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

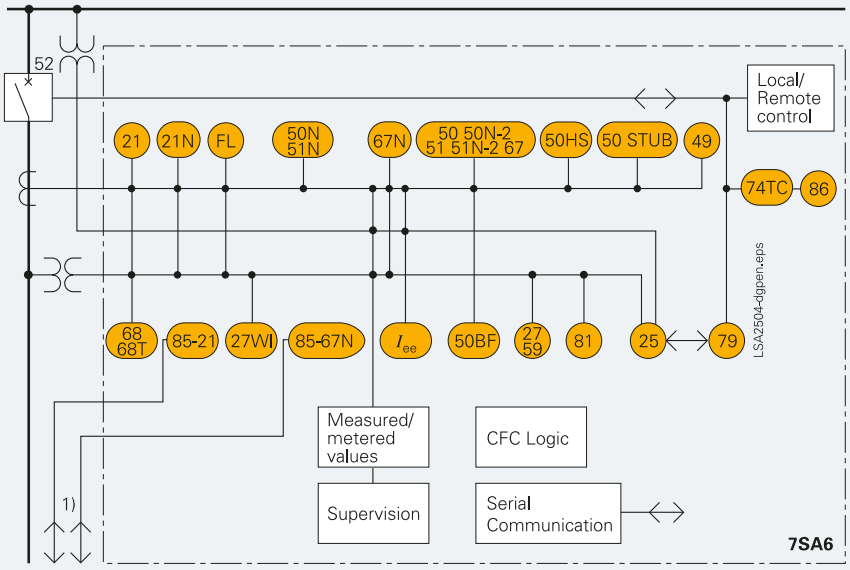
Application

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

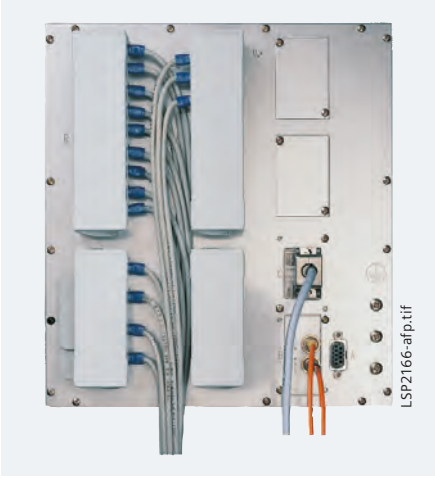


Fig. 6/4 Rear view of flush-mounting housing with covered connection terminals and wirings

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

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.

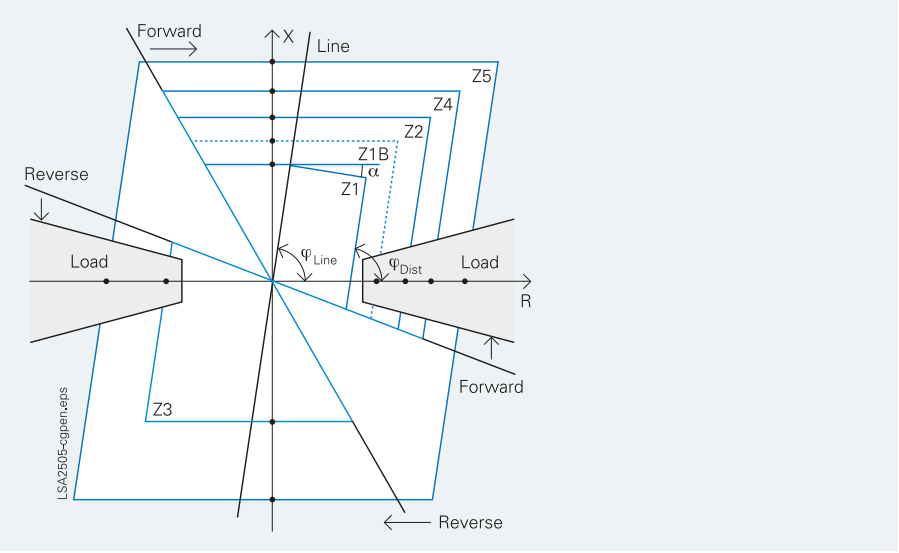


Fig. 6/8 Impedance fault detection $Z<$ with quadrilateral characteristic

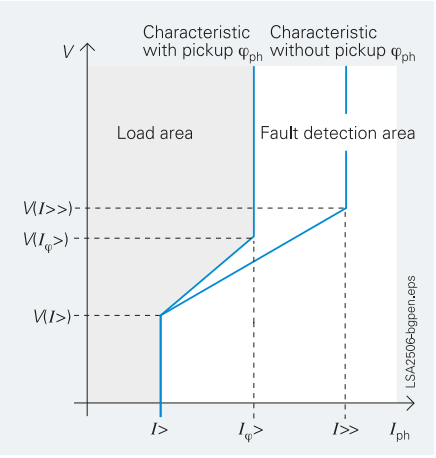


Fig. 6/9 Voltage and angle-dependent overcurrent fault detection $V/I/\varphi$

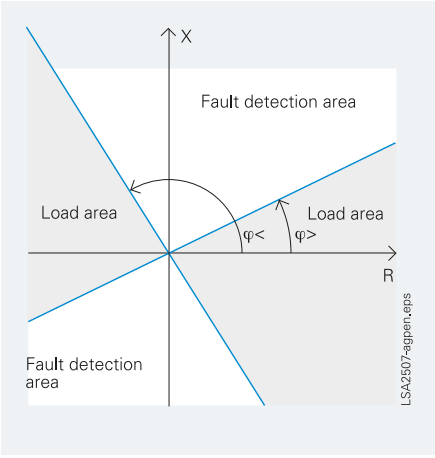


Fig. 6/10 Angle pickup for the $V/I/\varphi$ fault detection

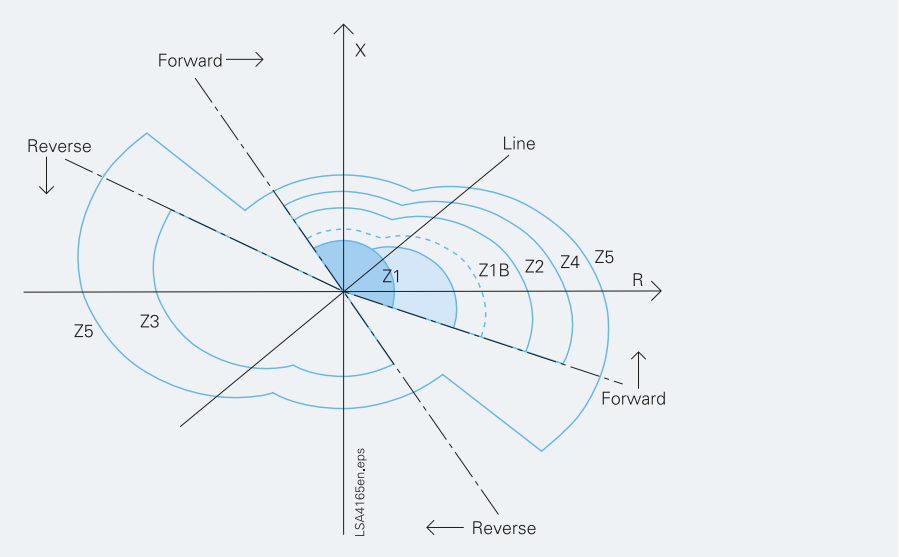


Fig. 6/11 Distance zones with circle characteristic

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.

