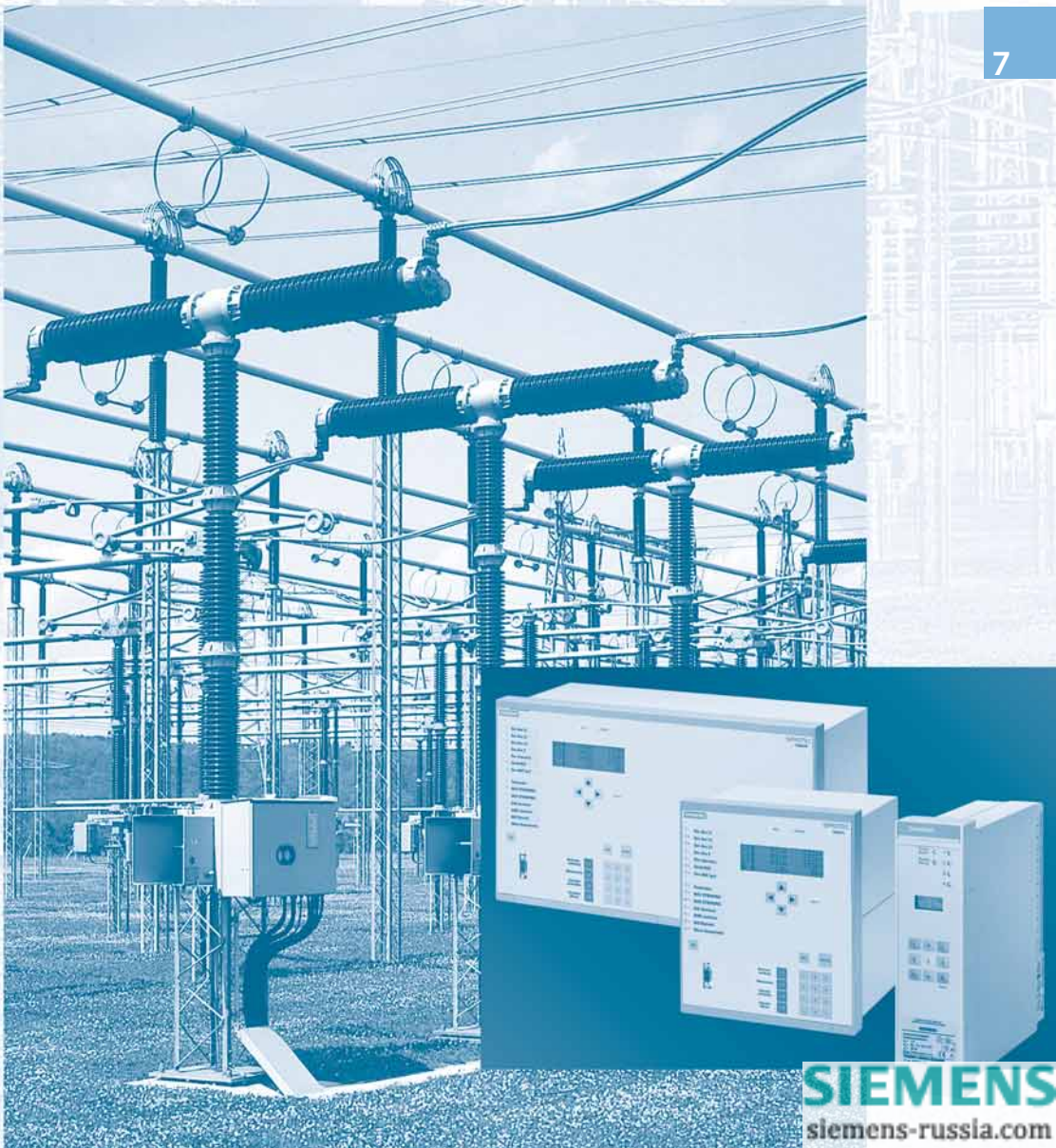
Line Differential Protection



SIPROTEC 7SD60
Numerical Pilot-Wire Current Differential Protection Relay

Fig. 7/1
SIPROTEC 7SD600
numerical current differential protection relay

Description

The 7SD600 relay is a numerical current differential protection relay, simple to set, operating in conjunction with the remote station via a two pilot-wire link. It is connected to the primary current transformers via an external summation current transformer. The primary field of application of the relay is protection of short overhead lines and cables with two line ends. However, transformers and reactors may be located within the protection zone. Features like inrush restraint, lockout, modern PCM-intertrip facilities, full self-monitoring facilities, local and remote interrogation are integrated in the unit.

Function overview

Differential protection relay for overhead lines and cables

- Current differential protection with external summation current transformer 4AM49 (87L)
- Suitable for use for distances of approx. 12 km max. via two pilot wires (1200 Ω loop resistance)
- Differential protection can be combined with an overcurrent release
- Pilot-wire monitoring function
- Bidirectional remote tripping
- Circuit-breaker intertripping at the remote station
- Seal-in of the TRIP command until manual reset (Lockout function)
- Minimal current transformer requirements due to integrated saturation detector
- Restraint against inrush/undelayed trip for high differential fault currents
- Emergency overcurrent protection

Operational measured values

- Local and remote current
- Differential current
- Restraint current

Monitoring functions

- Hardware
- Firmware
- Spill current supervision

Hardware

- Local operation by means of integrated keyboard
- LCD display for settings and analysis
- Housing

– Flush-mounting housing 1/6 19" 7XP20
– Surface-mounting housing 1/6 19" 7XP20

Communication

- Via personal computer and DIGSI 3
- Via RS232↔RS485 converter
- With modem
- With substation control system via IEC 60870-5-103 protocol
- 2 kV isolated RS485 interface, bus connection possible

Application

The 7SD60 relay is a numerical current differential protection relay, simple to set, and is operated in conjunction with the remote station via a two pilot-wire link.

It is connected to the primary current transformers via an external summation current transformer. The unit operates internally on the summated current taken from the secondary side of the summation current transformer. The link to the remote station is realized by means of a pair of symmetrical pilot wires allowing distances of up to approximately 12 km. Adaptation to the pilot-wire resistance is effected by means of software within the unit. Therefore, matching is not necessary.

The primary field of application of the unit is protection of short overhead lines and cables with two line ends. However, transformers and reactors may be located within the protection zone. The unit can be fitted with inrush restraint in such cases. A differential protection instantaneous tripping stage is also provided in this case. Vector group adaptation is not effected inside the unit and must, if necessary, be effected by means of a matching current transformer.

The 7SD60 can be fitted with a pilot-wire monitoring function. In addition to monitoring the pilot-wire link to the remote station, this also includes bidirectional circuit-breaker intertripping and a remote tripping command.

If the differential protection becomes inactive due to a pilot-wire failure, the relay has an emergency overcurrent function as an option. It includes one definite-time overcurrent stage and can be delayed.

This unit substitutes the 7SD24 steady-state differential protection. However, direct interoperation with the 7SD24 is not possible. On replacement of a 7SD24, its external summation current transformer can be used as the input transformer for the 7SD60.

ANSI	
(87L, 87T)	ΔI for lines/cables, transformers
(85)	Intertrip, remote trip
(86)	Lockout function
(50)	Single-stage, definite-time emergency overcurrent protection

Construction

The compact 7SD60 protection relay contains all the components for:

- Measured-value acquisition and evaluation
- Operation and LCD indications
- Alarm and command contacts
- Input and evaluation of binary signals
- Data transmission via the RS485 bus interface to DIGSI or a substation control system
- Auxiliary voltage supply

The primary current transformers are connected to the 4AM49 summation current transformer. At the rated current value of either 1 A or 5 A, the latter outputs a current of 20 mA which is measured by the 7SD60 unit. The summation current transformer is supplied together with the protection unit, if so ordered.

The unit can be supplied in two different housings. The one for flush mounting in a panel or cubicle has connection terminals at the rear.

The version for panel surface mounting is supplied with terminals accessible from the front. Alternatively, the unit can be supplied with two-tier terminals arranged above and below the unit.

Fig. 7/2
Rear view flush-mountig housing

Protection functions

Mode of operation of the differential protection relay

An external summation current transformer 4AM49, which can be supplied as an accessory either in a 1 A or a 5 A version, allows any secondary currents of the primary current transformers (see Fig. 7/3) to be connected. The standard ratios of the three primary windings of the summation current transformer are IL1:IL2:IL3 = 5:3:4 (IL1:IL3:IL0 = 2:1:3) (see Fig. 7/6). In consequence, the sensitivity of the tripping characteristic for single-phase faults is appreciably higher compared to that for two-phase and three-phase faults. Since the current on such faults is often weak, an amplification factor of 1.7 to 2.8 referred to the symmetrical response value is achieved.

Other sensitivity values can, however, be obtained by altering the connections at the summation CT.

With a symmetrical three-phase current of 1 x I_N, the secondary current of the summation current transformer is 20 mA.

The 7SD60 measures and digitalizes the current I_{M1} of the local relay by means of a sensitive current input (see Fig. 7/6). A voltage drop occurs across a fixed-value resistor R_b installed in the unit. With a through-flowing load or a through- flowing short-circuit current, the voltage drop at both ends of the line is approximately equal but of opposite polarity, so that no current flows through the pilot wire. On occurrence of an internal fault, different values are obtained for the voltage drop across R_b at both ends. In consequence, a current I_a flows through the pilot wire, which is measured by means of the current transformer. In conjunction with the pilot- wire resistance (available as a parameter in the unit) and the internal resistor R_a, it is possible to calculate the differential current from the measured current flowing through the pilot wire. As soon as an adjustable value is reached, the protection relay trips the line at both ends.

Matching of the sensitivity of the unit for different values of pilot-wire resistance is effected by the firmware of the unit during parameter setting, so that time-consuming matching of the pilot-wire resistance is unnecessary.

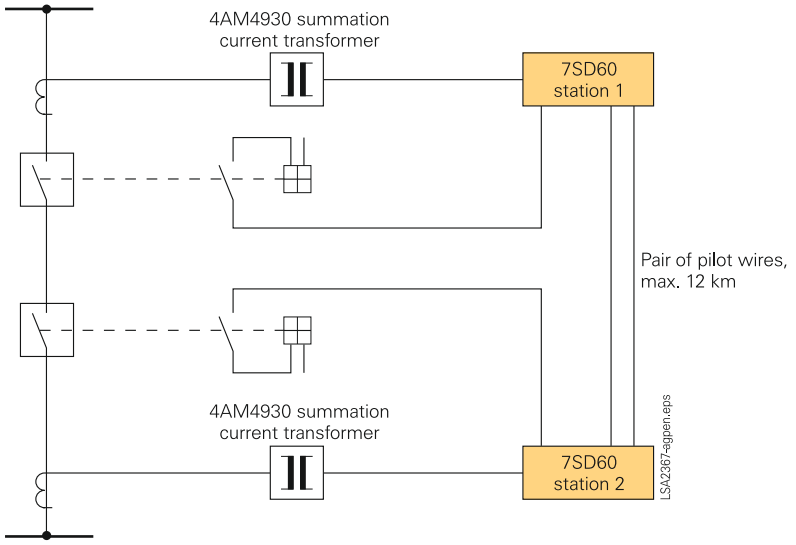
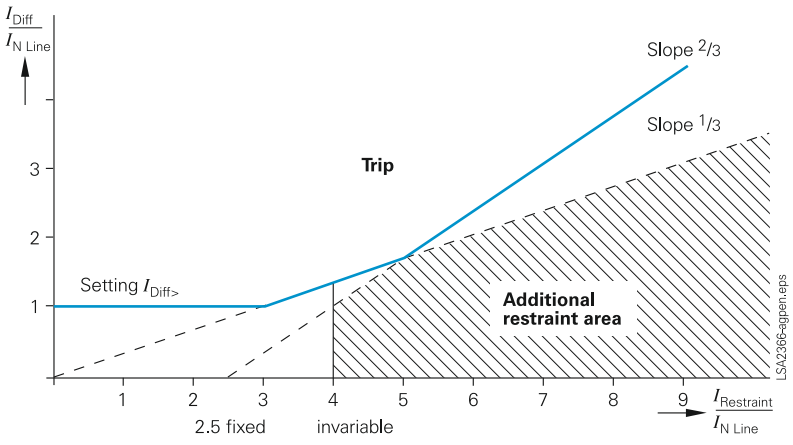


Fig. 7/3
7SD60 line differential protection for operation with two pilot wires



I_{Diff} $= |I_1 + I_2|$
$I_{Restraint}$ $= |I_1| + |I_2|$
I_1 = current at local relay end of line, current flowing into the line is positive
I_2 = current at remote relay, current flowing into the line is positive
$I_{N\ Line}$ = rated current of the line

Fig. 7/4
Trip characteristic of differential protection

Trip characteristic of the differential protection relay

The main function of the unit is current comparison protection. The trip characteristic is fixed and takes into account both the linear and the non-linear errors of the current transformers. It is only necessary to set the tripping value $I_{Diff>}$, although the standard setting is suitable for most applications. It should be parameterized according to the rated current of the line; sensitive setting is possible even when the current transformer rated currents and the line rated currents differ by as much as a factor of 2. Differences in the current transformation ratios at the ends of the line must, however, be compensated for by means of external matching current transformers.

In some cases, this can be realized by the summation current transformer.

Protection functions

Overcurrent release / differential current monitoring

The differential protection function can be combined with an additional overcurrent release. To this end, the criteria "overcurrent" and "differential current" are linked logically so that a TRIP command is given out by the differential function only when a differential current and an overcurrent coexist.

By this means it is often possible to avoid malfunctioning due to pilot-wire short-circuit or wire-break of a connection between a current transformer and the summation current transformer. For this purpose, the 7SD60 is fitted with an additional differential current monitoring function, which can effectively block the differential protection after a delay of some seconds on reaching of an adjustable value of differential current in conjunction with simultaneous operational current I_{M1} within the load range.

Saturation detector

Improved stability on single-ended saturation of the primary current transformers is ensured by means of an integrated saturation detector. It provides additional stability during external faults. 5 ms are enough time to measure an external fault due to a high restraint and small differential current. Indication is done within the additional restraint area (see Fig. 7/4). If – due to CT saturation – the differential current flows into the trip area, the differential trip is blocked for a certain time. Transient saturation of current transformers caused by decaying DC components in the short-circuit current can thus be recognized.

As a result, the requirements on the current transformers are reduced so that they are only required to conduct the steady-state through-flowing short-circuit current without saturation.

Pilot-wire link / pilot-wire monitoring

The link to the remote station comprises a symmetrical pair of wires (e.g. telephone lines). The maximum permissible distance between two stations is approximately 12 km. 7XR9513 (20 kV) or 7XR9515 (5 kV) isolation transformers can be employed for potential isolation against interference induced by longitudinal voltages where the pilot wires run parallel to power cables over long distances.

Since the pilot wires form an integral part of the differential protection, these are normally monitored continuously. This function is available as an option. To achieve this, 2 kHz pulses with a defined pulse width ratio are transmitted to the remote relay via the pilot wires. Detection of a fault in the pilot-wire link results in blocking of the differential protection.

Emergency overcurrent protection

If the differential protection becomes inactive due to a pilot-wire failure or an internal or external blocking of the differential function, the relay offers a single-stage, definite-time overcurrent function. It works with the local flowing operational current I_{M1}. The pickup value and the delay time are settable via parameters in the device.

Circuit-breaker intertripping / remote tripping

Normally, tripping is effected at both stations as a result of current comparison. Tripping at one end only can occur when an overcurrent release is used or with short-circuit currents only slightly above the tripping value. Circuit-breaker intertripping can be parameterized in the unit with integral pilot-wire monitor, so that definite tripping at both ends of the line is assured.

In addition, it is possible by means of a binary input to output a remote tripping command for both directions. The command transmission time is approximately 80 ms.

Lockout of the TRIP command with manual reset

The TRIP command can be locked-out after tripping. In particular, in the case of transformers within the protection zone, reclosure of the line is normally effected only after the cause of the fault has been ascertained by the user. Manual reset is possible either via the operator panel (with password) or via a binary input. As a result, premature reclosure of the circuit-breaker is prevented. The logic state of the TRIP command remains stored even during failure of the auxiliary supply voltage, so that it is still present on restoration of the auxiliary supply voltage.

Inrush restraint / instantaneous tripping stage

Where transformers or reactors are located within the protection zone, inrush restraint can be supplied as an option. This inrush restraint evaluates the second harmonic of the differential current, which is typical for inrush phenomena. If the second harmonic value of the differential current referred to the fundamental frequency exceeds a preset value, tripping by the differential protection is blocked. In the case of high-current internal faults, whose amplitude exceeds the inrush current peak, tripping can be carried out instantaneously.

Vector group adaptation is not effected inside the unit and must, where necessary, be brought about by means of an external matching transformer scheme.

Features

Serial data transmission

As standard, the unit is fitted with an RS485 interface. This is suitable for connection to a bus and allows up to 32 devices to be connected via a two-wire serial interface (use of a third core for earth is recommended). A PC is connected via this interface using an RS232↔RS485 converter, thus allowing the DIGSI operator program to be used, by means of which PC-aided planning, parameter setting and evaluation can be performed. By this readout, it is also possible to output the fault recordings stored by the unit on occurrence of faults.

Using an RS485↔820 nm optical converter as an accessory (7XV5650, 7XV5651), it is possible to provide an interference-free and isolated link to a central control system or a remote control system employing DIGSI, thus allowing economically viable configurations to be used, e.g. for remote diagnostics.

The serial interface can also be set to the IEC 60870-5-103 protocol (VDEW - Association of German Utilities - interface), thus allowing the unit to be integrated in a substation control system. However, only 2 messages (ready for operation and the trip signal) and the fault recording are available.
For this reason, it is recommended to use the 7SD610 unit combined with an external communication converter for pilot wires in those cases in which integration in the substation control system is a prime consideration.

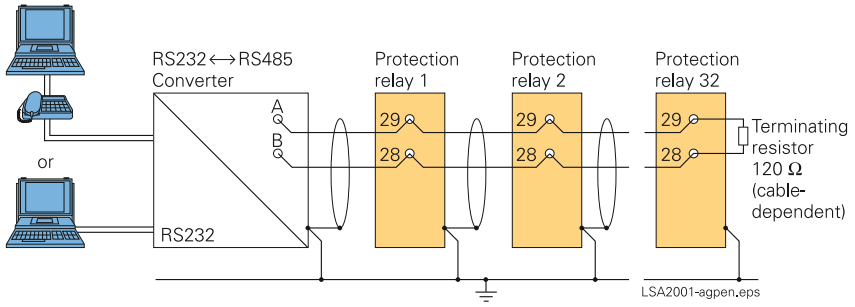
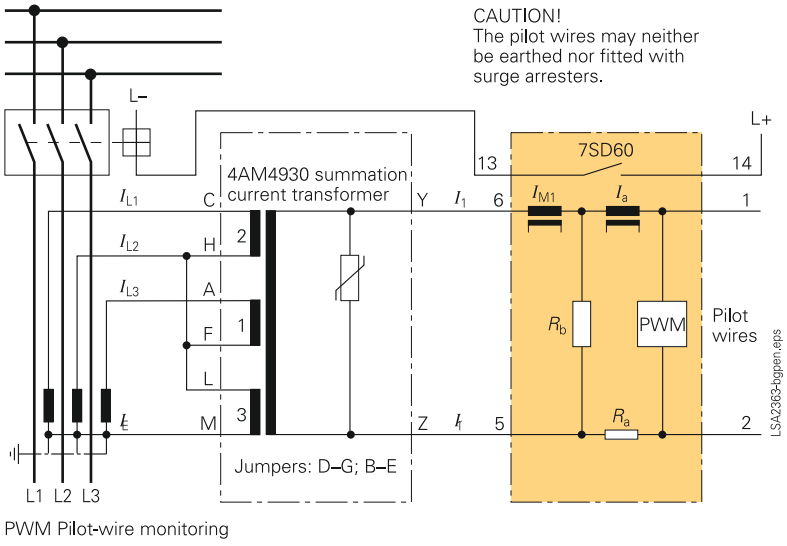


Fig. 7/4
Bus communication via RS485 interface
For convenient wiring of RS485 bus, use bus cable system 7XV5103 (see part 13 of this catalog).

Connection diagrams



PWM Pilot-wire monitoring

Fig. 7/6
Standard connection L1-L3-E, suitable for all types of networks

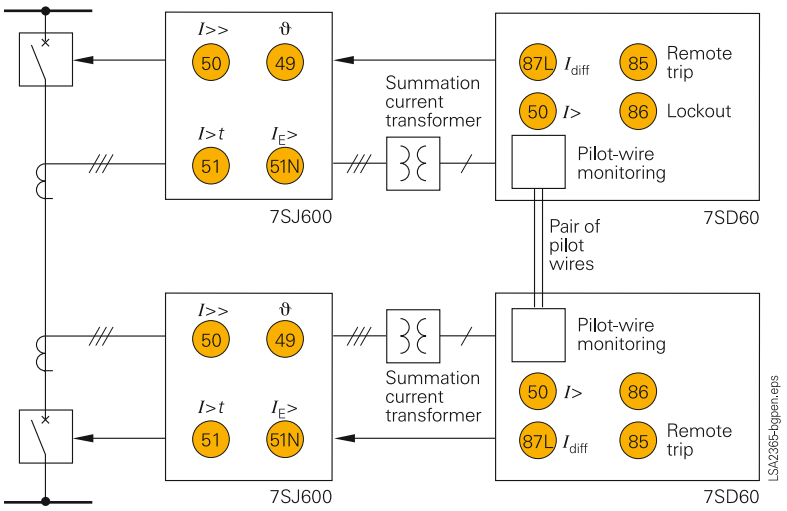


Fig. 7/7
Protection configuration with main (7SD60) and backup overcurrent (7SJ60) protection

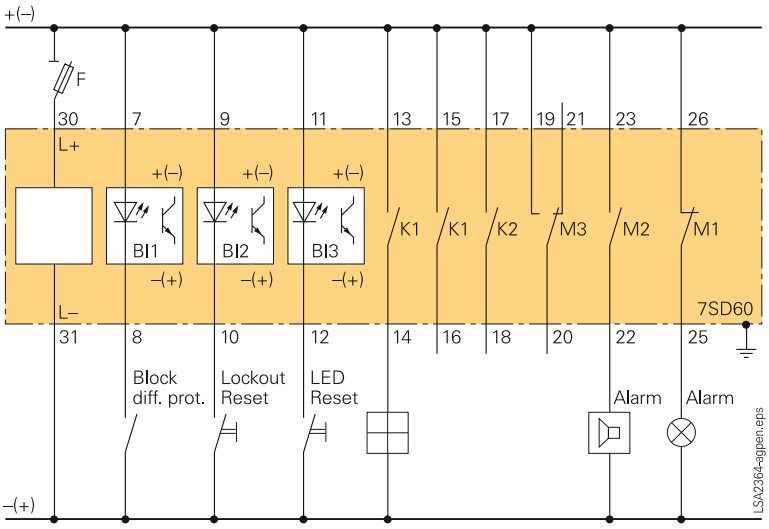


Fig. 7/8
Typical circuit for auxiliary voltage supply

Technical data

General unit data

Input circuits

Rated current I_N	20 mA without summation current transformer 1 or 5 A with summation current transformer
Rated frequency f_N	50/60 Hz parameterizable
Thermal overload capability current path	
Continuous	2 x I_N
For 10 s	30 x I_N
For 1 s	100 x I_N

Auxiliary voltage

Auxiliary voltage via integrated DC/DC converter	
Rated auxiliary DC voltage/ permissible variations	24/48 V DC /19 to 58 V DC 60/110/125 V DC /48 to 150 V DC 220/250 V DC /176 to 300 V DC
Superimposed AC voltage V_{aux} Peak-to-peak	≤ 12 % at rated voltage ≤ 6 % at limits of admissible voltage
Power consumption	
Quiescent	Approx. 2 W
Energized	Approx. 4 W
Bridging time during failure/ short-circuit of auxiliary voltage	≥ 50 ms (at V_{aux} ≥ 100 V AC/DC) ≥ 20 ms (at V_{aux} ≥ 24 V DC)
Rated auxiliary voltage AC V_{aux}/ permissible variations	115 V AC / 88 to 133 V AC

Command contacts

Number of relays	2 (marshallable)
Contacts per relay	2 NO or 1 NO
Switching capacity	
Make	1000 W/VA
Break	30 W/VA
Switching voltage	250 V
Permissible current	
Continuous	5 A
For 0.5 s	30 A

Signal contacts

Number of relays	3 (2 marshallable)
Contacts per relay	1 CO
Switching capacity	
Make	1000 W/VA
Break	30 W/VA
Switching voltage	250 V AC/DC
Permissible current	5 A

Binary inputs

Number	3 (marshallable)
Operating voltage	24 to 250 V DC
Current consumption, energized	Approx. 2.5 mA independent of operating voltage
Pick-up threshold reconnectable	By solder bridges
Rated aux. voltages 24/48/60 V DC	
$V_{pick-up}$	≥ 17 V DC
$V_{drop-off}$	< 8 V DC
Rated aux. voltages 110/125/220/250 V DC	
$V_{pick-up}$	≥ 74 V DC
$V_{drop-off}$	< 45 V DC

Unit design

Housing	7XP20
Dimensions	For dimensions, see dimension drawings, part 15
Weight	
With housing for surface mounting	Approx. 4.5 kg
With housing for flush mounting/cubicle mounting	Approx. 4 kg
Degree of protection acc. to EN 60529	
Housing	IP 51
Terminals	IP 21

Serial interface (Isolated)

Standard	RS485
Test voltage	2.8 kV DC for 1 min
Connection	Via wire to housing terminals, 2 data transmission lines, 1 earthing cable for connection to an RS485↔RS232 converter, cables have to be shielded, screen has to be earthed Setting at supply: 9600 baud
Baud rate	Min. 1200 baud; max. 19200 baud

Technical data

Electrical tests

Specification

Standards	IEC 60255-5 ANSI/IEEE C37.90.0

Insulation tests

Voltage test (routine test)	
All circuits except DC voltage supply and RS485	2 kV (r.m.s.), 50 Hz
Only DC voltage supply and RS485	2.8 kV DC
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
Test crosswise:	
Measurement circuits, pilot wire connections, power supply, binary inputs, class III, (no tests crosswise over open contacts, RS458 interface terminals)	

