Overcurrent Protection

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SIPROTEC easy 7SJ45
Numerical Overcurrent Protection Relay Powered by CTs

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

Description

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

Function overview

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

Protection functions

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

Monitoring functions

- Hardware and software are continuously monitored during operation

Front design

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

Additional features

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

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Application

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

The 7SJ45 relay does not require auxiliary voltage supply. It imports its power supply (1.4 VA at I_N, sum of all phases) from the current transformers.
Impulse output for low-energy trip release or contact output for additional auxiliary transformer are available. An optional integrated trip indication shows that a trip occurred.

ANSI	IEC	Protection functions
50	I>>	Instantaneous overcurrent protection
50, 51	I>t, I_p	Time-overcurrent protection (phase)
50N, 51N	I_E>t, I_{Ep}	Time-overcurrent protection (earth)

Construction

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

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

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

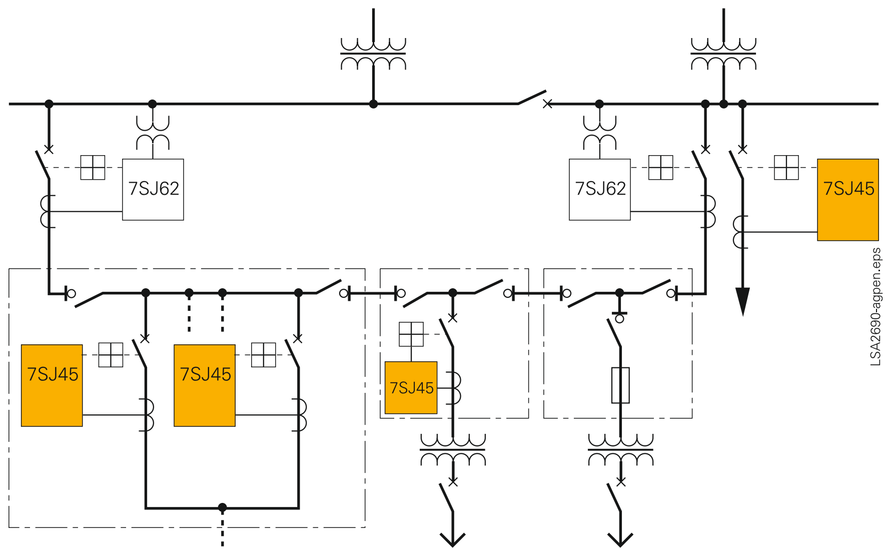

Fig. 5/2 Typical application

Fig. 5/3 Application in distribution switchgear

Fig. 5/4 Screw-type terminals

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Protection functions

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

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

The relay has always a normal stage for phase currents *I*> (50/51). For the second stage, the user can choose between a high-current stage for phase currents *I*>> (50) or a normal stage for calculated earth currents I_E> (50N/51N).

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

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

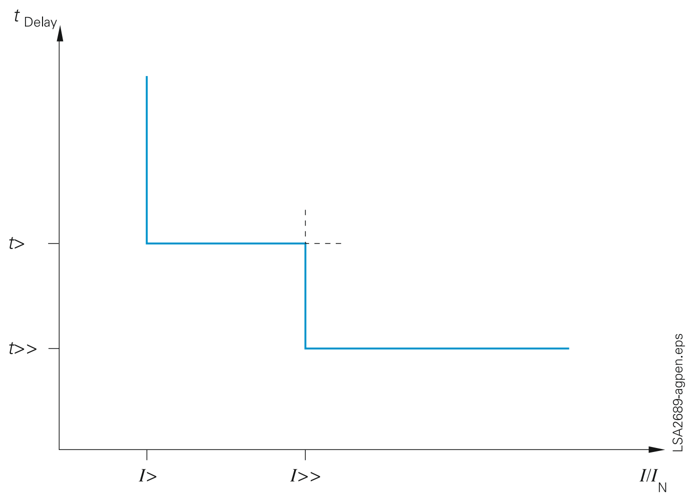

Fig. 5/5 Definite-time overcurrent characteristic

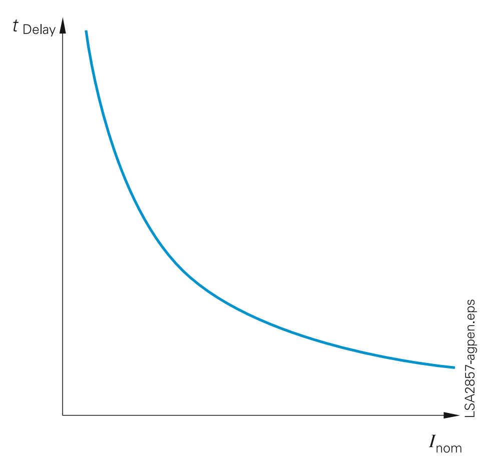

Fig. 5/6 Inverse-time overcurrent characteristic

Available inverse-time characteristics

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

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Connection diagrams

Pulse output or relay output are optionally available.

Pulse output

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

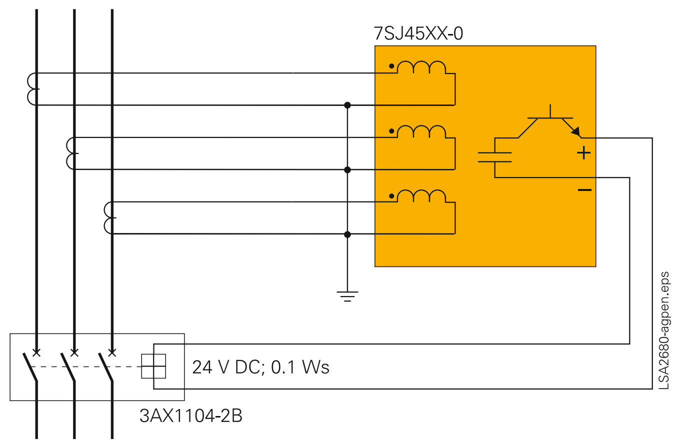

Fig. 5/7 Connection of 3 CTs with pulse output

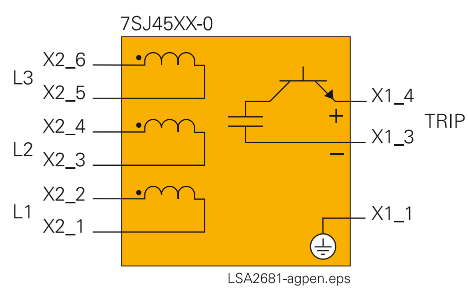

Fig. 5/8 Connection diagram 7SJ45 with impulse output

Relay output

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

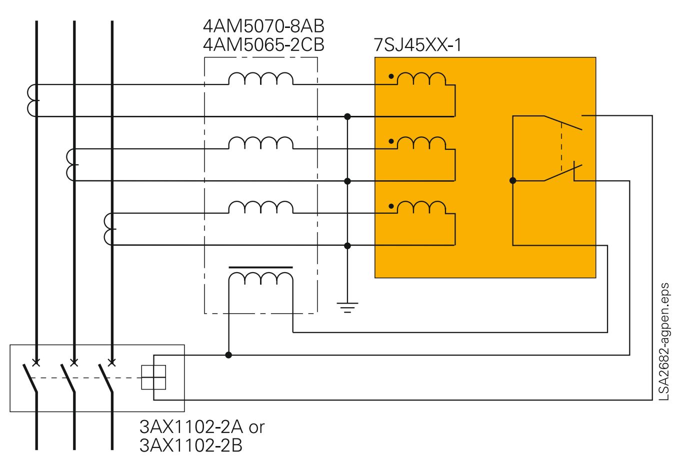

Fig. 5/9 Connection of 3 CTs with trigger transformer and relay output

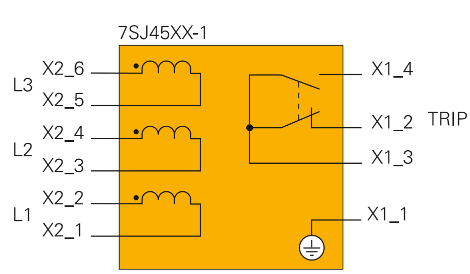

Fig. 5/10 Connection diagram 7SJ45 with relay output

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Technical data

General unit data	
Analog input	
System frequency I_N	50 or 60 Hz (selectable)
Current transformer inputs	
Rated current, normal earth current I_N	1 or 5 A
Power consumption At I_N = 1 / 5 A	 Approx. 1.4 VA at I_N (relay)
Rating of current transformer circuit Thermal (r.m.s.)	 50 · I_N for 1 s 15 · I_N for 10 s 2 · I_N continuous
Dynamic (peak)	100 · I_N for half a cycle
Recommended primary current transformers	10 P 10, 2.5 VA or according to the requirements and required tripping power
Output relays	
Pulse output (7SJ45XX-0*)	
Number	1 pulse output 24 V DC / 0.1 Ws
Relay output (7SJ45XX-1*)	
Number	1 changeover contact
Contact rating	Make 1000 W/VA Break 30 VA 40 W resistive 25 VA at L/R ≤ 50 ms
Rated contact voltage	≤ 250 V DC or ≤ 240 V AC
Permissible current per contact	5 A continuous 30 A for 0.5 s (inrush current)
Unit design	
Housing	Flush mounting DIN 43700/IEC 61554 Adaptable for rail mounting (recommended for local mounting only)
Dimensions (WxHxD) in mm	78.5 x 147 x 205.8 (incl. transparent cover and terminal blocks)
Weight (mass) approx.	1.5 kg
Degree of protection according to IEC 60529	
Housing Front Rear	 IP 51 IP 20
Protection of personnel	IP1X
U_L-listing	
Listed under “69CA”.	

Electrical tests	
Specifications	
Standards	IEC 60255 (product standards) ANSI C37.90.0/.1/.2; UL508 See also standards for individual tests
Insulation tests	
Standards	IEC 60255-5
Voltage test (routine test)	2.5 kV (r.m.s.), 50 Hz, 1 min
All circuits except for pulse output-earth	
Voltage test (type test) across open command contacts	 1.0 kV (r.m.s.), 50 Hz, 1 min
Impulse voltage test (type test) all circuits, class III	5 kV (peak); 1.2/50 µs; 0.5 J; 3 positive and 3 negative impulses in intervals of 1 s

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

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Technical data

Mechanical stress tests

Vibration, shock stress and seismic vibration

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

Climatic stress tests

Temperatures

Temperatures during service	–20 °C to +70 °C / –4 °F to +158 °F With continuous current $2I_N$: –20 °C to +55 °C / –4 °F to +131 °F
Permissible temperature during storage	–25 °C to +55 °C / –13 °F to +131 °F
Permissible temperature during transport	–25 °C to +85 °C / –13 °F to +185 °F

Humidity

Permissible humidity class (standard)	Annual mean value ≤ 75 % relative humidity; on 30 days per year up to 95 % relative humidity; condensation not permissible.
Permissible humidity class (condensation proof)	Condensation is permissible according to IEC 60654-1, class III

Functions

Overcurrent protection

Definite time (DT O/C ANSI 50/51)

Setting range / steps	
Current pickup I>> (phases)	2 I_N to 20 I_N or deactivated, step 0.5 I_N
Current pickup I> (phases) 3-phase supply: see note*	0.5 I_N to 6.2 I_N or deactivated, step 0.1 I_N
Current pickup I_E> 3-phase supply: see note*	0.5 I_N to 6.2 I_N or deactivated, step 0.1 I_N
Delay times T_I>>	0 to 1575 ms, step 25 ms
Delay times T_I>	0 to 6300 ms, step 100 ms
The set time delays are pure delay times.	

Inverse time (IEC or ANSI 51)

Setting range / steps	
Current pickup I_p (phases) 3-phase supply: see note*	0.5 I_N to 4 I_N or deactivated, step 0.1 I_N
Current pickup I_{Ep}> (earth calculated) 3-phase supply: see note*	0.5 I_N to 4 I_N or deactivated, step 0.1 I_N
Delay times T_{Ip} (IEC)	0.05 to 3.15 s, step 0.05 s
Delay times D (ANSI)	0.5 to 15.00 s, step 0.25 s
Trip times	
Total time delay impulse output	Approx. 32 ms
Total time delay relay output	Approx. 38 ms
Reset ratio	Approx. 0.95 (with definite time) Approx. 0.91 (with inverse time)
Tolerances	
Definite time (DT O/C 50/51) Current pickup I>>, I>, I_E>	5 % of the set value or 5 % of I_N (at threshold < I_N)
Delay times T	1 % or 30 ms
Inverse time (IEC or ANSI 51) Pickup thresholds	5 % of the set value or 5 % of I_N (at threshold < I_N)
Time behavior for $2 \leq I/I_p \leq 20$	5 % or 50 ms
Deviation of the measured values as a result of various interferences	
Frequency in the range of $0.95 < f/f_N < 1.05$	< 2.5 %
Frequency in the range of $0.9 < f/f_N < 1.1$	< 10 %
Harmonics up to 10 % 3rd and 5th harmonic	< 1 %
DC components	< 5 %
Temperature in the range of – 5 °C to 70 °C / 23 °F to 158 °F	< 0.5 %/10 K

* Note: The device allows minimum setting values of 0.5 I_N (3-phase). With single supply, operation is ensured from 0.8 I_N (7SJ45XX-0*; pulse output) or 1.3 I_N (7SJ45XX-1*; relay output) onwards (printed on the front).

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Technical data

CE conformity

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

This unit conforms to the international standard IEC 60255.

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

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

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Selection and ordering data

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

Accessories

Protection relay with pulse output	
Low energy trip release	*3AX1104-2B*
Protection relay with relay output	
Auxiliary transformers for the trip circuit (30 VA CTs recommended)	
1 A	*4AM5065-2CB00-0AN2*
5 A	*4AM5070-8AB00-0AN2*
Current transformer-operated trip release	
0.5 A (rated operating current)	*3AX1102-2A*
1 A (rated operating current)	*3AX1102-2B*

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SIPROTEC easy 7SJ46 Numerical Overcurrent Protection Relay

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

Description

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

Function overview

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

Protection functions

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

Monitoring functions

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

Front design

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

Additional features

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

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Application

The SIPROTEC easy 7SJ46 is a numerical overcurrent protection relay which is primarily intended as a radial feeder or transformer protection (backup) in electrical networks.
It provides definite-time and inverse-time overcurrent protection according to IEC and ANSI standards. The convenient setting with DIP switches is self-explanatory and simple.

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

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

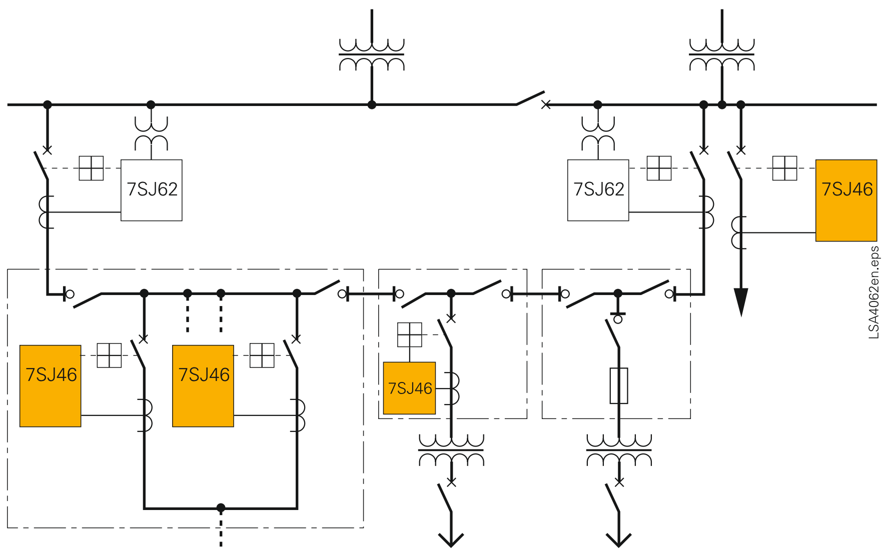

Fig. 5/12 Typical application

Fig. 5/13 Application in distribution switchgear

Construction

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

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

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

Fig. 5/14 Screw-type terminals

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Protection functions

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

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

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

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

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

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

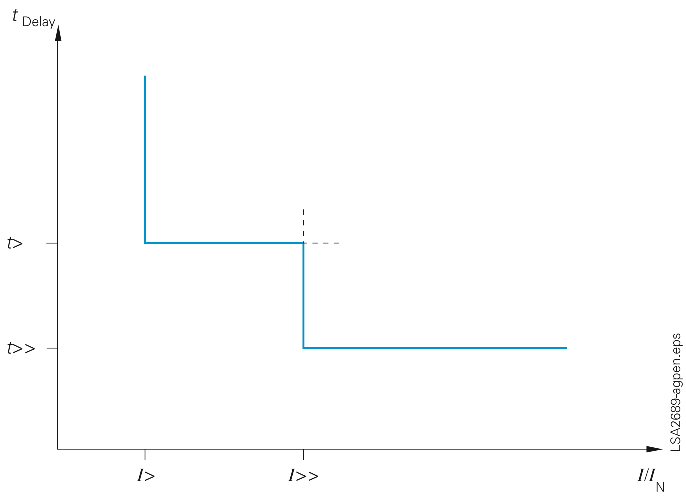

Fig. 5/15 Definite-time overcurrent characteristic

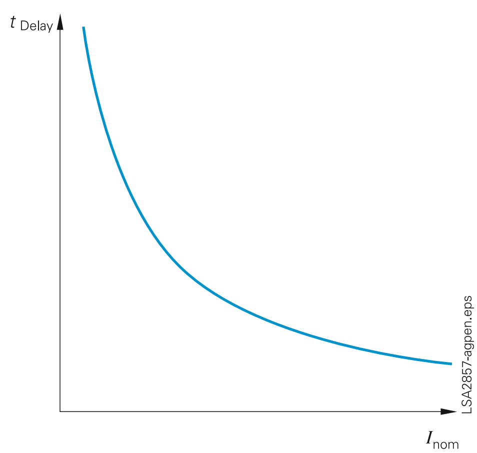

Fig. 5/16 Inverse-time overcurrent characteristic

Available inverse-time characteristics

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

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Connection diagrams

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

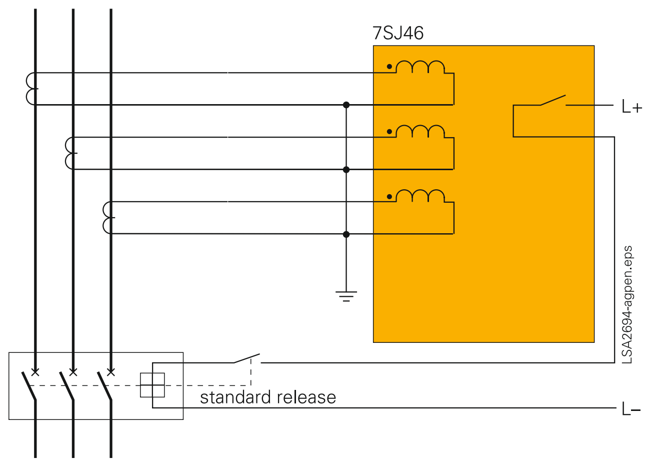

Fig. 5/17 Connection of 3 CTs

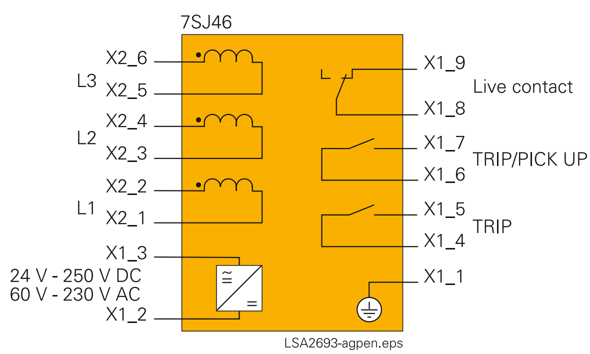

Fig. 5/18 Connection diagram 7SJ46

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Technical data

General unit data	
Analog input	
System frequency f_N	50 or 60 Hz (selectable)
Current transformer inputs	
Rated current, normal earth current I_N	1 or 5 A
Power consumption Per phase at $I_N = 1$ A Per phase at $I_N = 5$ A	 Approx. 0.01 VA at I_N Approx. 0.2 VA at I_N (relay)
Rating of current transformer circuit Thermal (r.m.s.)	 100 · I_N for 1 s 30 · I_N for 10 s 4 · I_N continuous
Dynamic (peak)	250 · I_N for half a cycle
Auxiliary voltage AC/DC powered	
Input voltage range	24 to 250 V DC (± 20 %) 60 to 230 V AC (–20 %, +15 %)
Power consumption	DC – power supply: Approx. 1.5 W AC – power supply: Approx. 3 VA at 110 V approx. 5.5 VA at 230 V
Output relays	
Number	2 (normally open), 1 live contact
Contact rating	Make 1000 W/VA Break 30 VA 40 W resistive 25 VA at L/R ≤ 50 ms
Rated contact voltage	≤ 250 V DC or ≤ 240 V AC
Permissible current per contact	5 A continuous 30 A for 0.5 s (inrush current)
Unit design	
Housing	Flush mounting DIN 43700/IEC 61554 Adaptable for rail mounting recommended for local mounting only
Dimensions (WxHxD) in mm	78.5 x 147 x 205.8 (incl. transparent cover and terminal blocks)
Weight (mass) approx.	1 kg
Degree of protection according to IEC 60529	
Housing Front	 IP 51
Rear	IP 20
Protection of personnel	IP 1X
U_L-listing	
Listed under “69CA”.	

Electrical tests	
Specifications	
Standards	IEC 60255 (product standards) ANSI C37.90.0/.1/.2; UL508 See also standards for individual tests
Insulation tests	
Standards	IEC 60255-5
Voltage test (routine test) all circuits except auxiliary supply	2.5 kV (r.m.s.), 50 Hz; 1 min
Voltage test (routine test) auxiliary supply	3.5 kV DC; 30 s; both polarities
Voltage test (type test) Across open contacts Across open live contact	 1.5 kV (r.m.s.), 50 Hz; 1 min 1.0 kV (r.m.s.), 50 Hz; 1 min
Impulse voltage test (type test) all circuits, class III	5 kV (peak); 1.2/50 µs; 0.5 J; 3 positive and 3 negative impulses in intervals of 1 s
EMC tests for interference immunity; *type tests*	
Standards	IEC 60255-6, IEC 60255-22, EN 50263 (product standards) EN 50082-2 (generic standard) EN 61000-6-2 IEC 61000-4 (generic standards)
High-frequency tests IEC 60255-22-1, class III	2.5 kV (peak); 1 MHz; τ = 15 ms; R_i = 200 Ω; 400 surges/s; duration ≥ 2 s
Electrostatic discharge IEC 60255-22-2, class III EN 61000-4-2, class III	4 kV/6 kV contact discharge; 8 kV air discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with radio-frequency field, amplitude-modulated IEC 60255-22-3 and IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 %; 1 kHz; AM
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 % 30 V/m 1810 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transient interference/bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; duration 1 min
High-energy surge voltage, IEC 61000-4-5 installation class III	Impulse: 1.2/50 µs
Auxiliary voltage	circuit groups to earth: 2 kV; 12 Ω, 9 µF between circuit groups: 1 kV; 2 Ω, 18 µF
Measuring inputs, binary outputs	circuit groups to earth: 2 kV; 42 Ω, 0.5 µF between circuit groups: 1 kV; 42 Ω, 0.5 µF
Line-conducted HF, amplitude-modulated. IEC 60255-22-6 and IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 %; 1 kHz; AM; R_i = 150 Ω
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m continuous; 300 A/m for 5 s; 50 Hz 0.5 mT; 50 Hz
Damped wave IEC 60694, IEC 61000-4-12, class III	2.5 kV (peak, polarity alternating) 100 kHz, 1 MHz, 10 MHz and 50 MHz , R_i = 200 Ω, duration ≥ 2 s
Oscillatory surge withstand capability ANSI/IEEE C37.90.1 not across open contacts	2.5 to 3 kV (peak); 1 to 1.5 MHz damped wave; 50 shots per s; duration ≥ 2 s; R_i = 150 Ω to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1 not across open contacts	4 kV to 5 kV; 10/150 ns; 50 and 120 surges per s; both polarities; duration ≥ 2 s; R_i = 80 Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m 25 MHz to 1000 MHz amplitude and pulse-modulated
EMC tests for interference emission; *type test*	
Standard	EN 50081–* (generic)
Conducted interference voltage, auxiliary voltage IEC CISPR 22, EN 55022, DIN EN VDE 0878 Part 22	150 kHz to 30 MHz, class B
Interference field strength IEC CISPR 22	30 MHz to 1000 MHz, class B

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Technical data

Mechanical stress test

Vibration, shock and seismic vibration

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

Climatic stress tests

Temperatures

Temperatures during service	–20 °C to +70 °C / –4 °F to +158 °F with continuous current 4 I_N: –20 °C to +55 °C / –4 °F to +131 °F
Maximum temperature during storage	–25 °C to +55 °C / –13 °F to +131 °F
Maximum temperature during transport	–25 °C to +85 °C / –13 °F to +185 °F

Humidity

Permissible humidity class (standard)	Annual mean value ≤ 75 % relative humidity; on 30 days per year up to 95 % relative humidity; condensation not permissible.
Permissible humidity class (condensation proof)	Condensation is permissible according to IEC 60654-1, class III

Functions

Overcurrent protection

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

CE conformity

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

This unit conforms to the international standard IEC 60255.

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

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

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Selection and ordering data

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

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SIPROTEC 7SJ600
Numerical Overcurrent, Motor and Overload Protection Relay

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

Function overview

Feedder protection

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

Motor protection

- Starting time supervision
- Locked rotor

Control functions

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

Measuring functions

- Operational measured values *I*

Monitoring functions

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

Communication

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

Hardware

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

Description

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

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

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Application

Wide range of applications

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

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

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

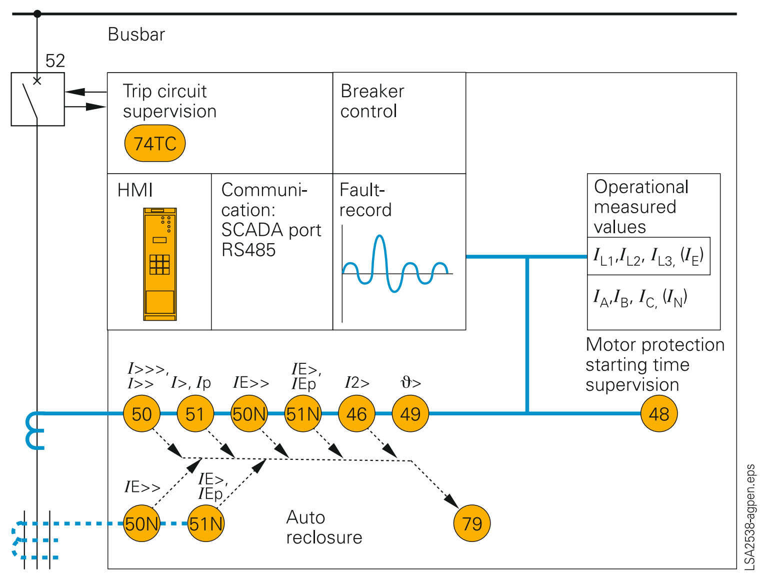

Fig. 5/20 Function diagram

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

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Construction

The relay contains all the components needed for

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

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

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

Fig. 5/21
Rear view of flush-mounting housing

Protection functions

Definite-time characteristics

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

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

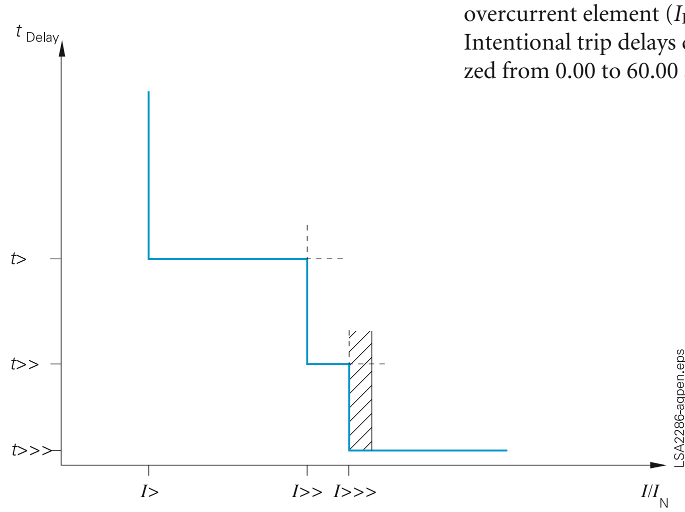

Fig. 5/22 Definite-time overcurrent characteristic

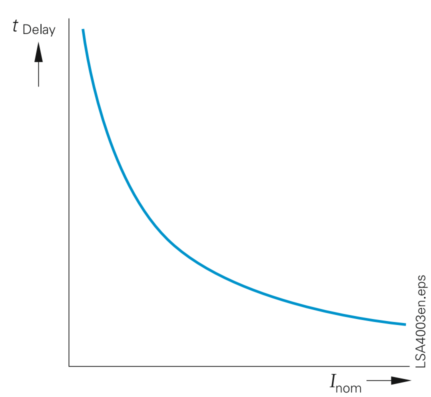

Fig. 5/23 Inverse-time overcurrent characteristic

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

Inverse-time characteristics

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

Available inverse-time characteristic

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

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Protection functions

Thermal overload protection (ANSI 49)

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

Thermal overload protection without preload

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

$I \geq 1.1 \cdot I_L$

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

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

I = Load current

I_2 = Pickup current

T_L = Time multiplier

The reset threshold is above $1.03125 \cdot I/I_N$

Thermal overload protection with preload

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

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

t = Tripping time after beginning of the thermal overload

τ = $35.5 \cdot T_L$

I_{pre} = Pre-load current

T_L = Time multiplier

I = Load current

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

ln = Natural logarithm

I_N = Rated (nominal) current

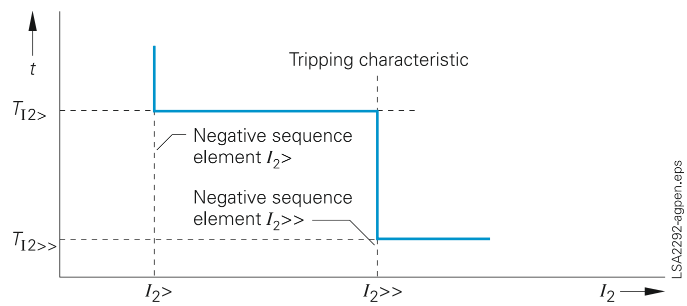

Fig. 5/24 Tripping characteristic of the negative-sequence protection function

Negative-sequence protection (I_2>>, I_2>/ANSI 46 Unbalanced-load protection)

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

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

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

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

I_2 = Negative-sequence current
T_{12} = Tripping time

Transformer protection

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

Cold load pickup

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

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

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

Trip circuit supervision (ANSI 74TC)

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

Control

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

For further details please refer to part 2 “Overview”.

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Protection functions

Switch-onto-fault protection

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

Busbar protection (Reverse interlocking)

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

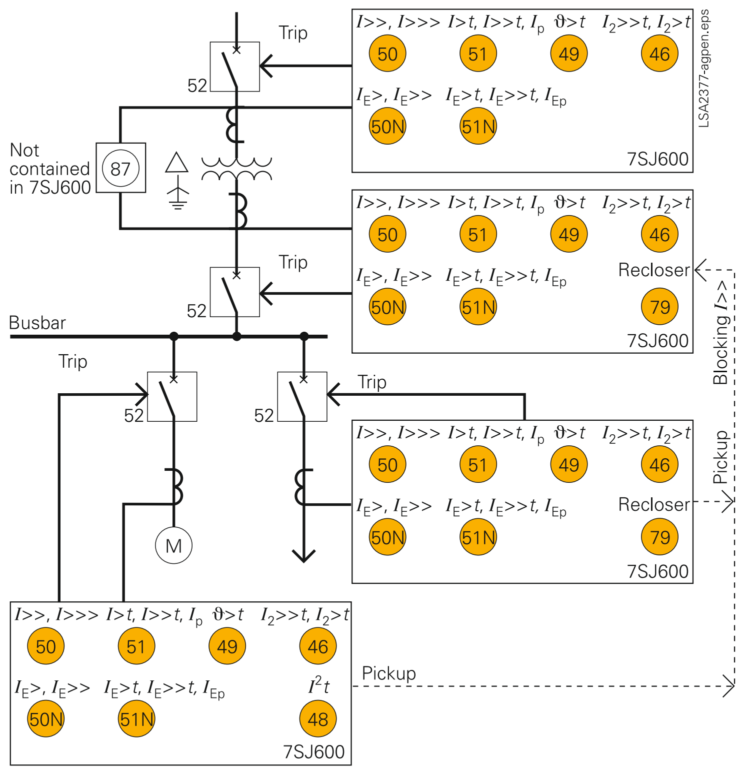

Fig. 5/25 Reverse interlocking

Motor protection

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

Motor starting time supervision (ANSI 48)

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

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

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

approx. 0.94

t_{TRIP} = Tripping time

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

$t_{start\ max}$ = Maximum permissible starting time

I_{rms} = Actual current flowing

Features

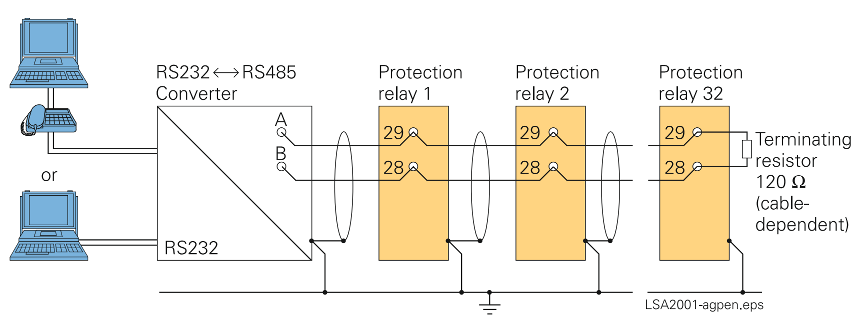

Fig. 5/26 Wiring communication
For convenient wiring of the RS485 bus, use bus cable system 7XV5103 (see part 15 of this catalog).

