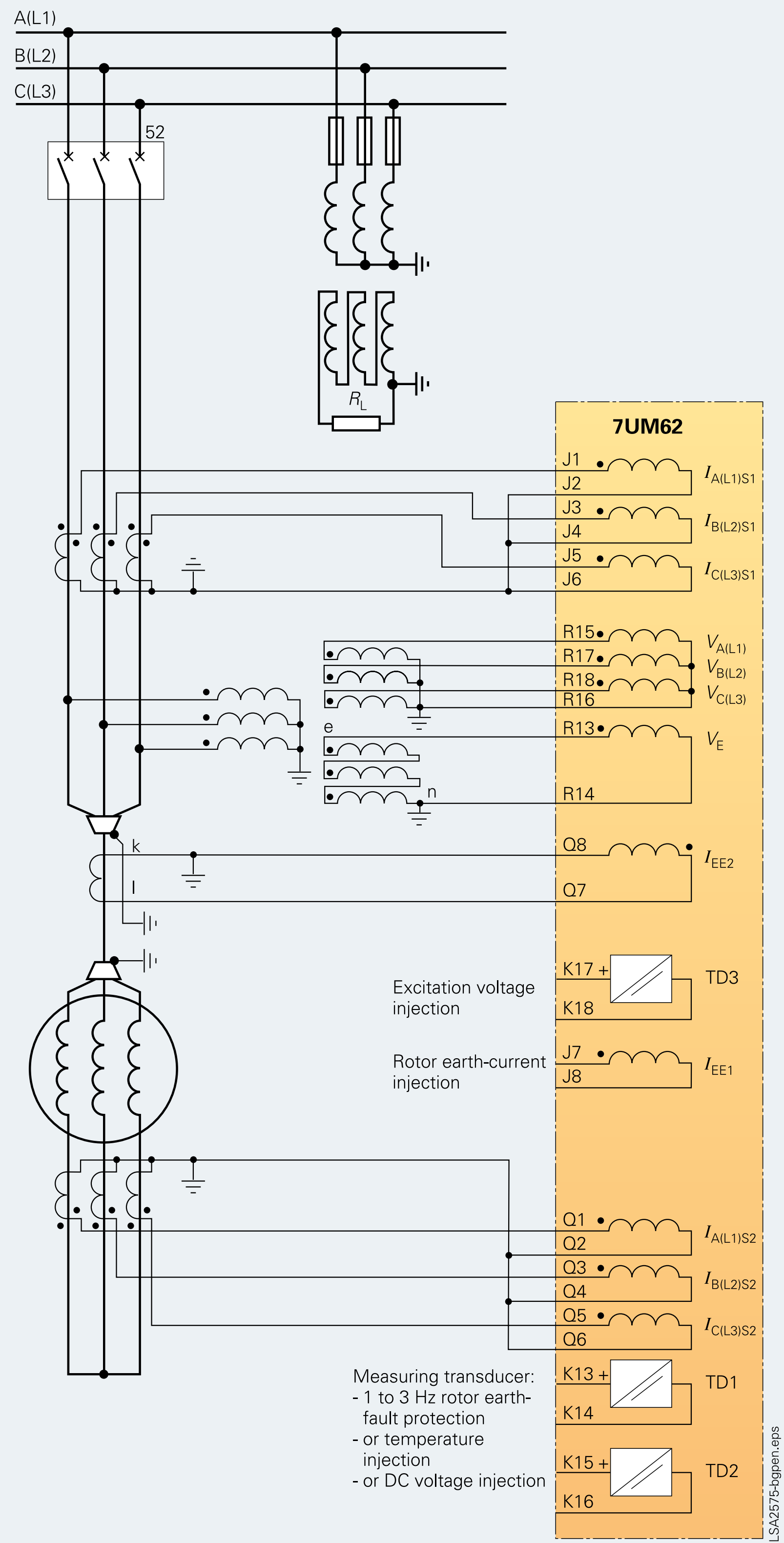

Fig. 11/18

11

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).

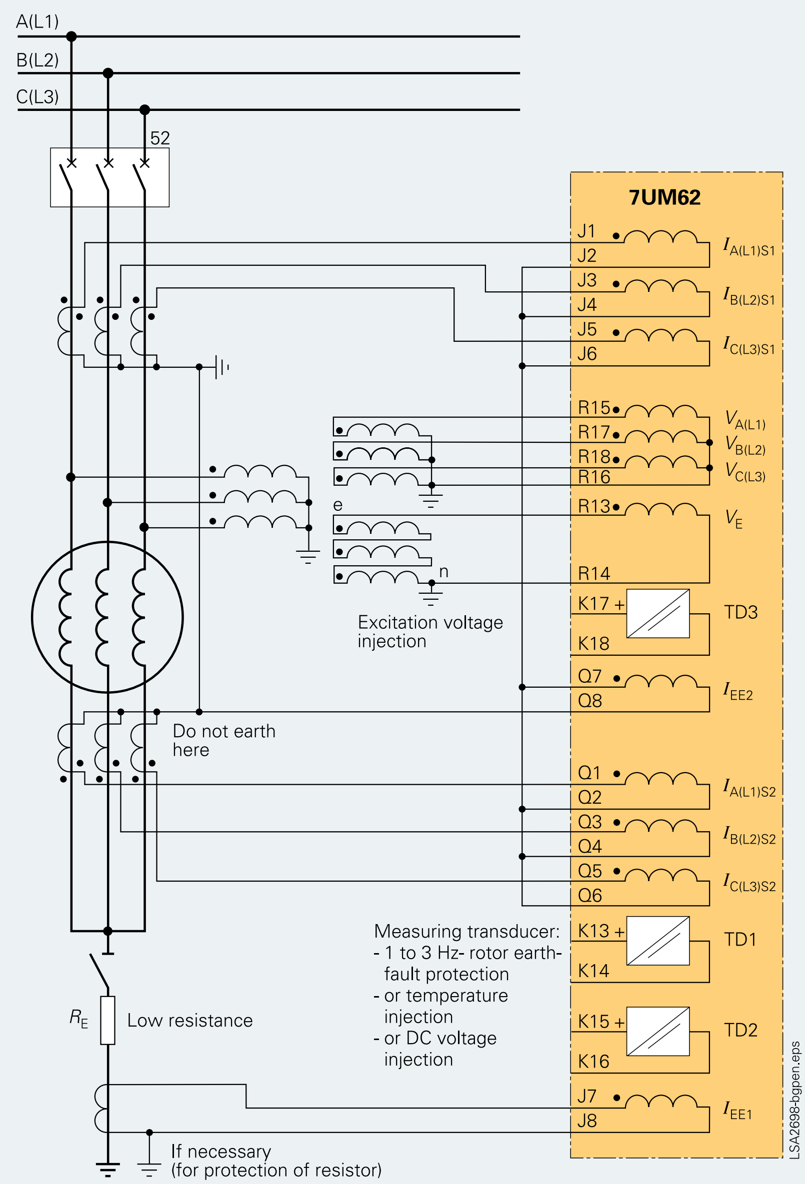

Fig. 11/19

11

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).

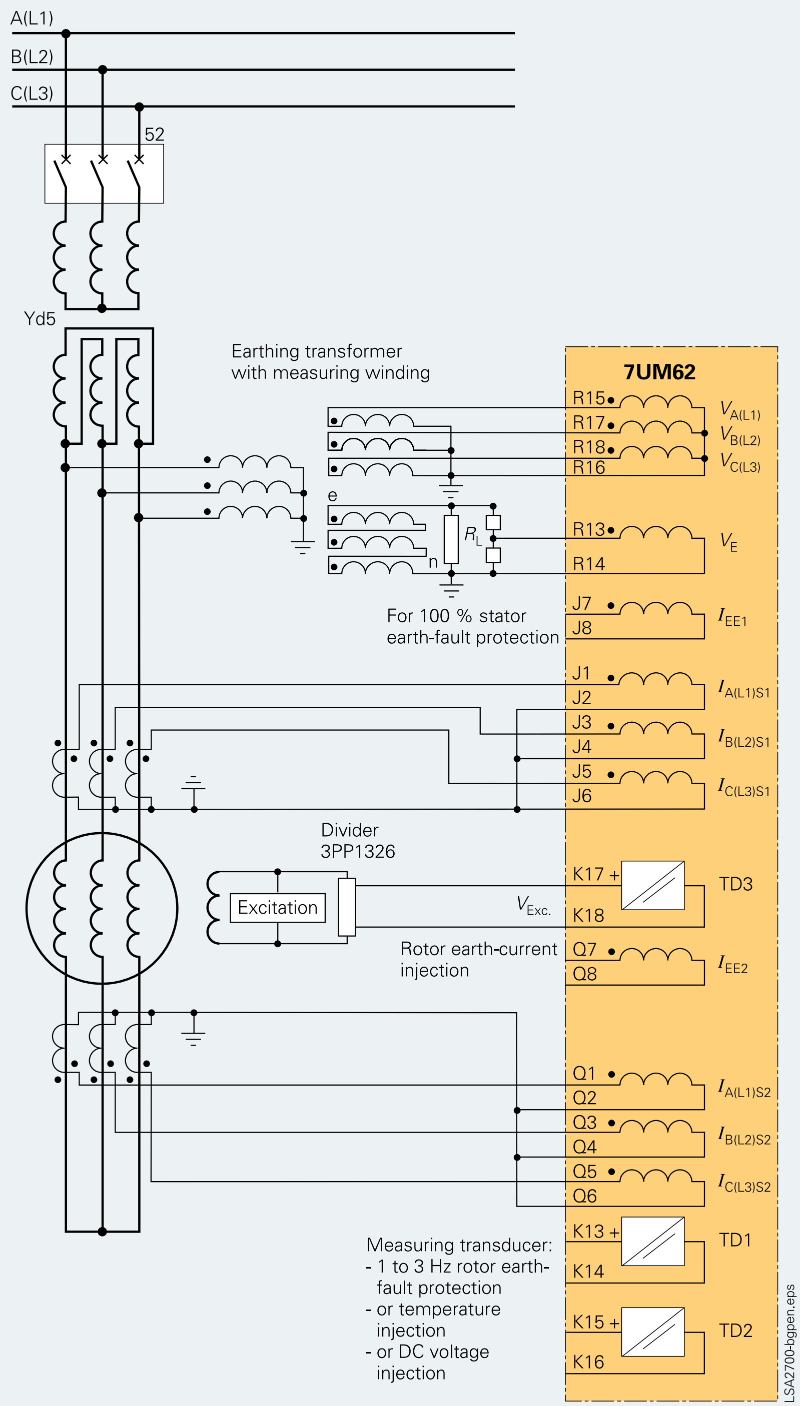

Fig. 11/20

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

$$\left(\frac{V_{Gen}}{\sqrt{3}} \Big/ 500\,\text{V}\right)$$

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.

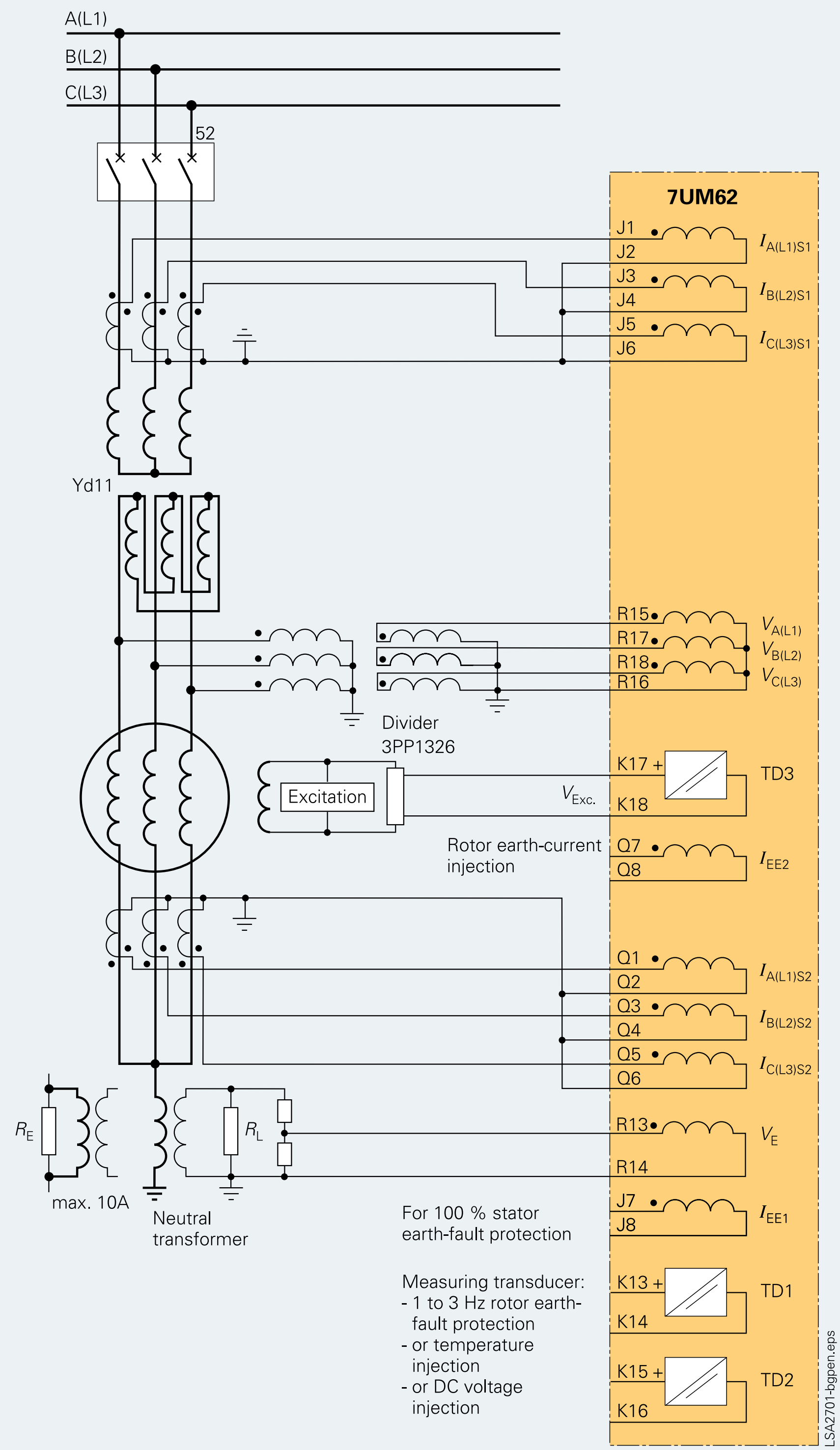

Fig. 11/21

11

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 ($R_{Connection} < R_L$). 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.

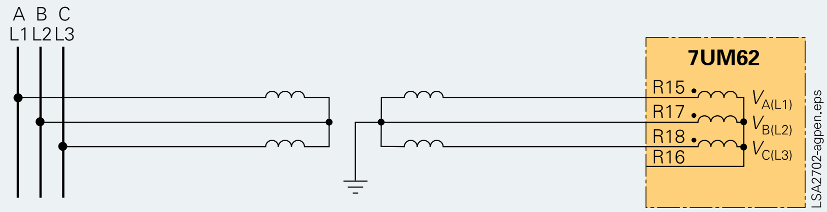

Fig. 11/22

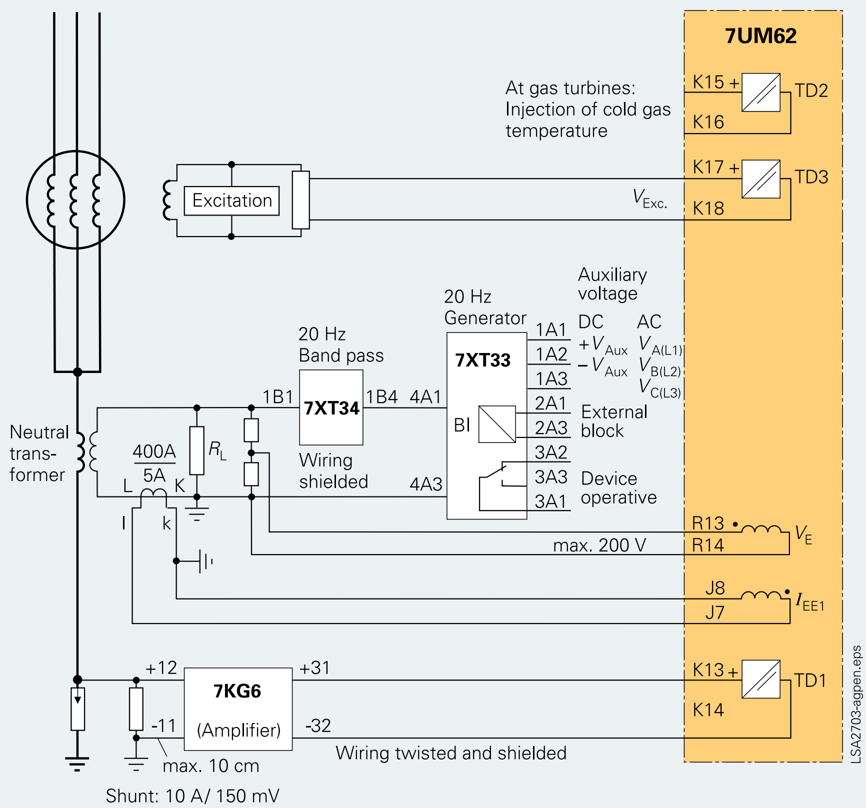

Fig. 11/23

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.

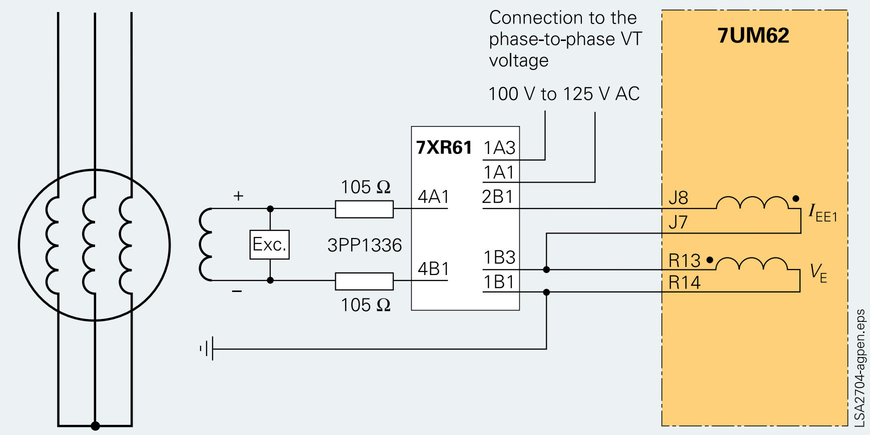

Fig. 11/24

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.

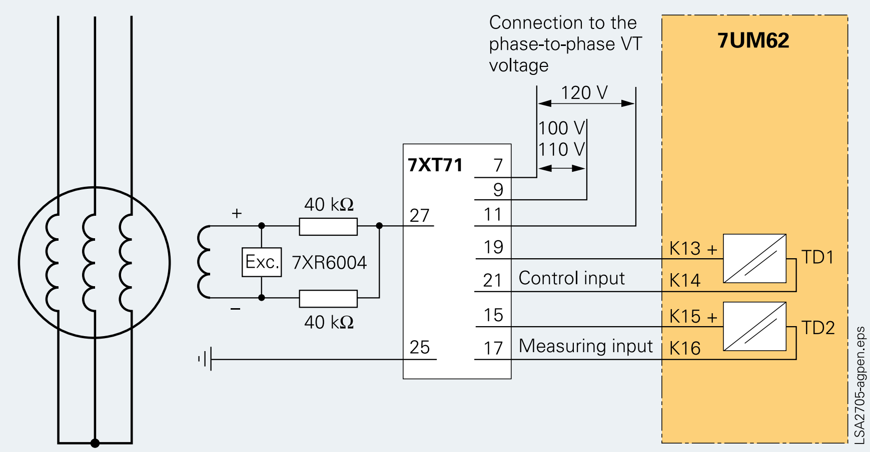

Fig. 11/25

11

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.

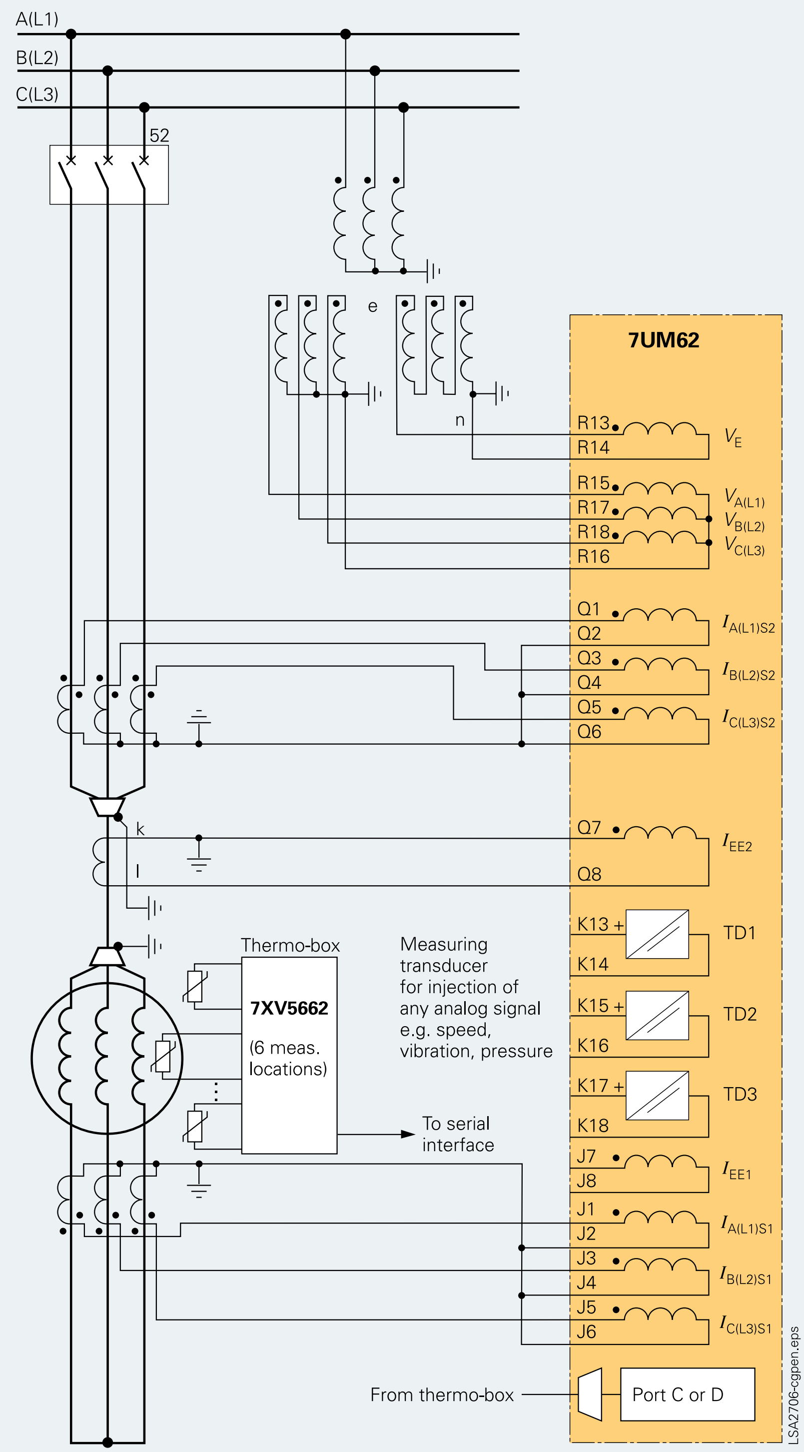

Fig. 11/26

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 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 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) $I_{N,\,G}$ > 5 000 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

11

General unit data	
Analog inputs	
Rated frequency	50 or 60 Hz
Rated current I_N	1 or 5 A
Ground current, sensitive I_{Emax}	1.6 A
Rated voltage V_N	100 to 125 V
Measuring transducer	- 10 to + 10 V (R_i=1 MΩ) or - 20 to + 20 mA (R_i = 10 Ω)
Power consumption With I_N = 1 A With I_N = 5 A For sensitive ground current Voltage inputs (with 100 V)	 Approx. 0.05 VA Approx. 0.3 VA Approx. 0.05 VA 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 Dynamic (peak)	300 A for 1 s 100 A for 10 s 15 A continuous 750 A (one half cycle)
Capability in voltage paths	230 V continuous
Capability of measuring transducer As voltage input As current input	 60 V continuous 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)	≤ 15 %
Power consumption During normal operation 7UM621 7UM622 7UM623 During pickup with all inputs and outputs activated 7UM611 7UM612 7UM623	 Approx. 5.3 W Approx. 5.5 W Approx. 8.1 W Approx. 12 W Approx. 15 W Approx. 14.5 W
Bridging time during auxiliary voltage failure at V_{aux} = 48 V and V_{aux} ≥ 110 V at V_{aux} = 24 V and V_{aux} = 60 V	 ≥ 50 ms ≥ 20 ms
Binary inputs	
Number 7UM621, 7UM623 7UM622	 7 15
3 pickup thresholds Range is selectable with jumpers	DC 10 to 19 V or DC 44 to 88 V DC 88 to 176 V[1)]
Maximum permissible voltage	DC 300 V
Current consumption, energized	Approx. 1.8 mA

Output relays	
Number 7UM621 7UM622	 12 (1 NO, 4 optional as NC, via jumper) 21 (1 NO, 5 optional as NC, via jumper)
Switching capacity Make Break Break (for resistive load) Break (for L/R ≤ 50 ms)	 1000 W / VA 30 VA 40 W 25 VA
Switching voltage	250 V
Permissible current	5 A continuous 30 A for 0.5 seconds
LEDs	
Number RUN (green) ERROR (red)	 1 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 For flush-mounting housing Front Rear For the terminals	 IP 51 IP 51 IP 50 IP 2x with terminal cover put on
Weight Flush mounting housing 7UM621 (½ x 19") 7UM622 (1 x 19")	 Approx. 7 kg Approx. 9.5 kg
Surface mounting housing 7UM621 (½ x 19") 7UM622 (1 19")	 Approx. 12 kg Approx. 15 kg

Electrical tests	
Specifications	
Standards	IEC 60255 (product standards) ANSI/IEEE C37.90.0/.1/.2 UL 508 DIN 57435, part 303 For further standards see below
Insulation tests	
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; ▯ = 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 Ω
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 Ω; test duration 1 min
High-energy surge voltages (SURGE), IEC 61000-4-5 installation, class III	Impulse: 1.2/50 µs
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 Ω
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 Ω
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

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 **L0A** (DP RS485) and additionally order:
For single ring: SIEMENS OLM 6GK1502-3AB10
For double ring: SIEMENS OLM 6GK1502-4AB10

Mechanical stress tests	
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 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

**Futher information can be found in the current manual at:
www.siemens.com/siprotec**

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	
Housing ▯ 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 0 A
PROFIBUS DP slave, optical 820 nm, double ring, ST connector*	9	L 0 B
MODBUS, electrical RS485	9	L 0 D
MODBUS, optical 820 nm, ST connector*	9	L 0 E
DNP 3.0, electrical RS485	9	L 0 G
DNP 3.0, optical 820 nm, ST connector*	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[4)]	9	L 0 S
PROFINET I/O, 100 Mbit Ethernet, electrical, double, RJ45-plug	9	L 3 R
PROFINET I/O, 100 Mbit Ethernet, with integrated switch, optical, double, LC connectors[3)]	9	L 3 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

Continued on 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 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.