EMC tests for noise immunity; type tests

Standards	IEC 60255-6; IEC 60255-22 (international product standard) EN 50082-2 (generic standard) VDE 0435, Part 303 (German product standard)
High-frequency test IEC 60255-22-1, VDE 0435 Part 303; class III	2.5 kV (peak); 1 MHz; τ = 15 µs; 400 surges; duration 2 s
Electrostatic discharge IEC 60255-22-2, EN 61000-4-2; class III	4/6 kV contact discharge; 8 kV air discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with RF field, non-modulated IEC 60255-22-3 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; AM 80 %; 1 kHz
Irradiation with RF field, pulse-modulated IEC 61000-4-3/ENV 50204; class III	10 V/m, 900 MHz; repetition rate 200 Hz, duty cycle 50 %
Fast transients/bursts IEC 60255-22-3, IEC 61000-4-4, class IV	2 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; duration 1 min
Line-conducted RF amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; AM 80 %; 1 kHz
Power frequency magnetic field IEC 61000-4-8; class IV; EN 60255-6	30 A/m; 50 Hz, continuous 300 A/m for 3 s; 50 Hz; 0.5 mT, 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1 (common mode)	2.5 to 3 kV (peak), 1 MHz to 1.5 MHz decaying oscillation; 50 shots per s; duration 2 s; R_i = 150 Ω to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1 (common mode)	4 to 5 kV; 10/150 ns; 50 shots per s both polarities; duration 2 s; R_i = 80 Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	10 to 20 V/m; 25 to 1000 MHz; amplitude and pulse-modulated
High-frequency test Document 17C (SEC) 102	2.5 kV (peak, alternating polarity) 100 kHz, 1 MHz, 10 and 50 MHz, decaying oscillation; R_i = 50 Ω

EMC tests for interference emission; type tests

Standard	EN 50081- (generic standard)
Conducted interference voltage on lines, auxiliary voltage only, EN 55022, VDE 0878 Part 22, CISPR 22, limit value, limit class B	150 kHz to 30 MHz
Interference field strength EN 55011, VDE 0875 Part 11, IEC CISPR 11, limit value, limit class A	30 to 1000 MHz

Mechanical dynamic tests

Vibration, shock stress and seismic vibration

During operation

Standards	IEC 60255-21; IEC 60068-2
Vibration IEC 60255-21-1, class I IEC 60068-2-6	Sinusoidal 10 to 60 Hz; ± 0.035 mm amplitude; 60 to 150 Hz; 0.5 *g* acceleration; sweep rate 1 octave/min; 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I	Half-sine 5 *g* acceleration, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
Seismic vibration IEC 60255-21-3, class I IEC 60068-2-6	Sinusoidal 1 to 8 Hz; ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz; ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz; 1 *g* acceleration (horizontal axis) 8 to 35 Hz; 0.5 *g* acceleration (vertical axis) Sweep rate 1 octave/min 1 cycle in 3 orthogonal axes

During transport

Standards	IEC 60255-21; IEC 60068-2
Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 5 Hz to 8 Hz: ±7.5 mm amplitude 8 Hz to 150 Hz: 2 *g* acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I	Half-sine Acceleration 15 *g*, duration 11 ms, 3 shocks
IEC 60068-2-27	Shocks in each direction of 3 orthogonal axes
Continuous shock IEC 60255-21-2, class I IEC 60068-2-29	Half-sine Acceleration 10 *g*, duration 16 ms, 1000 shocks in each direction of 3 orthogonal axes

Technical data

Climatic stress test

Temperatures

Standards	EN 60255-6, IEC 60255-6 DIN VDE 0435 Part 303	
Recommended temperature	-5 to +55 °C (>55 °C/131 °F decreased display contrast)	
Limit temperature		
During service	-20 to +70 °C	- 4 to +158 °F
During storage	-25 to +55 °C	-13 to +131 °F
During transport (Storage and transport with standard works packing!)	-25 to +70 °C	-13 to +158 °F

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	Mean value per year ≤ 75 % relative humidity, on 30 days a year up to 95 % relative humidity, condensation not permissible!

Functions

Line differential protection

Note	All current values refer to the symmetrical current using standard connection
Setting ranges	
Current threshold I_1 (release by local station current)	$I/I_{N\,Line}$: 0 to 1.5 (step 0.01)
Differential current	$I/I_{N\,Line}$: 0.5 to 2.5 (step 0.01)
Delay time t	0 to 60 s (step 0.01 s)
Restraint by 2nd harmonic (see Fig. 7/4)	
$2f_N/f_N$	10 to 80 %
Reset ratio	Approx. 0.7 – drop-off ratio ($I_{Restraint} = 0$)
Inherent delays	
TRIP time for two-end supply at 4 x set value	Approx. 20 to 28 ms without restraint by 2nd harmonic Approx. 32 to 42 ms with restraint by 2nd harmonic
Drop-off time	Approx. 35 ms
Tolerances at preset values under reference conditions	
Local station current threshold	± 3 % of setpoint, min. 0.02 x I_N
Differential current	± 5 % of setpoint, min. 0.02 x I_N
Influence parameters	
Auxiliary supply voltage $0.8 \le V_{aux}/V_{auxN} \le$ x 1.15	≤ 1 %
Temperature in range $0\,°C \le \Theta_{amb} \le 40\,°C$	≤ 1 %/10 K
Frequency in range $0.9 \le f/f_N \le 1.1$	≤ 4 %
Pilot wires	
Number	2 Symmetric telephone pairs are recommended with loop resistance 73 Ω/km and capacitance 60 nF/km
Core-to-core asymmetry at 800 Hz	Max. 10^{-3}
Maximum loop resistance	1200 Ω
Permissible induced longitudinal voltages	
On direct connection of the pilot wires	≤ 1.2 kV, however, max. 60 % of the test voltage of the pilot wires
For connection via isolating transformer	≥ 1.2 kV, however, max. 60 % of the test voltage of the pilot wires and max. 60 % of the test voltage of the isolating transformers
Pilot-wire monitoring and intertripping (optional)	
Monitoring signal	2000 Hz, pulse-code modulation
Alarm signal delay	1 to 60 s (step 1 s)
Inherent delay time of intertripping	Approx. 65 ms
Extension of the intertripping signal	0 to 5 s (step 0.01 s)

Emergency overcurrent protection

Setting ranges	
Overcurrent pickup value I_{M1} / I_{Nline}	0.1 to 15 (step 0.1)
Delay time	0.0 to 60 s (step 0.01 s)

Remote trip

Note	Tripping of the remote end circuit-breaker for units with pilot-wire monitoring only
Setting ranges	
Prolongation time for transmission to remote station	0 to 60 s (step 0.01 s)
Delay time for reception from the remote station	0 to 60 s (step 0.01 s)
Prolongation time for reception from the remote station	0 to 60 s (step 0.01 s)
Tolerances	
Delay time/release delay	1 % and 10 ms respectively
Inherent delay	
Transmission time without delay	Approx. 80 ms

Lockout function

Lockout seal-in of trip command	For differential protection and remote trip until reset
Lockout reset	By means of binary input and/or local operator panel/DIGSI

Additional functions

Operational measured values	
Operational currents	I_1, I_2, I_{Diff}, $I_{restraint}$
Measurement range	0 to 240 % I_N
Tolerance (I_1)	3 % of rated value or of measured value
Fault event recording	Storage of the events relating to the last 8 faults
Time-tagging	
Resolution for operational events	1 s
for fault events	1 ms
Fault recording (max. 8 faults)	
Storage time (from response or trip command)	Total of 5 s max., pre-trigger and post-fault time settable
Maximum length per recording T_{max}	0.30 to 5.00 s (step 0.01 s)
Pre-trigger time T_{pre}	0.05 to 0.50 s (step 0.01 s)
Post-fault time T_{post}	0.05 to 0.50 s (step 0.01 s)
Time resolution at 50 Hz	1 instantaneous value per 1.66 ms
Time resolution at 60 Hz	1 instantaneous value per 1.38 ms
Circuit-breaker test	Using test circuit

Technical data

4AM4930 summation current transformer

Power consumption in the circuit with standard connection L1-L3-E (Fig. 7/6) referred to the through-flowing rated current (7SD600 unit in operation).

I_N		in phase (approx. VA) L1	L2	L3
1 A	Single-phase	2.2	1.3	1.7
	Symmetrical three-phase	0.6	0.2	0.35
5 A	Single-phase	3.5	1.5	2.2
	Symmetrical three-phase	0.7	0.2	0.5

	Connections	4AM4930-7DB I_N = 1 A	4AM4930-6DB I_N = 5 A
CT rated current			
Number of turns			
Primary windings	A to B	5	1
	C to D	10	2
	E to F	15	3
	G to H	30	6
	I to K	30	6
	K to L	30	6
	L to M	60	12
Secondary windings	Y to Z	1736	1736
Thermal rating			
Continuous current in Amperes	A to B	4.5	20
	C to D	4.5	20
	E to F	4.5	20
	G to H	4.5	20
	I to K	1.2	6.5
	K to L	1.2	6.5
	L to M	1.2	6.5
	Y to Z	0.2	0.2
Secondary rated current with standard connection (see Fig. 7/6) and symmetrical 3-phase current	Y to Z	20 mA	20 mA

Requirements for the current transformers (CT)

$$K'ssc \geq \frac{I_{scc\,max\,(ext.\,fault)}}{I_{pn}}$$

and:

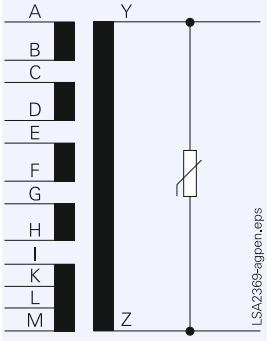
$$\frac{3}{4} \leq \frac{(K'_{ssc} \cdot I_{pn})_{end\,1}}{(K'_{ssc} \cdot I_{pn})_{end\,2}} \leq \frac{4}{3}$$

K'_{ssc1} = effective symmetrical short-circuit current factor end 1

K'_{ssc2} = effective symmetrical short-circuit current factor end 2

$I_{scc\,max}$ = maximum symmetrical short-circuit current

I_{pn} = CT rated primary current



CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".

Selection and ordering data

Description		Order No.
7SD60 numerical pilot-wire current comparison protection relay		*7SD600☐-☐☐A☐0-☐DA0*
Rated current; rated frequency		
20 mA, 50/60 Hz; without external summation current transformer	*0*	
1 A, 50/60 Hz; with external summation CT 4AM4930-7DB00-0AN2	*1*	
5 A, 50/60 Hz; with external summation CT 4AM4930-6DB00-0AN2	*5*	
Rated auxiliary voltage		
24, 48 V DC	*2*	
60, 110, 125 V DC	*4*	
220, 250 V DC, 115 V AC, 50/60 Hz	*5*	
Unit design		
For panel surface mounting with terminals at the side	*B*	
with terminals on top and bottom	*D*	
For panel flush mounting or cubicle mounting	*E*	
Operating language		
English – alternatively either German or Spanish can be selected	*0*	
Scope of functions		
Differential protection		*0*
Differential protection, inrush restraint		*1*
Differential protection, pilot-wire monitoring, remote trip		*2*
Differential protection, pilot-wire monitoring, remote trip, inrush restraint		*3*

Accessories

DIGSI 4	
Software for configuration and operation of Siemens protection units running under MS Windows (Windows 2000 or XP Professional) device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	*7XS5402-0AA00*
SIGRA 4	
(generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows (Windows 2000 and XP Professional). Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	*7XS5410-0AA00*
Connecting cable	
Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	*7XV5100-4*

Accessories

Description	Order No.
*Converter R232 (V.24) - RS485**	
With connecting cable 1 m, PC adapter, with plug-in power supply unit 230 V AC	*7XV5700-0□□00*[1]
With plug-in power supply unit 110 V AC	*7XV5700-1□□00*[1]
Converter RS485-FO	
Rated auxiliary voltage 24 to 250 V DC and 250 V AC	
Single optical interface	*7XV5650-0BA00*
Double optical interface (cascadable)	*7XV5651-0BA00*
Summation current transformer	
1 A, 50/60 Hz, for 7SD600	*4AM4930-7DB00-0AN2*
5 A, 50/60 Hz, for 7SD600	*4AM4930-6DB00-0AN2*
Isolating transformer	
Up to 20 kV	*7XR9513*
Up to 5 kV	*7XR9515*
Manual for 7SD60	
English	*E50417-G1176-C069-A3*

7

1) Possible versions see part 13.

* RS485 bus system up to 115 kbaud
RS485 bus cable and adaptor
7XV5103-□AA□□; see part 13.

Connection diagram

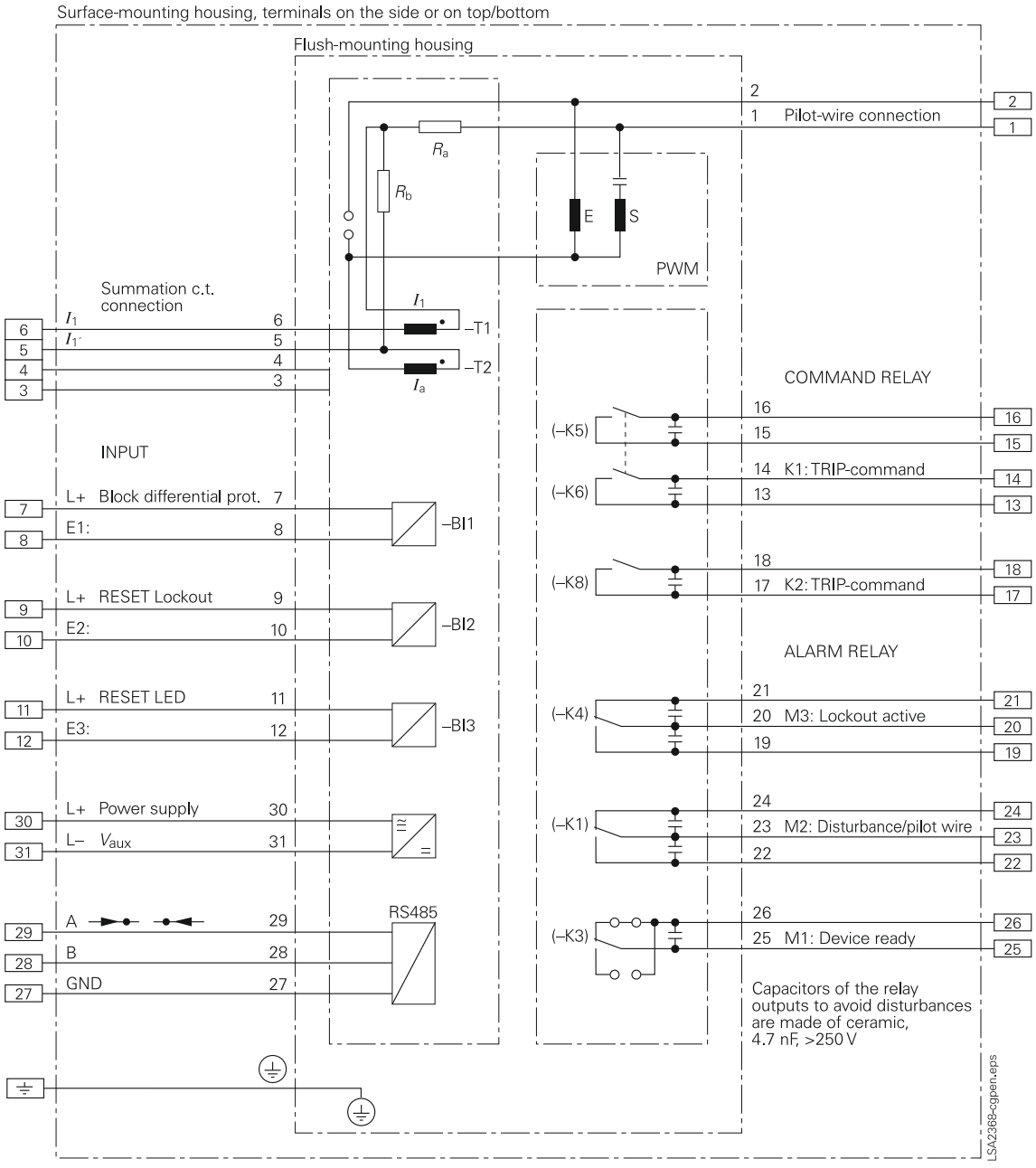


Fig. 7/9 Connection diagram of the 7SD60 current differential protection

SIPROTEC 4 7SD61
Differential Protection Relay for Two Line Ends

Fig. 7/10
SIPROTEC 4 7SD61
differential protection relay

Description

The 7SD610 relay is a differential protection relay suitable for all types of applications and incorporating all those functions required for differential protection of lines, cables and transformers. Transformers and compensation coils within the differential protection zone are protected by means of integrated functions, which were previously to be found only in transformer differential protection. It is also well-suited for complex applications such as series and parallel compensation of lines and cables.

It is designed to provide differential and directional back-up protection for all voltage levels and types of networks. The relay features high speed and phase-selective short-circuit measurement. The unit is thus suitable for single-phase and three-phase fault clearance.

Digital data communication for differential current measurement is effected via fiber-optic cables, networks or pilot wires connections, so that the line ends can be quite far apart. The serial protection data 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 earth 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 earth-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 earth 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 ctrl. 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 f. local alarm

Communication interfaces

- 1 serial protection data (R2R) interface
- Front interface for PC connection
- System interface
  - IEC 61850 Ethernet
  - IEC 60870-5-103 protocol
  - PROFIBUS-DP, DNP 3.0 and MODBUS
- Service / modem interface (rear)
- Time synchronization via IRIG-B, DCF77 or system interface

Features

- Browser-based commissioning tool
- Direct connection to digital communication networks

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	
87L	ΔI for lines/cables
87T	ΔI for lines / cables with transformers
87N	Restricted earth-fault protection
85	Phase-selective intertrip, remote trip
86	Lockout function
50 50N 51 51N 67 67N	Three-stage 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	Over/undervoltage protection
81O/U	Over/underfrequency protection
74TC	Trip circuit supervision

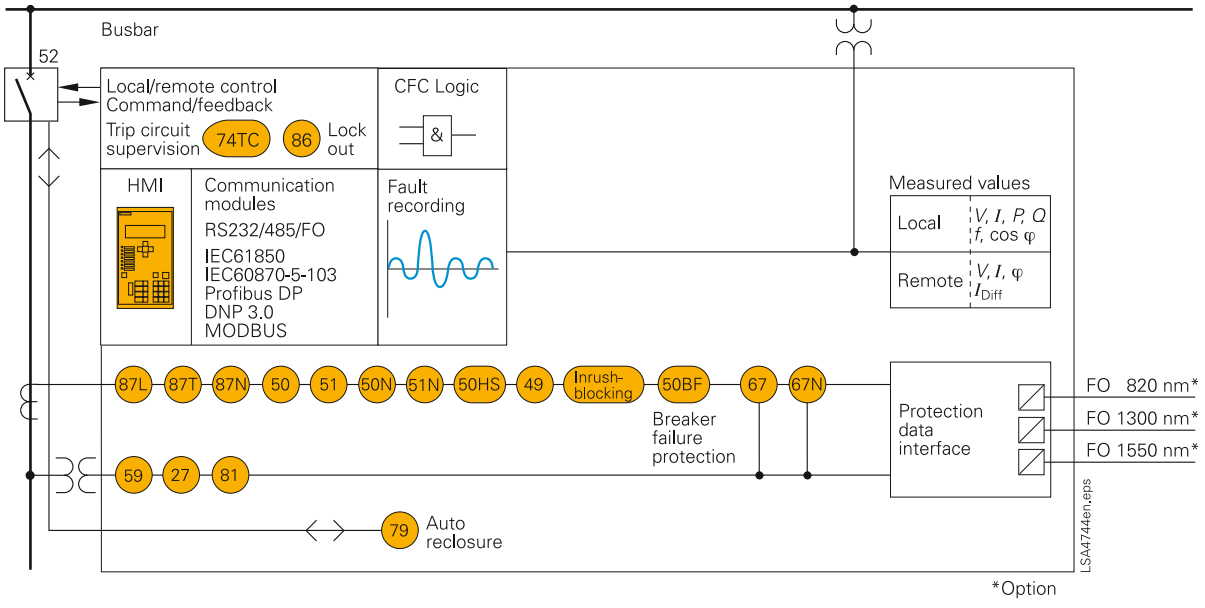


Fig. 7/11

Application

Typical applications employing fiber-optic cables or communication networks

Four applications are shown in Fig. 7/12. The 7SD610 differential protection relay is connected to the current transformers and to the voltage transformers at one end of the cable, although only the currents are required for the differential protection function. The voltage connection improves, among other things, the frequency measurement and allows the measured values and the fault records to be extended. Direct connection to the other units is effected via mono-mode fiber-optic cables and is thus immune to interference.

Five different modules are available. In the case of direct connection via fiber-optic cables, data communication is effected at 512 kbit/s and the command time of the protection unit is reduced to 15 ms. Parallel compensation (for the load currents) is provided within the protection zone of the cable. By means of the integrated inrush restraint, the differential protection relay can tolerate the surge on switching-on of the cable and the compensation reactors, and thus allows sensitive settings to be used under load conditions.

7SD610 offers many features to reliably and safely handle data exchange via communication networks.

Depending on the bandwidth available a communication converter for G703-64 kbit/s or X21-64/128/512 kbit/s can be selected. For higher communication speed a communication converter with G703-E1 (2,048 kbit/s) or G703-T1 (1,554 kbit/s) is available. Furthermore the 7SD610 supports the IEEE C37.94 interface with 1/2/4 and 8 timeslots.

The connection to the communication converter is effected via a cost-effective 820 nm interface with multi-mode fiber. This communication converter converts the optical input to electrical signals in accordance to the specified telecommunication interface.

The fourth example shows the relays being connected via a twisted pilot pair. Data exchange and transmission is effected via pilot wires of a typical length of 15 km. Here a transformer is in the protected zone. In this application, 7SD610 is set like a transformer differential relay. Vector group matching and inrush restraint is provided by the relay.

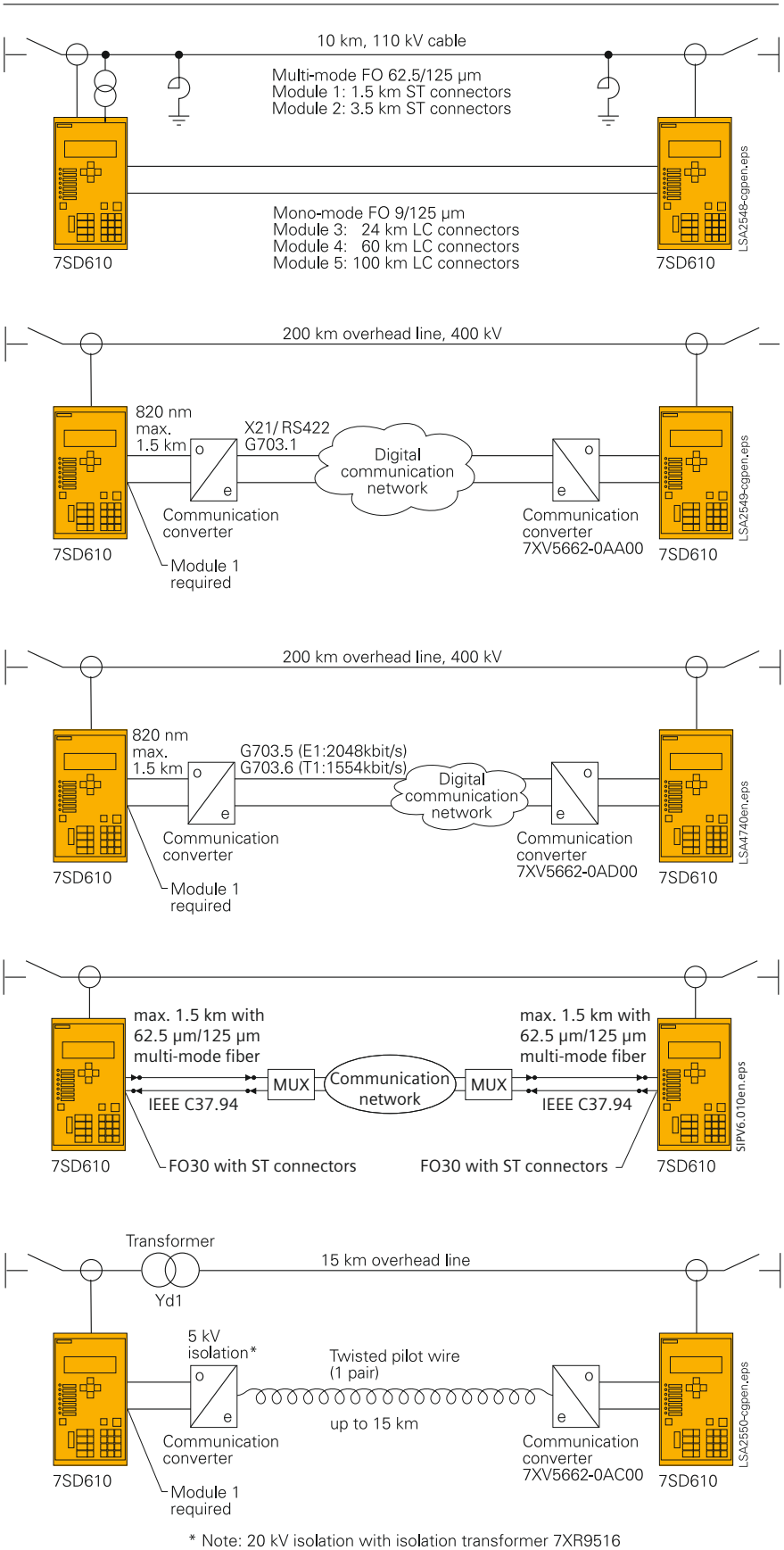


Fig. 7/12
Typical applications

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".

Fig. 7/13

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 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.
- 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 earth 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 earthed 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 earthed winding. Therefore the I_E current measurement input has to be used.