Serial data transmission

A PC can be connected to ease setup of the relay using the Windows-based program DIGSI which runs under MS-Windows. It can also be used to evaluate up to 8 oscillographic fault records, 8 fault logs and 1 event log containing up to 30 operational indications. The SIPROTEC 7SJ600 transmits a subset of data via IEC 60870-5-103 protocol:

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

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Connection diagrams

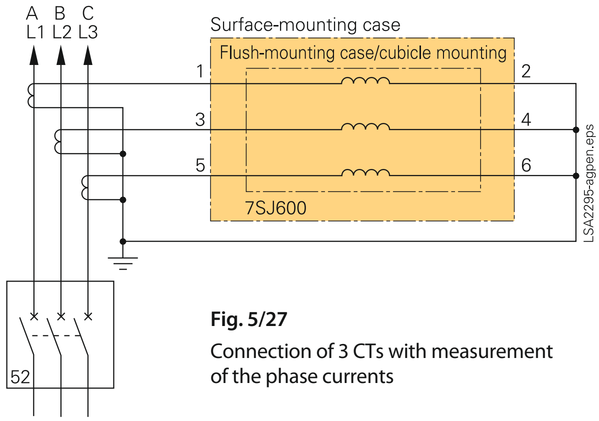

Fig. 5/27
Connection of 3 CTs with measurement of the phase currents

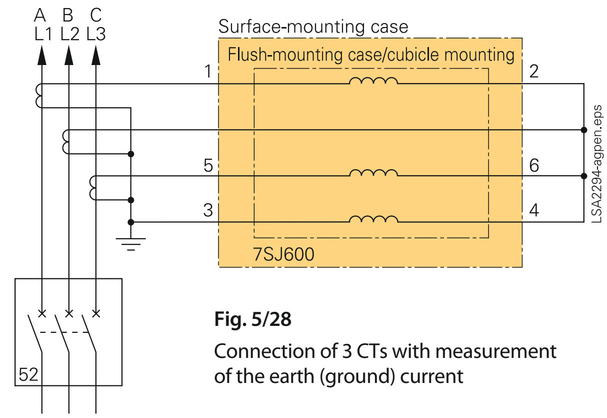

Fig. 5/28
Connection of 3 CTs with measurement of the earth (ground) current

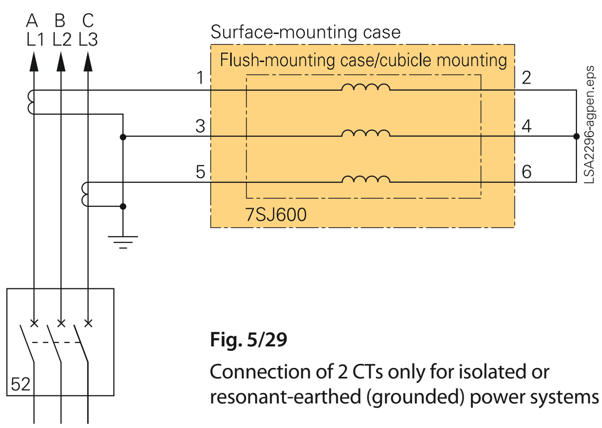

Fig. 5/29
Connection of 2 CTs only for isolated or resonant-earthed (grounded) power systems

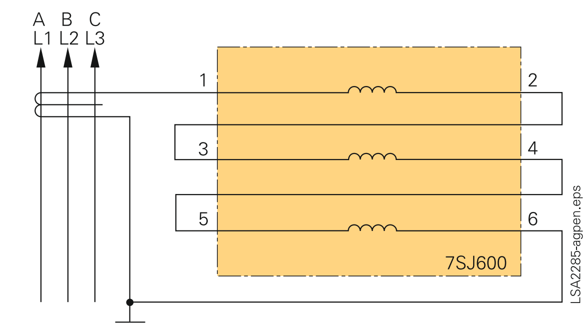

Fig. 5/30
Sensitive earth-fault protection (3 -times increased sensitivity)

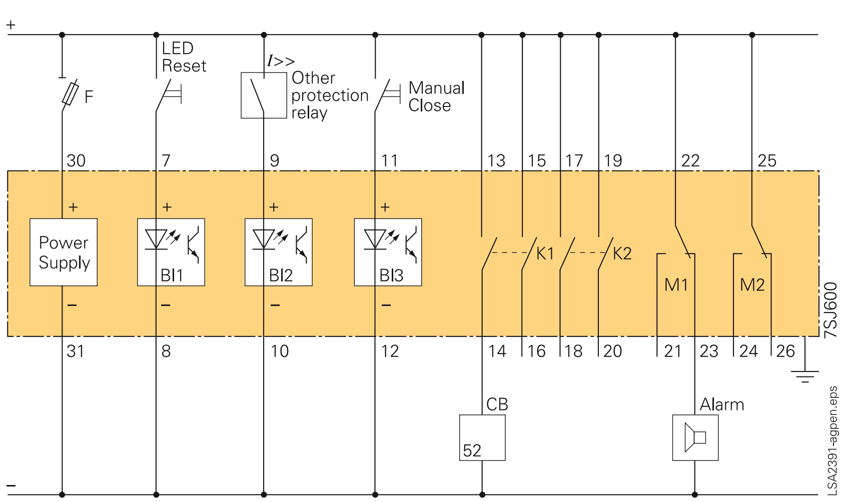

Fig. 5/31 Example of typical wiring

Technical data

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

Heavy-duty (command) contacts	
Trip relays, number	2 (marshallable)
Contacts per relay	2 NO
Switching capacity Make Break	 1000 W / VA 30 W / VA
Switching voltage	250 V
Permissible current Continuous For 0.5 s	 5 A 30 A
Design	
Housing 7XP20	Refer to part 15 for dimension drawings
Weight Flush mounting /cubicle mounting Surface mounting	 Approx. 4 kg Approx. 4.5 kg
Degree of protection acc. to EN 60529 Housing Terminals	 IP51 IP21

Serial interface	
Interface, serial; isolated	
Standard	RS485
Test voltage	2.8 kV DC for 1 min
Connection	Data cable at housing terminals, two data wires, one frame reference, for connection of a personal computer or similar; core pairs with individual and common screening, screen must be earthed (grounded), communication possible via modem
Transmission speed	As delivered 9600 baud min. 1200 baud, max. 19200 baud

Electrical tests	
Specifications	
Standards	IEC 60255-5; ANSI/IEEE C37.90.0
Insulation test	
Standards	IEC 60255-5, ANSI/IEEE C37.90.0
High-voltage test (routine test) Except DC voltage supply input and RS485 Only DC voltage supply input and RS485	 2 kV (r.m.s.), 50 Hz 2.8 kV DC
High-voltage test (type test) Between open contacts of trip relays Between open contacts of alarm relays	 1.5 kV (r.m.s.), 50 Hz 1 kV (r.m.s.), 50 Hz
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

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Technical data

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

Mechanical stress tests	
Vibration, shock and seismic vibration	
During operation	
Standards	Acc. to IEC 60255-2-1 and IEC 60068-2
Vibration IEC 60255-21-1, class1 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.035 mm amplitude, 60 to 150 Hz: 0.5 *g* acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1	Half-sine, acceleration 5 *g*, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
Seismic vibration IEC 60255-21-3, class 1, IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Sweep rate 1 octave/min 1 cycle in 3 orthogonal axes
During transport	
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 *g* acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sine, acceleration 15 *g*, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Half-sine, acceleration 10 *g* duration 16 ms, 1000 shocks in each direction of 3 orthogonal axes

Climatic stress tests	
Temperatures	
Recommended temperature during operation	–5 °C to +55 °C / +23 °F to +131 °F > 55 °C decreased display contrast
Permissible temperature during operation during storage during transport (Storage and transport with standard works packaging)	–20 °C to +70 °C / –4 °F to +158 °F –25 °C to +55 °C / –13 °F to +131 °F –25 °C to +70 °C / –13 °F to +158 °F
Humidity	
	Mean value per year ≤ 75 % relative humidity, on 30 days per year 95 % relative humidity, condensation not permissible

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Technical data

Functions

Definite-time overcurrent protection (ANSI 50, 50N)

Setting range/steps	
Overcurrent pickup phase $I>$	I/I_N = 0.1 to 25 (steps 0.1), or ∞
earth $I_E>$	= 0.05 to 25 (steps 0.01), or ∞
phase $I>>$	I/I_N = 0.1 to 25 (steps 0.1), or ∞
earth $I_E>>$	= 0.05 to 25 (steps 0.01), or ∞
phase $I>>>$	I/I_N = 0.3 to 12.5 (steps 0.1), or ∞
Delay times T for $I>$, $I_E>$, $I>>$ and $I_E>>$	0 s to 60 s (steps 0.01 s)
The set times are pure delay times	
Pickup times $I>$, $I>>$, $I_E>$, $I_E>>$	
At 2 x setting value, without meas. repetition	Approx. 35 ms
At 2 x setting value, with meas. repetition	Approx. 50 ms
Pickup times for $I>>>$ at 2 x setting value	Approx. 20 ms
Reset times $I>$, $I>>$, $I_E>$, $I_E>$	Approx. 35 ms
$I>>>$	Approx. 65 ms
Reset ratios	Approx. 0.95
Overshot time	Approx. 25 ms
Tolerances	
Pickup values $I>$, $I>>$, $I>>>$, $I_E>$, $I_E>>$	5 % of setting value
Delay times T	1 % of setting value or 10 ms
Influencing variables	
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range: $0\,°C \leq \Theta_{amb} \leq 40\,°C$	≤ 0.5 %/10 K
Frequency, range: $0.98 \leq f/f_N \leq 1.02$	≤ 1.5 %
Frequency, range: $0.95 \leq f/f_N \leq 1.05$	≤ 2.5 %
Harmonics	
Up to 10 % of 3rd harmonic	≤ 1 %
Up to 10 % of 5th harmonic	≤ 1 %

Inverse-time overcurrent protection (ANSI 51/51N)

Setting range/steps	
Overcurrent pickup phase I_p	I/I_N = 0.1 to 4 (steps 0.1)
earth I_{Ep}	= 0.05 to 4 (steps 0.01)
Time multiplier for I_p, I_{Ep} T_p	(IEC charac.) 0.05 to 3.2 s (steps 0.01 s)
	(ANSI charac.) 0.5 to 15 s (steps 0.1 s)
Overcurrent pickup phase $I>>$	I/I_N = 0.1 to 25 (steps 0.1), or ∞
phase $I>>>$	= 0.3 to 12.5 (steps 0.1), or ∞
earth $I_E>>$	= 0.05 to 25 (steps 0.01), or ∞
Delay time T for $I>>$, $I_E>>$	0 s to 60 s (steps 0.01 s)
Tripping time characteristics acc. to IEC	
Pickup threshold	Approx. 1.1 x I_p
Drop-out threshold	Approx. 1.03 x I_p
Drop-out time	Approx. 35 ms
Tripping time characteristics acc. to ANSI / IEEE	
Pickup threshold	Approx. 1.06 x I_p
Drop-out threshold, alternatively: disk emulation	Approx. 1.03 x I_p

Tolerances	
Pickup values	5 %
Delay time for $2 \leq I/I_p \leq 20$ and $0.5 \leq I/I_N \leq 24$	5 % of theoretical value ± 2 % current tolerance, at least 30 ms
Influencing variables	
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range: $-5\,°C \leq \Theta_{amb} \leq 40\,°C$ $+23\,°F \leq \Theta_{amb} \leq 104\,°F$	≤ 0.5 %/10 K
Frequency, range: $0.95 \leq f/f_N \leq 1.05$	≤ 8 % referred to theoretical time value

Negative-sequence overcurrent protection (ANSI 46)

Setting range/steps			
Tripping stage $I_2>$ in steps of 1 %	8 % to 80 % of I_N		
$I_2>>$ in steps of 1 %	8 % to 80 % of I_N		
Time delays $T(I_2>)$, $T(I_2>>)$ in steps of 0.01s	0.00 s to 60.00 s		
Lower function limit	At least one phase current ≥ 0.1 x I_N		
Pickup times	At f_N =	50 Hz	60 Hz
Tripping stage $I_2>$, tripping stage $I_2>>$	Approx.	60 ms	75 ms
But with currents I/I_N>1.5 (overcurrent case) or negative-sequence current < (set value +0.1 x I_N)	Approx.	200 ms	310 ms
Reset times	At f_N =	50 Hz	60 Hz
Tripping stage $I_2>$, tripping stage $I_2>>$	Approx.	35 ms	42 ms
Reset ratios			
Tripping stage $I_2>$, tripping stage $I_2>>$	Approx. 0.95 to 0.01 x I_N		
Tolerances			
Pickup values $I_2>$, $I_2>>$			
with current $I/I_N \leq 1.5$	± 1 % of I_N ± 5 % of set value		
with current $I/I_N > 1.5$	± 5 % of I_N ± 5 % of set value		
Stage delay times	± 1 % or 10 ms		
Influence variables			
Auxiliary DC voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %		
Temperature, range: $-5\,°C \leq \Theta_{amb} \leq +40\,°C$ $+23\,°F \leq \Theta_{amb} \leq +104\,°F$	≤ 0.5 %/10 K		
Frequency,			
range: $0.98 \leq f/f_N \leq 1.02$	≤ 2 % of I_N		
range: $0.95 \leq f/f_N \leq 1.05$	≤ 5 % of I_N		

Auto-reclosure (option) (ANSI 79)

Number of possible shots	1 up to 9
Auto-reclose modes	3-pole
Dead times for 1st to 3rd shot	0.05 s to 1800 s (steps 0.01 s)
for 4th and any further shot	0.05 s to 1800 s (steps 0.01 s)
Reclaim time after successful AR	0.05 s to 320 s (steps 0.01 s)
Lock-out time after unsuccessful AR	0.05 s to 320 s (steps 0.01 s)
Reclaim time after manual close	0.50 s to 320 s (steps 0.01 s)
Duration of RECLOSE command	0.01s to 60 s (steps 0.01 s)
Control	
Number of devices	1
Evaluation of breaker control	None

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Thermal overload protection with memory *(ANSI 49)* *(total memory according to IEC 60255-8)*	
Setting ranges	
Factor k acc. to IEC 60255-8	0.40 to 2 (steps 0.01)
Thermal time constant τ_{th}	1 to 999.9 min (steps 0.1 min)
Thermal alarm stage $\Theta_{alarm}/\Theta_{trip}$	50 to 99 % referred to trip temperature rise (steps 1 %)
Prolongation factor at motor stand-still k_τ	1 to 10 (steps 0.01)
Reset ratios	
Θ/Θ_{trip}	Reset below Θ_{alarm}
Θ/Θ_{alarm}	Approx. 0.99
Tolerances	
Referring to k · I_N	± 5 % (class 5 % acc. to IEC 60255-8)
Referring to trip time	± 5 % ± 2 s (class 5 % acc. to IEC 60255-8)
Influence variables referred to k · I_N	
Auxiliary DC voltage in the range of $0.8 \le V_{aux} / V_{auxN} \le 1.2$	≤ 1 %
Temperature, range: $-5\ °C \le \Theta_{amb} \le +40\ °C$ $+23\ °F \le \Theta_{amb} \le +104\ °F$	≤ 0.5 % / 10 K
Frequency, range: $0.95 \le f/f_N \le 1.05$	≤ 1 %
Without pickup value I_L / I_N	0.4 to 4 (steps 0.1)
Memory time multiplier T_L (= t_6 -time)	1 to 120 s (steps 0,1 s)
Reset ratio I/I_L	Approx. 0.94
Tolerances	
Referring to pickup threshold $1.1 \cdot I_L$	± 5 %
Referring to trip time	± 5 % ± 2 s
Influence variables	
Auxiliary DC voltage in the range of $0.8 \le V_{aux} / V_{auxN} \le 1.2$	≤ 1 %
Temperature, range: $-5\ °C \le \Theta_{amb} \le +40\ °C$ $+23\ °F \le \Theta_{amb} \le +104\ °F$	≤ 0.5 %/10 K
Frequency, range: $0.95 \le f/f_N \le 1.05$	≤ 1 %

Starting time supervision (motor protection)	
Setting ranges	
Permissible starting current I_{Start}/I_N	0.4 to 20 (steps 0.1)
Permissible starting time t_{Start}	1 to 360 s (steps 0.1 s)
Tripping characteristic	$t = \left(\frac{I_{Start}}{I_{rms}}\right)^2 \cdot t$ for $I_{rms} > I_{Start}$
Reset ratio I_{rms} / I_{Start}	Approx. 0.94
Tolerances	
Pickup value	5 %
Delay time	5 % of setting value or 330 ms

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

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

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 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).

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".

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Selection and ordering data

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

Accessories

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


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Mounting rail

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

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Connection diagram

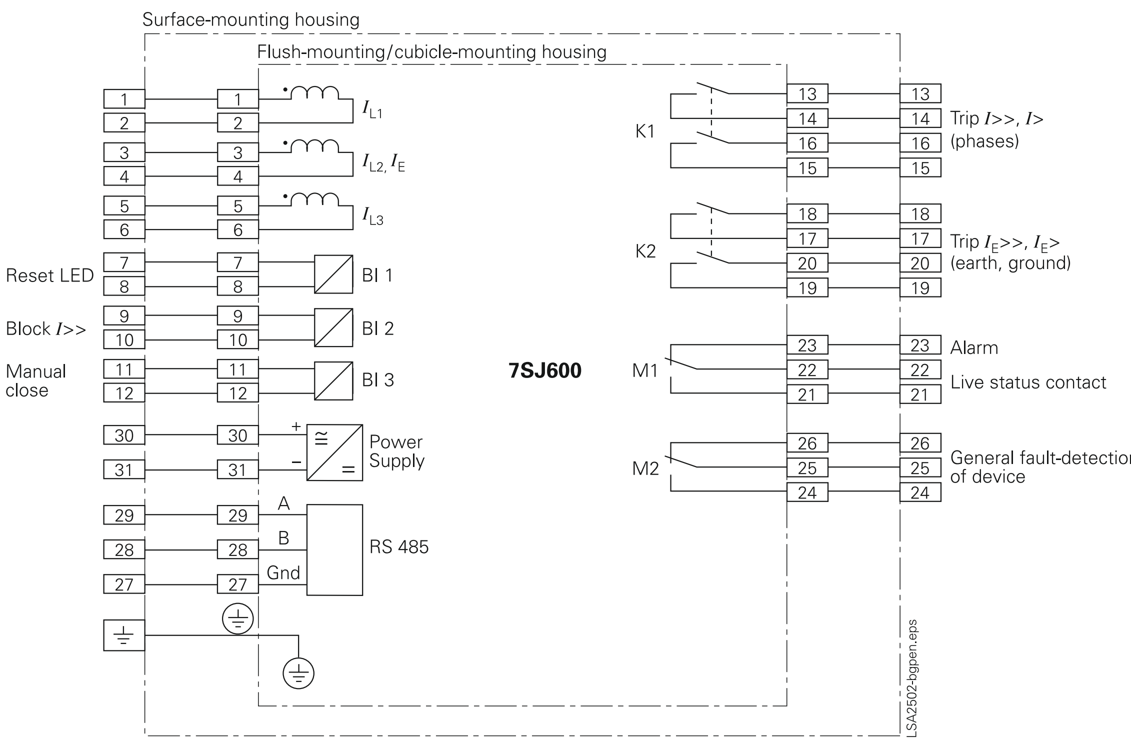

Fig. 5/32
Connection diagram according to IEC standard

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SIPROTEC 7SJ602
Multifunction Overcurrent and Motor Protection Relay

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Fig. 5/33 SIPROTEC 7SJ602 multifunction protection relay

Description

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

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

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

Function overview

Feeder protection

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

Motor protection

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

Control functions

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

Measuring functions

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

Monitoring functions

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

Communication interfaces

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

Hardware

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

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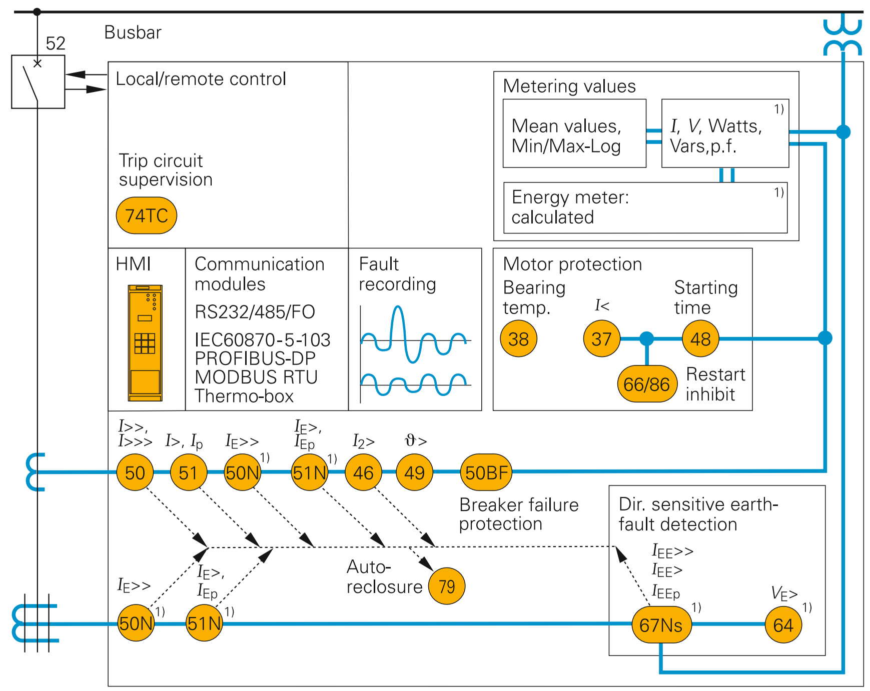
Application

Wide range of applications

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

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

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



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

Fig. 5/34 Function diagram

ANSI No.	IEC	Protection functions
50, 50N	$I>$, $I>>$, $I>>>$ $I_E>$, $I_E>>$	Definite-time overcurrent protection (phase/neutral)
51, 51N	I_p, I_{Ep}	Inverse-time overcurrent protection (phase/neutral)
67Ns/50Ns	$I_{EE}>$, $I_{EE}>>$, I_{EEp}	Directional/non-directional sensitive earth-fault detection
64	$V_E>$	Displacement voltage
50BF		Breaker failure protection
79		Auto-reclosure
46	$I_2>$	Phase-balance current protection (negative-sequence protection)
49	$\vartheta>$	Thermal overload protection
48		Starting time supervision
66/86		Restart inhibit
37	$I<$	Undercurrent monitoring
38		Temperature monitoring via external device, e.g. bearing temperature monitoring
74TC		Trip circuit supervision breaker control

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Construction

The relay contains all the components needed for

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

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

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

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

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

Protection functions

Definite-time characteristics

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

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

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

Inverse-time characteristics

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

Reset characteristics

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

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

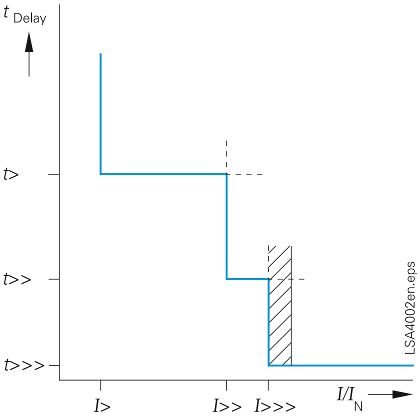

Fig. 5/37
Definite-time overcurrent characteristic

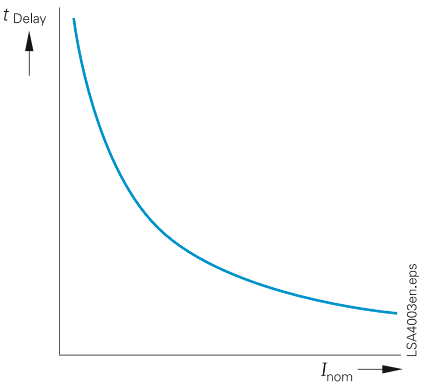

Fig. 5/38
Inverse-time overcurrent characteristic

Available inverse-time characteristics

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

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Protection functions

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

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

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

It has the following functions:

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

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

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

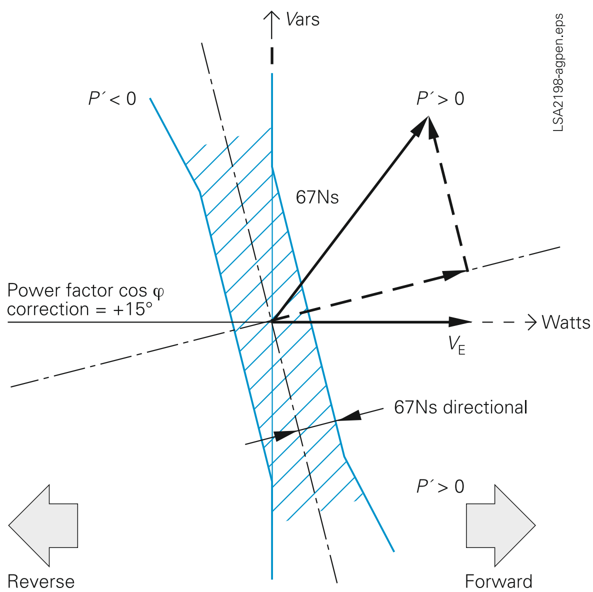

Fig. 5/39 Directional determination using cosine measurements

Thermal overload protection (ANSI 49)

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

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

Thermal overload protection without preload:

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

$I \geq 1.1 \cdot I_L$

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

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

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

The reset threshold is above $1.03125 \cdot I/I_N$

Thermal overload protection with preload

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

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

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

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Protection functions

Breaker failure protection (ANSI 50BF)

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

Negative-sequence protection (I_2>>, I_2>/ANSI 46 Unbalanced-load protection)

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

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

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

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

I_2 = negative-sequence current
T_{12} = tripping time

Transformer protection

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

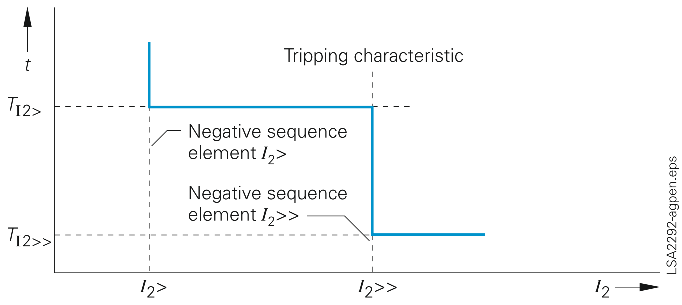

Fig. 5/40 Tripping characteristics of the negative-sequence protection function

Cold load pickup

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

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

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

Trip circuit supervision (ANSI 74TC)

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

Control

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

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Protection functions

Switch-onto-fault protection

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

Busbar protection (Reverse interlocking)

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

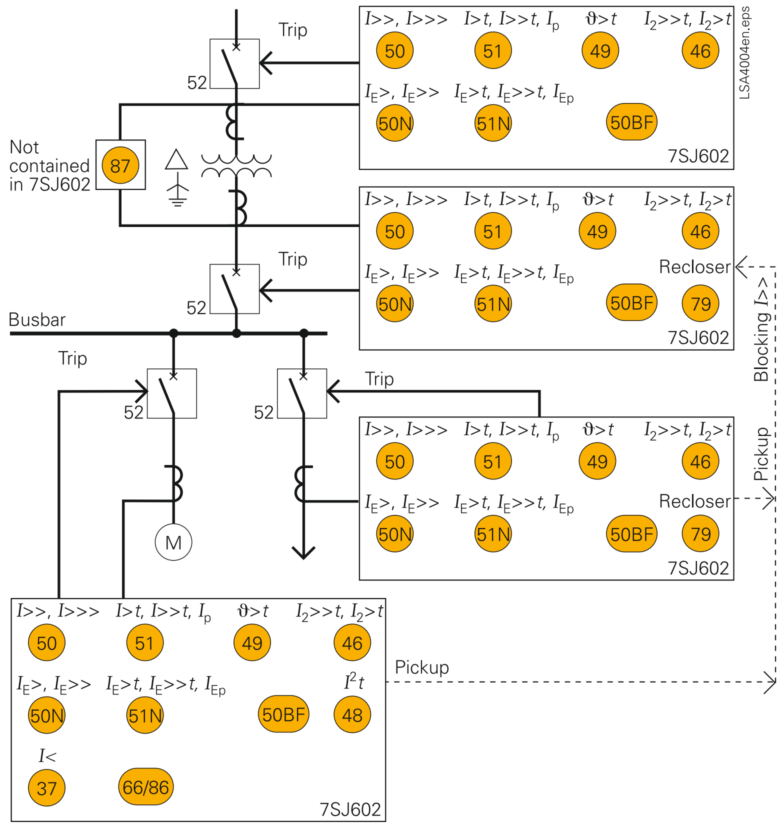

Fig. 5/41 Reserve interlocking

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Motor protection

Starting time supervision (ANSI 48)

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

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

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

t_{TRIP} = tripping time

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

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

I_{rms} = actual current flowing

Restart inhibit (ANSI 66/86)

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

Undercurrent monitoring (ANSI 37)

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

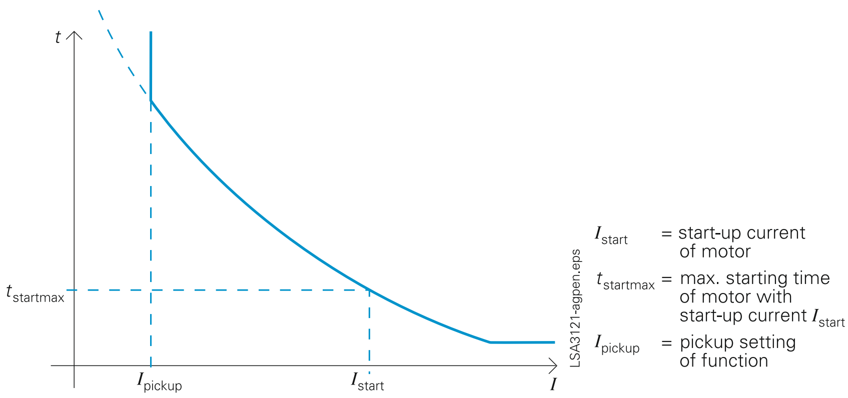

Fig. 5/42 Starting time supervision

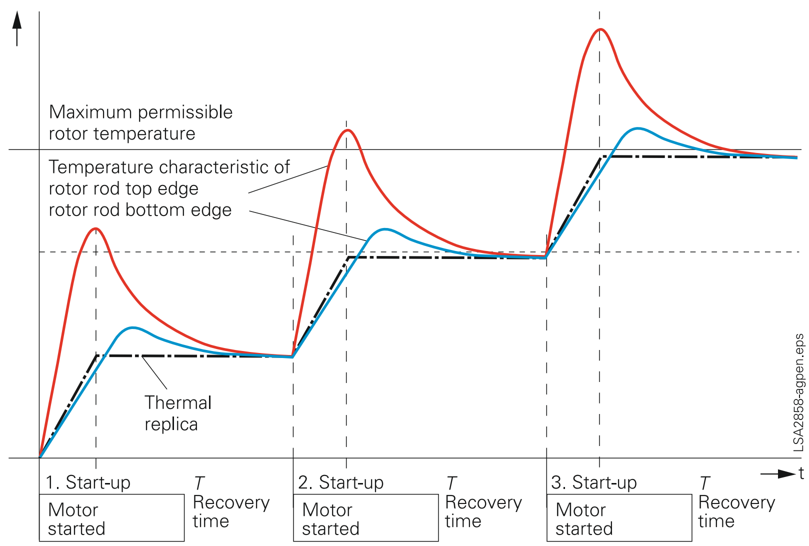

Fig. 5/43 Restart inhibit

Temperature monitoring (ANSI 38)

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

Additional functions

Measured values

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

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

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Communication

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

Local PC interface

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

System interface on bottom of the unit

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

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

IEC 60870-5-103 protocol

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

PROFIBUS-DP

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

MODBUS RTU

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

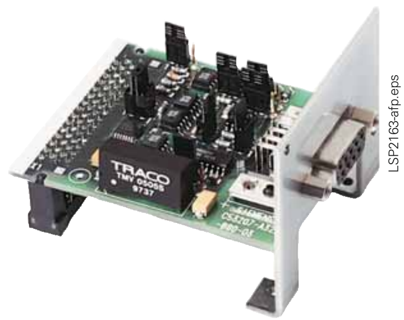

Fig. 5/44
RS232/RS485 electrical communication module

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

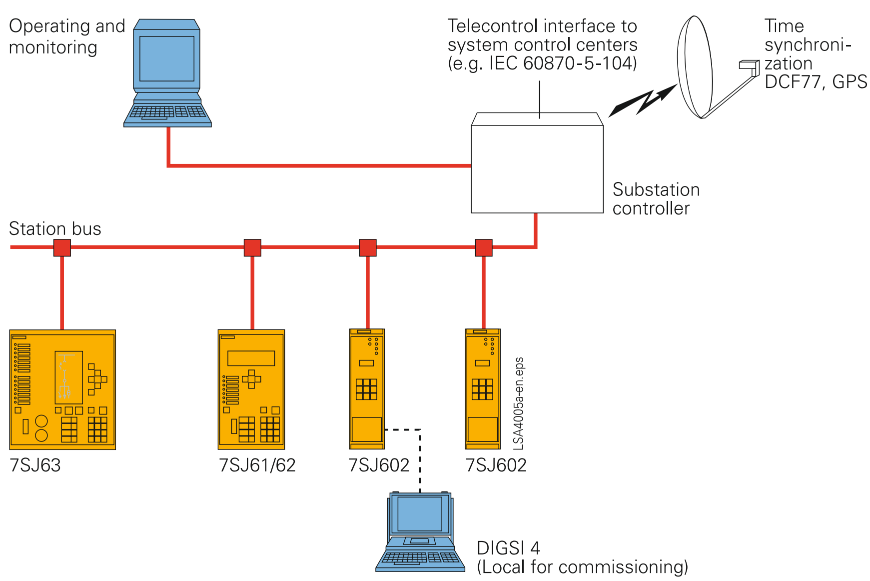

Fig. 5/46 System solution/communication

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Typical connections

CT connections

Fig. 5/47 Standard
- Phase current measured
- Earth current measured (e. g. core balance CT)