11

Selection and ordering data

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.
	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
		Short code
	Series resistor for rotor ground-fault protection (group: 013002)	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

LSP2289-afp.eps

Fig. 11/27 Mounting rail for 19" rack

LSP2090-afp.eps

Fig. 11/28
2-pin connector

LSP2091-afp.eps

Fig. 11/29
3-pin connector

LSP2093-afp.eps

Fig. 11/30
Short-circuit link for current contacts

LSP2092-afp.eps

Fig. 11/31
Short-circuit link for voltage contacts/ indications contacts

Description		Order No.	Size of package	Supplier	Fig.
Connector	2-pin	**C73334-A1-C35-1**	1	Siemens	11/61
	3-pin	**C73334-A1-C36-1**	1	Siemens	11/62
Crimp connector	CI2 0.5 to 1 mm^2	**0-827039-1**	4000	1)	
		0-827396-1	1	1)	
	CI2 0.5 to 2.5 mm^2	**0-827040-1**	4000	1)	
		0-827397-1	1	1)	
	Type III+ 0.75 to 1.5 mm^2	**0-163083-7**	4000	1)	
		0-163084-2	1	1)	
Crimping tool	For type III+	**0-539635-1**	1	1)	
	and matching female	**0-539668-2**		1)	
	For CI2	**0-734372-1**	1	1)	
	and matching female	**1-734387-1**		1)	
19"-mounting rail		**C73165-A63-D200-1**	1	Siemens	11/60
Short-circuit links	For current terminals	**C73334-A1-C33-1**	1	Siemens	11/63
	For other terminals	**C73334-A1-C34-1**	1	Siemens	11/64
Safety cover for terminals	large	**C73334-A1-C31-1**	1	Siemens	11/35
	small	**C73334-A1-C32-1**	1	Siemens	11/35

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram, IEC

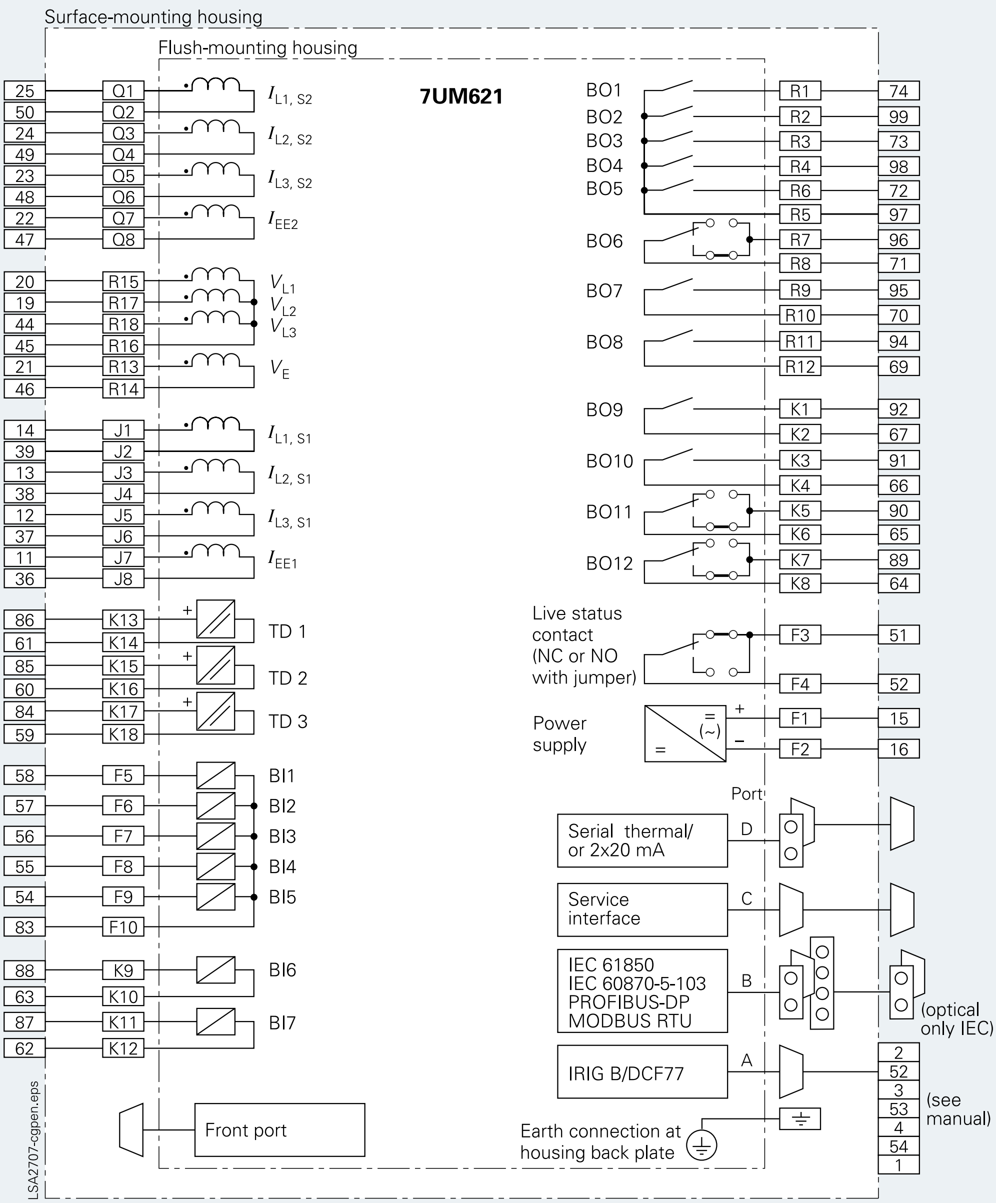

Fig. 11/32 7UM621 and 7UM623 connection diagram (IEC standard)

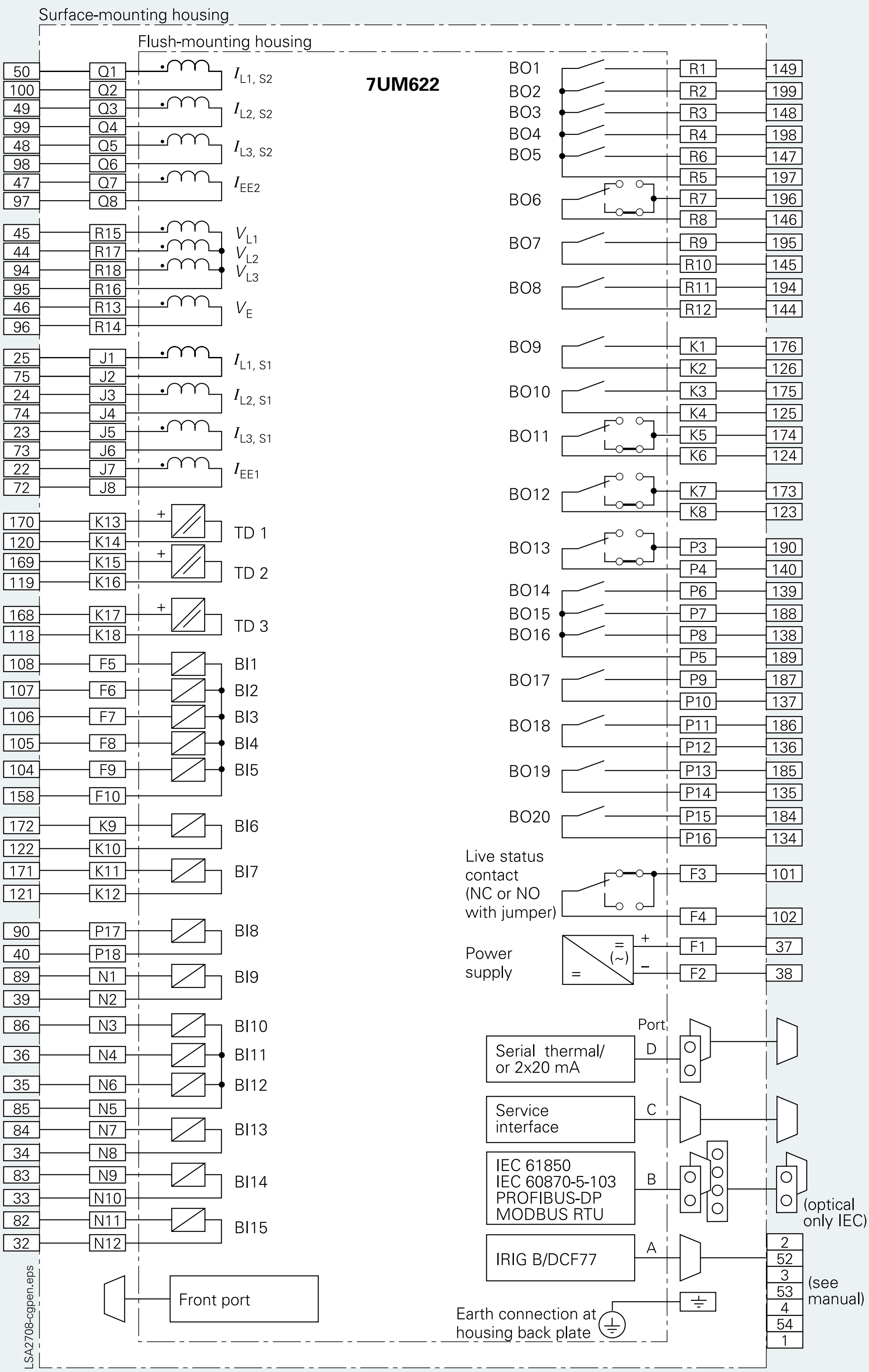

Fig. 11/33 7UM622 connection diagram (IEC standard)

Connection diagram, ANSI

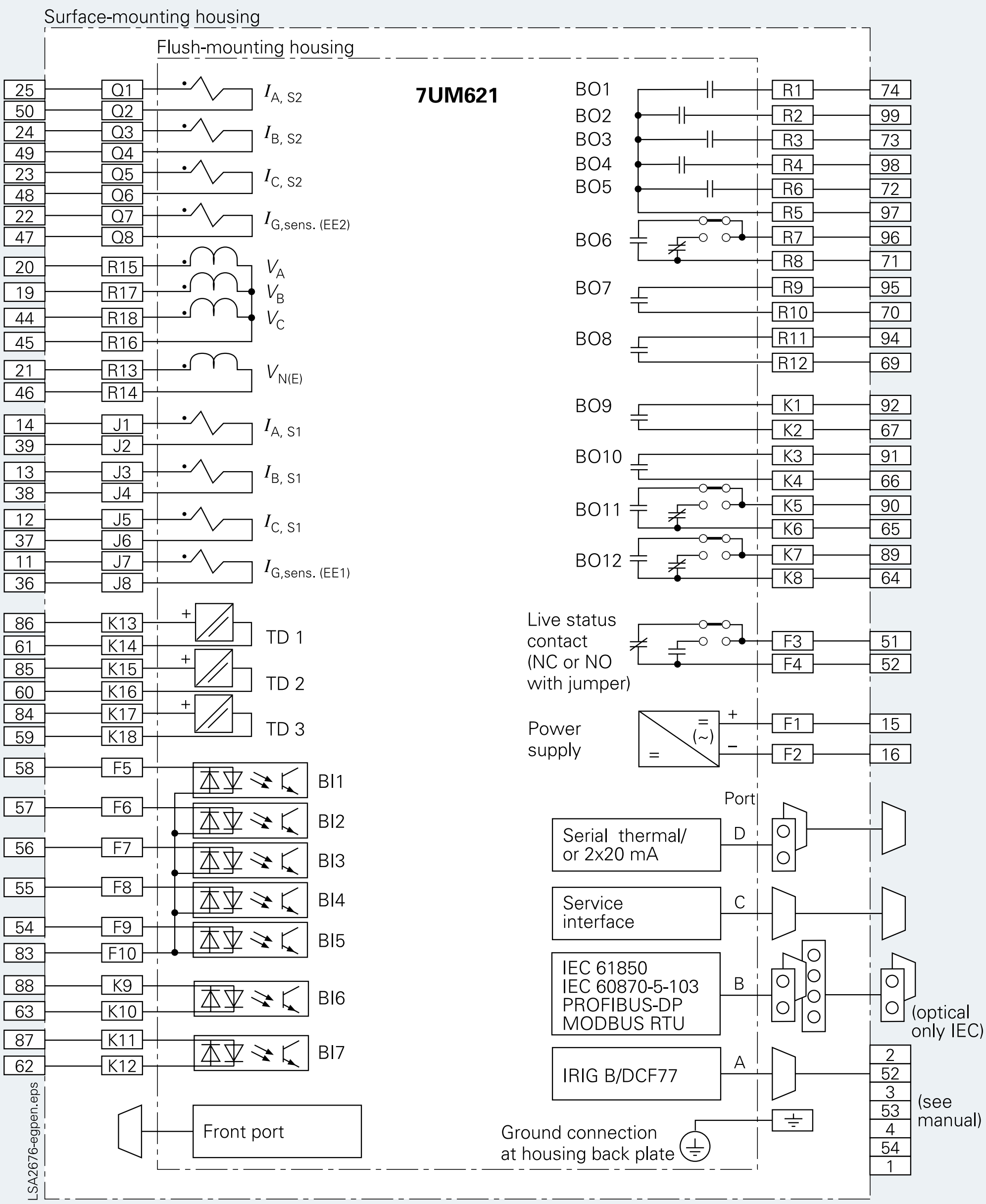

Fig. 11/34 7UM621 and 7UM623 connection diagram (ANSI standard)

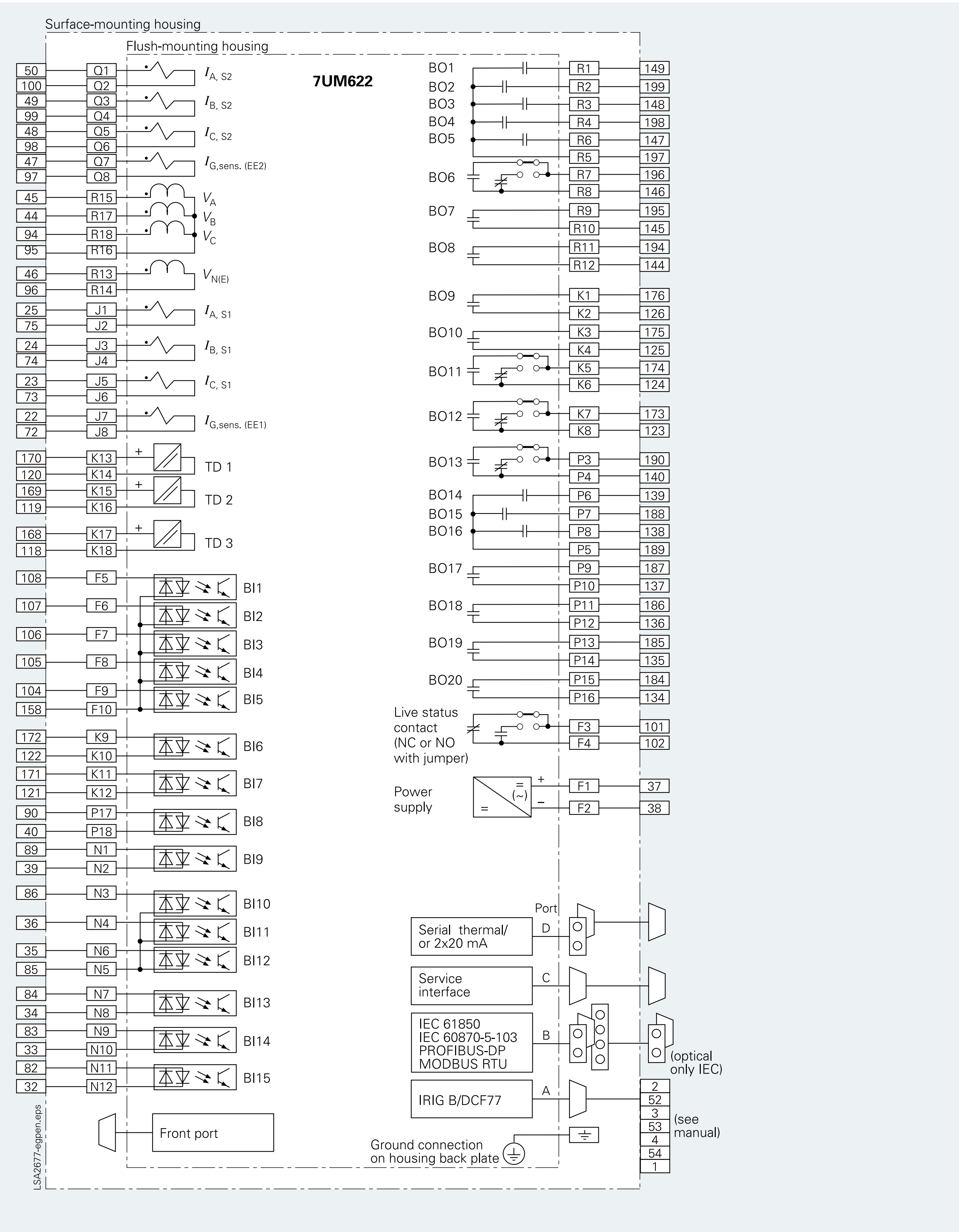

Fig. 11/35 7UM622 connection diagram (ANSI standard)

11

Connection diagram, ANSI

SIPROTEC 7VE6 multifunction paralleling device

Fig. 11/36 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< 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
- Service interface for DIGSI 4 (modem)
- Front interface for DIGSI 4
- Time synchronization via IRIG B/DCF77

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.

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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 ΔV, Δf, $\Delta\alpha$ 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, ΔV, Δf, $\Delta\alpha$) 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 ΔV, Δf, $\Delta\alpha$ 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)

11

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.

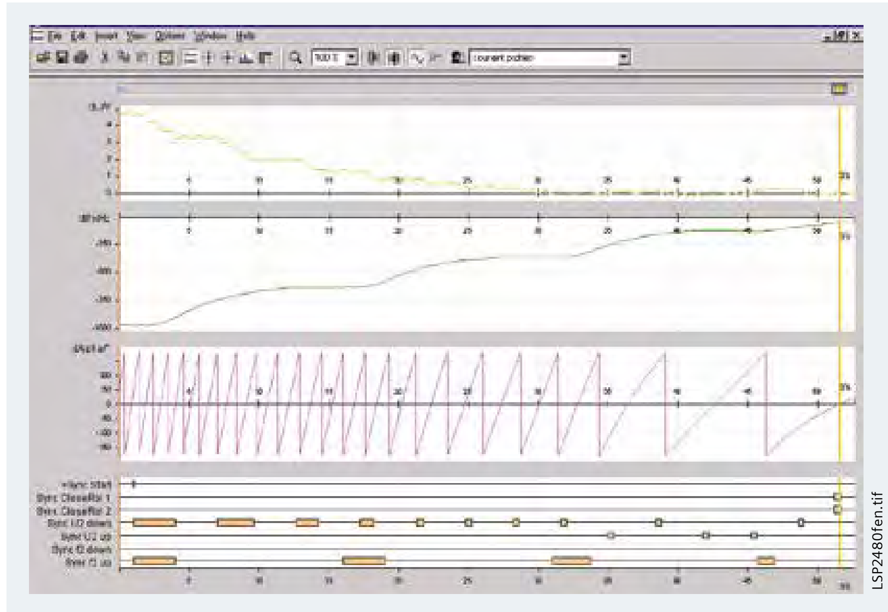


Fig. 11/37 SIGRA 4, synchronization record with balancing commands

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.

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.

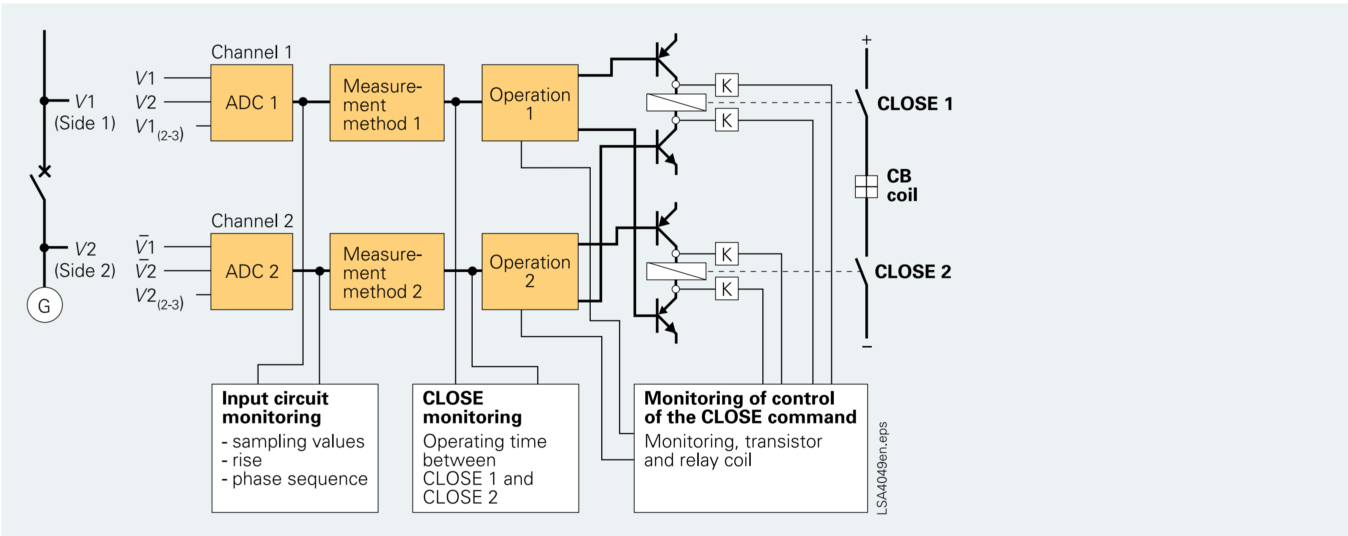


Fig. 11/38 Two-channel redundancy

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 CLOSE 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 CLOSE 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 CLOSE command is given when the two methods simultaneously decide on CLOSE. 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. $\bar{V}1$). 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 (synchronism monitoring of both methods). Unwanted relay operation is avoided by two-channel operation of both CLOSE relays. The two measurement methods operate the transistors crossed over.

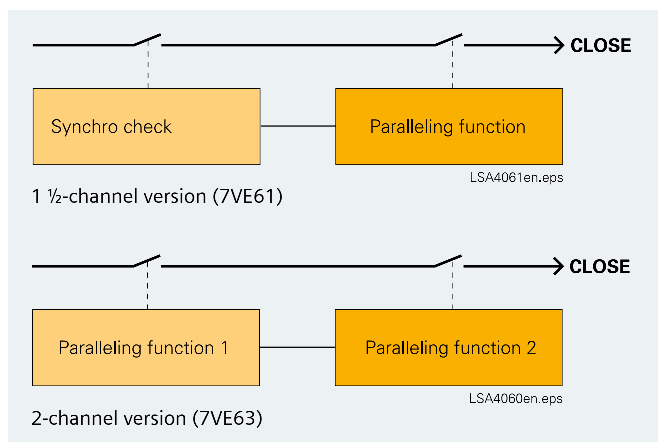


Fig. 11/39 Design of multi-channel redundancy

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.

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. 11/88 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).

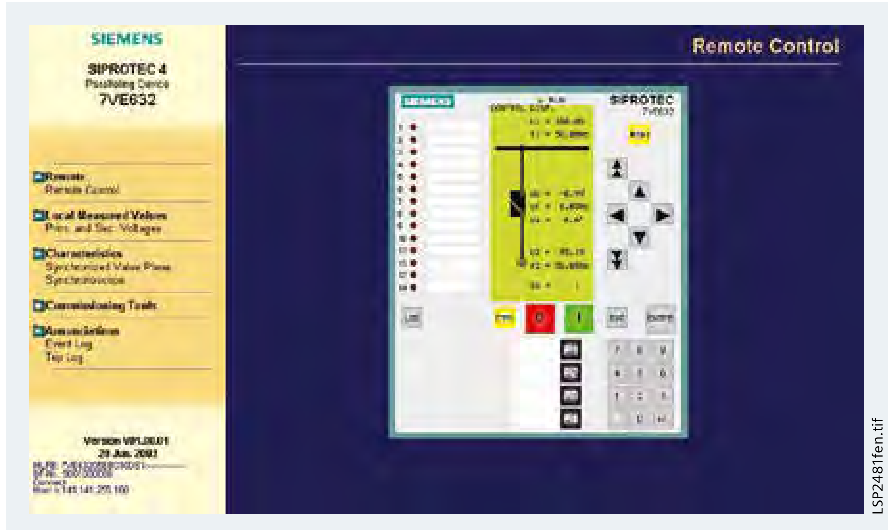


Fig. 11/40 Browser-based operation

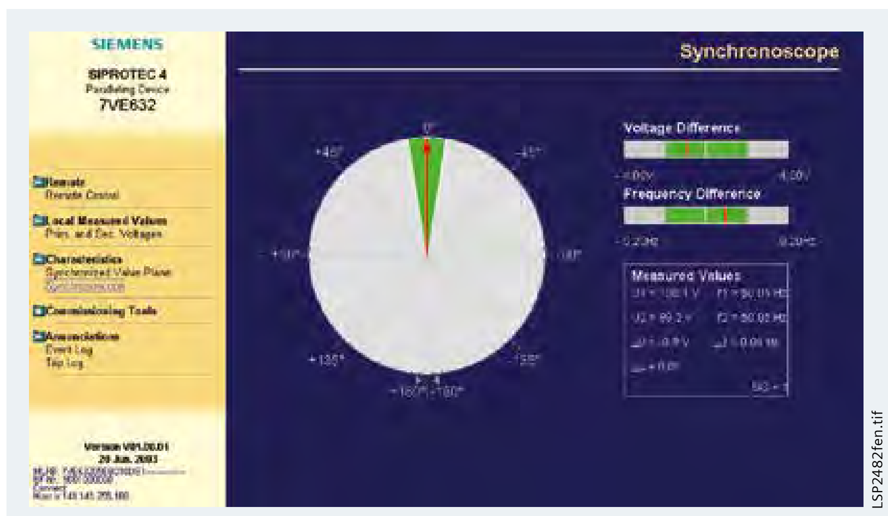


Fig. 11/41 Overview display of the synchronization function

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).

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 thedirection of balancing commands.

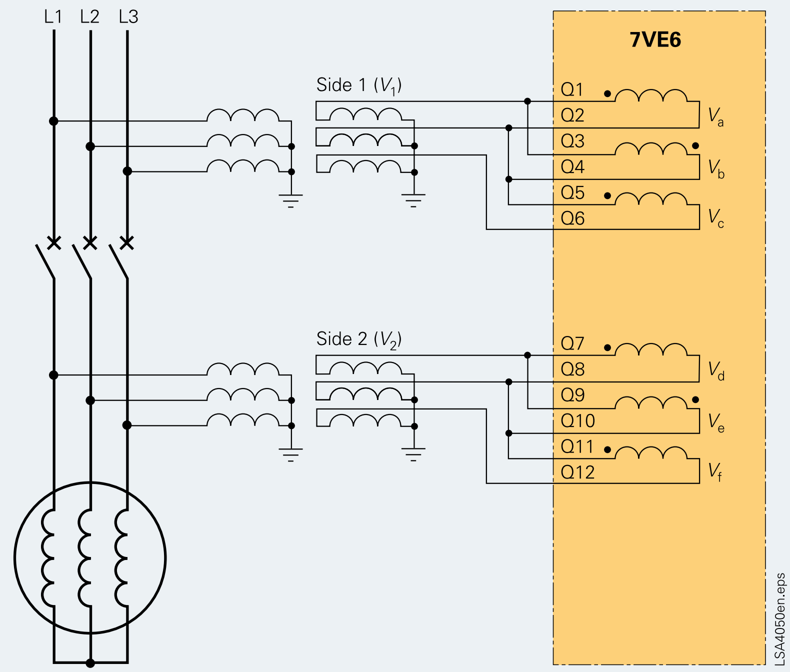


Fig. 11/42

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.

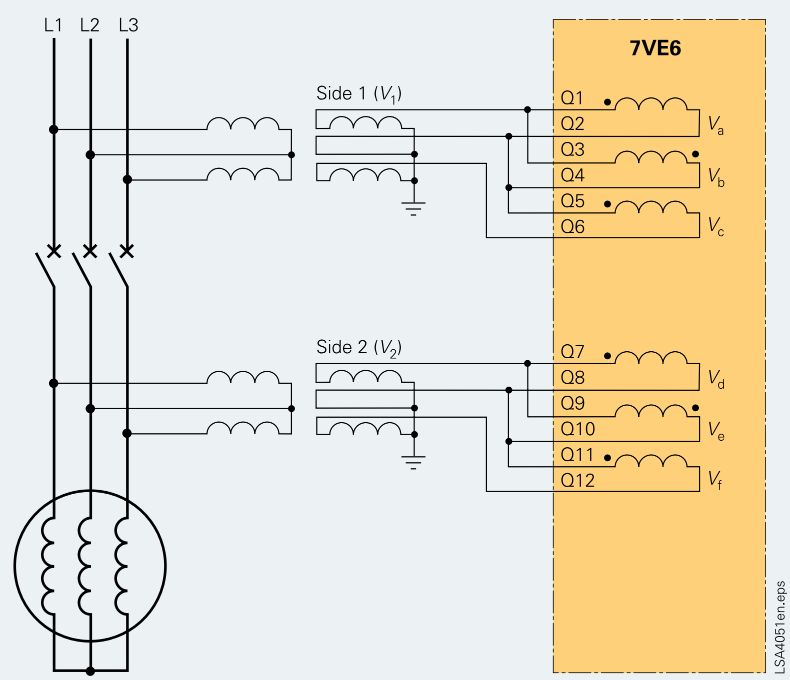


Fig. 11/43

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 busbarmust be accepted.

Full two-channel redundancy is ensured.

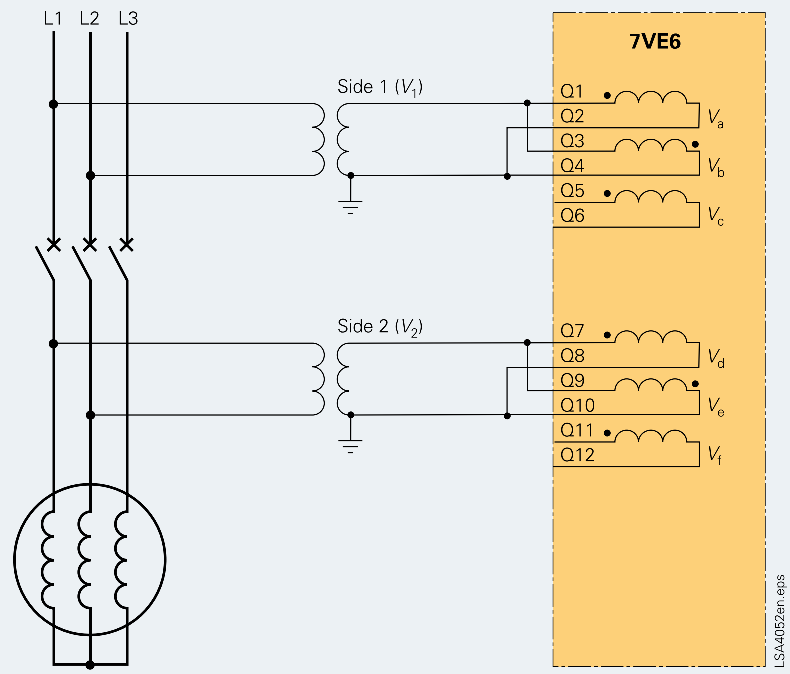


Fig. 11/44

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, an 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, an 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.

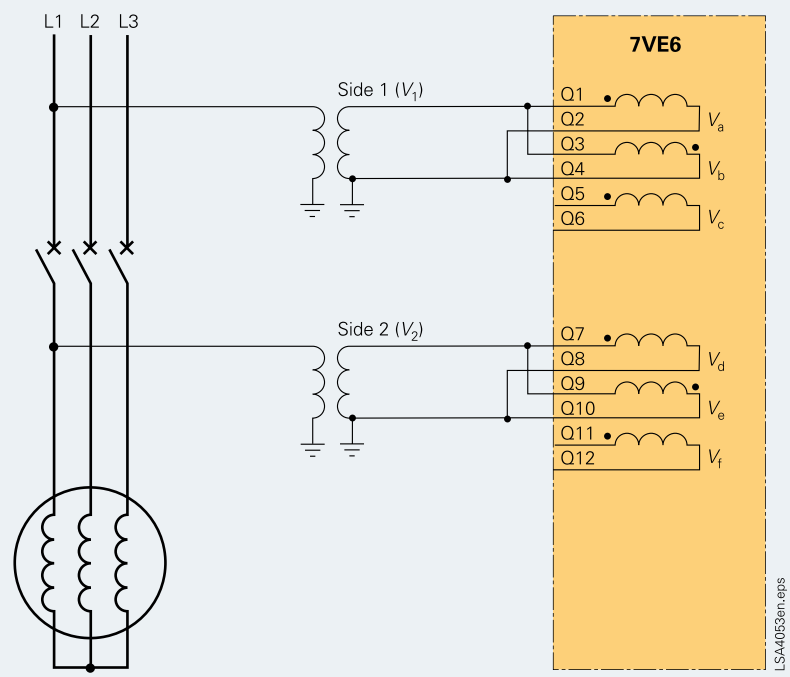


Fig. 11/45

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.

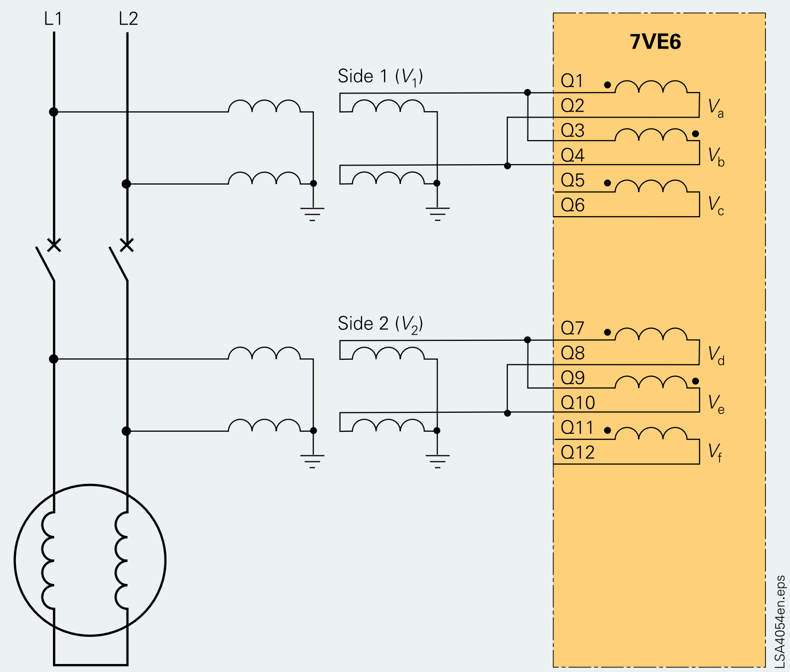


Fig. 11/46

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 bemonitored 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.