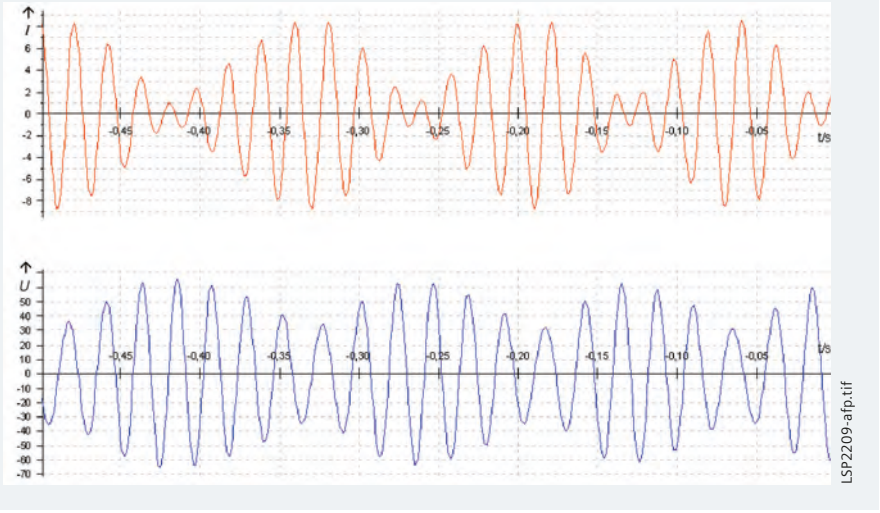


Fig. 6/12 Power swing current and voltage wave forms

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

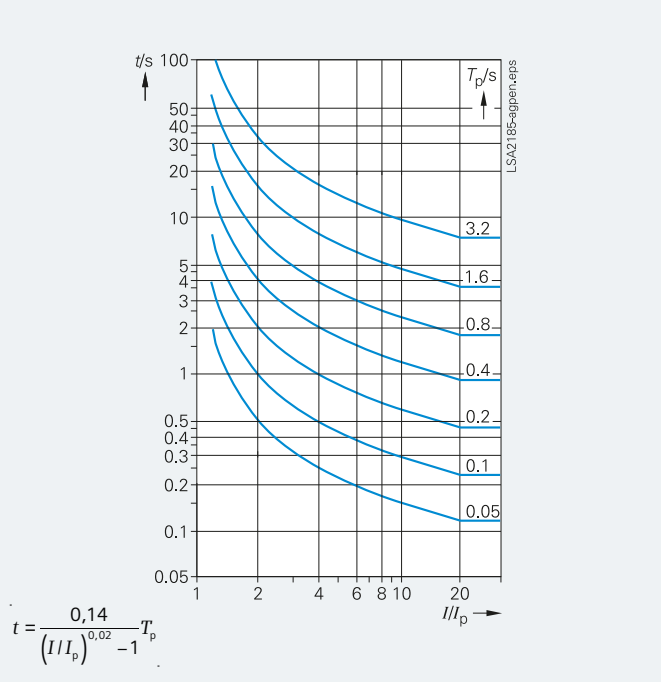


Fig. 6/13 Normal inverse

ground faults. The 7SA6 protection relay therefore offers protection functions for faults of this nature.

The ground-fault protection can be used with three definite-time stages and one inverse-time stage (IDMT).

Inverse-time characteristics according to IEC 60255-3 and ANSI/IEEE are provided (see "Technical data"). A 4th definite-time stage can be applied instead of the 1st inverse-time stage.

An additional logarithmic inverse-time characteristic is also available.

The direction decision is determined by the ground current and the zero-sequence voltage or by the negative-sequence components V_2 and I_2. In addition or as an alternative, the direction can be determined with the ground current of an grounded power transformer and the zero-sequence voltage. Dual polarization applications can therefore be fulfilled. Alternatively, the direction can be determined by evaluation of zero-sequence power. Each overcurrent stage can be set in forward or reverse direction or in both directions (non-directional).

The function is equipped with special digital filter algorithms, providing the elimination of higher harmonics. This feature is particularly important for small zero-sequence fault currents which usually have a high content of 3rd and 5th harmonic.

Inrush stabilization and instantaneous switch-onto-fault tripping can be activated separately for each stage as well.

Different operating modes can be selected. The ground-fault protection is suitable for three-phase and, optionally, for single-phase tripping by means of a sophisticated phase selector. It may be blocked during the dead time of single-pole auto-reclose cycles or during pickup of the distance protection.

Tele (pilot) protection for directional ground-fault protection (ANSI 85-67N)

The directional ground-fault protection can be combined with the available signaling methods:

- Directional comparison
- BLOCKING
- UNBLOCKING

The transient blocking function (current reversal guard) is also provided in order to suppress interference signals during tripping of parallel lines.

The pilot functions for distance protection and for ground-fault protection can use the same signaling channel or two separate and redundant channels.

Backup overcurrent protection (ANSI 50, 50N, 51, 51N, 67)

The 7SA6 provides a backup overcurrent protection. Two definite-time stages and one inverse-time stage (IDMTL) are available, separately for phase currents and for the ground current. The application can be extended to a directional overcurrent protection (ANSI 67) by taking into account the decision of the available direction detection elements. Two operating modes are selectable. The function can run in parallel to the distance protection or only during failure of the voltage in the VT secondary circuit (emergency operation).

The secondary voltage failure can be detected by the integrated fuse failure monitor or via a binary input from a VT miniature circuit-breaker (VT m.c.b. trip).

Inverse-time characteristics according to IEC 60255-3 and ANSI/IEEE are provided (see "Technical data").

Instantaneous high-speed switch-onto-fault overcurrent protection (ANSI 50HS)

Instantaneous tripping is required when energizing a faulty line. In the event of large fault currents, the high-speed switch-onto-fault overcurrent stage can initiate very fast three-pole tripping.

With smaller fault currents, instantaneous tripping after switch-onto-fault is also possible with the overreach distance zone Z1B or with pickup.

The switch-onto-fault initiation can be detected via the binary input "manual close" or automatically via measurement.

Ground-fault detection in systems with a star-point that is not effectively grounded

In systems with an isolated or resonant grounded (grounded) star-point, single-phase ground faults can be detected. The following functions are integrated for this purpose:

- Detection of an ground fault by monitoring of the displacement voltage
- Determination of the faulted phase by measurement of the phase-to-ground voltage
- Determination of the ground-fault direction by highly accurate measurement of the active and reactive power components in the residual ground fault current.
- Alarm or trip output can be selected in the event of an ground-fault in the forward direction.
- Operation measurement of the active and reactive component in the residual ground current during an ground-fault.

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.

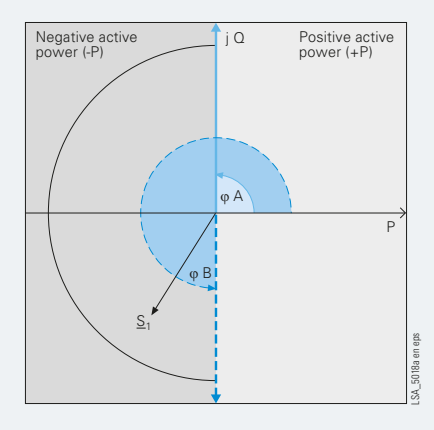


Fig. 6/14 Monitoring of active power direction

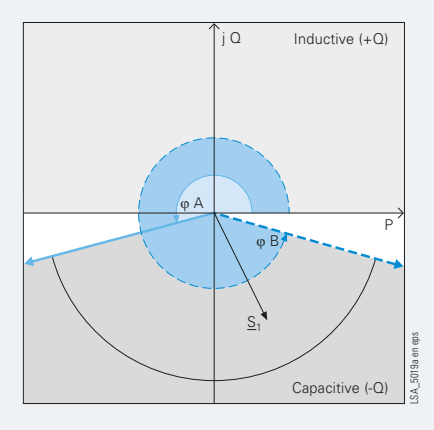


Fig. 6/15 Monitoring of reactive power

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.

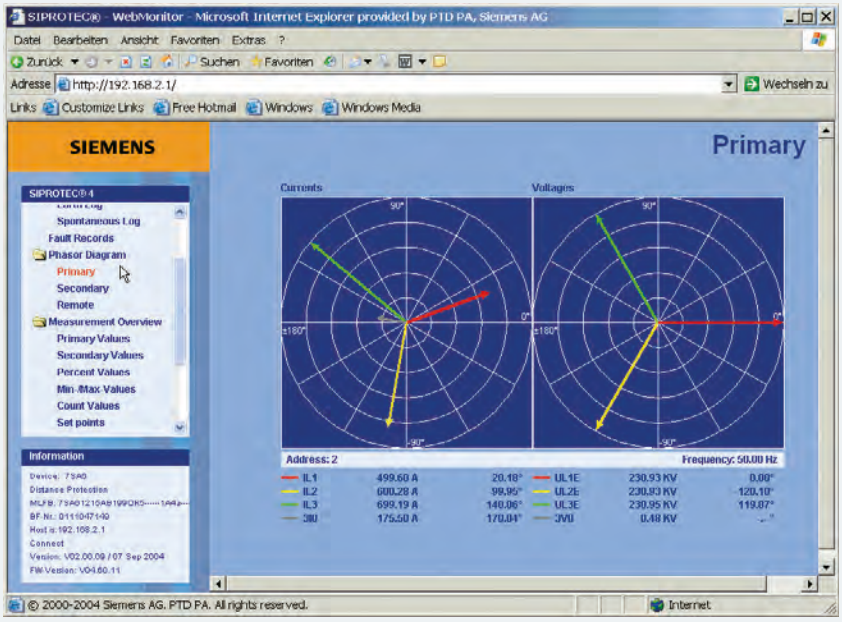


Fig. 6/16 Web Monitor: Supported commissioning by phasor diagram

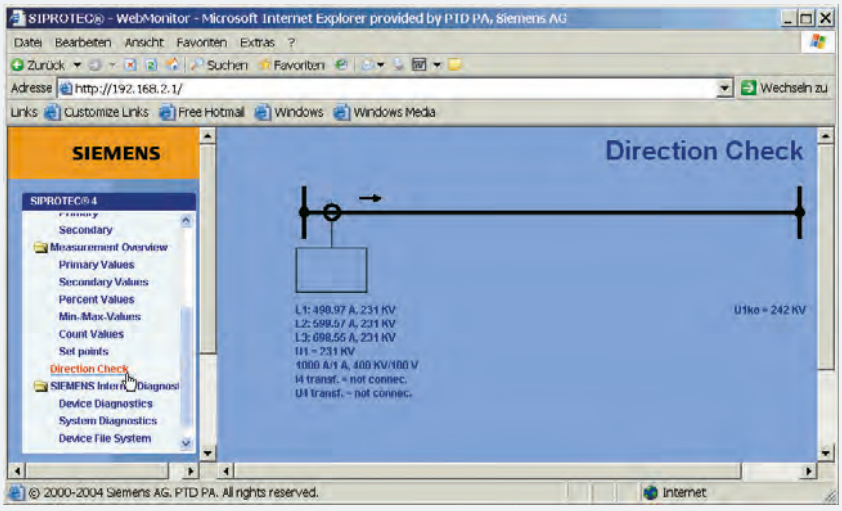


Fig. 6/17 Web Monitor: Display of the protection direction

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.