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

Fig. 5/49
- Isolated networks only

7SJ6021/7SJ6025

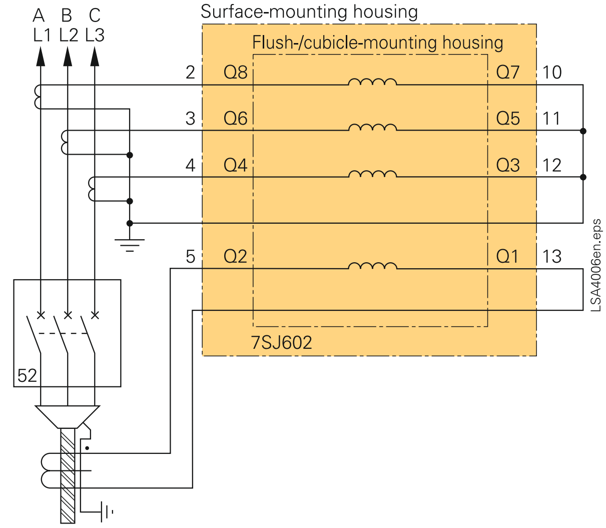

Fig. 5/47
Connection of 4 CTs with measurement of the earth (ground) current

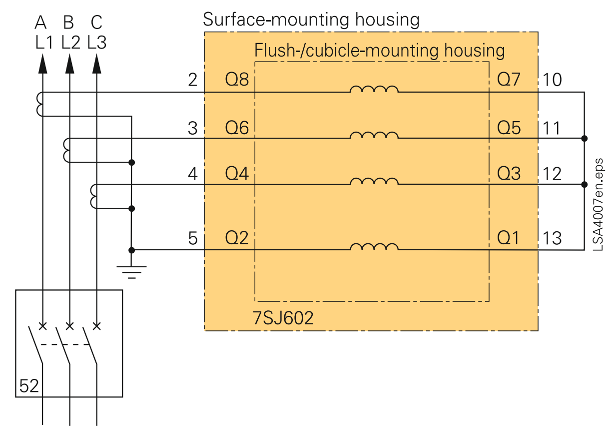

Fig. 5/48
Connection of 3 CTs with residual connection for neutral fault

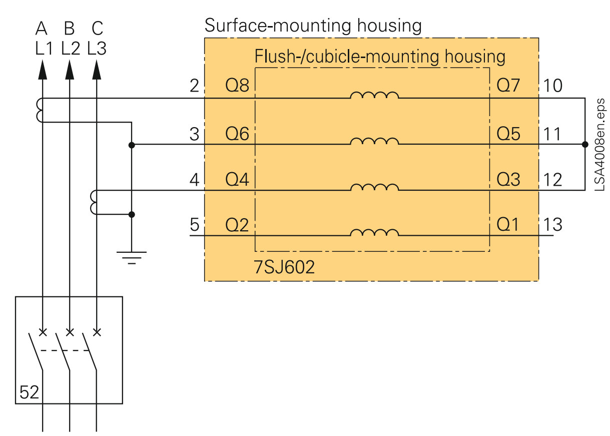

Fig. 5/49
Connection of 2 CTs only for isolated or resonant-earthed (grounded) power systems

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Typical connections

7SJ6022/7SJ6026

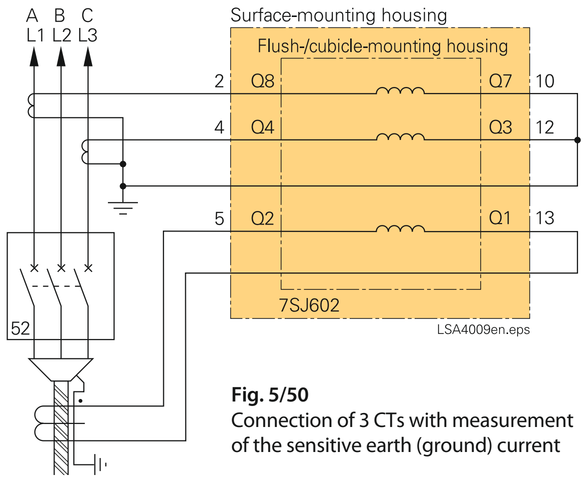

Fig. 5/50
Connection of 3 CTs with measurement of the sensitive earth (ground) current

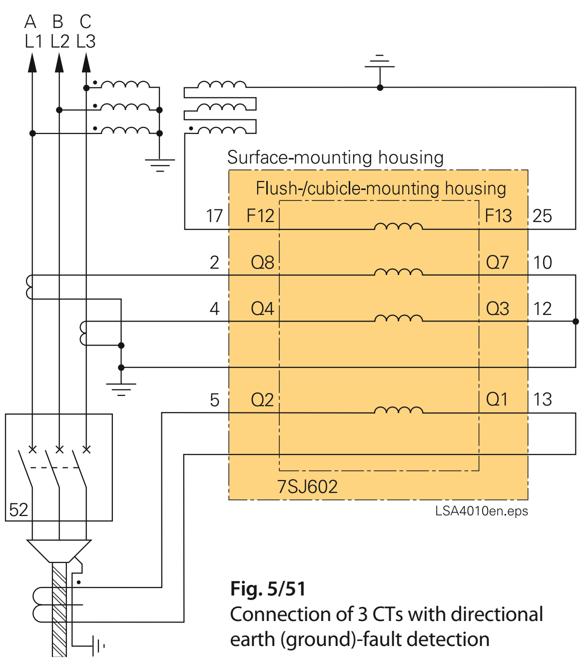

Fig. 5/51
Connection of 3 CTs with directional earth (ground)-fault detection

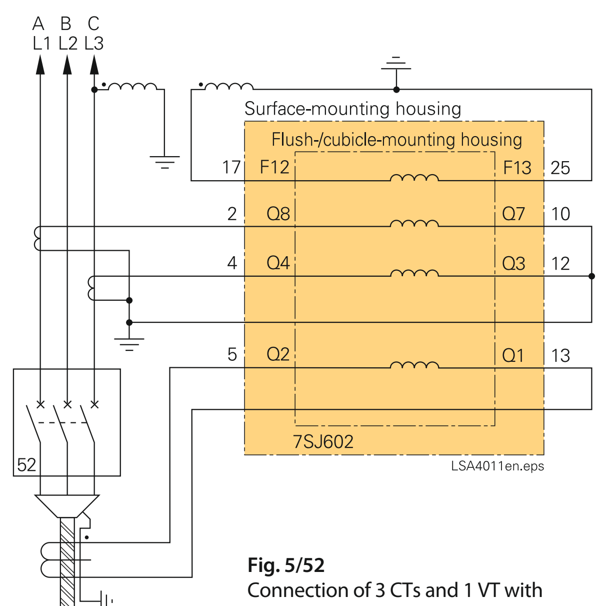

Fig. 5/52
Connection of 3 CTs and 1 VT with measurement of the earth (ground) current and one phase voltage

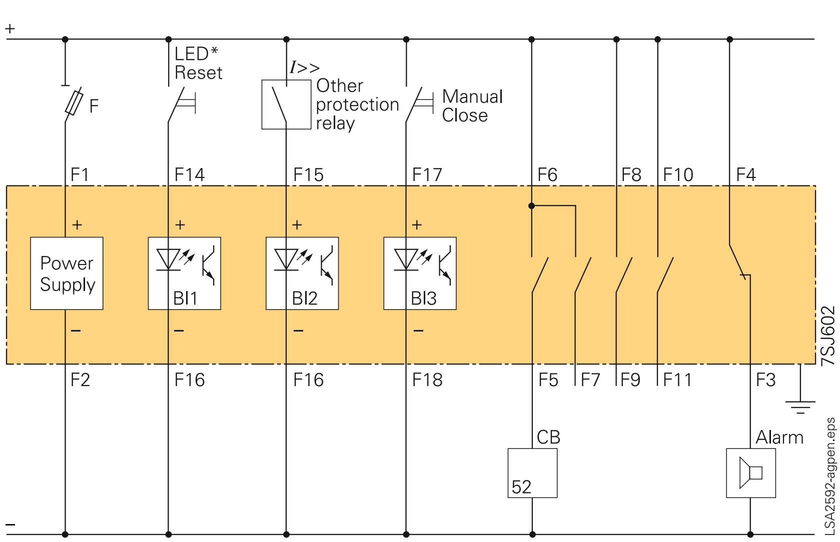

Fig. 5/53 Example of typical wiring

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Technical data

General unit data	
CT circuits	
Rated current I_N	1 or 5 A (settable)
Option: sensitive earth-fault CT	I_{EE} < 1.6 A or < 8 A (settable)
Rated frequency f_N	50/60 Hz (selectable)
Power consumption Current input at I_N = 1 A at I_N = 5 A For sensitive earth-fault detection at 1 A	 < 0.1 VA < 0.3 VA Approx. 0.05 VA
Overload capability Thermal (r.m.s) Dynamic (pulse current)	 100 x I_N for 1 s 30 x I_N for 10 s 4 x I_N continuous 250 x I_N one half cycle
Overload capability if equipped with sensitive earth-fault current transformer Thermal (r.m.s.) Dynamic (impulse current)	 300 A for 1 s 100 A for 10 s 15 A continuous 750 A (half cycle)
Voltage transformer	
Rated voltage V_N	100 to 125 V
Power consumption at V_N = 100 V	< 0.3 VA per phase
Overload capability in voltage path (phase-neutral voltage) Thermal (r.m.s.)	 230 V continuous
Power supply	
Power supply via integrated DC/DC converter	
Rated auxiliary voltage V_{aux} / permissible variations	24/48 V DC/± 20 % 60/110 V DC/± 20 % 110/125/220/250 V DC/± 20 % 115 V AC/- 20 %, + 15 % 230 V AC/- 20 %, + 15 %
Superimposed AC voltage, peak-to-peak At rated voltage At limits of admissible voltage	 ≤ 12 % ≤ 6 %
Power consumption	Approx. 3 to 6 W, depending on operational status and selected auxiliary voltage
Bridging time during failure/ short-circuit of auxiliary voltage	≥ 50 ms at V_{aux} ≥ 110 V AC/DC ≥ 20 ms at V_{aux} ≥ 24 V DC
Binary outputs	
Trip relays	4 (configurable)
Contacts per relay	1 NO/form A (Two contacts changeable to NC/form B, via jumpers)
Switching capacity Make Break	 1000 W/VA 30 VA, 40 W resistive 25 VA with L/R ≤ 50 ms
Switching voltage	250 V
Permissible current Continuous For 0.5 s	 5 A 30 A
Permissible total current For common potential: Continuous For 0.5 s	 5 A 30 A
Alarm relays	1
Contacts per relay	1 NO/NC (form A/B)
Switching capacity Make Break	 1000 W/VA 30 VA, 40 W resistive 25 VA with L/R ≤ 50 ms
Switching voltage	250 V
Permissible current	5 A continuous
Binary inputs	
Number	3 (configurable)
Operating voltage	24 to 250 V DC
Current consumption, independent of operating voltage	Approx. 1.8 mA
Pickup threshold, selectable via bridges Rated aux. voltage 24/48/60/110 V DC V_{pickup} 110/125/220/250 V DC V_{pickup}	 ≥ 19 V DC ≥ 88 V DC
Permissible maximum voltage	300 V DC
***Connection** (with screws)*	
Current terminals	
Connection ring cable lugs Wire size	W_{max} = 11 mm, d_1 = 5 mm 2.0 - 5.3 mm² (AWG 14-10)
Direct connection Wire size	Solid conductor, flexible lead, connector sleeve 2.0 - 5.3 mm² (AWG 14-10)
Voltage terminals	
Connection ring cable lugs Wire size	W_{max} = 10 mm, d_1 = 4 mm 0.5 - 3.3 mm² (AWG 20-12)
Direct connection Wire size	Solid conductor, flexible lead, connector sleeve 0.5 - 3.3 mm² (AWG 20-12)
Unit design	
Housing 7XP20	For dimensions please refer to dimension drawings, part 15
Degree of protection acc. to EN 60529 For the device in surface-mounting housing in flush-mounting housing front rear For personal safety	 IP 51 IP 51 IP 20 IP 2x with closed protection cover
Weight Flush mounting/ cubicle mounting Surface mounting	 Approx. 4 kg Approx. 4.5 kg

Serial interfaces	
Operating interface	
Connection	At front side, non-isolated, RS232, 9-pin subminiature connector
Operation	With DIGSI 4.3 or higher
Transmission speed	As delivered 19200 baud, parity: 8E1 Min. 1200 baud Max. 19200 baud
Distance	15 m

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Technical data

System interface *(bottom of unit)*	
IEC 60870-5-103 protocol	
Connection	Isolated interface for data transmission
Transmission rate	Min. 1200 baud, max. 19200 baud As delivered 9600 baud
RS232/RS485 acc. to ordered version	
Connection	9-pin subminiature connector on the bottom part of the housing
Test voltage	500 V AC
RS232 maximum distance	15 m
RS485 maximum distance	1000 m
Fiber-optic	
Connector type	ST connector on the bottom part of the housing
Optical wavelength	λ = 820 nm
Laser class 1 acc. to EN 60825-1/-2	For glass fiber 50/125 µm or 62.5/125 µm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Bridgeable distance	Max. 1.5 km
No character position	Selectable, setting as supplied „light off"
PROFIBUS-DP	
Isolated interface for data transfer to a control center	
Transmission rate	Up to 1.5 Mbaud
Transmission reliability	Hamming distance d = 4
RS485	
Connection	9-pin subminiature connector
Distance	1000 m/3300 ft ≤ 93.75 kbaud; 500 m/1500 ft ≤ 187.5 kbaud; 200 m/600 ft ≤ 1.5 Mbaud
Test voltage	500 V AC against earth
Fiber optic	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
Optical wavelength	λ = 820 nm
Laser class 1 acc. to EN 60825-1-2	For glass fiber 50/125 µm or 62.5/125 µm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	500 kB/s 1.6 km/0.99 miles 1500 kB/s 530 m/0.33 miles
Idle state of interface	Settable, setting as supplied "light off"

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

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

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Technical data

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

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

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

Climatic stress tests	
Temperatures	
Recommended temperature During operation	 –5 °C to +55 °C /23 °F to 131 °F, (> 55 °C decreased display contrast)
Limit temperature During operation During storage During transport (Storage and transport with standard works packaging)	 –20 °C to +70 °C /–4 °F to 158 °F –25 °C to +55 °C /–13 °F to 131 °F –25 °C to +70 °C /–13 °F to 158 °F
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 per year 95 % relative humidity, condensation not permissible!

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Technical data

Functions

Definite-time overcurrent protection (ANSI 50, 50N)

Setting ranges/steps	
Low-set overcurrent element	
Phase $I>$	I/I_N = 0.1 to 25 (steps 0.1); or ∞
Earth $I_E>$	I/I_N = 0.05 to 25 (steps 0.01); or ∞
High-set overcurrent element	
Phase $I>>$	I/I_N = 0.1 to 25 (steps 0.1); or ∞
Earth $I_E>>$	I/I_N = 0.05 to 25 (steps 0.01); or ∞
Instantaneous tripping	
Phase $I>>>$	I/I_N = 0.3 to 12.5 (steps 0.1); or ∞
Delay times T for $I>$, $I_E>$, $I>>$, $I_E>>$ and $I>>>$	0 to 60 s (steps 0.01 s)
The set times are pure delay times	
Pickup times $I>$, $I>>$, $I_E>$, $I_E>>$	
At 2 x setting value, without meas. repetition	Approx. 25 ms
At 2 x setting value, with meas. repetition	Approx. 35 ms
Pickup times for $I>>>$ at 2 x setting value	Approx. 15 ms
Reset times $I>$, $I>>$, $I_E>$, $I_E>>$	Approx. 40 ms
Reset time $I>>>$	Approx. 50 ms
Reset ratios	Approx. 0.95
Overshot time	Approx. 55 ms
Tolerances	
Pickup values $I>$, $I>>$, $I>>>$, $I_E>$, $I_E>>$	5 % of setting value or 5 % of rated value
Delay times T	1 % of setting value or 10 ms
Influencing variables	
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range: $-5\ °C \leq \Theta_{amb} \leq 40\ °C$ / $23\ °F \leq \Theta_{amb} \leq 104\ °F$	≤ 0.5 %/10 K
Frequency, range	
$0.98 \leq f/f_N \leq 1.02$	≤ 1.5 %
$0.95 \leq f/f_N \leq 1.05$	≤ 2.5 %
Harmonics	
Up to 10 % of 3rd harmonic	≤ 1%
Up to 10 % of 5th harmonic	≤ 1 %

Inverse-time overcurrent protection (ANSI 51/51N)

Setting ranges/steps	
Low-set overcurrent element	
Phase I_p	I/I_N = 0.1 to 4 (steps 0.1)
Earth I_{Ep}	I/I_N = 0.05 to 4 (steps 0.01)
Time multiplier for I_p, I_{Ep} (IEC charac.)	T_p = 0.05 to 3.2 s (steps 0.01 s)
Time multiplier for I_p, I_{Ep} (ANSI charac.)	D = 0.5 to 15 s (steps 0.1 s)
High-set overcurrent element	
Phase $I>>$	I/I_N = 0.1 to 25 (steps 0.1); or ∞
Earth $I_E>>$	I/I_N = 0.05 to 25 (steps 0.01); or ∞
Instantaneous tripping	
Phase $I>>>$	I/I_N = 0.3 to 12.5 (steps 0.1); or ∞
Delay time $T_I>>$	0 to 60 s (steps 0.01 s)
Tripping time characteristic acc. to IEC	See page 5/33
Pickup threshold	Approx. 1.1 x I_p
Reset threshold, alternatively disk emulation	Approx. 1.03 x I_p
Dropout time	
50 Hz	Approx. 50 ms
60 HZ	Approx. 60 ms
Tolerances	
Pickup values	5 % of setting value or 5 % of rated value
Timing period for $2 \leq I/I_p \leq 20$ and $0.5 \leq I/I_p \leq 24$	5 % of theoretical value ± 2 % current tolerance; at least 30 ms
Influencing variables	
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range: $-5\ °C \leq \Theta_{amb} \leq 40\ °C$ / $-23\ °F \leq \Theta_{amb} \leq 104\ °F$	≤ 0.5 %/10 K
Frequency, range: $0.95 \leq f/f_N \leq 1.05$	≤ 8 %, referred to theoretical time value
Tripping characteristic acc. to ANSI/IEEE	See page 5/33
Pickup threshold	Approx. 1.06 x I_p
Dropout threshold, alternatively disk emulation	Approx. 1.03 x I_p
Tolerances	
Pickup threshold	5 % of setting value or 5 % of rated value
Timing period for $2 \leq I/I_p \leq 20$ and $0.5 \leq I/I_p \leq 24$	5 % of theoretical value ± 2 % current tolerance; at least 30 ms
Influencing variables	
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range: $-5\ °C \leq \Theta_{amb} \leq 40\ °C$ / $23\ °F \leq \Theta_{amb} \leq 104\ °F$	≤ 0.5 %/10 K
Frequency, range: $0.95 \leq f/f_N \leq 1.05$	≤ 8 %, referred to theoretical time value

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Technical data

(Sensitive) earth-fault protection (directional/non-directional)

Definite-time earth-fault protection *(ANSI 50Ns)*

Setting ranges/steps	
Low-set element I_{EE}>	I/I_{EEN} = 0.003 to 1.5 (steps 0.001); or ∞ (deactivated)
High-set element I_{EE}>>	I/I_{EEN} = 0.003 to 1.5 (steps 0.001); or ∞ (deactivated)
Delay times T for I_{EE}> and I_{EE}>>	0 to 60 s (steps 0.01 s)
Pickup times I_{EE}>, I_{EE}>>	
At 2 x setting value without meas. repetition	Approx. 35 ms
At 2 x setting value with meas. repetition	Approx. 55 ms
Reset times I_{EE}>, I_{EE}>>	
At 50 Hz	Approx. 65 ms
At 60 Hz	Approx. 95 ms
Reset ratios	Approx. 0.95
Overshot time	Approx. 55 ms
Tolerances	
Pickup values I_{EE}>, I_{EE}>>	5 % of setting value or 5 % of rated value
Delay times T	1 % of setting value or 10 ms
Influencing variables	
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range: $-5\ °C \leq \Theta_{amb} \leq 40\ °C$ / $23\ °F \leq \Theta_{amb} \leq 104\ °F$	≤ 0.5 %/10 K
Frequency, ranges:	
$0.98 \leq f/f_N \leq 1.02$	≤ 1.5 %
$0.95 \leq f/f_N \leq 1.05$	≤ 2.5 %
Harmonics	
Up to 10 % of 3rd harmonic	≤ 1%
Up to 10 % of 5rd harmonic	≤ 1 %

Inverse-time earth-fault protection *(ANSI 51Ns)*

Setting ranges/steps	
Low-set element I_{EEp}	I/I_{EEN} = 0.003 to 1.4 (steps 0.001)
Time multiplier for I_{EEp} (IEC characteristic)	T_p = 0.05 to 3.2 s (steps 0.01 s)
Time multiplier for I_{EEp} (ANSI characteristic)	D = 0.5 to 15 s (steps 0.1 s)
High-set element I_{EE}>>	I/I_{EEN} = 0.003 to 1.5 (steps 0.001); or ∞ (deactivated)
Delay time T for I_{EE}>>	0 to 60 s (steps 0.01 s)
Tripping time characteristic acc. to IEC	See page 5/33
Pickup threshold	Approx. 1.1 x I_{EEp}
Reset threshold alternatively disk emulation	Approx. 1.03 x I_{EEp}
Dropout time	
50 Hz	Approx. 50 ms
60 Hz	Approx. 60 ms
Tolerances	
Pickup values	5 % of setting value or 5 % of rated value
Timing period for $2 \leq I/I_{EEp} \leq 20$ and $0.5 \leq I/I_{EEN} \leq 24$	5 % of theoretical value ± 2 % current tolerance; at least 30 ms
Influencing variables	
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %

Inverse-time earth-fault protection *(ANSI 51Ns), cont'd*

Temperature, range: $-5\ °C \leq \Theta_{amb} \leq 40\ °C$ / $23\ °F \leq \Theta_{amb} \leq 104\ °F$	≤ 0.5 %/10 K
Frequency, range: $0.95 \leq f/f_N \leq 1.05$	≤ 8 %, referred to theoretical time value
Tripping characteristic acc. to ANSI/IEEE	See page 5/33
Pickup threshold	Approx. 1.06 x I_{EEp}
Dropout threshold, alternatively disk emulation	Approx. 1.03 x I_{EEp}
Tolerances	
Pickup threshold	5 % of setting value or 5 % of rated value
Timing period for $2 \leq I/I_{EEp} \leq 20$ and $0.5 \leq I/I_{EEN} \leq 24$	5 % of theoretical value ± 2 % current tolerance; at least 30 ms
Influencing variables	
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range: $-5\ °C \leq \Theta_{amb} \leq 40\ °C$ / $23\ °F \leq \Theta_{amb} \leq 104\ °F$	≤ 0.5 %/10 K
Frequency, range: $0.95 \leq f/f_N \leq 1.05$	≤ 8 %, referred to theoretical time value

Direction detection *(ANSI 67Ns)*

Direction measurement	I_E, V_E (measured)
Measuring principle	Active/reactive measurement
Measuring enable	
For sensitive input	I/I_{EEN} = 0.003 to 1.2 (in steps of 0.001 I/I_{EEN})
Reset ratio	Approx. 0.8
Measuring method	cos φ and sin φ
Direction vector	-45 ° to +45 ° (in steps of 0.1 °)
Dropout delay $T_{Reset\ Delay}$	1 to 60 s (steps 1 s)
Angle correction for cable converter (for resonant-earthed system)	In 2 operating points F1 and F2
Angle correction F1, F2	0 ° to 5 ° (in steps of 0.1 °)
Current values I_1, I_2	
For sensitive input	I/I_{EEN} = 0.003 to 1.6 (in steps of 0.001 I/I_{EEN})
Measuring tolerance acc. to DIN 57435	2 % of the setting value or 1 mA
Angle tolerance	3 °

Displacement voltage (ANSI 64)

Displacement voltage, measured	V_E>/V_N = 0.02 to 1.3 (steps 0.001)
Measuring time	Approx. 60 ms
Pickup delay time	0.04 to 320 s or ∞ (steps 0.01 s)
Time delay	0.1 to 40000 s or ∞ (steps 0.01 s)
Dropout ratio	0.95 or (pickup value -0.6 V)
Measuring tolerance	
V_E (measured)	3 % of setting value, or 0.3 V
Operating time tolerances	1 % of setting value, or 10 ms
The set times are pure delay times	

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Technical data

Thermal overload protection with memory (ANSI 49) with preload	
Setting ranges	
Factor k according to IEC 60255-8	0.40 to 2 (steps 0.01)
Thermal time constant τ_{th}	1 to 999.9 min (steps 0.1 min)
Thermal warning stage $\Theta_{alarm}/\Theta_{trip}$	50 to 99 % referred to trip temperature rise (steps 1 %)
Prolongation factor at motor stand-still kτ	1 to 10 (steps 0.01)
Reset ratios	
Θ/Θ_{trip}	Reset below 0.99 Θ_{alarm}
Θ/Θ_{alarm}	Approx. 0.99
Tolerances	
Referring to k · I_N	± 5 % (class 5 % acc. to IEC 60255-8)
Referring to trip time	± 5 % ± 2 s (class 5 % acc. to IEC 60255-8)
Influencing variables	
Auxiliary DC voltage, range $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range $-5\ °C \leq \Theta_{amb} \leq +40\ °C$ / $23\ °F \leq \Theta_{amb} \leq 104\ °F$	≤ 0.5 %/10 K
Frequency, range $0.95 \leq f/f_N \leq 1.05$	≤ 1 %

Thermal overload protection without memory (ANSI 49) without preload	
Setting ranges	
Pickup value	I_L/I_N = 0.4 to 4 (steps 0.1)
Time multiplier t_L (= t_6 -time)	1 to 120 s (steps 0.1 s)
Reset ratio I/I_L	Approx. 0.94
Tolerances	
Referring to pickup threshold 1.1 I_L	± 5 % of setting value or 5 % of rated value
Referring to trip time	± 5 % ± 2 s
Influencing variables	
Auxiliary DC voltage, range $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range $-5\ °C \leq \Theta_{amb} \leq +40\ °C$ / $23\ °F \leq \Theta_{amb} \leq 104\ °F$	≤ 0.5 %/10 K
Frequency, range $0.95 \leq f/f_N \leq 1.05$	≤ 1 %

Breaker failure protection	
Setting ranges/steps	
Pickup of current element	CB $I>/I_N$ = 0.04 to 1.0 (steps 0.01)
Delay time	0.06 to 60 s or ∞ (steps 0.01 s)
Pickup times (with internal start)	is contained in the delay time
(via control)	is contained in the delay time
(with external start)	is contained in the delay time
Dropout time	Approx. 25 ms
Tolerances	
Pickup value	2 % of setting value
Delay time	1 % or 20 ms

Negative-sequence protection (ANSI 46)		
Setting ranges/steps		
Tripping stages $I_2>$ and $I_2>>$	8 to 80 % to I_N (steps 1 %)	
Delay times $T(I_2>)$, $T(I_2>>)$	0 to 60 s (steps 0.01 s)	
Lower function limit	At least one phase current ≥ 0.1 x I_N	
Pickup times	at f_N = 50 Hz	at f_N = 60 Hz
Tripping stages $I_2>$ and $I_2>>$	Approx. 60 ms	Approx. 75 ms
But with currents $I/I_N > 1.5$ (overcurrent case) or negative-sequence current < (set value +0.1 x I_N)	Approx. 200 ms	Approx. 310 ms
Reset times		
Tripping stages $I_2>$ and $I_2>>$	Approx. 35 ms	Approx. 42 ms
Reset ratios		
Tripping stages $I_2>$ and $I_2>>$	Approx. 0.9 to 0.01 x I_N	
Tolerances		
Pickup values $I_2>$, $I_2>>$		
Current $I/I_N \leq 1.5$	± 1 % of I_N ± 5 % of set value	
Current $I/I_N > 1.5$	± 5 % of I_N ± 5 % of set value	
Delay times $T(I_2>)$ and $T(I_2>>)$	± 1 % but min. 10 ms	
Influencing variables		
Auxiliary DC voltage, range $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %	
Temperature, range $-5\ °C \leq \Theta_{amb}$ +40 °C / $23\ °F \leq \Theta_{amb} \leq 104\ °F$	≤ 0.5 %/10 K	
Frequency, range $0.98 \leq f/f_N \leq 1.02$	≤ 1 % of I_N	
$0.95 \leq f/f_N \leq 1.05$	≤ 5 % of I_N	

Auto-reclosure (ANSI 79)	
Number of possible shots	1 to 9, configurable
Auto-reclosure modes	3-pole
Dead times for 1st and any further shot	0.05 s to 1800 s (steps 0.01 s)
Blocking time after successful AR	0.05 s to 320 s (steps 0.01 s)
Lock-out time after unsuccessful AR	0.05 s to 320 s (steps 0.01 s)
Reclaim time after manual close	0.50 s to 320 s (steps 0.01 s)
Duration of reclose command	0.01 s to 60 s (steps 0.01 s)

Trip circuit supervision (ANSI 74TC)	
Trip circuit supervision	With one or two binary inputs
Circuit-breaker trip test	Trip/reclosure cycle

Control	
Number of devices	1
Evaluation of breaker contact	None

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Technical data

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

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

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

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Technical data

Min/max. LOG (memory)	
Measured values	With date and time
Reset automatic	Time of day (settable in minutes) Time range (settable in days; 1 to 365, ∞)
Reset manual	Via binary input Via keyboard Via communication
Min./max. values of primary currents	I_{L1}; I_{L2}; I_{L3}
Min./max. values of primary voltages	V_{L1-E}
Min./max. values of power	S Apparent Power P Active power Q Reactive power Power factor cos φ
Min./max. values of primary currents mean values	I_{L1dmd}, I_{L2dmd}, I_{L3dmd}
Min./max. values of power mean value	P_{dmd}, Q_{dmd}, S_{dmd}
Fault event log	
Storage	Storage of the last 8 faults
Time assignment	
Resolution for operational indications	1 s
Resolution for fault event indications	1 ms
Max. time deviation	0.01 %
Fault recording	
Storage	Storage of max. 8 fault events
Total storage time (fault detection or trip command = 0 ms)	Max. 5 s, selectable pre-trigger and post-fault time
Max. storage period per fault event T_{max}	0.30 s to 5 s (steps 0.01 s)
Pre-trigger time T_{pre}	0.05 s to 0.50 s (steps 0.01 s)
Post-fault time T_{post}	0.05 s to 0.50 s (steps 0.01 s)
Sampling rate at 50 Hz	1 instantaneous value per ms
Sampling rate at 60 Hz	1 instantaneous value per 0.83 ms
Backup battery	Lithium battery 3 V/1 Ah, type CR ½ AA Self-discharge time > 5 years “Battery fault” battery charge warning

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).

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”.

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Selection and ordering data

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

See next page

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

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Selection and ordering data

Description	Order No.
7SJ602 multifunction overcurrent and motor protection relay	*7SJ602□-□□□□□-□□□□*

ANSI No.	Description			
	Basic version			
50/51	Time-overcurrent protection TOC phase			
	$I>$, $I>>$, $I>>>$, I_p, reverse interlocking			
50N/51N	Ground/earth-fault protection TOC ground/earth $I_E>$, $I_E>>$, I_{Ep}			
49	Overload protection			
74TC	Trip circuit supervision			
50BF	Breaker-failure protection			
	Cold load pickup			
46	Negative sequence/unbalanced load protection	F	A	1)
	Basic version + directional ground/earth-fault detection			
50/51	Time-overcurrent protection TOC phase			
	$I>$, $I>>$, $I>>>$, I_p, reverse interlocking			
67Ns	Directional sensitive ground/earth-fault detection $I_{EE}>$, $I_{EE}>>$, I_{Ep}			
64	Displacement voltage			
49	Overload protection			
74TC	Trip circuit supervision			
50BF	Breaker-failure protection			
	Cold load pickup			
46	Negative sequence/unbalanced load protection	F	B	2)
	Basic version + sensitive ground/earth-fault detection + measuring			
50/51	Time-overcurrent protection TOC phase			
	$I>$, $I>>$, $I>>>$, I_p, reverse interlocking			
50Ns/51Ns	Sensitive ground/earth-fault detection $I_{EE}>$, $I_{EE}>>$, I_{Ep}			
49	Overload protection			
74TC	Trip circuit supervision			
50BF	Breaker-failure protection			
	Cold load pickup			
46	Negative sequence/unbalanced load protection			
	Voltage and power measuring	F	J	2)
	Basic version + motor protection			
50/51	Time-overcurrent protection TOC phase			
	$I>$, $I>>$, $I>>>$, I_p, reverse interlocking			
50N/51N	Ground/earth-fault protection TOC ground/earth $I_E>$, $I_E>>$, I_{Ep}			
49	Overload protection			
74TC	Trip circuit supervision			
50BF	Breaker-failure protection			
	Cold load pickup			
46	Negative sequence/unbalanced load protection			
48	Starting time supervision			
37	Undercurrent/loss of load monitoring			
66/86	Restart inhibit	H	A	1)
	Basic version + directional ground/earth fault protection + motor protection			
50/51	Time-overcurrent protection TOC phase			
	$I>$, $I>>$, $I>>>$, I_p, reverse interlocking			
67Ns	Directional sensitive ground/earth-fault detection $I_{EE}>$, $I_{EE}>>$, I_{Ep}			
64	Displacement voltage			
49	Overload protection			
74TC	Trip circuit supervision			
50BF	Breaker-failure protection			
	Cold load pickup			
46	Negative sequence/unbalanced load protection			
48	Starting time supervision			
37	Undercurrent/loss of load monitoring			
66/86	Restart inhibit	H	B	2)
	Basic version + sensitive ground/earth-fault detection + measuring + motor protection			
50/51	Time-overcurrent protection TOC phase			
	$I>$, $I>>$, $I>>>$, I_p, reverse interlocking			
50Ns/51Ns	Sensitive ground/earth-fault detection $I_{EE}>$, $I_{EE}>>$, I_{Ep}			
49	Overload protection			
74TC	Trip circuit supervision			
50BF	Breaker-failure protection			
	Cold load pickup			
46	Negative sequence/unbalanced load protection			
	Voltage and power measuring			
48	Starting time supervision			
37	Undercurrent/loss of load monitoring			
66/86	Restart inhibit	H	J	2)
	Auto-reclosure (ARC)			
	Without auto-reclosure ARC			0
79	With auto-reclosure ARC			1

1) Only with position 7 = 1 or 5
2) Only with position 7 = 2 or 6

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Accessories

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

LSP2093-afp.eps

Short-circuit links
for current terminals

LSP2289-afp.eps

Mounting rail

Description	Order No.	Size of package	Supplier
Terminal safety cover			
Voltage/current terminal 18-pole	C73334-A1-C31-1	1	Siemens
Voltage/current terminal 8-pole	C73334-A1-C32-1	1	Siemens
Short-circuit links			
For current terminals	C73334-A1-C33-1	1	Siemens
For other terminals	C73334-A1-C34-1	1	Siemens
Mounting rail for 19" rack	C73165-A63-D200-1	1	Siemens

Your local Siemens representative
can inform you on local suppliers.