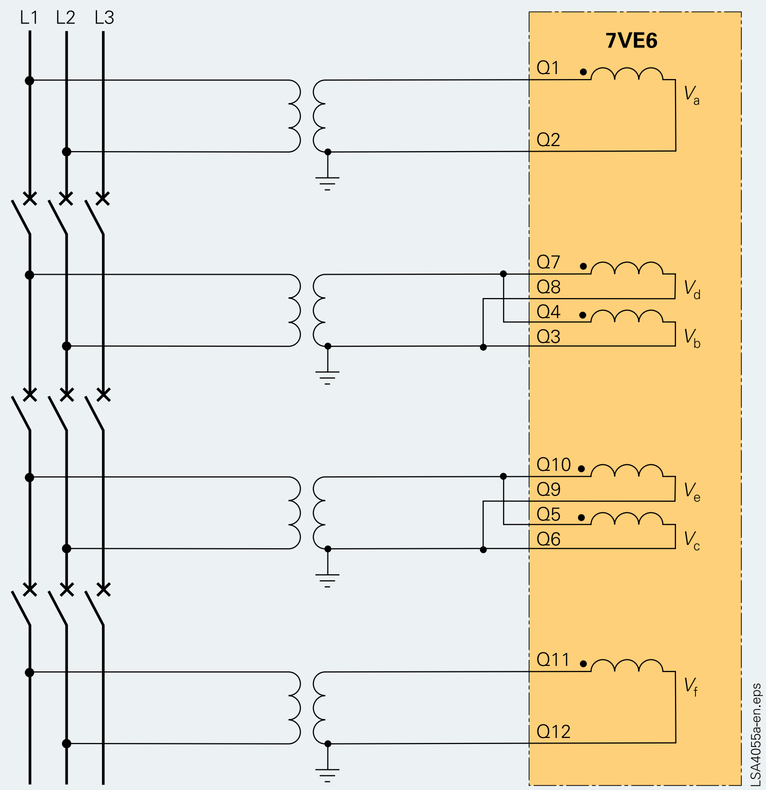


Fig. 11/47

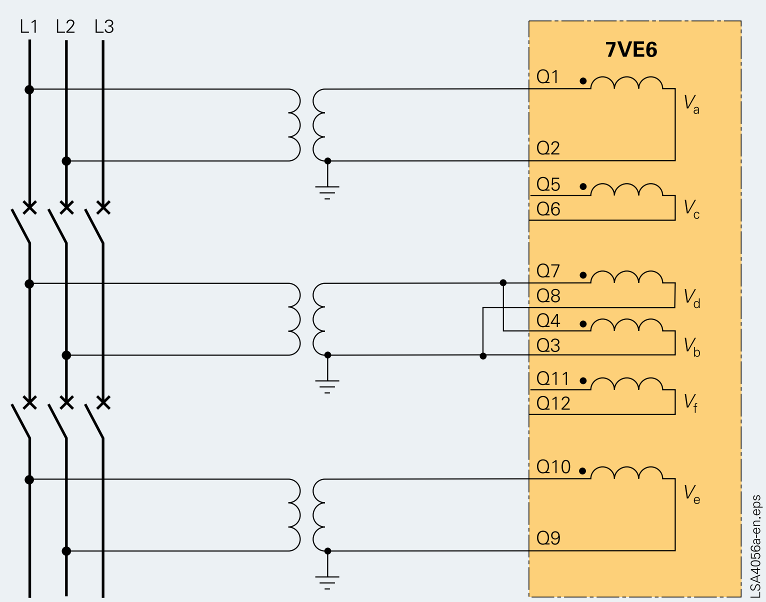


Fig. 11/48

11

Typical applications

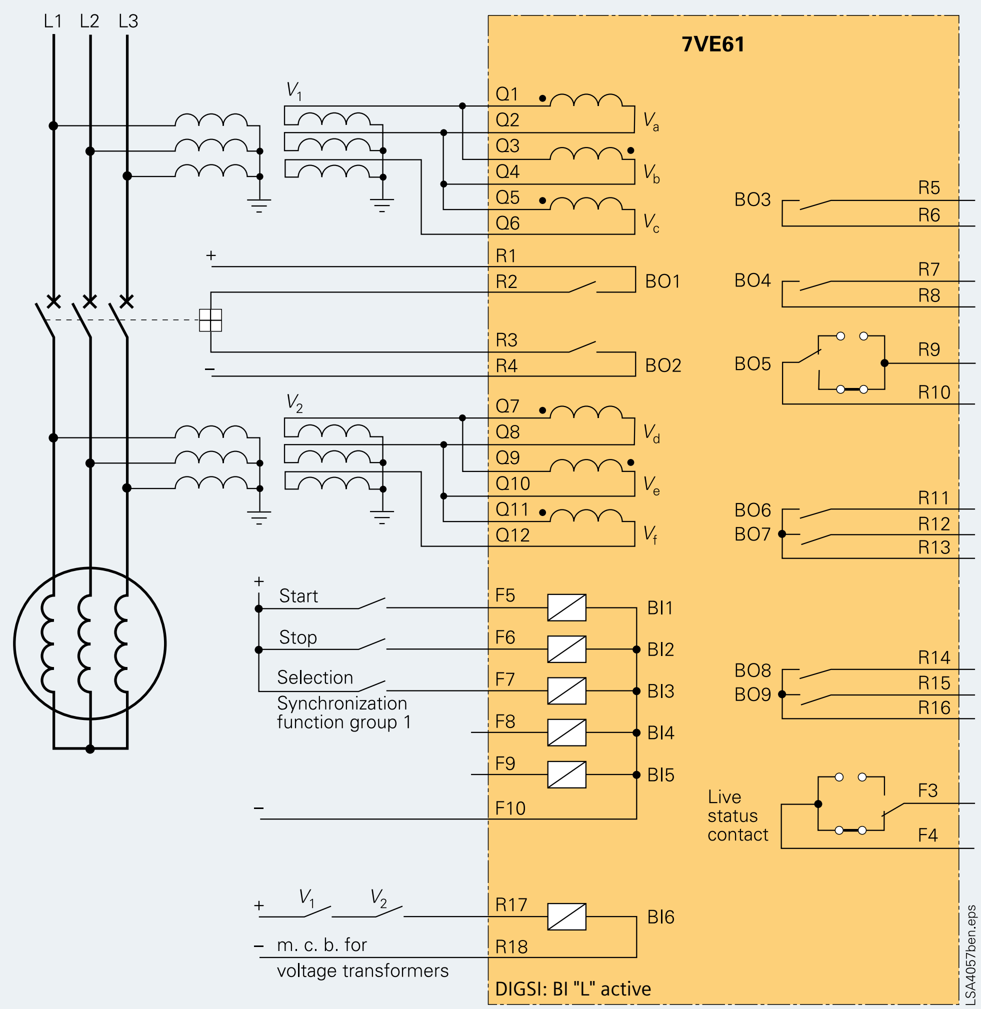


Fig. 11/49

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.

General unit data	
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 7VE63	 Approx. 4 W Approx. 5.5 W
Energized 7VE61 7VE63	 Approx. 9.5 W Approx. 12 W
Bridging time during auxiliary voltage failure at V_{aux} = 48 V and V_{aux} ≥ 110 V at V_{aux} = 24 V and V_{aux} = 60 V	 ≥ 50 ms ≥ 20 ms
Binary inputs	
Quantity 7VE61 7VE63	 6 14
3 pickup thresholds Range is settable with jumpers	DC 14 to 19 V, DC 66 to 88 V; DC 117 to 176 V
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 Break Break (for resistive load) Break (for L/R ≤ 50 ms)	 1000 W / VA 30 VA 40 W 25 W
Switching voltage	250 V
Permissible current	5 A continuous 30 A for 0.5 seconds
LEDs	
Quantity RUN (green) ERROR (red) Assignable LED (red) 7VE61 7VE63	 1 1 7 14

Unit design	
7XP20 housing	For dimensions see dimension drawings part 14
Degree of protection acc. to EN 60529 For surface-mounting housing For flush-mounting housing Front Rear For the terminals	 IP 51 IP 51 IP 50 IP 2x with terminal cover put on
Weight Flush-mounting housing 7VE61 (½ x 19”) 7VE63 (½ x 19”) Surface-mounting housing 7VE61 (½ x 19”) 7VE63 (½ x 19”)	 Approx. 5.2 kg Approx. 7 kg Approx. 9.2 kg Approx. 12

Electrical tests	
Specifications	
Standards	IEC 60255 (product standards) ANSI/IEEE C37.90.0/.1/.2 UL 508 DIN 57435, part 303 For further standards see below
Insulating tests	
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 µs; 0.5 J; 3 positive and 3 negative impulses at intervals of 5 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; □ = 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 Ω
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

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 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
High-energy surge voltages (SURGE), IEC 61000-4-5 installation, class III	Impulse: 1.2/50 μs
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 Ω
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 Ω
EMC tests for interference emission (type test)	
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	
<u>During operation</u>	
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
<u>During transport</u>	
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 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; conden-sation is not permit

Futher information can be found in the current manual at: www.siemens.com/siprotec

Description	Order No.	Order code
7VE61multifunction paralleling unit **Housing ⅓ 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 □
DIGSI 4 / modem, electrical RS485	9	M 2 □
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, 1½-channel, synchro-check in 2nd channel	B	
Paralleling function for 2 synchronizing points with balancing commands, 1½-channel, synchro-check in 2nd channel	C	
Paralleling function for 4 synchronizing points with balancing commands, 1½-channel, synchro-check in 2nd 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 = 16.7Hz)	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"**

11

Selection and ordering data

Description	Order No.	Order code
7VE63multifunction paralleling unit **Housing ½ 19", 14 BI, 17 BO,1 live status contact**	7VE6320-□□□□□-0□□□-□□□	
Auxiliary voltage (power supply, indication voltage)		
DC 24 to 48 V, threshold binary input 19 V	2	
DC 60 to 125 V, threshold binary input 19 V	4	
DC 110 to 250 V, AC 115 to 230 V, threshold binary input DC 88 V	5	
DC 220 to 250 V, AC 115 to 230 V, threshold binary input DC 176 V	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 □
DIGSI 4 / modem, electrical RS485	9	M 2 □
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, 2-channel, independent measuring procedures	B	
Paralleling function for 2 synchronizing points with balancing commands, 2-channel, independent measuring procedures	C	
Paralleling function for 8 synchronizing points with balancing commands, 2-channel, independent measuring procedures	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 = 16.7Hz)	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.
	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**

Fig. 11/50 Short-circuit link for voltage contacts

Fig. 11/51 Mounting rail for 19" rack

Accessories	Description		Order No.	Size of package	Supplier
	Crimp connector	CI2 0.5 to 1 mm^2	**0-827039-1** **0-827396-1**	4000 1	1) 1)
		CI2 0.5 to 2.5 mm^2	**0-827040-1** **0-827397-1**	4000 1	1) 1)
		Type III+ 0.75 to 1.5 mm^2	**0-163083-7** **0-163084-2**	4000 1	1) 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 	1) 1) 1) 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.

11

Connection diagram

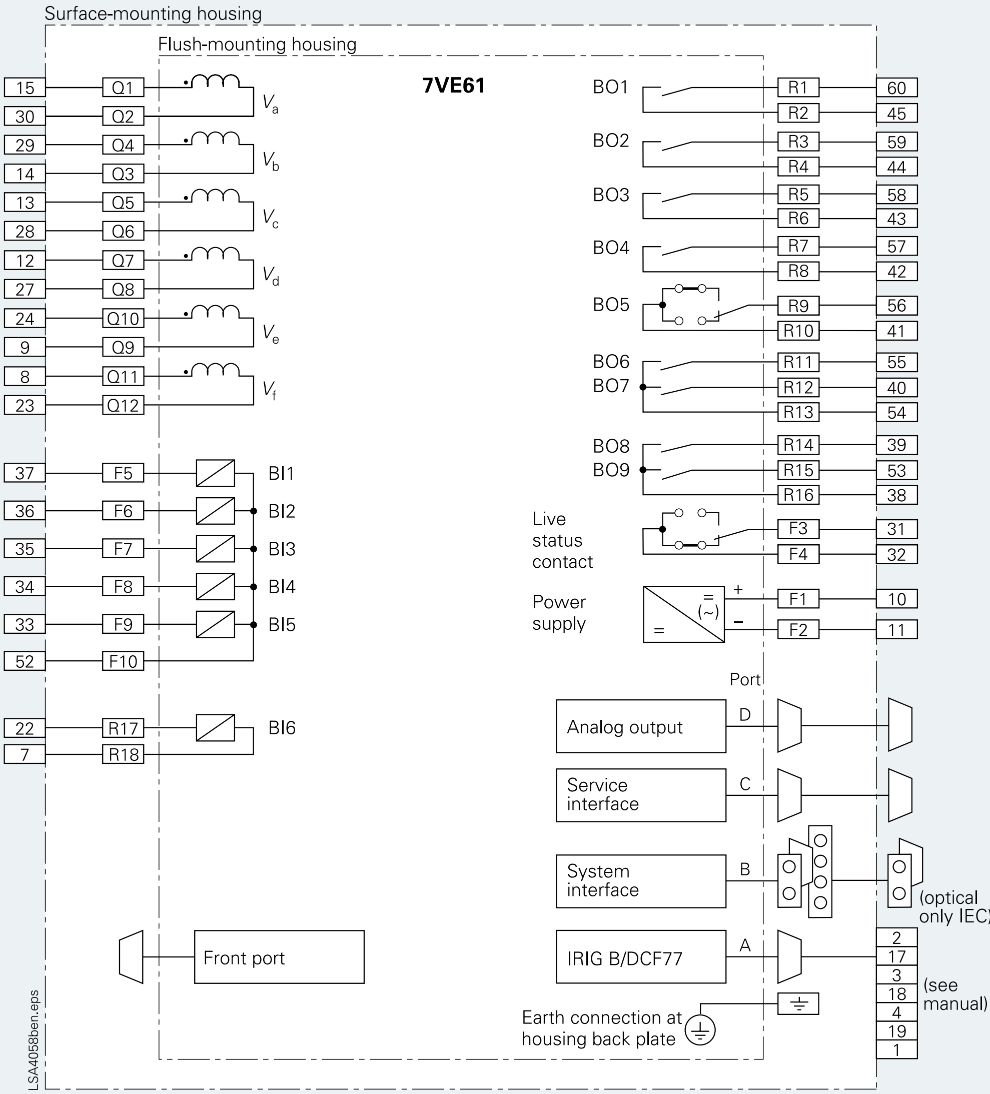


Fig. 11/52 Connection diagram

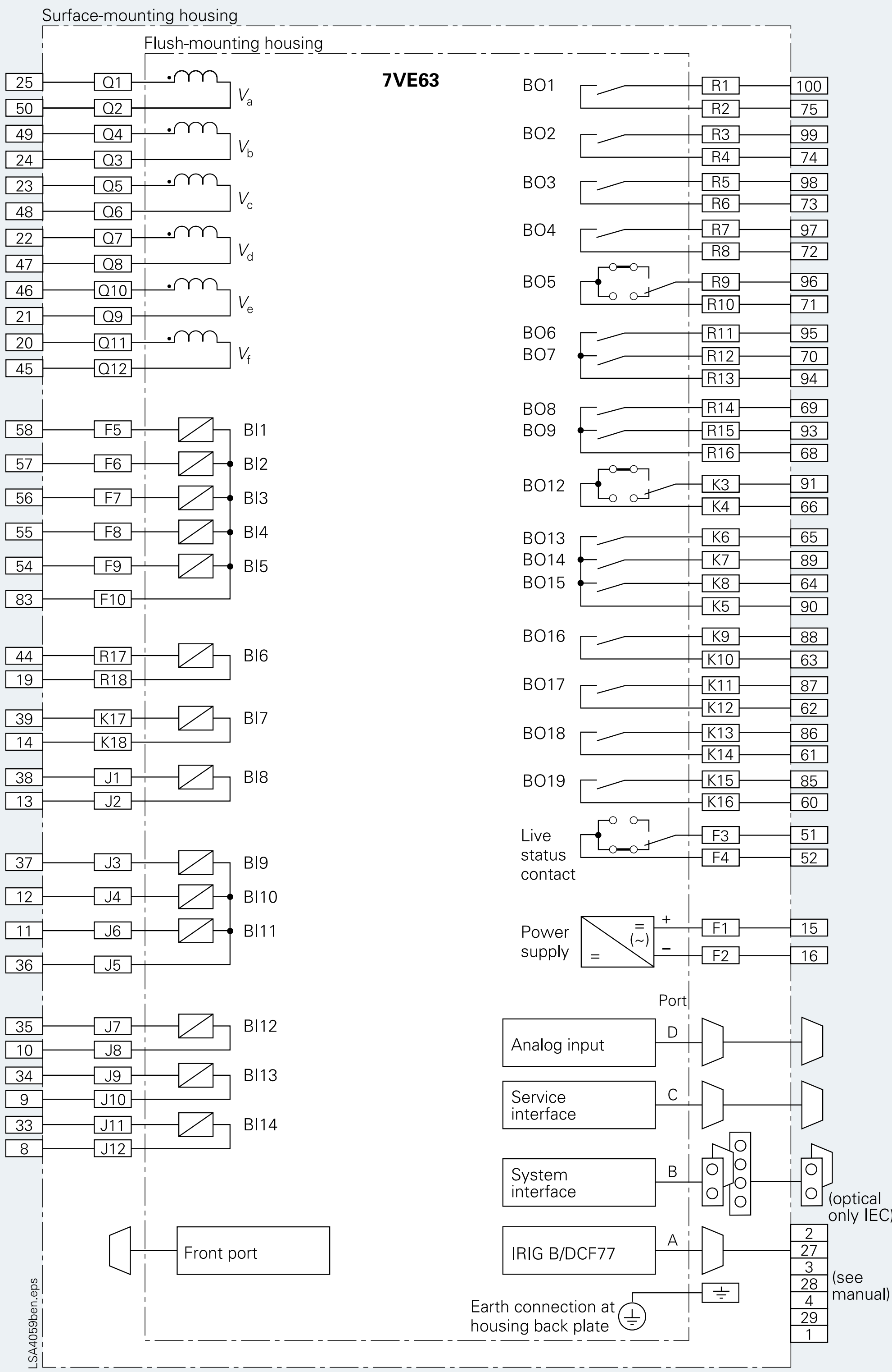


Fig. 11/53 Connection diagram

11

Fig. 11/54 SIPROTEC 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

Application

The 7VU683 high speed busbar transfer (HBST) 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.

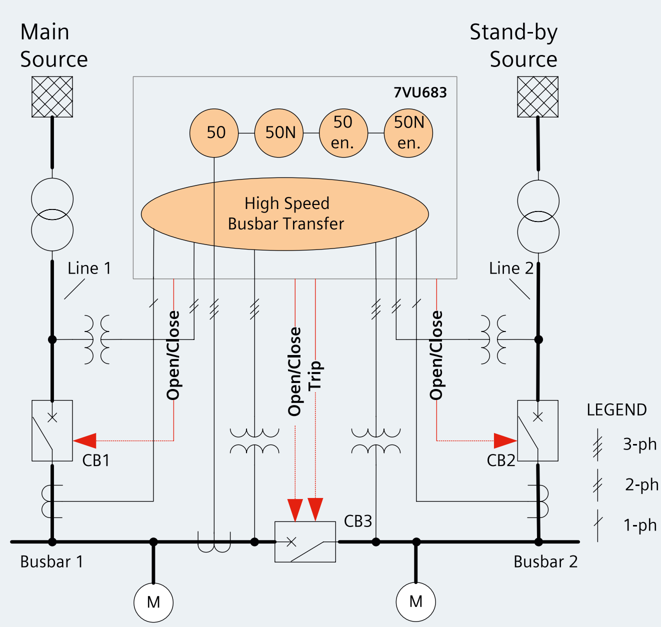


Fig. 11/55 Function diagram

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.

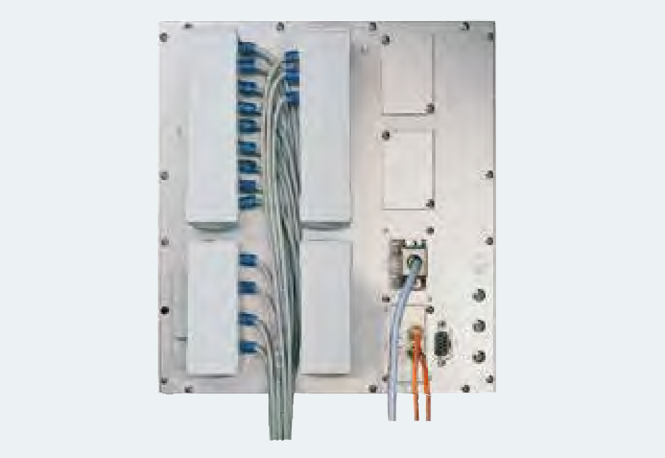


Fig. 11/56 Rear view with wiring terminal safety cover and serial interface

HSBT functions

Starting conditions

The device HSBT 7VU683 is designed to support the following staring 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 SIMULATEOUS 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).

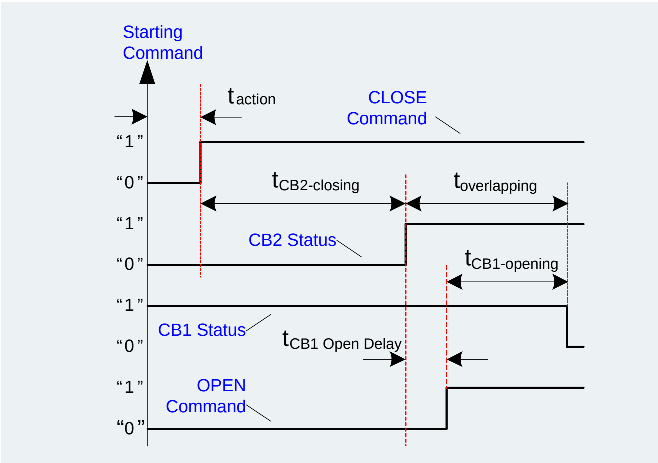


Fig. 11/57 Time sequence of PARALLEL

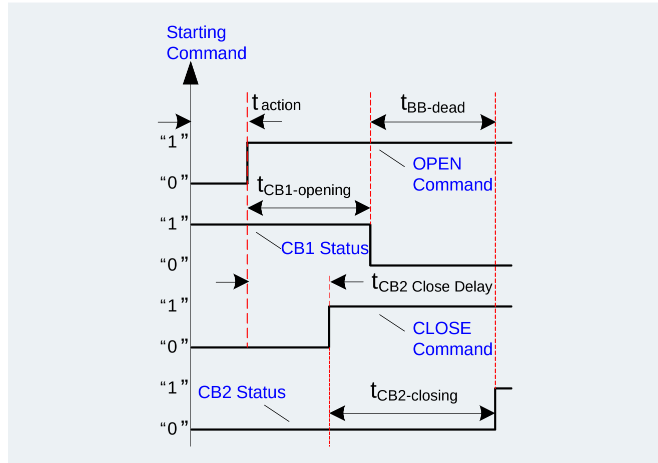


Fig. 11/58 Time sequence of SIMULTANEOUS

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).

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).

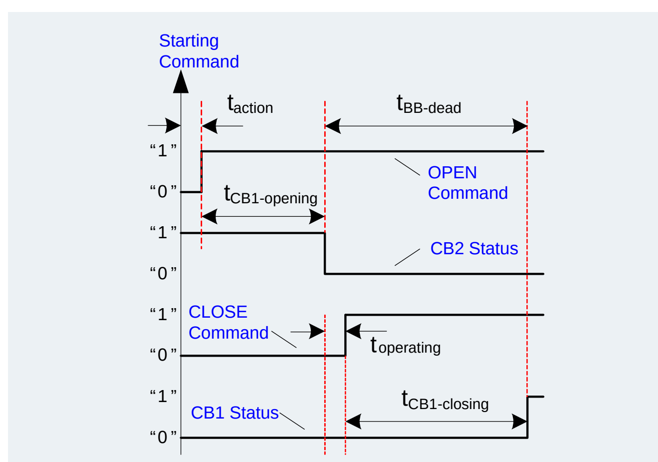


Fig. 11/59 Time sequence of SEQUENTIAL

<u>Transfer modes</u>

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.

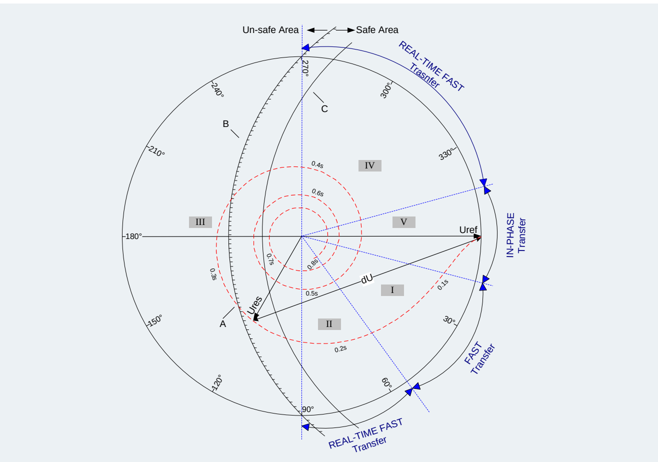


Fig. 11/60 Vector trajectory of residual voltage

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.

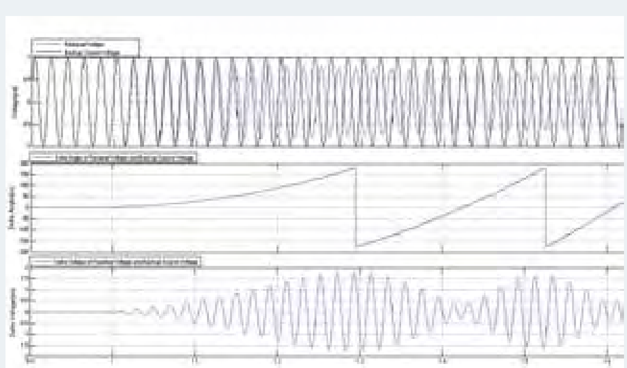


Fig. 11/61 Vector trajectory of residual voltage

The equivalent circuit of residual voltage Ures and referred voltage Uref is shown in Fig. 11/109.

The voltage drop on motor Um at instant of CB closing is calculated by following,

$$Um = dU \cdot xm /(xm + xs) = k \cdot dU \qquad \text{(Equa.-1)}$$

Here, xm and xs are respectively the equivalent reactance of busbar loading and referred system.

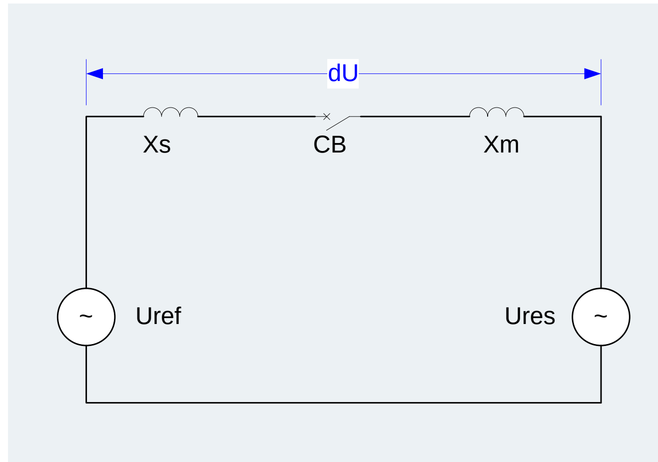


Fig. 11/62 Equivalent circuit of dU

For safety reason, the value |Um| must not exceed the permissible voltage ko/v · |Un.|, Then, the maximum of permissible differential voltage |dU|max will be,

$$|dU|max = ko/v /k \cdot |Un| \qquad \text{(Equa.-2)}$$

In case ko/v = 1.1 and k = 0.67, the calculated |dU|max should be less than 1.64 · |Un| (refer to curve B in Fig. 11/107).
In case ko/v = 1.1 and k = 0.95, the calculated |dU|max should be less than 1.15 · |Un| (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 IV)
– IN-PHASE transfer mode (area V)
– 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 |Ures| 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"**

– |Ures| > 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 |Ures| 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"**

– |Ures| > 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 If all the quantity of predicted dj, the real-time df and |Ures| 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"**

– |Ures| > 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 |Ures| 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%Un.

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.

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 Un-derfrequency	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 Un-derfrequency	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.

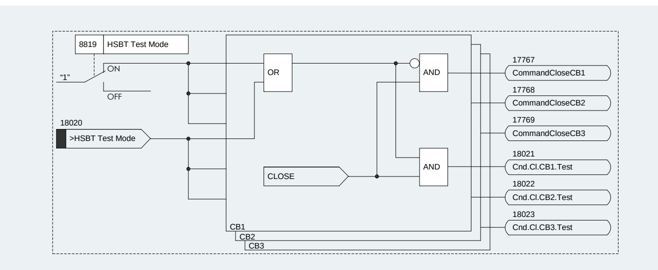


Fig. 11/63 Logic diagram of test mode

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

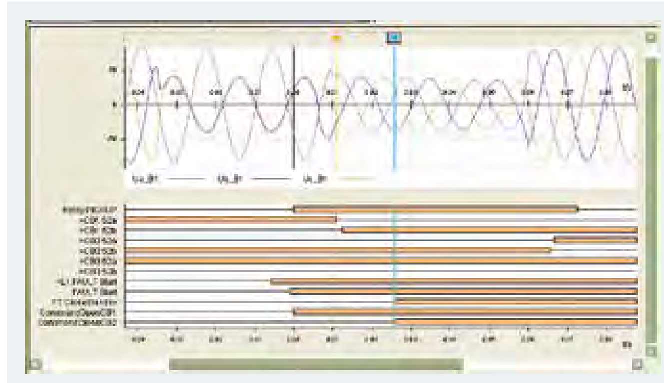
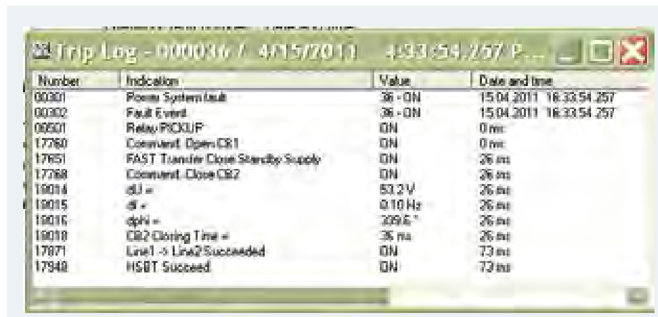


Fig. 11/64 Oscillographic FAST transfer at segmented single busbar



Trip Log - 000036 / 4/15/2011 4:33:54.257 P...

Number	Indication	Value	Date and time
00301	Power System fault	36 - ON	15.04.2011 16:33:54.257
00302	Fault Event	36 - ON	15.04.2011 16:33:54.257
00501	Relay PICKUP	ON	0 ms
17760	Command Open CB1	ON	0 ms
17651	FAST Transfer Close Standby Supply	ON	26 ms
17768	Command Close CB2	ON	26 ms
18014	dU =	53.2 V	26 ms
18015	df =	0.10 Hz	26 ms
18016	dphi =	309.6 °	26 ms
18018	CB2 Closing Time =	36 ms	26 ms
17871	Line1 -> Line2 Succeeded	ON	73 ms
17948	HSBT Succeed	ON	73 ms

Fig. 11/65 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

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.