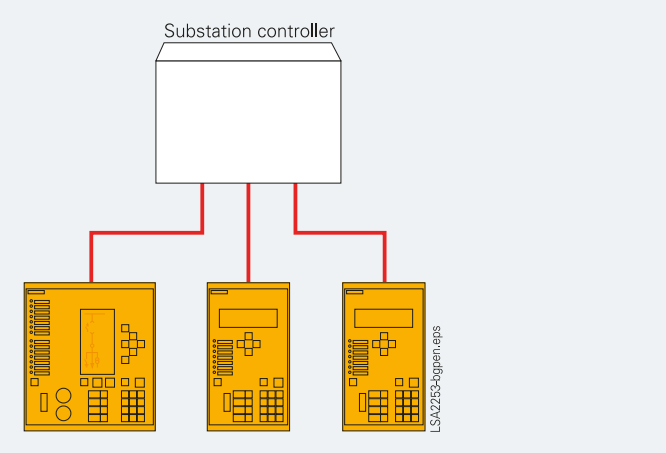


Fig. 6/18 IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

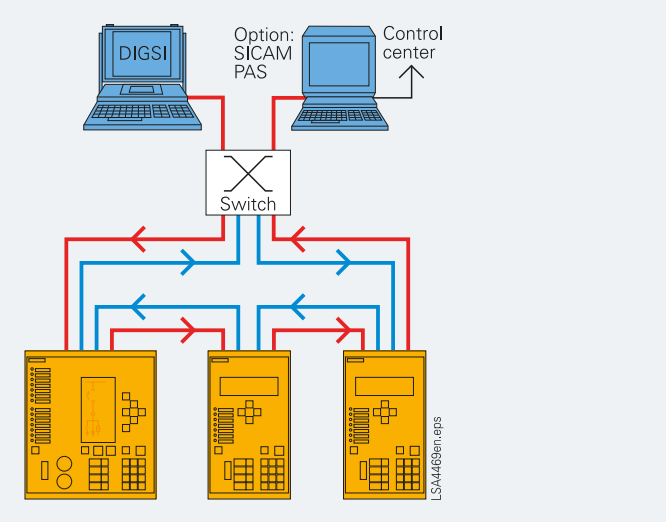


Fig. 6/19 Bus structure for station bus with Ethernet and IEC 61850

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.

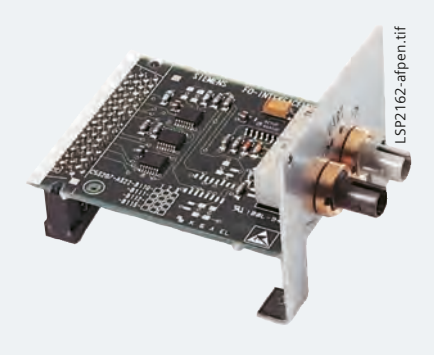


Fig. 6/20 820 nm fiber-optic communication module

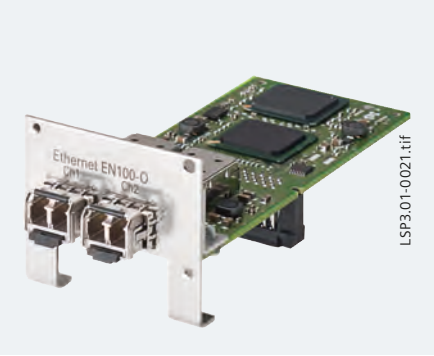


Fig. 6/21 Fiber-optic Ethernet communication module for IEC 61850 with integrated Ethernet switch

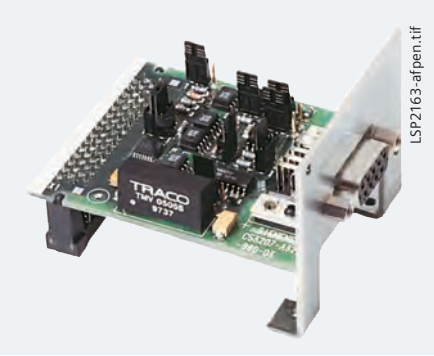


Fig. 6/22 RS232/RS485 electrical communication module

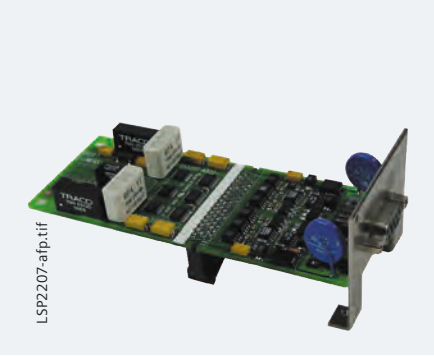


Fig. 6/23 Output module 0 to 20 mA, 2 channels

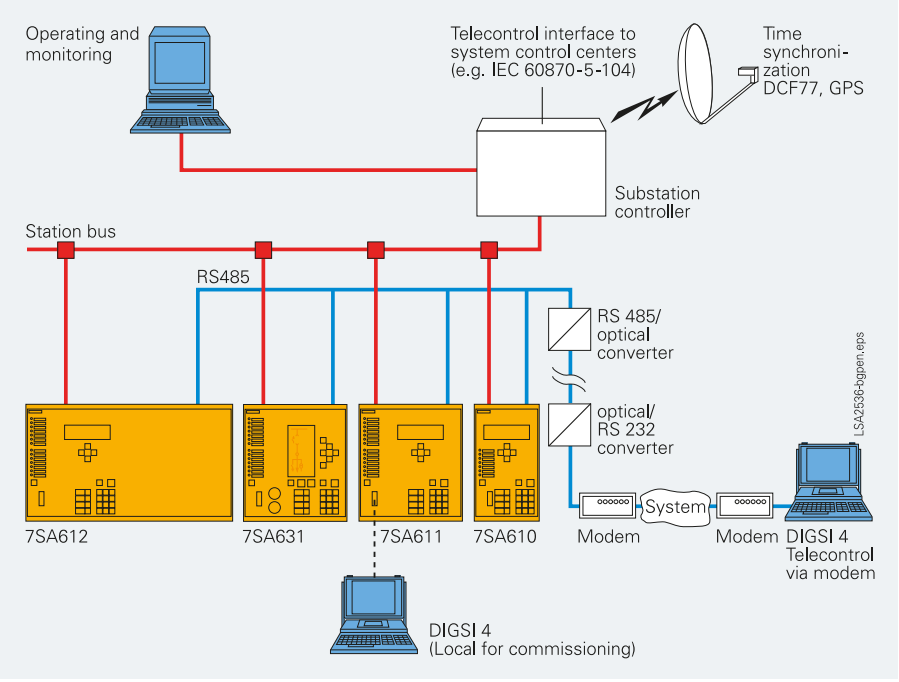


Fig. 6/24 Communication

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 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 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.