Protection functions

If the sum of the phase currents of a winding is compared with the measured star-point current, a sensitive earth-current differential protection (REF) can be implemented. This function is substantially more sensitive than the differential protection during faults to earth 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 checksums 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.
- 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.

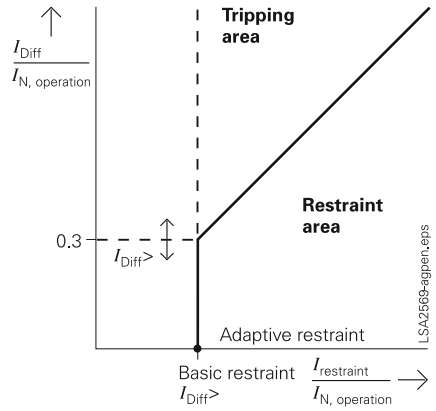


Fig. 7/14
Tripping characteristic

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 earth 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 cicuit-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 earth). 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.

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 earth, 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 earth 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 synchrocheck

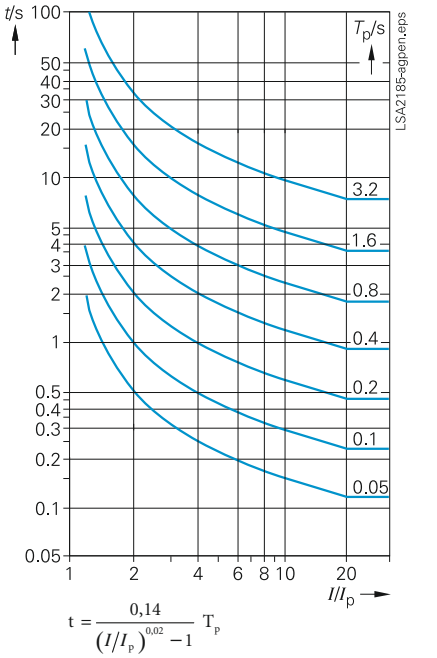


Fig. 7/15 Inverse

- 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.

Protection functions

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-earth 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-earth 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.

Protection functions

Monitoring and supervision functions

The 7SD610 relay provides comprehensive monitoring functions covering both hardware and software. Furthermore, the measured values are continuously checked for plausibility. Therefore the current and voltage transformers are also included in this monitoring system.

Current transformer / Monitoring functions

A broken wire between the CTs and relay inputs under load may lead to maloperation of a differential relay if the load current exceeds the differential setpoint. The 7SD610 provides fast broken wire supervision which 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 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}, 3 I_0, I_E, $I_{E\ sensitive}$
- Voltages 3 x $V_{Phase\text{-}Ground,\ 3\ x}$ $V_{Phase\text{-}Phase}$, 3 V_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.

Protection functions

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.

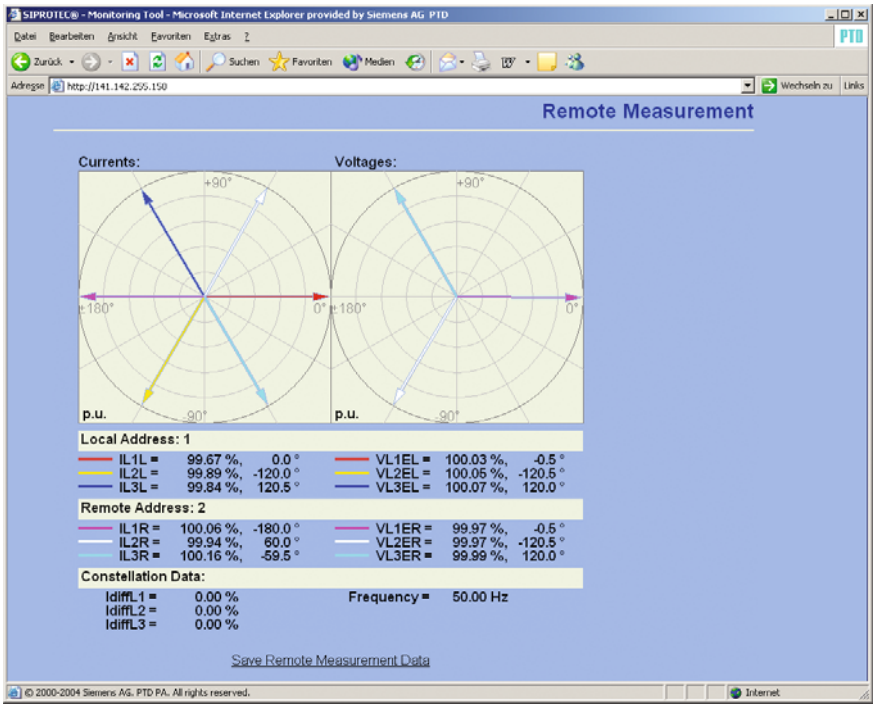


Fig. 7/16
Browser-aided commissioning: Phasor diagram

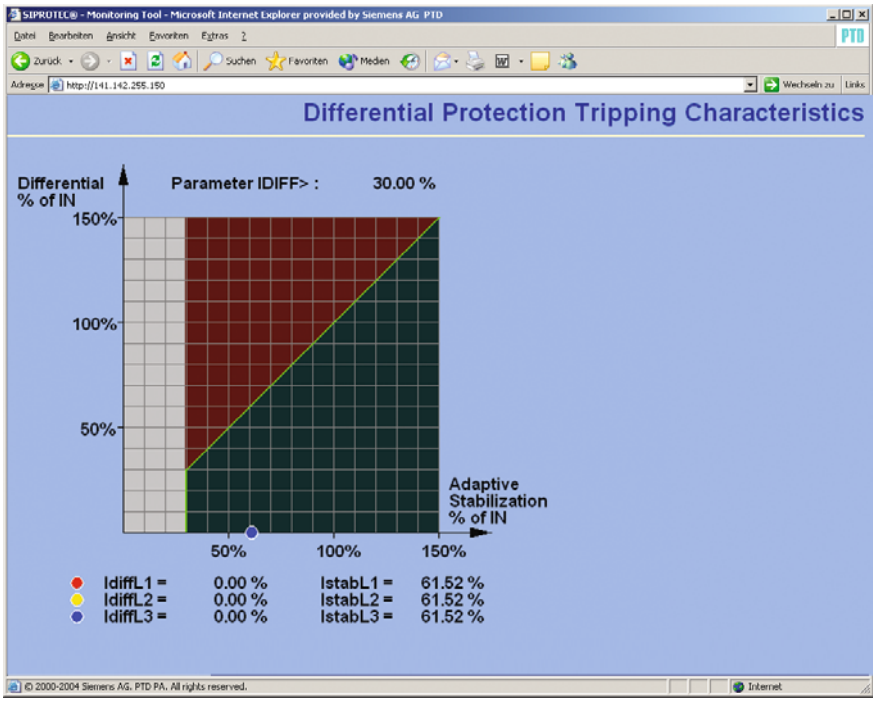


Fig. 7/17
Browser-aided commissioning:
Differential protection tripping characteristic

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

Event log and trip log messages are also available. Remote control can be used, if the local front panel cannot be accessed.

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 earthing 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.

Functions

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.

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.

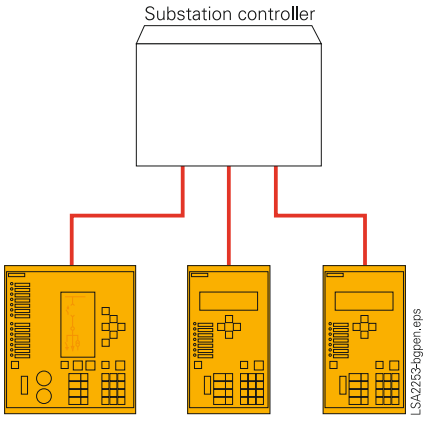


Fig. 7/18
IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

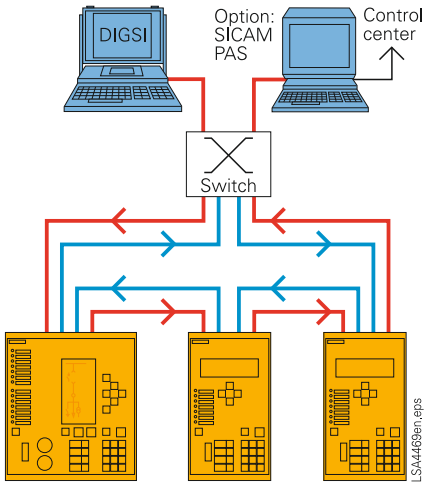


Fig. 7/19
Bus structure for station bus with Ethernet and IEC 61850

Communication

IEC 61850 Ethernet

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

IEC 60870-5-103

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

PROFIBUS-DP

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

MODBUS RTU

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

DNP 3.0

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

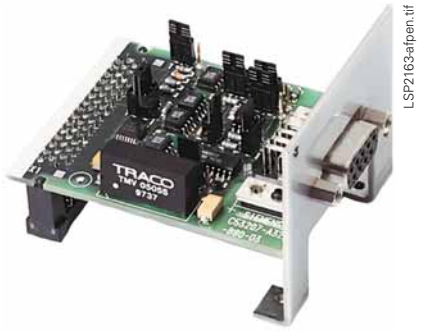


Fig. 7/20
RS232/RS485 electrical communication module

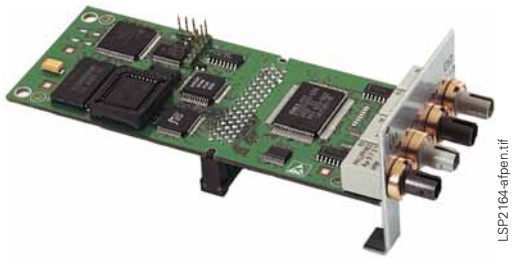


Fig. 7/21
PROFIBUS communication module, optical double-ring

Fig. 7/22
820 nm fiber-optic communication module

Fig. 7/23
Fiber-optic Ethernet communication module for IEC 61850 with integrated Ethernet switch

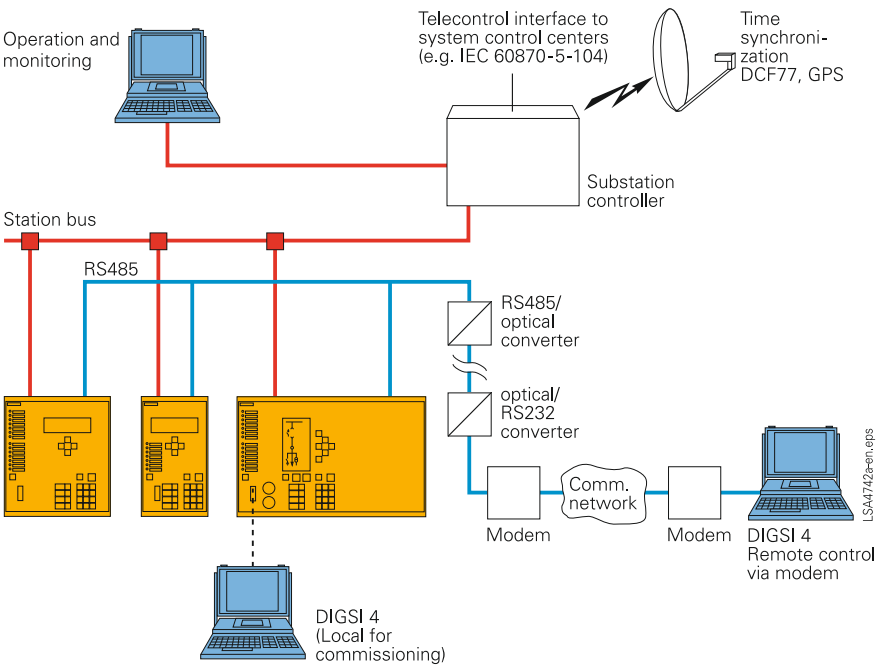


Fig. 7/24
System solution: Communications

Communication

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system.

Units featuring IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 7/18).

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 7/19).

Via modem and service interface, the protection engineer has access to the protection devices at all times. This permits remote maintenance and diagnosis (cyclic testing).

Parallel to this, local communication is possible, for example, during a major inspection.

Serial protection data interface (R2R interface)

The 7SD610 provides one protection data 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 data 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 data 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.

Communication

Communication possibilities between relays

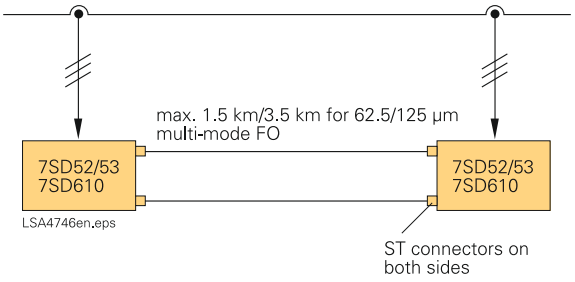


Fig. 7/25
Direct optical link up to 1.5 km/3.5 km, 820 nm

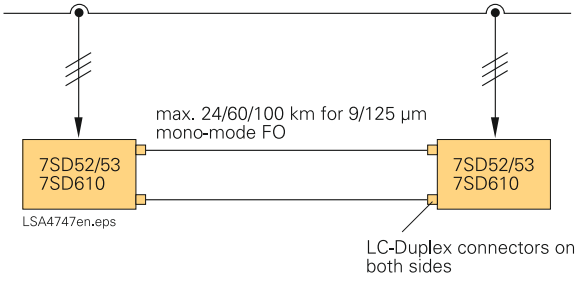


Fig. 7/26
Direct optical link up to 25/60 km with 1300 nm
or up to 100 km with 1550 nm

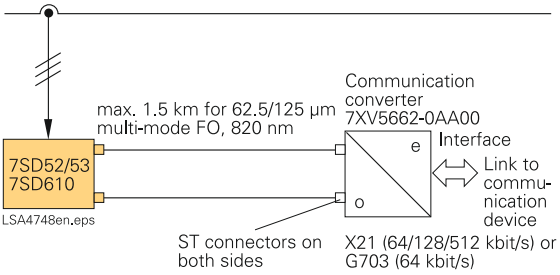


Fig. 7/27
Connection to a communication network CC-XG

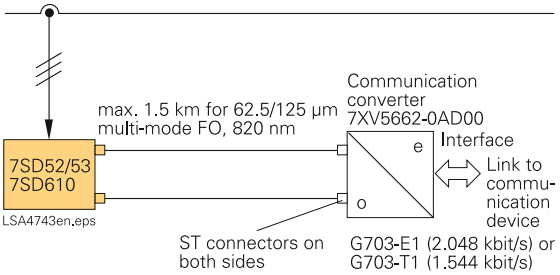


Fig. 7/28
Connection to a communication network CC-2M

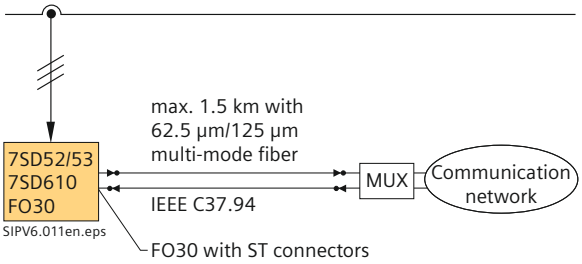


Fig. 7/29
Connection to a communication network via IEEE C37.94

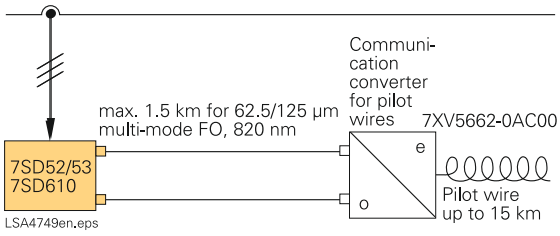


Fig. 7/30
Connection to a pilot wire

Typical connection

Connection to 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-earth 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 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 restricted earth-fault protection (REF) or directional ground (earth)-fault protection.

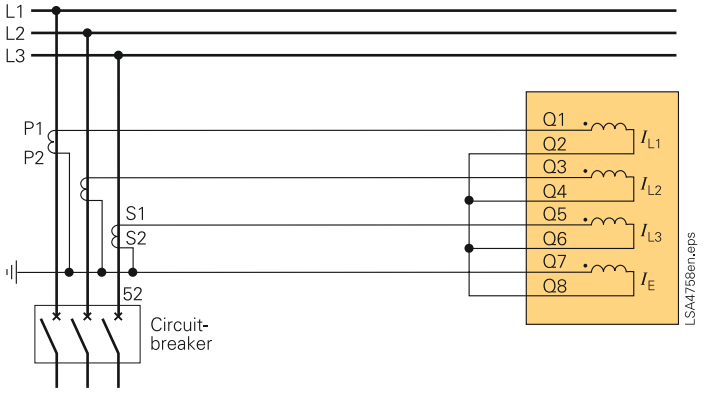


Fig. 7/31
Typical connection to current transformers

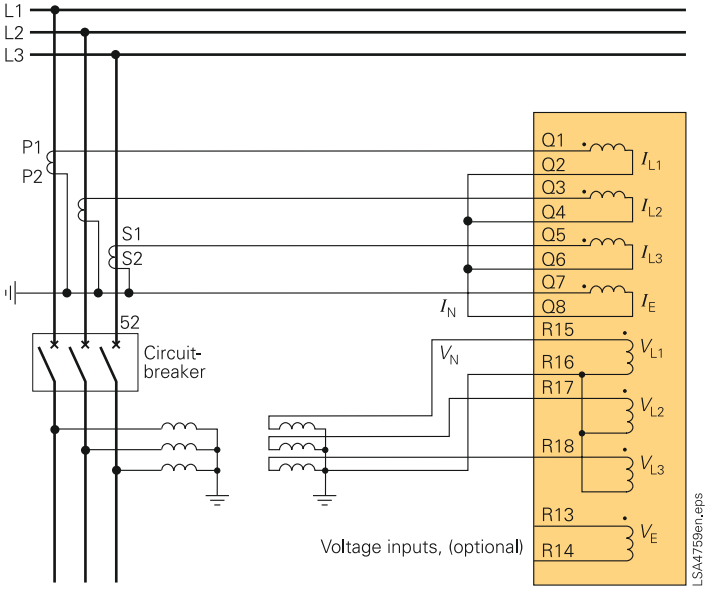


Fig. 7/32
Typical connection to current transformers with optional voltage inputs

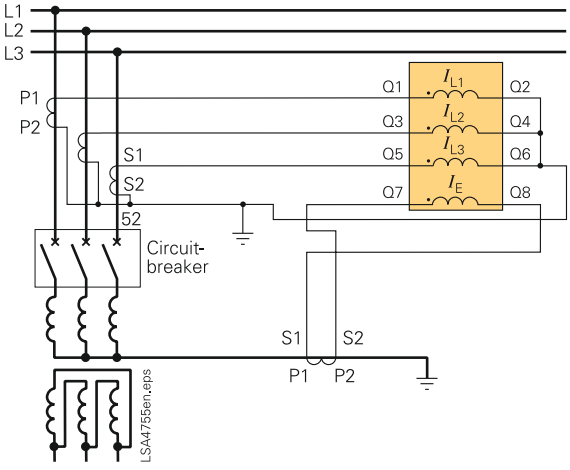


Fig. 7/33
Connection for transformer with restricted earth-fault protection (REF)

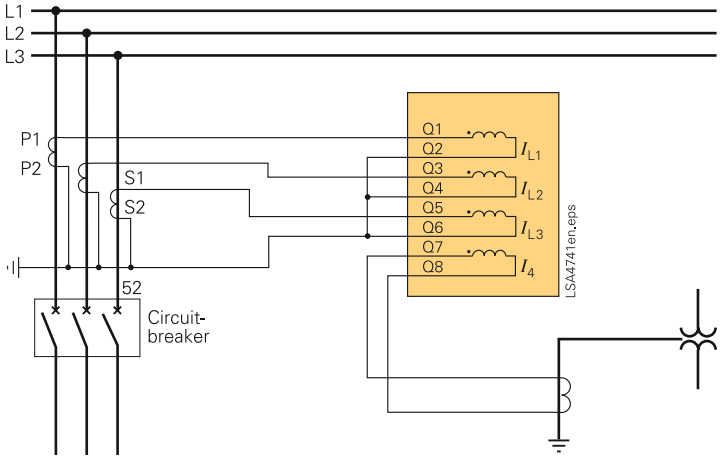


Fig. 7/34
Alternative connection of current transformers for measuring neutral current of a grounded (earthed) power transformer

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	Approx. 0.05 VA
with I_N = 5 A	Approx. 0.3 VA
in VT circuits	Approx. 0.1 VA
Thermal overload capacity	I_N
in CT circuits (for I_N = 5 A)	100 A for 1 s
	30 I_N for 10 s
	4 I_N continuous
Dynamic (peak value)	250 I_N (half sine)
In VT circuits for highly sensitive earth-fault protection	300 A for 1 s
	100 A for 10 s
	15 A continuous
in VT circuits	230 V per phase continuous
Auxiliary voltage	
Rated voltages	24 to 48 V DC
Ranges are settable by means of jumpers	60 to 125 V DC[1]
	110 to 250 V DC[1]
	and 115 V AC (50/60 Hz)[1]
Permissible tolerance	-20 % to +20 %
Superimposed AC voltage (peak-to-peak)	≤ 15 %
Power consumption	
Under normal operating conditions	Approx. 8 W
During pickup with all inputs and outputs activated	Approx. 18 W
Bridging time during failure of the auxiliary voltage	
V_{aux} ≥ 110 V	≥ 50 ms
Binary inputs	
Number	7 (marshallable)
Rated voltage range	24 to 250 V, bipolar
Pickup threshold	17 or 73 V (selectable)
Functions are freely assignable	
Minimum pickup threshold	
Ranges are settable by means of jumpers for each binary input	17 or 73 V DC, bipolar
Maximum permissible voltage	300 V DC
Current consumption, energized	Approx. 1.8 mA
Output relay	
Command / indication relay	
Number	5 (marshallable)
	1 alarm contact (not marshallable)
Switching capacity	
Make	1000 W/VA
Break	30 VA
Break (with resistive load)	40 W
Break (with L/R ≤ 50 ms)	25 W
Switching voltage	250 V
Permissible total current	30 A for 0.5 seconds
	5 A continuous

1) Ranges are settable by means of jumpers.

LEDs	
Number	
RUN (green)	1
ERROR (red)	1
LED (red), function can be assigned	7
Unit design	
Housing 7XP20	For dimensions refer to dimension drawings, part 15
Degree of protection acc. to EN 60529	
Surface-mounting housing	IP 51
Flush-mounting housing	
front	IP 51
rear	IP 50
for the terminals	IP 20 with terminal cover put on
Weight	
Flush-mounting housing 1/3 x 19"	4 kg
Surface-mounting housing 1/3 x 19"	6 kg

Serial interfaces	
Operating interface 1 for DIGSI 4 or browser *(front of unit)*	
Connection	Non-isolated, RS232, front panel, 9-pin subminiature connector (SUB-D)
Baud rate	4800 to 115200 baud, setting as supplied: 38400 baud; parity 8E1
Time synchronization *(rear of unit DCF77/IRIG-B signal format IRIG-B000)*	
Connection	9-pin subminiature connector (SUB-D) (terminals with surface-mounting housing)
Voltage levels	5, 12 or 24 V (optional)
Dielectric test	500 V/50 Hz
Service interface (op. interface 2) for DIGSI 4/modem/service/browser *(rear of unit)*	
Isolated RS232/RS485	9-pin subminiature connector (SUB-D)
Dielectric test	500 V/50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m
System interface *(rear of unit)*	
Refer to ordering code	IEC 61850 Ethernet
	IEC 60870-5-103
	PROFIBUS-DP
	DNP 3.0, MODBUS
Isolated RS232/RS485	9-pin subminiature connector (SUB-D)
Baud rate	4800 to 38400 baud
Dielectric test	500 V/50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m
For fiber-optic cable	ST connector
Optical wavelength	λ = 820 nm
Permissible attenuation	Max. 8 dB for 62.5/125 µm fiber
Distance (spanned)	Max. 1.5 km

Technical data

System interface, continued	
PROFIBUS RS485	
Dielectric test	500 V/50 Hz
Baud rate	Max. 12 Mbaud
Distance	1 km at 93.75 kbd; 100 m at 12 Mbd
PROFIBUS fiber-optic[2]	
Only for flush-mounting housing	ST connector
For surface-mounting housing	Optical interface with OLM[2]
Baud rate	Max. 1.5 Mbaud
Optical wavelength	λ = 820 nm
Permissible attenuation	Max. 8 dB for 62.5/125 µm fiber
Distance	500 kbit/s 1.6 km; 1500 kbit/s 530 m
Protection data interface (R2R interface)	
FO5[1], OMA1[2]: Fiber-optic interface with clock recovery for direct connection up to 1.5 km or for connection to a comm. converter, 820 nm	For multi-mode fiber 62.5/125 µm, ST connectors Permissible fiber attenuation: 8 dB
FO6[1], OMA2[2]: Fiber-optic interface for direct connection up to 3.5 km, 820 nm	For multi-mode fiber 62.5/125 µm, ST connectors Permissible fiber attenuation: 16 dB
New fiber-optic interfaces, series FO1	
FO30: Fiber-optic interface to support the IEEE C37.94 interface and for direct fiber – optic connection up to 1.5 km	For multi-mode fiber 62.5/125 µm, ST connectors Permissible fiber attenuation: 8 dB
FO17[1]: for direct connection up to 24 km[3], 1300 nm	For mono-mode fiber 9/125 µm, LC-Duplex connector Permissible fiber attenuation: 13 dB
FO18[1]: for direct connection up to 60 km[3], 1300 nm	For mono-mode fiber 9/125 µm, LC-Duplex connector Permissible fiber attenuation: 29 dB
FO19[1]: for direct connection up to 100 km[3], 1550 nm	For mono-mode fiber 9/125 µm, LC-Duplex connector Permissible fiber attenuation: 29 dB
Relay communication equipment	
External communication converter 7XV5662-0AA00 for communication networks X21/G703-64 kbit/s	
External communication converter to interface between the relays, optical 820 nm interface and the X21/RS422/G703-64 kbit/s interface of a communication device	
X21/G703, RS422 selectable by jumpers. Baud rate selectable by jumpers	
Input: fiber-optic 820 nm with clock recovery	Max. 1.5 km with 62.5/125 µm multi-mode FO cable to device side
Output: X21 (RS422) electrical interface on communication device	64/128/512 kbit (selectable by jumper) max. 800 m, 15-pin connector
G703-64 kbit/s electrical interface on communication device	64 kbit/s, max. 800 m, screw-type terminal
External communication converter 7XV5662-0AD00 for communication networks with G703-E1 or G703-T1	
External communication converter to interface between the relays, optical 820 nm interfac and G703-E1 or G703-T1 interface of a communication network	
Inputs: 2 fiber-optic inputs 820 nm, 1 RS232 input	Max. 1.5 km with 62.5/125µm multi-mode 1 FO cable to device side
Output: G703.5 G703.6	 E1: 2,048 kbit/s T1: 1,554 kbit/s
Electrical interface on communication network	max. 800 m, screw-type terminal

External communication converter 7XV5662-0AC00 for pilot wires	
External communication converter to interface between relays, optical 820 nm interface and a pilot wire or twisted telephone pair.	
Typical distance	15 km
Fiber-optic 820 nm with clock recovery	Max. 1.5 km with 62.5/125 µm multi-mode FO cable
Pilot wire	Screw-type terminal 5 kV isolated
Permissible time delay (duration of data transmission)	
Delay of telegrams due to transmission for one unit to the other. Delay is constantly measured and adjusted	Max. 30 ms per transmission path Permissible max. value can be selected
Electrical tests	
Specification	
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)	3.5 kV DC
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.