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Connection diagram

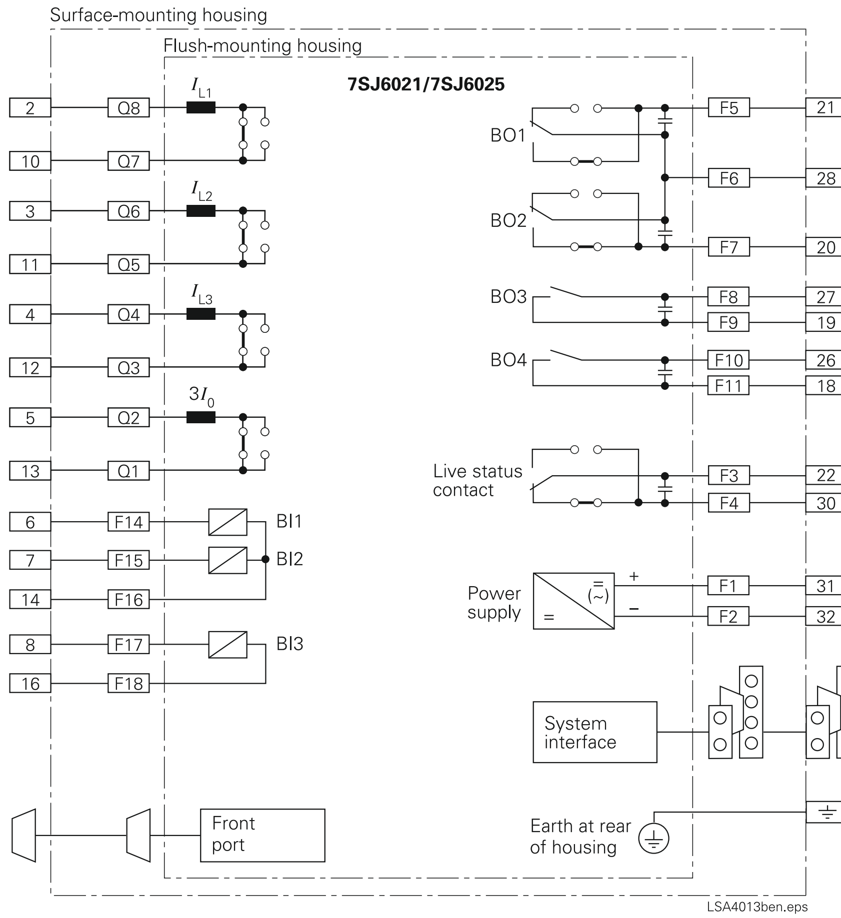

Fig. 5/54
Connection diagram according to IEC standard

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Connection diagram

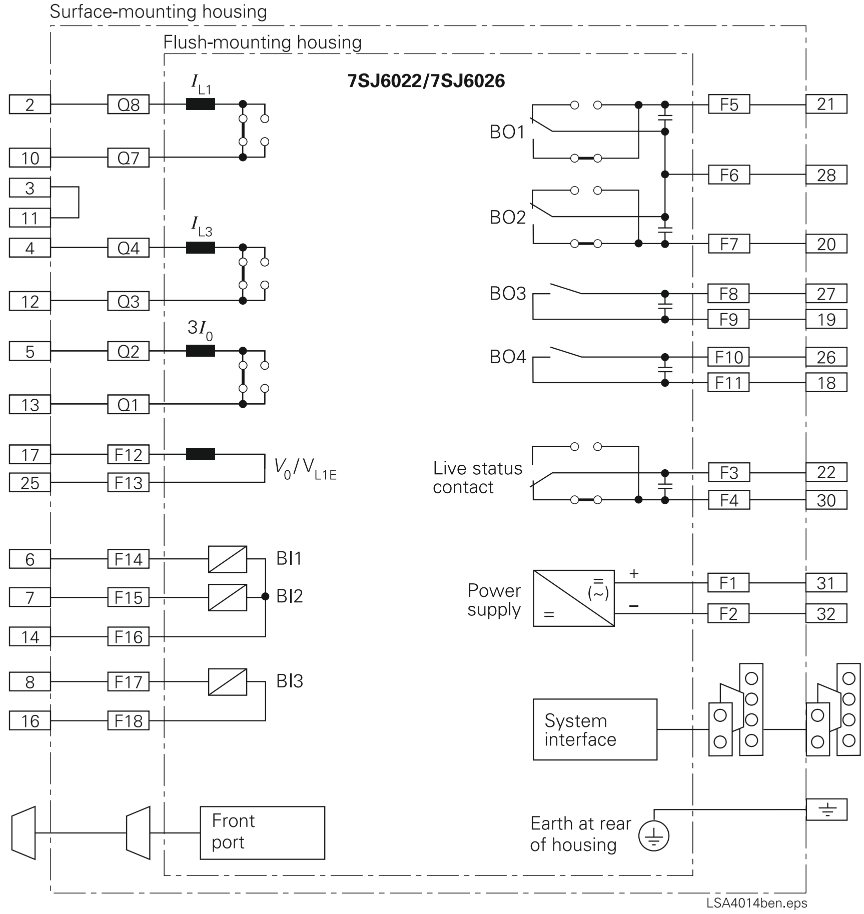

Fig. 5/55
Connection diagram according to IEC standard

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SIPROTEC 4 7SJ61
Multifunction Protection Relay

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

Description

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

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

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

Function overview

Protection functions

- Time-overcurrent protection (definite-time/inverse-time/user-def.)
- Sensitive earth-fault detection
- Intermittent earth-fault protection
- High-impedance restricted earth fault
- Inrush restraint
- Motor protection
  - Undercurrent monitoring
  - Starting time supervision
  - Restart inhibit
  - Locked rotor
  - Load jam protection
- Overload protection
- Temperature monitoring
- Breaker failure protection
- Negative-sequence protection
- Auto-reclosure
- Lockout

Control functions/programmable logic

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

Monitoring functions

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

Communication interfaces

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

Hardware

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

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Application

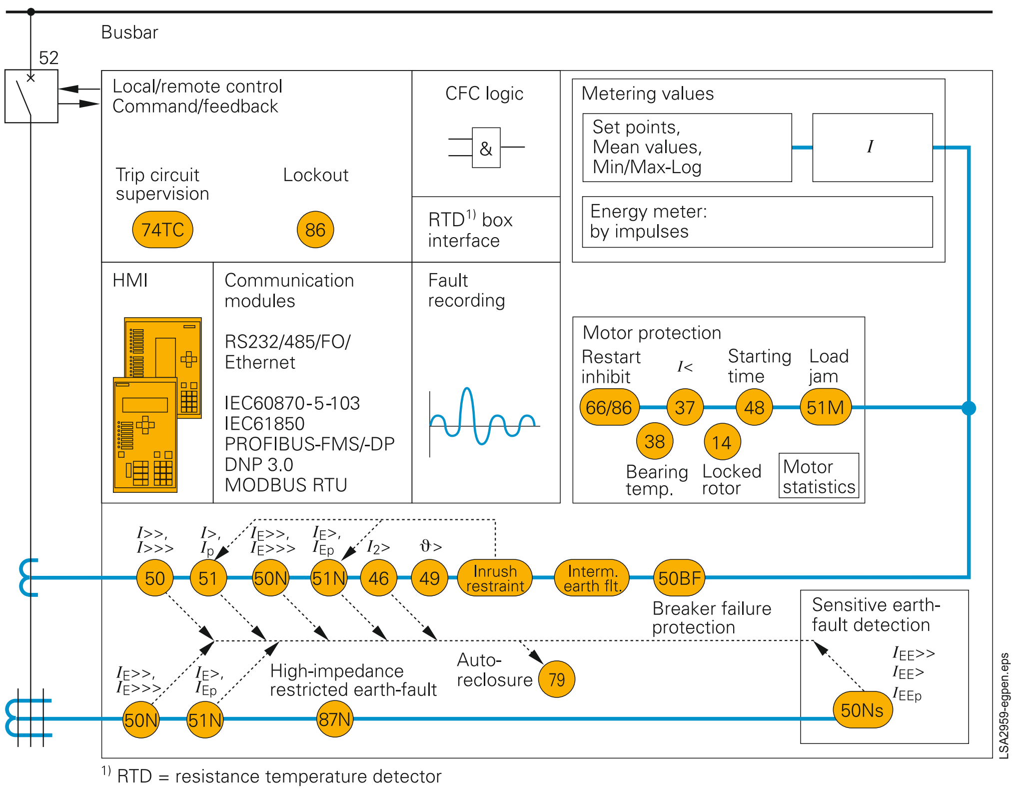

Fig. 5/58 Function diagram

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

Control

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

Programmable logic

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

Line protection

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

Motor protection

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

Transformer protection

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

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

Backup protection

The 7SJ61can be used universally for backup protection.

Flexible protection functions

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

Metering values

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

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Application

ANSI No.	IEC	Protection functions
50, 50N	$I>$, $I>>$, $I>>>$ $I_E>$, $I_E>>$, $I_E>>>$	Definite-time overcurrent protection (phase/neutral)
51, 51N	I_p, I_{Ep}	Inverse-time overcurrent protection (phase/neutral)
50Ns, 51Ns	$I_{EE}>$, $I_{EE}>>$, I_{EEp}	Sensitive earth-fault protection
–		Cold load pick-up (dynamic setting change)
–	$I_E>$	Intermittent earth fault
87N		High-impedance restricted earth-fault protection
50BF		Breaker failure protection
79		Auto-reclosure
46	$I_2>$	Phase-balance current protection (negative-sequence protection)
49	$\vartheta>$	Thermal overload protection
48		Starting time supervision
51M		Load jam protection
14		Locked rotor protection
66/86		Restart inhibit
37	$I<$	Undercurrent monitoring
38		Temperature monitoring via external device (RTD-box), e.g. bearing temperature monitoring

Construction

Connection techniques and housing with many advantages

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

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

Fig. 5/59 Rear view with screw-type, 1/3-rack size

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Protection functions

Time-overcurrent protection (ANSI 50, 50N, 51, 51N)

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

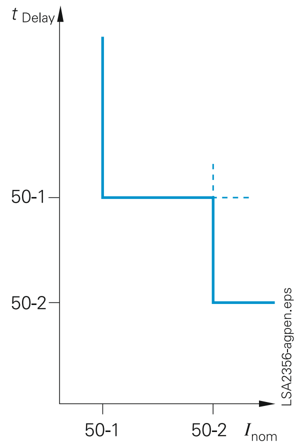

Fig. 5/60
Definite-time overcurrent protection

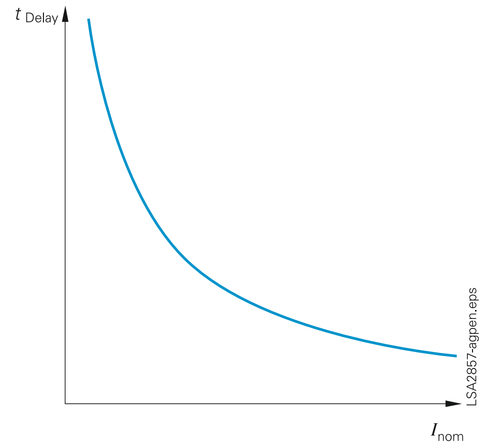

Fig. 5/61
Inverse-time overcurrent protection

Available inverse-time characteristics

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

Reset characteristics

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

User-definable characteristics

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

Inrush restraint

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

Cold load pickup/dynamic setting change

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

Flexible protection functions

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

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

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Protection functions

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

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

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

Intermittent earth-fault protection

Intermittent (re-striking) faults occur due to insulation weaknesses in cables or as a result of water penetrating cable joints. Such faults either simply cease at some stage or develop into lasting short-circuits. During intermittent activity, however, star-point resistors in networks that are impedance-earthed may undergo thermal overloading. The normal earth-fault protection cannot reliably detect and interrupt the current pulses, some of which can be very brief.
The selectivity required with intermittent earth faults is achieved by summating the duration of the individual pulses and by triggering when a (settable) summed time is reached. The response threshold I_{IE}> evaluates the r.m.s. value, referred to one systems period.

Breaker failure protection (ANSI 50BF)

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

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

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

Settable dropout delay times

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

Auto-reclosure (ANSI 79)

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

- 3-pole ARC for all types of faults
- Separate settings for phase and earth faults
- Multiple ARC, one rapid auto-reclosure (RAR) and up to nine delayed auto-reclosures (DAR)
- Starting of the ARC depends on the trip command selection (e.g. 46, 50, 51)
- Blocking option of the ARC via binary inputs
- ARC can be initiated externally or via CFC
- The overcurrent elements can either be blocked or operated non-delayed depending on the auto-reclosure cycle
- Dynamic setting change of the overcurrent elements can be activated depending on the ready AR

Thermal overload protection (ANSI 49)

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

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

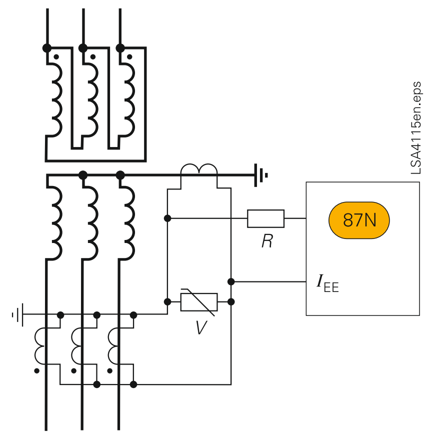

Fig. 5/62 High-impedance restricted earth-fault protection

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

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

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

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

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Protection functions/Functions

■ Motor protection

Starting time supervision (ANSI 48)

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

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

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

I = Actual current flowing

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

t = Tripping time

I_A = Rated motor starting current

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

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

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

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

Temperature monitoring (ANSI 38)

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

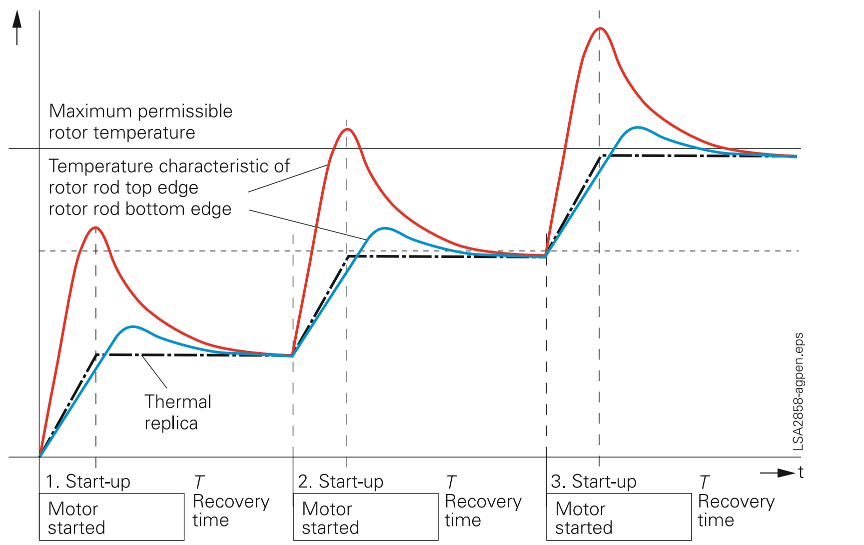

Fig. 5/63

Load jam protection (ANSI 51M)

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

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

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

Restart inhibit (ANSI 66/86)

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

Emergency start-up

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

Undercurrent monitoring (ANSI 37)

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

Motor statistics

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

Circuit-breaker wear monitoring

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

There is no mathematically exact method of calculating the wear or the remaining service life of circuit-breakers that takes into account the arc-chamber's physical conditions when the CB opens. This is why various methods of determining CB wear have evolved which reflect the different operator philosophies. To do justice to these, the devices offer several methods:

- ΣI
- ΣI^x, with x = 1... 3
- $\Sigma i^2 t$

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

- Two-point method

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Protection functions/Functions

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

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

Commissioning

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

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

Test operation

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

■ Control and automatic functions

Control

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

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

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

The switchgear or circuit-breaker can be controlled via:

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

Automation / user-defined logic

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

Switching authority

Switching authority is determined according to parameters and communication.

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

Command processing

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

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable bay interlocks
- Operating sequences combining several switching operations such as control of circuit-breakers, disconnectors and earthing switches
- Triggering of switching operations, indications or alarm by combination with existing information

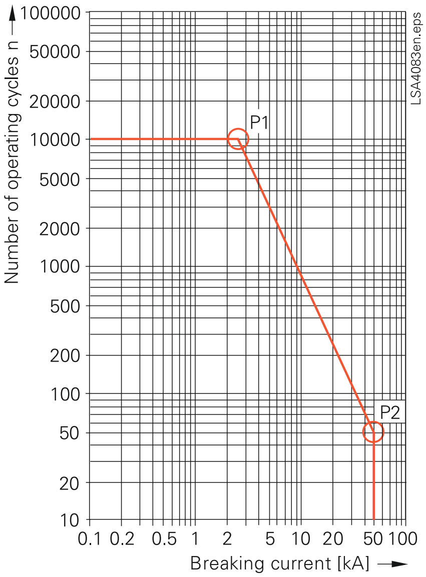

Fig. 5/64 CB switching cycle diagram

Assignment of feedback to command

The positions of the circuit-breaker or switching devices and transformer taps are acquired by feedback. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication change is a consequence of switching operation or whether it is a spontaneous change of state.

Chatter disable

Chatter disable feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

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Functions

Indication filtering and delay

Binary indications can be filtered or delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time. In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

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

Measured values

The r.m.s. values are calculated from the acquired current. The following functions are available for measured value processing:

- Currents I_{L1}, I_{L2}, I_{L3}, I_E, I_{EE} (50Ns)
- Symmetrical components I_1, I_2, $3I_0$
- Mean as well as minimum and maximum current values
- Operating hours counter
- Mean operating temperature of overload function
- Limit value monitoring
- Limit values are monitored using programmable logic in the CFC. Commands can be derived from this limit value indication.
- Zero suppression
  In a certain range of very low measured values, the value is set to zero to suppress interference.

Metered values

If an external meter with a metering pulse output is available, the SIPROTEC 4 unit can obtain and process metering pulses via an indication input.

The metered values can be displayed and passed on to a control center as an accumulation with reset.

Switchgear cubicles for high/medium voltage

All units are designed specifically to meet the requirements of high/medium-voltage applications.

In general, no separate measuring instruments or additional control components are necessary.

LSP2077f.eps

Fig. 5/65
NXAIR panel (air-insulated)

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Communication

In terms of communication, the units offer substantial flexibility in the context of connection to industrial and power automation standards. Communication can be extended or added on thanks to modules for retrofitting on which the common protocols run. Therefore, also in the future it will be possible to optimally integrate units into the changing communication infrastructure, for example in Ethernet networks (which will also be used increasingly in the power supply sector in the years to come).

Serial front interface

There is a serial RS232 interface on the front of all the units. All of the unit's functions can be set on a PC by means of the DIGSI 4 protection operation program. Commissioning tools and fault analysis are also built into the program and are available through this interface.

Rear-mounted interfaces[1)]

A number of communication modules suitable for various applications can be fitted in the rear of the flush-mounting housing. In the flush-mounting housing, the modules can be easily replaced by the user. The interface modules support the following applications:

- Time synchronization interface
  All units feature a permanently integrated electrical time synchronization interface. It can be used to feed timing telegrams in IRIG-B or DCF77 format into the units via time synchronization receivers.
- System interface
  Communication with a central control system takes place through this interface. Radial or ring type station bus topologies can be configured depending on the chosen interface. Furthermore, the units can exchange data through this interface via Ethernet and IEC 61850 protocol and can also be operated by DIGSI.
- Service interface
  The service interface was conceived for remote access to a number of protection units via DIGSI. On all units, it can be an electrical RS232/RS485 or an optical interface. For special applications, a maximum of two temperature monitoring boxes (RTD-box) can be connected to this interface as an alternative.

System interface protocols (retrofittable)

IEC 61850 protocol

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

IEC 60870-5-103 protocol

The IEC 60870-5-103 protocol is an international standard for the transmission of protective data and fault recordings. All messages from the unit and also control commands can be transferred by means of published, Siemens-specific extensions to the protocol.
Redundant solutions are also possible. Optionally it is possible to read out and alter individual parameters (only possible with the redundant module).

PROFIBUS-DP protocol

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

MODBUS RTU protocol

This uncomplicated, serial protocol is mainly used in industry and by power supply corporations, and is supported by a number of unit manufacturers. SIPROTEC units function as MODBUS slaves, making their information available to a master or receiving information from it.
A time-stamped event list is available.

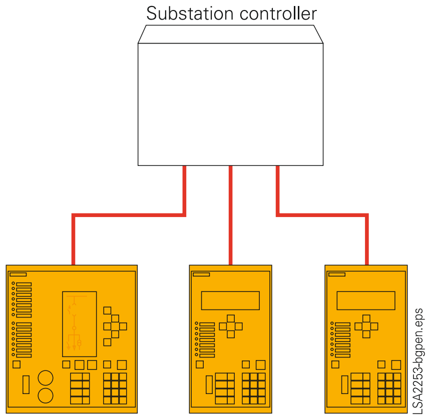

Fig. 5/66
IEC 60870-5-103: Radial fiber-optic connection

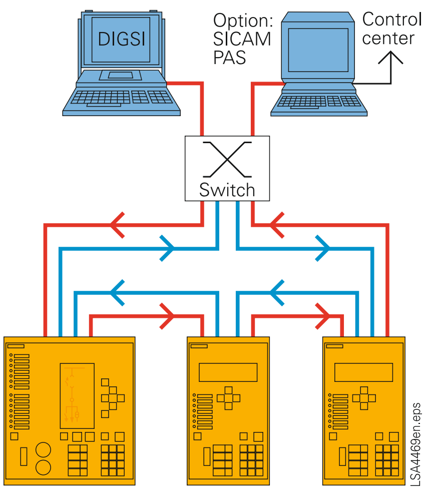

Fig. 5/67
Bus structure for station bus with Ethernet and IEC 61850, fiber-optic ring

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

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Communication

DNP 3.0 protocol

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

System solutions for protection and station control

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

Units featuring IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 5/65).

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

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 5/66).

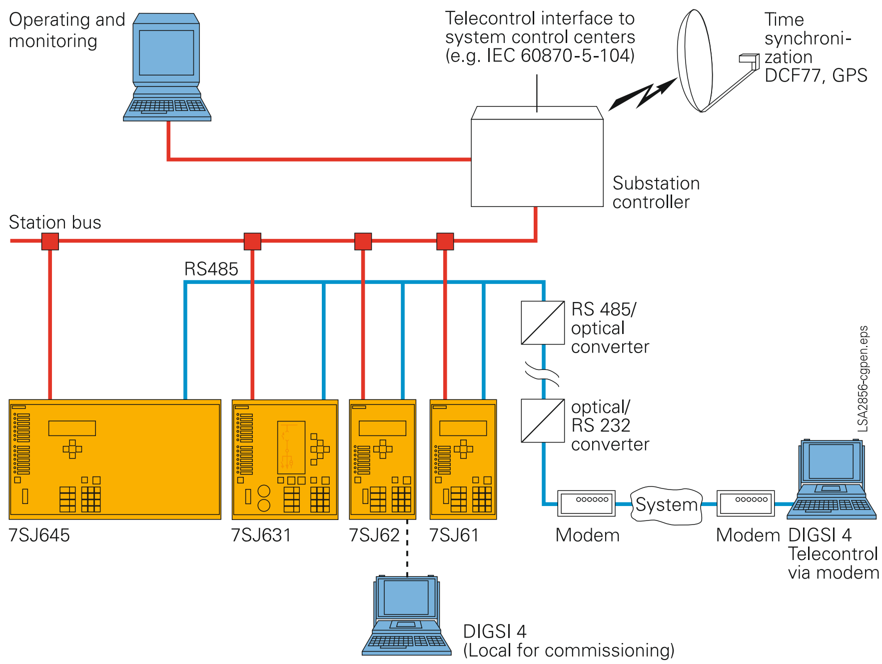

Fig. 5/67
System solution/communication

Fig. 5/68
Optical Ethernet communication module for IEC 61850 with integrated Ethernet-switch

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Typical connections

Connection of current and voltage transformers

Standard connection

For earthed networks, the earth current is obtained from the phase currents by the residual current circuit.

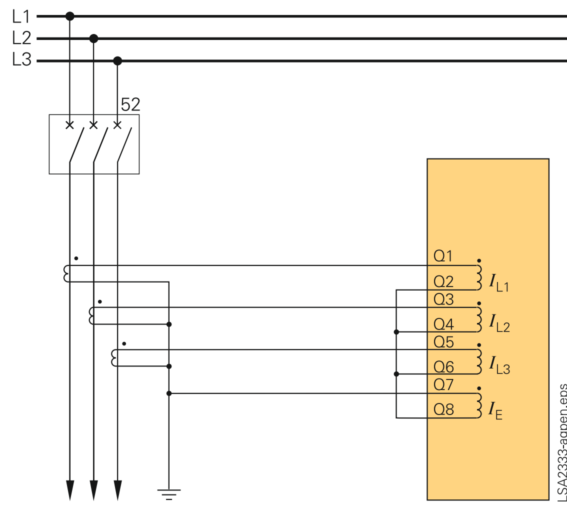

Fig. 5/69
Residual current circuit

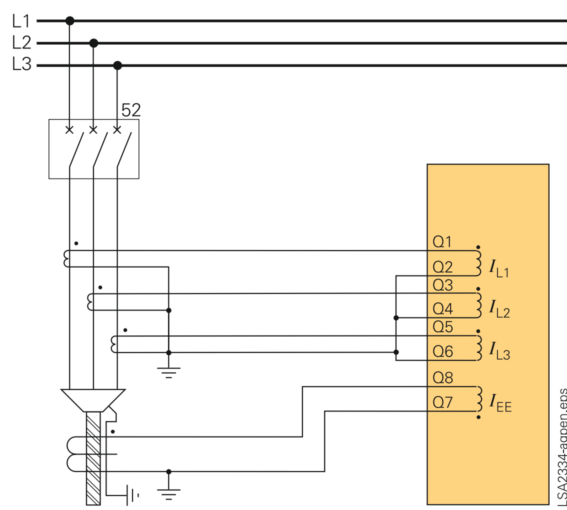

Fig. 5/70
Sensitive earth current detection

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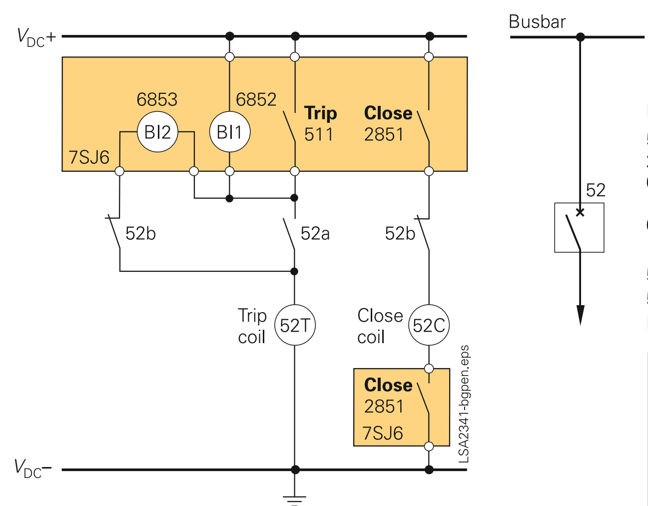
Typical applications

Overview of connection types

Type of network	Function	Current connection
(Low-resistance) earthed network	Time-overcurrent protection phase/earth non-directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformer possible
(Low-resistance) earthed networks	Sensitive earth-fault protection	Phase-balance neutral current transformers required
Isolated or compensated networks	Time-overcurrent protection phases non-directional	Residual circuit, with 3 or 2 phase current transformers possible
Isolated networks	Sensitive earth-fault protection	Phase-balance neutral current transformers required
Compensated networks	Sensitive earth-fault protection	Phase-balance neutral current transformers required

Trip circuit supervision (ANSI 74TC)

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



Protection indications

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

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

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

Fig. 5/71 Trip circuit supervision with 2 binary inputs

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Technical data

General unit data	
Measuring circuits	
System frequency	50 / 60 Hz (settable)
Current transformer	
Rated current I_{nom}	1 or 5 A (settable)
Option: sensitive earth-fault CT	I_{EE} < 1.6 A
Power consumption at I_{nom} = 1 A at I_{nom} = 5 A for sensitive earth-fault CT at 1 A	 Approx. 0.05 VA per phase Approx. 0.3 VA per phase Approx. 0.05 VA
Overload capability Thermal (effective) Dynamic (impulse current)	 100 x I_{nom} for 1 s 30 x I_{nom} for 10 s 4 x I_{nom} continuous 250 x I_{nom} (half cycle)
Overload capability if equipped with sensitive earth-fault CT Thermal (effective) Dynamic (impulse current)	 300 A for 1 s 100 A for 10 s 15 A continuous 750 A (half cycle)

Auxiliary voltage *(via integrated converter)*					
Rated auxiliary voltage V_{aux}	DC AC	24/48 V	60/125 V	110/250 V 115/230 V	
Permissible tolerance	DC AC	19–58 V	48–150 V	88–330 V 92–138 V	 184–265 V
Ripple voltage, peak-to-peak	≤ 12 %				
Power consumption Quiescent Energized	 Approx. 3 W Approx. 7 W				
Backup time during loss/short-circuit of auxiliary voltage	≥ 50 ms at V ≥ 110 V DC ≥ 20 ms at V ≥ 24 V DC ≥ 200 ms at 115 V/230 V AC				

Binary inputs/indication inputs			
Type	7SJ610	7SJ611, 7SJ613	7SJ612, 7SJ614
Number	3	8	11
Voltage range	24–250 V DC		
Pickup threshold	Modifiable by plug-in jumpers		
Pickup threshold	DC 19 V		88 V
For rated control voltage	DC 24/48/60/110/125 V		110/220/250 V
Response time/drop-out time	Approx. 3.5 ms		
Power consumption energized	1.8 mA (independent of operating voltage)		

Binary outputs/command outputs				
Type		7SJ610	7SJ611, 7SJ613	7SJ612, 7SJ614
Number command/indication relay		4	8	6
Contacts per command/ indication relay		1 NO / form A (2 contacts changeable to NC/form B, via jumpers)		
Live status contact		1 NO / NC (jumper) / form A / B		
Switching capacity	Make	1000 W / VA		
	Break	30 W / VA / 40 W resistive / 25 W at L/R ≤ 50 ms		
Switching voltage	≤ 250 V DC			
Permissible current	5 A continuous, 30 A for 0.5 s making current, 2000 switching cycles			

Electrical tests	
Specification	
Standards	IEC 60255 ANSI C37.90, C37.90.1, C37.90.2, UL508
Insulation tests	
Standards	IEC 60255-5; ANSI/IEEE C37.90.0
Voltage test (100 % test) all circuits except for auxiliary voltage and RS485/RS232 and time synchronization	2.5 kV (r.m.s. value), 50/60 Hz
Auxiliary voltage	3.5 kV DC
Communication ports and time synchronization	500 V AC
Impulse voltage test (type test) all circuits, except communication ports and time synchronization, class III	5 kV (peak value); 1.2/50 µs; 0.5 J 3 positive and 3 negative impulses at intervals of 5 s
EMC tests for interference immunity; *type tests*	
Standards	IEC 60255-6; IEC 60255-22 (product standard) EN 50082-2 (generic specification) DIN 57435 Part 303
High-frequency test IEC 60255-22-1, class III and VDE 0435 Part 303, class III	2.5 kV (peak value); 1 MHz; τ =15 ms; 400 surges per s; test duration 2 s
Electrostatic discharge IEC 60255-22-2 class IV and EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air gap discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with radio-frequency field, non-modulated IEC 60255-22-3 (Report) class III	10 V/m; 27 to 500 MHz
Irradiation with radio-frequency field, amplitude-modulated IEC 61000-4-3; class III	10 V/m, 80 to 1000 MHz; AM 80 %; 1 kHz
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204; class III	10 V/m, 900 MHz; repetition rate 200 Hz, on duration 50 %
Fast transient interference/burst IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; test duration 1 min
High-energy surge voltages (Surge) IEC 61000-4-5; class III Auxiliary voltage	 From circuit to circuit: 2 kV; 12 Ω; 9 µF across contacts: 1 kV; 2 Ω ;18 µF
Binary inputs/outputs	From circuit to circuit: 2 kV; 42 Ω; 0.5 µF across contacts: 1 kV; 42 Ω; 0.5 µF
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; AM 80 %; 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m; 50 Hz, continuous 300 A/m; 50 Hz, 3 s 0.5 mT, 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak value), 1 to 1.5 MHz damped wave; 50 surges per s; duration 2 s, R_i = 150 to 200 Ω

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Technical data

EMC tests for interference immunity; *type tests (cont'd)*	
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per s both polarities; duration 2 s, R_i = 80 Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz; amplitude and pulse-modulated
Damped wave IEC 60694 / IEC 61000-4-12	2.5 kV (peak value, polarity alternating) 100 kHz, 1 MHz, 10 and 50 MHz, R_i = 200 Ω
EMC tests for interference emission; *type tests*	
Standard	EN 50081-* (generic specification)
Conducted interferences only auxiliary voltage IEC/CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC/CISPR 11	30 to 1000 MHz Limit class B
Units with a detached operator panel must be installed in a metal cubicle to maintain limit class B	