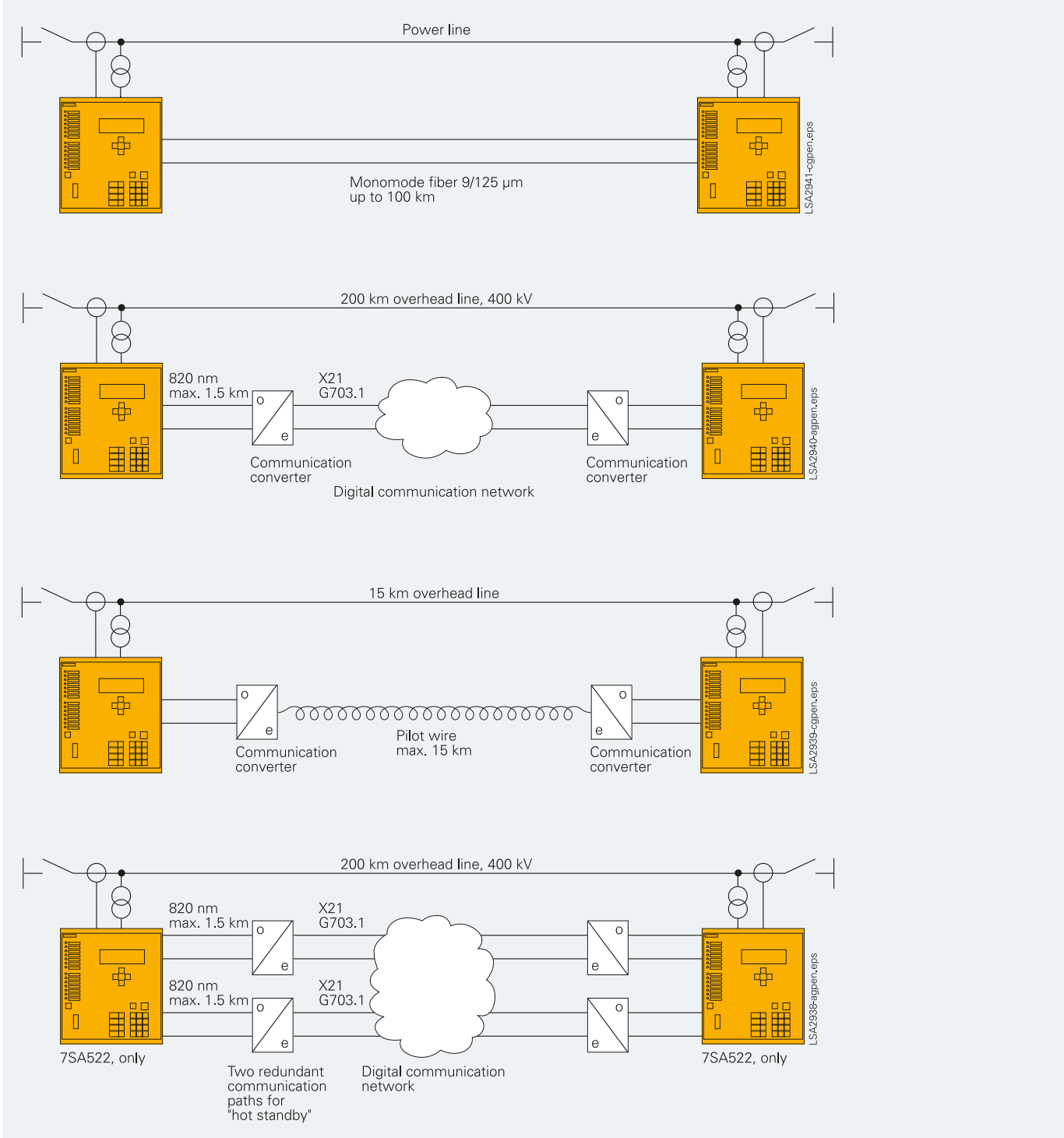


Fig. 6/25 Communication topologies for the serial protection data interface on a two-terminal line

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.

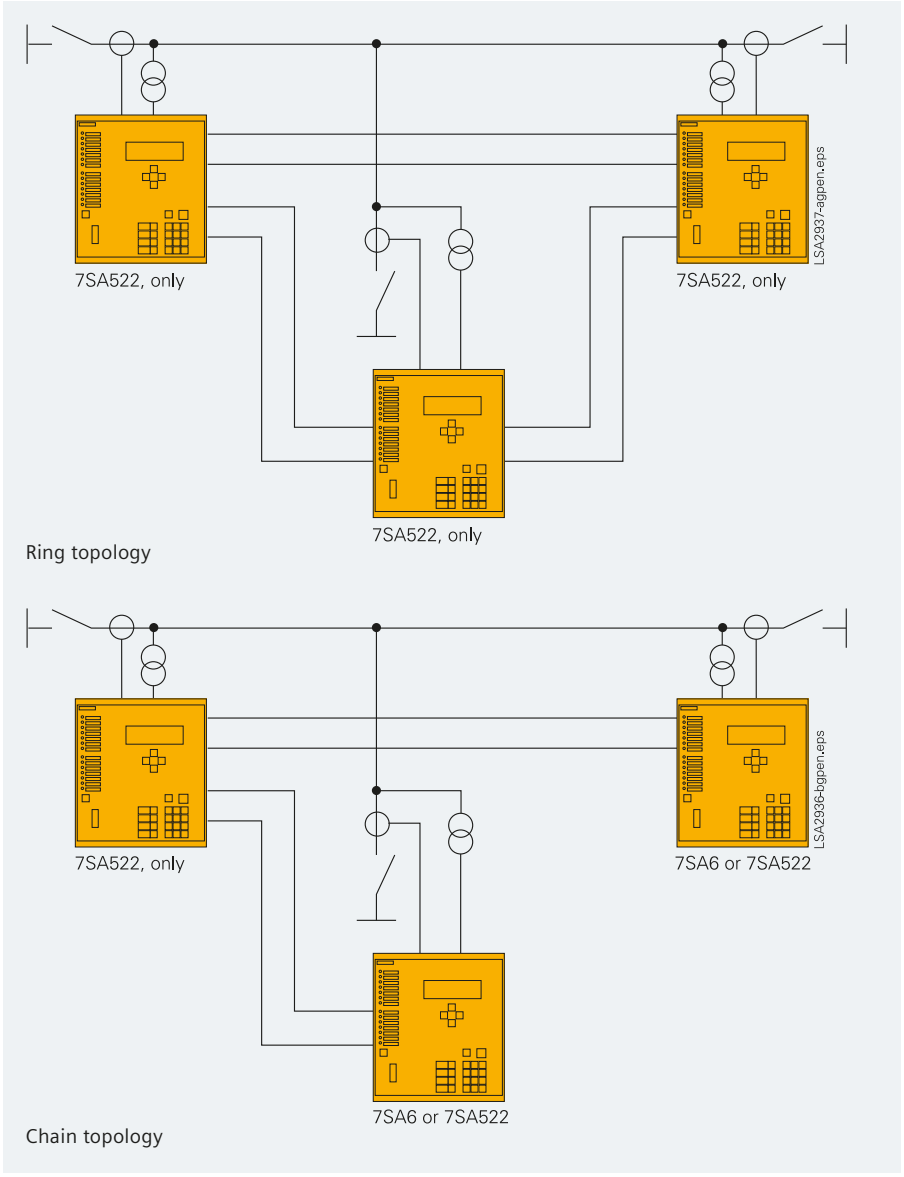


Fig. 6/26 Ring or chain communication topology

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.

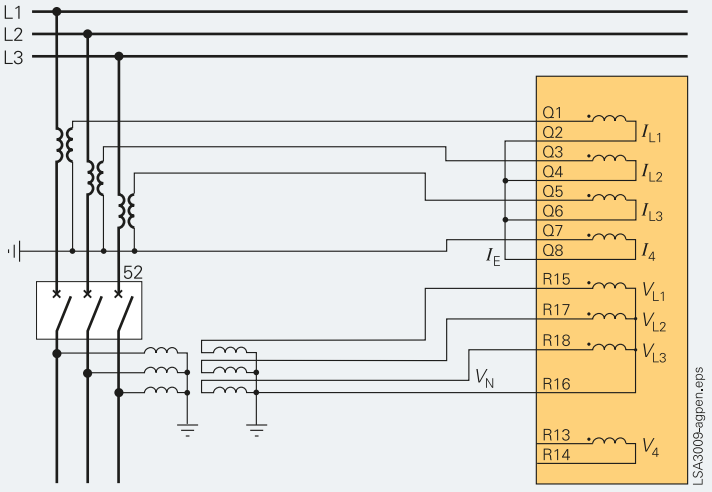


Fig. 6/27 Example of connection for current and voltage transformers

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.

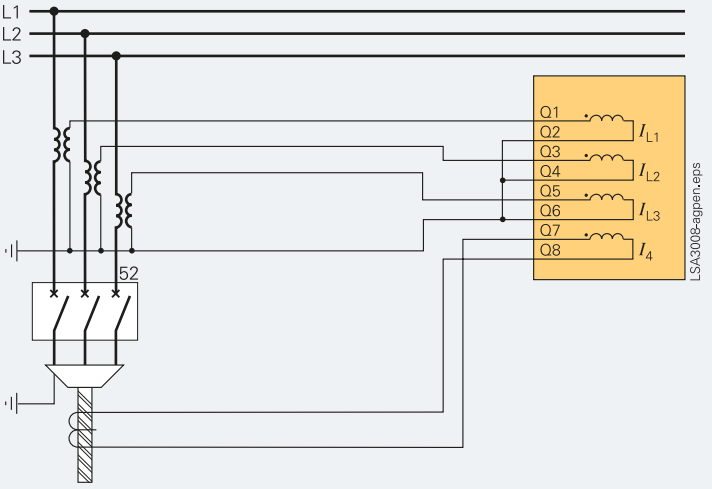


Fig. 6/28 Alternative connection of current transformers for sensitive ground-current measuring with core-balance current transformers

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.