Technical data

Irradiation with RF field, pulse-modulated IEC 61000-4-3/ ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transients, bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 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	
During operation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 *g* acceleration frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 5 *g*, duration 11 ms, 3 shocks on each of the 3 axes in both directions
Seismic vibration IEC 60255-21-2, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis), 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis), 8 to 35 Hz: 1 *g* acceleration (horizontal axis), 8 to 35 Hz: 0.5 *g* acceleration (vertical axis), frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
During transport	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ±7.5 mm amplitude; 8 to 150 Hz: 2 *g* acceleration, Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 15 *g*, duration 11 ms, 3 shocks on each of the 3 axes in both directions
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Half-sinusoidal Acceleration 10 *g*, duration 16 ms, 1000 shocks on each of the 3 axes in both directions

Climatic stress test	
Temperatures	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	–25 °C to +85 °C / –13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	–20 °C to +70 °C / –4 °F to +158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C / +131 °C)	–5 °C to +55 °C / +25 °F to +131 °F
– Limiting temperature during permanent storage	–25 °C to +55 °C / –13 °F to +131 °F
– Limiting temperature during transport	–25 °C to +70 °C / –13 °F to +158 °F
Humidity	
Permissible humidity stress; It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average ≤ 75 % relative humidity; on 56 days in the year up to 93 % relative humidity; moisture condensation during operation is not permitted

Technical data

Functions

Differential protection (ANSI 87L, 87T)

Sensitive differential current trip stage $I_{Diff}>$

Setting range		
$I_{Diff}> I_N$	secondary 1 A	0.1 to 20 A (steps 0.01 A)
	secondary 5 A	0.5 to 100 A
Tripping time $I_{Diff}> 2 \times I_{Diff} >$ (setting value)		Typical 35 ms with FO cable

High current differential trip stage $I_{Diff}>>$

Setting range		
$I_{Diff}>>$	secondary 1 A	0.8 to 100 A (steps 0.01 A)
	secondary 5 A	4.0 to 50 A
Tripping time $I_{Diff}> 2 \times I_{Diff} >>$ (setting value)		Typical 16 ms with FO cable

Vector group adaption with transformers in the differential zone

Adaption of connection sympol	0 to 11 (x 30°)(step 1)
Neutral point connection	Grounded (earthed) or not grounded (earthed)(for each winding)

Inrush restaint

Restraint ratio 2nd harmonic I_{2fn}/I_{fN}	10 % to 45 % (step 1 %)
Max. current for restraint	1.1 A to 25 A[1)] (step 0.1 A)
Crossblock function	Can be switched on and off
Max. operative time for crossblock $T_{oper\ crossblk}$	0 to 60 s (step 0.01 s) or deactivated (operating up to release)

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

Operating modes	Backup (always active) or emergency (e.g. loss of data connection)
Characteristic	2 definite-time stages / 1 inverse-time stage

Definite-time stage (ANSI 50, 50N)

Phase current pickup $I_{ph}>>$	0.1 to 25 A (1A) / 0.5 to 125 A (5A) (step 0.01 A) or deactivated
Earth current pickup $3I_0>>$	0.05 to 25 A (1A) / 0.25 to 125 A (5A) (step 0.01 A) or deactivated
Phase current pickup $I_{ph}>$	0.1 to 25 A (1A) / 0.5 to 125 A (5A) (step 0.01 A)
Earth current pickup $3I_0>$	0.05 to 25 A (1A) / 0.25 to 125 A (5A) (step 0.01 A)
Phase current pickup $I_{ph} >$ with directional element	0.1 to 25 A(1 A) / 0.5 to 125 A(5 A)
Earth current pickup $3I_0 >$ with directional element	0.05 to 25 A(1 A) / 0.25 to 125 A(5 A) (step 0.01 A)
Time delay	0 to 30 s (step 0.01 s) or deactivated
Tolerances	
Current pickup	≤ 3 % setting value or 1 % of I_N
Delay times	± 1 % setting value or 10 ms
Operating time	Approx. 25 ms

Inverse-time stage (ANSI 51, 51N)

Phase current pickup I_p	0.1 to 4 A (1A) / 0.5 to 20 A (5A) (step 0.01 A)
Earth current pickup $3I_{0P}$	0.05 to 4 A (1A) / 0.25 to 20 A (5A) (step 0.01 A)
Phase current pickup $I_p >$ with directional element	0.1 to 4 A(1 A) / 0.5 to 20 A(5 A) (step 0.01 A)
Earth current pickup $3I_{0P} >$ with directional element	0.05 to 25(1 A) / 0.25 to 20 A(5 A) (step 0.01 A)
Tripping characteristics	
Tripping time characteristics acc. to IEC 60255-3	Normal inverse; very inverse; extremely inverse; long time inverse
Tripping time characteristics acc. to ANSI/IEEE (not for DE region, see selection and ordering data 10th position)	Inverse; short inverse; long inverse; moderately inverse; very inverse; extremely inverse; definite inverse
Time multiplier for IEC characteristics T	T_p = 0.05 to 3 s (step 0.01 s) or deactivated
Time multiplier for ANSI characteristics D	D_{IP} = 0.5 to 15 (step 0.01) or deactivated
Pickup threshold	Approx. 1.1 I/I_p (ANSI: I/I_p = M)
Reset threshold	Approx. 1.05 x I/I_p (ANSI: I/I_p = M)
Tolerances	
Operating time for 2 ≤ I/I_p ≤ 20	≤ 5 % of setpoint ± 15 ms

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

Operating mode	Active only with connected auxiliary contacts
Characteristic	2 independent stages
Pickup current $I>>>$	0.1 to 15 A (1A) / 0.5 to 75 A (5A) (step 0.01 A) or deactivated
Pickup current $I>>>>$	1 to 25 A (1A) / 5 to 125 A (5A) (step 0.01 A) or deactivated
Reset ratio	Approx. 0.95
Tolerances	
Current starting	≤ 3 % of setting value or 1 % I_N

Auto-reclosure (ANSI 79)

Number of auto-reclosures	Up to 8
Operating modes with line voltage check	Only 1-pole; only 3-pole, 1 or 3-pole, adaptive AR Discrimination between successful and non-successful reclose attempts
Dead times $T_{1\text{-ph}}$, $T_{3\text{-ph}}$, T_{Seq}	0.01 to 1800 s (step 0.01 s) or deactivated
Action times	0.01 to 300 s (step 0.01 s) or deactivated
Reclaim times	0.5 to 300 s (step 0.01 s)
CLOSE command duration	0.01 to 30 s (steps 0.01 s)
Tolerances	
Time stages	1 % of setting value or 10 ms
Voltage limit values	≤ 3 % of setting value or 0.5 V

Technical data

Breaker failure protection *(ANSI 50BF)*	
Number of stages	2
Pickup of current element	0.05 to 20 A (1A) / 0.25 to 100 A (5A) (step 0.01 A)
Time delays $T1_{1phase}$, $T1_{3phase}$, $T2$	0 to 30 s (steps 0.01 s) or deactivated
Additional functions	CB synchronism monitoring
Reset time	10 ms, typical
Tolerances	
Current limit value	≤ 3 % of setting value or 1 % I_N
Time stages	1 % of setting value or 10 ms
Voltage protection *(ANSI 59, 27)*	
Operating modes	Local tripping or only indication
Overvoltage protection	
Pickup values V_{PH-Gnd}>>, V_{PH-Gnd}> (phase-ground (earth) overvoltage)	1 to 170 V (step 0.1 V) or deactivated
Pickup values V_{PH-PH}>>, V_{PH-PH}> (phase-phase overvoltage)	2 to 220 V (step 0.1 V) or deactivated
Pickup values $3V_0$>>, $3V_0$> ($3V_0$ can be measured via V4 transformers or calculated by the relay) (zero-sequence overvoltage)	1 to 220 V (step 0.1 V) or deactivated
Pickup values V_1>>, V_1> (positive-sequence overvoltage)	2 to 220 V (step 0.1 V) or deactivated
Measured voltage	Local positive-sequence voltage or calculated remote positive-sequence voltage (compounding)
Pickup values V_2>>, V_2> (negative-sequence overvoltage)	2 to 220 V (step 0.1 V) or deactivated
Reset ratio (settable)	0.5 to 0.98 (step 0.01)
Undervoltage protection	
Pickup values V_{PH-Gnd}<<, V_{PH-Gnd}< (phase-ground (earth) undervoltage)	1 to 100 V (step 0.1 V) or deactivated
Pickup values V_{PH-PH}<<, V_{PH-PH}< (phase-phase undervoltage)	1 to 175 V (step 0.1 V) or deactivated
Pickup values V_1<<, V_1< (positive-sequence undervoltage)	1 to 100 V (step 0.1 V) or deactivated
Blocking of undervoltage protection stages	Minimum current; binary input
Reset ratio	1.05
Time delays	
Time delay for all over- and undervoltage stages	0 to 100 s (steps 0.01 s) or deactivated
Command / pickup time	Approx. 40 ms
Tolerances	
Voltage limit values	≤ 3 % of setting value or 0.5 V
Time stages	1 % of setting value or 10 ms
Frequency protection *(ANSI 81)*	
Number of frequency elements	4
Setting range	45.5 to 54.5 Hz (in steps of 0.01) at f_{nom} = 50 Hz 55.5 to 64.5 Hz (in steps of 0.01) at f_{nom} = 60 Hz
Delay times	0 to 600 s or ∞ (in steps of 0.01 s)
Operating voltage range	6 to 230 V (phase-to-ground (earth))
Pickup times	Approx. 85 ms
Dropout times	Approx. 30 ms
Hysteresis	Approx. 20 mHz
Dropout condition	Voltage = 0 V and current = 0 A
Tolerances	
Frequency	12 m Hz for V = 29 to 230 V
Delay times	1 % of the setting value or 10 ms
Restricted earth-fault protection *(ANSI 87N)*	
Multiple availability	2 times (option)
Settings	
Differential current I_{REF}>/I_{Nobj}	0.05 to 2.00 (steps 0.01)
Limit angle φ_{REF}	110 ° (fixed)
Time delay T_{REF}	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
The set times are pure delay times	
Operating times	
Pickup time (in ms) at frequency	50 Hz / 60 Hz
At 1.5 · setting value I_{REF}>, approx.	35 / 30
At 2.5 · setting value I_{REF}>, approx.	33 / 29
Dropout time (in ms), approx.	26 / 23
Dropout ratio, approx.	0.7
Overcurrent-time protection for phase and residual currents	
Multiple availability	3 times (option)
Characteristics	
Definite-time stages (DT)	I_{Ph} >>, $3I_0$ >>, I_{Ph} >, $3I_0$ >
Inverse-time stages (IT)	I_P, $3I_{0P}$
Acc. to IEC	Inverse, very inverse, extremely inverse, long-time inverse
Acc. to ANSI	Inverse, moderately inverse, very inverse, extremely inverse, definite inverse, short inverse, long inverse
	Alternatively, user-specified trip and reset characteristics
Reset characteristics (IT)	Acc. to ANSI with disk emulation
Current stages	
High-current stages I_{Ph} >>	0.10 to 35.00 A [1] (steps 0.01 A) or deactivated (stage ineffective)
T_{IPh} >>	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
$3I_0$ >>	0.05 to 35.00 A [1] (steps 0.01 A) or deactivated (stage ineffective)
T_{3I0} >>	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
Definite-time stages I_{Ph} >	0.10 to 35.00 A [1] (steps 0.01 A) or deactivated (stage ineffective)
T_{IPh}	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
$3I_0$ >	0.05 to 35.00 A [1] (steps 0.01 A) or deactivated (stage ineffective)
T_{3I0} >	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)

Technical data

Inverse-time stages	I_P	0.10 to 4.00 A [1] (steps 0.01 A)
Acc. to IEC	T_{IP}	0.05 to 3.20 s (steps 0.01 s) or deactivated (no trip)
	$3I_{0P}$	0.05 to 4.00 A [1] (steps 0.01 A)
	T_{3I0P}	0.05 to 3.20 s (steps 0.01 s) or deactivated (no trip)
Inverse-time stages	I_P	0.10 to 4.00 A [1] (steps 0.01 A)
Acc. to ANSI	D_{IP}	0.50 to 15.00 s (steps 0.01 s) or deactivated (no trip)
	$3I_{0P}$	0.05 to 4.00 A [1] (steps 0.01 A)
	D_{3I0P}	0.50 to 15.00 s (steps 0.01 s) or deactivated (no trip)

Thermal overload protection (ANSI 49)

Setting range	
Factor k to IEC 60255.8	0.1 to 4 (steps 0.01)
Time constant τ	1 to 999.9 min (steps 0.1 min)
Thermal alarm stage $\Theta_{Alarm}/\Theta_{Trip}$	50 to 100 % referred to tripping temperature (steps 1 %)
Current-based alarm stage I_{alarm}	0.1 to 4 $A_{(1A)}$ / 0.5 to 5 $A_{(5A)}$ (steps 0.01 A)
Calculating mode for overtemperature	Θ_{max}, Θ_{mean}, Θ with I_{max}
Pickup time characteristic	$t = \tau \ln \frac{I^2 - I_{pre}^2}{I^2 - (k\, I_N)^2}$
Reset ratio	
Θ/Θ_{Alarm}	Approx. 0.99
Θ/Θ_{Trip}	Approx. 0.99
I / I_{Alarm}	Approx. 0.99
Tolerances	Class 10 % acc. to IEC 60255-8

Additional functions

Operational measured values

Representation	Primary, secondary and percentage referred to rated value
Currents	3 x I_{Phase} ; $3I_0$; I_E; I_1; I_2
Tolerances	
10 to 50 % I_N	Typical ≤ 1 % of 50 % I_N
50 to 200 % I_N	Typical ≤ 1 % of measured value
Voltages	3 x $V_{Phase-Earth}$; 3 x $V_{Phase-Phase}$; $3V_0$, V_1, V_2, V_{en}
Tolerances	
10 to 50 % V_N	Typical ≤ 1 % of 50 % V_N
50 to 200 % V_N	Typical ≤ 1 % of measured value
Power with direction indication	P, Q, S
Tolerances	
P: for $\lvert\cos\varphi\rvert$ = 0.7 to 1 and V/V_N, I/I_N = 50 to 120 %	Typical ≤ 3 %
Q: for $\lvert\sin\varphi\rvert$ = 0.7 to 1 and V/V_N, I/I_N = 50 to 120 %	Typical ≤ 3 %
S: for V/V_N , I/I_N = 50 to 120 %	Typical ≤ 2 %
Frequency	f
Tolerance	≤ 20 mHz
Power factor	p.f. ($\cos\varphi$)
Tolerance for $\lvert\cos\varphi\rvert$ = 0.7 to 1	Typical ≤ 3 %
Remote measurements	3 x $I_{Phase-Earth}$; $3I_0$, 3 x $V_{Phase-Earth}$; $3V_0$
Overload measured values	Θ/Θ_{Trip} L1; Θ/Θ_{Trip} L2; Θ/Θ_{Trip} L3; Θ/Θ_{Trip}

Fault record storage

Measured analog channels	3 x I_{Phase}, $3I_0$, $3I_{Diff}$ 3 x V_{Phase}, $3V_0$, $3I_{Restraint}$
Max. number of available recordings	8, backed up by battery if auxiliary voltage supply fails
Sampling intervals	20 samplings per cycle
Total storage time	Approx. 10 s
Binary channels	Pickup and trip information; number and contents can be freely configured by the user

Further additional functions

Measured value supervision	Current sum Current symmetry Voltage sum Voltage symmetry Voltage phase sequence Fuse failure monitor
Indications	
Operational indications	Buffer size 200
System disturbance indication	Storage of signals of the last 8 faults, buffer size 600
Switching statistics	Number of breaking operations per CB pole Sum of breaking current per phase Breaking current of last trip operations Max. breaking current per phase
Circuit-breaker test	TRIP/CLOSE cycle, 3 phases TRIP/CLOSE cycle per phase
Dead time for CB TRIP / CLOSE cycle	0 to 30 s (steps 0.01 s)
Commissioning support	Operational measured values, CB test, status display of binary indication inputs, setting of output relays, generation of indications for testing serial interfaces, commissioning support via Web-browser, test mode, commissioning mode

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1.

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

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".

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 transformers		
I_{ph} = 1 A [1], I_e = 1 A [1]		*1*
I_{ph} = 5 A [1], I_e = 5 A [1]		*5*
Auxiliary voltage		
(Power supply, BI operating voltage)		
24 to 48 V DC, trigger level binary input 19 V [3]		*2*
60 to 125 V DC [2], trigger level binary input 19 V [3]		*4*
110 to 250 V DC [2], 115 to 230 V AC, trigger level binary input 88 V [3]		*5*
110 to 250 V DC [2], 115 to 230 V AC, trigger level binary input 176 V [3]		*6*
Housing, number of binary inputs/outputs		
Flush-mounting housing with screw-type terminals 1/3 19", 7 BI, 5 BO, 1 live-status contact		*B*
Surface-mounting housing with screw-type terminals 1/3 19", 7 BI, 5 BO, 1 live-status contact		*F*
Flush-mounting housing with plug-in term., 1/3 19", 7 BI, 5 BO , 1 live-status contact		*K*
Region-specific default settings/ function versions and language settings		
Region DE, German language (language changeable)		*A*
Region world, English language (language changeable)		*B*
Region US, US-English language (language changeable)		*C*
Region world, French language (language changeable)		*D*
Region world, Spanish language (language changeable)		*E*
Region world, Italian language (language changeable)		*F*
System interfaces, functions and hardware		
Without system interface		*0*
IEC 60870-5-103 protocol, electric RS232		*1*
IEC 60870-5-103 protocol, electric RS485		*2*
IEC 60870-5-103 protocol, optical 820 nm, ST connector		*3*
Further protocols see supplement L		*9*
		L 0 ☐
PROFIBUS DP slave, RS485		*A*
PROFIBUS DP slave, optical 820 nm, double ring, ST connector [4]		*B*
MODBUS, RS485		*D*
MODBUS, optical 820 nm, ST connector [4]		*E*
DNP 3.0, RS485		*G*
DNP 3.0, optical 820 nm, ST connector [4]		*H*
IEC 61850, 100 Mbit Ethernet electrical, double, RS45 connector (EN 100)		*R*
IEC 61850, 100 Mbit Ethernet, with integrated switch optical, double, LC connector [5]		*S*

see next page

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

Selection and ordering data

Description	Order No.	Short code
7SD61 numerical line differential protection 87L SIPROTEC 4 (continued)	7SD610 ☐ - ☐☐☐☐☐ - ☐☐☐☐ - ☐☐☐	

DIGSI/Modem interface (on rear of device) and protection interface 1	9	M ☐☐
DIGSI/Modem interface (on rear of device) 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
without with emergency or back-up overcurrent and breaker failure protection		C
with directional – emergency or back-up overcurrent protection		R
with directional – emergency or back-up overcurrent and breaker failure protection		S

Additional functions 1

4 Remote commands/ 24 Remote indications	Transformer expansions	Voltage-/frequence protection	Restricted earth fault (low impedance)	
				A
		■		B
	■			E
	■	■		F
■				J
■		■		K
■	■			N
■	■	■		P
■	■		■	S
■	■	■	■	T

without external GPS synchronisation of differential protection	0
with external GPS synchronisation of differential protection	1

1) Communication converter 7XV5662, see Accessories.

2) Device for surface mounting housing (Order No. pos. 9 = F) will be delivered with external repeater 7XV5461-0Bx00.

3) For distances less than 25 km a set of optical attenuators 7XV5107-0AA00 must be installed to avoid saturation of the receiver element.

4) For distances less than 50 km a set of optical attenuators 7XV5107-0AA00 must be installed to avoid saturation of the receiver element.

5) Only available in flush-mounting housing (Order No. pos. 9 = B, K).

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 data interface mod. opt. 820 nm, multi-mode FO cable, ST connector, 1.5 km	*C53207-A351-D651-1*
Protection data interface mod. opt. 820 nm, multi-mode FO cable, ST connector, 3.5 km	*C53207-A351-D652-1*
Further modules	
Protection data interface mod. opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 24 km	*C53207-A351-D655-1*
Protection data interface mod. opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	*C53207-A351-D656-1*
Protection data interface mod. opt. 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	*C53207-A351-D657-1*
Protection data interface mod. opt. 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), 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*

Accessories

Description	Order No.
DIGSI 4	
Software for configuration and operation of Siemens protection units running under MS Windows (Windows 2000/XP Professional) device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional Complete version: DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	*7XS5402-0AA00*
SIGRA 4	
(generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows (Windows 2000/XP Professional). Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	*7XS5410-0AA00*
Connecting cable	
Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	*7XV5100-4*
Manual for 7SD61 V4.6	
English	*C53000-G1176-C145-4*

Fig. 7/35 Mounting rail for 19" rack

Fig. 7/36
2-pin connector

Fig. 7/37
3-pin connector

Fig. 7/38
Short-circuit link for current terminals

Fig. 7/39
Short-circuit link for voltage terminals/ indications terminals

Description		Order No.	Size of package	Supplier	Fig.
Connector	2-pin	*C73334-A1-C35-1*	1	Siemens	7/36
	3-pin	*C73334-A1-C36-1*	1	Siemens	7/37
Crimp connector	CI2 0.5 to 1 mm^2	*0-827039-1*	4000	AMP [1]	
		0-827396-1	1	AMP [1]	
	CI2 1 to 2.5 mm^2	*0-827040-1*	4000	AMP [1]	
		0-827397-1	1	AMP [1]	
	Type III+ 0.75 to 1.5 mm^2	*0-163083-7*	4000	AMP [1]	
		0-163084-2	1	AMP [1]	
Crimping tool	For Type III+	*0-539635-1*	1	AMP [1]	
	and matching female	*0-539668-2*		AMP [1]	
	For CI2	*0-734372-1*	1	AMP [1]	
	and matching female	*1-734387-1*		AMP [1]	
19" mounting rail		*C73165-A63-D200-1*	1	Siemens	7/35
Short-circuit links	For current terminals	*C73334-A1-C33-1*	1	Siemens	7/38
	For other terminals	*C73334-A1-C34-1*	1	Siemens	7/39
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

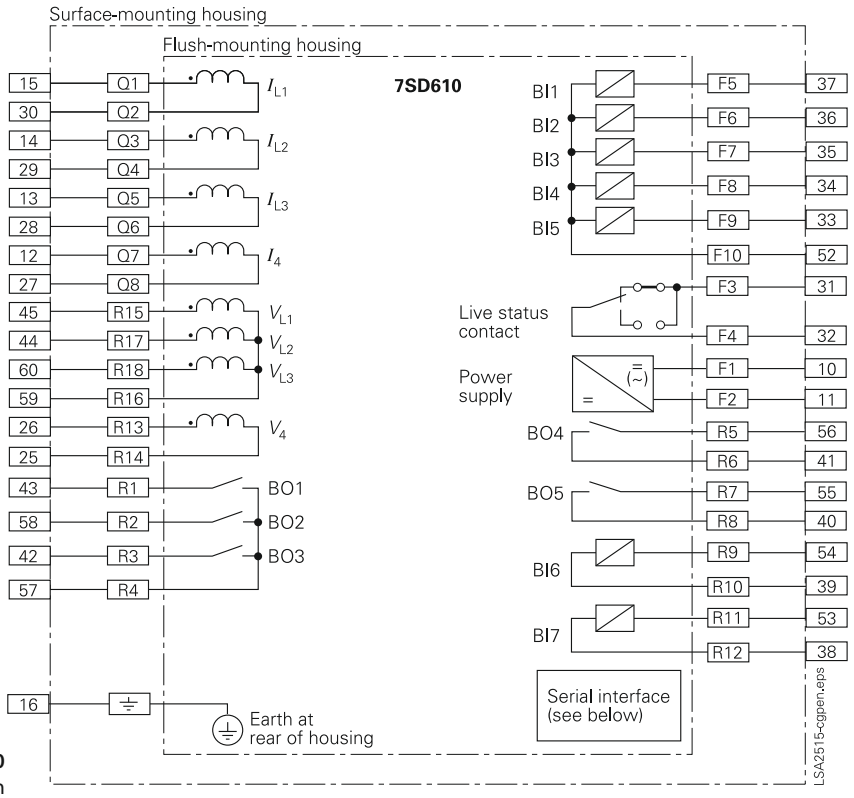


Fig. 7/40
Connection diagram

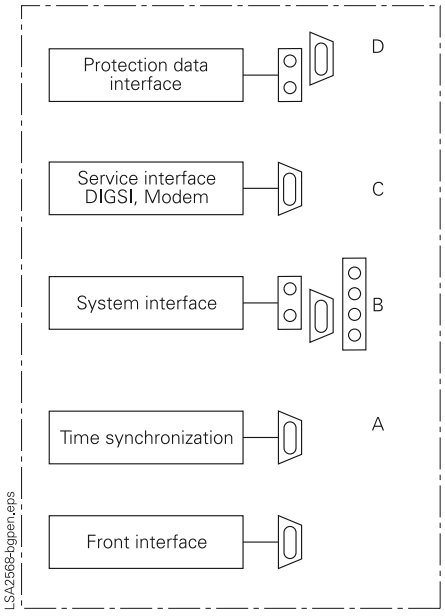


Fig. 7/41
Serial interfaces

SIPROTEC 4 7SD52/53
Multi-End Differential and Distance Protection in One Relay

Fig. 7/42
SIPROTEC 4
7SD52/53 differential protection relay

Description

The 7SD52/53 relay provides full scheme differential protection and incorporates all functions usually required for the protection of power lines. It is designed for all power and distribution levels and protects lines with two up to six line ends. The relay is designed to provide high-speed and phase-selective fault clearance. The relay uses fiber-optic cables or digital communication networks to exchange telegrams and includes special features for the use in multiplexed communication networks. Also pilot wires connections can be used with an external converter. This contributes toward improved reliability and availability of the electrical power system.