Mechanical stress tests	
Vibration, shock stress and seismic vibration	
During operation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz; +/- 0.075 mm amplitude; 60 to 150 Hz; 1 *g* acceleration frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 5 *g*, duration 11 ms; 3 shocks in both directions of 3 axes
Seismic vibration IEC 60255-21-3, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 perpendicular axes
During transportation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz; 2 *g* acceleration, frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, Class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 15 *g*, duration 11 ms 3 shocks in both directions of 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Semi-sinusoidal Acceleration 10 *g*, duration 16 ms 1000 shocks in both directions of 3 axes

Climatic stress tests	
Temperatures	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C / -13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	-20 °C to +70 °C / -4 °F to -158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C / +131 °F)	-5 °C to +55 °C / +25 °F to +131 °F
– Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to +131 °F
– Limiting temperature during transport	-25 °C to +70 °C / -13 °F to +158 °F
Humidity	
Permissible humidity It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average 75 % relative humidity; on 56 days a year up to 95 % relative humidity; condensation not permissible!
Unit design	
Housing	7XP20
Dimensions	See dimension drawings, part 15
Weight	
1/3 19”, surface-mounting housing	4.5 kg
1/3 19”, flush-mounting housing	4.0 kg
1/2 19”, surface-mounting housing	7.5 kg
1/2 19”, flush-mounting housing	6.5 kg
Degree of protection acc. to EN 60529	
Surface-mounting housing	IP 51
Flush-mounting housing	Front: IP 51, rear: IP 20;
Operator safety	IP 2x with cover

Serial interfaces	
Operating interface *(front of unit)*	
Connection	Non-isolated, RS232; front panel, 9-pin subminiature connector
Transmission rate	Factory setting 115200 baud, min. 4800 baud, max. 115200 baud
Service/modem interface *(rear of unit)*	
Isolated interface for data transfer	Port C: DIGSI 4/modem/RTD-box
Transmission rate	Factory setting 38400 baud, min. 4800 baud, max. 115200 baud
RS232/RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location “C”
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	15 m /49.2 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth

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System interface *(rear of unit)*	
IEC 60870-5-103 protocol	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Factory setting 9600 baud, min. 1200 baud, max. 115200 baud
RS232/RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	Max. 15 m/49 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth
Fiber optic	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles
IEC 60870-5-103 protocol, redundant	
RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
For surface-mounting housing with two-tier terminal on the top/bottom part	(not available)
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth
IEC 61850 protocol	
Isolated interface for data transfer: - to a control center - with DIGSI - between SIPROTEC 4 relays	Port B, 100 Base T acc. to IEEE802.3
Transmission rate	100 Mbit
Ethernet, electrical	
Connection For flush-mounting housing/ surface-mounting housing with detached operator panel	Two RJ45 connectors mounting location "B"
Distance	Max. 20 m / 65.6 ft
Test voltage	500 V AC against earth
Ethernet, optical	
Connection For flush-mounting housing/ surface-mounting housing with detached operator panel	Integr. LC connector for FO connection Mounting location "B"
Optical wavelength	1300 nm
Distance	1.5 km/0.9 miles

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Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 1.5 Mbaud
RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location "B"
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance	1000 m/3300 ft ≤ 93.75 kbaud; 500 m/1500 ft ≤ 187.5 kbaud; 200 m/600 ft ≤ 1.5 Mbaud; 100 m/300 ft ≤ 12 Mbaud
Test voltage	500 V AC against earth
Fiber optic	
Connection fiber-optic cable	Integr. ST connector for FO connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing Important: Please refer to footnotes [1] and [2] on page 5/99
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	500 kB/s 1.6 km/0.99 miles 1500 kB/s 530 m/0.33 miles
MODBUS RTU, ASCII, DNP 3.0	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 19200 baud
RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location "B"
For surface-mounting housing with two-tier terminal at the top/bottom part	At bottom part of the housing: shielded data cable
Distance	Max. 1 km/3300 ft max. 32 units recommended
Test voltage	500 V AC against earth
Fiber-optic	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing Important: Please refer to footnotes [1] and [2] on page 5/77
Optical wavelength	820 nm
Permissible path attenuaion	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles

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Time synchronization DCF77/IRIG-B signal (Format IRIG-B000)	
Connection	9-pin subminiature connector (SUB-D) (terminal with surface-mounting housing)
Voltage levels	5 V, 12 V or 24 V (optional)
Functions	
***Definite-time overcurrent protection** (ANSI 50, 50N)*	
Operating mode phase protection (ANSI 50)	3-phase (standard) or 2-phase (L1 and L3)
Number of elements (stages)	I>, I>>, I>>> (phases) I_E>, I_E>>, I_E>>> (earth)
Setting ranges	
Pickup phase elements Pickup earth elements	0.5 to 175 A or ∞[1] (in steps of 0.01 A) 0.25 to 175 A or ∞[1] (in steps of 0.01 A)
Delay times T Dropout delay time T_{DO}	0 to 60 s or ∞ (in steps of 0.01 s) 0 to 60 s (in steps of 0.01 s)
Times Pickup times (without inrush restraint, with inrush restraint + 10 ms)	
With twice the setting value With five times the setting value	Approx. 30 ms Approx. 20 ms
Dropout times	Approx. 40 ms
Dropout ratio	Approx. 0.95 for $I/I_{nom} \geq 0.3$
Tolerances Pickup Delay times T, T_{DO}	 2 % of setting value or 50 mA[1] 1 % or 10 ms
***Inverse-time overcurrent protection** (ANSI 51, 51N)*	
Operating mode phase protection (ANSI 51)	3-phase (standard) or 2-phase (L1 and L3)
Setting ranges Pickup phase element I_P Pickup earth element I_{EP} Time multiplier T (IEC characteristics) Time multiplier D (ANSI characteristics)	 0.5 to 20 A or ∞ [1] (in steps of 0.01 A) 0.25 to 20 A or ∞ [1] (in steps of 0.01 A) 0.05 to 3.2 s or ∞ (in steps of 0.01 s) 0.05 to 15 s or ∞ (in steps of 0.01 s)
Trip characteristics IEC ANSI	 Normal inverse, very inverse, extremely inverse, long inverse Inverse, short inverse, long inverse moderately inverse, very inverse, extremely inverse, definite inverse
User-defined characteristic	Defined by a maximum of 20 value pairs of current and time delay
Dropout setting Without disk emulation With disk emulation	 Approx. 1.05 · setting value I_p for $I_p/I_{nom} \geq 0.3$, corresponds to approx. 0.95 · pickup threshold Approx. 0.90 · setting value I_p
Tolerances Pickup/dropout thresholds I_p, I_{Ep} Pickup time for $2 \leq I/I_p \leq 20$	 2 % of setting value or 50 mA[1] 5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms
Dropout ratio for $0.05 \leq I/I_p \leq 0.9$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms

1) For I_{nom} = 1 A, all limits divided by 5.

Inrush blocking	
Influenced functions	Time-overcurrent elements, I>, I_E>, I_p, I_{Ep}
Lower function limit phases	At least one phase current (50 Hz and 100 Hz) ≥ 125 mA [1]
Lower function limit earth	Earth current (50 Hz and 100 Hz) ≥ 125 mA [1]
Upper function limit (setting range)	1.5 to 125 A [1] (in steps of 0.01 A)
Setting range I_{2f}/I	10 to 45 % (in steps of 1 %)
Crossblock (I_{L1}, I_{L2}, I_{L3})	ON/OFF
Dynamic setting change	
Controllable function	Pickup, tripping time
Start criteria	Current criteria, CB position via aux. contacts, binary input, auto-reclosure ready
Time control	3 timers
Current criteria	Current threshold (reset on dropping below threshold; monitoring with timer)
***(Sensitive) earth-fault detection** (ANSI 50 Ns, 51Ns)*	
***Earth-fault pickup** for all types of earth faults*	
***Definite-time characteristic** (ANSI 50Ns)*	
Setting ranges Pickup threshold I_{EE}>, I_{EE}>> For sensitive input For normal input Delay times T for I_{EE}>, I_{EE}>> Dropout delay time T_{DO}	 0.001 to 1.5 A (in steps of 0.001 A) 0.25 to 175 A[1] (in steps of 0.01 A) 0 to 320 s or ∞ (in steps of 0.01 s) 0 to 60 s (in steps of 0.01 s)
Times Pickup times	 Approx. 50 ms
Dropout ratio	Approx. 0.95
Tolerances Pickup threshold I_{EE}>, I_{EE}>> Delay times	 2 % of setting value or 1 mA 1 % of setting value or 20 ms
***Earth-fault pickup** for all types of earth faults*	
***Inverse-time characteristic** (ANSI 51Ns)*	
User-defined characteristic	Defined by a maximum of 20 pairs of current and delay time values
Setting ranges Pickup threshold I_{EEp} For sensitive input For normal input User defined Time multiplier T	 0.001 A to 1.4 A (in steps of 0.001 A) 0.25 to 20 A[1] (in steps of 0.01 A) 0.1 to 4 s or ∞ (in steps of 0.01 s)
Times Pickup times	 Approx. 50 ms
Pickup threshold	Approx. 1.1 · I_{EEp}
Dropout ratio	Approx. 1.05 · I_{EEp}
Tolerances Pickup threshold For sensitive input For normal input Dropout times in linear range	 2 % of setting value or 1 mA 2 % of setting value or 50 mA[1] 7 % of reference value for $2 \leq I/I_{EEp} \leq 20$ + 2 % current tolerance, or 70 ms
Logarithmic inverse	Refer to the manual
Logarithmic inverse with knee point	Refer to the manual

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***High-impedance restricted earth-fault protection** (ANSI 87N) / single-phase overcurrent protection*	
Setting ranges	
Pickup thresholds I>, I>>	
For sensitive input	0.003 to 1.5 A or ∞ (in steps of 0.001 A)
For normal input	0.25 to 175 A[1] or ∞ (in steps of 0.01 A)
Delay times T_I>, T_I>>	0 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
Minimum	Approx. 20 ms
Typical	Approx. 30 ms
Dropout times	Approx. 30 ms
Dropout ratio	Approx. 0.95 for $I/I_{nom} \geq 0.5$
Tolerances	
Pickup thresholds	3 % of setting value or 1 % rated current at I_{nom} = 1 or 5 A; 5 % of setting value or 3 % rated current at I_{nom} = 0.1 A
Delay times	1 % of setting value or 10 ms
Intermittent earth-fault protection	
Setting ranges	
Pickup threshold	
For I_E I_{IE}>	0.25 to 175 A[1] (in steps of 0.01 A)
For $3I_0$ I_{IE}>	0.25 to 175 A[1] (in steps of 0.01 A)
For I_{EE} I_{IE}>	0.005 to 1.5 A (in steps of 0.001 A)
Pickup prolongation time T_V	0 to 10 s (in steps of 0.01 s)
Earth-fault accumulation time T_{sum}	0 to 100 s (in steps of 0.01 s)
Reset time for accumulation T_{res}	1 to 600 s (in steps of 1 s)
Number of pickups for intermittent earth fault	2 to 10 (in steps of 1)
Times	
Pickup times	
Current = 1.25 · pickup value	Approx. 30 ms
Current ≥ 2 · pickup value	Approx. 22 ms
Dropout time	Approx. 22 ms
Tolerances	
Pickup threshold I_{IE}>	3 % of setting value, or 50 mA[1]
Times T_V, T_{sum}, T_{res}	1 % of setting value or 10 ms
***Thermal overload protection** (ANSI 49)*	
Setting ranges	
Factor k	0.1 to 4 (in steps of 0.01)
Time constant	1 to 999.9 min (in steps of 0.1 min)
Warning overtemperature $\Theta_{alarm}/\Theta_{trip}$	50 to 100 % with reference to the tripping overtemperature (in steps of 1 %)
Current warning stage I_{alarm}	0.5 to 20 A (in steps of 0.01 A)
Extension factor when stopped k_τ factor	1 to 10 with reference to the time constant with the machine running (in steps of 0.1)
Rated overtemperature (for I_{nom})	40 to 200 °C (in steps of 1 °C)

1) For I_{nom} = 1 A, all limits divided by 5.

Tripping characteristic For $(I/k \cdot I_{nom}) \leq 8$	$t=\tau_{th}\cdot\ln\frac{(I/k\cdot I_{nom})^2-(I_{pre}/k\cdot I_{nom})^2}{(I/k\cdot I_{nom})^2-1}$
	t = Tripping time τ_{th} = Temperature rise time constant I = Load current I_{pre} = Preload current k = Setting factor acc. to VDE 0435 Part 3011 and IEC 60255-8 I_{nom} = Rated (nominal) current of the protection relay
Dropout ratios	
Θ/Θ_{Trip}	Drops out with Θ_{Alarm}
Θ/Θ_{Alarm}	Approx. 0.99
I/I_{Alarm}	Approx. 0.97
Tolerances	
With reference to k · I_{nom}	Class 5 acc. to IEC 60255-8
With reference to tripping time	5 % +/- 2 s acc. to IEC 60255-8
***Auto-reclosure** (ANSI 79)*	
Number of reclosures	0 to 9 Shot 1 to 4 individually adjustable
Program for phase fault Start-up by	Time-overcurrent elements, negative sequence, binary input
Program for earth fault Start-up by	Time-overcurrent elements, sensitive earth-fault protection, binary input
Blocking of ARC	Pickup of protection functions, three-phase fault detected by a protective element, binary input, last TRIP command after the reclosing cycle is complete (unsuccessful reclosing), TRIP command by the breaker failure protection (50BF), opening the CB without ARC initiation, external CLOSE command
Setting ranges	
Dead time (separate for phase and earth and individual for shots 1 to 4)	0.01 to 320 s (in steps of 0.01 s)
Blocking duration for manual-CLOSE detection	0.5 s to 320 s or 0 (in steps of 0.01 s)
Blocking duration after reclosure	0.5 s to 320 s (in steps of 0.01 s)
Blocking duration after dynamic blocking	0.01 to 320 s (in steps of 0.01 s)
Start-signal monitoring time	0.01 to 320 s or ∞ (in steps of 0.01 s)
Circuit-breaker supervision time	0.1 to 320 s (in steps of 0.01 s)
Max. delay of dead-time start	0 to 1800 s or ∞ (in steps of 0.1 s)
Maximum dead time extension	0.5 to 320 s or ∞(in steps of 0.01 s)
Action time	0.01 to 320 s or ∞ (in steps of 0.01 s)

The delay times of the following protection function can be altered individually by the ARC for shots 1 to 4 (setting value $T = T$, non-delayed $T = 0$, blocking $T = \infty$):
I>>>, I>>, I>, I_p,
I_E>>>, I_E>>, I_E>, I_{Ep}

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Technical data

***Auto-reclosure** (ANSI 79) (cont'd)*	
Additional functions	Lockout (final trip), delay of dead-time start via binary input (monitored), dead-time extension via binary input (monitored), co-ordination with other protection relays, circuit-breaker monitoring, evaluation of the CB contacts
***Breaker failure protection** (ANSI 50 BF)*	
Setting ranges	
Pickup thresholds	0.2 to 5 A[1)] (in steps of 0.01 A)
Delay time	0.06 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
with internal start	is contained in the delay time
with external start	is contained in the delay time
Dropout times	Approx. 25 ms
Tolerances	
Pickup value	2 % of setting value (50 mA)[1)]
Delay time	1 % or 20 ms
***Flexible protection functions** (ANSI 47, 50, 50N)*	
Operating modes/measuring quantities	
3-phase	I, I_1, I_2, I_2/I_1, $3I_0$
1-phase	I, I_E, I_E sens.
Without fixed phase relation	Binary input
Pickup when	Exceeding or falling below threshold value
Setting ranges	
Current I, I_1, I_2, $3I_0$, I_E	0.15 to 200 A[1)] (in steps of 0.01 A)
Current ratio I_2 / I_1	15 to 100 % (in steps of 1 %)
Sensitive earth current $I_{E\ sens.}$	0.001 to 1.5 A (in steps of 0.001 A)
Dropout ratio >- stage	1.01 to 3 (in steps of 0.01)
Dropout ratio <- stage	0.7 to 0.99 (in steps of 0.01)
Pickup delay time	0 to 60 s (in steps of 0.01 s)
Trip delay time	0 to 3600 s (in steps of 0.01 s)
Dropout delay time	0 to 60 s (in steps of 0.01 s)
Times	
Pickup times, phase quantities	
With 2 times the setting value	Approx. 30 ms
With 10 times the setting value	Approx. 20 ms
Pickup times, symmetrical components	
With 2 times the setting value	Approx. 40 ms
With 10 times the setting value	Approx. 30 ms
Binary input	Approx. 20 ms
Dropout times	
Phase quantities	< 20 ms
Symmetrical components	< 30 ms
Binary input	< 10 ms
Tolerances	
Pickup threshold	
Phase quantities	1 % of setting value or 50 mA[1)]
Symmetrical components	2 % of setting value or 100 mA[1)]
Times	1 % of setting value or 10 ms
***Negative-sequence current detection** (ANSI 46)*	
***Definite-time characteristic** (ANSI 46-1 and 46-2)*	
Setting ranges	
Pickup current I_2>, I_2>>	0.5 to 15 A or ∞ (in steps of 0.01 A)
Delay times	0 to 60 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Functional limit	All phase currents ≤ 50 A[1)]
Times	
Pickup times	Approx. 35 ms
Dropout times	Approx. 35 ms
Dropout ratio	Approx. 0.95 for $I_2/I_{nom} > 0.3$
Tolerances	
Pickup thresholds	3 % of the setting value or 50 mA[1)]
Delay times	1 % or 10 ms
***Inverse-time characteristic** (ANSI 46-TOC)*	
Setting ranges	
Pickup current	0.5 to 10 A[1)] (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.5 to 15 s or ∞ (in steps of 0.01 s)
Functional limit	All phase currents ≤ 50 A[1)]
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse
ANSI	Inverse, moderately inverse, very inverse, extremely inverse
Pickup threshold	Approx. 1.1 · I_{2p} setting value
Dropout	
IEC and ANSI (without disk emulation)	Approx. 1.05 · I_{2p} setting value, which is approx. 0.95 · pickup threshold
ANSI with disk emulation	Approx. 0.90 · I_{2p} setting value
Tolerances	
Pickup threshold	3 % of the setting value or 50 mA[1)]
Time for 2 ≤ M ≤ 20	5 % of setpoint (calculated) +2 % current tolerance, at least 30 ms
***Starting time monitoring for motors** (ANSI 48)*	
Setting ranges	
Motor starting current $I_{STARTUP}$	2.5 to 80 A[1)] (in steps of 0.01)
Pickup threshold $I_{MOTOR\ START}$	2 to 50 A[1)] (in steps of 0.01)
Permissible starting time $T_{STARTUP}$, cold motor	1 to 180 s (in steps of 0.1 s)
Permissible starting time $T_{STARTUP}$, warm motor	0.5 to 180 s (in steps of 0.1 s)
Temperature threshold cold motor	0 to 80 % (in steps of 1 %)
Permissible blocked rotor time $T_{LOCKED\text{-}ROTOR}$	0.5 to 120 s or ∞ (in steps of 0.1 s)
Tripping time characteristic	
For I > $I_{MOTOR\ START}$	$t = \left(\frac{I_{STARTUP}}{I}\right)^2 \cdot T_{STARTUP}$ $I_{STARTUP}$ = Rated motor starting current I = Actual current flowing $T_{STARTUP}$ = Tripping time for rated motor starting current t = Tripping time in seconds
Dropout ratio $I_{MOTOR\ START}$	Approx. 0.95
Tolerances	
Pickup threshold	2 % of setting value or 50 mA[1)]
Delay time	5 % or 30 ms
***Load jam protection for motors** (ANSI 51M)*	
Setting ranges	
Current threshold for alarm and trip	0.25 to 60 A[1)] (in steps of 0.01 A)
Delay times	0 to 600 s (in steps of 0.01 s)
Blocking duration after close signal detection	0 to 600 s (in steps of 0.01 s)
Tolerances	
Pickup threshold	2 % of setting value or 50 mA[1)]
Delay time	1 % of setting value or 10 ms

1) At I_{nom} = 1 A, all limits divided by 5.

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Technical data

Restart inhibit for motors (ANSI 66)	
Setting ranges	
Motor starting current relative to rated motor current $I_{MOTOR\ START}/I_{Motor\ Nom}$	1.1 to 10 (in steps of 0.1)
Rated motor current $I_{Motor\ Nom}$	1 to 6 A[1)] (in steps of 0.01 A)
Max. permissible starting time $T_{Start\ Max}$	1 to 320 s (in steps of 1 s)
Equilibrium time T_{Equal}	0 min to 320 min (in steps of 0.1 min)
Minimum inhibit time $T_{MIN.\ INHIBIT\ TIME}$	0.2 min to 120 min (in steps of 0.1 min)
Max. permissible number of warm starts	1 to 4 (in steps of 1)
Difference between cold and warm starts	1 to 2 (in steps of 1)
Extension k-factor for cooling simulations of rotor at zero speed $k_{\tau\ at\ STOP}$	0.2 to 100 (in steps of 0.1)
Extension factor for cooling time constant with motor running $k_{\tau\ RUNNING}$	0.2 to 100 (in steps of 0.1)
Restarting limit	$\Theta_{restart} = \Theta_{rot\ max\ perm} \cdot \frac{n_c - 1}{n_c}$
	$\Theta_{restart}$ = Temperature limit below which restarting is possible
	$\Theta_{rot\ max\ perm}$ = Maximum permissible rotor overtemperature (= 100 % in operational measured value $\Theta_{rot}/\Theta_{rot\ trip}$)
	n_c = Number of permissible start-ups from cold state
Undercurrent monitoring (ANSI 37)	
Signal from the operational measured values	Predefined with programmable logic
Temperature monitoring box (ANSI 38)	
Temperature detectors	
Connectable boxes	1 or 2
Number of temperature detectors per box	Max. 6
Type of measuring	Pt 100 Ω or Ni 100 Ω or Ni 120 Ω
Mounting identification	“Oil” or “Environment” or “Stator” or “Bearing” or “Other”
Thresholds for indications	
For each measuring detector	
Stage 1	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)
Stage 2	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)

1) At rated frequency.

Additional functions	
Operational measured values	
Currents I_{L1}, I_{L2}, I_{L3} Positive-sequence component I_1 Negative-sequence component I_2 I_E or $3I_0$	In A (kA) primary, in A secondary or in % I_{nom}
Range Tolerance[1)]	10 to 200 % I_{nom} 1 % of measured value or 0.5 % I_{nom}
Temperature overload protection Θ/Θ_{Trip}	In %
Range Tolerance[1)]	0 to 400 % 5 % class accuracy per IEC 60255-8
Temperature restart inhibit $\Theta_L/\Theta_{L\ Trip}$	In %
Range Tolerance[1)]	0 to 400 % 5 % class accuracy per IEC 60255-8
Restart threshold $\Theta_{Restart}/\Theta_{L\ Trip}$	In %
Reclose time $T_{Reclose}$	In min
Current of sensitive ground fault detection I_{EE}	In A (kA) primary and in mA secondary
Range Tolerance[1)]	0 mA to 1600 mA 2 % of measured value or 1 mA
RTD-box	See section "Temperature monitoring box"
Long-term averages	
Time window	5, 15, 30 or 60 minuets
Frequency of updates	Adjustable
Long-term averages of currents	I_{L1dmd}, I_{L2dmd}, I_{L3dmd}, I_{1dmd} in A (kA)
Max. / Min. report	
Report of measured values	With date and time
Reset, automatic	Time of day adjustable (in minutes, 0 to 1439 min) Time frame and starting time adjustable (in days, 1 to 365 days, and ∞)
Reset, manual	Using binary input, using keypad, via communication
Min./Max. values for current	I_{L1}, I_{L2}, I_{L3} I_1 (positive-sequence component)
Min./Max. values for overload protection	Θ/Θ_{Trip}
Min./Max. values for mean values	I_{L1dmd}, I_{L2dmd}, I_{L3dmd} I_1 (positive-sequence component)
Local measured values monitoring	
Current asymmetry	I_{max}/I_{min} > balance factor, for $I > I_{balance\ limit}$
Current phase sequence	Clockwise (ABC) / counter-clockwise (ACB)
Limit value monitoring	Predefined limit values, user-defined expansions via CFC
Fault recording	
Recording of indications of the last 8 power system faults	
Recording of indications of the last 3 power system ground faults	

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Technical data

Time stamping	
Resolution for event log (operational annunciations)	1 ms
Resolution for trip log (fault annunciations)	1 ms
Maximum time deviation (internal clock)	0.01 %
Battery	Lithium battery 3 V/1 Ah, type CR 1/2 AA, message "Battery Fault" for insufficient battery charge

Oscillographic fault recording	
Maximum 8 fault records saved, memory maintained by buffer battery in case of loss of power supply	
Recording time	Total 20 s Pre-trigger and post-fault recording and memory time adjustable
Sampling rate for 50 Hz Sampling rate for 60 Hz	1 sample/1.25 ms (16 samples/cycle) 1 sample/1.04 ms (16 samples/cycle)

Statistics	
Saved number of trips	Up to 9 digits
Number of automatic reclosing commands (segregated according to 1^{st} and $\geq 2^{nd}$ cycle)	Up to 9 digits

Circuit-breaker wear	
Methods	• ΣI^x with x = 1 .. 3 • 2-point method (remaining service life) • $\Sigma i^2 t$
Operation	Phase-selective accumulation of measured values on TRIP command, up to 8 digits, phase-selective limit values, monitoring indication

Motor statistics		
Total number of motor start-ups	0 to 9999	(resolution 1)
Total operating time	0 to 99999 h	(resolution 1 h)
Total down-time	0 to 99999 h	(resolution 1 h)
Ratio operating time/down-time	0 to 100 %	(resolution 0.1 %)
Motor start-up data:	of the last 5 start-ups	
– start-up time	0.30 s to 9999.99 s	(resolution 10 ms)
– start-up current (primary)	0 A to 1000 kA	(resolution 1 A)

Operating hours counter	
Display range	Up to 7 digits
Criterion	Overshoot of an adjustable current threshold (BkrClosed I_{MIN})

Trip circuit monitoring	
With one or two binary inputs	

Commissioning aids	
Phase rotation field check, operational measured values, circuit-breaker/switching device test, creation of a test measurement report	

Clock	
Time synchronization	DCF77/IRIG-B signal (telegram format IRIG-B000), binary input, communication

Setting group switchover of the function parameters	
Number of available setting groups	4 (parameter group A, B, C and D)
Switchover performed	Via keypad, DIGSI, system (SCADA) interface or binary input

Control	
Number of switching units	Depends on the binary inputs and outputs
Interlocking	Programmable
Circuit-breaker signals	Feedback, close, open, intermediate position
Control commands	Single command / double command 1, 1 plus 1 common or 2 trip contacts
Programmable controller	CFC logic, graphic input tool
Local control	Control via menu, assignment of a function key
Remote control	Via communication interfaces, using a substation automation and control system (e.g. SICAM), DIGSI 4 (e.g. via modem)

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 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 conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

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

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Selection and ordering data

Description	Order No.
7SJ61 multifunction protection relay	*7SJ61□□ – □□□□□ – □□□□*

The last four positions: see next page.

Housing, binary inputs (BI) and outputs (BO)	
Housing 1/3 19”, 4 line text display, 3 BI, 4 BO, 1 live status contact	*0*
Housing 1/3 19”, 4 line text display, 8 BI, 8 BO, 1 live status contact	*1*
Housing 1/3 19”, 4 line text display, 11 BI, 6 BO, 1 live status contact	*2*
Housing 1/2 19”, graphic display, 8 BI, 8 BO, 1 live status contact 7)	*3*
Housing 1/2 19”, graphic display, 11 BI, 6 BO, 1 live status contact 7)	*4*

Measuring inputs (4 x I)	
I_{ph} = 1 A1), I_e = 1 A1) (min. = 0.05 A) Position 15 only with *A*	*1*
I_{ph} = 1 A1), I_e = sensitive (min. = 0.001 A) Position 15 only with *B*	*2*
I_{ph} = 5 A1), I_e = 5 A1) (min. = 0.25 A) Position 15 only with *A*	*5*
I_{ph} = 5 A1), I_e = sensitive (min. = 0.001 A) Position 15 only with *B*	*6*
I_{ph} = 5 A1), I_e = 1 A1) (min. = 0.05 A) Position 15 only with *A*	*7*

Rated auxiliary voltage (power supply, indication voltage)	
24 to 48 V DC, threshold binary input 19 DC3)	*2*
60 to 125 V DC2), threshold binary input 19 DC3)	*4*
110 to 250 V DC2), 115 to 230 V4) AC, threshold binary input 88 V DC3)	*5*
110 to 250 V DC2), 115 to 230 V4) AC, threshold binary input 176 V DC3)	*6*

Unit version	
For panel surface mounting, 2 tier terminal top/bottom	*B*
For panel flush mounting, plug-in terminal (2/3 pin connector)	*D*
For panel flush mounting, screw-type terminal (direct connection/ring-type cable lugs)	*E*

Region-specific default settings/function versions and language settings	
Region DE, 50 Hz, IEC, language: German, selectable	*A*
Region World, 50/60 Hz, IEC/ANSI, language: English (GB), selectable	*B*
Region US, 60 Hz, ANSI, language: English (US), selectable	*C*
Region FR, 50/60 Hz, IEC/ANSI, language: French, selectable	*D*
Region World, 50/60 Hz, IEC/ANSI, language: Spanish, selectable	*E*
Region IT, 50/60 Hz, IEC/ANSI, language: Italian, selectable	*F*

System interface (Port B): Refer to page 5/77	
No system interface	*0*
Protocols see page 5/77	

Service interface (Port C)	
No interface at rear side	*0*
DIGSI 4/modem, electrical RS232	*1*
DIGSI 4/modem/RTD-box5), electrical RS485	*2*
DIGSI 4/modem/RTD-box5)6), optical 820 nm wavelength, ST connector	*3*

Measuring/fault recording	
Fault recording	*1*
Slave pointer, mean values, min/max values, fault recording	*3*

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

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

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

4) 230 V AC, starting from device version …/EE.

5) Temperature monitoring box 7XV5662-□AD10, refer to “Accessories”.

6) When using the temperature monitoring box at an optical interface, the additional RS485 fiber-optic converter 7XV5650-0□A00 is required.

7) starting from device version .../GG and FW-Version V4.82

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Selection and ordering data

Description	Order No.	Order code
7SJ61 multifunction protection relay	*7SJ61□□ – □□□□□ – □□□□–□□□□*	

Designation	ANSI No.	Description	Order code
Basic version		Control	
	50/51	Time-overcurrent protection $I>$, $I>>$, $I>>>$, I_p	
	50N/51N	Earth-fault protection $I_E>$, $I_E>>$, $I_E>>>$, I_{Ep}	
	50N/51N	Earth-fault protection via insensitive IEE function: $I_{EE}>$, $I_{EE}>>$, I_{EEp} 1)	
	50/50N	Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I_2>$, $I>>>>$, $I_E>>>>$	
	49	Overload protection (with 2 time constants)	
	46	Phase balance current protection (negative-sequence protection)	
	50BF	Breaker failure protection	
	37	Undercurrent monitoring	
	74TC	Trip circuit supervision	
		4 setting groups, cold-load pickup	
		Inrush blocking	
	86	Lockout	F A
■ IEF		Intermittent earth fault	P A
■	50Ns/51Ns	Sensitive earth-fault detection (non-directional)	
	87N	High-impedance restricted earth fault	F B 2)
■ IEF	50Ns/51Ns	Sensitive earth-fault detection (non-directional)	
	87N	High-impedance restricted earth fault	
		Intermittent earth fault	P B 2)
■ Motor IEF	50Ns/51Ns	Sensitive earth-fault detection (non-directional)	
	87N	High-impedance restricted earth fault	
		Intermittent earth fault	
	48/14	Starting time supervision, locked rotor	
	66/86	Restart inhibit	
	51M	Load jam protection, motor statistics	R B 2)
■ Motor	50Ns/51Ns	Sensitive earth-fault detection (non-directional)	
	87N	High-impedance restricted earth fault	
	48/14	Starting time supervision, locked rotor	
	66/86	Restart inhibit	
	51M	Load jam protection, motor statistics	H B 2)
■ Motor	48/14	Starting time supervision, locked rotor	
	66/86	Restart inhibit	
	51M	Load jam protection, motor statistics	H A
ARC		Without	0
	79	With auto-reclosure	1

Description	Order code
ATEX100 Certification For protection of explosion-protected motors (increased-safety type of protection "e")	Z X 9 9 3)

■ Basic version included

IEF = Intermittent earth fault

1) 50N/51N only with insensitive earth-current transformer when position 7 = *1*, *5*, *7*.

2) Sensitive earth-current transformer only when position 7 = *2*, *6*.

3) This variant will be supplied with a previous firmware version.

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Order numbers for system port B

Description	Order No.	Order code
7SJ61 multifunction protection relay	*7SJ61□□ – □□□□□ – □□□□–□□□*	
System interface (on rear of unit, Port B)		
No system interface	0	
IEC 60870-5-103 protocol, RS232	1	
IEC 60870-5-103 protocol, RS485	2	
IEC 60870-5-103 protocol, 820 nm fiber, ST connector	3	
PROFIBUS-FMS Slave, RS485	4	
PROFIBUS-FMS Slave, 820 nm wavelength, single ring, ST connector 1)	5	
PROFIBUS-FMS Slave, 820 nm wavelength, double ring, ST connector 1)	6	
PROFIBUS-DP Slave, RS485	9	L 0 A
PROFIBUS-DP Slave, 820 nm wavelength, double ring, ST connector 1)	9	L 0 B
MODBUS, RS485	9	L 0 D
MODBUS, 820 nm wavelength, ST connector 2)	9	L 0 E
DNP 3.0, RS485	9	L 0 G
DNP 3.0, 820 nm wavelength, ST connector 2)	9	L 0 H
IEC 60870-5-103 protocol, redundant, RS485, RJ45 connector 2)	9	L 0 P
IEC 61850, 100 Mbit Ethernet, electrical, double, RSJ45 connector (EN 100)	9	L 0 R
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector (EN 100)2)	9	L 0 S

1) Not with position 9 = "B"; if 9 = "B", please order 7SJ6 unit with RS485 port and separate fiber-optic converters.
For single ring, please order converter 6GK1502-3AB10, not available with position 9 = "B".
For double ring, please order converter 6GK1502-4AB10, not available with position 9 = "B".
The converter requires a 24 V AC power supply (e.g. power supply 7XV5810-0BA00).
2) Not available with position 9 = "B".