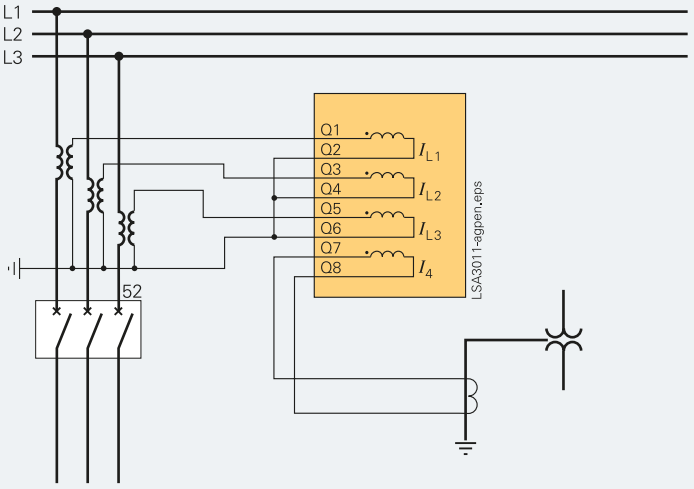


Fig. 6/29 Alternative connection of current transformers for measuring neutral current of an grounded power transformer

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.

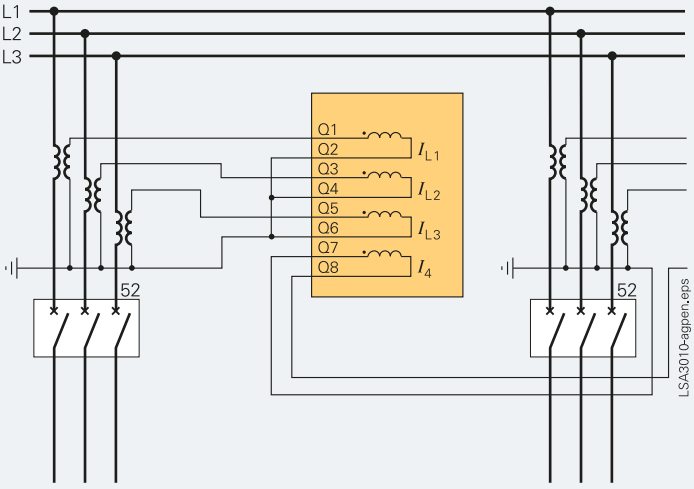


Fig. 6/30 Alternative connection of current transformers for measuring the ground current of a parallel line

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.

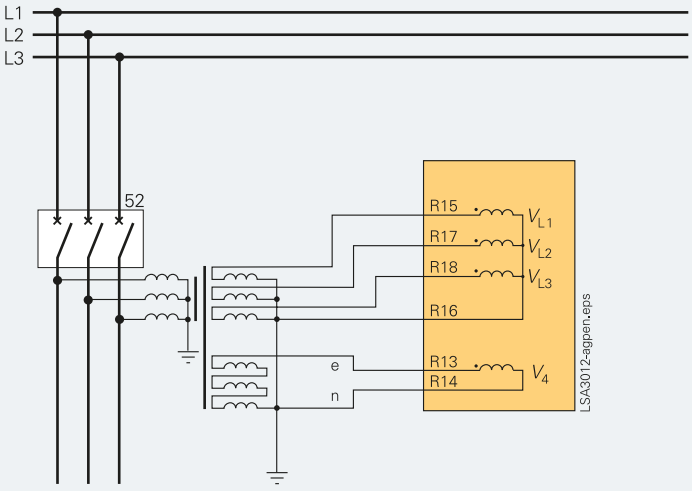


Fig. 6/31 Alternative connection of voltage transformers for measuring the displacement voltage (e-n voltage)

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.

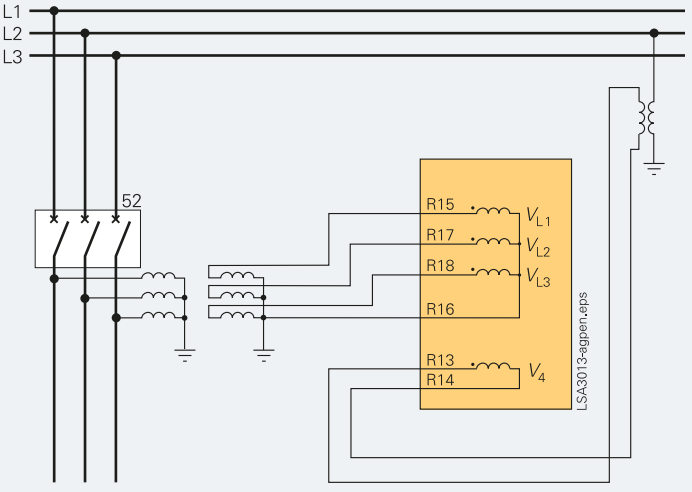


Fig. 6/32 Alternative connection of voltage transformers for measuring the busbar voltage

Technical data

General unit data	
Analog inputs	
Rated frequency	50 or 60 Hz (selectable)
Rated current I_{nom}	1 or 5 A (selectable)
Rated voltage V_{nom}	80 to 125 V (selectable)
Power consumption	
With I_{nom} = 1 A	Approx. 0.05 VA
With I_{nom} = 5 A	Approx. 0.30 VA
For I_E, sensitive with 1 A	Approx. 0.05 VA
Voltage inputs	≤ 0.10 VA
Overload capacity of current circuit (r.m.s.)	
Thermal	500 A for 1 s 150 A for 10 s 20 A continuous
Dynamic (peak value)	1250 A (half cycle)
Ground current	
Sensitive	300 A for 1 s 100 A for 10 s 15 A continuous
Dynamic (peak value)	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	Approx. 5 W
Energized	Approx. 12 W to 18 W, depending on design
Bridging time during failure of the auxiliary voltage	
For V_{aux} = 48 V and V_{aux} ≥ 110 V	≥ 50 ms
For V_{aux} = 24 V and V_{aux} = 60 V	≥ 20 ms
Binary inputs	
Quantity	
7SA610*-*A/E/J	5
7SA610*-*B/F/K	7
7SA6*1*-*A/E/J	13
7SA6*1*-*B/F/K	20
7SA6*2*-*A/E/J	21
7SA6*2*-*B/F/K	29
7SA6*2*-*C/G/L	33
Rated voltage range	24 to 250 V, bipolar
Pickup threshold	DC 17 or 73 or 154 V, bipolar
Functions are freely assignable	1
Pickup/reset voltage thresholds 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	5 NO contacts, 3 NC/NO contact[1]
7SA610*-*B/F/K	5 NO contacts,
7SA6*1*-*A/E/J	12 NO contacts, 4 NC/NO contacts[1]
7SA6*1*-*B/F/K	8 NO contacts, 4 power relays[2]
7SA6*2*-*A/E/J	19 NO contacts, 5 NC/NO contacts[1]
7SA6*2*-*B/F/K	26 NO contacts, 6 NC/NO contacts[1]
7SA6*2*-*C/G/L	11 NO contacts, 8 power relays[2]
NO/NC contact	
Switching capacity	
Make	1000 W / VA
Break, high-speed trip outputs	1000 W / VA
Break, contacts	30 VA
Break, contacts (for resistive load)	40 W
Break, contacts (for τ = L/R ≤ 50 ms)	25 VA
Switching voltage	250 V
Permissible total current	30 A for 0.5 seconds 5 A continuous
Operating time, approx.	
NO contact	8 ms
NO/NC contact (selectable)	8 ms
Fast NO contact	5 ms
High-speed NO trip outputs	< 1 ms
Power relay for direct control of disconnector actuator motors	
Switching capacity	
Make for 48 to 250 V	1000 W/ VA
Break for 48 to 250 V	1000 W/ VA
Make for 24 V	500 W/ VA
Break for 24 V	500 W/ VA
Switching voltage	250 V
Permissible total current	30 A for 0.5 seconds 5 A continuous
Max. operating time	30 s
Permissible relative operating time	1 %

LEDs	
	Quantity
RUN (green)	1
ERROR (red)	1
LED (red), function can be assigned	
7SA610	7
7SA6*1/2/3	14

1) Can be set via jumpers.

2) Each pair of power relays is mechanically interlocked to prevent simultaneous closing.

Unit design		
Housing		7XP20
Dimensions		Refer to part 14 for dimension drawings
Degree of protection acc. to EN 60529		
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	10 V/m; 80 to 1000 MHz: 80 % AM; 1 kHz 10 V/m; 800 to 960 MHz: 80 % AM; 1 kHz
IEC 61000-4-3, class III	10 V/m; 1.4 to 2 GHz: 80 % AM; 1 kHz
Irradiation with HF field, single frequencies IEC 60255-22-31, IEC 61000-4-3, class III amplitude/pulse modulated	10 V/m; 80, 160, 450, 900 MHz; 80 % AM; 1 kHz; duty cycle > 10 s 900 MHz; 50 % PM, repetition frequency 200 Hz
Fast transient disturbance/bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 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

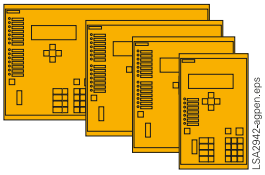
Technical data

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

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 1/3 19", 7 LEDs	0
Housing width 1/2 19", 14 LEDs	1
Housing width 1/1 19", 14 LEDs	2
Housing width 2/3 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	
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.