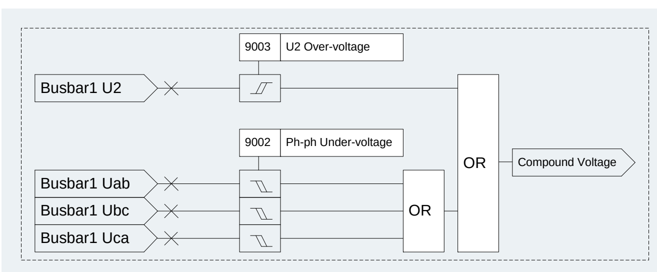


Fig. 11/66 Logic of compound voltage element

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- overcurrent 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 esigned for this utilization.

The function has the same criterion and stages to ground- overcurrent 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.

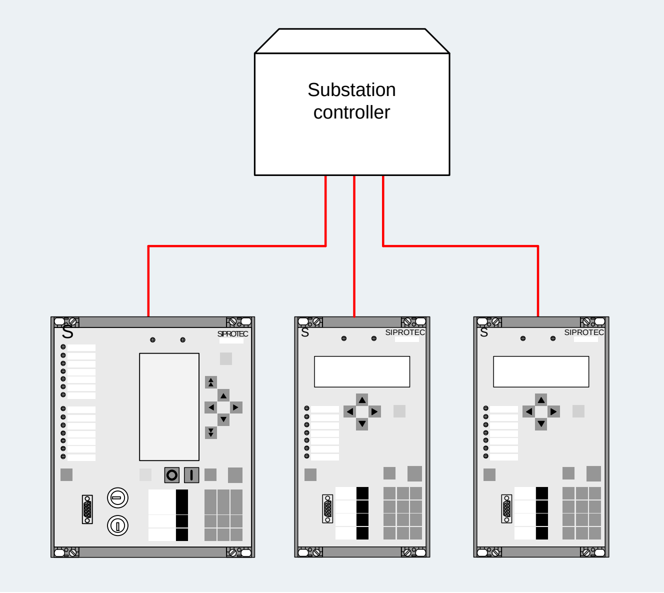


Fig. 11/67 IEC 60870-5-103: Radial electrical or fiber-optic connection

11

High Speed Busbar Transfer – Communication

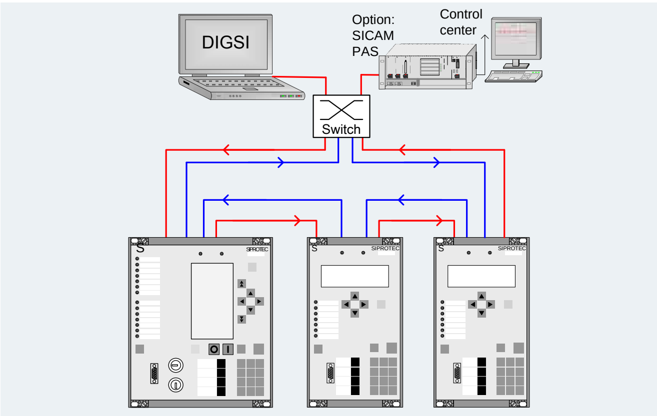


Fig. 11/68 Bus structure for station bus with Ethernet and IEC 61850, fiber-optic ring

Fig. 11/69 Optical Ethernet communication module for IEC 61850 with integrated Ethernet-switch

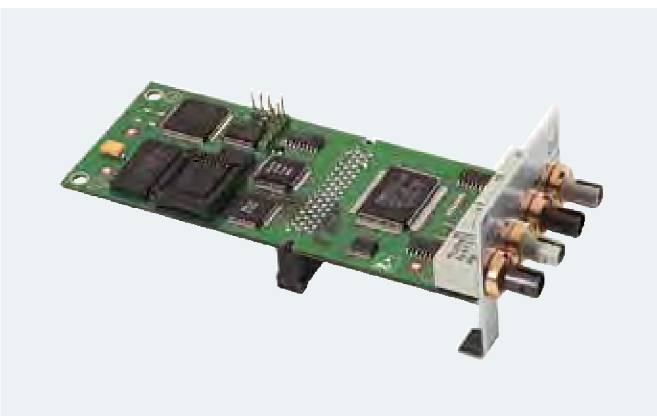


Fig. 11/70 PROFIBUS communication module, optical, double ring

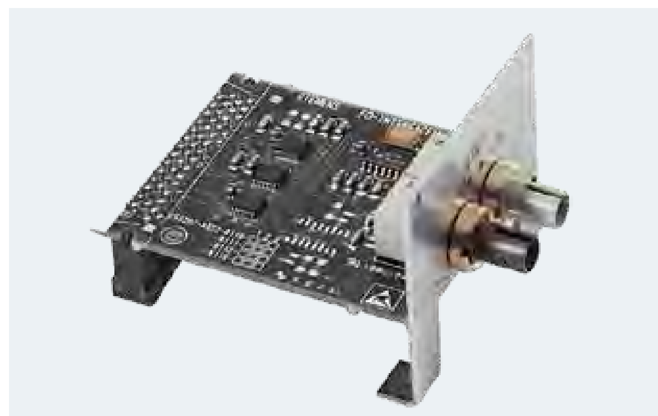


Fig. 11/71 Fiber-optic communication module

Fig. 11/72 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.

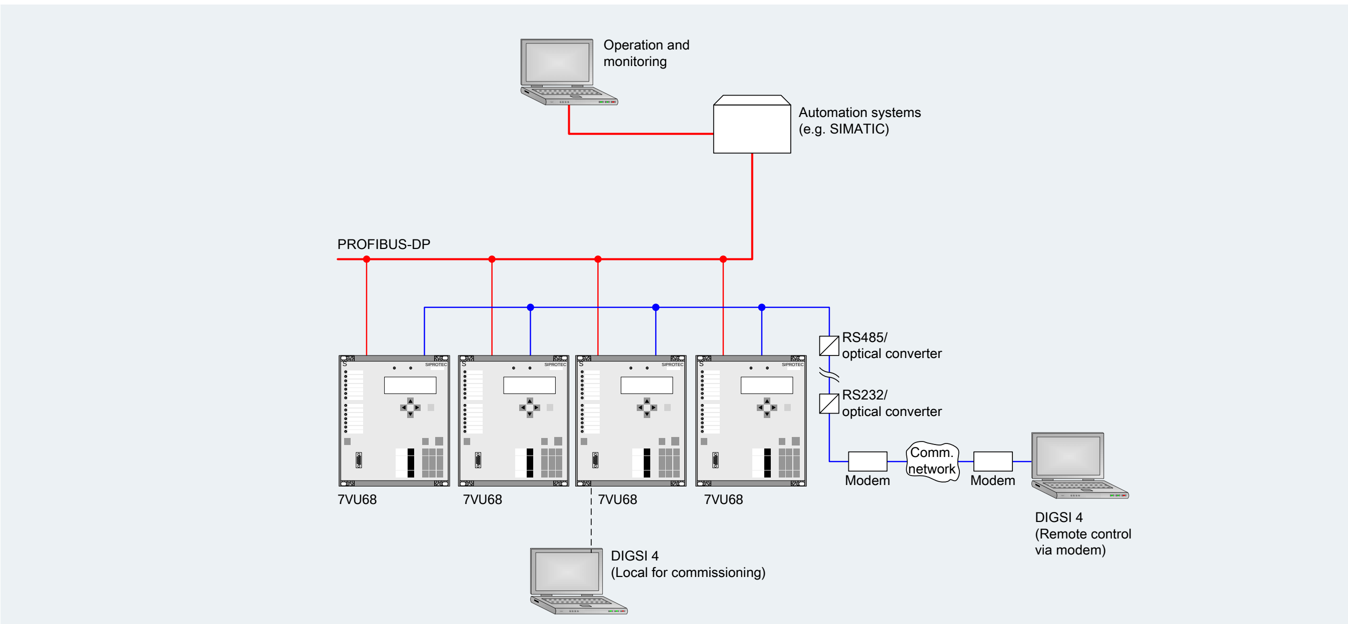


Fig. 11/73 System solution: communication

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.

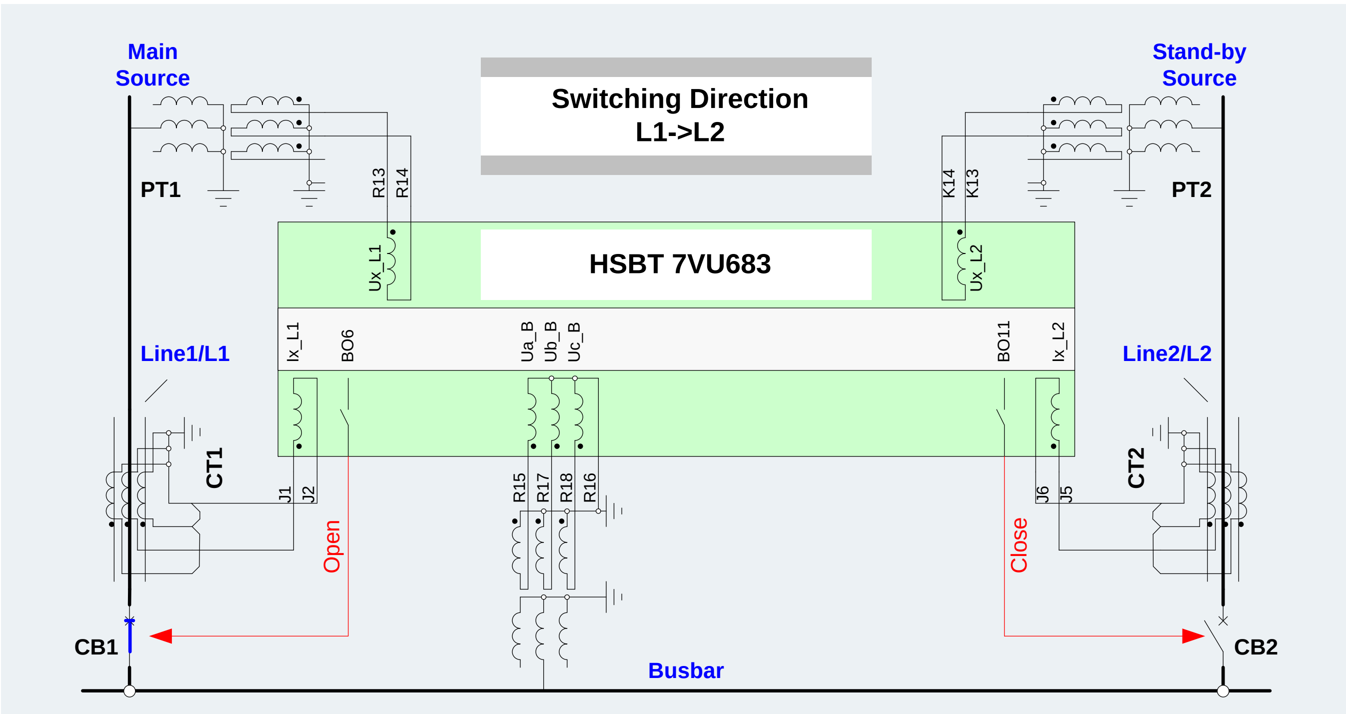


Fig. 11/74 Switching-over L1->L2, single busbar

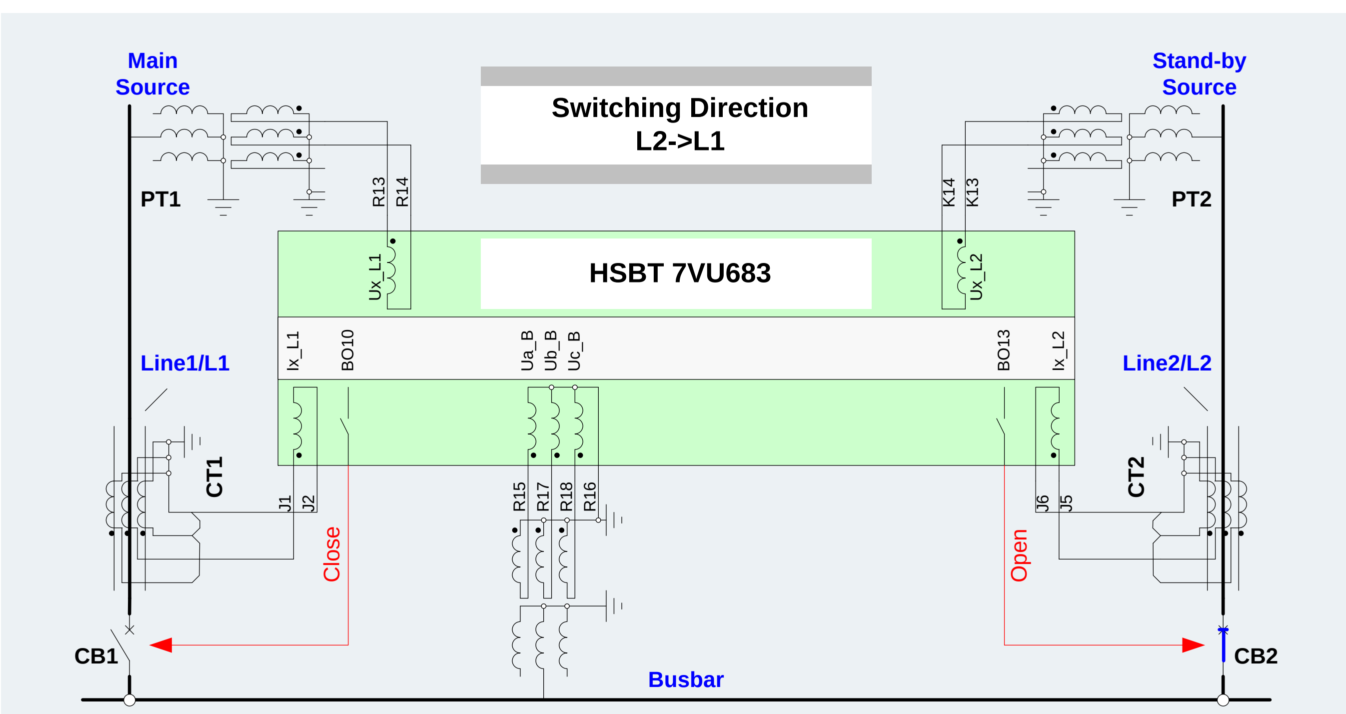


Fig. 11/75 Switching-over L2->L1, single busbar

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.

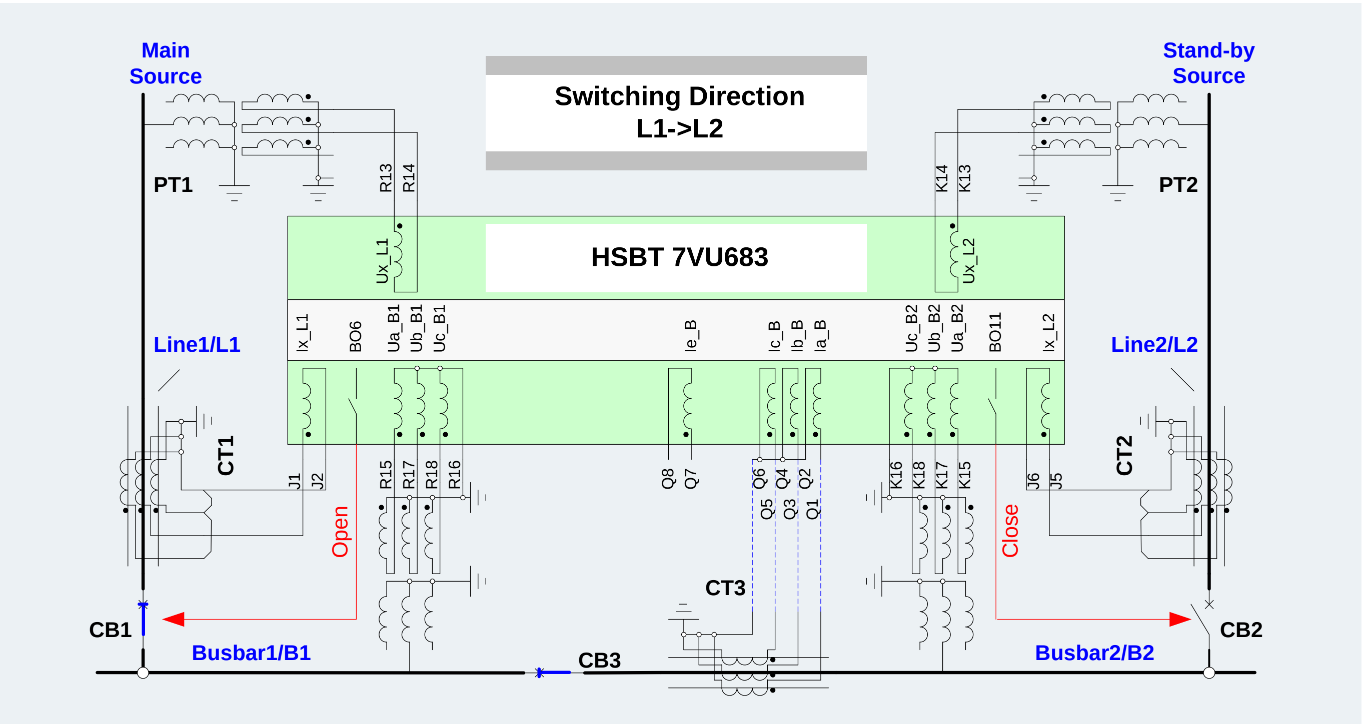


Fig. 11/76 Switching-over L1->L2, segmented single busbar

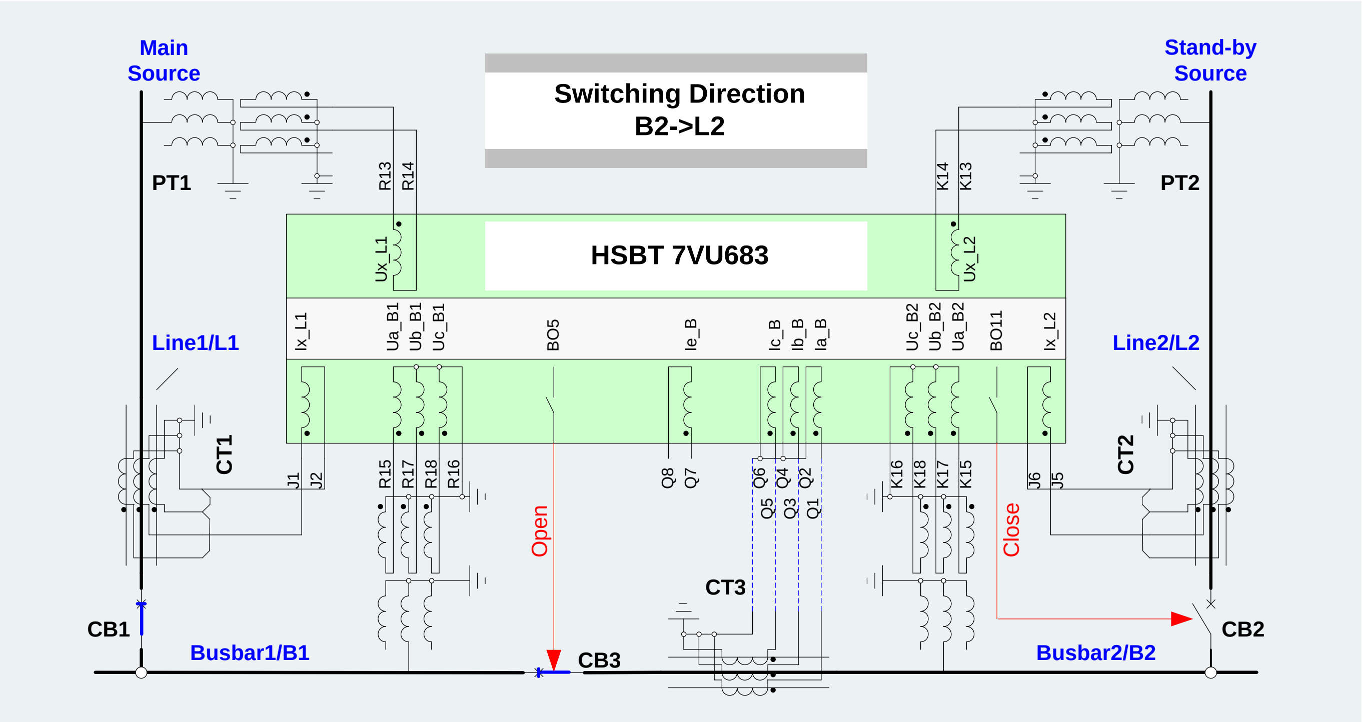


Fig. 11/77 Switching-over B2->L2, segmented single busbar

11

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.

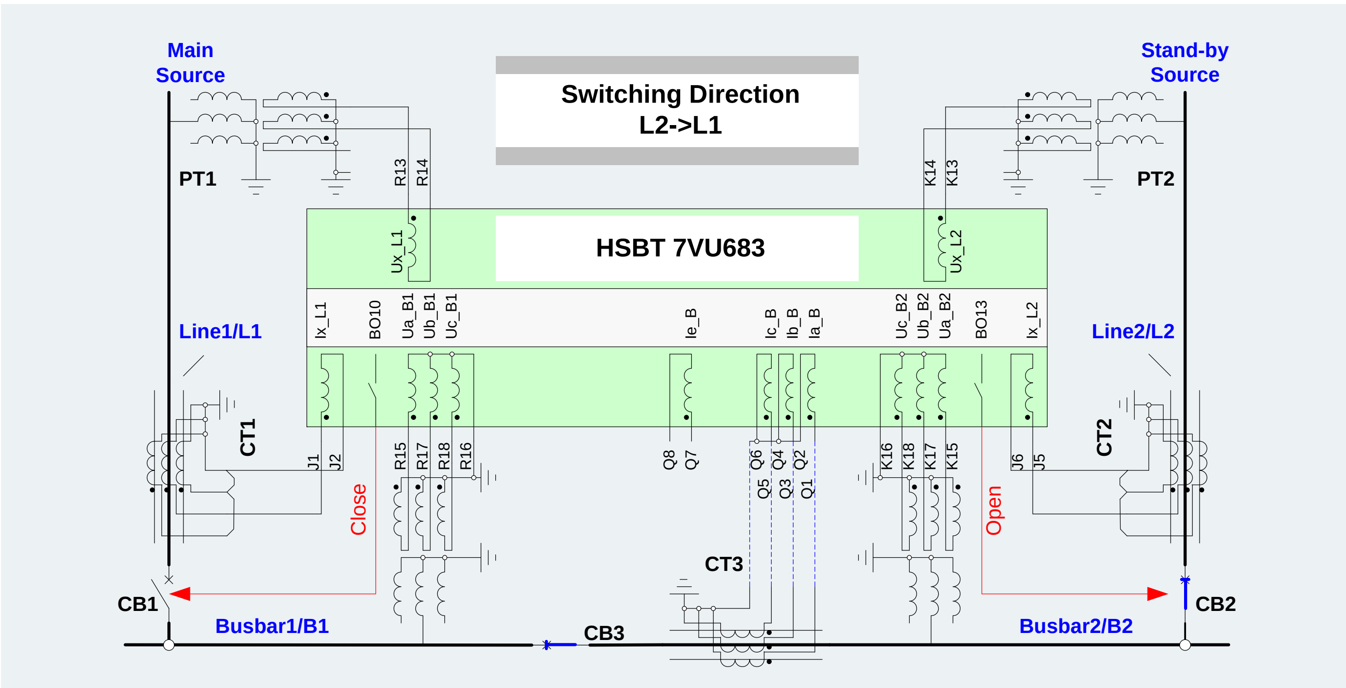


Fig. 11/78 Switching-over L2->L1, segmented single busbar

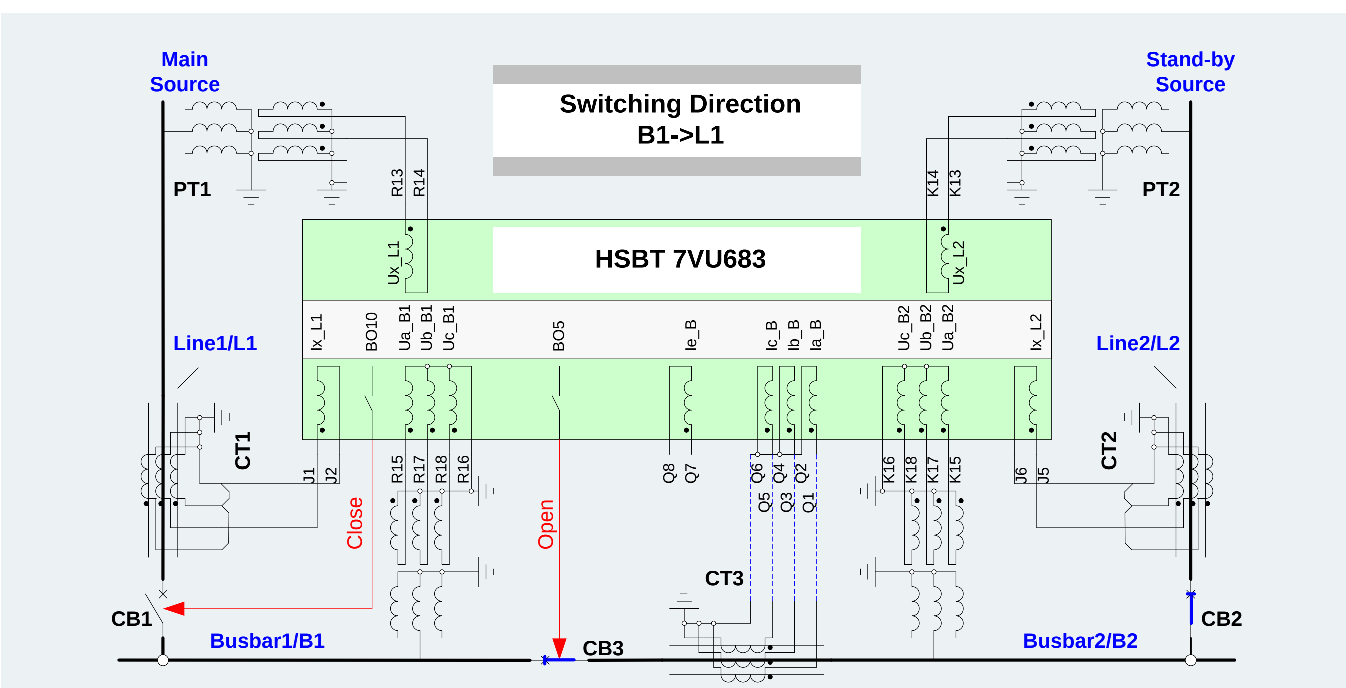


Fig. 11/79 Switching-over B1->L1, segmented single busbar

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.

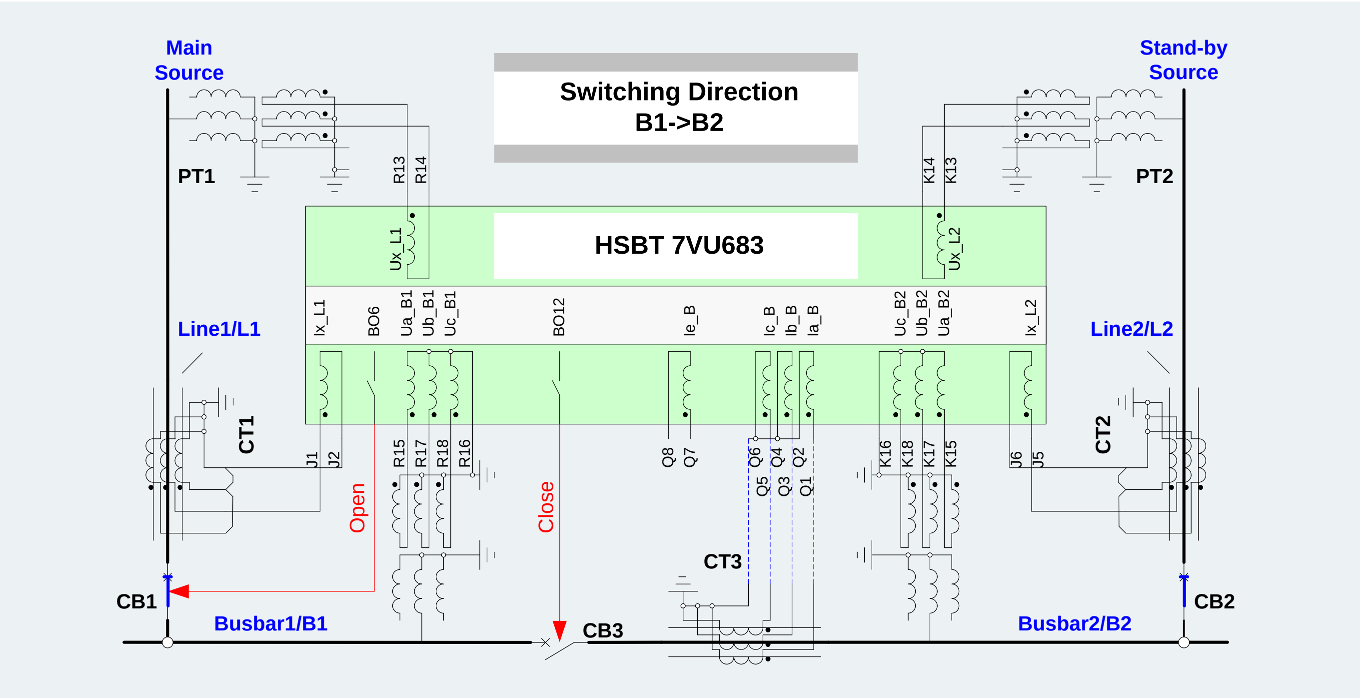


Fig. 11/80 Switching-over B1->B2, segmented single busbar

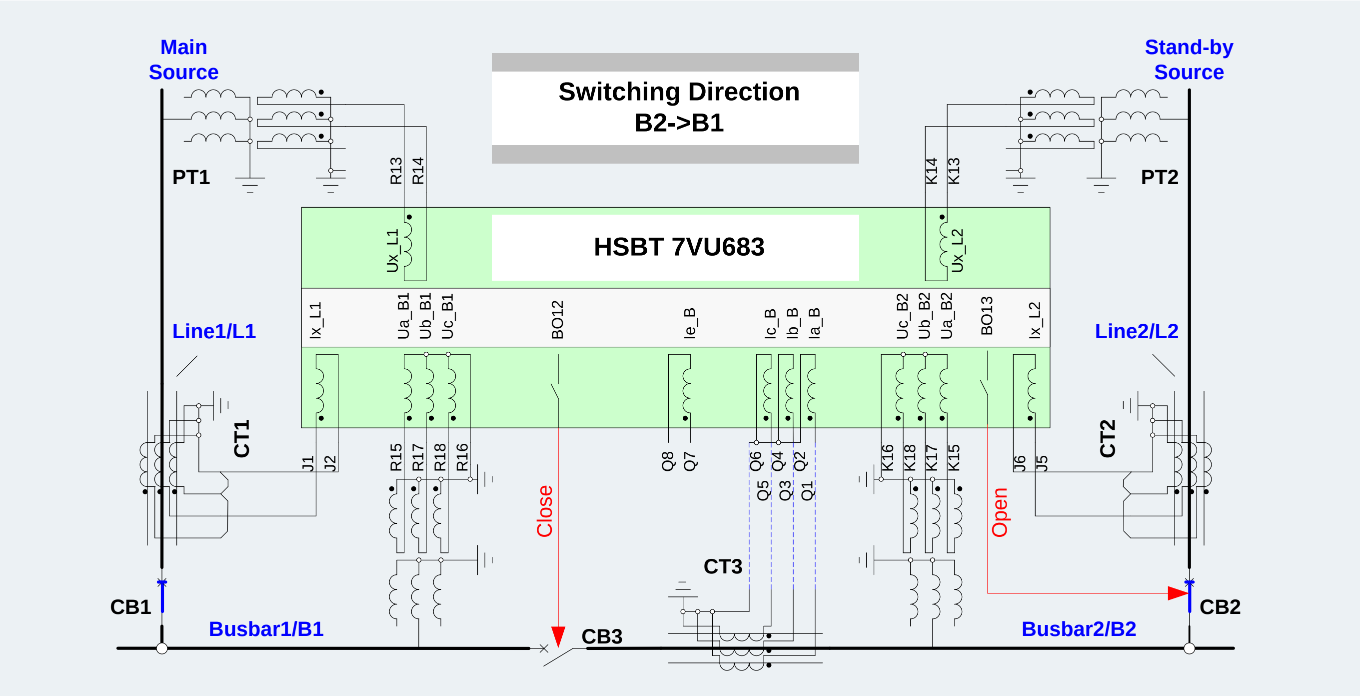


Fig. 11/81 Switching-over B2->B1, segmented single busbar

11

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	L 0 □
Profibus DP Slave, RS485	9	A
Profibus DP Slave, 820 nm fibre, double ring, ST-connector	9	B
Modbus, RS485	9	D
Modbus, 820 nm fibre, ST-connector	9	E
IEC 60870-5-103 Protocol, redundant RS485	9	P
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45-connector	9	R
IEC 61850, 100 Mbit Ethernet, with integrated switch optical, double, LC-connector	9	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.
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

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.