Sample order

Position		Order No. + Order code
		7SJ6125-5EC91-3FA1+L0G
6	I/O's: 11 BI/6 BO, 1 live status contact	2
7	Current transformer: 5 A	5
8	Power supply: 110 to 250 V DC, 115 V AC to 230 V AC	5
9	Unit version: Flush-mounting housing, screw-type terminals	E
10	Region: US, English language (US); 60 Hz, ANSI	C
11	Communication: System interface: DNP 3.0, RS485	9 L0G
12	Communication: DIGSI 4, electric RS232	1
13	Measuring/fault recording: Extended measuring and fault records	3
14/15	Protection function package: Basic version	FA
16	With auto-reclosure	1

5

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Accessories

Description		Order No.
DIGSI 4		
Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition		
Basis	Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional	DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	*7XS5402-0AA00*
Professional + IEC 61850	Complete version: DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for control displays), DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	*7XS5403-0AA00*
IEC 61850 System configurator		
Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM		*7XS5460-0AA00*
SIGRA 4		
Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000 or XP Professional Edition. (generally contained in DIGSI Professional, but can be ordered additionally) Authorization by serial number. On CD-ROM.		*7XS5410-0AA00*
Temperature monitoring box		
24 to 60 V AC/DC		*7XV5662-2AD10*
90 to 240 V AC/DC		*7XV5662-5AD10*
Varistor/Voltage Arrester		
Voltage arrester for high-impedance REF protection		
125 Vrms; 600 A; 1S/S 256		*C53207-A401-D76-1*
240 Vrms; 600 A; 1S/S 1088		*C53207-A401-D77-1*
Connecting cable		
Cable between PC/notebook (9-pin con.) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)		*7XV5100-4*
Cable between temperature monitoring box and SIPROTEC 4 unit		
- length 5 m /16.4 ft		*7XV5103-7AA05*
- length 25 m /82 ft		*7XV5103-7AA25*
- length 50 m /164 ft		*7XV5103-7AA50*
Manual for 7SJ61		
English		*C53000-G1140-C118-x* [1)]

1) x = please inquire for latest edition (exact Order No.).

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Accessories

Mounting rail

2-pin connector

3-pin connector

Short-circuit links for current terminals

Short-circuit links for other terminals

Description	Order No.	Size of package	Supplier
Terminal safety cover			
Voltage/current terminal 18-pole/12-pole	C73334-A1-C31-1	1	Siemens
Voltage/current terminal 12-pole/8-pole	C73334-A1-C32-1	1	Siemens
Connector 2-pin	C73334-A1-C35-1	1	Siemens
Connector 3-pin	C73334-A1-C36-1	1	Siemens
Crimp connector CI2 0.5 to 1 mm^2	0-827039-1	4000 taped on reel	AMP 1)
Crimp connector CI2 0.5 to 1 mm^2	0-827396-1	1	AMP 1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	0-163084-2	1	AMP 1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	0-163083-7	4000 taped on reel	AMP 1)
Crimping tool for Type III+	0-539635-1	1	AMP 1)
and matching female	0-539668-2	1	AMP 1)
Crimping tool for CI2	0-734372-1	1	AMP 1)
and matching female	1-734387-1	1	AMP 1)
Short-circuit links			
for current terminals	C73334-A1-C33-1	1	Siemens
for other terminals	C73334-A1-C34-1	1	Siemens
Mounting rail for 19" rack	C73165-A63-D200-1	1	Siemens

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

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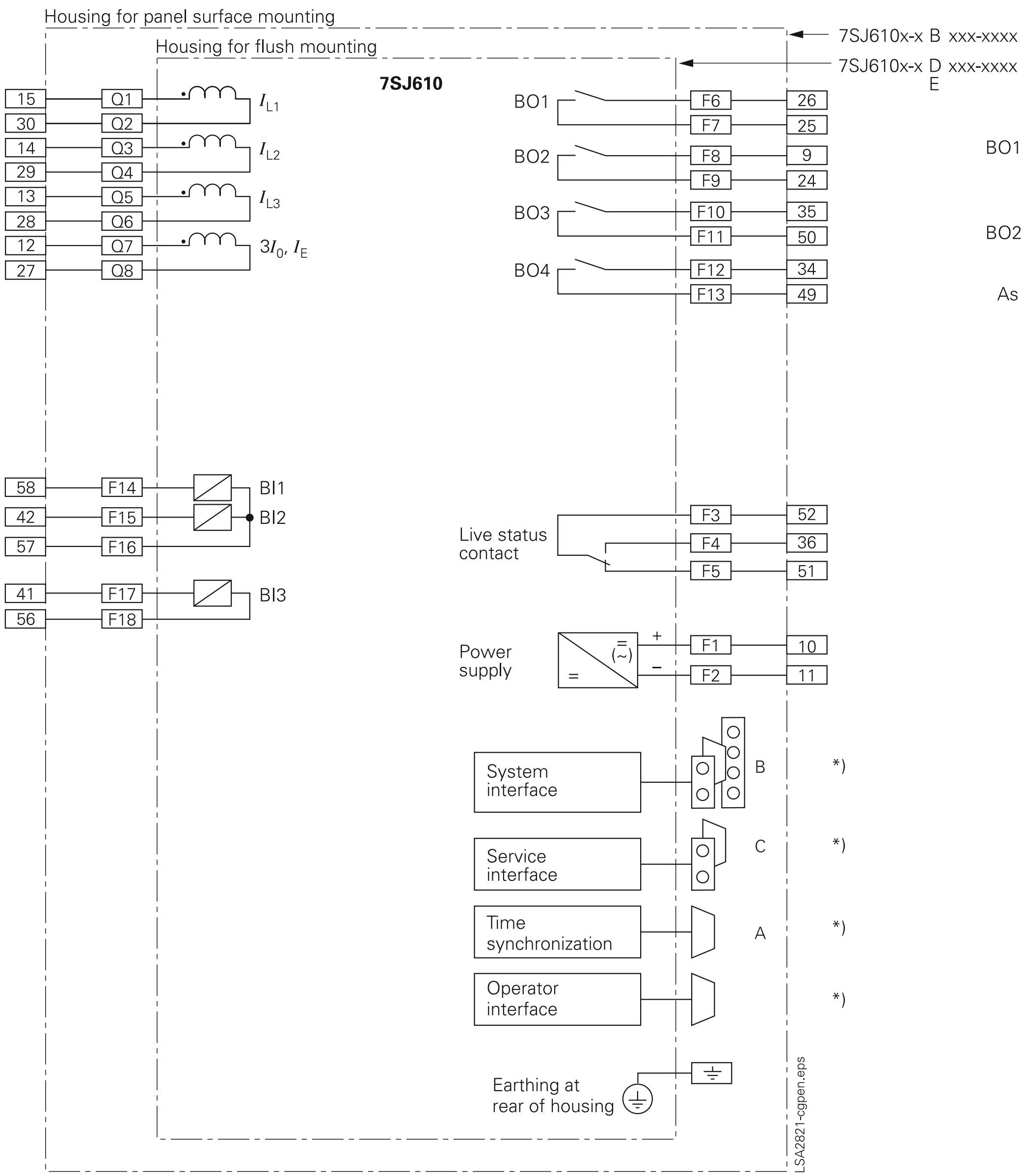
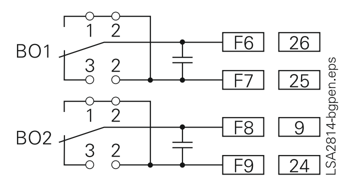
Connection diagram





As of unit version .../EE

Fig. 5/72
7SJ610 connection diagram

*) For pinout of communication ports see part 15 of this catalog.
For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siemens.com/siprotec).

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Connection diagram

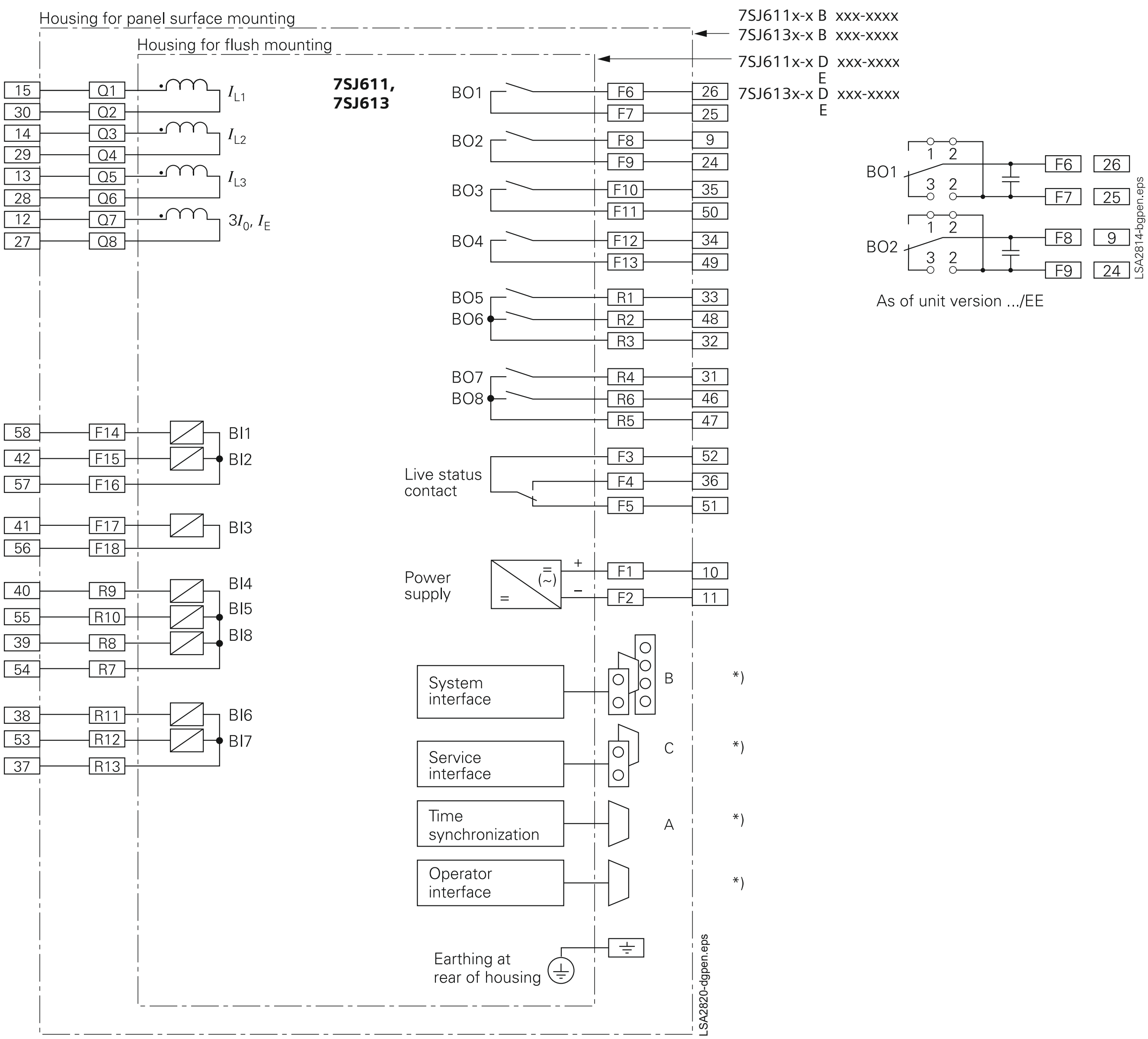

Fig. 5/73
7SJ611, 7SJ613 connection diagram

*) For pinout of communication ports see part 15 of this catalog.
For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siemens.com/siprotec).

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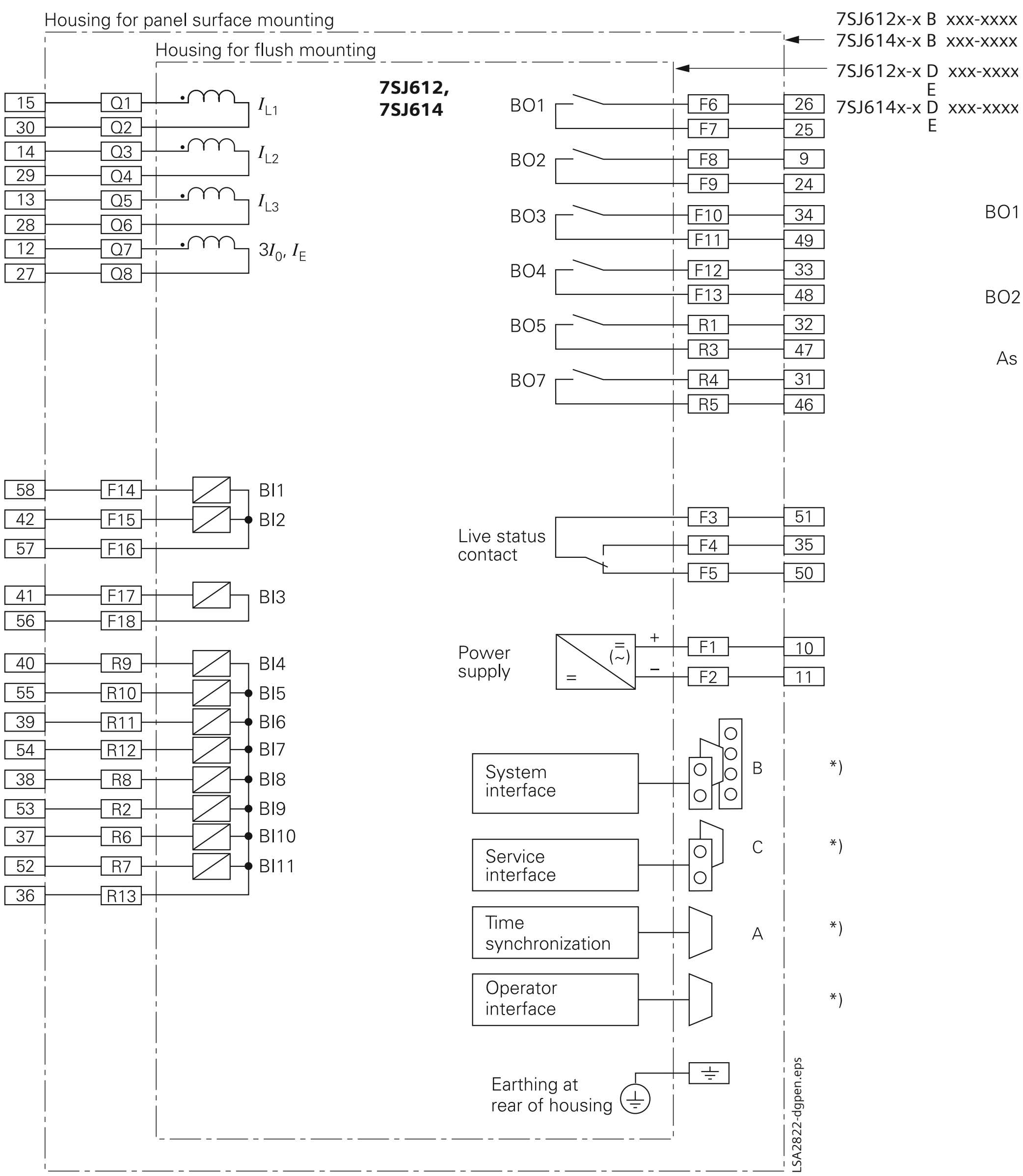
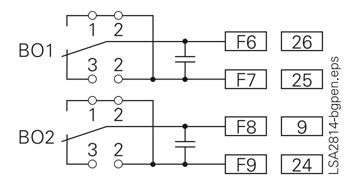
Connection diagram





As of unit version .../EE

Fig. 5/74
7SJ612, 7SJ614 connection diagram

*) For pinout of communication ports see part 15 of this catalog.
For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siemens.com/siprotec).

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SIPROTEC 4 7SJ62
Multifunction Protection Relay

Fig. 5/75 SIPROTEC 4 7SJ62 multifunction protection relay with text (left) and graphic display

Description

The SIPROTEC 4 7SJ62 relays can be used for line protection of high and medium voltage networks with earthed (grounded), low-resistance earthed, isolated or compensated neutral point. With regard to motor protection, the SIPROTEC 4 7SJ62 is suitable for asynchronous machines of all sizes. The relay performs all functions of backup protection supplementary to transformer differential protection.

7SJ62 is featuring the "flexible protection functions". Up to 20 protection functions can be added according to individual requirements. Thus, for example, a rate-of-frequency-change protection or reverse power protection can be implemented.

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

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

Function overview

Protection functions

- Time-overcurrent protection
- Directional time-overcurrent protection
- Sensitive dir. earth-fault detection
- Displacement voltage
- Intermittent earth-fault protection
- High-impedance restricted earth fault
- Inrush restraint
- Motor protection
  - Undercurrent monitoring
  - Starting time supervision
  - Restart inhibit
  - Locked rotor
  - Load jam protection
- Overload protection
- Temperature monitoring
- Under-/overvoltage protection
- Under-/overfrequency protection
- Breaker failure protection
- Negative-sequence protection
- Phase-sequence monitoring
- Synchro-check
- Fault locator
- Lockout
- Auto-reclosure

Control functions/programmable logic

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

Monitoring functions

- Operational measured values V, I, f
- Energy metering values W_p, W_q
- Circuit-breaker wear monitoring
- Slave pointer
- Trip circuit supervision
- Fuse failure monitor
- 8 oscillographic fault records
- Motor statistics

Communication interfaces

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

Hardware

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

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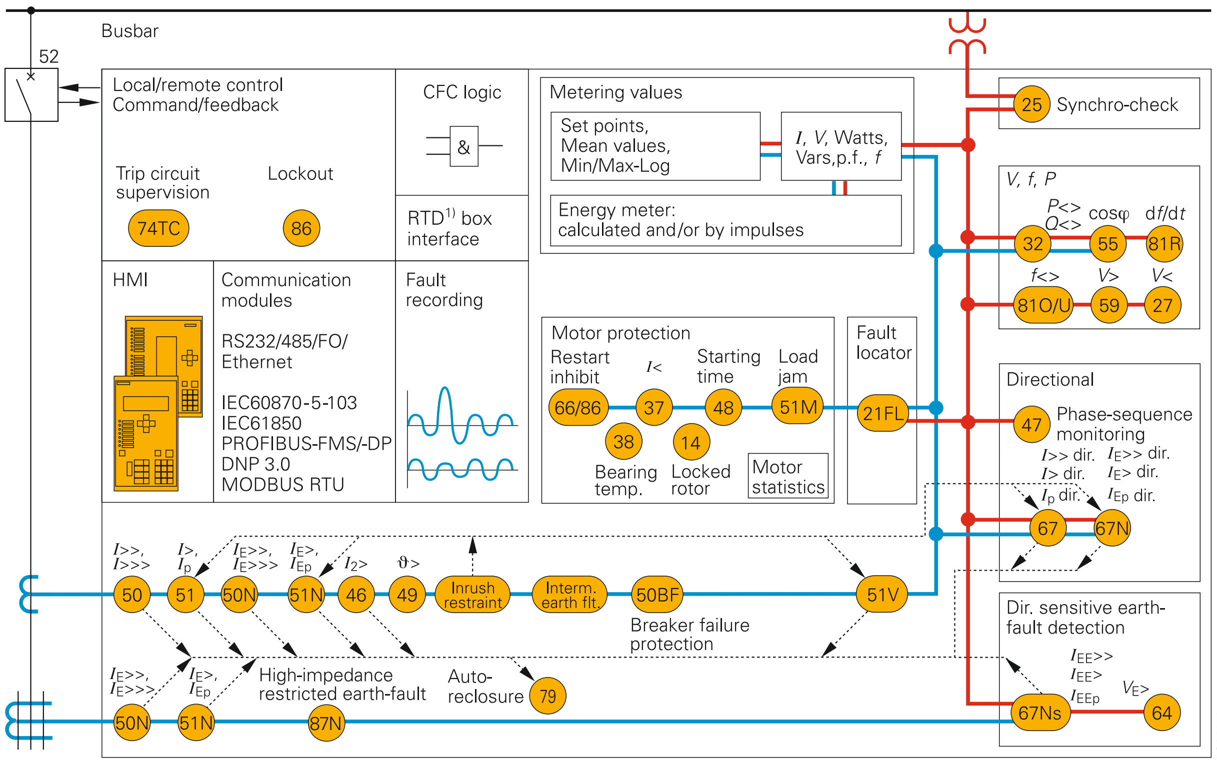
Application



1) RTD = resistance temperature detector

Fig. 5/76 Function diagram

The SIPROTEC 4 7SJ62 unit is a numerical protection relay that also performs control and monitoring functions and therefore supports the user in cost-effective power system management, and ensures reliable supply of electric power to the customers. Local operation has been designed according to ergonomic criteria. A large, easy-to-read display was a major design aim.

Control

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

Programmable logic

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

Line protection

The 7SJ62 units can be used for line protection of high and medium-voltage networks with earthed (grounded), low-resistance earthed, isolated or compensated neutral point.

Synchro-check

In order to connect two components of a power system, the relay provides a synchro-check function which verifies that switching ON does not endanger the stability of the power system.

Motor protection

When protecting motors, the 7SJ62 relay is suitable for asynchronous machines of all sizes.

Transformer protection

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

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

Backup protection

The 7SJ62can be used universally for backup protection.

Flexible protection functions

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

Metering values

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

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Application

ANSI No.	IEC	Protection functions
50, 50N	$I>$, $I>>$, $I>>>$, $I_E>$, $I_E>>$, $I_E>>>$	Definite time-overcurrent protection (phase/neutral)
51, 51V, 51N	I_p, I_{Ep}	Inverse time-overcurrent protection (phase/neutral), phase function with voltage-dependent option
67, 67N	$I_{dir}>$, $I_{dir}>>$, $I_{p\,dir}$ $I_{Edir}>$, $I_{Edir}>>$, $I_{Ep\,dir}$	Directional time-overcurrent protection (definite/inverse, phase/neutral), Directional comparison protection
67Ns/50Ns	$I_{EE}>$, $I_{EE}>>$, I_{EEp}	Directional/non-directional sensitive earth-fault detection
–		Cold load pick-up (dynamic setting change)
59N/64	V_E, $V_0>$	Displacement voltage, zero-sequence voltage
–	$I_{IE}>$	Intermittent earth fault
87N		High-impedance restricted earth-fault protection
50BF		Breaker failure protection
79		Auto-reclosure
25		Synchro-check
46	$I_2>$	Phase-balance current protection (negative-sequence protection)
47	$V_2>$, phase-sequence	Unbalance-voltage protection and/or phase-sequence monitoring
49	$\vartheta>$	Thermal overload protection
48		Starting time supervision
51M		Load jam protection
14		Locked rotor protection
66/86		Restart inhibit
37	$I<$	Undercurrent monitoring
38		Temperature monitoring via external device (RTD-box), e.g. bearing temperature monitoring
27, 59	$V<$, $V>$	Undervoltage/overvoltage protection
59R	dV/dt	Rate-of-voltage-change protection
32	$P<>$, $Q<>$	Reverse-power, forward-power protection
55	$\cos \varphi$	Power factor protection
81O/U	$f>$, $f<$	Overfrequency/underfrequency protection
81R	df/dt	Rate-of-frequency-change protection
21FL		Fault locator

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Construction

Connection techniques and housing with many advantages

1/3-rack size (text display variants) and 1/2-rack size (graphic display variants) are the available housing widths of the 7SJ62 relays, referred to a 19" module frame system. This means that previous models can always be replaced. The height is a uniform 244 mm for flush-mounting housings and 266 mm for surface-mounting housing. All cables can be connected with or without ring lugs.

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

Fig. 5/79 Rear view with screw-type terminals, 1/3-rack size

Protection functions

Time-overcurrent protection (ANSI 50, 50N, 51, 51V, 51N)

This function is based on the phase-selective measurement of the three phase currents and the earth current (four transformers). Three definite-time overcurrent protection elements (DMT) exist both for the phases and for the earth. The current threshold and the delay time can be set within a wide range. In addition, inverse-time overcurrent protection characteristics (IDMTL) can be activated.
The inverse-time function provides – as an option – voltage-restraint or voltage-controlled operating modes.

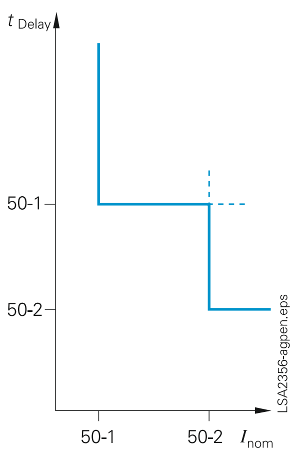

Fig. 5/77
Definite-time overcurrent protection

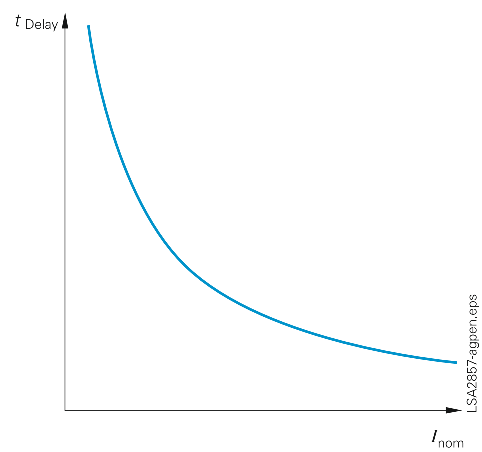

Fig. 5/78
Inverse-time overcurrent protection

Available inverse-time characteristics

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

Reset characteristics

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

User-definable characteristics

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

Inrush restraint

The relay features second harmonic restraint. If the second harmonic is detected during transformer energization, pickup of non-directional and directional normal elements are blocked.

Cold load pickup/dynamic setting change

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

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Protection functions

Directional time-overcurrent protection (ANSI 67, 67N)

Directional phase and earth protection are separate functions. They operate in parallel to the non-directional overcurrent elements. Their pickup values and delay times can be set separately. Definite-time and inverse-time characteristics are offered. The tripping characteristic can be rotated about ± 180 degrees.

By means of voltage memory, directionality can be determined reliably even for close-in (local) faults. If the switching device closes onto a fault and the voltage is too low to determine direction, directionality (directional decision) is made with voltage from the voltage memory. If no voltage exists in the memory, tripping occurs according to the coordination schedule.

For earth protection, users can choose whether the direction is to be determined via zero-sequence system or negative-sequence system quantities (selectable). Using negative-sequence variables can be advantageous in cases where the zero voltage tends to be very low due to unfavorable zero-sequence impedances.

Directional comparison protection (cross-coupling)

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

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

For isolated-neutral and compensated networks, the direction of power flow in the zero sequence is calculated from the zero-sequence current I_0 and zero-sequence voltage V_0.

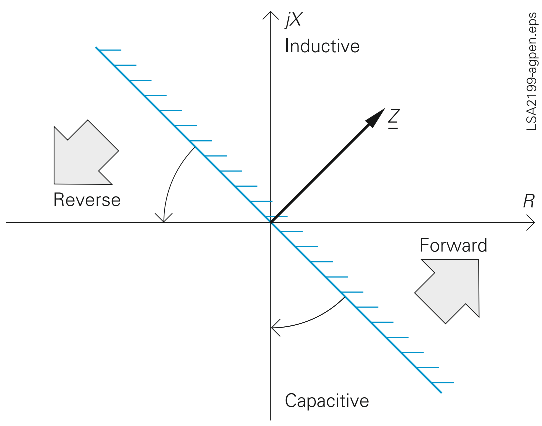

Fig. 5/80
Directional characteristic of the directional time-overcurrent protection

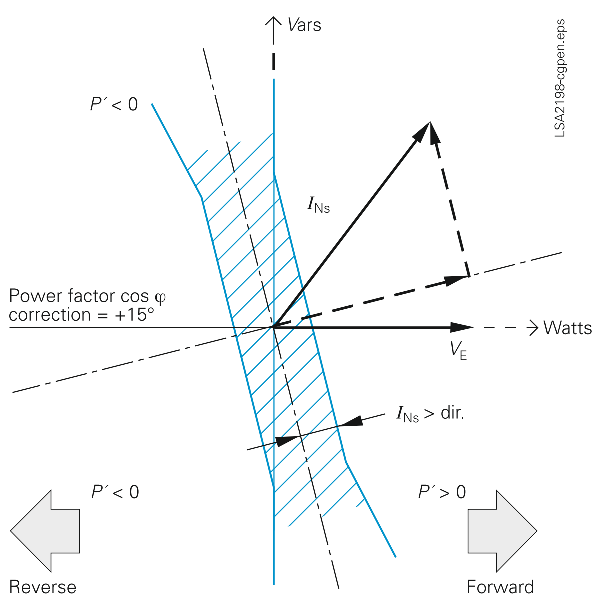

Fig. 5/81
Directional determination using cosine measurements for compensated networks

For networks with an isolated neutral, the reactive current component is evaluated; for compensated networks, the active current component or residual resistive current is evaluated. For special network conditions, e.g. high-resistance earthed networks with ohmic-capacitive earth-fault current or low-resistance earthed networks with ohmic-inductive current, the tripping characteristics can be rotated approximately ± 45 degrees.

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

It has the following functions:

- TRIP via the displacement voltage V_E.
- Two instantaneous elements or one instantaneous plus one user-defined characteristic.
- Each element can be set in forward, reverse, or non-directional.
- The function can also be operated in the insensitive mode as an additional short-circuit protection.

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

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

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

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Protection functions

Intermittent earth-fault protection

Intermittent (re-striking) faults occur due to insulation weaknesses in cables or as a result of water penetrating cable joints. Such faults either simply cease at some stage or develop into lasting short-circuits. During intermittent activity, however, star-point resistors in networks that are impedance-earthed may undergo thermal overloading. The normal earth-fault protection cannot reliably detect and interrupt the current pulses, some of which can be very brief.
The selectivity required with intermittent earth faults is achieved by summating the duration of the individual pulses and by triggering when a (settable) summed time is reached. The response threshold I_{IE}> evaluates the r.m.s. value, referred to one systems period.

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

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

Breaker failure protection (ANSI 50BF)

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

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

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

When the high-impedance measurement principle is applied, all current transformers in the protected area are connected in parallel and operated on one common resistor of relatively high *R* whose voltage is measured (see Fig. 5/82). In the case of 7SJ6 units, the voltage is measured by detecting the current through the (external) resistor *R* at the sensitive current measurement input I_{EE}. The varistor *V* serves to limit the voltage in the event of an internal fault. It cuts off the high momentary voltage spikes occurring at transformer saturation. At the same time, this results in smoothing of the voltage without any noteworthy reduction of the average value.
If no faults have occurred and in the event of external faults, the system is at equilibrium, and the voltage through the resistor is approximately zero. In the event of internal faults, an imbalance occurs which leads to a voltage and a current flow through the resistor *R*.

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

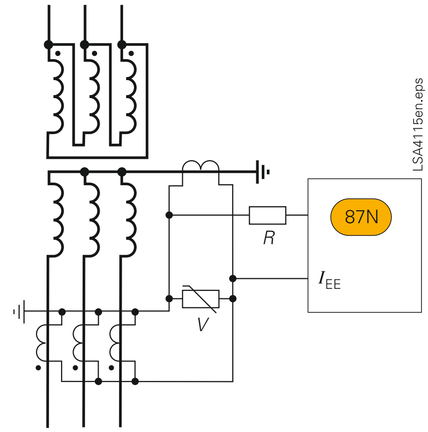

Fig. 5/82 High-impedance restricted earth-fault protection

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Protection functions

Flexible protection functions

The 7SJ62 units enable the user to easily add on up to 20 protective functions. To this end, parameter definitions are used to link a standard protection logic with any chosen characteristic quantity (measured or derived quantity) (Fig. 5/80). The standard logic consists of the usual protection elements such as the pickup message, the parameter-definable delay time, the TRIP command, a blocking possibility, etc. The mode of operation for current, voltage, power and power factor quantities can be three-phase or single-phase. Almost all quantities can be operated as greater than or less than stages. All stages operate with protection priority.

Protection stages/functions attainable on the basis of the available characteristic quantities:

Function	ANSI No.
I>, I_E>	50, 50N
V<, V>, V_E>, dV/dt	27, 59, 59R, 64
$3I_0$>, I_1>, I_2>, I_2/I_1 $3V_0$>, V_1><, V_2><	50N, 46 59N, 47
P><, Q><	32
cos φ (p.f.)><	55
f><	81O, 81U
df/dt><	81R

For example, the following can be implemented:

- Reverse power protection (ANSI 32R)
- Rate-of-frequency-change protection (ANSI 81R)

Synchro-check (ANSI 25)

In case of switching ON the circuit-breaker, the units can check whether the two subnetworks are synchronized. Voltage-, frequency- and phase-angle-differences are being checked to determine whether synchronous conditions are existent.

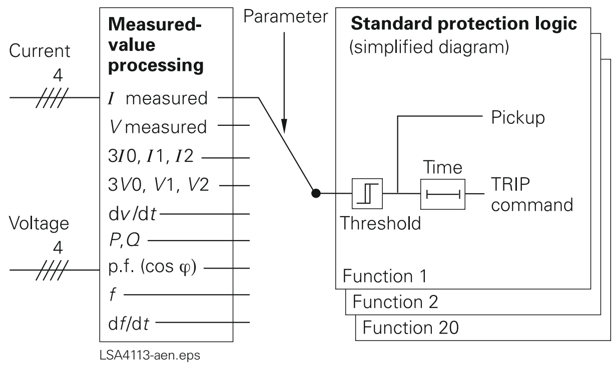

Fig. 5/83 Flexible protection functions

Auto-reclosure (ANSI 79)

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

- 3-pole ARC for all types of faults
- Separate settings for phase and earth faults
- Multiple ARC, one rapid auto-reclosure (RAR) and up to nine delayed auto-reclosures (DAR)
- Starting of the ARC depends on the trip command selection (e.g. 46, 50, 51, 67)
- Blocking option of the ARC via binary inputs
- ARC can be initiated externally or via CFC
- The directional and non-directional elements can either be blocked or operated non-delayed depending on the auto-reclosure cycle
- Dynamic setting change of the directional and non-directional elements can be activated depending on the ready AR

Thermal overload protection (ANSI 49)

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

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

Settable dropout delay times

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

5

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Protection functions

Motor protection

Restart inhibit (ANSI 66/86)

If a motor is started up too many times in succession, the rotor can be subject to thermal overload, especially the upper edges of the bars. The rotor temperature is calculated from the stator current. The reclosing lockout only permits start-up of the motor if the rotor has sufficient thermal reserves for a complete start-up (see Fig. 5/84).