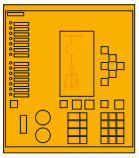
2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

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



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 1/1 19", 14 LEDs	2
Measuring inputs (4 x V/4 x I)	
I_{ph} = 1 A[1], I_e = 1 A[1] (min. = 0.05 A)	1
I_{ph} = 1 A[1], I_e = 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	
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

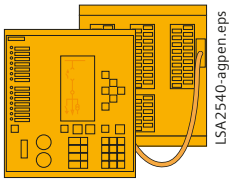
1) Rated current can be selected by means of jumpers.

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.



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 1/1 19", 14 LEDs	2
Measuring inputs (4 x V/4 x I)	
I_{ph} = 1 A[1)], I_e = 1 A[1)] (min. = 0.05 A)	1
I_{ph} = 1 A[1)], I_e = 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	
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.

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**

6

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		
Port C: DIGSI/modem, electrical RS232, Port D: empty	1	see pages 6/34 and 6/35
Port C: DIGSI/modem, electrical RS485, Port D: empty	2	
Port C and Port D installed	9	M □□
Port C		
DIGSI/modem, electrical RS232		1
DIGSI/modem, electrical RS485		2
Port D		
Protection data interface: optical 820 nm, two ST connectors, FO cable length up to 1.5 km For direct connection via multi-mode FO cable or communication networks [1]		A
Protection data interface: optical 820 nm, two ST connectors, FO cable length up to 3.5 km For direct connection via multi-mode FO cable		B
Two analog outputs, each 0...20 mA		K
Protection data interface: optical 1300 nm, LC-Duplex connector FO cable length up to 24 km for direct connection via mono-mode FO cable[2]		G
Protection data interface: optical 1300 nm, LC-Duplex connector FO cable length up to 60 km for direct connection via mono-mode FO cable[2)3]		H
Protection data interface: optical 1550 nm, LC-Duplex connector FO cable length up to 100 km for direct connection via mono-mode FO cable[2)4]		J
FO30 optical 820 nm, 2-ST-connector, length of optical fibre up to 1.5 km for multimode fibre, for communication networks with IEEEC37.94 interface or direct optical fibre connection (not available for surface-mounted housing)		S

1) For suitable communication converters 7XV5662 (optical to G703.1/X21/RS422 or optical to pilot wire) see "Accessories".

2) For surface-mounting housing applications an internal fiber-optic module 820 nm will be delivered in combination with an external repeater.

3) For distances less than 25 km, two optical attenuators 7XV5107-0AA00 are required to avoid optical saturation of the receiver element.

4) For distances less than 50 km, two optical attenuators 7XV5107-0AA00 are required to avoid optical saturation of the receiver element.

Distance Protection 7SA6

Selection and ordering data

Description				Order No.
7SA6 distance protection relay for all voltage levels				**7SA6**□□□-□□□□□-□□□□
Functions 1				
Trip mode	Thermal overload protection (ANSI 49)	BCD-coded output for fault location		
3-pole				**0**
3-pole		■		**1**
3-pole	■			**2**
3-pole	■	■		**3**
1/3-pole				**4**
1/3-pole		■		**5**
1/3-pole	■			**6**
1/3-pole	■	■		**7**
Functions 2				
Distance protection pickup (ANSI 21, 21N)		Power swing detection (ANSI 68, 68T)	Parallel line compensation	
$I>$				**A**
$V< / I>$				**B**
Quadrilateral ($Z<$)				**C**
Quadrilateral ($Z<$), $V< / I> / \varphi$				**D**
Quadrilateral ($Z<$)		■		**F**
Quadrilateral ($Z<$), $V< / I> / \varphi$		■		**G**
$V< / I>$			■ 1)	**J**
Quadrilateral ($Z<$)			■ 1)	**K**
Quadrilateral ($Z<$), $V< / I> / \varphi$			■ 1)	**L**
Quadrilateral ($Z<$)		■	■ 1)	**N**
Quadrilateral ($Z<$), $V< / I> / \varphi$		■	■ 1)	**P**
Functions 3				
Auto-reclosure (ANSI 79)	Synchro-check (ANSI 25)	Breaker failure protection (ANSI 50BF)	Over/undervoltage protection $V>$, $V<$ (ANSI 27, 59) Over/underfrequency protection (ANSI 81)	
				A
			■	**B**
		■		**C**
		■	■	**D**
	■			**E**
	■		■	**F**
	■	■		**G**
	■	■	■	**H**
■				**J**
■			■	**K**
■		■		**L**
■		■	■	**M**
■	■			**N**
■	■		■	**P**
■	■	■		**Q**
■	■	■	■	**R**
Functions 4				
Directional ground-fault protection, grounded networks (ANSI 50N, 51N, 67N)	Ground-fault detection compensated/ isolated networks	Measured values extended Min, max, mean		
				0
		■		**1**
	■ 2)			**2**
	■ 2)	■		**3**
■				**4**
■		■		**5**
■	■ 2)			**6**
■	■ 2)	■		**7**

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

2) Only with position 7 of Order No. = **2** or **6**.

Description	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	Order No. 7SA6□□□-□□□□□-□□□□
7SA6 distance protection relay for all voltage levels																
Preferential types Functions 1																
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**.

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 FO 5, OMA1, 820 nm, multi-mode FO cable, ST connector, 1.5 km	**C53207-A351-D651-1**
	Protection data interface FO 6, OMA2, 820 nm, multi-mode FO cable, ST connector, 3.5 km	**C53207-A351-D652-1**
	Protection data interface FO 17, 1300 nm, mono-mode FO cable, LC-Duplex connector, 24 km	**C53207-A322-B115-3**
	Protection data interface FO 18, 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	**C53207-A322-B116-3**
	Protection data interface FO 19, 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	**C53207-A322-B117-3**
	Optical repeaters	
	Serial repeater (2-channel), opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 24 km	**7XV5461-0BG00**
	Serial repeater (2-channel), opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	**7XV5461-0BH00**
	Serial repeater (2-channel), opt. 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	**7XV5461-0BJ00**