The relay is suitable for single and three-phase tripping applications for two up to six line ends. Also, transformers and compensation coils within the differential protection zone are protected as are serial and parallel-compensated lines and cables. The relays may be employed with any type of system earthing.
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 data 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 earth-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)
- Earth-fault detection in isolated and resonant-earthed 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 f. ctrl of CB and isolators

Monitoring functions

- Self-supervision of relay and protection data (R2R) communication
- Trip circuit supervision (74TC)
- Measured-value supervision
- Oscillographic fault recording
- Event logging/fault logging
- Switching statistics

Front design

- User-friendly local operation
- PC front port for relay setting
- Function keys and 14 LEDs f. local alarm

Communication interfaces

- 2 serial protection data (R2R) interfaces for ring and chain topology
- Front interface for connecting a PC
- System interface for connection to a control system via various protocols
  – IEC 61850 Ethernet
  – IEC 60870-5-103
  – PROFIBUS-FMS/-DP and DNP 3.0
- Rear-side service/modem interface
- Time synchronization via IRIG-B or DCF77 or system interface

Application

ANSI		ANSI	
87L	Δ *I* for lines / cables	50HS	Instantaneous high-current tripping (switch-onto-fault)
87T	Δ *I* for lines / cables with transformers	59 27	Overvoltage/undervoltage protection
87N	Low impedance restricted earth-fault protection for transformers	81O/U	Over/underfrequency protection
85	Phase-selective intertrip, remote trip	25	Synchro-check
86	Lockout function	79	Single or three-pole auto-reclosure with new adaptive technology
21 21N	Distance protection	49	Overload protection
FL	Fault locator	50BF	Breaker failure protection
68 68T	Power swing detection/tripping	74TC	Trip circuit supervision
85/21	Teleprotection for distance protection	50-STUB	STUB bus protection
27WI	Weak-infeed protection		
50N 51N 67N	Directional earth(ground)-fault protection		
85/67N	Teleprotection for earth (ground)-fault protection		
50 50N 51 51N	Three-stage overcurrent protection		

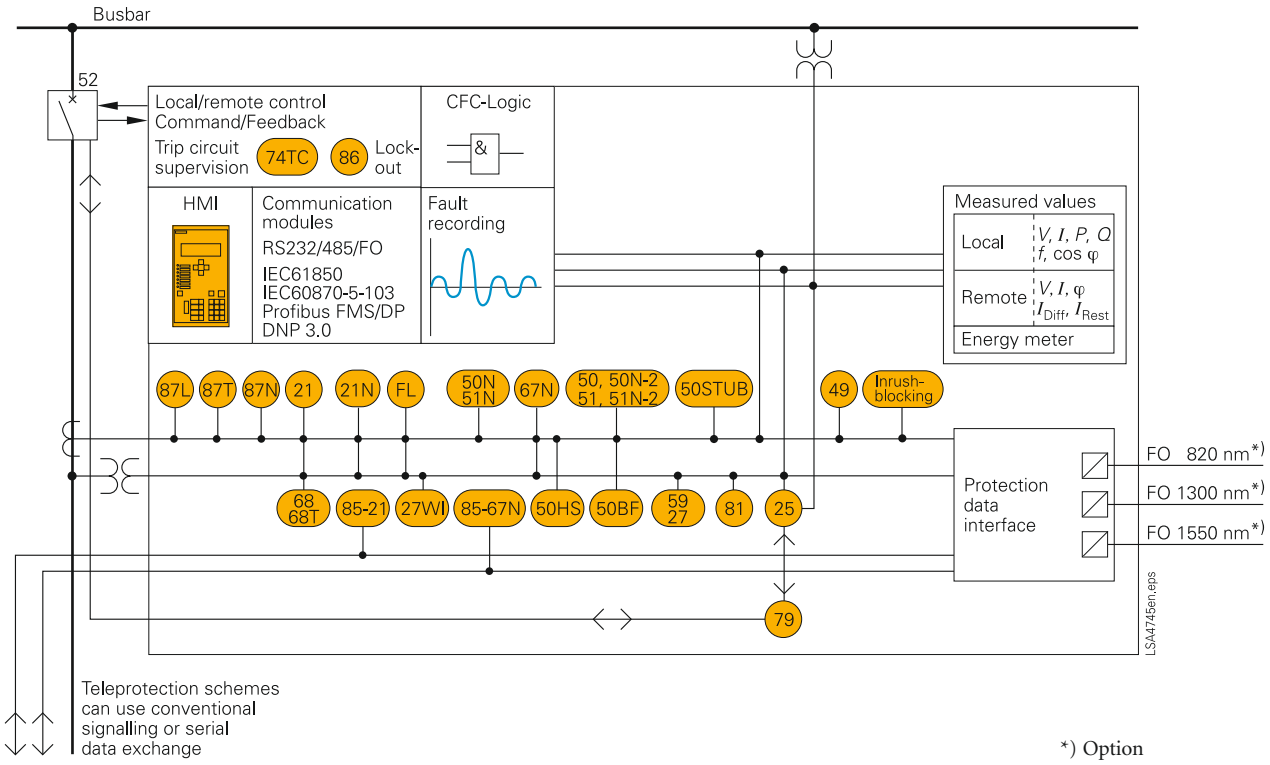


Fig. 7/43

Application

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-earthed 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.

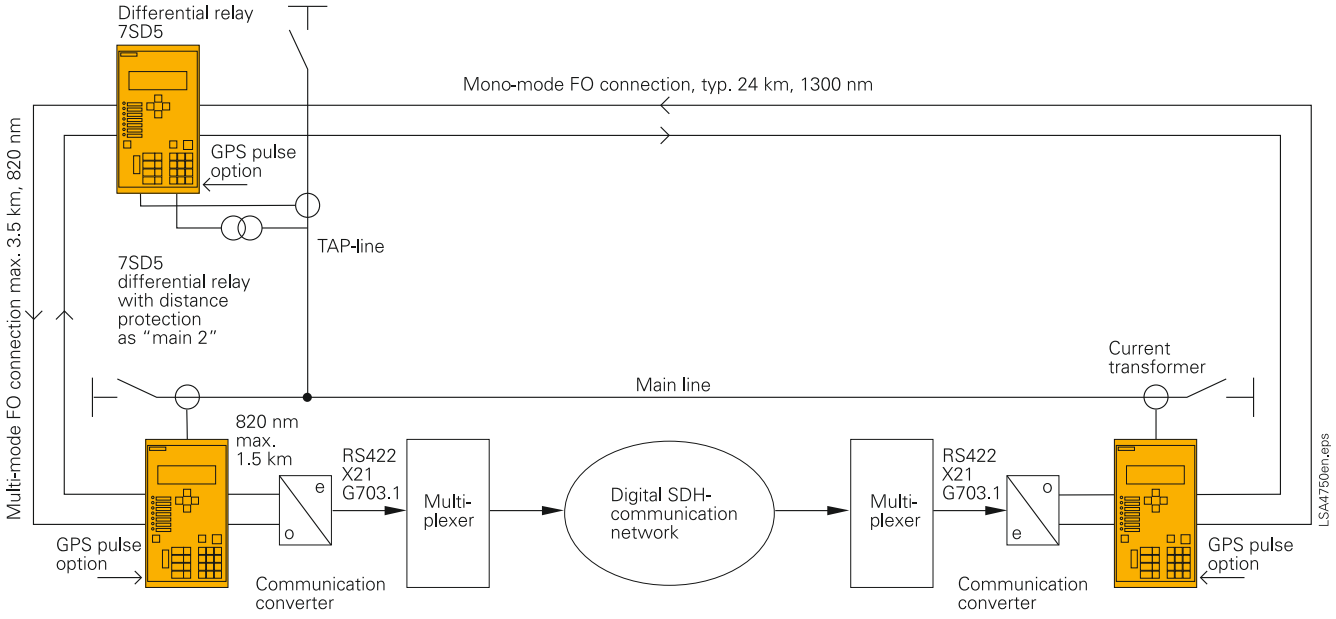


Fig. 7/44 Application for three line ends (Ring topology)

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

1/3, 1/2, 2/3, and 1/1-rack sizes:
These are the available housing widths of the 7SD52/53 relays, referred to a 19" module frame system. This means that previous models can always be replaced. The height is a uniform 245 mm for flush-mounting housings and 266 mm for surface-mounting housings for all housing widths. All cables can be connected with or without ring lugs. Plug-in terminals are available as an option. It is thus possible to employ prefabricated cable harnesses. In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located in a sloped case at the top and bottom of the housing.

Fig. 7/45
Flush-mounting housing
with screw-type terminals

Fig. 7/46
Rear view of flush-mounting housing with covered connection terminals and wirings

Fig. 7/47
Surface-mounting housing with screw-type terminals

Fig. 7/48
Communication interfaces
in a sloped case in a surface-mounting 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 earthed 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.
- A more sensitive protection for transformers within the protection zone is given by measurement of the star-point current on an earthed 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 earth-current differential protection (REF) can be implemented.
  This function is substantially more sensitive than the differential protection during faults to earth 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.

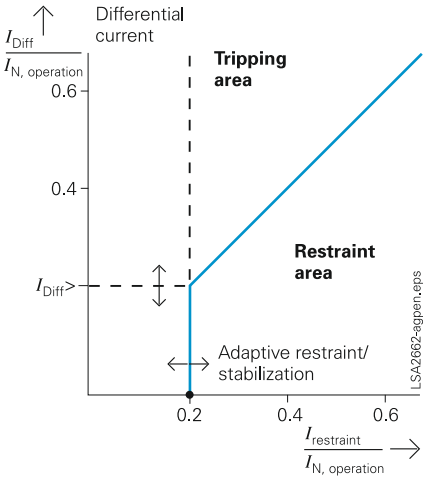


Fig. 7/49 Tripping characteristic

- 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.
- 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.

Protection functions

Phase-selective intertrip and remote trip/indications

Normally the differential fault current is calculated for each line end nearly at the same time. This leads to fast and uniform tripping times. Under weak infeed conditions, especially when the differential function is combined with an overcurrent pickup a phase-selective intertrip offers a tripping of all line ends.

- 7SD52/53 has 4 intertrip signals which are transmitted in high-speed (< 20 ms) to the other line ends. These intertrip signals can also be initiated by an external relay via binary inputs and therefore be used to indicate, for example, a directional decision of the backup distance relay.
- In addition, 4 high-speed remote trip signals are available, which may be initiated by an external or internal event.
- 24 remote signals can be freely assigned to inputs and outputs at each line end and are circulating between the different devices.

Communication topologies / modes of operation

The differential relays may work in a ring or daisy chain line topology. Use of a test mode offer advantages under commissioning and service conditions.

- The system tolerates the loss of one data connection in a ring topology. The ring topology is rerouted within 20 ms forming then a chain topology, while the differential protection function is immediately reactivated.
- When the communication connections need to be reduced or when these are not available, the whole system is able to function without interruption as chain topology. At the line ends, only cost-effective 7SD52/53 relays with one protection data 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.

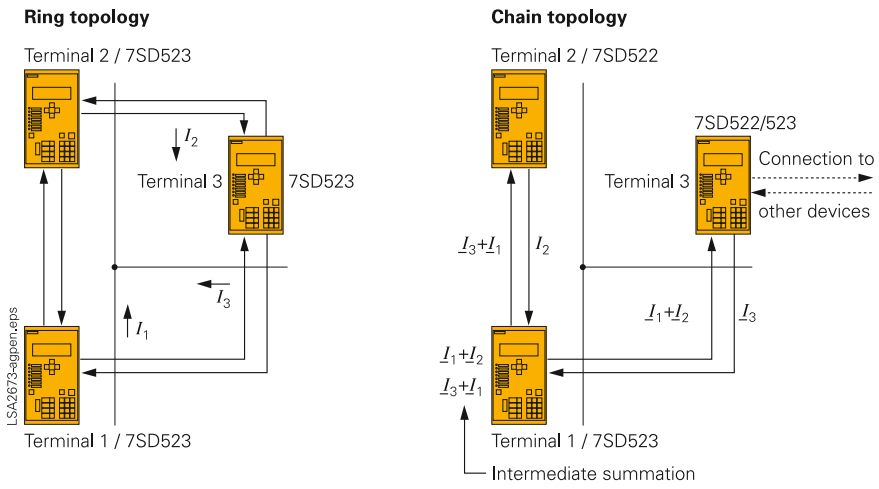


Fig. 7/50 Differential protection in ring or chain topology

- 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.

Protection functions

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 earthing, isolated, solid or low-resistance earthing) 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*/φ
- 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.

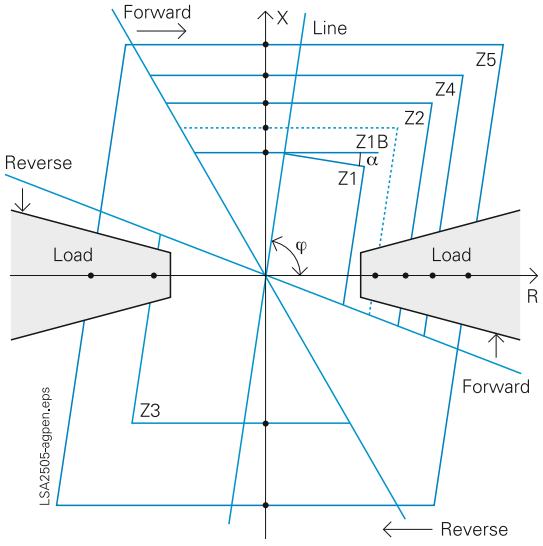


Fig. 7/51
Distance protection: quadrilateral characteristic

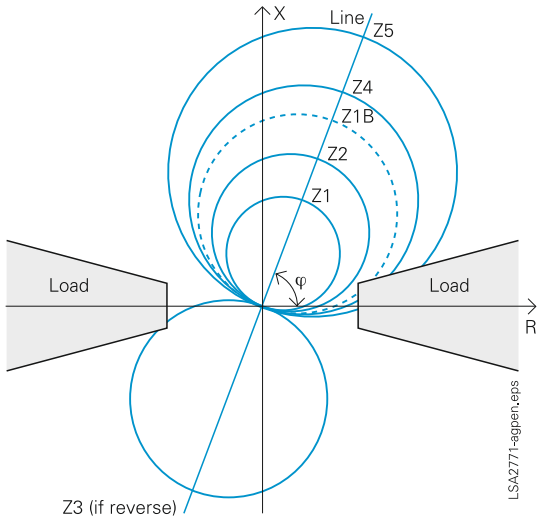


Fig. 7/52
Distance protection: mho characteristic

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 earth 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.

Protection functions

Elimination of interference signals

Digital filters render the unit immune to interference signals contained in the measured values. In particular, the influence of DC components, capacitive voltage transformers and frequency changes is considerably reduced. A special measuring method is employed in order to assure protection selectivity during saturation of the current transformers.

Measuring voltage monitoring

Tripping of the distance protection is blocked automatically in the event of failure of the measuring voltage, thus preventing spurious tripping.

The measuring voltage is monitored by the integrated fuse failure monitor. Distance protection is blocked if either the fuse failure monitor or the auxiliary contact of the voltage transformer protection switch operates and, in this case, the EMERGENCY definite-time overcurrent protection can be activated.

Power swing detection (ANSI 68, 68T)

Dynamic transient reactions, for instance short-circuits, load fluctuations, auto-reclosures or switching operations can cause power swings in the transmission network. During power swings, large currents along with small voltages can cause unwanted tripping of distance protection relays. To avoid uncontrolled tripping of the distance protection and to achieve controlled tripping in the event of loss of synchronism, the 7SD52/53 relay is equipped with an efficient power swing detection function. Power swings can be detected under symmetrical load conditions as well as during single-pole auto-reclosures.

Tele (pilot) protection for distance protection (ANSI 85-21)

A teleprotection function is available for fast clearance of faults up to 100 % of the line length. The following operating modes may be selected:

- PUTT, permissive underreaching zone transfer trip
- POTT, permissive overreaching zone transfer trip
- UNBLOCKING
- BLOCKING
- Directional comparison pickup
- Pilot-wire comparison
- Reverse interlocking

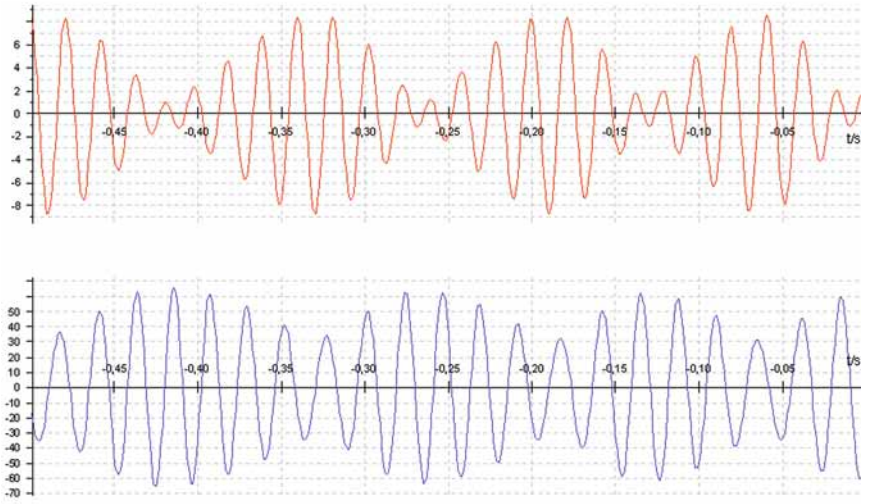


Fig. 7/53
Power swing current and voltage wave forms

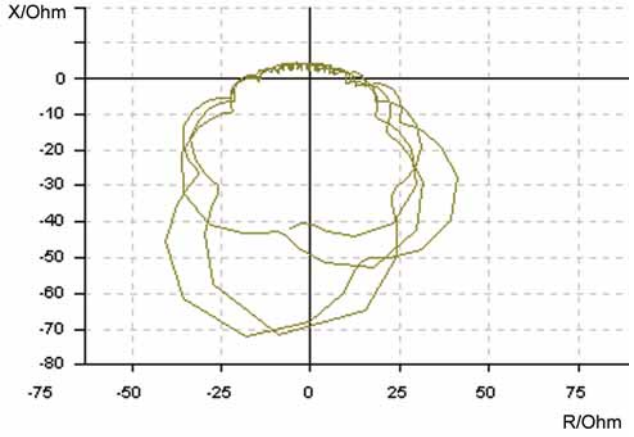


Fig. 7/54
Power swing circle diagram

- 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 data 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.

Protection functions

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-earth 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 autoreclose cycles or during pickup of the distance protection.

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:

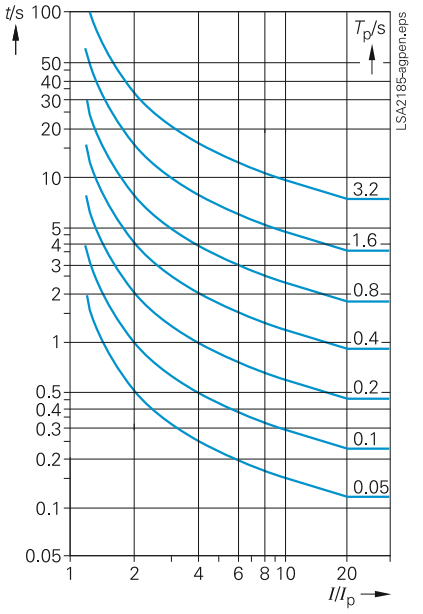
- Directional comparison
- BLOCKING
- UNBLOCKING

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)

The 7SD52/53 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. 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).



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

Fig. 7/55 Normal inverse

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

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.

Protection functions

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-earth 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-earth 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 earth, 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 earth 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).

Protection functions

- RDT
  Reduced dead time is employed in conjunction with auto-reclosure where no tele-protection method is employed: When faults within the zone extension, but external to the protected line, are switched off for rapid auto-reclosure (RAR), the RDT function decides on the basis of measurement of the return voltage from the remote station which has not tripped whether or not to reduce the dead time.

Synchronism check (ANSI 25)

Where two network sections are switched in by control command or following a 3-pole auto-reclosure, it must be ensured that both network sections are mutually synchronous. For this purpose, a synchronism-check function is provided. After verification of the network synchronism the function releases the CLOSE command. Alternatively, reclosing can be enabled for different criteria, e.g., checking that the busbar or line is not carrying a voltage (dead line or dead bus).

Thermal overload protection (ANSI 49)

A built-in overload protection with a current and thermal alarm stage is provided for the thermal protection of cables and transformers. The trip time characteristics are exponential functions according to IEC 60255-8. The preload is thus considered in the trip times for overloads. An adjustable alarm stage can initiate an alarm before tripping is initiated.

Monitoring and supervision functions

The 7SD52/53 relay provides comprehensive monitoring functions covering both hardware and software. Furthermore, the measured values are continuously checked for plausibility. Therefore the current and voltage transformers are also included in this monitoring system.

Current transformer / Monitoring functions

A broken wire between the CTs and relay inputs under load may lead to maloperation of a differential relay if the load current exceeds the differential setpoint. The 7SD52/53 provides fast broken wire supervision which 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 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}, 3 I_0, I_E, $I_{E\ sensitive}$
- Voltages 3 x $V_{Phase-Ground}$, 3 x $V_{Phase-Phase}$, 3 V_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 $R_{Phase-Ground}$, $X_{Phase-Ground}$
  3 x $R_{Phase-Phase}$, $X_{Phase-Phase}$
- 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 $V_{Phase-Ground}$
  3 x $V_{Phase-Phase}$, $3V_0$; 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.

Protection functions

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.

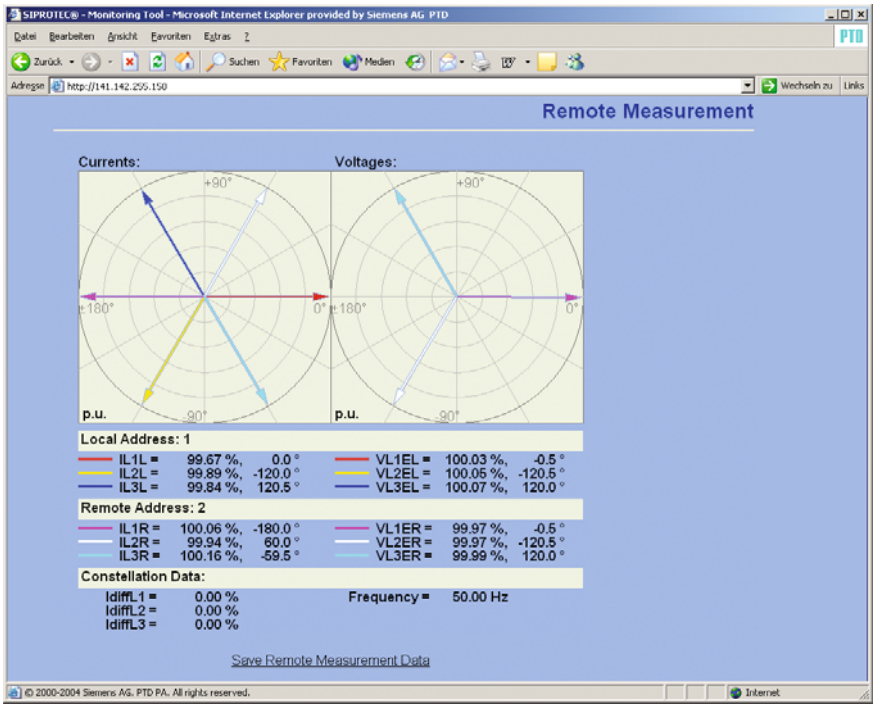


Fig. 7/56
Browser-aided commissioning: Phasor diagram

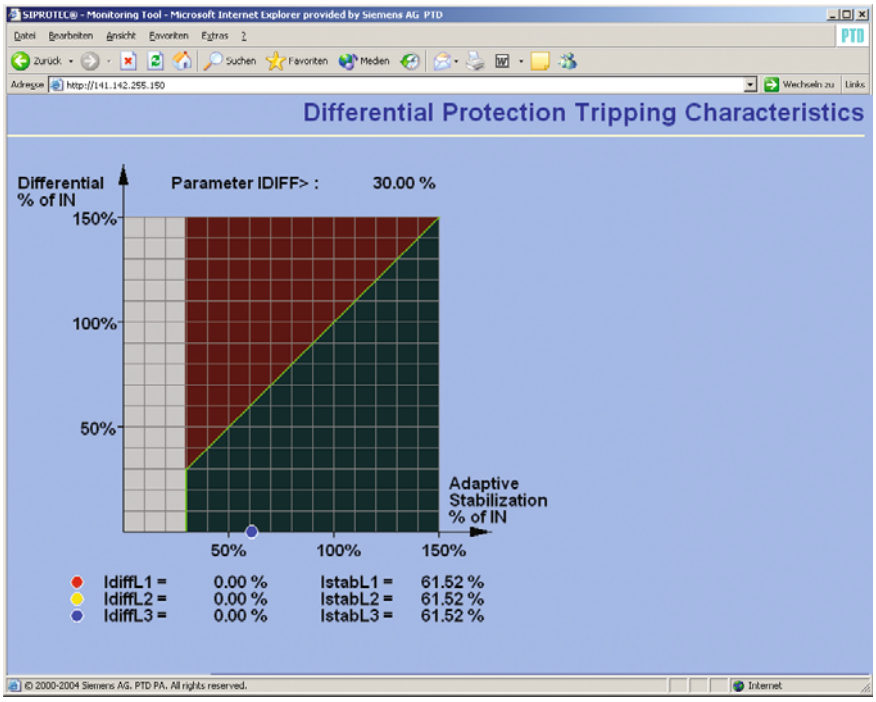


Fig. 7/57
Browser-aided commissioning:
Differential protection tripping characteristic

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.