Emergency start-up

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

Temperature monitoring (ANSI 38)

Up to two temperature monitoring boxes with a total of 12 measuring sensors can be used for temperature monitoring and detection by the protection relay. The thermal status of motors, generators and transformers can be monitored with this device. Additionally, the temperature of the bearings of rotating machines are monitored for limit value violation. The temperatures are being measured with the help of temperature detectors at various locations of the device to be protected. This data is transmitted to the protection relay via one or two temperature monitoring boxes (see “Accessories”, page 5/115).

Starting time supervision (ANSI 48/14)

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

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

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

I	=	Actual current flowing
$I_{\text{MOTOR START}}$	=	Pickup current to detect a motor start
t	=	Tripping time
I_A	=	Rated motor starting current
T_A	=	Tripping time at rated motor starting current (2 times, for warm and cold motor)

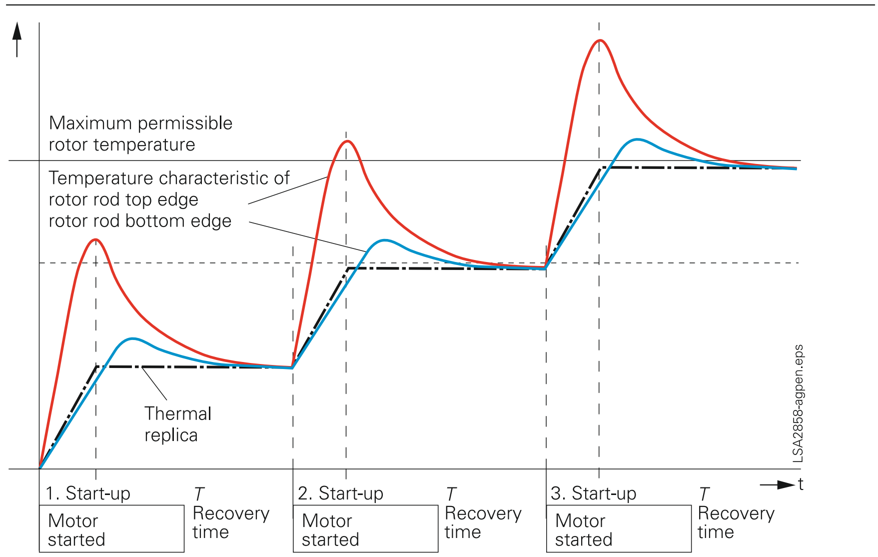

Fig. 5/84

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

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

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

Load jam protection (ANSI 51M)

Sudden high loads can cause slowing down and blocking of the motor and mechanical damages. The rise of current due to a load jam is being monitored by this function (alarm and tripping).

The overload protection function is too slow and therefore not suitable under these circumstances.

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

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

Undercurrent monitoring (ANSI 37)

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

Motor statistics

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

Voltage protection

Overvoltage protection (ANSI 59)

The two-element overvoltage protection detects unwanted network and machine overvoltage conditions. The function can operate either with phase-to-phase, phase-to-earth, positive phase-sequence or negative phase-sequence system voltage. Three-phase and single-phase connections are possible.

Undervoltage protection (ANSI 27)

The two-element undervoltage protection provides protection against dangerous voltage drops (especially for electric machines). Applications include the isolation of generators or motors from the network to avoid undesired operating states and a possible loss of stability. Proper operating conditions of electrical machines are best evaluated with the positive-sequence quantities. The protection function is active over a wide frequency range (45 to 55, 55 to 65 Hz)[1]. Even when falling below this frequency range the function continues to work, however, with a greater tolerance band.

1) The 45 to 55, 55 to 65 Hz range is available for f_N = 50/60 Hz.

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Protection functions/Functions

The function can operate either with phase-to-phase, phase-to-earth or positive phase-sequence voltage and can be monitored with a current criterion. Three-phase and single-phase connections are possible.

Frequency protection (ANSI 81O/U)

Frequency protection can be used for over-frequency and underfrequency protection. Electric machines and parts of the system are protected from unwanted speed deviations. Unwanted frequency changes in the network can be detected and the load can be removed at a specified frequency setting.

Frequency protection can be used over a wide frequency range (40 to 60, 50 to 70 Hz)[1)]. There are four elements (selectable as overfrequency or underfrequency) and each element can be delayed separately. Blocking of the frequency protection can be performed if using a binary input or by using an undervoltage element.

Fault locator (ANSI 21FL)

The integrated fault locator calculates the fault impedance and the distance-to-fault. The results are displayed in Ω, kilometers (miles) and in percent of the line length.

Circuit-breaker wear monitoring

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

There is no mathematically exact method of calculating the wear or the remaining service life of circuit-breakers that takes into account the arc-chamber's physical conditions when the CB opens. This is why various methods of determining CB wear have evolved which reflect the different operator philosophies. To do justice to these, the devices offer several methods:

- ΣI
- ΣI^x, with x = 1... 3
- $\Sigma i^2 t$

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

- Two-point method

1) The 40 to 60, 50 to 70 Hz range is available for f_N= 50/60 Hz

The CB manufacturers double-logarithmic switching cycle diagram (see Fig. 5/107) and the breaking current at the time of contact opening serve as the basis for this method. After CB opening, the two-point method calculates the number of still possible switching cycles. To this end, the two points P1 and P2 only have to be set on the device. These are specified in the CB's technical data.

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

Customized functions (ANSI 32, 51V, 55, etc.)

Additional functions, which are not time critical, can be implemented via the CFC using measured values. Typical functions include reverse power, voltage controlled overcurrent, phase angle detection, and zero-sequence voltage detection.

Commissioning

Commissioning could hardly be easier and is fully supported by DIGSI 4. The status of the binary inputs can be read individually and the state of the binary outputs can be set individually. The operation of switching elements (circuit-breakers, disconnect devices) can be checked using the switching functions of the bay controller. The analog measured values are represented as wide-ranging operational measured values. To prevent transmission of information to the control center during maintenance, the bay controller communications can be disabled to prevent unnecessary data from being transmitted. During commissioning, all indications with test marking for test purposes can be connected to a control and protection system.

Test operation

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

■ *Control and automatic functions*

Control

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

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

The status of primary equipment or auxiliary devices can be obtained from auxiliary

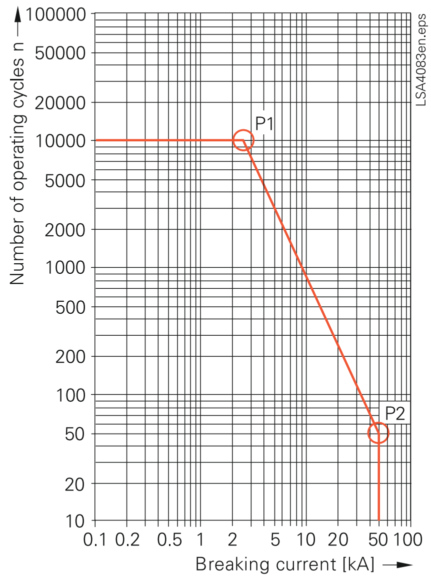

Fig. 5/85 CB switching cycle diagram

contacts and communicated to the 7SJ62 via binary inputs. Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a fault or intermediate circuit-breaker or auxiliary contact position.

The switchgear or circuit-breaker can be controlled via:
– integrated operator panel
– binary inputs
– substation control and protection system
– DIGSI 4

Automation / user-defined logic

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

Switching authority

Switching authority is determined according to parameters and communication.

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

Command processing

All the functionality of command processing is offered. This includes the processing of single and double commands with or without feedback, sophisticated monitoring of the control hardware and software, checking of the external process, control actions using functions such as runtime

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Functions

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

Assignment of feedback to command

The positions of the circuit-breaker or switching devices and transformer taps are acquired by feedback. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication change is a consequence of switching operation or whether it is a spontaneous change of state.

Chatter disable

Chatter disable feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

Indication filtering and delay

Binary indications can be filtered or delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time. In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

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

Switchgear cubicles for high/medium voltage

All units are designed specifically to meet the requirements of high/medium-voltage applications.

In general, no separate measuring instruments (e.g., for current, voltage, frequency, …) or additional control components are necessary.

Measured values

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

- Currents I_{L1}, I_{L2}, I_{L3}, I_E, I_{EE} (67Ns)
- Voltages V_{L1}, V_{L2}, V_{L3}, V_{L1L2}, V_{L2L3}, V_{L3L1}
- Symmetrical components I_1, I_2, $3I_0$; V_1, V_2, V_0
- Power Watts, Vars, VA/P, Q, S (P, Q: total and phase selective)
- Power factor (cos φ), (total and phase selective)
- Frequency
- Energy ± kWh, ± kVarh, forward and reverse power flow
- Mean as well as minimum and maximum current and voltage values
- Operating hours counter
- Mean operating temperature of overload function
- Limit value monitoring
  Limit values are monitored using programmable logic in the CFC. Commands can be derived from this limit value indication.
- Zero suppression
  In a certain range of very low measured values, the value is set to zero to suppress interference.

Metered values

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

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

Fig. 5/86
NXAIR panel (air-insulated)

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Communication

In terms of communication, the units offer substantial flexibility in the context of connection to industrial and power automation standards. Communication can be extended or added on thanks to modules for retrofitting on which the common protocols run. Therefore, also in the future it will be possible to optimally integrate units into the changing communication infrastructure, for example in Ethernet networks (which will also be used increasingly in the power supply sector in the years to come).

Serial front interface

There is a serial RS232 interface on the front of all the units. All of the unit's functions can be set on a PC by means of the DIGSI 4 protection operation program. Commissioning tools and fault analysis are also built into the program and are available through this interface.

Rear-mounted interfaces[1)]

A number of communication modules suitable for various applications can be fitted in the rear of the flush-mounting housing. In the flush-mounting housing, the modules can be easily replaced by the user. The interface modules support the following applications:

- Time synchronization interface
  All units feature a permanently integrated electrical time synchronization interface. It can be used to feed timing telegrams in IRIG-B or DCF77 format into the units via time synchronization receivers.
- System interface
  Communication with a central control system takes place through this interface. Radial or ring type station bus topologies can be configured depending on the chosen interface. Furthermore, the units can exchange data through this interface via Ethernet and IEC 61850 protocol and can also be operated by DIGSI.
- Service interface
  The service interface was conceived for remote access to a number of protection units via DIGSI. On all units, it can be an electrical RS232/RS485 or an optical interface. For special applications, a maximum of two temperature monitoring boxes (RTD-box) can be connected to this interface as an alternative.

System interface protocols (retrofittable)

IEC 61850 protocol

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

IEC 60870-5-103 protocol

The IEC 60870-5-103 protocol is an international standard for the transmission of protective data and fault recordings. All messages from the unit and also control commands can be transferred by means of published, Siemens-specific extensions to the protocol.
Redundant solutions are also possible. Optionally it is possible to read out and alter individual parameters (only possible with the redundant module).

PROFIBUS-DP protocol

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

MODBUS RTU protocol

This uncomplicated, serial protocol is mainly used in industry and by power supply corporations, and is supported by a number of unit manufacturers. SIPROTEC units function as MODBUS slaves, making their information available to a master or receiving information from it. A time-stamped event list is available.

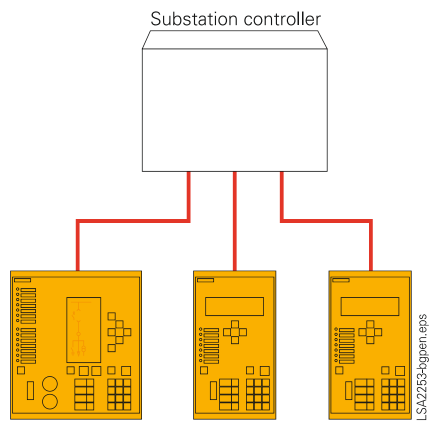

Fig. 5/87
IEC 60870-5-103: Radial fiber-optic connection

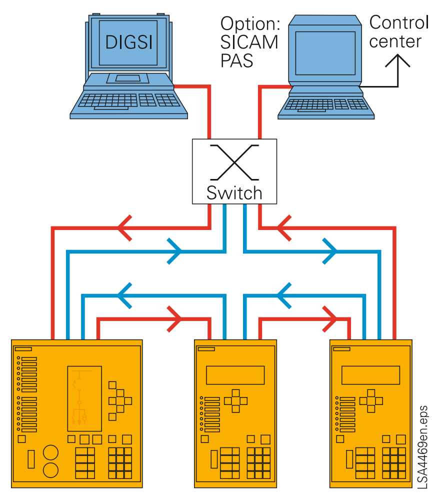

Fig. 5/88
Bus structure for station bus with Ethernet and IEC 61850, fiber-optic ring

1) For units in panel surface-mounting housings please refer to note on page 5/114.

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Communication

DNP 3.0 protocol

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

System solutions for protection and station control

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

Units featuring IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 5/87).

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

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 5/88).

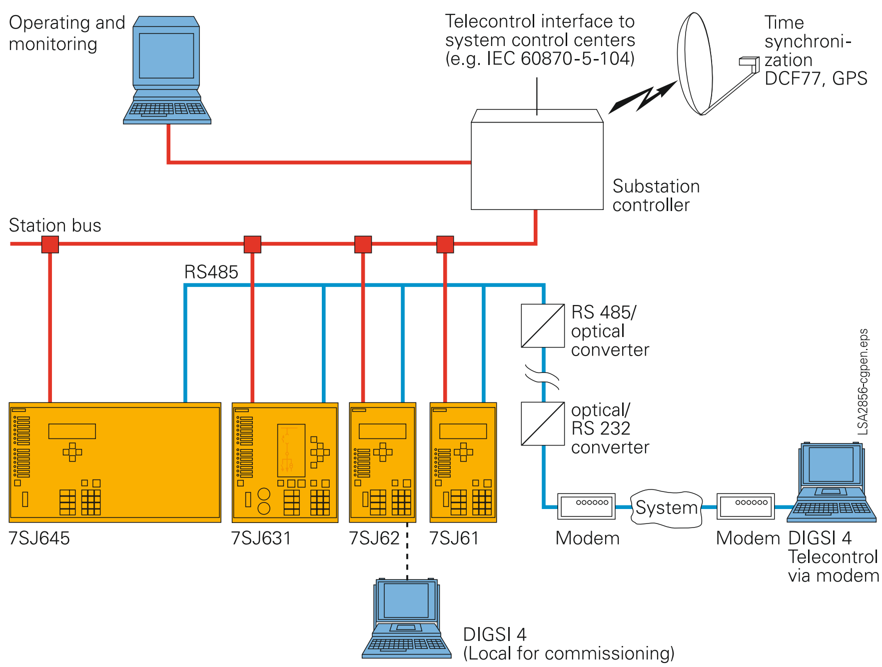

Fig. 5/90
System solution/communication

Fig. 5/89
Optical Ethernet communication module for IEC 61850 with integrated Ethernet-switch

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Typical connections

■ Connection of current and voltage transformers

Standard connection

For earthed networks, the earth current is obtained from the phase currents by the residual current circuit.

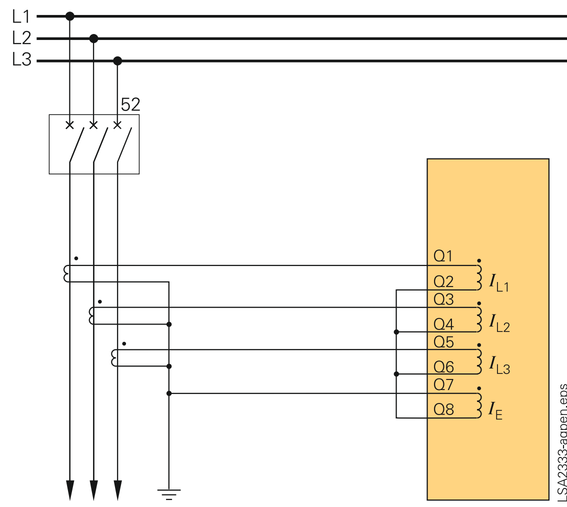

Fig. 5/91
Residual current circuit without directional element

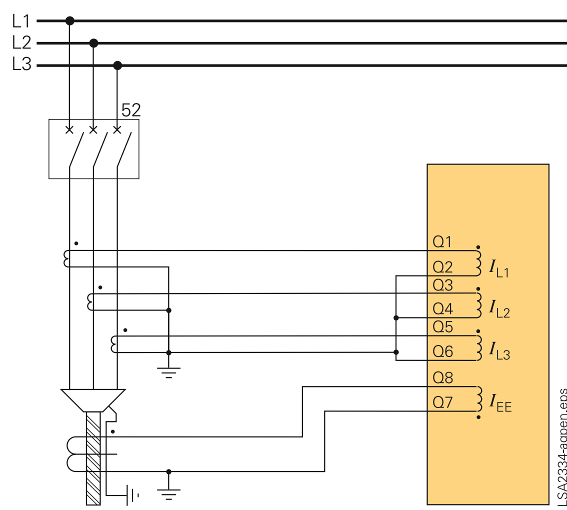

Fig. 5/92
Sensitive earth-current detection without directional element

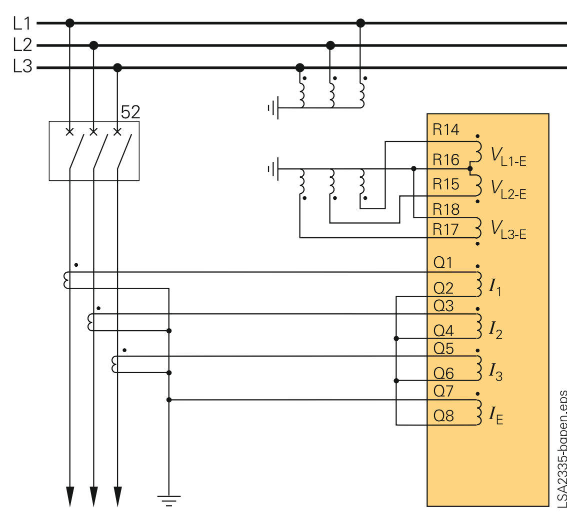

Fig. 5/93
Residual current circuit with directional element

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Typical connections

Connection for compensated networks

The figure shows the connection of two phase-to-earth voltages and the V_E voltage of the open delta winding and a phase-balance neutral current transformer for the earth current. This connection maintains maximum precision for directional earth-fault detection and must be used in compensated networks.
Fig. 5/94 shows sensitive directional earth-fault detection.

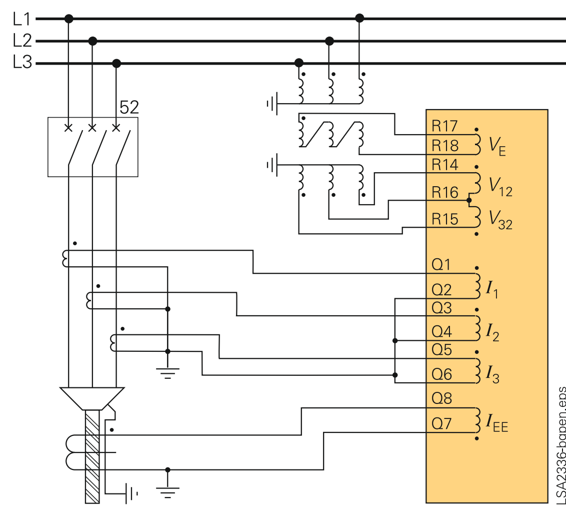

Fig. 5/94
Sensitive directional earth-fault detection with directional element for phases

Connection for isolated-neutral or compensated networks only

If directional earth-fault protection is not used, the connection can be made with only two phase current transformers. Directional phase short-circuit protection can be achieved by using only two primary transformers.

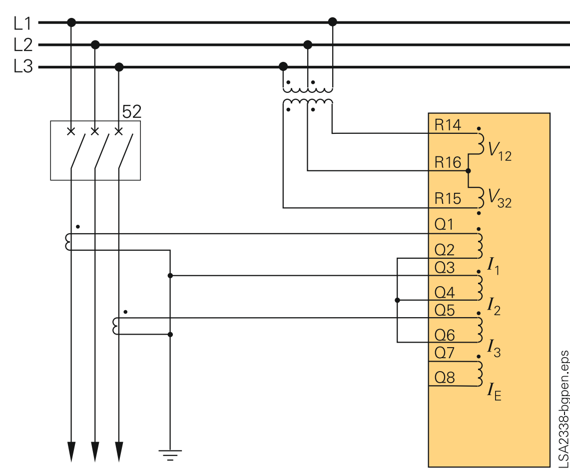

Fig. 5/95
Isolated-neutral or compensated networks

Connection for the synchro-check function

The 3-phase system is connected as reference voltage, i. e. the outgoing voltages as well as a single-phase voltage, in this case a busbar voltage, that has to be checked for synchronism.

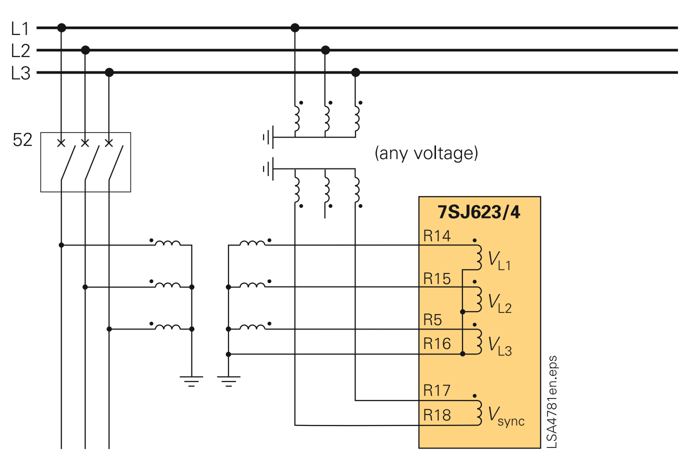

Fig. 5/96
Measuring of the busbar voltage and the outgoing feeder voltage for the synchro-check

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Typical applications

Overview of connection types

Type of network	Function	Current connection	Voltage connection
(Low-resistance) earthed network	Time-overcurrent protection phase/earth non-directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformer possible	-
(Low-resistance) earthed networks	Sensitive earth-fault protection	Phase-balance neutral current transformers required	-
Isolated or compensated networks	Time-overcurrent protection phases non-directional	Residual circuit, with 3 or 2 phase current transformers possible	-
(Low-resistance) earthed networks	Time-overcurrent protection phases directional	Residual circuit, with 3 phase-current transformers possible	Phase-to-earth connection or phase-to-phase connection
Isolated or compensated networks	Time-overcurrent protection phases directional	Residual circuit, with 3 or 2 phase-current transformers possible	Phase-to-earth connection or phase-to-phase connection
(Low-resistance) earthed networks	Time-overcurrent protection earth directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformers possible	Phase-to-earth connection required
Isolated networks	Sensitive earth-fault protection	Residual circuit, if earth current > 0.05 I_N on secondary side, otherwise phase-balance neutral current transformers required	3 times phase-to-earth connection or phase-to-earth connection with open delta winding
Compensated networks	Sensitive earth-fault protection cos φ measurement	Phase-balance neutral current transformers required	Phase-to-earth connection with open delta winding required

5

■ Connection of circuit-breaker

Undervoltage releases

Undervoltage releases are used for automatic tripping of high-voltage motors.

Example:
DC supply voltage of control system fails and manual electric tripping is no longer possible.

Automatic tripping takes place when voltage across the coil drops below the trip limit. In Fig. 5/97, tripping occurs due to failure of DC supply voltage, by automatic opening of the live status contact upon failure of the protection unit or by short-circuiting the trip coil in event of network fault.

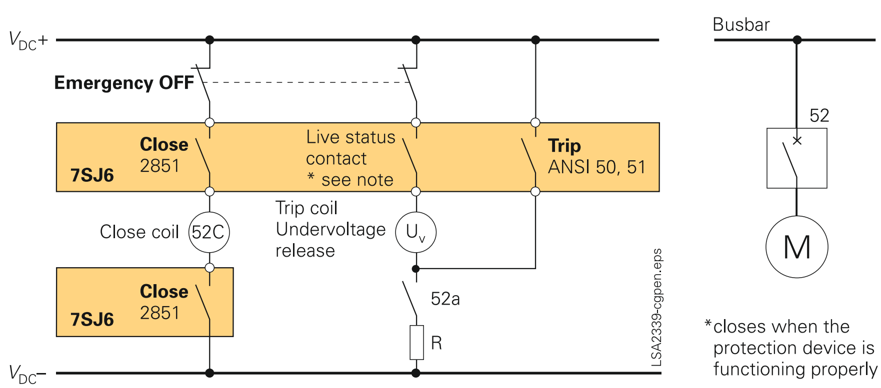

Fig. 5/97 Undervoltage release with make contact (50, 51)

In Fig. 5/98 tripping is by failure of auxiliary voltage and by interruption of tripping circuit in the event of network failure. Upon failure of the protection unit, the tripping circuit is also interrupted, since contact held by internal logic drops back into open position.

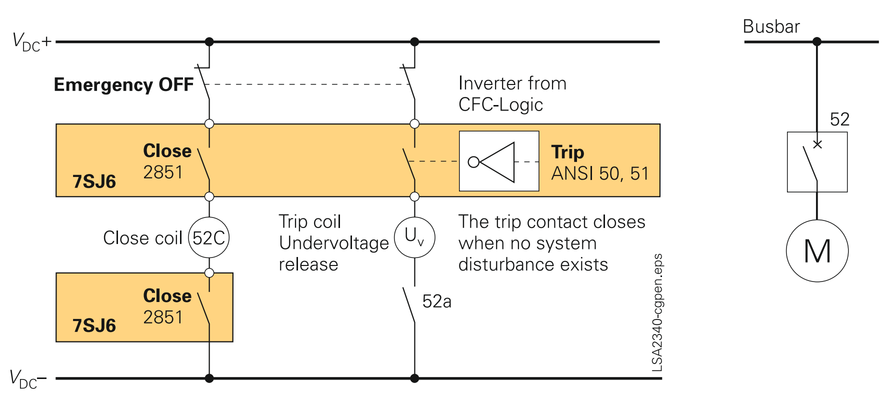

Fig. 5/98 Undervoltage trip with locking contact (trip signal 50 is inverted)

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5

Typical applications

Trip circuit supervision (ANSI 74TC)

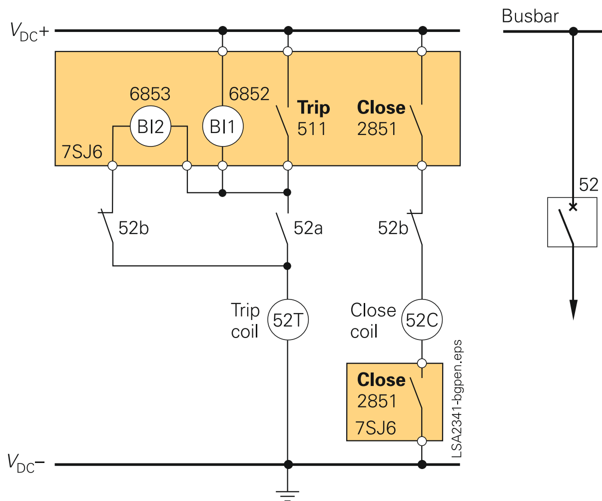
One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal occurs whenever the circuit is interrupted.

Lockout (ANSI 86)

All binary outputs can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only occur after the lockout state is reset.

Reverse-power protection for dual supply (ANSI 32R)

If power is fed to a busbar through two parallel infeeds, then in the event of any fault on one of the infeeds it should be selectively interrupted. This ensures a continued supply to the busbar through the remaining infeed. For this purpose, directional devices are needed which detect a short-circuit current or a power flow from the busbar in the direction of the infeed. The directional time-overcurrent protection is usually set via the load current. It cannot be used to deactivate low-current faults. Reverse-power protection can be set far below the rated power. This ensures that it also detects power feedback into the line in the event of low-current faults with levels far below the load current. Reverse-power protection is performed via the "flexible protection functions" of the 7SJ62.



Protection indications

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

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

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

Fig. 5/99 Trip circuit supervision with 2 binary inputs

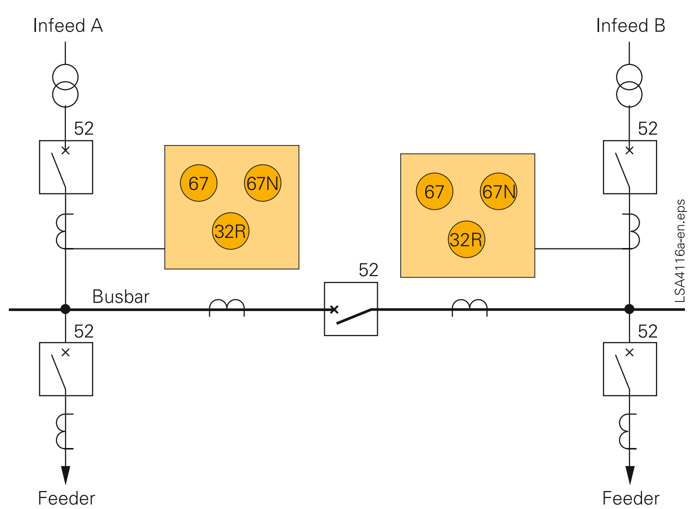


Fig. 5/100 Reverse-power protection for dual supply

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Technical data

General unit data

Measuring circuits

System frequency	50 / 60 Hz (settable)

Current transformer

Rated current I_{nom}	1 or 5 A (settable)
Option: sensitive earth-fault CT	I_{EE} < 1.6 A
Power consumption at I_{nom} = 1 A at I_{nom} = 5 A for sensitive earth-fault CT at 1 A	 Approx. 0.05 VA per phase Approx. 0.3 VA per phase Approx. 0.05 VA
Overload capability Thermal (effective)	 100 x I_{nom} for 1 s 30 x I_{nom} for 10 s 4 x I_{nom} continuous
Dynamic (impulse current)	250 x I_{nom} (half cycle)
Overload capability if equipped with sensitive earth-fault CT Thermal (effective)	 300 A for 1 s 100 A for 10 s 15 A continuous
Dynamic (impulse current)	750 A (half cycle)

Voltage transformer

Type	7SJ621, 7SJ622	7SJ623, 7SJ622	7SJ625, 7SJ626
Number	3	4	4
Rated voltage V_{nom}	100 V to 225 V		
Measuring range	0 V to 170 V		
Power consumption at V_{nom} = 100 V	< 0.3 VA per phase		
Overload capability in voltage path (phase-neutral voltage) Thermal (effective)	230 V continuous		

Auxiliary voltage

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

Binary inputs/indication inputs

Type	7SJ621, 7SJ623, 7SJ625	7SJ622, 7SJ624, 7SJ626
Number	8	11
Voltage range	24–250 V DC	
Pickup threshold modifiable by plug-in jumpers		
Pickup threshold	19 V DC	88 V DC
For rated control voltage	24/48/60/ 110/125 V	110/125/ 220/250 V DC
Response time/drop-out time	Approx. 3.5	
Power consumption energized	1.8 mA (independent of operating voltage)	

Binary outputs/command outputs

Type	7SJ621, 7SJ623, 7SJ625	7SJ622, 7SJ624, 7SJ626
Command/indication relay	8	6
Contacts per command/ indication relay	1 NO / form A (Two contacts changeable to NC/form B, via jumpers)	
Live status contact	1 NO / NC (jumper) / form A/B	
Switching capacity Make	1000 W / VA	
Break	30 W / VA / 40 W resistive / 25 W at L/R ≤ 50 ms	
Switching voltage	≤ 250 V DC	
Permissible current	5 A continuous, 30 A for 0.5 s making current, 2000 switching cycles	

Electrical tests

Specification

Standards	IEC 60255 ANSI C37.90, C37.90.1, C37.90.2, UL508

Insulation tests

Standards	IEC 60255-5; ANSI/IEEE C37.90.0
Voltage test (100 % test) all circuits except for auxiliary voltage and RS485/RS232 and time synchronization	2.5 kV (r.m.s. value), 50/60 Hz
Auxiliary voltage	3.5 kV DC
Communication ports and time synchronization	500 V AC
Impulse voltage test (type test) all circuits, except communication ports and time synchronization, class III	5 kV (peak value); 1.2/50 µs; 0.5 J 3 positive and 3 negative impulses at intervals of 5 s

EMC tests for interference immunity; type tests

Standards	IEC 60255-6; IEC 60255-22 (product standard) EN 50082-2 (generic specification) DIN 57435 Part 303
High-frequency test IEC 60255-22-1, class III and VDE 0435 Part 303, class III	2.5 kV (peak value); 1 MHz; τ =15 ms; 400 surges per s; test duration 2 s
Electrostatic discharge IEC 60255-22-2 class IV and EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air gap discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with radio-frequency field, non-modulated IEC 60255-22-3 (Report) class III	10 V/m; 27 to 500 MHz
Irradiation with radio-frequency field, amplitude-modulated IEC 61000-4-3; class III	10 V/m, 80 to 1000 MHz; AM 80 %; 1 kHz
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204; class III	10 V/m, 900 MHz; repetition rate 200 Hz, on duration 50 %
Fast transient interference/burst IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; test duration 1 min

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EMC tests for interference immunity; type tests (cont'd)	
High-energy surge voltages (Surge) IEC 61000-4-5; class III	
Auxiliary voltage	From circuit to circuit: 2 kV; 12 Ω; 9 µF across contacts: 1 kV; 2 Ω ;18 µF
Binary inputs/outputs	From circuit to circuit: 2 kV; 42 Ω; 0.5 µF across contacts: 1 kV; 42 Ω; 0.5 µF
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; AM 80 %; 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m; 50 Hz, continuous 300 A/m; 50 Hz, 3 s 0.5 mT, 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak value), 1 to 1.5 MHz damped wave; 50 surges per s; duration 2 s, R_i = 150 to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per s both polarities; duration 2 s, R_i = 80 Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz; amplitude and pulse-modulated
Damped wave IEC 60694 / IEC 61000-4-12	2.5 kV (peak value, polarity alternating) 100 kHz, 1 MHz, 10 and 50 MHz, R_i = 200 Ω
EMC tests for interference emission; *type tests*	
Standard	EN 50081-* (generic specification)
Conducted interferences only auxiliary voltage IEC/CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC/CISPR 11	30 to 1000 MHz Limit class B
Units with a detached operator panel must be installed in a metal cubicle to maintain limit class B	

Mechanical stress tests	
Vibration, shock stress and seismic vibration	
During operation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz; +/- 0.075 mm amplitude; 60 to 150 Hz; 1 *g* acceleration frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 5 *g*, duration 11 ms; 3 shocks in both directions of 3 axes
Seismic vibration IEC 60255-21-3, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 perpendicular axes
During transportation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz; 2 *g* acceleration, frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, Class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 15 *g*, duration 11 ms 3 shocks in both directions of 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Semi-sinusoidal Acceleration 10 *g*, duration 16 ms 1000 shocks in both directions of 3 axes

Climatic stress tests	
Temperatures	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C /-13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	-20 °C to +70 °C /-4 °F to -158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C /+131 °F)	-5 °C to +55 °C /+25 °F to +131 °F
– Limiting temperature during permanent storage	-25 °C to +55 °C /-13 °F to +131 °F
– Limiting temperature during transport	-25 °C to +70 °C /-13 °F to +158 °F
Humidity	
Permissible humidity It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average 75 % relative humidity; on 56 days a year up to 95 % relative humidity; condensation not permissible!