6

Fig. 6/33 Mounting rail for 19" rack

Fig. 6/34
2-pin connector

Fig. 6/35
3-pin connector

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

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

Accessories	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

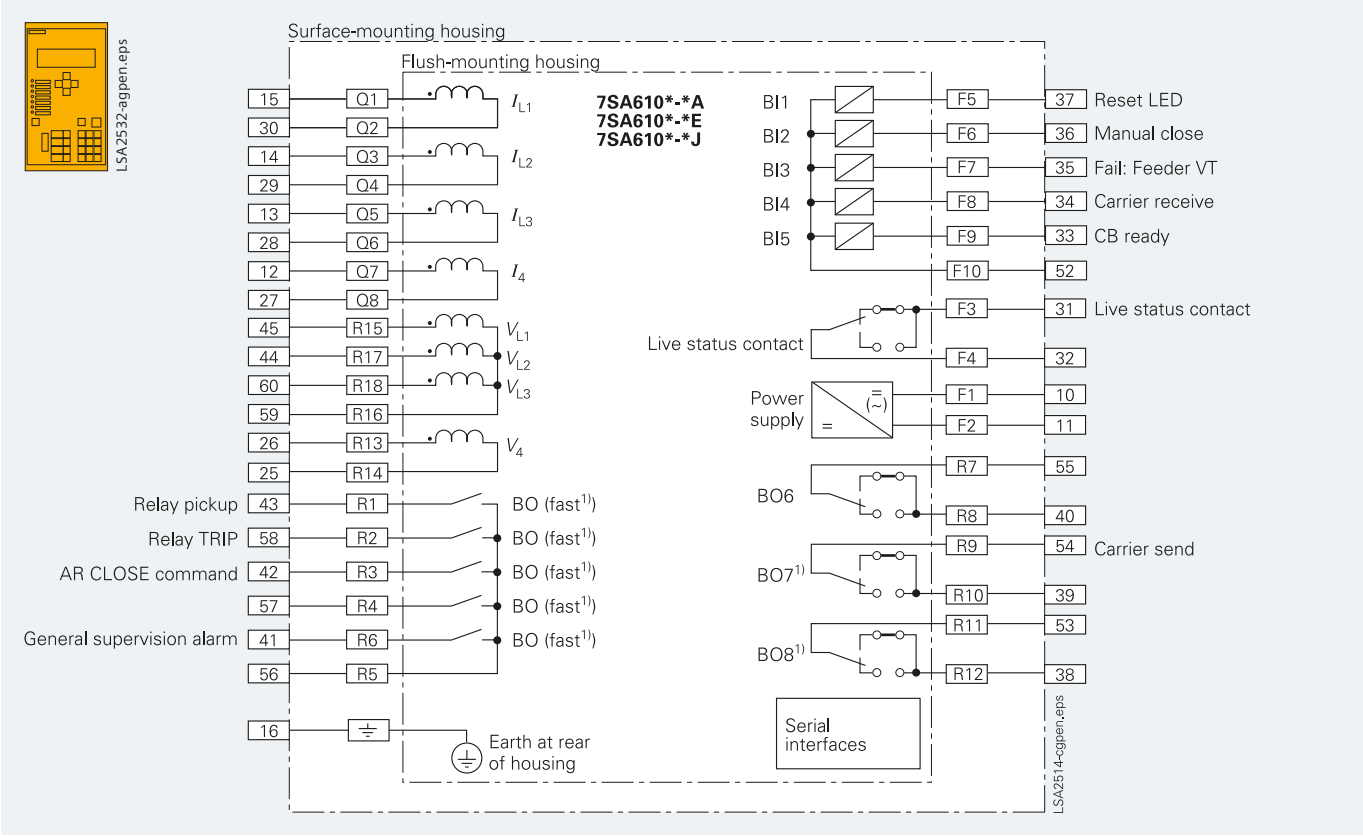
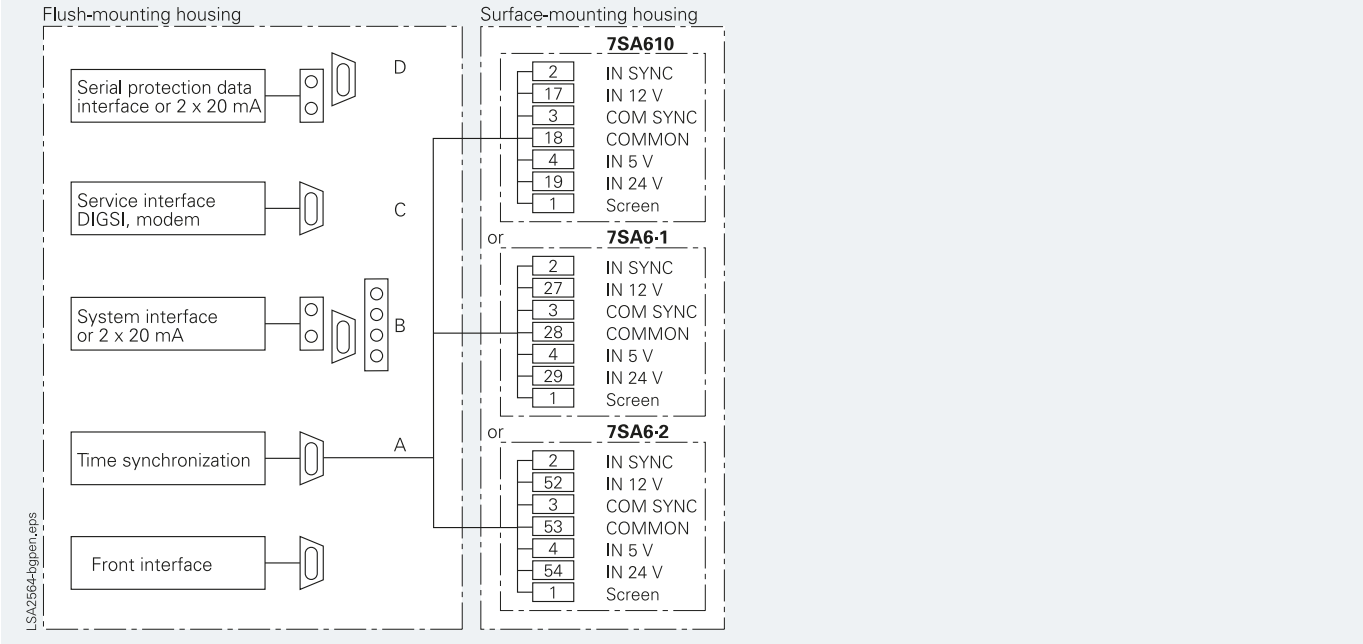
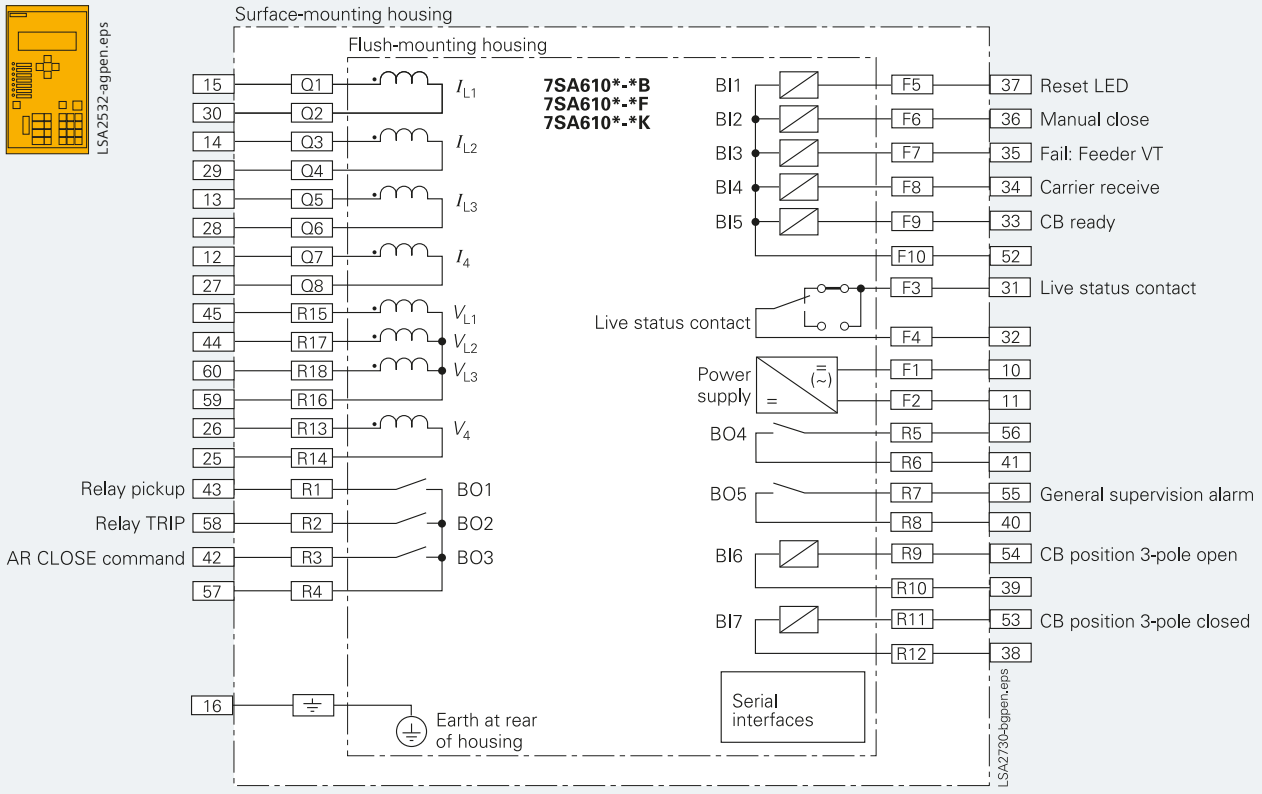