Protection 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 earthing 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-FMS/-DP, DNP 3.0, DIGSI, etc.) are required, such demands can be met.

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.

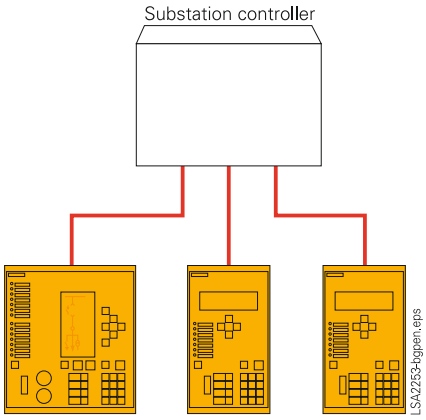


Fig. 7/58
IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

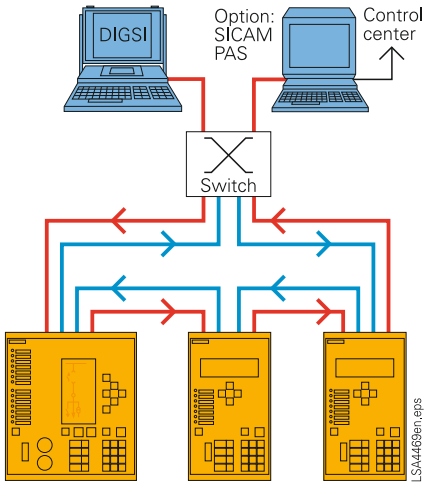


Fig. 7/59
Bus structure for station bus with Ethernet and IEC 61850

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 and system interlocking. Access to the units via the Ethernet bus is also possible with DIGSI.

IEC 60870-5-103

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

PROFIBUS-DP

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

DNP 3.0

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

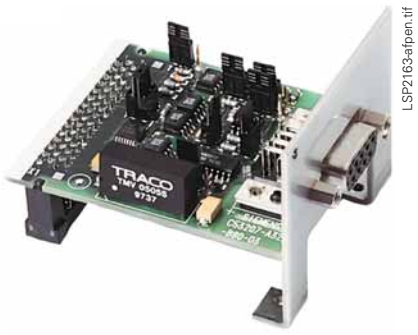


Fig. 7/60
RS232/RS485 electrical communication module

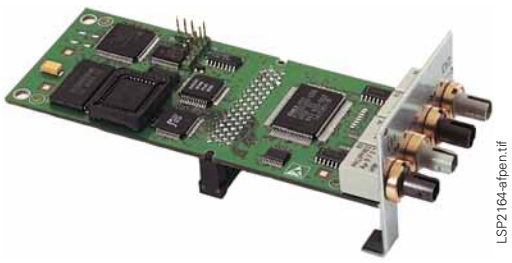


Fig. 7/61
PROFIBUS communication module, optical double-ring

Fig. 7/62
820 nm fiber-optic communication module

Fig. 7/63
Fiber-optic Ethernet communication module for IEC 61850 with integrated Ethernet switch

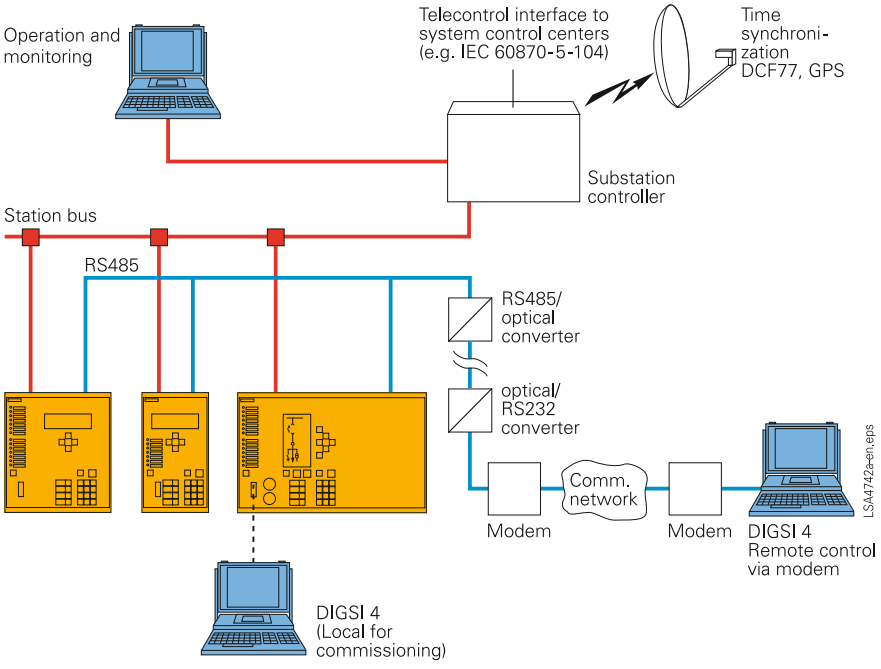


Fig. 7/64
System solution: Communications

Communication

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system.

Units featuring IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 7/58).

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 7/59).

Via modem and service interface, the protection engineer has access to the protection devices at all times. This permits remote maintenance and diagnosis (cyclic testing).

Parallel to this, local communication is possible, for example, during a major inspection.

Serial protection data interface (R2R interface)

As an option, the 7SD52/53 provides one or two protection data 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 earthed 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 data 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 data 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 FO module OMA1 will be delivered together with an external repeater.

Communication

Communication possibilities between relays

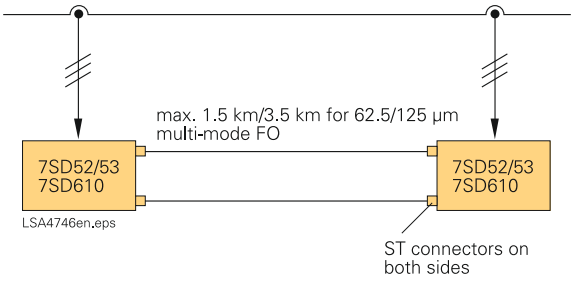


Fig. 7/65
Direct optical link up to 1.5 km/3.5 km, 820 nm

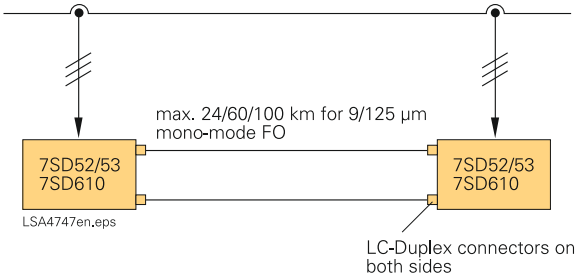


Fig. 7/66
Direct optical link up to 25/60 km with 1300 nm
or up to 100 km with 1550 nm

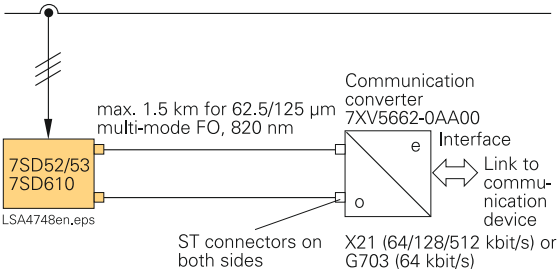


Fig. 7/67
Connection to a communication network CC-XG

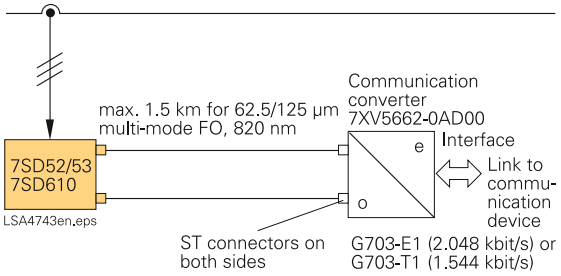


Fig. 7/68
Connection to a communication network CC-2M

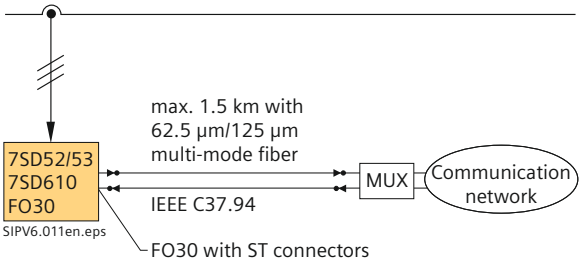


Fig. 7/69
Connection to a communication network via IEEE C37.94

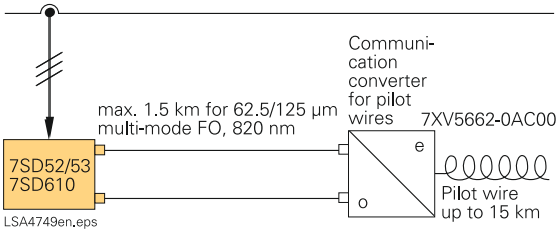


Fig. 7/70
Connection to a pilot wire

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.

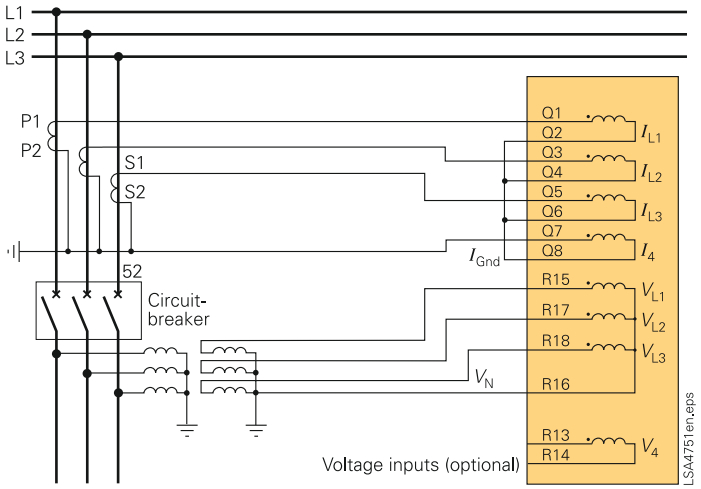


Fig. 7/71
Example of connection for current and voltage transformers

Alternative current measurement

The 3 phase current transformers are connected in the usual manner. The neutral point is in line direction. I_4 is connected to a separate neutral core-balance CT, thus permitting a high sensitive $3I_0$ measurement.

Note: Terminal Q7 of the I_4 transformer must be connected to the terminal of the core-balance CT pointing in the same direction as the neutral point of the phase current transformers (in this case in line direction). The voltage connection is effected in accordance with Fig. 7/71, 7/76 or 7/77.

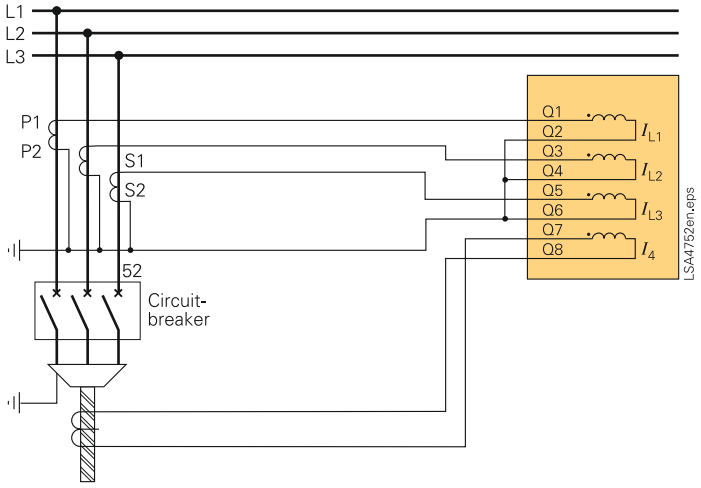


Fig. 7/72
Alternative connection of current transformers for sensitive ground(earth)-current measuring with core-balance current transformers

Typical connection

Alternative current connection

3 phase current transformers with neutral point in the line direction, I_4 connected to a current transformer in the neutral point of a grounded (earthed) transformer for directional ground(earth)-fault protection. The voltage connection is effected in accordance with Fig. 7/71, 7/76 or 7/77.

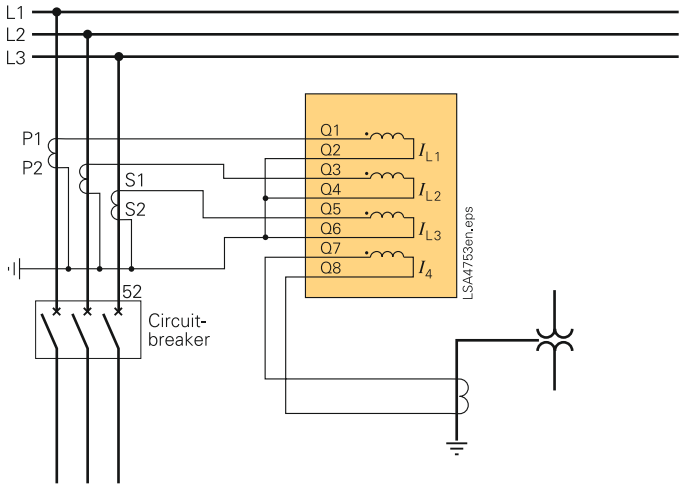


Fig. 7/73 Alternative connection of current transformers for measuring neutral current of a grounded (earthed) power transformer

Alternative current connection

3 phase current transformers with neutral point in the line direction, I_4 connected to the summation current of the parallel line for parallel line compensation on overhead lines. The voltage connection is effected in accordance with Fig. 7/71, 7/76 or 7/77.

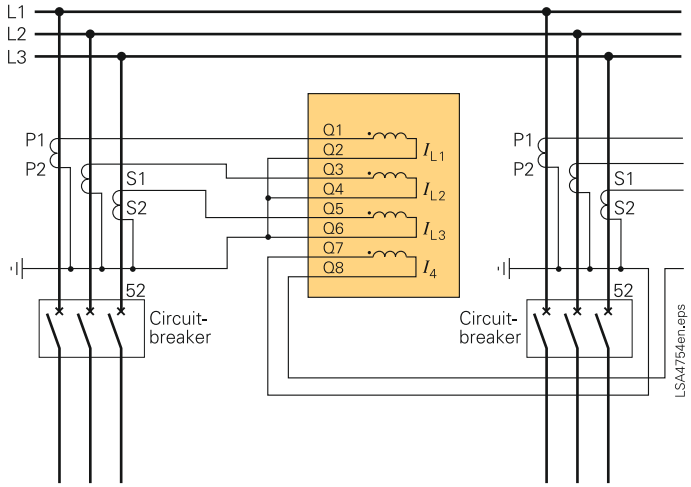


Fig. 7/74 Alternative connection of current transformers for measuring the ground (earth) current of a parallel line

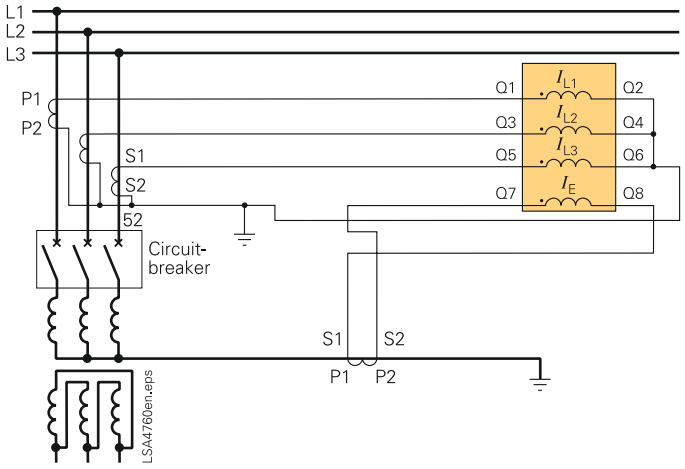


Fig. 7/75 Connection of current transformer with restricted earth-fault protection (REF)

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. 7/71, 7/72, 7/73 and 7/74.

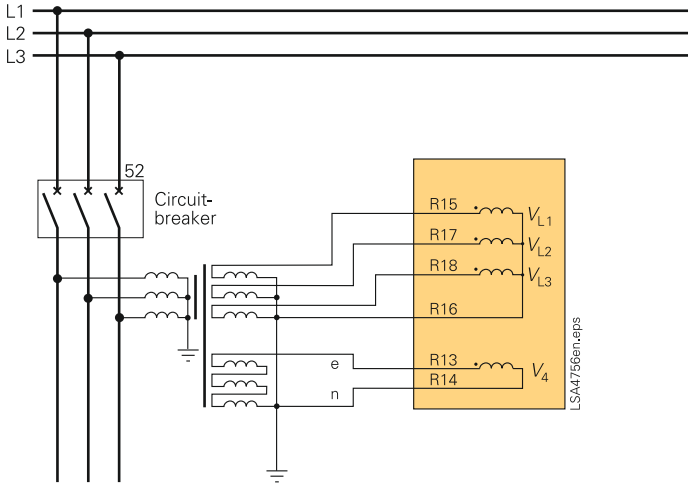


Fig. 7/76 Alternative connection of voltage transformers for measuring the displacement voltage (e-n voltage)

Alternative voltage connection

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

Note: Any phase-to-phase or phase-to-ground(earth) voltage may be employed as the busbar voltage. Parameterization is carried out on the unit. The current connection is effected in accordance with Fig. 7/71, 7/72, 7/73 and 7/74.

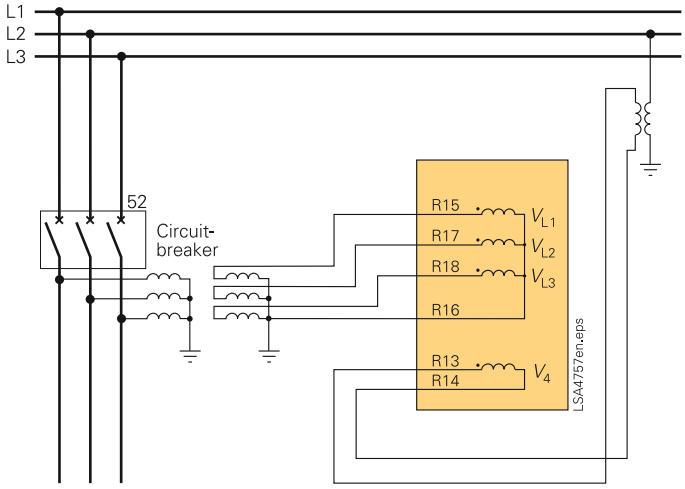


Fig. 7/77 Alternative connection of voltage transformers for measuring the busbar voltage

Technical data

General unit data	
Analog inputs	
Rated frequency	50 or 60 Hz (selectable)
Rated current I_N	1 or 5 A (selectable, controlled by firmware)
Rated voltage	80 to 125 V (selectable)
Power consumption	
In CT circuits with $I_N = 1$ A	Approx. 0.05 VA
In CT circuits with $I_N = 5$ A	Approx. 0.30 VA
In VT circuits	Approx. 0.10 VA
Thermal overload capacity	
In CT circuits	500 A for 1 s 150 A for 10 s 4 x I_N continuous
In VT circuits	230 V, continuous per phase
Dynamic overload capacity	
In CT circuits	1250 A (half cycle)
In the CT circuit for high sensitive earth-fault protection (refer to ordering code)	
Auxiliary voltage	
Rated voltage	24 to 48 V DC 60 to 125 V DC [1)] 110 to 250 V DC [1)] and 115 V AC with 50/60 Hz[1)]
Permissible tolerance	-20 % to +20 %
Max. superimposed AC voltage (peak-to-peak)	≤ 15 %
Power consumption	
During normal operation	Approx. 8 W
During pickup with all inputs and outputs activated	Approx. 18 W
Bridging time during auxiliary voltage failure V_{aux} 110 V AC/DC	≥ 50 ms
Binary inputs	
Quantity	8 or 16 or 24
Function can be assigned	
Minimum permissible voltage	19 or 88 or 176 V DC, bipolar (3 operating ranges)
Range is selectable with jumpers for each binary input	
Maximum permissible voltage	300 V DC
Current consumption, energized	Approx. 1.8 mA
Output relays	
Quantity	16 or 24 or 32
Function can be assigned	
Switching capacity	
Make	1000 W /VA
Break	30 VA
Break (for resistive load)	40 W
Break (for $\tau = L/R \leq 50$ ms)	25 VA
Switching voltage	250 V
Permissible current	30 A for 0.5 s 5 A continuous

1) Ranges are settable by means of jumpers.

LEDs	
	Quantity
RUN (green)	1
ERROR (red)	1
Indication (red), function can be assigned	14
Unit design	
Housing 7XP20 1/2 x 19″ or 1/1 x 19″	See dimension drawings, part 15
Degree of protection acc. to EN 60529	
Surface-mounting housing	IP 51
Flush-mounting housing	
Rear	IP 50
Front	IP 51
For the terminals	IP 2x with cover cap
Weight	
Flush-mounting housing	
1/2 x 19″	6 kg
1/1 x 19″	10 kg
Surface-mounting housing	
1/2 x 19″	11 kg
1/1 x 19″	19 kg

Serial interfaces (front of unit)	
Operating interface 1 for DIGSI 4 or browser	
Connection	Front panel, non-isolated, RS232, 9-pin subminiature connector
Baud rate	4800 to 115200 baud
Time synchronization (rear of unit)	
IRIG-B/DCF77/SCADA or 1 sec pulse from GPS (format IRIG-B000)	
Connection	9-pin subminiature connector (SUB-D)
Voltage levels	5 or 12 or 24 V
Dielectric test	500 V/50 Hz
Service interface (operating interface 2) for DIGSI 4 / modem / service	
Isolated RS232/RS485	9-pin subminiature connector
Dielectric test	500 V/50 Hz
Distance for RS232	Max. 15 m
Distance for RS485, depends on the baud rate	Max. 1000 m
Fiber-optic	Integrated ST connector
Optical wavelength	λ = 820 nm
Permissible attenuation	Max. 8 dB for glass-fiber 62.5/125 µm
Distance	Max. 1.5 km
System interface	
(refer to ordering code)	IEC 61850 Ethernet IEC 60870-5-103 PROFIBUS-FMS PROFIBUS-DP DNP 3.0
Isolated RS232/RS485	9-pin subminiature connector
Baud rate	4800 to 38400 baud
Dielectric test	500 V/50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m

Technical data

System interface, continued	
PROFIBUS RS485	
Dielectric test	500 V/50 Hz
Baud rate	Max. 12 Mbaud
Distance	1 km at 93.75 kB; 100 m at 12 MB
PROFIBUS fiber-optic[2]	
Only for flush-mounting housing	ST connector
For surface-mounting housing	Optical interface with OLM[2]
Baud rate	Max. 1.5 Mbaud
Optical wavelength	λ = 820 nm
Permissible attenuation	Max. 8 dB for glass-fiber 62.5/125 µm
Distance	500 kB/s 1.6 km, 1500 kB/s 530 m
Protection data interface (R2R interface)	
FO5[1], OMA1[2]: Fiber-optic interface with clock recovery for direct connection up to 1.5 km or for connection to a communication converter, 820 nm	For multi-mode fiber 62.5/125 µm, ST connectors Permissible fiber attenuation 8 dB
FO6[1], OMA2[2]: Fiber-optic interface for direct connection up to 3.5 km, 820 nm	For multi-mode fiber 62.5/125 µm, ST connectors Permissible fiber attenuation 16 dB
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 Permissible fiber attenuation 13 dB
FO18[1]: for direct connection up to 60 km[3], 1300 nm	For mono-mode fiber 9/125 µm, LC-Duplex connector Permissible fiber attenuation 29 dB
FO19[1]: for direct connection up to 100 km[3], 1550 nm	For mono-mode fiber 9/125 µm, LC-Duplex connector Permissible fiber attenuation 29 dB
Relay communication equipment	
External communication converter 7XV5662-0AA00 for communication networks ***X21/G703-64 kbit/s***	
External communication converter to interface between the relays, optical 820 nm interface and the X21(RS422) G703-64 kbit/s interface of a communication device	
X21/G703, RS422 selectable by jumpers. Baud rate selectable by jumpers	
Input: fiber-optic 820 nm with clock recovery	Max. 1.5 km with 62.5/125 µm multi-mode FO cable to device side
Output: X21 (RS422) electrical interface on communication device	64/128/512 kbit (selectable by jumper) max. 800 m, 15-pin connector
G703-64 kbit/s electrical interface on communication device	64 kbit/s, max. 800 m, screw-type terminal
External communication converter 7XV5662-0AD00 for communication networks with G703-E1 or G703-T1	
External communication converter to interface between the relays, optical 820 nm interface and G703-E1 or G703-T1 interface of a communication network.	
Inputs: 2 fiber-optic inputs 820 nm, 1RS232 input	Max. 1.5 km with 62.5/125µm multi-mode 1 FO cable to device side
Output: G703.5 G703.6	 E1: 2,048 kbit/s T1: 1,554 kbit/s
Electrical interface on communication network	max. 800 m, screw-type terminal

External communication converter 7XV5662-0AC00 for pilot wires	
External communication converter to interface between relays, optical 820 nm interface and a pilot wire or twisted telephone pair.	
Typical distance	15 km
Fiber-optic 820 nm with clock recovery	Max. 1.5 km with 62.5/125 µm multi-mode FO cable
Pilot wire	Screw-type terminal 5 kV isolated
Permissible time delay (duration of data transmission)	
Delay of telegrams due to transmission for one unit to the other. Delay is constantly measured and adjusted	Max. 30 ms per transmission path Permissible max. value can be selected
Electrical tests	
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)	3.5 kV DC
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.