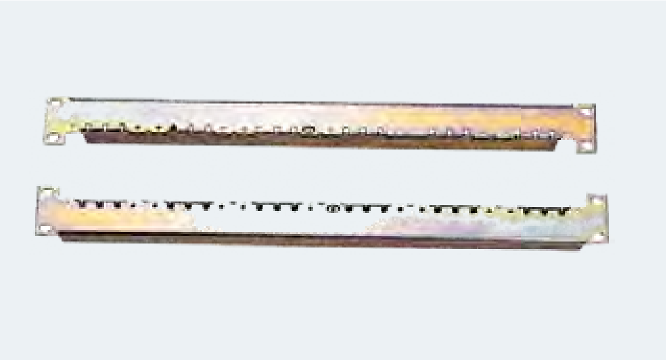


Fig. 11/82 Mounting rail for 19" rack

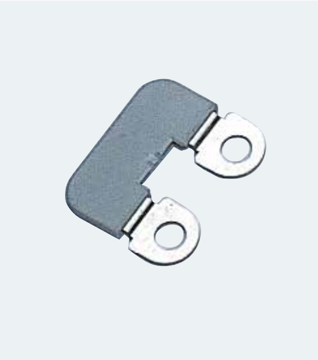


Fig. 11/83 Short-circuit link for current terminals

Fig. 11/84 Short-circuit link for voltage terminals/ indications terminals

High Speed Busbar Transfer – Connection diagram

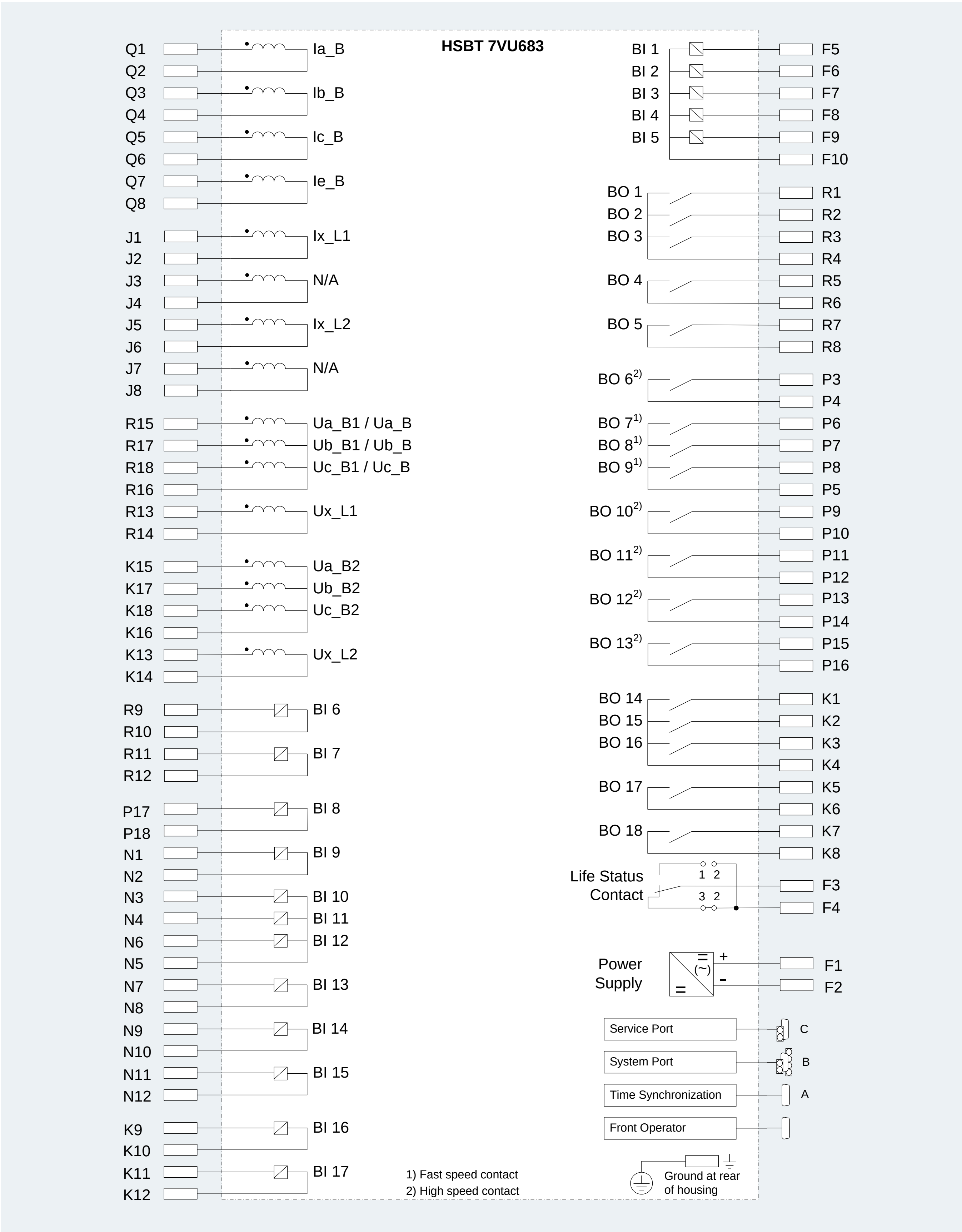


Fig. 11/85 7VU683 connection diagram

Substation Automation

12

SIPROTEC 6MD66 high-voltage bay control unit

Fig. 12/1 SIPROTEC 6MD66 high-voltage bay control unit

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 (± 0.5 %) for voltage, current and calculated values P and Q are another feature of the 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
- 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 φ (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 DP
  - Service interface for DIGSI 4 (modem)
  - Front interface for DIGSI 4
  - Time synchronization via IRIG B/DCF 77

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.

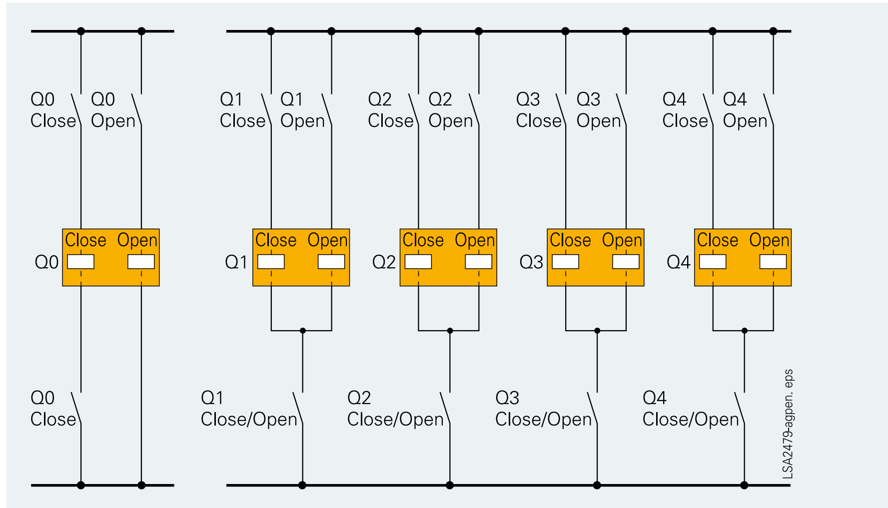


Fig. 12/2 Connection diagram of the switching devices (circuit-breaker 2 poles closed, 1 pole open; disconnector/grounding switch 1½ pole)

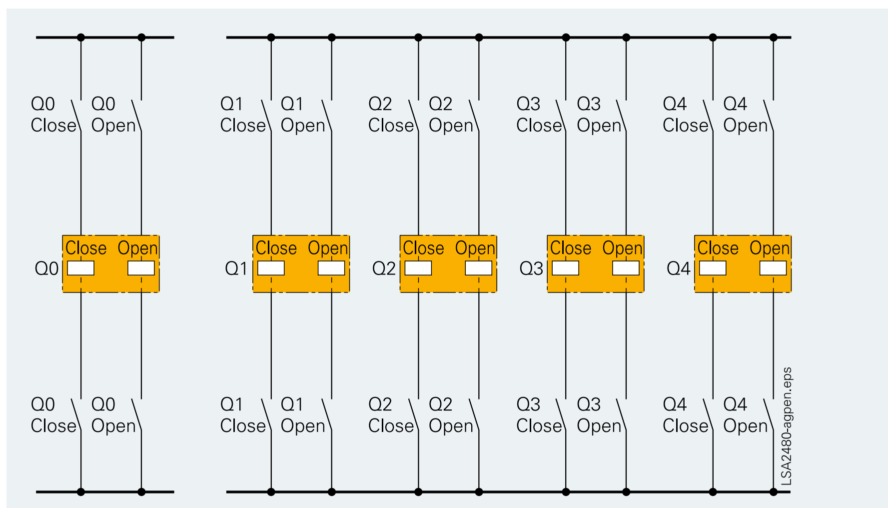


Fig. 12/3 2-pole connection diagram of circuit-breakers and disconnectors

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.

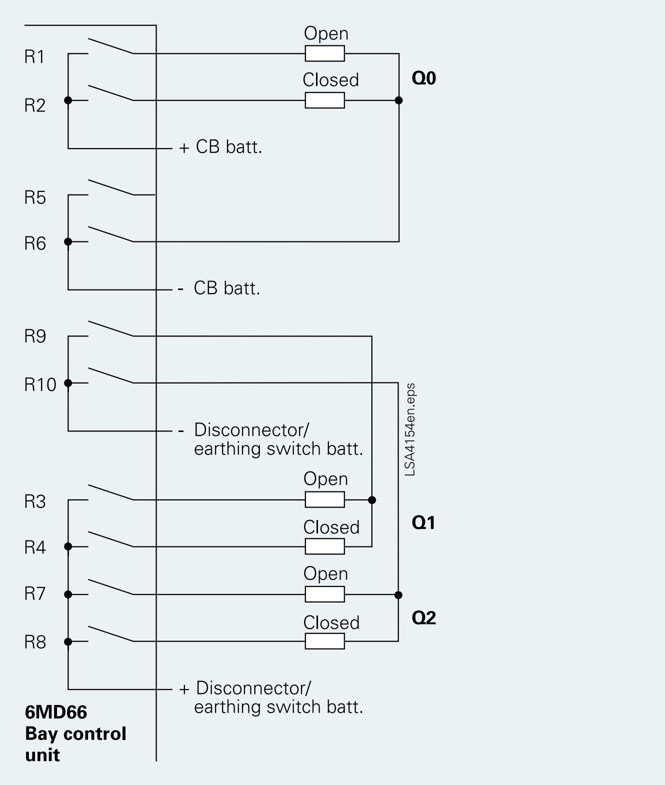


Fig. 12/4 Typical connection for 1½-pole control

12

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.

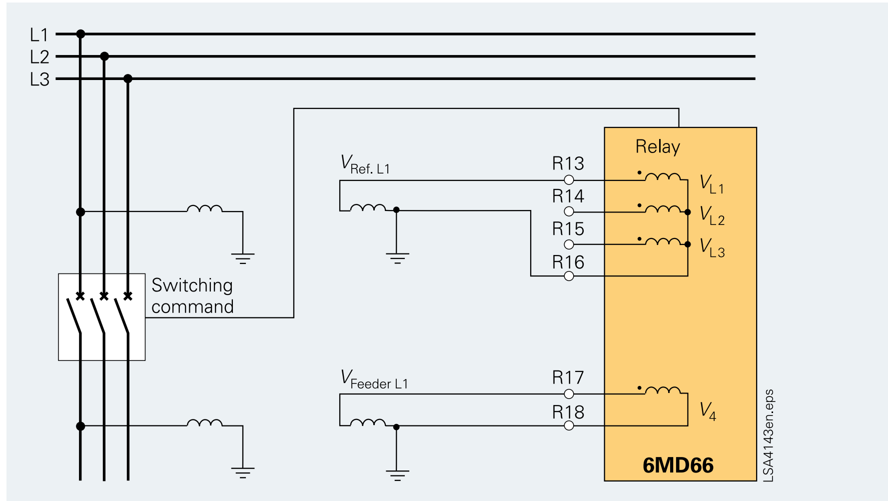


Fig. 12/5 Connection of the measured values for synchronization

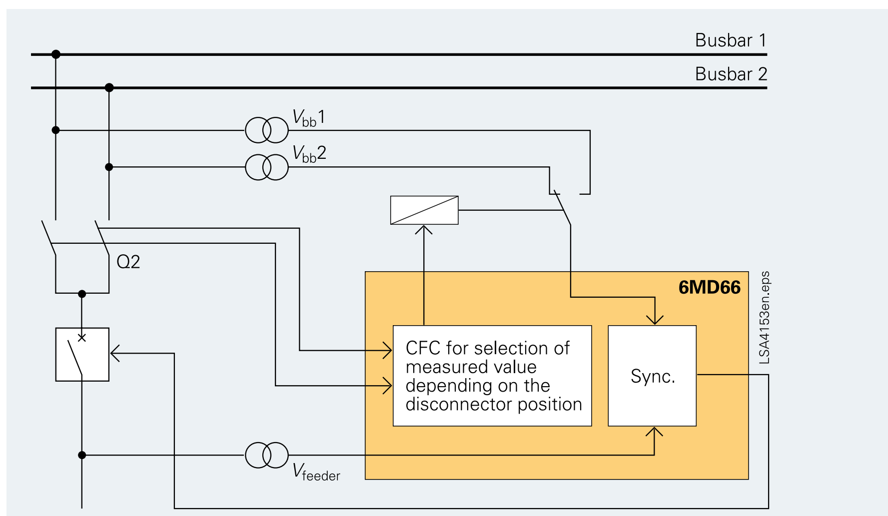


Fig. 12/6 Voltage selection for synchronization with duplicate busbar system

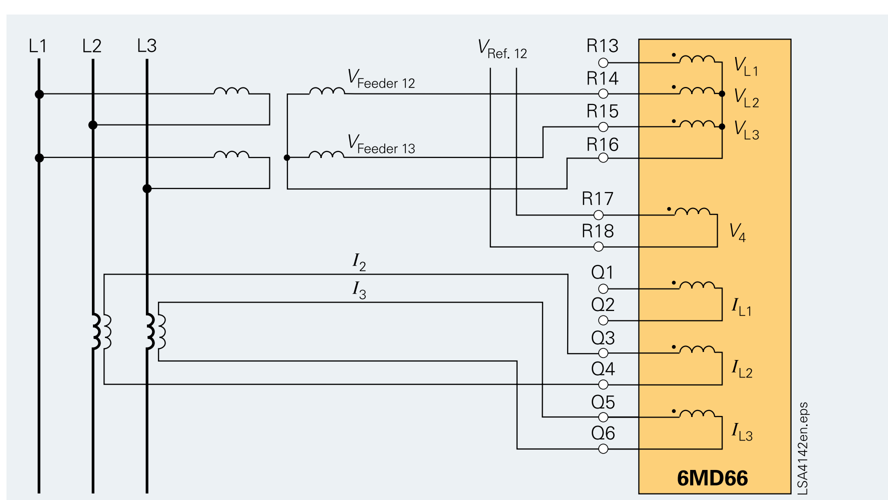


Fig. 12/7 Simultaneous connection of measured values according to a two-wattmeter circuit and synchronization

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.

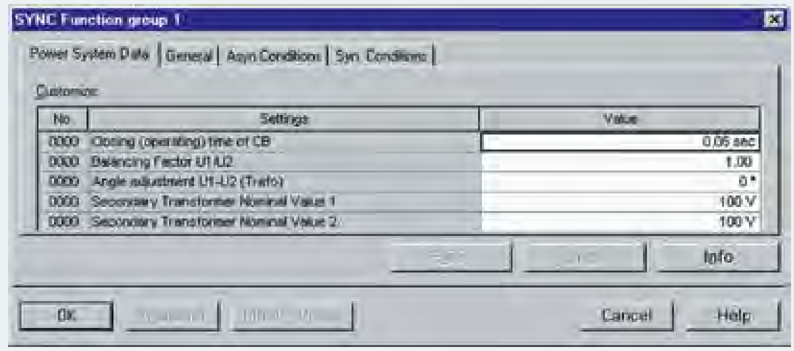


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Fig. 12/8 "Power System Data", sheet for parameters of the synchronization function

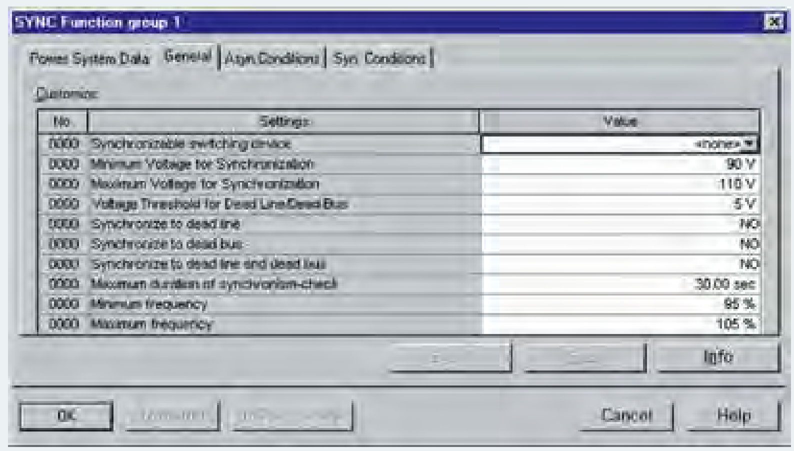

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Fig. 12/9 General parameters of the synchronization function

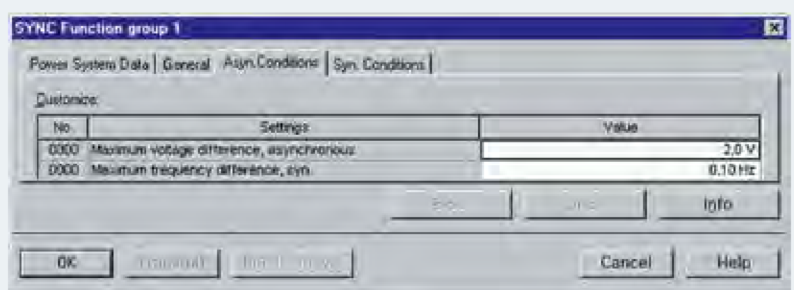

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Fig. 12/10 Parameter page for asynchronous networks

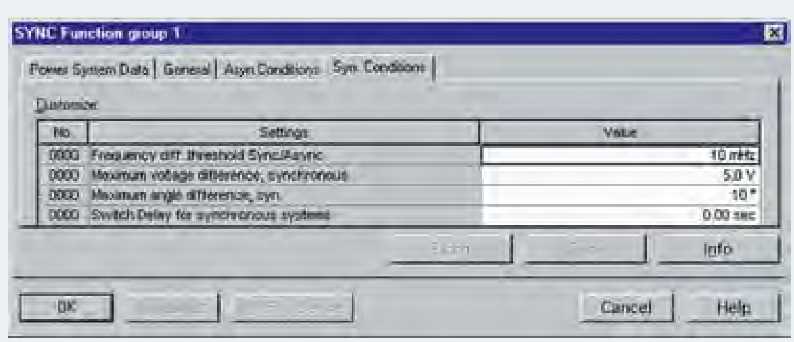

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Fig. 12/11 Parameter page for asynchronous networks

12

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.

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.

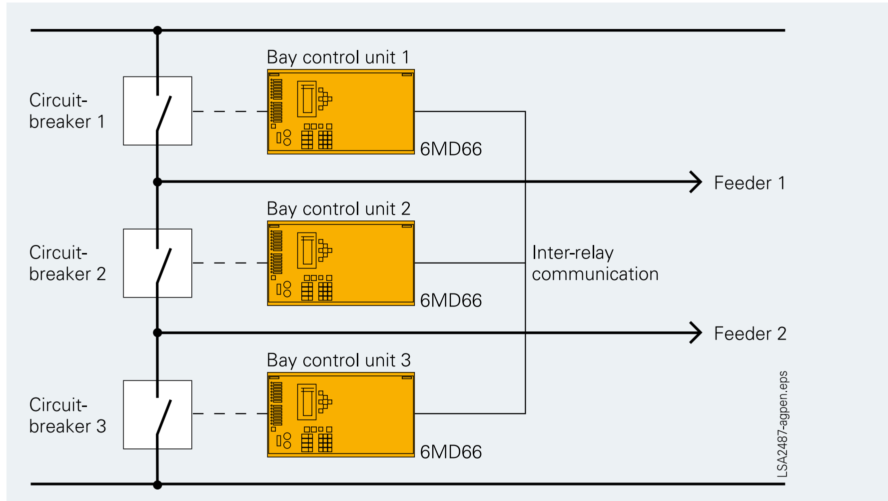

Fig. 12/12 Typical application: 1½ circuit-breaker method (disconnector and grounding switch not shown)

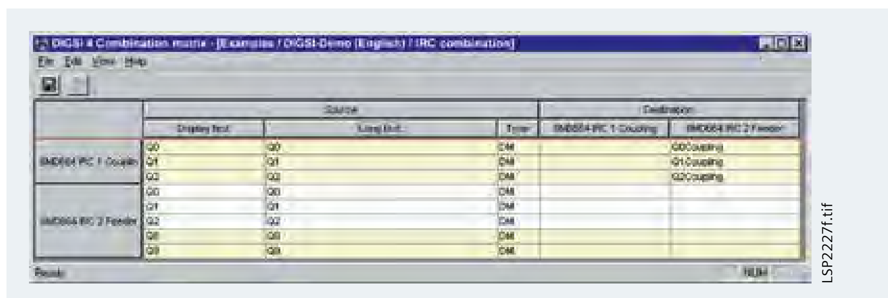

Fig. 12/13 Connection matrix of inter-relay communication in DIGSI 4

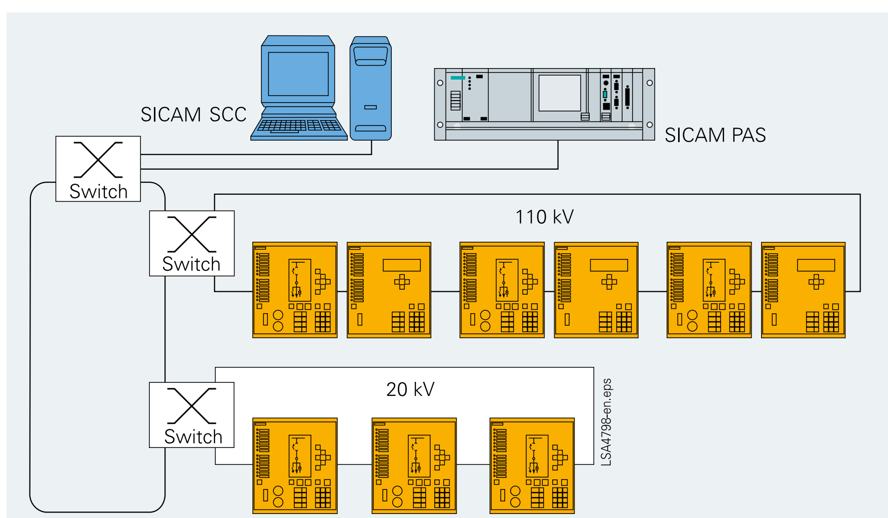

Fig. 12/14 Connection for IEC 61850-GOOSE communication

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).

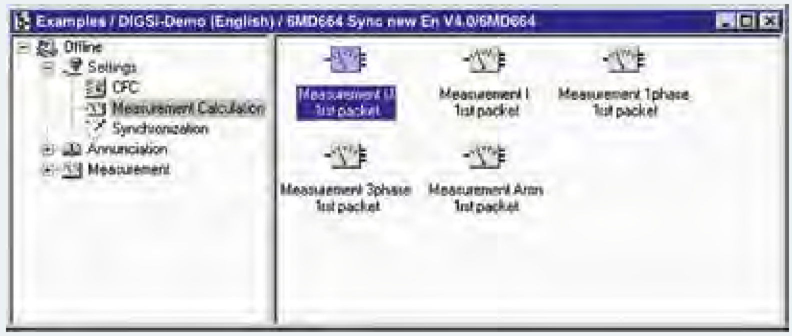

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Fig. 12/15 DIGSI 4 Parameter view – transducer packets

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 *φ* (PF), sin *φ*, *f*
Transducer packet 3 phase	x 1	*V*1, *V*2, *V*3, *I*1, *I*2, *I*3	*V*0, *V*1, *V*2, *V*3, *V*12, *V*23, *V*31, *I*0, *I*1, *I*2, *I*3, *P*, *Q*, *S*, *φ*, cos *φ* (PF), sin *φ*, *f*
Transducer packet two-wattmeter circuit	x 1	*V*1, *V*2, *I*1, *I*2	*V*12, *V*13, *I*2, *I*3, *P*, *Q*, *S*, *φ*, cos *φ* (PF), sin *φ*, *f*

Table 12/1 Properties of measured-value processing

Sample presentation of the measured value display.

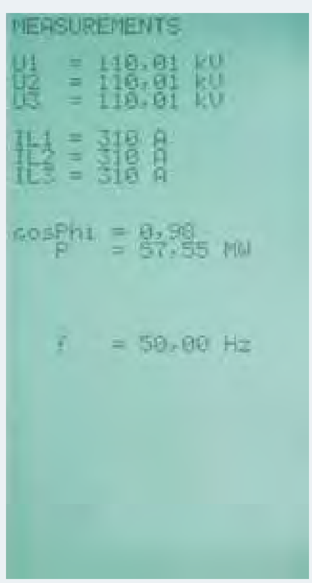

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Fig. 12/16

12

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.

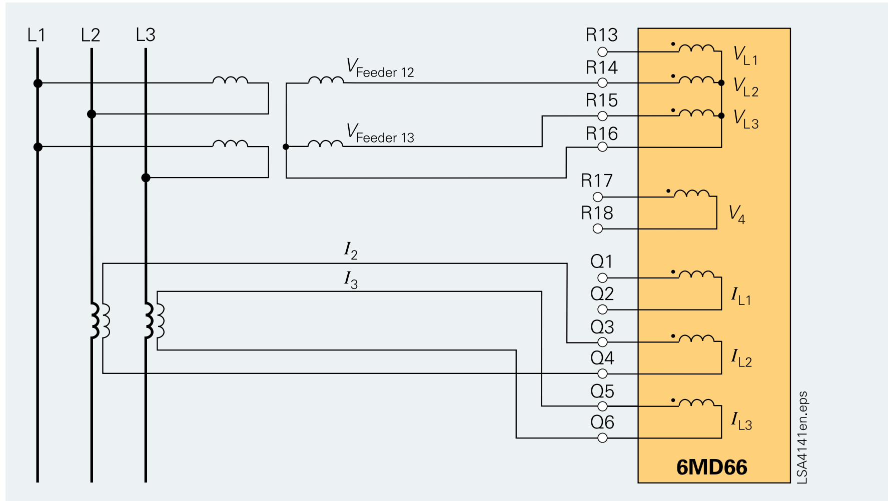


Fig. 12/17 Two-wattmeter circuit (connection to bay control unit)

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 (± kWh, ± 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.

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 retriggered.

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.

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.

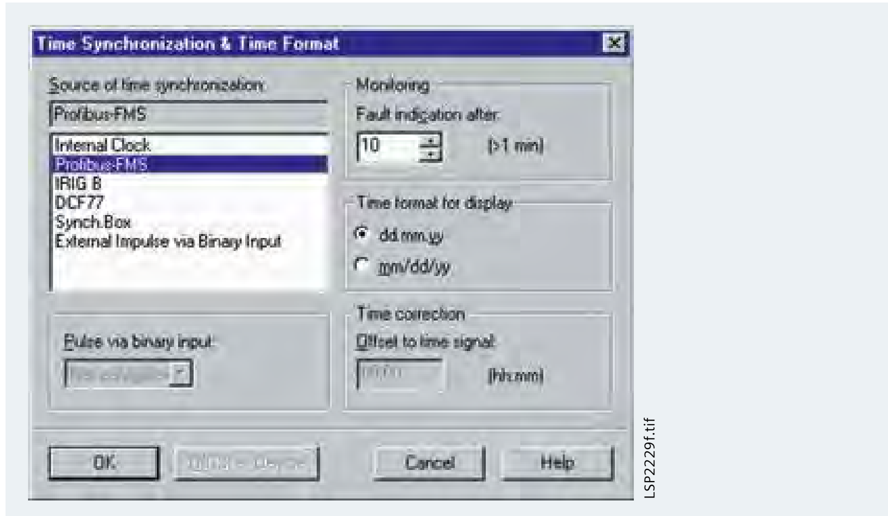


Fig. 12/18 Parameterization of time management

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 DP 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.