Fig. 6/38 Connection diagram



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

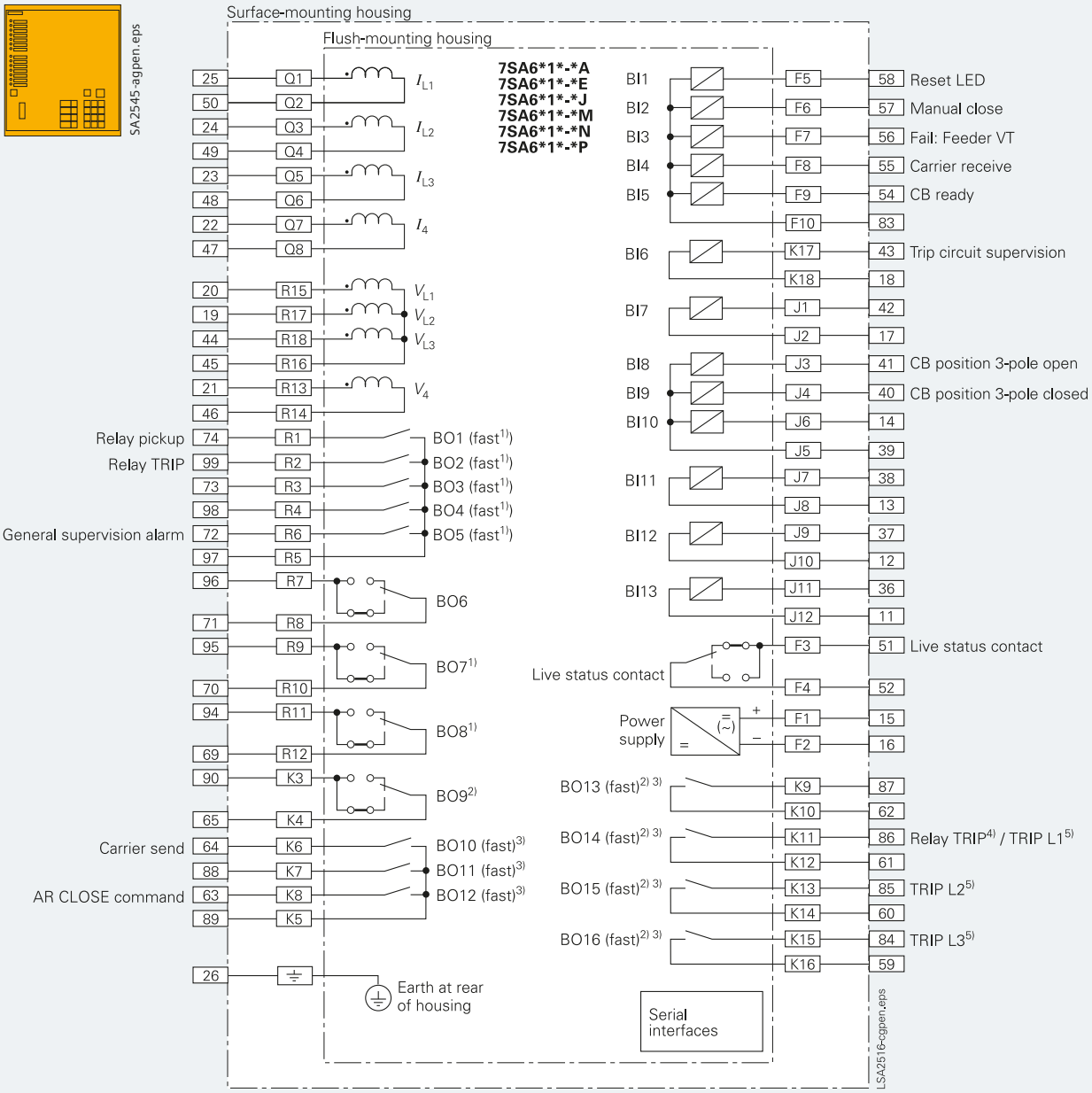
Fig. 6/39 Serial interfaces



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

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

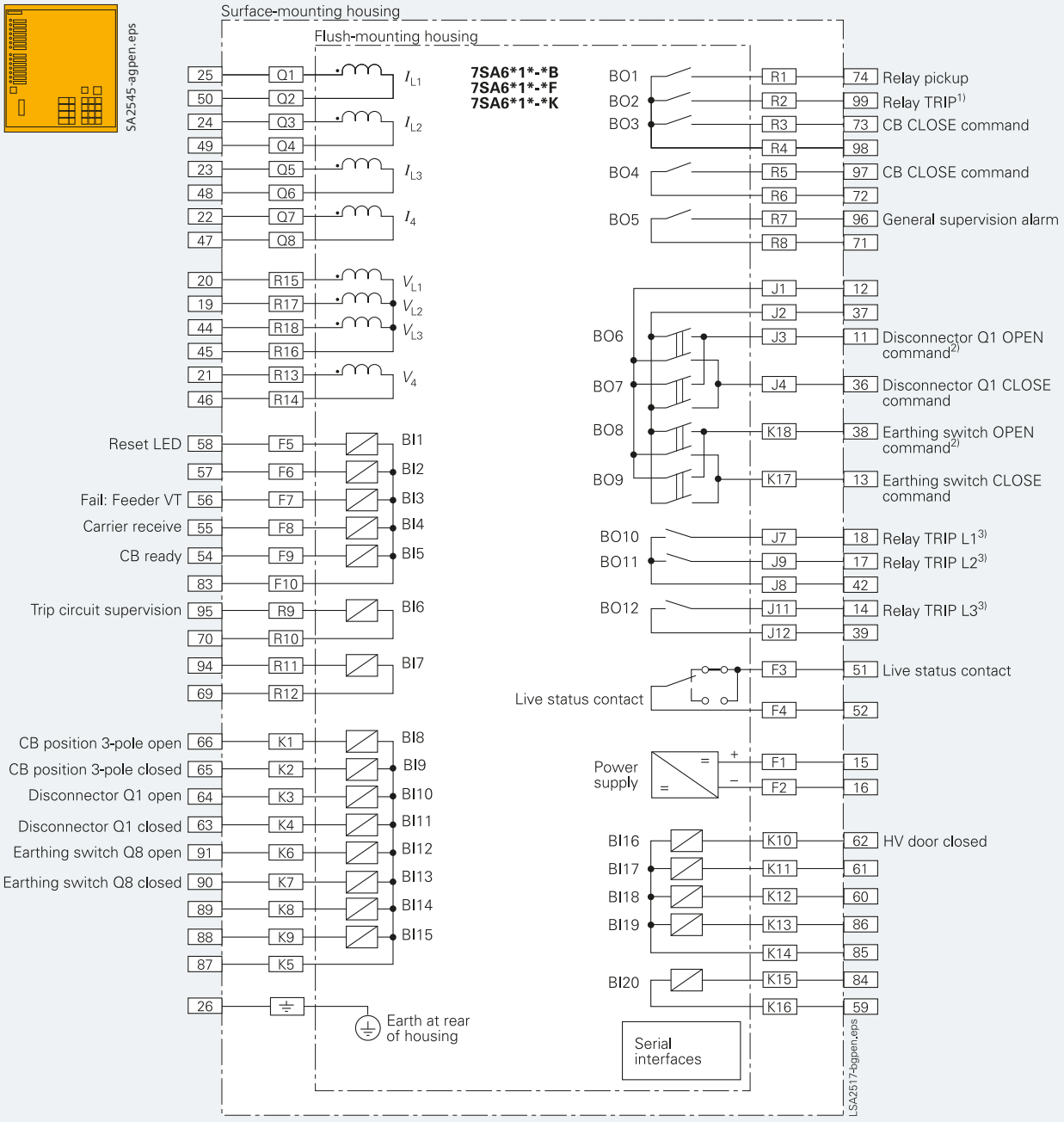
3) Time advantage with fast relay approx. 3 ms.

4) Version with 3-pole tripping.

5) Version with 1/3-pole tripping.

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

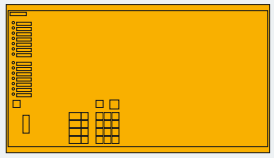
Fig. 6/41 Connection diagram



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

Connection diagram



1) 7SA613 is only available in a 2/3 x 19" flush-mounting housing.

2) Starting from unit version .../EE

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

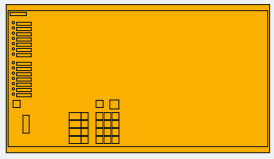
4) High-speed trip outputs in versions 7SA6*2*-*M, 7SA6*2*-*P, 7SA6*2*-*R.
Time advantage of high-speed relays over fast relays: approx. 5 ms

5) Version with 3-pole tripping.

6) Version with 1/3-pole tripping.

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

Fig. 6/43 Connection diagram



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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.

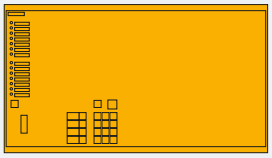
4) Version with 3-pole tripping.

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



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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

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.

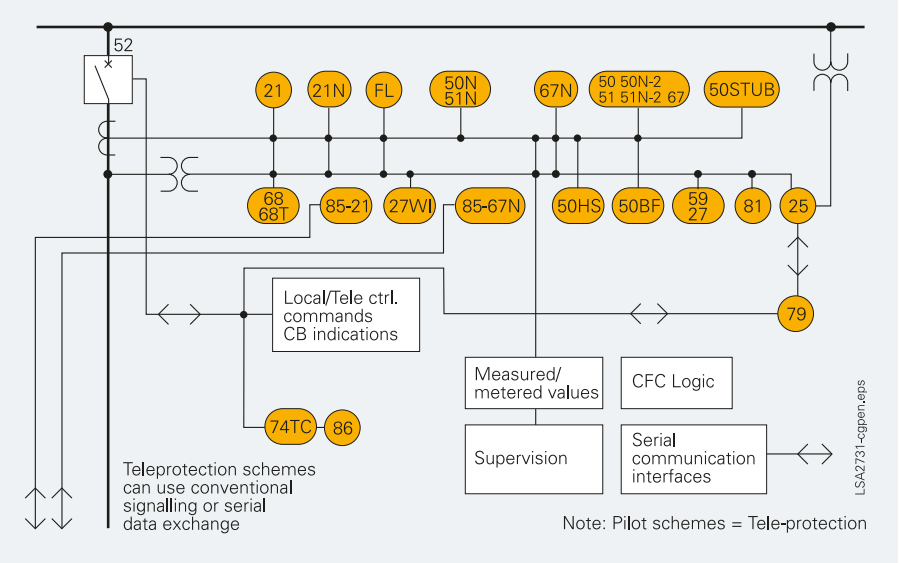

Fig. 6/47 Single-line diagram

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.

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)

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)