Technical data

Irradiation with RF field, pulse-modulated IEC 61000-4-3/ ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transients, bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 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

Functions

Differential protection (ANSI 87L, 87T)

Sensitive normal trip stage $I_{Diff}>$	
Setting range of $I_{Diff}>$ secondary 1 A secondary 5 A	0.1 to 20 A (step 0.1) 0.5 to 100 A
Tripping time (three line ends) $I_{Diff} > 2.5 \times I_{Diff} >$ (setting)	50 Hz Min. 27 ms Typ. 29 ms 60 Hz Min. 24 ms Typ. 26 ms
Delay time of $I_{Diff}>$ trip stage	
Delay time	0 to 60 s (step 0.01 s)
Capacitive current load compensation	
Restraint ratio $I_{C\,STAB}$ / I_{CN}	2 to 4 (steps 0.1)
High-set fast trip stage $I_{Diff}>>$	
Setting range $I_{Diff}>>$ secondary 1 A secondary 5 A	0.8 to 100 A (step 0.1) 4 to 500 A (step 0.5)
Tripping time (three line ends) $I_{Diff} \geq 2.5 \times I_{Diff} >>$ (setting)	Min. 9 ms[1)] Typ. 12 ms[1)]

Technical data

Vector group adaptation with transformers in the differential zone	
Adaptation of connection symbol	0 to 11 (x 30 °) (step 1)
Neutral point connection	Grounded (earthed) or not grounded (earthed) (for each winding)
Inrush restraint	
Restraint ratio 2nd harmonic I_{2fN}/I_{fN}	10 % to 45 % (step 1 %)
Max. current for restraint	1.1 A to 25 A[1] (step 0.1 A)
Crossblock function	Can be switched on and off
Max. operative time for crossblock $T_{oper\ crossblk}$	0 to 60 s (step 0.01 s) or deactivated (operating up to release)
Distance protection *(ANSI 21, 21N)*	
Distance protection zones	6, 1 of which as controlled zone, all zones can be set forward or/and reverse
Time stages for tripping delay	6 for multi-phase faults 3 for single-phase faults
Setting range	0 to 30 s or deactivated (steps 0.01 s)
Characteristic Selectable separately for phase and ground (earth) faults	(refer to ordering code) quadrilateral and/or Mho (only impedance pickup)
Types of pickup	Overcurrent pickup (I>); Voltage-dependent overcurrent pickup (V< / I>); Voltage-dependent and phase angle-dependent overcurrent pickup (V< / I> / φ>); Impedance pickup (Z<)
Types of tripping	Three-pole for all types of faults; Single-pole for single-phase faults / otherwise three-pole; Single-pole for single-phase faults and two-pole phase-to-phase faults / otherwise three-pole
Time range	0 to 30 s (step 0.01 s) or deactivated
Line angle φ_L	30 ° to 89 ° (step 1 °)
Inclination angle for quadrilateral characteristic	30° to 90° (step 1°)
Quadrilateral reactance reach X	0.05 to 600 Ω(1A) / 0.01 to 120 Ω(5A) (step 0.001 Ω)
Quadrilateral resistance reach R for phase-to-phase faults and phase-to-ground(earth) faults	0.05 to 600 Ω(1A) / 0.01 to 120 Ω(5A) (step 0.001Ω)
Mho impedance reach ZR	0.05 to 200 Ω(1A) / 0.01 to 40 Ω(5A) (step 0.01 Ω)
Minimum phase current I	0.05 to 4 A (1A) / 0.25 to 20 A (5A) (step 0.01 A)
Overcurrent pickup I>> (for I>>, V</I>, V</I>/φ>)	0.25 to 10 A (1A) / 1.25 to 50 A (5A) (step 0.01 A)
Minimum current pickup I> (for V</I>, V</I>/φ> and Z<)	0.05 to 4 A (1A) / 0.25 to 20 A (5A) (step 0.01 A)
Minimum current pickup $I_φ$> (for V</I>, V</I>/φ>)	0.1 to 8 A (1A) / 0.5 to 40 A (5A) (step 0.01 A)
Undervoltage pickup (for V</I> and V</I>/φ>)	
$V_{ph\text{-}e}$ $V_{ph\text{-}ph}$<	20 to 70 V (step 1 V) 40 to 130 V (step 1 V)
Load angle pickup (for V</I>/φ>)	
Load angle φ Load angle φ	30 ° to 80 ° 90 ° to 120 °

Ground(earth)-fault pickup	
Neutral (residual) current $3I_0$ (Ground current)	0.05 to 4 A (1A)/ 0.25 to 20 A (5A) (step 0.01 A)
Zero-sequence voltage $3V_0$> for earthed networks for resonant-earthed networks	1 to 100 V (step 1 V) or deactivated 10 to 200 V (step 1 V)
Zero-sequence compensation	
Selectable input formats	R_E/R_L and X_E/X_L k_0 and φ(k_0)
Separately selectable for zones	Z1 higher zones (Z1B, Z2 to Z5)
R_E/R_L and X_E/X_L	-0.33 to 7 (step 0.01)
k_0 φ(k_0)	0 to 4 (step 0.001) -135 to 135 ° (step 0.01 °)
Parallel line mutual compensation R_M/R_L and X_M/X_L	(refer to ordering code) 0.00 to 8 (step 0.01)
Phase reference on double earth-faults in resonant-earthed/ non-earthed network	Phase preference or no preference (selectable)
Load encroachment Minimum load resistance	0.10 to 600 Ω(1A) / 0.02 to 120 Ω(5A) (step 0.001 Ω) or deactivated
Maximum load angle	20 to 60 ° (step 1 °)
Directional decision for all types of faults	With sound phase polarization and/or voltage memory
Directional sensitivity	Dynamically unlimited
Tolerances	For sinusodial quantities
Impedances (in conformity with DIN 57435, Part 303)	$\left\|\frac{\Delta X}{X}\right\| \le 5\ \%$ for $30\ ° \le \varphi_{SC} \le 90\ °$ $\left\|\frac{\Delta R}{R}\right\| \le 5\ \%$ for $0\ ° \le \varphi_{SC} \le 60\ °$ $\left\|\frac{\Delta Z}{Z}\right\| \le 5\ \%$ for $-30\ ° \le (\varphi_{SC} - \varphi_{line}) \le +30\ °$
Response values (in conformity with DIN 57435, Part 303)	
V and I Angle (φ)	≤ 5 % of setting value ≤ 3 °
Timer tolerance	± 1 % of set value or 10 ms
Operating times	
Minimum trip time with fast relays Minimum trip time with high-speed relays Reset time	Approx. 17 ms at 50 Hz Approx. 15 ms at 60 Hz Approx. 12 ms at 50 Hz Approx. 10 ms at 60 Hz Approx. 30 ms

1) Secondary data for I_N = 1 A; with I_N = 5 A the values must be multiplied.

Technical data

Power swing detection *(ANSI 68, 68T)*	
Power swing detection principle	Measurement of the rate of impedance vector change and monitoring of the vector path
Max. detectable power swing frequency	Approx. 7 Hz
Operating modes	Power swing blocking and/or power swing tripping (out-of-step tripping)
Power swing blocking programs	All zones blocked Z1/Z1B blocked Z2 to Z5 blocked Z1, Z1B, Z2 blocked
Detection of faults during power swing blocking	Reset of power swing blocking for all types of faults
Tele (pilot) protection for distance protection *(ANSI 85-21)*	
Modes of operation	PUTT (Z1B acceleration); DUTT PUTT (acceleration with pickup); POTT; Directional comparison; Reverse interlocking Pilot-wire comparison; Unblocking; Blocking
Additional functions	Echo function (refer to weak-infeed function) Transient blocking for schemes with measuring range extension
Transmission and reception signals	Phase-selective signals available for maximum selectivity with single-pole tripping; signals for 2 and 3-end-lines
Direct transfer trip (DTT)	
Direct phase-selective tripping via binary input	Alternatively with or without auto-reclosure
Trip time delay	0 to 30 s (step 0.01 s) or deactivated
Timer tolerance	± 1 % of setting value or 10 ms
Backup overcurrent protection (ANSI 50N, 51N)	
Operating modes	Active only with loss of data connection and voltage or always active
Characteristics	3 definite-time stages / 1 inverse-time stage
Definite-time stage *(ANSI 50, 50N)*	
Pickup definite time stage 1, phase current	0.1 to 25 A $_{(1A)}$ / 0.5 to 125 A $_{(5A)}$ (step 0.01 A) or deactivated
Pickup definite-time stage 1, neutral (residual) current	0.5 to 25 A $_{(1A)}$ / 0.25 to 125 A $_{(5A)}$ (step 0.01 A) or deactivated
Pickup definite-time stage 2, phase current	0.1 to 25 A $_{(1A)}$ / 0.5 to 125 A $_{(5A)}$ (step 0.01 A) or deactivated
Pickup definite-time stage 2, neutral (residual) current	0.05 to 25 A $_{(1A)}$ / 0.25 to 125 A $_{(5A)}$ (step 0.01 A) or deactivated
Pickup definite-time stage 3, phase current	0.1 to 25 A $_{(1A)}$ / 0.5 to 125 A $_{(5A)}$ (step 0.01 A) or deactivated
Pickup definite-time stage 3, neutral (residual) current	0.05 to 25 A $_{(1A)}$ / 0.25 to 125 A $_{(5A)}$ (step 0.01 A) or deactivated
Time delay for definite-time stages	0 to 30 s, (step 0.01 s) or deactivated
Tolerances	
Current pickup	≤ 3 % of set value or 1 % of I_N
Delay times	± 1 % of set value or 10 ms
Operating time	Approx. 25 ms

Inverse-time stage *(ANSI 51, 51N)*	
Phase current pickup	0.1 to 4 A $_{(1A)}$ /0.5 to 20 A $_{(5A)}$ (step 0.01 A) or deactivated
Neutral (residual) current pickup	0.05 to 4 A $_{(1A)}$ /0.25 to 20 A $_{(5A)}$ (step 0.01 A) or deactivated
Characteristics	
Characteristics according to IEC 60255-3	Normal inverse Very inverse Extremely inverse Long time inverse
Time multiplier	T_p = 0.05 to 3 s (step 0.01 s) or deactivated
Pickup threshold	Approx. 1.1 x I / I_p
Reset threshold	Approx. 1.05 x I / I_p
Tolerances	
Operating time for 2 ≤I/I_p ≤ 20	≤ 5 % of setpoint ± 15 ms
Characteristics according to ANSI/IEEE	Inverse Short inverse Long inverse Moderately inverse Very inverse Extremely inverse Definite inverse
Time dial	0.5 to 15 (step 0.01) or deactivated
Pickup threshold	Approx. 1.1 x M
Reset threshold	Approx. 1.05 x M
Tolerances	
Operating time for 2 ≤ M ≤ 20	≤ 5 % of setpoint ± 15 ms
Instantaneous high-speed switch-onto-fault overcurrent protection *(ANSI 50HS)*	
Operating mode	Active only after c.b. closing; instantaneous trip after pickup
Characteristic	2 definite-time stages
Pickup current I >>>	0.1 to 15 A $_{(1A)}$ /0.5 to 75 A $_{(5A)}$ (step 0.01 A) or deactivated
Pickup current I >>>>	1 to 25 A $_{(1A)}$/5 to 125 A $_{(5A)}$ (step 0.01 A) or deactivated
Reset ratio	Approx. 0.95
Tolerances	< 3 % of set value or 1 % of I_N
Directional ground (earth)-fault overcurrent protection for high-resistance faults in systems with earthed star point *(ANSI 50N, 51N, 67N)*	
Characteristic	3 definite-time stages / 1 inverse-time stage or 4 definite-time stages or 3 definite-time stages / 1 $V_{0inv.}$ stage
Phase selector	Permits 1-pole tripping for single-phase faults or 3-pole tripping for multi-phase faults
Inrush restraint	Selectable for every stage
Instantaneous trip after switch-onto-fault	Selectable for every stage
Influence of harmonics	
Stages 1 and 2 (I>>> and I>>)	3rd and higher harmonics are completely suppressed by digital filtering
Stages 3 and 4 (I> and inverse 4th stage)	2nd and higher harmonics are completely suppressed by digital filtering

Technical data

***Definite-time stage** (ANSI 50N)*	
Pickup value $3I_0$>>>	0.5 to 25 A (1A) / 2.5 to 125 A (5A) (step 0.01 A)
Pickup value $3I_0$>>	0.2 to 25 A (1A) / 1 to 125 A (5A) (step 0.01 A)
Pickup value $3I_0$>	0.05 to 25 A (1A) / 0.25 to 125 A (5A) (step 0.01 A) Neutral (residual) current transformer with normal sensitivity (refer to ordering data, position 7); 0.003 to 25 A (1A) / 0.015 to 125 A (5A) (step 0.001 A) Neutral (residual) current transformer with high sensitivity (refer to ordering data, position 7)
Pickup value $3I_0$, 4th stage	0.05 to 25 A (1A) / 0.25 to 125 A (5A) (step 0.01 A) Neutral (residual) current transformer with normal sensitivity (refer to ordering data, position 7); 0.003 to 25 A (1A) / 0.015 to 125 A (5A) (step 0.001 A) Neutral (residual) current transformer with high sensitivity (refer to ordering data, position 7)
Time delay for definite-time stages	0 to 30 s (step 0.01 s) or deactivated
Tolerances Current pickup Delay times	 ≤ 3 % of setting value or 1 % I_N 1 % of setting value or 10 ms
Command / pickup times $3I_0$>>> and $3I_0$>>	Approx. 30 ms
Command / pickup times $3I_0$> and $3I_0$, 4th stage	Approx. 40 ms
***Inverse-time stage** (ANSI 51N)*	
Ground (earth)-current pickup $3I_{0P}$	0.05 to 4 A (1A) / 0.25 to 20 A (5A) (step 0.01 A) Neutral (residual) current transformer with normal sensitivity (refer to ordering data, position 7) 0.003 to 4 A (1A) / 0.015 to 20 A (5A) (step 0.001 A) Neutral (residual) current transformer with high sensitivity (refer to ordering data, position 7)
Tripping characteristics acc. to IEC 60255-3	Normal inverse; very inverse; extremely inverse; long inverse
ANSI/IEEE tripping characteristic (not for region DE, refer to ordering data, position 10)	Inverse; short inverse; long inverse; moderately inverse; very inverse; extremely inverse; definite inverse
Inverse logarithmic tripping characteristics (not for regions DE and US, refer to ordering data, position 10)	$t = T_{3I0\,Pmax} - T_{3I0\,P} \cdot \ln \frac{3I0}{3I0_p}$
Pickup threshold	1.1 to 4.0 x I/I_P (step 0.1 s)
Time multiplier for IEC T characteristics	T_P = 0.05 to 3 s (step 0.01 s)
Time multiplier for ANSI D characteristics	D_{I0P} = 0.5 to 15 s (step 0.01 s)
Pickup threshold	Approx. 1.1 x I/I_P (ANSI: I/I_P = M)
Inverse logarithmic pickup threshold	1.1 to 4.0 x I/I_{0P} (step 0.1)
Reset threshold	Approx. 1.05 x I/I_{0P} (ANSI: I/I_P = M)
Tolerance Operating time for 2 ≤ I/I_P ≤ 20	 ≤ 5 % of setpoint ± 15 ms

Zero-sequence voltage protection $V_{0inverse}$	
Tripping characteristic	$t = \frac{2\ s}{\frac{V_0}{4} - V_{0inv\,min}}$
***Direction decision** (ANSI 67N)*	
Measured signals for direction decision	$3I_0$ and $3V_0$ or $3I_0$ and $3V_0$ and I_Y (star point current of an earthed power transformer) or $3I_2$ and $3V_2$ (negative-sequence system) or zero-sequence power S_r or automatic selection of zero-sequence or negative-sequence quantities dependent on the magnitude of the component voltages
Min. zero-sequence voltage $3V_0$	0.5 to 10 V (step 0.1 V)
Min. current I_Y (of grounded (earthed) transformers)	0.05 to 1 A (1A) / 0.25 to 5 A (5A) (step 0.01 A)
Min. negative-sequence voltage $3V_2$	0.5 to 10 V (step 0.1 V)
Min. negative-sequence current $3I_2$	0.05 to 1 A (1A) / 0.25 to 5 A (5A) (step 0.01 A)
***Inrush current blocking,** capable of being activated for each stage*	
Component of the 2nd harmonic	10 to 45 % of the fundamental (step 1 %)
Max. current, which cancels inrush current blocking	0.5 to 25 A (1A) / 2.5 to 125 A (5A) (step 0.01 A)
***Tele (pilot) protection for directional ground(earth)-fault overcurrent protection** (ANSI 85-67N)*	
Operating modes	Directional comparison: Pickup Directional comparison: Blocking Directional comparison: Unblocking
Additional functions	Echo (see function "weak infeed"); transient blocking for schemes with parallel lines
Transmission and reception signals	Phase-selective signals available for maximum selectivity with single-pole tripping; signals for 2 and 3-end-lines
***Weak-infeed protection with undervoltage** (ANSI 27WI)*	
Operating modes with carrier (signal) reception	Echo Echo and trip with undervoltage
Undervoltage phase – ground (earth)	2 to 70 V (step 1 V)
Time delay	0.00 to 30 s (step 0.01 s)
Echo impulse	0.00 to 30 s (step 0.01 s)
Tolerances Voltage threshold Timer	 ≤ 5 % of set value or 0.5 V ± 1 % of set value or 10 ms
Fault locator	
Output of the distance to fault	X, R (secondary) in Ω X, R (primary) in Ω Distance in kilometers or in % of line length
Start of calculation	With trip, with reset of pickup, with binary input
Reactance per unit length	0.005 to 6.5 Ω/km(1A) / 0.001 to 1.3 Ω/km(5A) (step 0.0001 Ω/km)
Tolerance	For sinusoidal quantities ≤ 2.5 % line length for 30 ° ≤ φ_{SC} ≤ 90 ° and V_{SC}/V_{nom} > 0.1

Technical data

Voltage protection *(ANSI 59, 27)*	
Operating modes	Local tripping or only indication
Overvoltage protection	
Pickup values $V_{PH-Gnd}>>$, $V_{PH-Gnd}>$ (phase-ground (earth) overvoltage)	1 to 170 V (step 0.1 V) or deactivated
Pickup values $V_{PH-PH}>>$, $V_{PH-PH}>$ (phase-phase overvoltage)	2 to 220 V (step 0.1 V) or deactivated
Pickup values $3V_0>>$, $3V_0>$ ($3V_0$ can be measured via V4 transformers or calculated by the relay) (zero-sequence overvoltage)	1 to 220 V (step 0.1 V) or deactivated
Pickup values $V_1>>$, $V_1>$ (positive-sequence overvoltage)	2 to 220 V (step 0.1 V) or deactivated
Measured voltage	Local positive-sequence voltage or calculated remote positive-sequence voltage (compounding)
Pickup values $V_2>>$, $V_2>$ (negative-sequence overvoltage)	2 to 220 V (step 0.1 V) or deactivated
Reset ratio (settable)	0.5 to 0.98 (step 0.01)
Undervoltage protection	
Pickup values $V_{PH-Gnd}<<$, $V_{PH-Gnd}<$ (phase-ground (earth) undervoltage)	1 to 100 V (step 0.1 V) or deactivated
Pickup values $V_{PH-PH}<<$, $V_{PH-PH}<$ (phase-phase undervoltage)	1 to 175 V (step 0.1 V) or deactivated
Pickup values $V_1<<$, $V_1<$ (positive-sequence undervoltage)	1 to 100 V (step 0.1 V) or deactivated
Blocking of undervoltage protection stages	Minimum current; binary input
Reset ratio	1.05
Time delays	
Time delay for all over- and undervoltage stages	0 to 100 s (steps 0.01 s) or deactivated
Command / pickup time	Approx. 30 ms
Tolerances	
Voltage limit values	≤ 3 % of setting value or 0.5 V
Time stages	1 % of setting value or 10 ms
Frequency protection *(ANSI 81)*	
Number of frequency elements	4
Setting range	45.5 to 54.5 Hz (in steps of 0.01) at f_{nom} = 50 Hz 55.5 to 64.5 Hz (in steps of 0.01) at f_{nom} = 60 Hz
Delay times	0 to 600 s or ∞ (in steps of 0.01 s)
Operating voltage range	6 to 230 V (phase-to-ground (earth))
Pickup times	Approx. 80 ms
Dropout times	Approx. 80 ms
Hysteresis	Approx. 20 mHz
Dropout condition	Voltage = 0 V and current = 0 A
Tolerances	
Frequency	12 m Hz for V = 29 to 230 V
Delay times	1 % of the setting value or 10 ms

Breaker failure protection *(ANSI 50BF)*	
Number of stages	2
Pickup of current element	0.05 to 20 $A_{(1A)}$ / 0.25 to 100 $A_{(5A)}$ (step 0.01 A)
Time delays $T1_{1phase}$, $T1_{3phase}$, $T2$	0 to 30 s (steps 0.01 s) or deactivated
Additional functions	End-fault protection CB pole discrepancy monitoring
Reset time	Approx. 15 ms, typical; 25 ms max.
Tolerances	
Current limit value	≤ 5 % of setting value or 1 % I_{nom}
Time stages	1 % of setting value or 10 ms
Auto-reclosure *(ANSI 79)*	
Number of auto-reclosures	Up to 8
Operating mode	Only 1-pole; only 3-pole, 1 or 3-pole
Operating modes with line voltage check	DLC – dead-line check ADT – adaptive dead time RDT – reduced dead time
Dead times $T_{1\text{-ph}}$, $T_{3\text{-ph}}$, T_{Seq}	0 to 1800 s (step 0.01 s) or deactivated
Action times	0.01 to 300 s (step 0.01 s) or deactivated
Reclaim times	0.5 to 300 s (step 0.01 s)
Start-signal monitoring time	0.01 to 300 s (step 0.01 s)
Additional functions	Synchro-check request 3-phase intertripping InterCLOSE command to the remote end Check of CB ready state Blocking with manual CLOSE
Voltage limit values for DLC, ADT, RDT	
Healthy line voltage	30 to 90 V (step 1 V)
Dead line	2 to 70 V (step 1 V)
Tolerances	
Time stages	1 % of setting value or 10 ms
Voltage limit values	≤ 3 % of setting value or 0.5 V
Synchro-check *(ANSI 25)*	
Initiate options	Auto-reclosure; Manual CLOSE control Control commands
Operating modes	
with auto-reclosure	Synchro-check Line dead/busbar live Line live/busbar dead Line and busbar dead Bypassing
For manual closure and control commands	As for auto-reclosure
Permissible voltage difference	1 to 60 V (step 0.1 V)
Permissible frequency difference	0.03 to 2 Hz (step 0.01 Hz)
Permissible angle difference	2 to 80 ° (step 1 °)
Max. duration of synchronization	0.01 to 600 s (step 0.01 s) or deactivated
Release delay with synchronous networks	0 to 30 s (step 0.01 s)
Tolerances	
Time stages	1 % of setting value or 10 ms
Voltage limit values	≤ 2 % of setting value or 2 V

Technical data

Restricted earth-fault protection (ANSI 87N)

Multiple availability		2 times (option)
Settings		
Differential current	$I_{REF}>/I_{Nobj}$	0.05 to 2.00 (steps 0.01)
Limit angle	φ REF	110 ° (fixed)
Time delay	T_{REF}	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
The set times are pure delay times		
Operating times		
Pickup time (in ms) at frequency		50 Hz 60 Hz
At 1.5 · setting value $I_{REF}>$, approx.		30 25
At 2.5 · setting value $I_{REF}>$, approx.		28 24
Dropout time (in ms), approx.		26 23
Dropout ratio, approx.		0.7

Overcurrent-time protection for phase and residual currents

Multiple availability		3 times (option)
Characteristics		
Definite-time stages (DT)		$I_{Ph}>>$, $3I_0>>$, $I_{Ph}>$, $3I_0>$
Inverse-time stages (IT)		I_P, $3I_{0P}$
Acc. to IEC		Inverse, very inverse, extremely inverse, long-time inverse
Acc. to ANSI		Inverse, moderately inverse, very inverse, extremely inverse, definite inverse, short inverse, long inverse
		Alternatively, user-specified trip and reset characteristics
Reset characteristics (IT)		Acc. to ANSI with disk emulation
Current stages		
High-current stages	$I_{Ph}>>$	0.10 to 35.00 A [1] (steps 0.01 A) or deactivated (stage ineffective)
	$T_{IPh}>>$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
	$3I_0>>$	0.05 to 35.00 A [1] (steps 0.01 A) or deactivated (stage ineffective)
	$T_{3I0}>>$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
Definite-time stages	$I_{Ph}>$	0.10 to 35.00 A [1] (steps 0.01 A) or deactivated (stage ineffective)
	T_{IPh}	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
	$3I_0>$	0.05 to 35.00 A [1] (steps 0.01 A) or deactivated (stage ineffective)
	$T_{3I0}>$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
Inverse-time stages	I_P	0.10 to 4.00 A [1] (steps 0.01 A)
Acc. to IEC	T_{IP}	0.05 to 3.20 s (steps 0.01 s) or deactivated (no trip)
	$3I_{0P}$	0.05 to 4.00 A [1] (steps 0.01 A)
	T_{3I0P}	0.05 to 3.20 s (steps 0.01 s) or deactivated (no trip)
Inverse-time stages	I_P	0.10 to 4.00 A [1] (steps 0.01 A)
Acc. to ANSI	D_{IP}	0.50 to 15.00 s (steps 0.01 s) or deactivated (no trip)
	$3I_{0P}$	0.05 to 4.00 A [1] (steps 0.01 A)
	D_{3I0P}	0.50 to 15.00 s (steps 0.01 s) or deactivated (no trip)

Thermal overload protection (ANSI 49)

Setting ranges	
Factor k acc. to IEC 60255-8	1 to 4 (steps 0.01)
Time constant τ	1 to 999.9 min (steps 0.1 min)
Temperature alarm stage $\Theta_{alarm}/\Theta_{trip}$	50 to 100 % in relation to the trip temperature
Current alarm stage I_{alarm}	
Secondary 1 A	0.1 to 4 A (step 0.1)
Secondary 5 A	0.5 to 20 A (step 0.1)
Trip time characteristic	$t = \tau \ln \frac{I^2 - I_{pre}^2}{I^2 - (k \cdot I_N)^2}$
Reset ratios	
Θ / Θ_{alarm}	Approx. 0.99
Θ / Θ_{trip}	Approx. 0.99
I / I_{alarm}	Approx. 0.99
Tolerances	Class 10 % acc. to IEC