Technical data

General unit data	
Analog inputs	
Rated frequency	50 or 60 Hz (adjustable, depending on the order number)
Rated current I_N	1 or 5 A (can be changed via plug-in jumper)
Rated voltage V_N	100 V, 110 V, 125 V, 100 V/√3, 110 V/√3 can be adjusted using parameters
Power consumption at I_N = 1 A at I_N = 5 A Voltage inputs	 < 0.1 VA < 0.5 VA < 0.3 VA with 100 V
Measurement range current I	Up to 1.2 times the rated current
Thermal loading capacity	12 A continuous, 15 A for 10 s, 200 A for 1 s
Measurement range voltage V	Up to 170 V (rms value)
Max. permitted voltage	170 V (rms value) continuous
Transducer inputs Measurement range Max. permitted continuous current	 ± DC 24 mA ± DC 250 mA
Input resistance, recorded power loss at 24 mA	10 Ω ± 1 % 5.76 mW
Power supply	
Rated auxiliary voltages	DC 24 to 48 V, DC 60 to 125 V, DC 110 to 250 V
Permitted tolerance	-20 % to +20 %
Permitted ripple of the rated auxiliary voltage	15 %
Power consumption Max. at DC 60 to 250 V Max. at DC 24 to 48 V Typical at DC 60 to 250 V Typical at DC 24 to 48 V (typical = 5 relays picked up + live contact active + LCD display illuminated + 2 interface cards plugged in)	 20 W 21.5 W 17.5 W 18.5 W
Bridging time at DC 24 and 60 V at DC 48 and ≥ 110 V	 ≥ 20 ms ≥ 50 ms
Binary inputs	
Number 6MD662 6MD663 6MD664	 35 50 65
Rated voltage range	DC 24 to 250 V (selectable)
Pick-up value (range can be set using jumpers for every binary input)	DC 17, 73 or 154 V
Function (allocation)	Can be assigned freely
Minimum voltage threshold (presetting) for rated voltage 24, 48, 60 V for rated voltage 110 V for rated voltage 220, 250 V	 DC 17 V DC 73 V DC 154 V
Maximum permitted voltage	DC 300 V
Current consumption, excited for 3 ms	approx. 1.5 mA approx. 50 mA to increase pickup time
Permitted capacitive coupling of the indication inputs	220 nF
Minimum impulse duration for message	4.3 ms

Output relay	
Live contact	1 NC/NO (can be set via jumper: Factory setting is "Break contact", i.e. the contact is normally open but then closes in the event of an error)
Number of command relays, single pole 6MD662	 25, grouping in 2 groups of 4, 1 group of 3, 6 groups of 2 and two ungrouped relays
6MD663	35, grouping in 3 groups of 4, 1 group of 3, 9 groups of 2 and two ungrouped relays
6MD664	45, grouping 4 groups of 4, 1 group of 3, 12 groups of 2 plus two ungrouped relays
Switching capacity, command relay Make Break Break (at L/R ≤ 50 ms) Max. switching voltage Max. contact continuous current Max. (short-duration) current for 4 s	 max. 1000 W/ VA max. 30 VA 25 VA 250 V 5 A 15 A
Switching capacity, live contact ON and OFF Max. switching voltage Max. contact continuous current	 20 W/VA 250 V 1 A
Max. make-time	8 ms
Max. chatter time	2.5 ms
Max. break time	2 ms
LED	
Number RUN (green) ERROR (red) Display (red), function can be allocated	 1 1 14
Unit design	
Housing 7XP20	For dimensions drawings, see part 14
Type of protection acc. to EN60529 in the surface-mounting housing in the flush-mounting housing front rear	 IP20 IP51 IP20
Weight	
Flush-mounting housing, integrated local control 6MD663 6MD664	 approx. 10.5 kg approx. 11 kg
Surface-mounting housing, without local control, with assembly angle 6MD663 6MD664	 approx. 12.5 kg approx. 13 kg
Detached local control	approx. 2.5 kg

Electrical tests	
Specifications	
Standards	IEC 60255 (product standards) ANSI/IEEE C37.90.0/.1/.2 DIN 57435 Part 303 For further standards see specific tests
Insulation tests	
Standards	IEC 60255-5 and IEC 60870-2-1
Voltage test (100 % test) All circuits except for auxiliary supply, binary inputs, communication and time synchronization 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 communication 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
EMC tests for noise immunity; type test	
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 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 frequency 300 ms; both polarities; R_i = 50 Ω; test duration 1 min
High-energy surge voltages (SURGE), IEC 61000-4-5 installation class III	Impulse: 1.2/50 µs
Auxiliary supply	common mode: 2 kV; 12 Ω, 9 µF differential mode:1 kV; 2 Ω, 18 µF
Measurement inputs, binary inputs and relay outputs	common mode: 2 kV; 42 Ω, 0.5 µF differential mode: 1 kV; 42 Ω, 0.5 µF
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 Ω
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 Ω
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

12

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 °C	25 to 131 °F
Temporary permissible temperature limit during operation (The legibility of the display may be impaired above 55 °C/131 °F)	-20 to +70 °C	-4 to 158 °F
Limit temperature during storage	-25 to +55 °C	-13 to 131 °F
Limit temperature during transport Storage and transport with standard factory packaging	-25 to +70 °C	-13 to 158 °F
Humidity		
Permissible humidity stress 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	Annual average ≤ 75 % relative humidity; on 56 days a year up to 93 % relative humidity; condensation during operation is not permitted	

Futher information can be found in the current manual at: www.siemens.com/siprotec

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:		see next page
Number of inputs and outputs		
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 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 andD)		
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.

12

Selection and ordering data

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	

Description	Order No.	Order code
6MD66 high-voltage bay control unit	**6MD66□□-□□□□□-0□□□-□□□**	
Processor module with power supply, input/output modules with a total of:		see next page
Number of inputs and outputs		
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 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.

12

Selection and ordering data

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).

12

Bay unit 6MD662

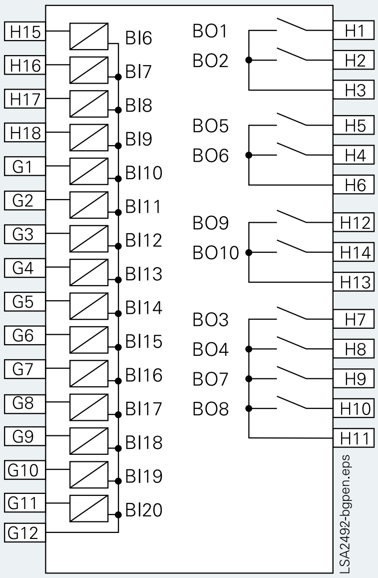


Fig. 12/19 Module 1, indications, commands

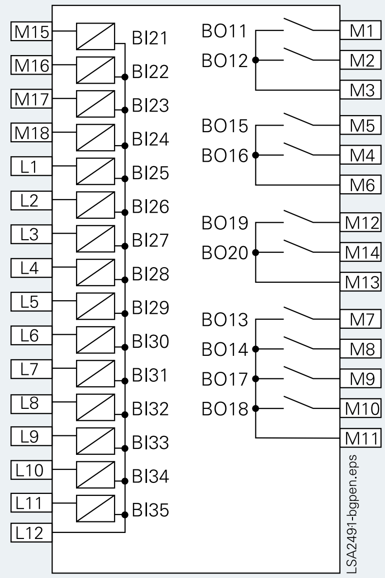


Fig. 12/20 Module 2, indications, commands

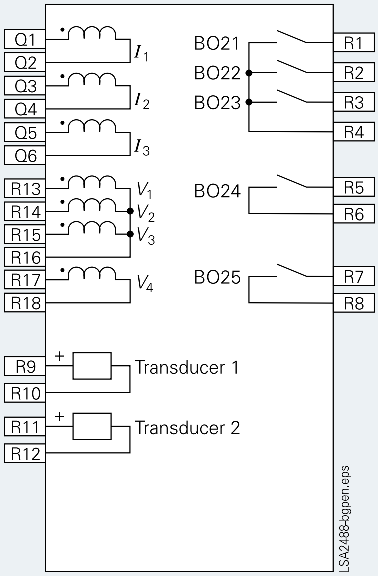
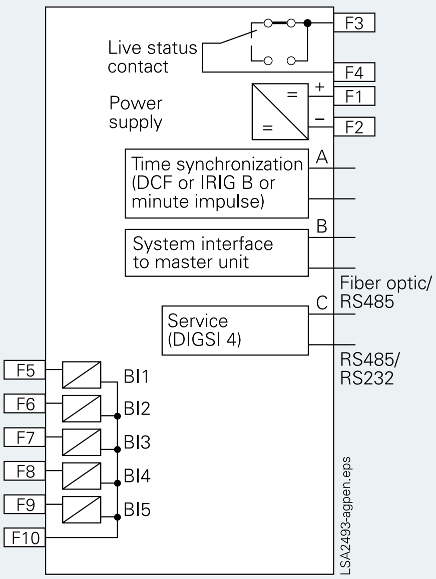


Fig. 12/21 Module 4, measuring values commands

12

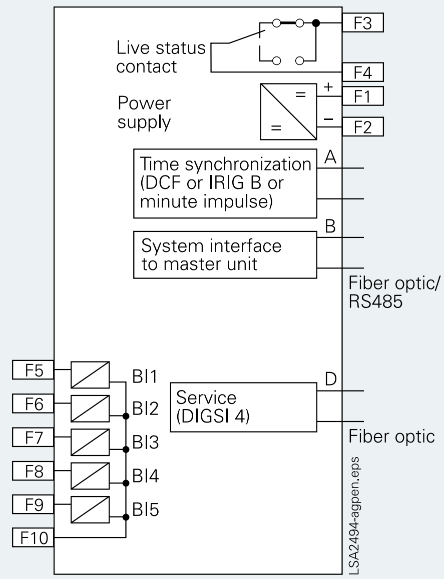
Connection diagrams

Bay unit 6MD662



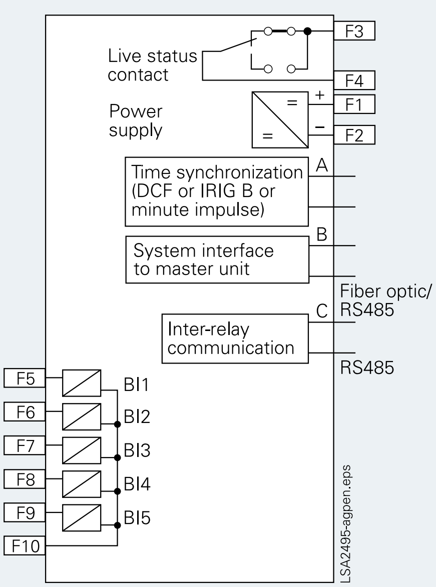
or

Fig. 12/22 CPU, C-CPU 2
For unit 6MD662*-****1-0AA0 and 6MD662*-****2-0AA0
(DIGSI interface, electrical, system interface optical or electrical)



or

Fig. 12/23 CPU, C-CPU 2
For unit 6MD662*-****3-0AA0
(DIGSI interface, optical, system interface optical or electrical)



or

Fig. 12/24 CPU, C-CPU 2
For unit 6MD662*-****4-0AA0
(Inter-relay communication interface electrical, system interface optical or electrical)

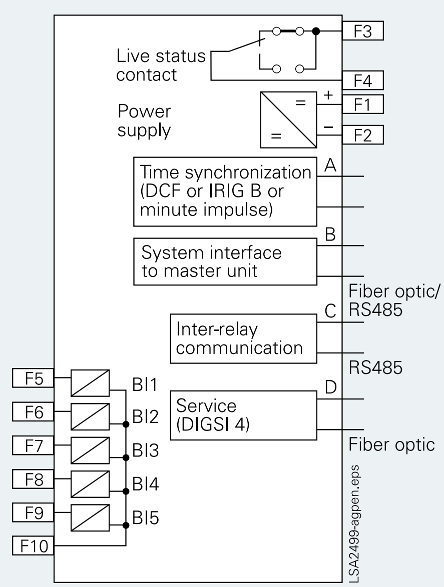


Fig. 12/25 CPU, C-CPU 2
For unit 6MD662*-****5-0AA0
(DIGSI interface, optical, Inter-relay communication interface electrical, system interface optical or electrical)

12

Bay unit 6MD664

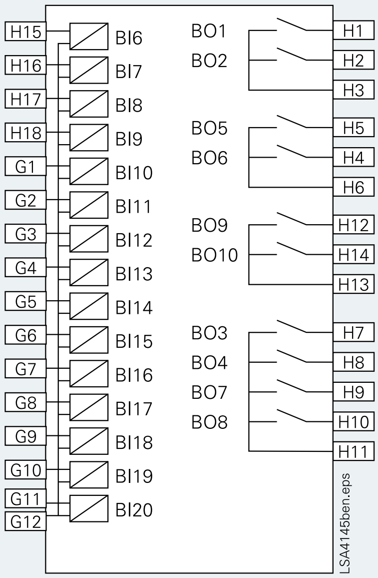


Fig. 12/26 Module 1, indications, commands

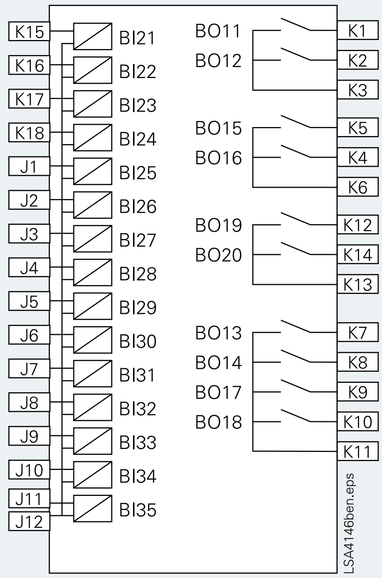


Fig. 12/30 Module 2, indications, commands

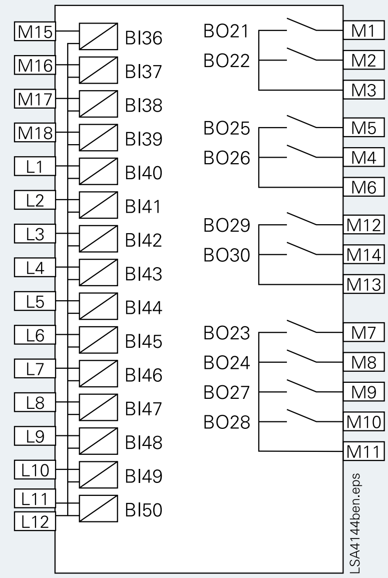


Fig. 12/27 Module 3, indications, commands

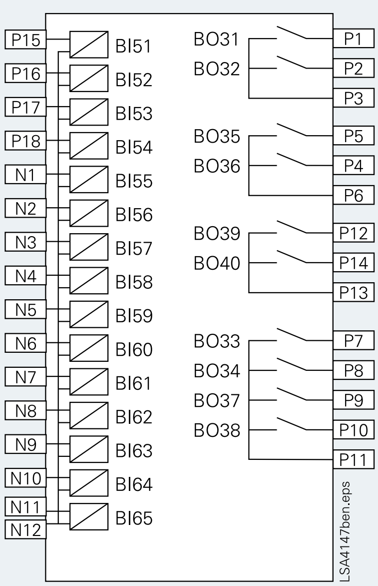


Fig. 12/28 Module 4, indications, commands

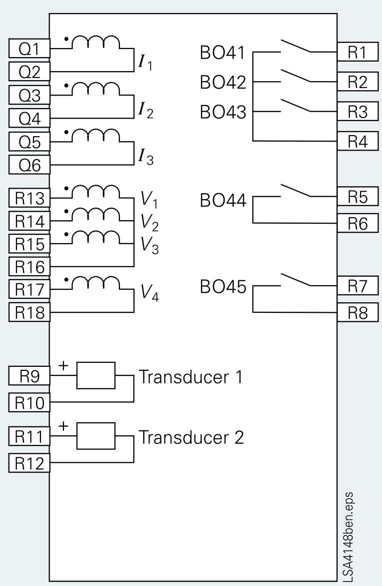
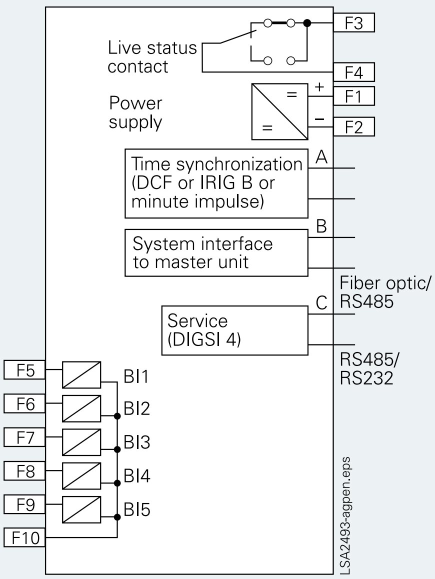


Fig. 12/29 Module 5, measuring values, commands

12

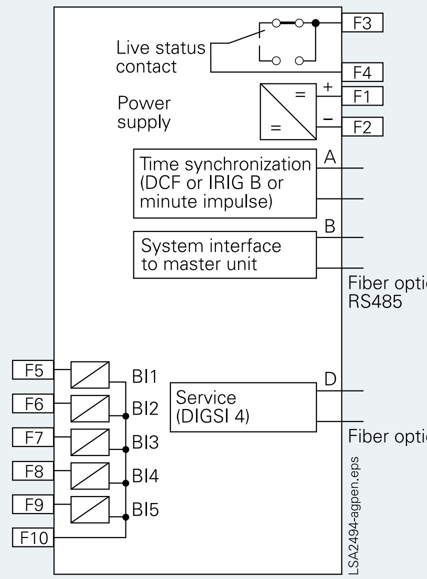
Connection diagrams

Bay unit 6MD664



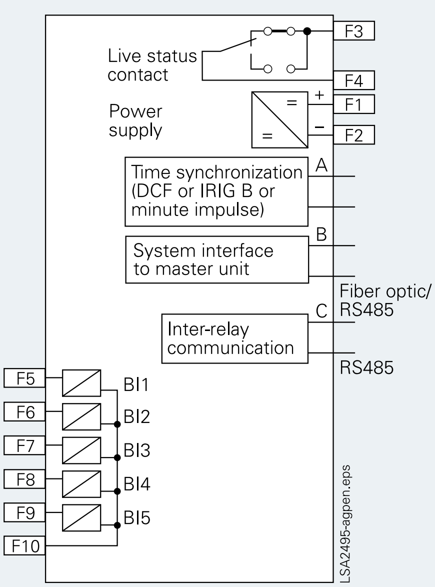
or

Fig. 12/31 CPU, C-CPU 2
For unit 6MD664*-****1-0AA0
and 6MD664*-****2-0AA0
(DIGSI interface electric,
system interface optical optical or electric)



or

Fig. 12/32 CPU, C-CPU 2
For unit 6MD664*-****3-0AA0
(DIGSI interface optical,
system interface optical optical or electric)



or

Fig. 12/33 CPU, C-CPU 2
For unit 6MD664*-****4-0AA0
(Inter-relay communication
interface electric,
system interface optical or electric)

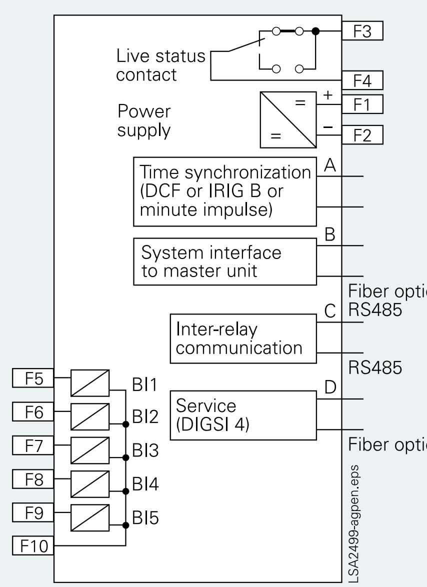
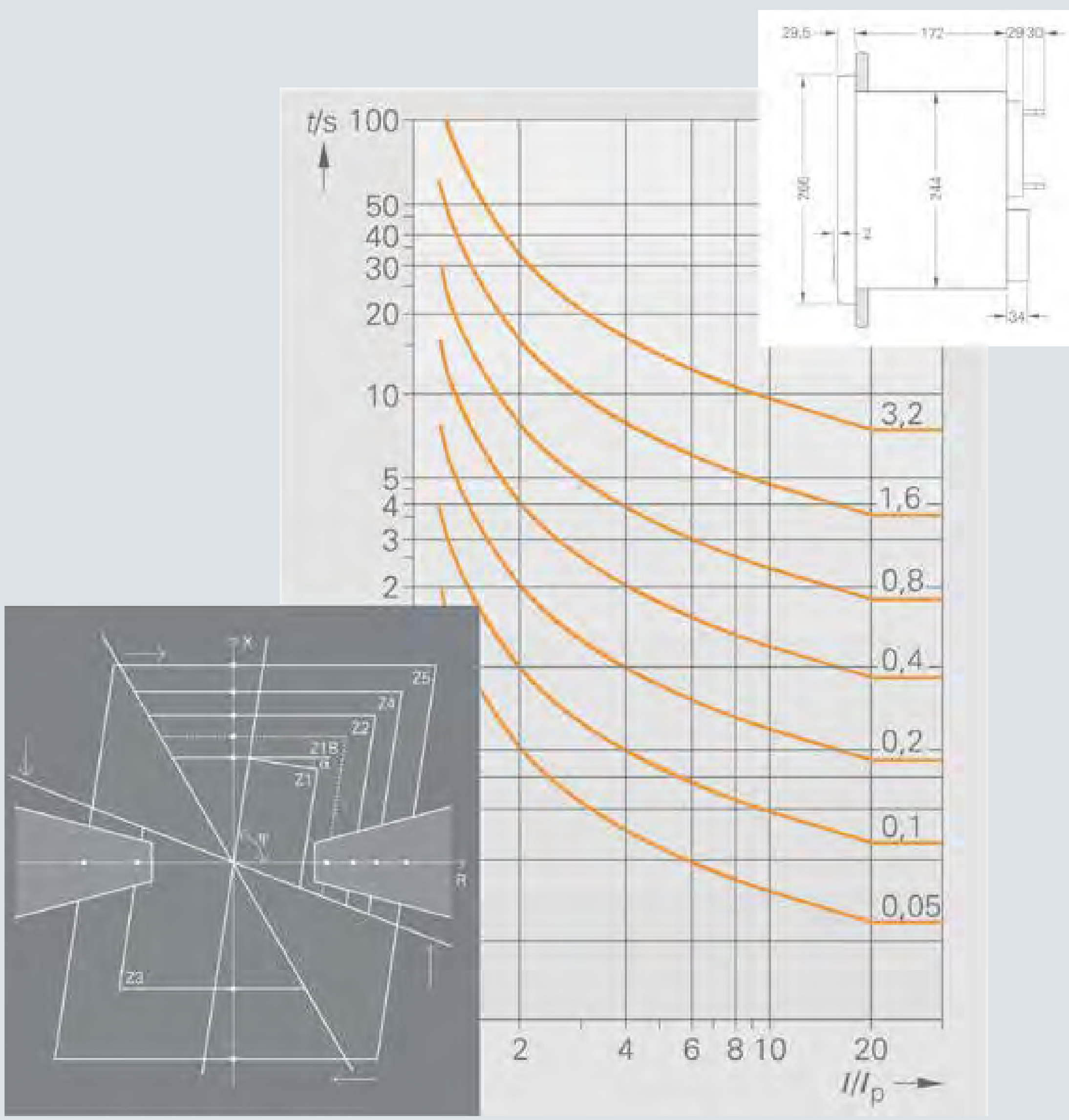


Fig. 12/34 CPU, C-CPU 2
For unit 6MD664*-****5-0AA0
(DIGSI interface optical,
(Inter-relay communication electric,
system interface optical or electric)

Appendix

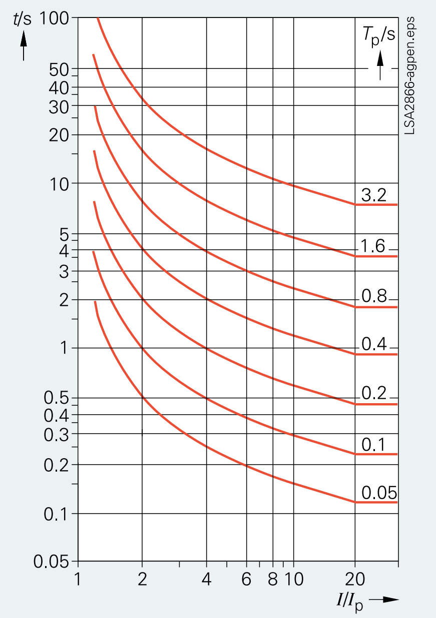


Relay characteristics

Inverse-time characteristics of TOC relays

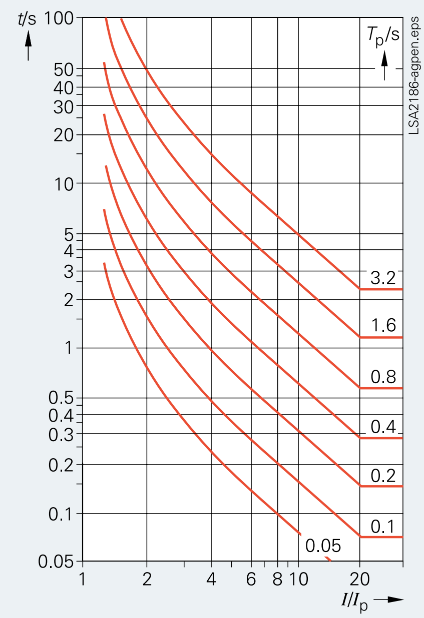
	IEC 60255-3				ANSI/IEEE						
	Normal inverse	Very inverse	Extremely inverse	Long inverse	Inverse	Short inverse	Long inverse	Definite inverse	Moderately inverse	Very inverse	Extremely inverse
Fig.	*13/1*	*13/2*	*13/3*	*13/4*	*13/5*	*13/6*	*13/7*	*13/8*	*13/9*	*13/11*	*13/13*
Relay											
7SD5	■	■	■	■	■	■	■	■	■	■	■
7SD610	■	■	■	■	■	■	■	■	■	■	■
7SJ61	■	■	■	■	■	■	■	■	■	■	■
7SJ62	■	■	■	■	■	■	■	■	■	■	■
7SJ64	■	■	■	■	■	■	■	■	■	■	■
7UM62	■	■	■		■			■	■	■	■
7UT612	■	■	■	■	■	■	■	■	■	■	■
7UT613	■	■	■	■	■	■	■	■	■	■	■
7UT63	■	■	■	■	■	■	■	■	■	■	■

Inverse-time overcurrent protection
characteristics according to IEC 60255 and BS142.



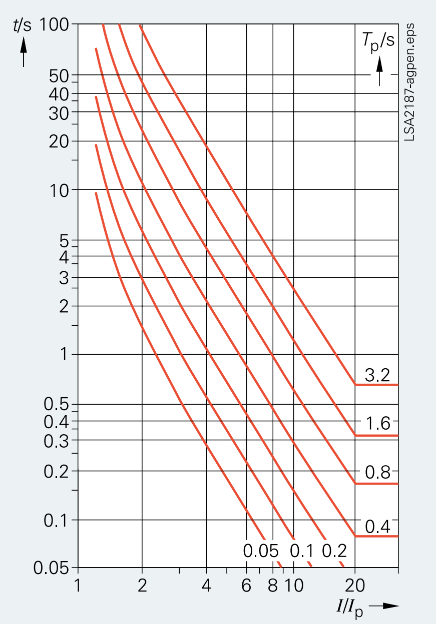
$$t = \frac{0.14}{\left(I/I_p\right)^{0.02} - 1} \cdot T_p$$

Fig. 13/1 Inverse



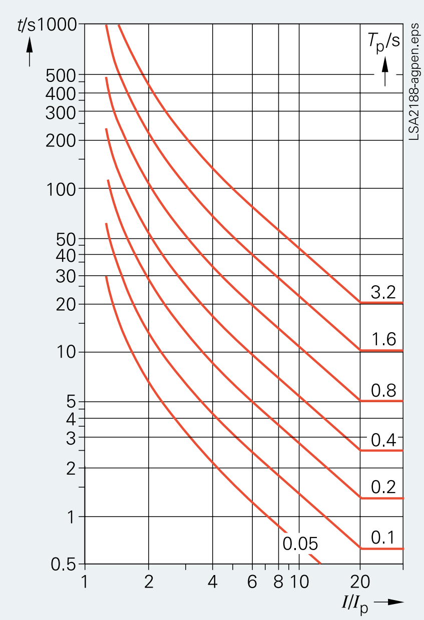
$$t = \frac{1.35}{\left(I/I_p\right) - 1} \cdot T_p$$

Fig. 13/2 Very inverse



$$t = \frac{80}{\left(I/I_p\right)^{2} - 1} \cdot T_p$$

Fig. 13/3 Extremely inverse



$$t = \frac{120}{\left(I/I_p\right) - 1} \cdot T_p$$

Fig. 13/4 Long inverse

13

I = current

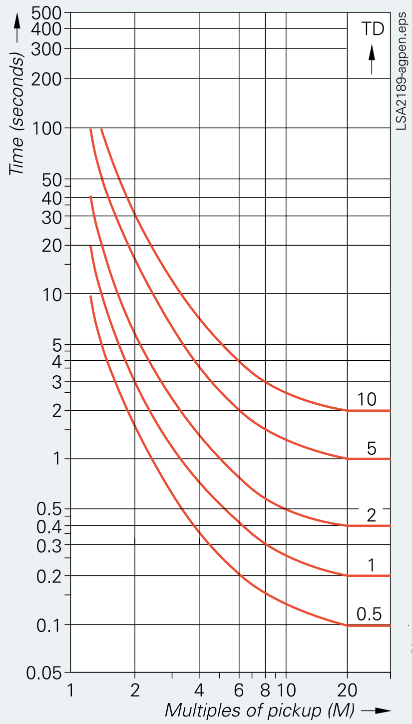
t = tripping time

I_p = pickup setting

T_p = time multiplier setting

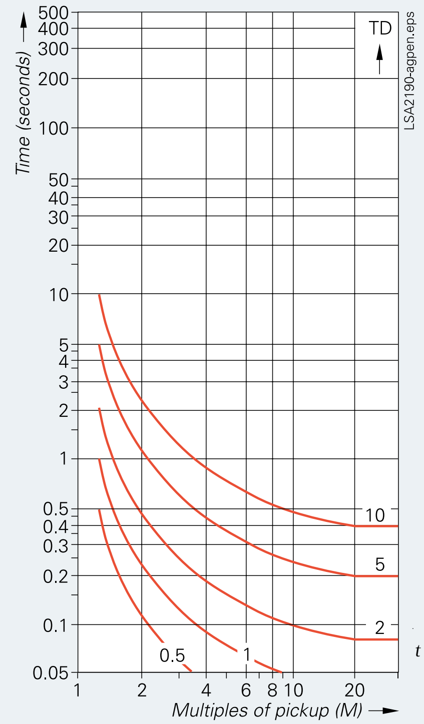
Relay characteristics

Inverse-time overcurrent protection characteristics
according to ANSI (IEEE) C37.112



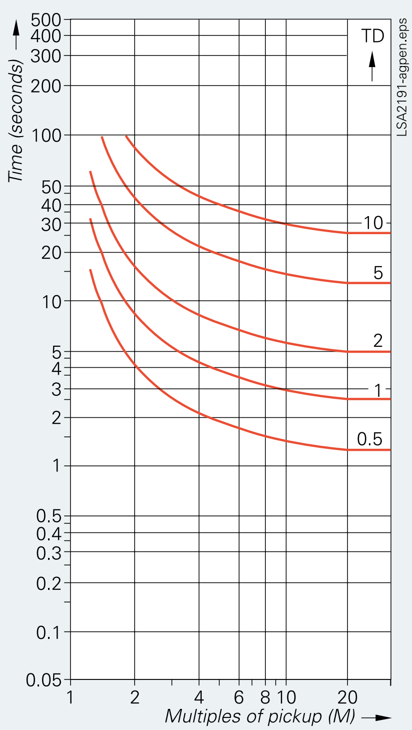
$$t = \left(\frac{8.9341}{M^{2.0938} - 1} + 0.17966 \right) \cdot TD$$