Trip circuit supervision (ANSI 74TC)

Number of supervisable trip circuits	Up to 3
Number of required binary inputs per trip circuit	1 or 2
Indication relay	1 to 30 s (step 1 s)

Additional functions

Operational measured values

Representation	Primary, secondary and percentage referred to rated value
Currents	3 x I_{Phase}; $3I_0$; $I_{Gnd\ sensitve}$; I_1; I_2; I_Y; 3_{I0PAR} 3 x I_{Diff}, 3 x I_{Stab}
Tolerances	≤ 0.5 % of indicated measured value or 0.5 % I_{nom}
Voltages	3 x $V_{Phase-Ground}$; 3 x $V_{Phase-Phase}$; $3V_0$, V_1, V_2, V_{SYNC}, V_{en}, V_{COMP}
Tolerances	≤ 0.5 % of indicated measured value or 0.5 % V_{nom}
Power with direction indication	*P, Q, S*
Tolerances	
P: for $\lvert\cos\varphi\rvert$ = 0.7 to 1 and V/V_{nom}, I/I_{nom} = 50 to 120 %	Typical ≤ 1 %
Q: for $\lvert\sin\varphi\rvert$ = 0.7 to 1 and V/V_{nom} , I/I_{nom} = 50 to 120 %	Typical ≤ 1 %
S: for V/V_{nom}, I/I_{nom} = 50 to 120 %	Typical ≤ 1 %
Frequency	*f*
Tolerance	≤ 20 mHz
Power factor	PF (cos φ)
Tolerance for $\lvert\cos\varphi\rvert$ = 0.7 to 1	Typical ≤ 3 %
Load impedances with directional indication	3 x $R_{Phase-Ground}$, $X_{Phase-Ground}$ 3 x $R_{Phase-Phase}$, $X_{Phase-Phase}$
Overload measured values	Θ/Θ_{Trip} L1; Θ/Θ_{Trip} L2; Θ/Θ_{Trip} L3; Θ/Θ_{Trip}

Long-term mean values

Interval for derivation of mean value	15 min / 1 min; 15 min / 3 min; 15 min / 15 min
Synchronization instant	Every ¼ hour; every ½ hour; every hour
Values	3 x I_{Phase}; I_1; *P*; *P*+; *P*-; *Q*; *Q*+; *Q*–; *S*

Technical data

Minimum/maximum memory	
Indication	Measured values with date and time
Resetting	Cyclically Via binary input Via the keyboard Via serial interface
Values	
Min./max. of measured values	3 x I_{Phase}; I_1; 3 x $V_{Phase-Ground}$; 3 x $V_{Phase-to-phase}$; $3V_0$; V_1; P+; P–; Q+; Q–; S; f; power factor (+); power factor (–)
Min./max. of mean values	3 x I_{Phase}; I_1; P; Q; S
Energy meters	
Four-quadrant meters	W_{P+}; W_{P-}; W_{Q+}; W_{Q-}
Tolerance for $\lvert \cos \varphi \rvert > 0.7$ and $V > 50$ % V_{nom} and $I > 50$ % I_{nom}	5 %
Oscillographic fault recording	
Analog channels	3 x I_{Phase}, $3I_0$, $3I_{0PAR}$, $3I_{0\ Gnd\ sensitive}$, 3 x I_{Diff}, 3 x I_{Stab} 3 x V_{Phase}, $3V_0$, V_{SYNC}, V_{en}, V_x
Max. number of available recordings	8, backed-up by battery if auxiliary voltage supply fails
Sampling intervals	20 samplings per cycle
Total storage time	Approx. 15 s
Binary channels	Pickup and trip information; number and contents can be freely configured by the user
Max. number of displayed binary channels	40
Control	
Number of switching units	Depends on the number of binary / indication inputs and indication / command outputs
Control commands	Single command / double command 1, 1 plus 1 common or 2 pole
Feed back	CLOSE, TRIP, intermediate position
Interlocking	Freely configurable
Local control	Control via menu, function keys
Remote control	Control protection, DIGSI, pilot wires

Further additional functions	
Measurement supervision	Current sum Current symmetry Voltage sum Voltage symmetry Voltage phase sequence Fuse failure monitor
Annunciations	
Event logging	Buffer size 200
Fault logging	Storage of signals of the last 8 faults, buffer size 800
Switching statistics	Number of breaking operations per c.b. pole Sum of breaking current per phase Breaking current of last trip operation Max. breaking current per phase
Circuit-breaker test	TRIP/CLOSE cycle 3-phase TRIP/CLOSE cycle per phase
Setting range Dead time for CB TRIP/CLOSE cycle	0.00 to 30 s (step 0.01 s) 0.00 to 30 s (step 0.01 s)
Commissioning support	Operational measured values Circuit-breaker test Read binary test Initiate binary inputs Set binary outputs Set serial interface outputs Lockout of a device Test mode ot the differential protection topology

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1.

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

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".

Selection and ordering data

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

see next page

Measurement input

I_{ph} = 1 A [2], I_e = 1 A [2]	1
I_{ph} = 1 A [2], I_e = sensitive (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

Binary / indication inputs	Signal / command outputs incl. one live contact	Fast relays [5]	High Speed [6] trip outputs	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	–	1/2	■			A
8	4	12	–	1/2			■	E
8	4	12	–	1/2		■		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

Region-specific default/language settings and funtion 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 stepy 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

Selection and ordering data

Description	Order No.	Short code
7SD5 combined multi-end line differential protection with distance protection (continued)	*7SD52* ☐☐ - ☐☐☐☐ - ☐☐☐☐ - ☐☐☐	

System interfaces

No system interface	*0*	
IEC protocol, electrical RS232	*1*	
IEC protocol, electrical RS485	*2*	
IEC protocol, optical 820 nm, ST-plug	*3*	
PROFIBUS FMS Slave, electrical RS485	*4*	
PROFIBUS FMS Slave, optical 820 nm, twin-ring, ST-plug	*6*	
Further protocols see supplement L	*9*	*L 0* ☐
PROFIBUS DP slave, RS485		*A*
PROFIBUS DP slave, optical 820 nm, double ring, ST connector [1]		*B*
DNP 3.0, RS485		*G*
DNP 3.0, optical 820 nm, ST connector [1]		*H*
IEC 61850, 100 Mbit Etherrnet, electrical, double, RS45 connector (EN100)		*R*
IEC 61850, 100 Mbit Ethernet, with integrated switch optical, double, LC-connector (EN100) [2]		*S*

see next page

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*

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*).

Selection and ordering data

Description	Order No.	Short code
7SD5 combined multi-end line differential protection with distance protection (continued)	*7SD52* ☐☐ - ☐☐☐☐☐ - ☐☐☐☐ - ☐☐☐	

Functions 1 / Protection data interface 2

Trip mode	Auto-reclosure (ANSI 79)	Synchrocheck (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*	
With protection data interface 2 see additional specification N Relays (Ord.-No. 6 = *2*) are available with a second protection data interface (Hot Standby)			*9*	*N* ☐☐

Functions 1

Trip mode	Auto-reclosure (ANSI 79)	Synchrocheck (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*
FO 30: 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*).

Selection and ordering data

Description	Order No.	Short code
7SD5 combined multi-end line differential protection with distance protection (continued)	*7SD5* □□□ - □□□□□ - □□□□ - □□□	

Functions

Time overcurrent protection/
Breaker failure protection (ANSI 50, 50N, 51, 51N, 50BF)
Earth fault protection (ANSI 67N)
Distance protection (Pickup *Z*<, polygon, MHO, parallel line comp.)
Power Swing detection (ANSI 21, 21N, 68, 68T)
Distance protection (I_{pickup} *I*>,-*VI*/*φ*, -Z<), polygon, parallel line comp. [2], power swing det. (ANSI 21, 21N, 68, 68T)
Earth fault detection for isolated/compensated networks [1]

with	without	without	without	without	*C*
with	without	without	with	without	*D*
with	without	with	without	without	*E*
with	with	without	without	without	*F*
with	with	without	with	without	*G*
with	with	with	without	without	*H*
with	without	without	without	with	*J*
with	without	without	with	with	*K*
with	with	without	without	with	*L*
with	with	without	with	with	*M*

Additional functions 1

4 Remote commands/24 Remote indications
Transformer expansions
Fault locator
Voltage protection, frequence protection (ANSI 27, 50)
Restricted earth fault low impedance (ANSI 87N) [2]

with	without	1-side measuring	without	without	*J*
with	without	1-side measuring	with	without	*K*
with	without	2-side measuring	without	without	*L*
with	without	2-side measuring	with	without	*M*
with	with	1-side measuring	without	without	*N*
with	with	1-side measuring	with	without	*P*
with	with	2-side measuring	without	without	*Q*
with	with	2-side measuring	with	without	*R*
with	with	1-side measuring	without	with	*S*
with	with	1-side measuring	with	with	*T*
with	with	2-side measuring	without	with	*U*
with	with	2-side measuring	with	with	*V*

Additional functions 2

Measured values, extended, Min/Max values
External GPS synchronization
Capacitive current load compensation

without	without	without	*0*
without	with	without	*1*
with	without	without	*2*
with	with	without	*3*
without	without	with	*4*
without	with	with	*5*
with	without	with	*6*
with	with	with	*7*

1) Only available with Order No. Pos. 7 = *2* or *6*
2) Only available with Order No. Pos. 7 = *1* or *5*

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 data interface mod. opt. 820 nm, multi-mode FO cable, ST connector, 1.5 km	*C53207-A351-D651-1*
Protection data interface mod. opt. 820 nm, multi-mode FO cable, ST connector, 3.5 km	*C53207-A351-D652-1*
Further modules	
Protection data interface mod. opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 24 km	*C53207-A351-D655-1*
Protection data interface mod. opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	*C53207-A351-D656-1*
Protection data 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*

Accessories

Description	Order No.
DIGSI 4	
Software for configuration and operation of Siemens protection units running under MS Windows (Windows 2000 or XP Professional) device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	*7XS5402-0AA00*
SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows (Windows 2000 or XP Professional). Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	*7XS5410-0AA00*
Connecting cable Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	*7XV5100-4*
Manual for 7SD522/523 V4.6 English	*C53000-G1176-C169*

Fig. 7/78 Mounting rail for 19" rack

Fig. 7/79
2-pin connector

Fig. 7/80
3-pin connector

Fig. 7/81
Short-circuit link for current contacts

Fig. 7/82
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	7/79
	3-pin	*C73334-A1-C36-1*	1	Siemens	7/80
Crimp connector	CI2 0.5 to 1 mm²	*0-827039-1*	4000	AMP [1]	
		0-827396-1	1	AMP [1]	
	CI2 1 to 2.5 mm²	*0-827040-1*	4000	AMP [1]	
		0-827397-1	1	AMP [1]	
	Type III+ 0.75 to 1.5 mm²	*0-163083-7*	4000	AMP [1]	
		0-163084-2	1	AMP [1]	
Crimping tool	For Type III+ and matching female	*0-539635-1*	1	AMP [1]	
		0-539668-2		AMP [1]	
	For CI2 and matching female	*0-734372-1*	1	AMP [1]	
		1-734387-1		AMP [1]	
19"-mounting rail		*C73165-A63-D200-1*	1	Siemens	7/78
Short-circuit links	For current terminals	*C73334-A1-C33-1*	1	Siemens	7/81
	For other terminals	*C73334-A1-C34-1*	1	Siemens	7/82
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

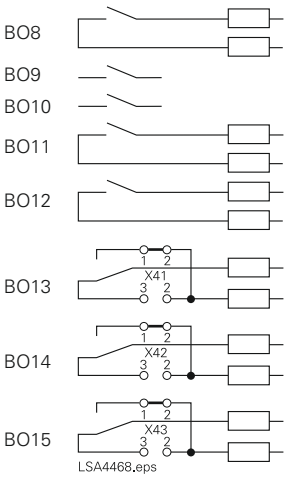


Fig. 7/85

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.

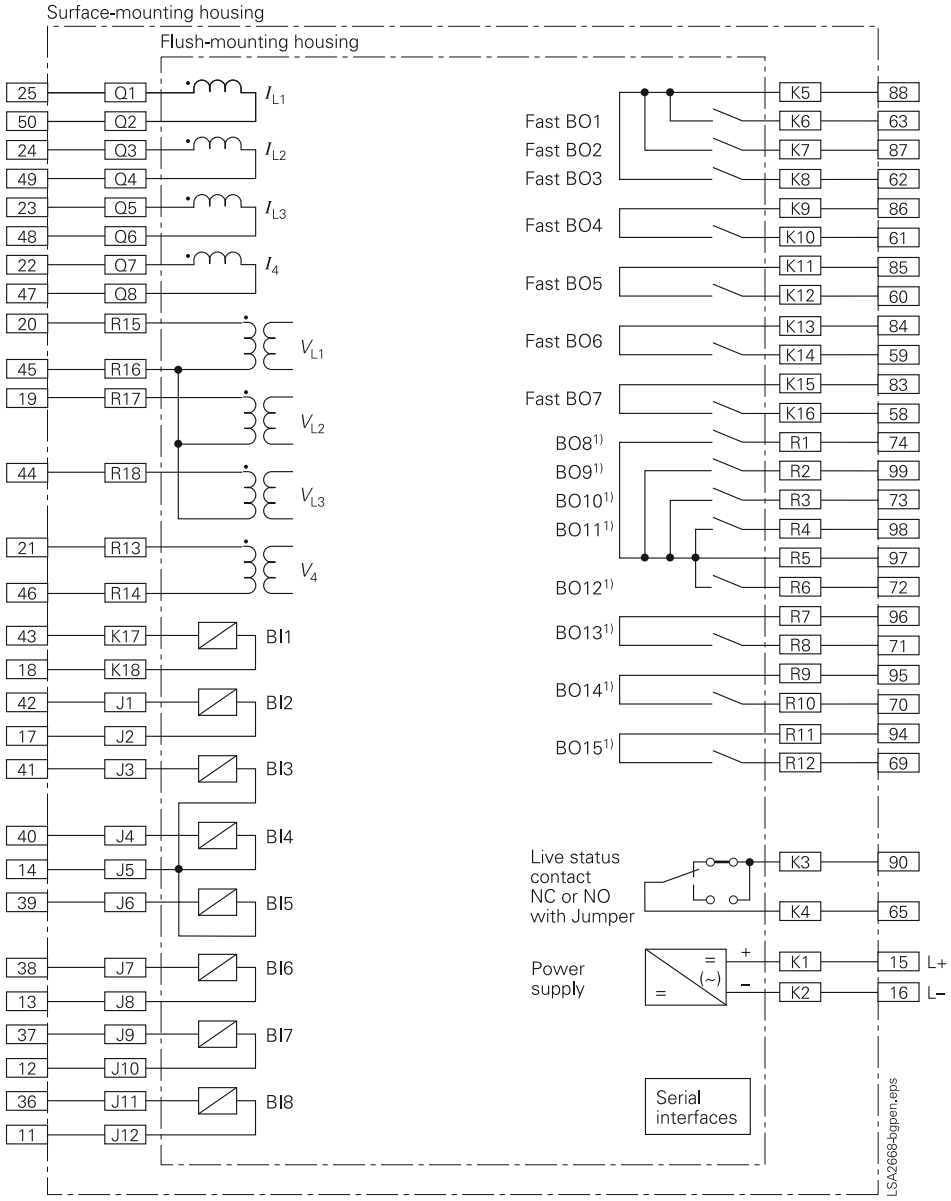


Fig. 7/83 Basic version in housing 1/2 x 19" with 8 binary inputs and 16 binary outputs

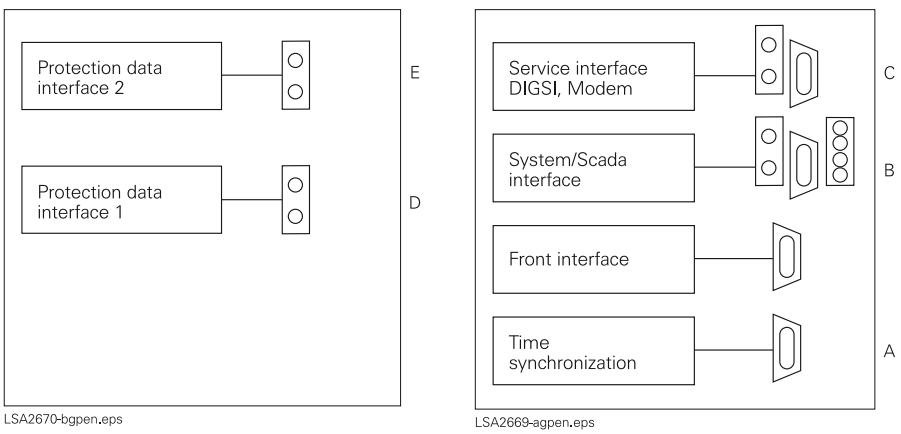


Fig. 7/84 Serial interfaces

1) Configuration of binary outputs until Hardware-version /EE. For advanced flexibility see Fig. 7/85.

Connection diagram

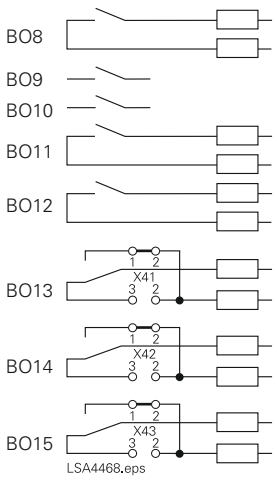


Fig. 7/87

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.

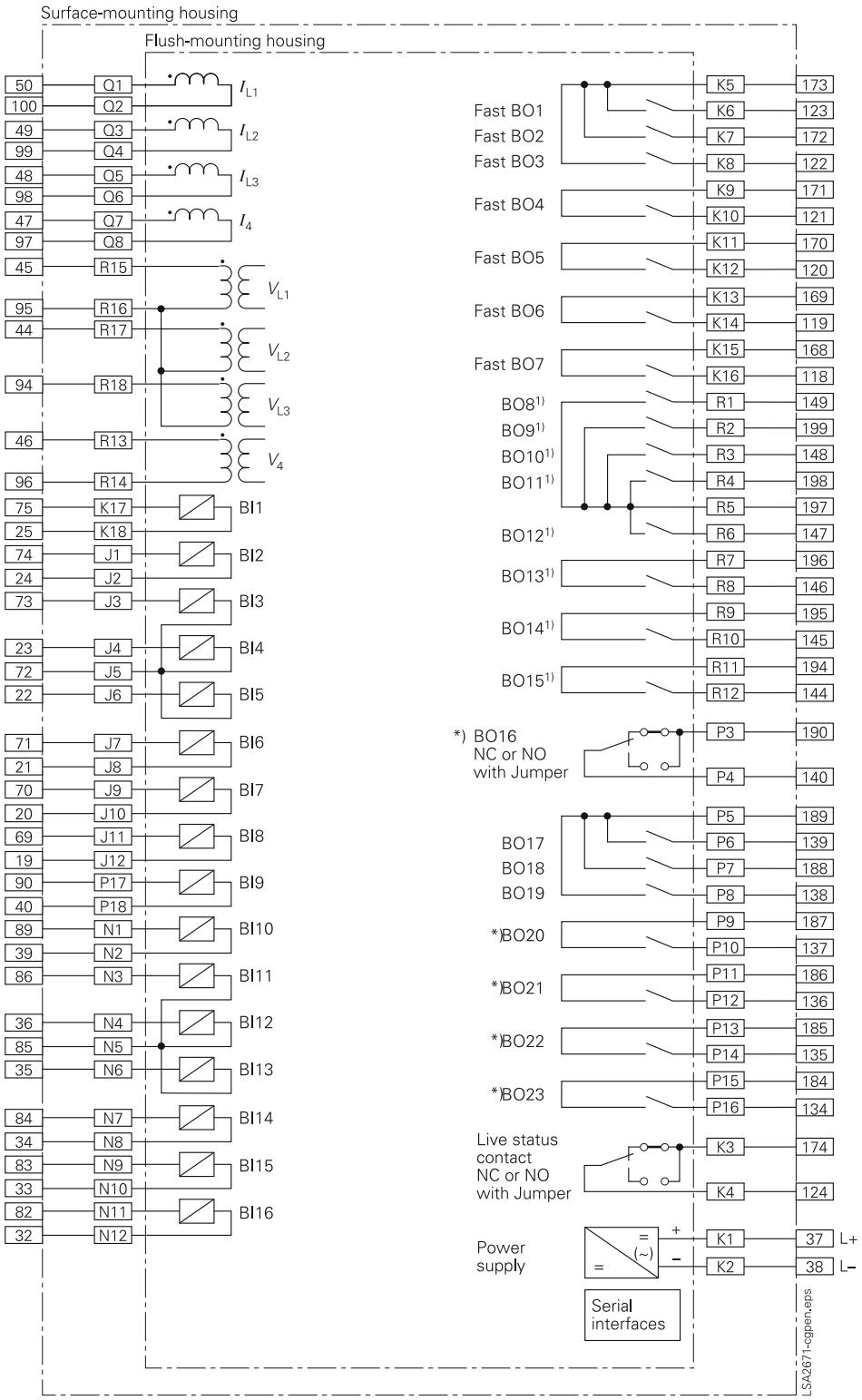


Fig. 7/86 Medium version in housing 1/1 x 19"

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

1) Configuration of binary outputs until Hardware-version /EE. For advanced flexibility see Fig. 7/87.

Connection diagram

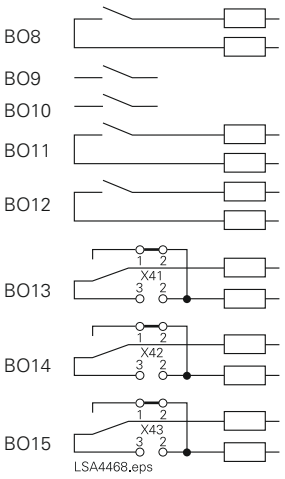


Fig. 7/89

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.

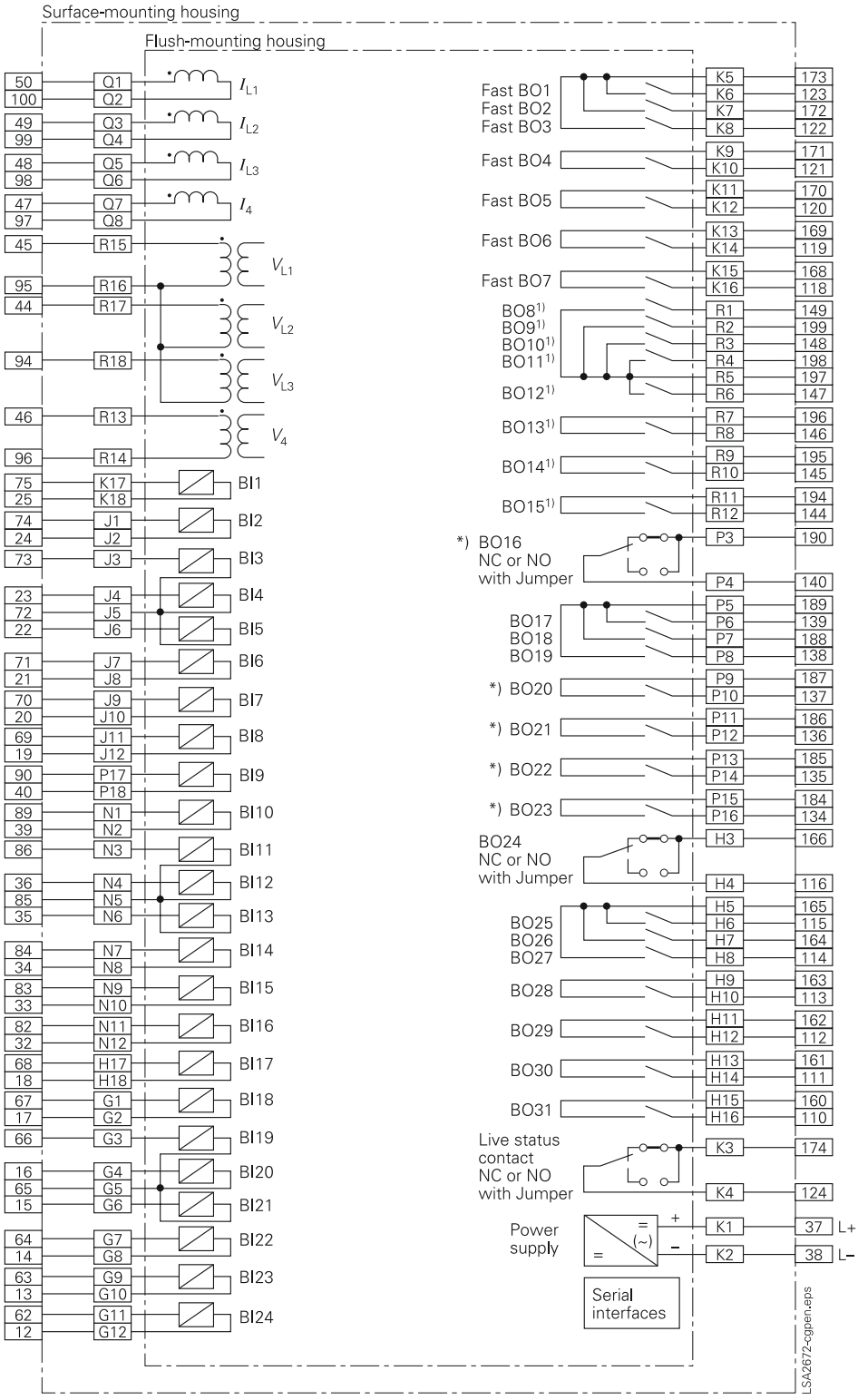


Fig. 7/88 Maximum version in housing 1/1 x 19"

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

1) Configuration of binary outputs until Hardware-version /EE. For advanced flexibility see Fig. 7/89.