Fig. 13/5 Inverse



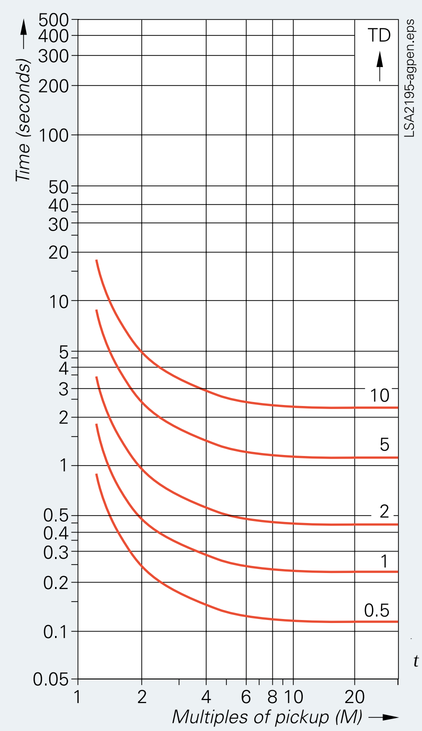
$$t = \left(\frac{0.2663}{M^{1.2969} - 1} + 0.03393 \right) \cdot TD$$

Fig. 13/6 Short inverse



$$t = \left(\frac{5.6143}{M - 1} + 2.18592 \right) \cdot TD$$

Fig. 13/7 Long inverse



$$t = \left(\frac{0.4797}{M^{1.5625} - 1} + 0.21359 \right) \cdot TD$$

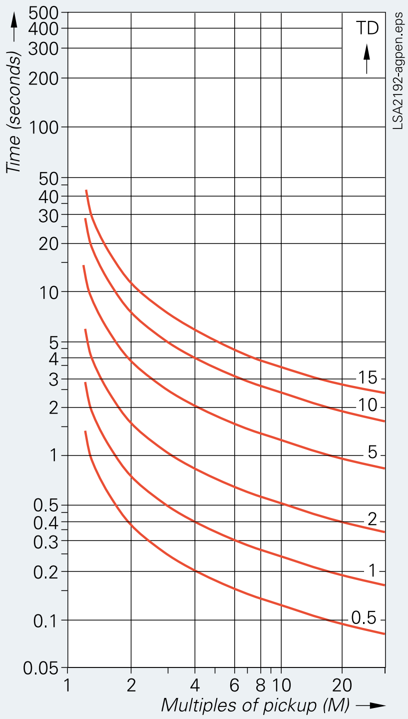
Fig. 13/8 Definite inverse

t = tripping time in seconds

M = current in multiples of pickup setting (I/I_p) range 0.1 to 4

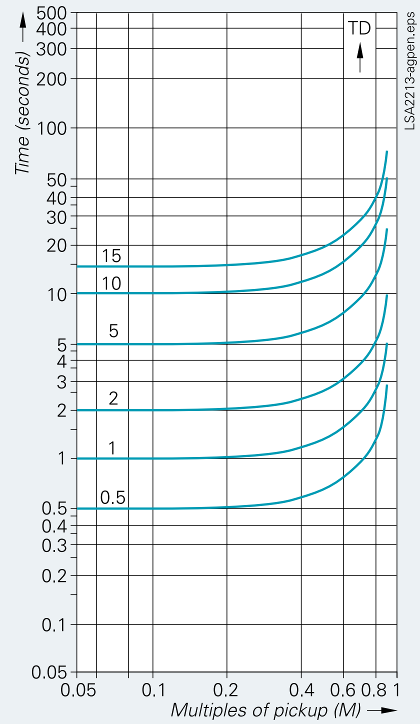
TD = time dial

Inverse-time overcurrent protection characteristics according to ANSI (IEEE) C37.112



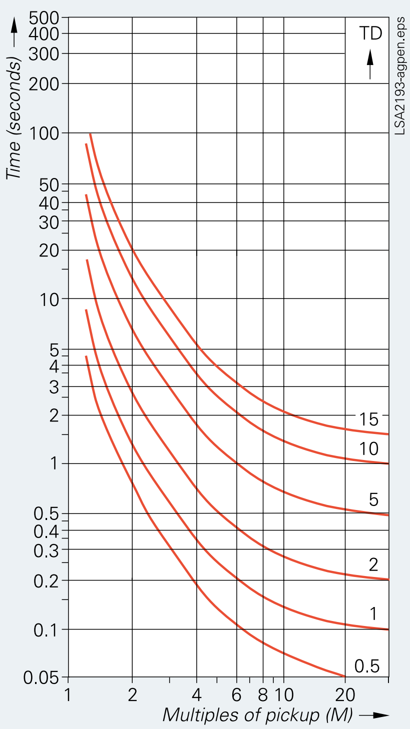
$$t = \left(\frac{0.0103}{M^{0.02}-1}+0.0228\right)\cdot TD$$

Fig. 13/9 Moderately inverse



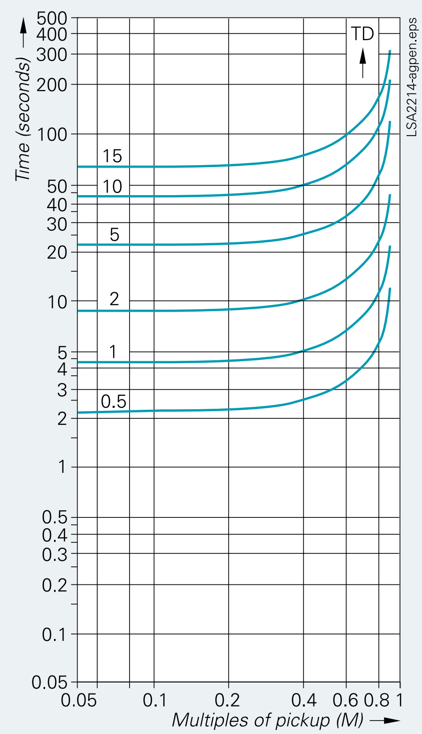
$$t_{reset} = \frac{0.97 \cdot TD}{M^2-1}$$

Fig. 13/10 Reset moderately inverse



$$t = \left(\frac{3.922}{M^2-1}+0.0982\right)\cdot TD$$

Fig. 13/11 Very inverse



$$t_{reset} = \frac{4.32 \cdot TD}{M^2-1}$$

Fig. 13/12 Reset very inverse

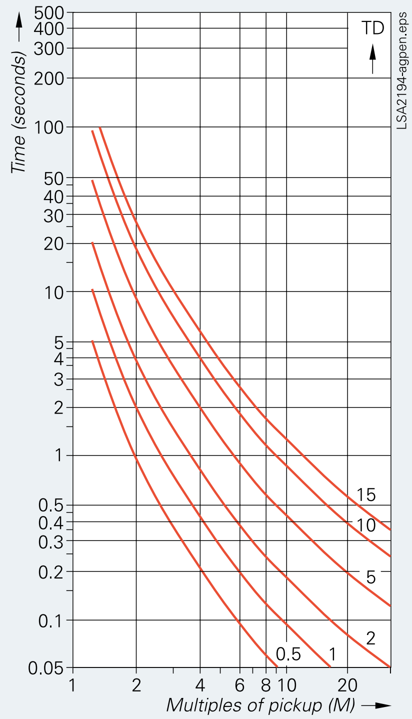
t = tripping time in seconds

M = current in multiples of pickup setting (I/I_p) range 0.1 to 4

TD = time dial

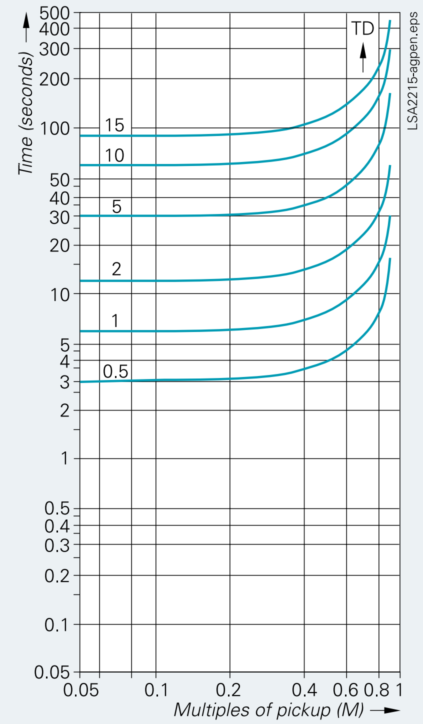
Relay characteristics, pinout of communication port

Inverse-time overcurrent protection characteristics
according to ANSI (IEEE) C37.112



$$t = \left(\frac{5.64}{M^2 - 1} + 0.0243 \right) \cdot TD$$

Fig. 13/13 Extremely inverse



$$t_{reset} = \frac{5.82 \cdot TD}{M^2 - 1}$$

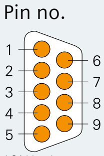
Fig. 13/14 Reset extremely inverse

t = tripping time in seconds

M = current in multiples of pickup setting (I/I_p) range 0.1 to 4

TD = time dial

Pinout of communication port

		Port A: Time synchronization	Port B: System interface				Port C/D Rear service interface or protection data interface	
Pin no. 	PC interface at front		RS232 IEC 60870-5-103	RS485 IEC 60870-5-10	RS485 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	$\overline{RTS}$	P12 input 12 V	$\overline{RTS}$	–*)	–*)	–	$\overline{RTS}$	($\overline{RTS}$ RS232 used)
8	$\overline{CTS}$	–	$\overline{CTS}$	B/B' (RxD/TxD-P)	A/A' (RxD/TxD-N)	B	$\overline{CTS}$	B
9	–	Shield	–	–	–	–	–	–

*) Pin 7 also can carry the RS232 RTS signal to an RS485 interface.
Pin 7 must therefore not be connected

Dimension drawings, reference table

Relay	Flush/cubicle-mounting version		Surface-mounting version		Detached HMI	
	Page	Fig.	Page	Fig.	Page	Fig.
6MD66	13/12	13/22	13/13	13/23	13/14	13/24
7SA522	13/10, 13/12	13/19, 13/22	13/13	13/23	-	-
7SA61	13/9, 13/10, 13/11, 13/12	13/18, 13/19, 13/20, 13/22	13/11, 13/13	13/21, 13/23	-	-
7SA63	13/9, 13/10, 13/12	13/18, 13/19, 13/22	13/11, 13/13	13/21, 13/23	-	-
7SA64	-	-		-	13/14	13/24
7SD5	13/10, 13/12	13/19, 13/22	13/13	13/23	-	-
7SD600	13/8	13/15	13/8, 13/9	13/16, 13/17	-	-
7SD610	13/9	13/18	13/11	13/21	-	-
7SJ61	13/9	13/18	13/11	13/21	-	-
7SJ62	13/9	13/18	13/11	13/21	-	-
7SJ64	13/9, 13/10, 13/12	13/18, 13/19, 13/22	13/11, 13/13	13/21, 13/23	13/14	13/24
7SJ66	13/15, 13/16	13/25, 13/26	-	-	-	-
7SS522 central unit	13/18	13/29	13/18	13/29	-	-
7SS523 bay unit	13/17	13/27	13/17	13/27	-	-
7SS525	13/18	13/29		-	-	-
7UM62	13/10, 13/12	13/19, 13/22	13/13	13/23	-	-
7UT6	13/9, 13/10, 13/12	13/18, 13/19, 13/22	13/11, 13/13	13/21, 13/22	-	-
7VE61	13/9	13/18	13/11	13/21	-	-
7VE63	13/10	13/19	13/13	13/23	-	-
7VK610/7VK611	13/9, 13/10	13/18, 13/19	13/11, 13/13	13/21, 13/23	-	-
7VU683	13/12	13/22	-	-	-	-

Dimension drawings for ⅙ × 19" housing (7XP20)

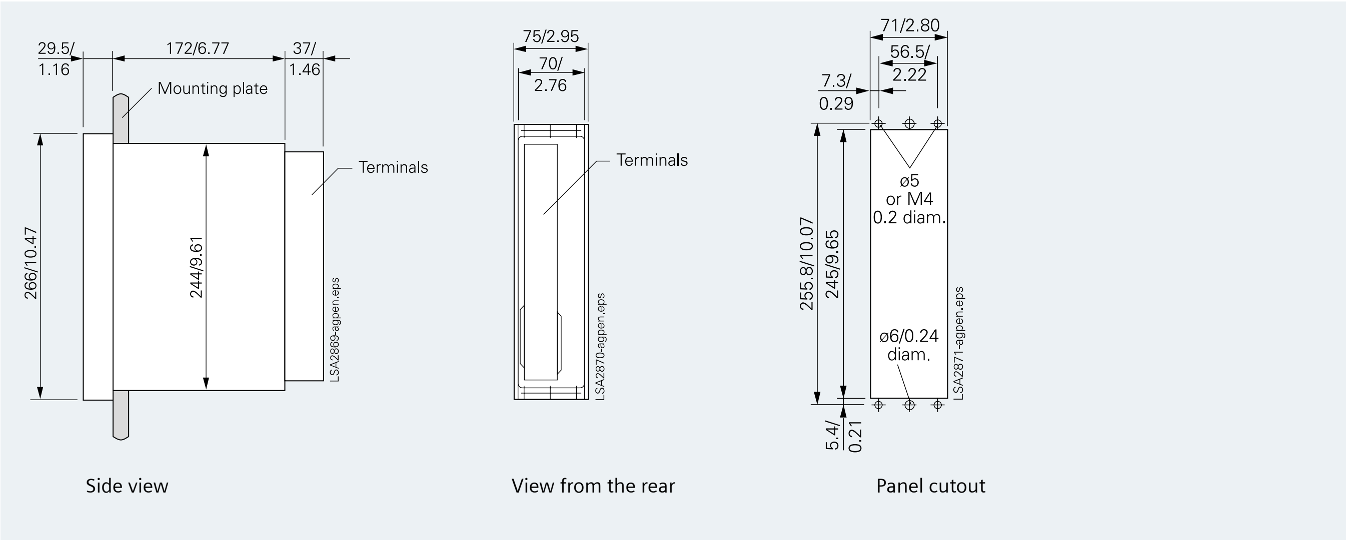


Fig. 13/15 Housing for panel flush mounting/cubicle mounting, terminals at rear (⅙ × 19")

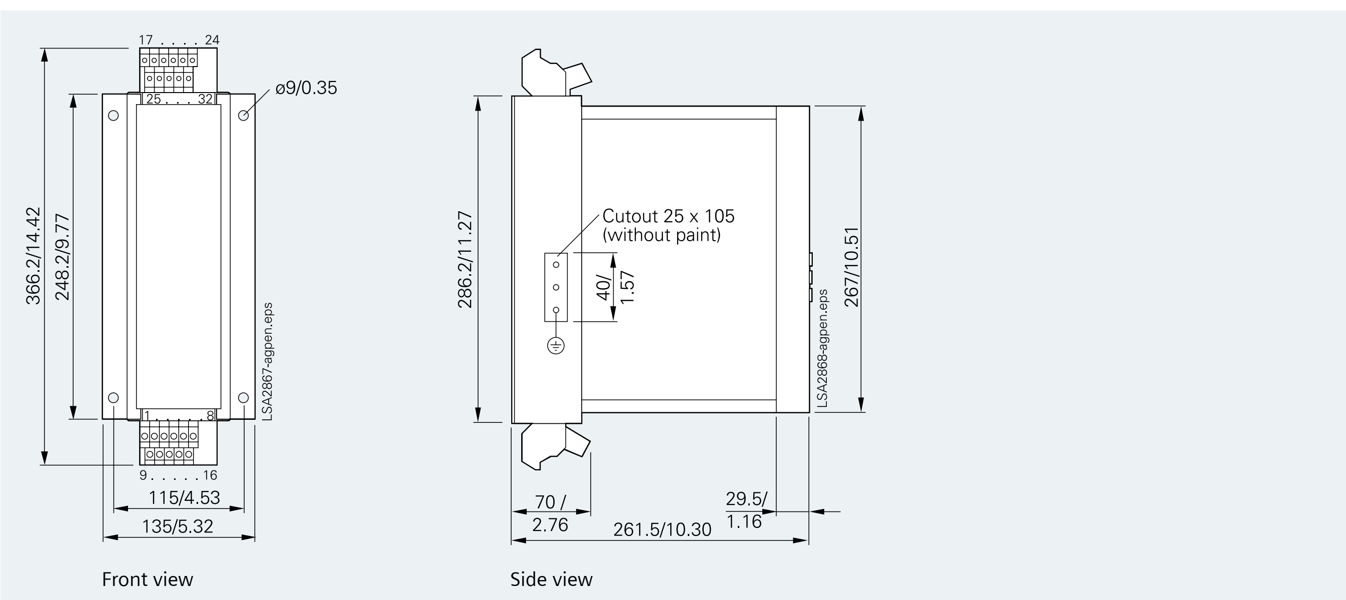


Fig. 13/16 Housing for surface mounting, terminals at top and bottom (⅙ × 19")

Dimension drawings for ⅙ × 19" housing (7XP20)

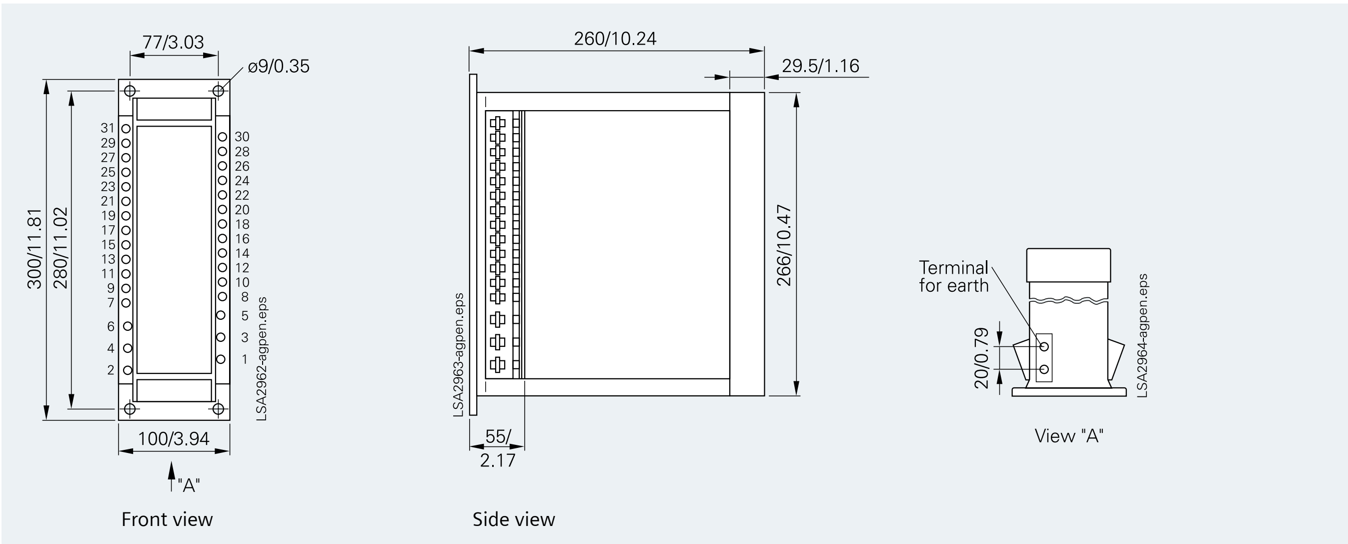


Fig. 13/17 Housing for panel surface mounting, terminals on the side (⅙ × 19")

Dimension drawings for SIPROTEC 4 □ x 19" housing (7XP20)

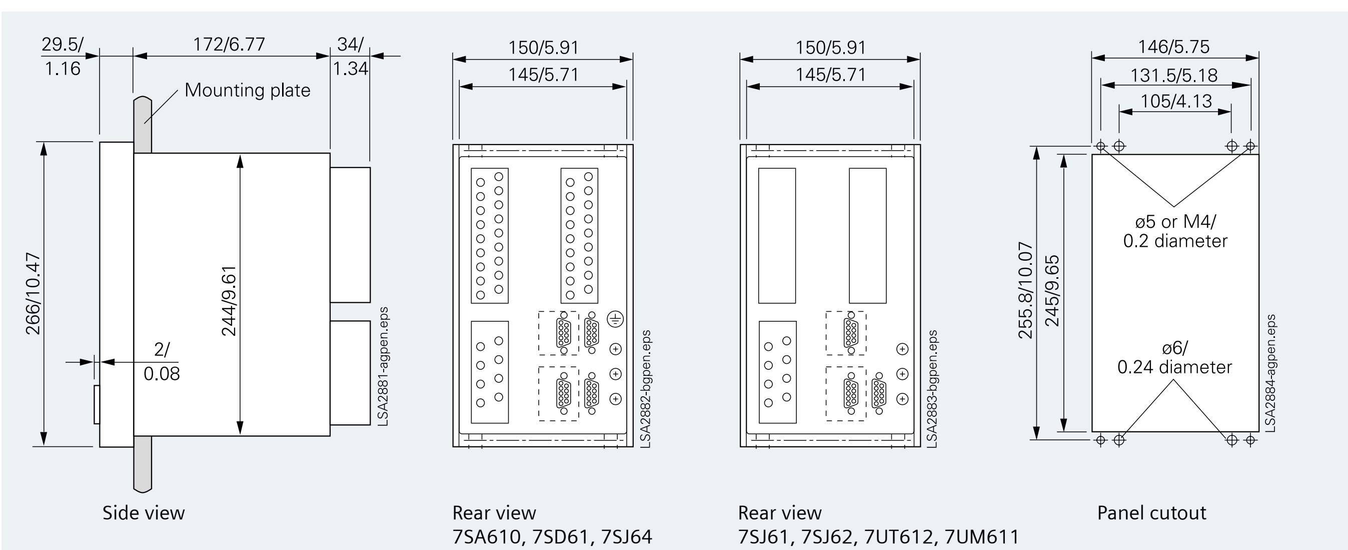


Fig. 13/18 Housing for panel flush mounting / cubicle mounting (□ × 19")

13

Dimension drawings in mm / inch

Dimension drawings for SIPROTEC 4
½ × 19" flush-mounting housings (7XP20)

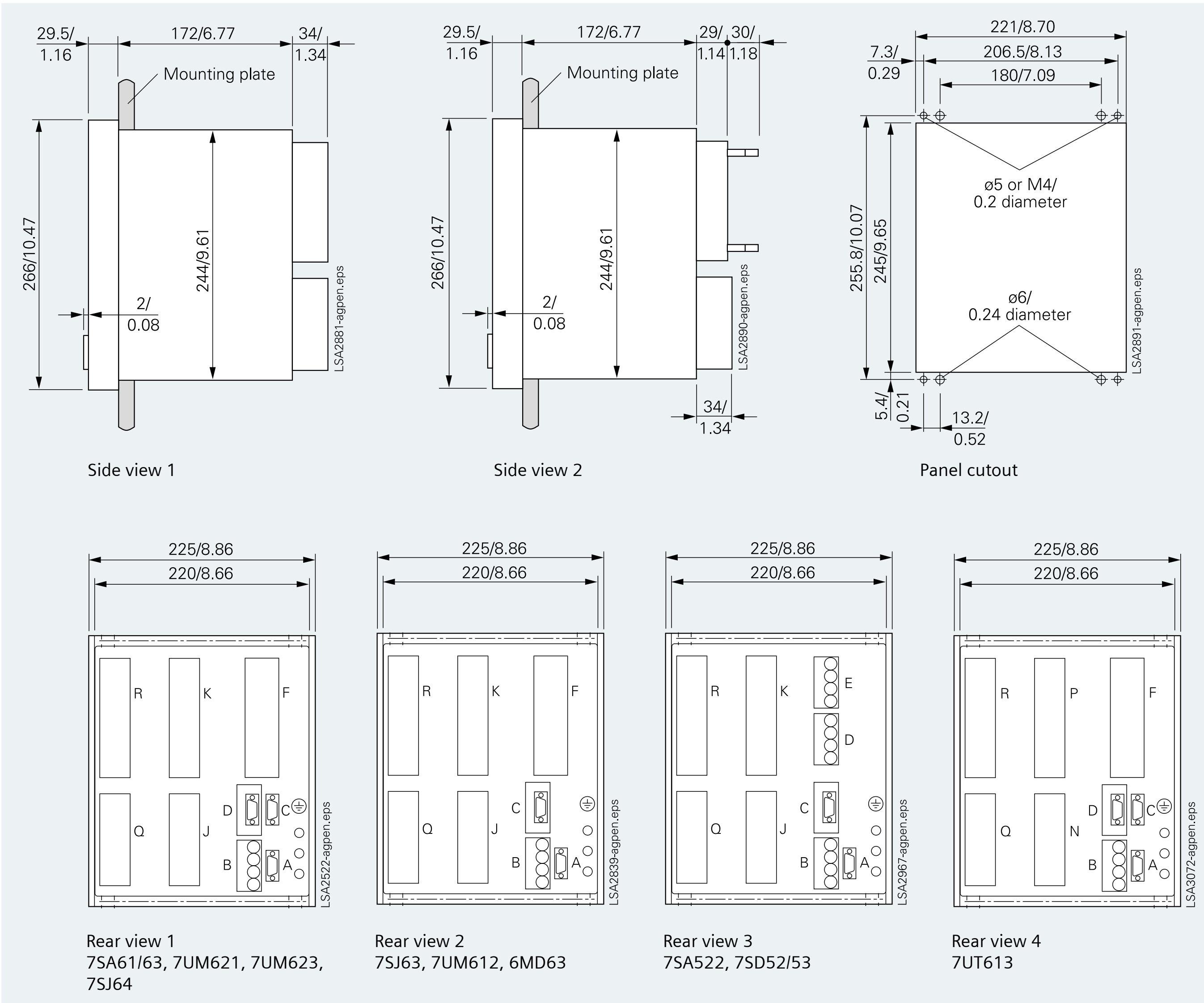


Fig. 13/19 ½ × 19" flush-mounting housing

Dimension drawings for SIPROTEC 4
⅔ × 19" flush-mounting housings (7XP20)

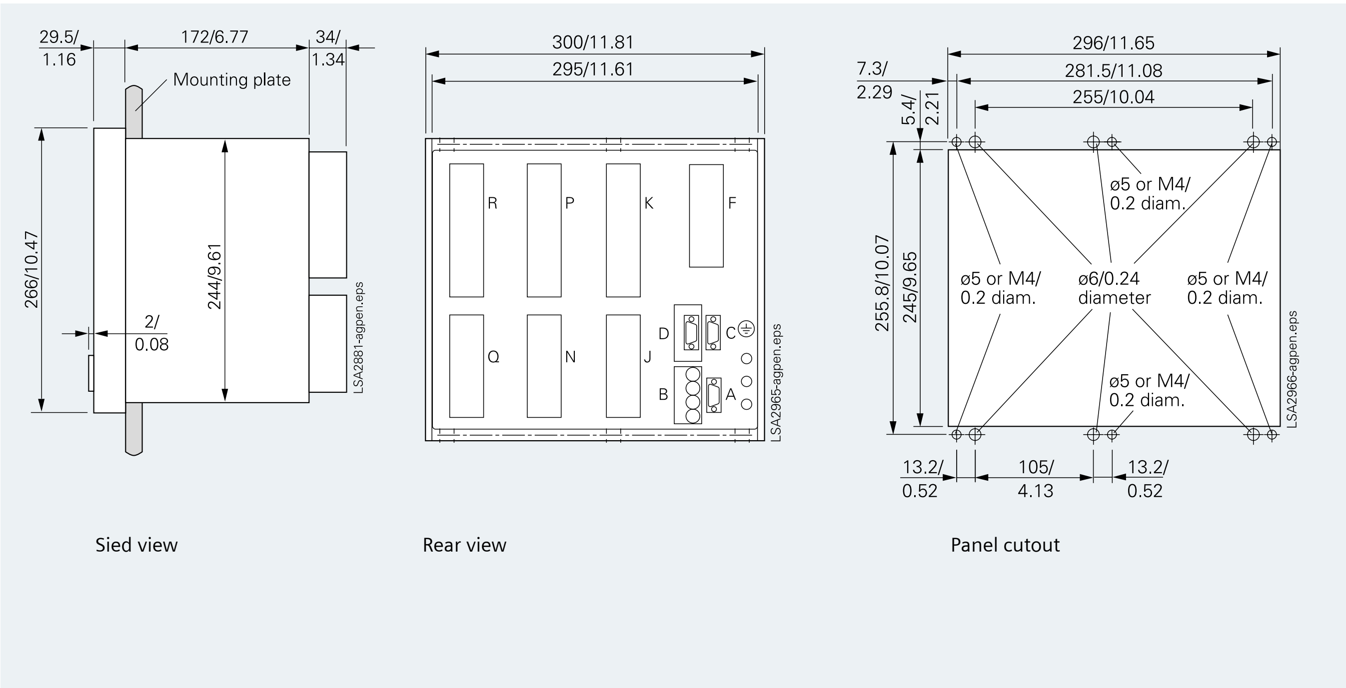


Fig. 13/20 ⅔ × 19" flush-mounting housing for 7SA613

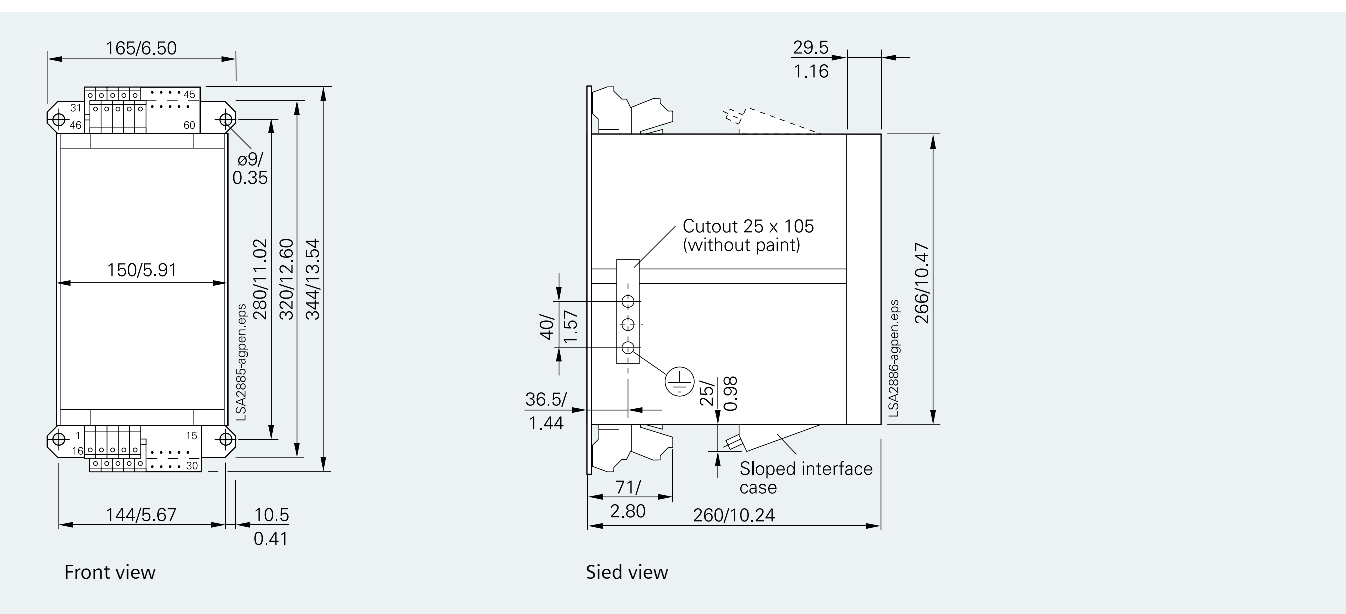


Fig. 13/21 ▯ × 19" surface-mounting housing, terminals at top and bottom

13

Appendix

Dimension drawings in mm / inch

Dimension drawings for SIPROTEC 4
 × 19" flush-mounting housings (7XP20)

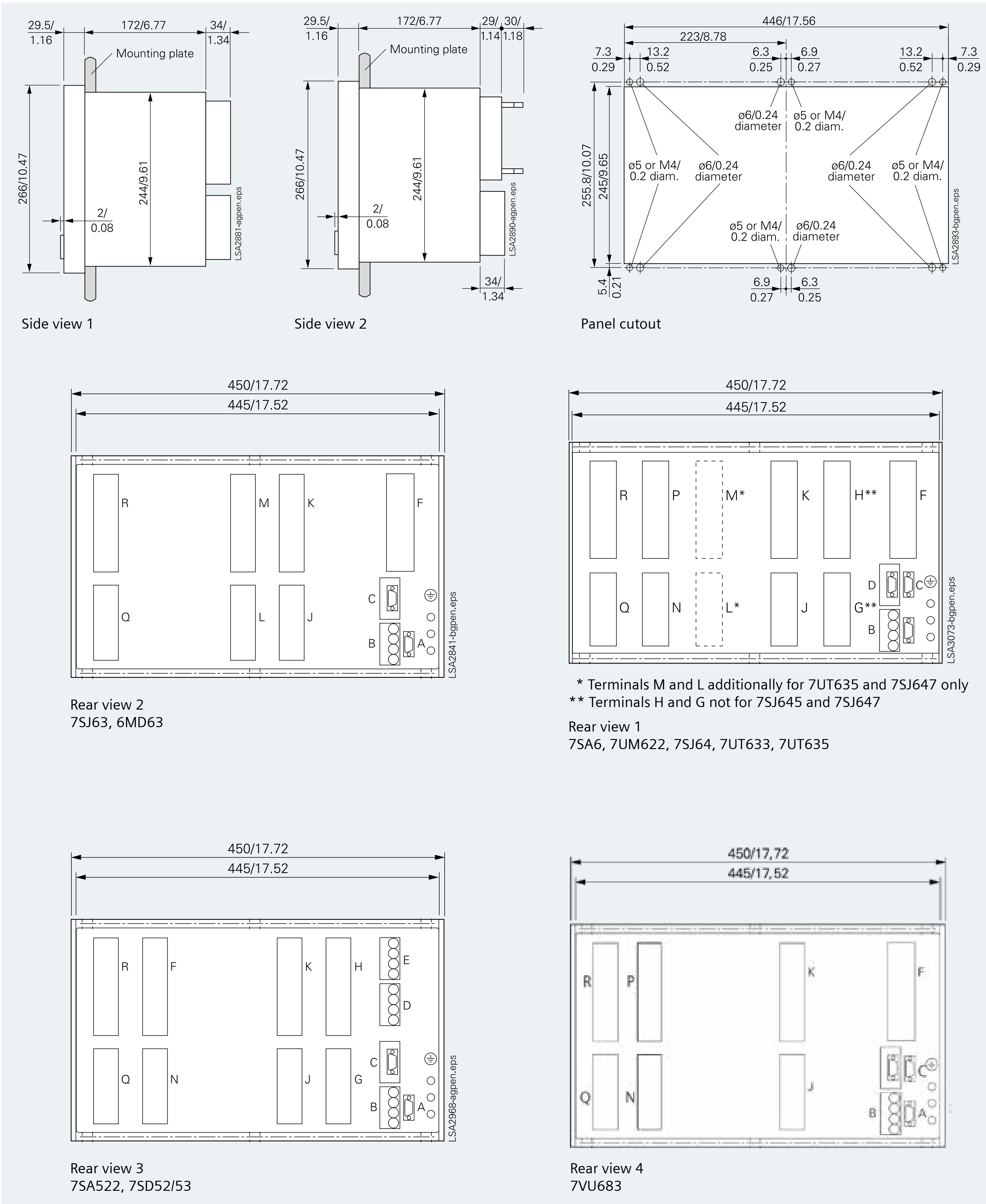
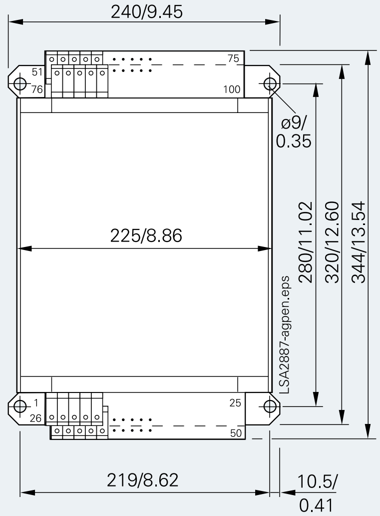
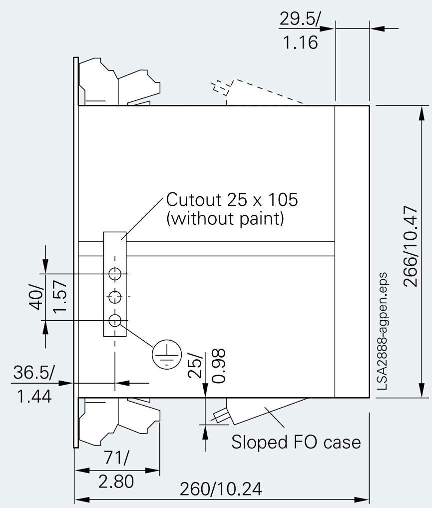


Fig. 13/22 × 19" flush-mounting housing

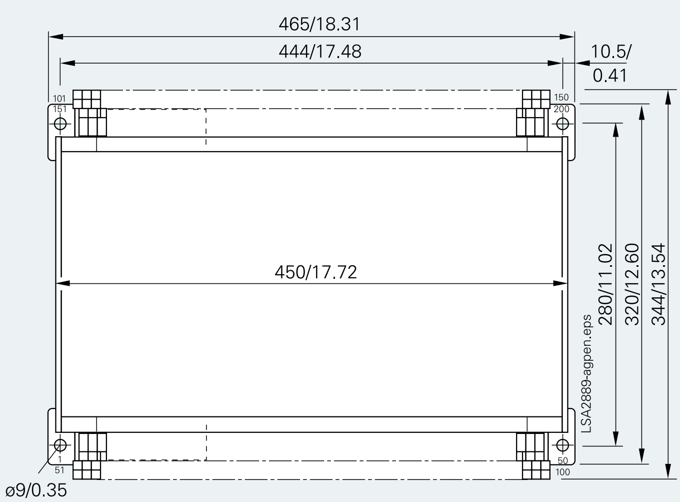
Dimension drawings for SIPROTEC 4
½ and × 19" surface-mounting housing (7XP20)



Front view
½ × 19" surface-mounting,
terminals at top and bottom housing 7XP20



Side view



Front view
 x 19" surface-mounting housing 7XP20
(without sloped FO case)

Fig. 13/23 ½ and × 19" surface-mounting housing

Dimension drawings in mm / inch

Dimension drawings for SIPROTEC 4
½ and × 19" housings with detached operator panel

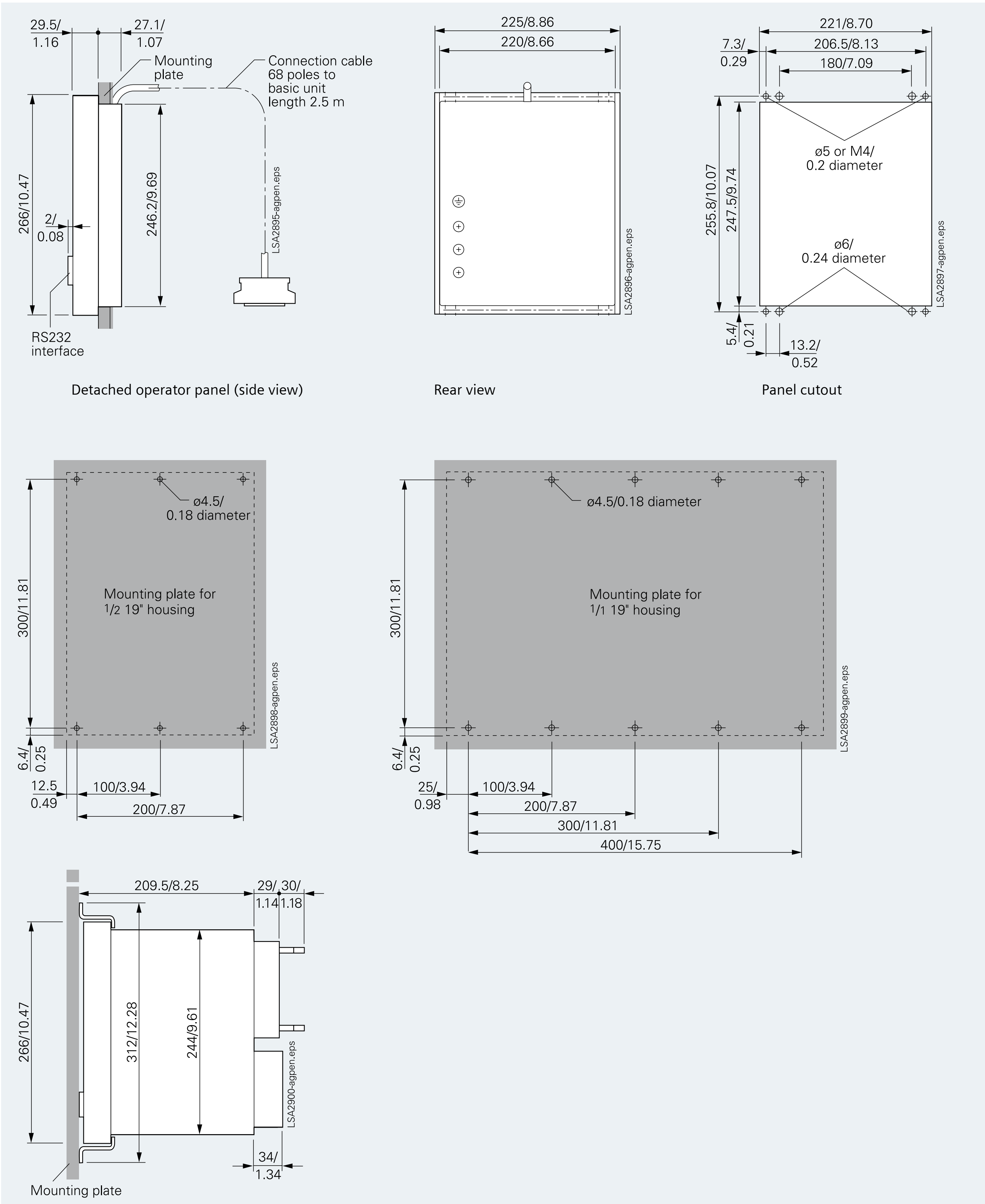


Fig. 13/24 Housing with detached or no operator panel

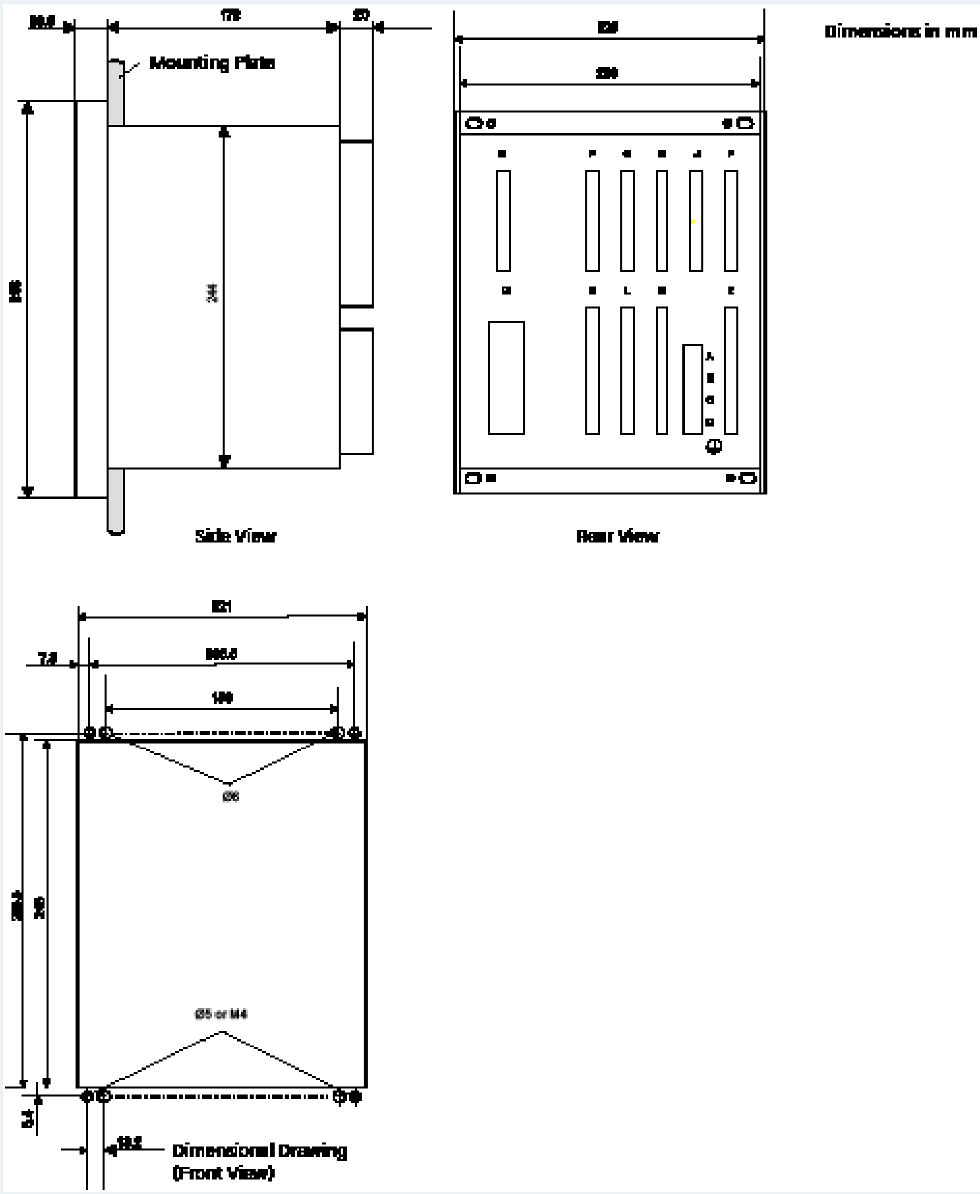


Fig. 13/25 Dimensional Drawing of a 7SJ66 for Panel Flush and Cubicle Mounting (Housing Size ½)

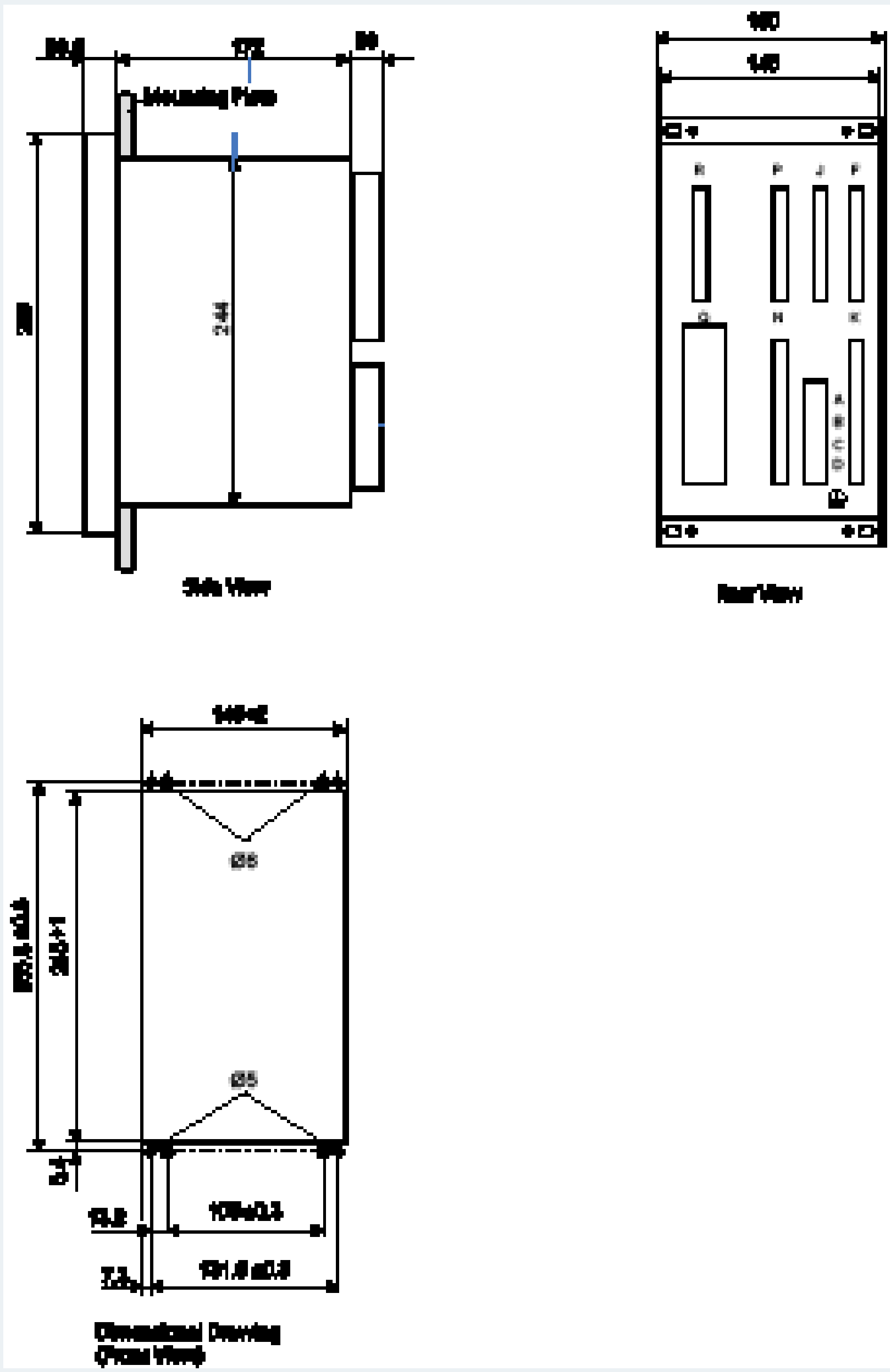


Fig. 13/26 Dimensional Drawing of a 7SJ66 for Panel Flush and Cubicle Mounting (Housing Size [illegible])

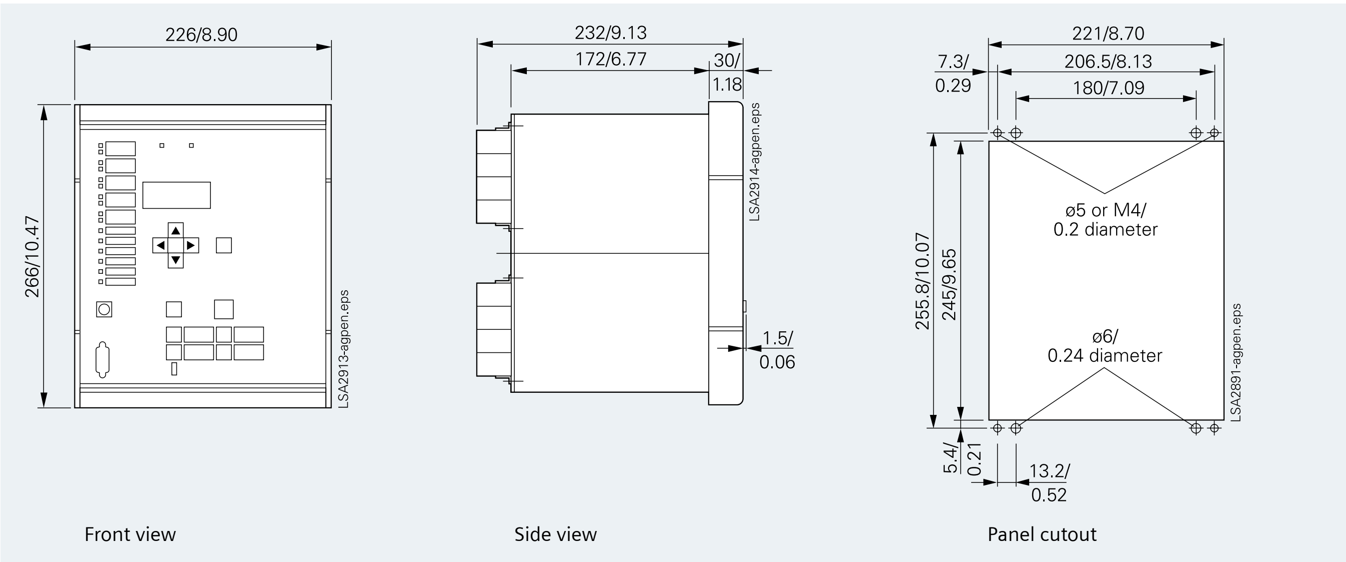


Fig. 13/27 7SS523 bay unit in 7XP2040-2 housing for panel flush mounting/cubicle mounting

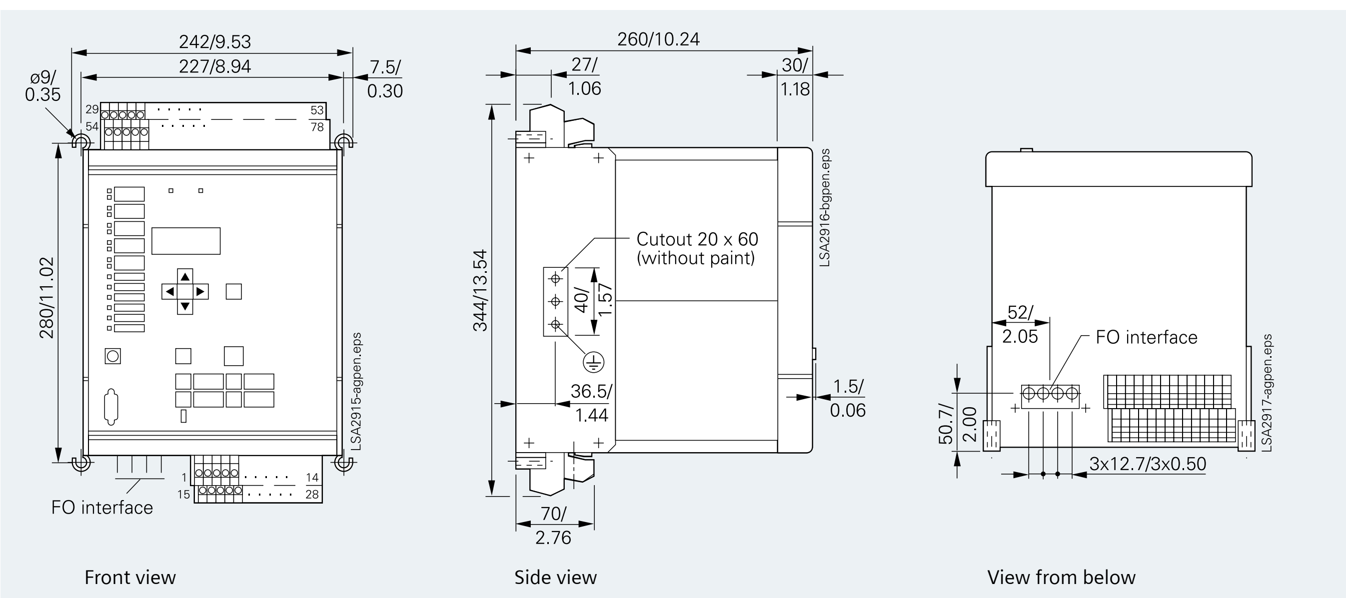


Fig. 13/28 7SS523 bay unit in 7XP2040-1 housing for panel surface mounting

Dimension drawings in mm / inch

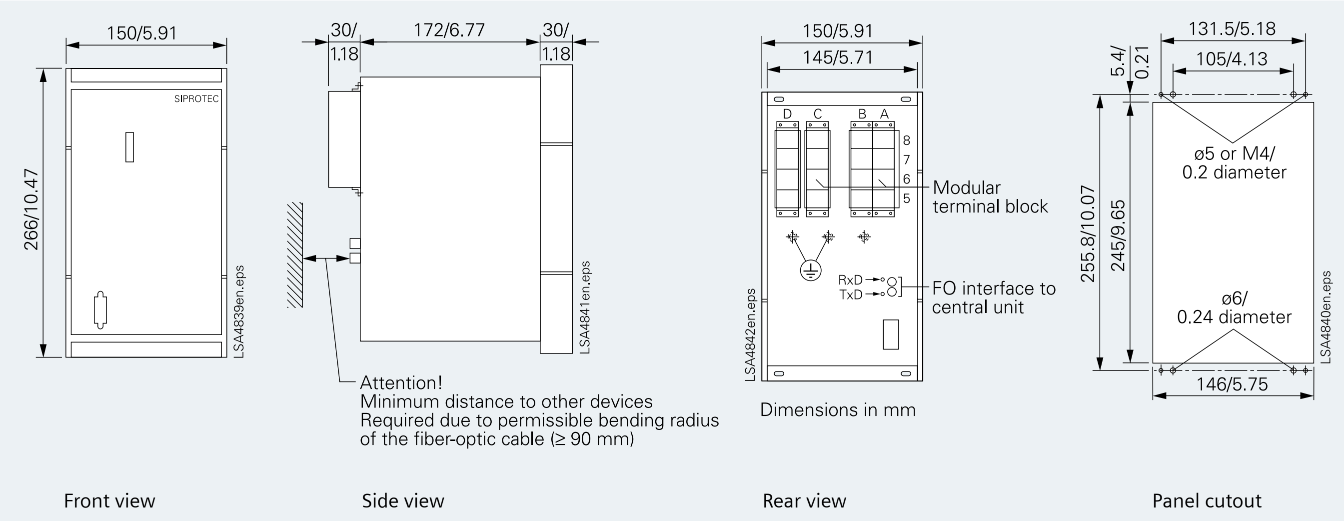


Fig. 13/29 7SS525 busbar and breaker failure protection unit for panel flush mounting/cubicle mounting with housing for wall mounting

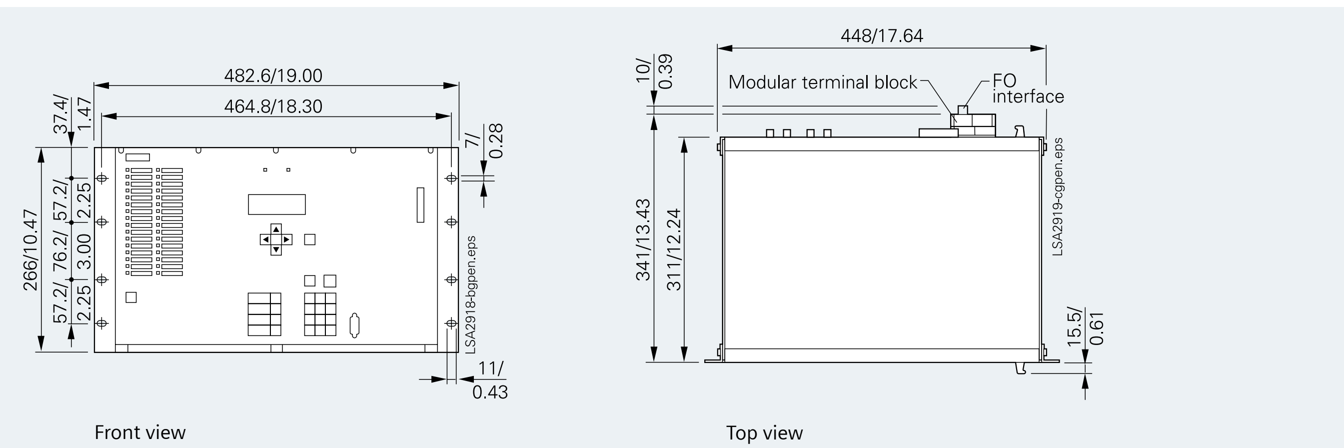


Fig. 13/30 7SS522 central unit in SIPAC subrack

Products applied until now	Function	Recommended new products
7RP72	Frequency relay	7RW80 (SIPROTEC Compact)
7SD24	Line differential relay	7SD600
7SD510/511	Line differential relay via FO	7SD610
7SD512	Line differential relay via FO	7SD5
7SA500	Distance protection	7SA6, 7SA522
7SA501	Distance protection	7SA6, 7SA522
7SA502	Distance protection	7SA6, 7SA522
7SA510	Distance protection	7SA6, 7SA522
7SA511	Distance protection	7SA6, 7SA522
7SA513	Distance protection	7SA6, 7SA522
7SJ41	Overcurrent relay	7SR45 (Reyrolle)
7SJ50	Overcurrent relay	7SJ80
7SJ510	Overcurrent relay	7SJ61
7SJ511	Overcurrent relay	7SJ61
7SJ512	Overcurrent relay	7SJ62
7SJ531	Overcurrent relay	7SJ63
7SJ600, 7SJ601, 7SJ602	Overcurrent relay	7SJ80
7SK52	Motor protection	7SK80 (SIPROTEC Compact)
7UT512	Transformer differential relay	7UT612
7UT513	Transformer differential relay	7UT613/7UT63
7UM51	Machine protection	7UM61/62
7SS51	Busbar protection	7SS52
7SS13	Busbar protection	7SS85
7SS60	Busbar protection	7SS85
7RW600	Voltage and frequency protection	7RW80
7VH80/83, 7VH60	High-impedance diff. protection	7SR23 (Reyrolle)
7SN60	Transient ground-fault relay	SIPROTEC 5
7SV512	Breaker failure relay	7VK61
7VK512	Auto-reclosure and synchronism check relay	7VK61
7XV72	Test switch	7XV75
7XS50	DIGSI operating program	7XS54

Order No. index

Training

Equipment reliability and availability are essential for all owners and users. At the same time, maintenance costs need to be kept to a minimum. The liberalization of energy markets presents new challenges to all; maintaining and enhancing competitive strength are among today's most important business goals. Investment in technical plants and human resources enables these goals to be realized. Innovations in the technical field confront the users with the need of establishing, maintaining and extending their qualification and know-how. Our training programs are tailored to meet your specific needs. With our know-how, we can help you to keep ahead.

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Each course and the corresponding training documents are available in many languages. On the Internet at www.siemens.com/power-academy you will find our complete training program with details of contents, dates, costs and contacts.

Legal notice

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). Further standards are ANSI/IEEE C37.90.0 and C37.90.1.

The device has been designed and produced for industrial use.

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