Unit design	
Housing	7XP20
Dimensions	See dimension drawings, part 15
Weight Surface-mounting housing Flush-mounting housing	4.5 kg 4.0 kg
Degree of protection acc. to EN 60529 Surface-mounting housing Flush-mounting housing Operator safety	IP 51 Front: IP 51, rear: IP 20; IP 2x with cover

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Technical data

Serial interfaces	
Operating interface *(front of unit)*	
Connection	Non-isolated, RS232; front panel, 9-pin subminiature connector
Transmission rate	Factory setting 115200 baud, min. 4800 baud, max. 115200 baud
Service/modem interface *(rear of unit)*	
Isolated interface for data transfer	Port C: DIGSI 4/modem/RTD-box
Transmission rate	Factory setting 38400 baud, min. 4800 baud, max. 115200 baud
RS232/RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location “C”
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	15 m /49.2 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth
System interface *(rear of unit)*	
IEC 60870-5-103 protocol	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Factory setting 9600 baud, min. 1200 baud, max. 115200 baud
RS232/RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	Max. 15 m/49 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth
Fiber optic	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles
IEC 60870-5-103 protocol, redundant	
RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	(not available)
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth

IEC 61850 protocol	
Isolated interface for data transfer: - to a control center - with DIGSI - between SIPROTEC 4 relays	Port B, 100 Base T acc. to IEEE802.3
Transmission rate	100 Mbit
Ethernet, electrical	
Connection For flush-mounting housing/ surface-mounting housing with detached operator panel	Two RJ45 connectors mounting location "B"
Distance	Max. 20 m / 65.6 ft
Test voltage	500 V AC against earth
Ethernet, optical	
Connection	Intergr. LC connector for FO connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
Optical wavelength	1300 nmm
Distance	1.5 km/0.9 miles
PROFIBUS-FMS/DP	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 1.5 Mbaud
RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance	1000 m/3300 ft ≤ 93.75 kbaud; 500 m/1500 ft ≤ 187.5 kbaud; 200 m/600 ft ≤ 1.5 Mbaud; 100 m/300 ft ≤ 12 Mbaud
Test voltage	500 V AC against earth
Fiber optic	
Connection fiber-optic cable	Integr. ST connector for FO connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing Important: Please refer to footnotes 1) and 2) on page 5/136
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	500 kB/s 1.6 km/0.99 miles 1500 kB/s 530 m/0.33 miles
MODBUS RTU, ASCII, DNP 3.0	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 19200 baud

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Technical data

System interface *(rear of unit) (cont'd)*	
RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location "B"
For surface-mounting housing with two-tier terminal at the top/bottom part	At bottom part of the housing: shielded data cable
Test voltage	500 V AC against earth
Fiber-optic	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing Important: Please refer to footnotes [1] and [2] on page 5/136
Optical wavelength	820 nm
Permissible path attenuation	Max 8 dB. for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles
Time synchronization DCF77/IRIG-B signal (Format IRIG-B000)	
Connection	9-pin subminiature connector (SUB-D) (terminal with surface-mounting housing)
Voltage levels	5 V, 12 V or 24 V (optional)

Functions

Definite-time overcurrent protection, directional/non-directional *(ANSI 50, 50N, 67, 67N)*		
Operating mode non-directional phase protection (ANSI 50)	3-phase (standard) or 2-phase (L1 and L3)	
Number of elements (stages)	$I>$, $I>>$, $I>>>$ (phases) $I_E>$, $I_E>>$, $I_E>>>$ (earth)	
Setting ranges		
Pickup phase elements	0.5 to 175 A or ∞[1] (in steps of 0.01 A)	
Pickup earth elements	0.25 to 175 A or ∞[1] (in steps of 0.01 A)	
Delay times T	0 to 60 s or ∞ (in steps of 0.01 s)	
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)	
Times		
Pickup times (without inrush restraint, with inrush restraint + 10 ms)	Non-directional	Directional
With twice the setting value	Approx. 30 ms	45 ms
With five times the setting value	Approx. 20 ms	40 ms
Dropout times	Approx. 40 ms	
Dropout ratio	Approx. 0.95 for $I/I_{nom} \geq 0.3$	
Tolerances		
Pickup	2 % of setting value or 50 mA[1]	
Delay times T, T_{DO}	1 % or 10 ms	

1) At I_{nom} = 1 A, all limits divided by 5.

Inverse-time overcurrent protection, directional/non-directional *(ANSI 51, 51N, 67, 67N)*	
Operating mode non-directional phase protection (ANSI 51)	3-phase (standard) or 2-phase (L1 and L3)
Setting ranges	
Pickup phase element I_P	0.5 to 20 A or ∞ [1] (in steps of 0.01 A)
Pickup earth element I_{EP}	0.25 to 20 A or ∞ [1] (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.05 to 15 s or ∞ (in steps of 0.01 s)
Undervoltage threshold $V<$ for release I_p	10.0 to 125.0 V (in steps of 0.1 V)
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse, long inverse
ANSI	Inverse, short inverse, long inverse moderately inverse, very inverse, extremely inverse, definite inverse
User-defined characteristic	Defined by a maximum of 20 value pairs of current and time delay
Dropout setting	
Without disk emulation	Approx. 1.05 · setting value I_p for $I_p/I_{nom} \geq 0.3$, corresponds to approx. 0.95 · pickup threshold
With disk emulation	Approx. 0.90 · setting value I_p
Tolerances	
Pickup/dropout thresholds I_p, I_{Ep}	2 % of setting value or 50 mA[1]
Pickup time for $2 \leq I/I_p \leq 20$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms
Dropout ratio for $0.05 \leq I/I_p \leq 0.9$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms
Direction detection	
For phase faults	
Polarization	With cross-polarized voltages; With voltage memory for measurement voltages that are too low
Forward range	$V_{ref,rot} \pm 86°$
Rotation of reference voltage $V_{ref,rot}$	- 180° to 180° (in steps of 1°)
Direction sensitivity	For one and two-phase faults unlimited; For three-phase faults dynamically unlimited; Steady-state approx. 7 V phase-to-phase
For earth faults	
Polarization	With zero-sequence quantities $3V_0$, $3I_0$ or with negative-sequence quantities $3V_2$, $3I_2$
Forward range	$V_{ref,rot} \pm 86°$
Rotation of reference voltage $V_{ref,rot}$	- 180° to 180° (in steps of 1°)
Direction sensitivity	
Zero-sequence quantities $3V_0$, $3I_0$	$V_E \approx 2.5$ V displacement voltage, measured; $3V_0 \approx 5$ V displacement voltage, calculated
Negative-sequence quantities $3V_2$, $3I_2$	$3V_2 \approx 5$ V negative-sequence voltage; $3I_2 \approx 225$ mA negative-sequence current[1]
Tolerances (phase angle error under reference conditions)	
For phase and earth faults	± 3 ° electrical

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Technical data

Inrush blocking

Influenced functions	Time-overcurrent elements, I>, I_E>, I_p, I_{Ep} (directional, non-directional)
Lower function limit phases	At least one phase current (50 Hz and 100 Hz) ≥ 125 mA[1)]
Lower function limit earth	Earth current (50 Hz and 100 Hz) ≥ 125 mA[1)]
Upper function limit (setting range)	1.5 to 125 A[1)] (in steps of 0.01 A)
Setting range I_{2f}/I	10 to 45 % (in steps of 1 %)
Crossblock (I_{L1}, I_{L2}, I_{L3})	ON/OFF

Dynamic setting change

Controllable function	Directional and non-directional pickup, tripping time
Start criteria	Current criteria, CB position via aux. contacts, binary input, auto-reclosure ready
Time control	3 timers
Current criteria	Current threshold (reset on dropping below threshold; monitoring with timer)

(Sensitive) earth-fault detection *(ANSI 64, 50 Ns, 51Ns, 67Ns)*

Displacement voltage starting *for all types of earth fault (ANSI 64)*

Setting ranges	
Pickup threshold V_E> (measured)	1.8 to 170 V (in steps of 0.1 V)
Pickup threshold $3V_0$> (calculated)	10 to 225 V (in steps of 0.1 V)
Delay time $T_{Delay\ pickup}$	0.04 to 320 s or ∞ (in steps of 0.01 s)
Additional trip delay T_{VDELAY}	0.1 to 40000 s or ∞ (in steps of 0.01 s)
Times	
Pickup time	Approx. 50 ms
Dropout ratio	0.95 or (pickup value -0.6 V)
Tolerances	
Pickup threshold V_E (measured)	3 % of setting value or 0.3 V
Pickup threshold $3V_0$ (calculated)	3 % of setting value or 3 V
Delay times	1 % of setting value or 10 ms

Phase detection for earth fault in an unearthed system

Measuring principle	Voltage measurement (phase-to-earth)
Setting ranges	
$V_{ph\ min}$ (earth-fault phase)	10 to 100 V (in steps of 1 V)
$V_{ph\ max}$ (unfaulted phases)	10 to 100 V (in steps of 1 V)
Measuring tolerance acc. to DIN 57435 part 303	3 % of setting value, or 1 V

Earth-fault pickup *for all types of earth faults*

Definite-time characteristic *(ANSI 50Ns)*

Setting ranges	
Pickup threshold I_{EE}>, I_{EE}>>	
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A[1)] (in steps of 0.01 A)
Delay times T for I_{EE}>, I_{EE}>>	0 to 320 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Times	
Pickup times	Approx. 50 ms
Dropout ratio	Approx. 0.95

1) For I_{nom} = 1 A, all limits divided by 5.

Tolerances	
Pickup threshold	
For sensitive input	2 % of setting value or 1 mA
For normal input	2 % of setting value or 50 mA[1)]
Delay times	1 % of setting value or 20 ms

Earth-fault pickup *for all types of earth faults*

Inverse-time characteristic *(ANSI 51Ns)*

User-defined characteristic	Defined by a maximum of 20 pairs of current and delay time values
Setting ranges	
Pickup threshold I_{EEp}	
For sensitive input	0.001 A to 1.4 A (in steps of 0.001 A)
For normal input	0.25 to 20 A[1)] (in steps of 0.01 A)
User defined	
Time multiplier T	0.1 to 4 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	Approx. 50 ms
Pickup threshold	Approx. 1.1 · I_{EEp}
Dropout ratio	Approx. 1.05 · I_{EEp}
Tolerances	
Pickup threshold	
For sensitive input	2 % of setting value or 1 mA
For normal input	2 % of setting value or 50 mA[1)]
Delay times in linear range	7 % of reference value for 2 ≤ I/I_{EEp} ≤ 20 + 2 % current tolerance, or 70 ms
Logarithmic inverse	Refer to the manual
Logarithmic inverse with knee point	Refer to the manual

Direction detection *for all types of earth-faults (ANSI 67Ns)*

Measuring method "cos φ / sin φ"	
Direction measurement	I_E and V_E measured or $3I_0$ and $3V_0$ calculated
Measuring principle	Active/reactive power measurement
Setting ranges	
Measuring enable $I_{Release\ direct.}$	
For sensitive input	0.001 to 1.2 A (in steps of 0.001 A)
For normal input	0.25 to 150 A[1)] (in steps of 0.01 A)
Direction phasor $\varphi_{Correction}$	- 45 ° to + 45 ° (in steps of 0.1 °)
Dropout delay $T_{Reset\ delay}$	1 to 60 s (in steps of 1 s)
Reduction of dir. area $\alpha_{Red.dir.area}$	1 ° to 15 ° (in steps of 1 °)
Tolerances	
Pickup measuring enable	
For sensitive input	2 % of setting value or 1 mA
For normal input	2 % of setting value or 50 mA[1)]
Angle tolerance	3 °
Measuring method "φ (V_0 / I_0)"	
Direction measurement	I_E and V_E measured or $3I_0$ and $3V_0$ calculated
Minimum voltage V_{min}, measured	0.4 to 50 V (in steps of 0.1 V)
Minimum voltage V_{min}, calculated	10 to 90 V (in steps of 1 V)
Phase angle φ	- 180° to 180° (in steps of 0.1°)
Delta phase angle $\Delta\varphi$	0° to 180° (in steps of 0.1°)
Tolerances	
Pickup threshold V_E (measured)	3 % of setting value or 0.3 V
Pickup threshold $3V_0$ (calculated)	3 % of setting value or 3 V
Angle tolerance	3 °

Angle correction for cable CT

Angle correction F1, F2	
Current value I_1, I_2	0 ° to 5 ° (in steps of 0.1 °)
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A[1)] (in steps of 0.01 A)

Note: Due to the high sensitivity the linear range of the measuring input IN with integrated sensitive input transformer is from 0.001 A to 1.6 A. For currents greater than 1.6 A, correct directionality can no longer be guaranteed.

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Technical data

High-impedance restricted earth-fault protection *(ANSI 87N) / single-phase overcurrent protection*	
Setting ranges	
Pickup thresholds $I>$, $I>>$	
For sensitive input	0.003 to 1.5 A or ∞ (in steps of 0.001 A)
For normal input	0.25 to 175 A[1] or ∞ (in steps of 0.01 A)
Delay times $T_I>$, $T_I>>$	0 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
Minimum	Approx. 20 ms
Typical	Approx. 30 ms
Dropout times	Approx. 30 ms
Dropout ratio	Approx. 0.95 for $I/I_{nom} \geq 0.5$
Tolerances	
Pickup thresholds	3 % of setting value or 1 % rated current at I_{nom} = 1 or 5 A; 5 % of setting value or 3 % rated current at I_{nom} = 0.1 A
Delay times	1 % of setting value or 10 ms
Intermittent earth-fault protection	
Setting ranges	
Pickup threshold	
For I_E $I_{IE}>$	0.25 to 175 A[1] (in steps of 0.01 A)
For $3I_0$ $I_{IE}>$	0.25 to 175 A[1] (in steps of 0.01 A)
For I_{EE} $I_{IE}>$	0.005 to 1.5 A (in steps of 0.001 A)
Pickup prolongation time T_V	0 to 10 s (in steps of 0.01 s)
Earth-fault accumulation time T_{sum}	0 to 100 s (in steps of 0.01 s)
Reset time for accumulation T_{res}	1 to 600 s (in steps of 1 s)
Number of pickups for intermittent earth fault	2 to 10 (in steps of 1)
Times	
Pickup times	
Current = 1.25 · pickup value	Approx. 30 ms
Current ≥ 2 · pickup value	Approx. 22 ms
Dropout time	Approx. 22 ms
Tolerances	
Pickup threshold $I_{IE}>$	3 % of setting value, or 50 mA[1]
Times T_V, T_{sum}, T_{res}	1 % of setting value or 10 ms
Thermal overload protection *(ANSI 49)*	
Setting ranges	
Factor k	0.1 to 4 (in steps of 0.01)
Time constant	1 to 999.9 min (in steps of 0.1 min)
Warning overtemperature $\Theta_{alarm}/\Theta_{trip}$	50 to 100 % with reference to the tripping overtemperature (in steps of 1 %)
Current warning stage I_{alarm}	0.5 to 20 A (in steps of 0.01 A)
Extension factor when stopped k_τ factor	1 to 10 with reference to the time constant with the machine running (in steps of 0.1)
Rated overtemperature (for I_{nom})	40 to 200 °C (in steps of 1 °C)
Tripping characteristic For $(I/k \cdot I_{nom}) \leq 8$	$t = \tau_{th} \cdot \ln \frac{(I/k \cdot I_{nom})^2 - (I_{pre}/k \cdot I_{nom})^2}{(I/k \cdot I_{nom})^2 - 1}$
	t = Tripping time τ_{th} = Temperature rise time constant I = Load current I_{pre} = Preload current k = Setting factor acc. to VDE 0435 Part 3011 and IEC 60255-8 I_{nom} = Rated (nominal) current of the protection relay
Dropout ratios	
Θ/Θ_{Trip}	Drops out with Θ_{Alarm}
Θ/Θ_{Alarm}	Approx. 0.99
I/I_{Alarm}	Approx. 0.97
Tolerances	
With reference to k · I_{nom}	Class 5 acc. to IEC 60255-8
With reference to tripping time	5 % +/- 2 s acc. to IEC 60255-8

1) For I_{nom} = 1 A, all limits divided by 5.

Auto-reclosure *(ANSI 79)*	
Number of reclosures	0 to 9 Shot 1 to 4 individually adjustable
Program for phase fault Start-up by	Time-overcurrent elements (dir., non-dir.), negative sequence, binary input
Program for earth fault Start-up by	Time-overcurrent elements (dir., non-dir.), sensitive earth-fault protection, binary input
Blocking of ARC	Pickup of protection functions, three-phase fault detected by a protective element, binary input, last TRIP command after the reclosing cycle is complete (unsuccessful reclosing), TRIP command by the breaker failure protection (50BF), opening the CB without ARC initiation, external CLOSE command
Setting ranges	
Dead time (separate for phase and earth and individual for shots 1 to 4)	0.01 to 320 s (in steps of 0.01 s)
Blocking duration for manual-CLOSE detection	0.5 s to 320 s or 0 (in steps of 0.01 s)
Blocking duration after reclosure	0.5 s to 320 s (in steps of 0.01 s)
Blocking duration after dynamic blocking	0.01 to 320 s (in steps of 0.01 s)
Start-signal monitoring time	0.01 to 320 s or ∞ (in steps of 0.01 s)
Circuit-breaker supervision time	0.1 to 320 s (in steps of 0.01 s)
Max. delay of dead-time start	0 to 1800 s or ∞ (in steps of 0.1 s)
Maximum dead time extension	0.5 to 320 s or ∞ (in steps of 0.01 s)
Action time	0.01 to 320 s or ∞ (in steps of 0.01 s)

The delay times of the following protection function can be altered individually by the ARC for shots 1 to 4 (setting value $T = T$, non-delayed $T = 0$, blocking $T = \infty$):
$I>>>$, $I>>$, $I>$, I_p, $I_{dir}>>$, $I_{dir}>$, I_{pdir}
$I_E>>>$, $I_E>>$, $I_E>$, I_{Ep}, $I_{Edir}>>$, $I_{Edir}>$, I_{Edir}

Additional functions	Lockout (final trip), delay of dead-time start via binary input (monitored), dead-time extension via binary input (monitored), co-ordination with other protection relays, circuit-breaker monitoring, evaluation of the CB contacts

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Technical data

Breaker failure protection (ANSI 50 BF)	
Setting ranges	
Pickup thresholds	0.2 to 5 A[1] (in steps of 0.01 A)
Delay time	0.06 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
with internal start	is contained in the delay time
with external start	is contained in the delay time
Dropout times	Approx. 25 ms
Tolerances	
Pickup value	2 % of setting value (50 mA)[1]
Delay time	1 % or 20 ms

Synchro- and voltage check (ANSI 25)	
Operating mode	• Synchro-check
Additional release conditions	• Live-bus / dead line • Dead-bus / live-line • Dead-bus <u>and</u> dead-line • Bypassing
Voltages	
Max. operating voltage V_{max}	20 to 140 V (phase-to-phase) (in steps of 1 V)
Min. operating voltage V_{min}	20 to 125 V (phase-to-phase) (in steps of 1 V)
V< for dead-line / dead-bus check	1 to 60 V (phase-to-phase) (in steps of 1 V)
V> for live-line / live-bus check	20 to 140 V (phase-to-phase) (in steps of 1 V)
Primary rated voltage of transformer $V2_{nom}$	0.1 to 800 kV (in steps of 0.01 kV)
Tolerances	2 % of pickup value or 2 V
Drop-off to pickup ratios	approx. 0.9 (V>) or 1.1 (V<)
ΔV-measurement	
Voltage difference	0.5 to 50 V (phase-to-phase) (in steps of 1 V)
Tolerance	1 V
Δf-measurement	
Δf-measurement ($f2>f1$; $f2<f1$)	0.01 to 2 Hz (in steps of 0.01 Hz)
Tolerance	15 mHz
$\Delta\alpha$-measurement	
$\Delta\alpha$-measurement ($\alpha2>\alpha1$; $\alpha2>\alpha1$)	2 ° to 80 ° (in steps of 1 °)
Tolerance	2 °
Max. phase displacement	5 ° for $\Delta f \leq$ 1 Hz 10 ° for $\Delta f >$ 1 Hz
Adaptation	
Vector group adaptation by angle	0 ° to 360 ° (in steps of 1 °)
Different voltage transformers V_1/V_2	0.5 to 2 (in steps of 0.01)
Times	
Minimum measuring time	Approx. 80 ms
Max. duration $T_{SYN\ DURATION}$	0.01 to 1200 s; ∞ (in steps of 0.01 s)
Supervision time $T_{SUP\ VOLTAGE}$	0 to 60 s (in steps of 0.01 s)
Closing time of CB $T_{CB\ close}$	0 to 60 s (in steps of 0.01 s)
Tolerance of all timers	1 % of setting value or 10 ms
Measuring values of synchro-check function	
Reference voltage $V1$	In kV primary, in V secondary or in % V_{nom}
Range	10 to 120 % V_{nom}
Tolerance*)	≤ 1 % of measured value or 0.5 % of V_{nom}
Voltage to be synchronized $V2$	In kV primary, in V secondary or in % V_{nom}
Range	10 to 120 % V_{nom}
Tolerance*)	≤ 1 % of measured value or 0.5 % of V_{nom}
Frequency of $V1$ and $V2$	$f1$, $f2$ in Hz
Range	f_N ± 5 Hz
Tolerance*)	20 mHz
Voltage difference ($V2 - V1$)	In kV primary, in V secondary or in % V_{nom}
Range	10 to 120 % V_{nom}
Tolerance*)	≤ 1 % of measured value or 0.5 % of V_{nom}
Frequency difference ($f2 - f1$)	In mHz
Range	f_N ± 5 Hz
Tolerance*)	20 mHz
Angle difference ($\alpha2 - \alpha1$)	In °
Range	0 to 180 °
Tolerance*)	0.5 °

Flexible protection functions (ANSI 27, 32, 47, 50, 55, 59, 81R)	
Operating modes / measuring quantities	
3-phase	I, I_1, I_2, I_2/I_1, $3I_0$, V, V_1, V_2, $3V_0$, dV/dt, P,
1-phase	Q, cos φ I, I_E, $I_{E\ sens.}$, V, V_E, P, Q, cos φ
Without fixed phase relation	f, df/dt, binary input
Pickup when	Exceeding or falling below threshold value
Setting ranges	
Current I, I_1, I_2, $3I_0$, I_E	0.15 to 200 A[1] (in steps of 0.01 A)
Current ratio I_2/I_1	15 to 100 % (in steps of 1 %)
Sens. earth curr. $I_{E\ sens.}$	0.001 to 1.5 A (in steps of 0.001 A)
Voltages V, V_1, V_2, $3V_0$	2 to 260 V (in steps of 0.1 V)
Displacement voltage V_E	2 to 200 V (in steps of 0.1 V)
Power P, Q	0.5 to 10000 W (in steps of 0.1 W)
Power factor (cos φ)	- 0.99 to + 0.99 (in steps of 0.01)
Frequency f_N = 50 Hz	40 to 60 Hz (in steps of 0.01 Hz)
f_N = 60 Hz	50 to 70 Hz (in steps of 0.01 Hz)
Rate-of-frequency change df/dt	0.1 to 20 Hz/s (in steps of 0.01 Hz/s)
Voltage change dV/dt	4 V/s to 100 V/s (in steps of 1 V/s)
Dropout ratio >- stage	1.01 to 3 (insteps of 0.01)
Dropout ratio <- stage	0.7 to 0.99 (in steps of 0.01)
Dropout differential f	0.02 to 1.00 Hz (in steps of 0.01 Hz)
Pickup delay time	0 to 60 s (in steps of 0.01 s)
Trip delay time	0 to 3600 s (in steps of 0.01 s)
Dropout delay time	0 to 60 s (in steps of 0.01 s)
Times	
Pickup times	
Current, voltage (phase quantities)	
With 2 times the setting value	Approx. 30 ms
With 10 times the setting value	Approx. 20 ms
Current, voltages (symmetrical components)	
With 2 times the setting value	Approx. 40 ms
With 10 times the setting value	Approx. 30 ms
Power	
Typical	Approx. 120 ms
Maximum (low signals and thresholds)	Approx. 350 ms
Power factor	300 to 600 ms
Frequency	Approx. 100 ms
Rate-of-frequency change	
With 1.25 times the setting value	Approx. 220 ms
Voltage change dV/dt	
For 2 times pickup value	Approx. 220 ms
Binary input	Approx. 20 ms

*) With rated frequency.

1) At I_{nom} = 1 A, all limits divided by 5.

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Technical data

Flexible protection functions (ANSI 27, 32, 47, 50, 55, 59, 81R) (cont'd)

Dropout times	
Current, voltage (phase quantities)	< 20 ms
Current, voltages (symmetrical components)	< 30 ms
Power	
Typical	< 50 ms
Maximum	< 350 ms
Power factor	< 300 ms
Frequency	< 100 ms
Rate-of-frequency change	< 200 ms
Voltage change	< 220 ms
Binary input	< 10 ms
Tolerances	
Pickup threshold	
Current	0.5 % of setting value or 50 mA[1)]
Current (symmetrical components)	1 % of setting value or 100 mA[1)]
Voltage	0.5 % of setting value or 0.1 V
Voltage (symmetrical components)	1 % of setting value or 0.2 V
Power	1 % of setting value or 0.3 W
Power factor	2 degrees
Frequency	5 mHz (at $V = V_N$, $f = f_N$) 10 mHz (at $V = V_N$)
Rate-of-frequency change	5 % of setting value or 0.05 Hz/s
Voltage change dV/dt	5 % of setting value or 1.5 V/s
Times	1 % of setting value or 10 ms

Negative-sequence current detection (ANSI 46)

Definite-time characteristic (ANSI 46-1 and 46-2)

Setting ranges	
Pickup current $I_2>$, $I_2>>$	0.5 to 15 A or ∞ (in steps of 0.01 A)
Delay times	0 to 60 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Functional limit	All phase currents ≤ 50 A[1)]
Times	
Pickup times	Approx. 35 ms
Dropout times	Approx. 35 ms
Dropout ratio	Approx. 0.95 for $I_2 / I_{nom} > 0.3$
Tolerances	
Pickup thresholds	3 % of the setting value or 50 mA[1)]
Delay times	1 % or 10 ms

Inverse-time characteristic (ANSI 46-TOC)

Setting ranges	
Pickup current	0.5 to 10 A[1)] (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.5 to 15 s or ∞ (in steps of 0.01 s)
Functional limit	All phase currents ≤ 50 A[1)]
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse
ANSI	Inverse, moderately inverse, very inverse, extremely inverse
Pickup threshold	Approx. 1.1 · I_{2p} setting value
Dropout	
IEC and ANSI (without disk emulation)	Approx. 1.05 · I_{2p} setting value, which is approx. 0.95 · pickup threshold
ANSI with disk emulation	Approx. 0.90 · I_{2p} setting value
Tolerances	
Pickup threshold	3 % of the setting value or 50 mA[1)]
Time for 2 ≤ M ≤ 20	5 % of setpoint (calculated) +2 % current tolerance, at least 30 ms

Starting time monitoring for motors (ANSI 48)

Setting ranges	
Motor starting current $I_{STARTUP}$	2.5 to 80 A[1)] (in steps of 0.01)
Pickup threshold $I_{MOTOR\ START}$	2 to 50 A[1)] (in steps of 0.01)
Permissible starting time $T_{STARTUP}$, cold motor	1 to 180 s (in steps of 0.1 s)
Permissible starting time $T_{STARTUP}$, warm motor	0.5 to 180 s (in steps of 0.1 s)
Temperature threshold cold motor	0 to 80 % (in steps of 1 %)
Permissible blocked rotor time $T_{LOCKED\text{-}ROTOR}$	0.5 to 120 s or ∞ (in steps of 0.1 s)
Tripping time characteristic	
For $I > I_{MOTOR\ START}$	$t = \left(\frac{I_{STARTUP}}{I}\right)^2 \cdot T_{STARTUP}$
	$I_{STARTUP}$ = Rated motor starting current I = Actual current flowing $T_{STARTUP}$ = Tripping time for rated motor starting current t = Tripping time in seconds
Dropout ratio $I_{MOTOR\ START}$	Approx. 0.95
Tolerances	
Pickup threshold	2 % of setting value or 50 mA[1)]
Delay time	5 % or 30 ms

Load jam protection for motors (ANSI 51M)

Setting ranges	
Current threshold for alarm and trip	0.25 to 60 A[1)] (in steps 0.01 A)
Delay times	0 to 600 s (in steps 0.01 s)
Blocking duration after CLOSE signal detection	0 to 600 s (in steps 0.01 s)
Tolerances	
Pickup threshold	2 % of setting value or 50 mA[1)]
Delay time	1 % of setting value or 10 ms

Restart inhibit for motors (ANSI 66)

Setting ranges	
Motor starting current relative to rated motor current $I_{MOTOR\ START}/I_{Motor\ Nom}$	1.1 to 10 (in steps of 0.1)
Rated motor current $I_{Motor\ Nom}$	1 to 6 A[1)] (in steps of 0.01 A)
Max. permissible starting time $T_{Start\ Max}$	1 to 320 s (in steps of 1 s)
Equilibrium time T_{Equal}	0 min to 320 min (in steps of 0.1 min)
Minimum inhibit time $T_{MIN.\ INHIBIT\ TIME}$	0.2 min to 120 min (in steps of 0.1 min)
Max. permissible number of warm starts	1 to 4 (in steps of 1)
Difference between cold and warm starts	1 to 2 (in steps of 1)
Extension k-factor for cooling simulations of rotor at zero speed $k_{\tau\ at\ STOP}$	0.2 to 100 (in steps of 0.1)
Extension factor for cooling time constant with motor running $k\tau_{RUNNING}$	0.2 to 100 (in steps of 0.1)
Restarting limit	$\Theta_{restart} = \Theta_{rot\ max\ perm} \cdot \frac{n_c - 1}{n_c}$
	$\Theta_{restart}$ = Temperature limit below which restarting is possible $\Theta_{rot\ max\ perm}$ = Maximum permissible rotor overtemperature (= 100 % in operational measured value $\Theta_{rot}/\Theta_{rot\ trip}$) n_c = Number of permissible start-ups from cold state

1) For I_{nom} = 1 A, all limits divided by 5.

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Technical data

***Undercurrent monitoring** (ANSI 37)*	
Signal from the operational measured values	Predefined with programmable logic
***Temperature monitoring box** (ANSI 38)*	
Temperature detectors	
Connectable boxes	1 or 2
Number of temperature detectors per box	Max. 6
Type of measuring	Pt 100 Ω or Ni 100 Ω or Ni 120 Ω
Mounting identification	“Oil” or “Environment” or “Stator” or “Bearing” or “Other”
Thresholds for indications	
For each measuring detector	
Stage 1	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)
Stage 2	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)
***Undervoltage protection** (ANSI 27)*	
Operating modes/measuring quantities	
3-phase	Positive phase-sequence voltage or phase-to-phase voltages or phase-to-earth voltages
1-phase	Single-phase phase-earth or phase-phase voltage
Setting ranges	
Pickup thresholds V<, V<< dependent on voltage connection and chosen measuring quantity	10 to 120 V (in steps of 1 V) 10 to 210 V (in steps of 1 V)
Dropout ratio r	1.01 to 3 (in steps of 0.01)
Delay times T	0 to 100 s or ∞ (in steps of 0.01 s)
Current Criteria "Bkr Closed I_{MIN}"	0.2 to 5 A[1)] (in steps of 0.01 A)
Times	
Pickup times	Approx. 50 ms
Dropout times	As pickup times
Tolerances	
Pickup thresholds	1 % of setting value or 1 V
Times	1 % of setting value or 10 ms
***Overvoltage protection** (ANSI 59)*	
Operating modes/measuring quantities	
3-phase	Positive phase-sequence voltage or negative phase-sequence voltage or phase-to-phase voltages or phase-to-earth voltages
1-phase	Single-phase phase-earth or phase-phase voltage
Setting ranges	
Pickup thresholds V>, V>> dependent on voltage connection and chosen measuring quantity	40 to 260 V (in steps of 1 V) 40 to 150 V (in steps of 1 V) 2 to 150 V (in steps of 1 V)
Dropout ratio r	0.9 to 0.99 (in steps of 0.01)
Delay times T	0 to 100 s or ∞ (in steps of 0.01 s)
Times	
Pickup times V	Approx. 50 ms
Pickup times V_1, V_2	Approx. 60 ms
Dropout times	As pickup times

1) For I_{nom} = 1 A, all limits divided by 5.

Tolerances	
Pickup thresholds	1 % of setting value or 1 V
Times	1 % of setting value or 10 ms
***Frequency protection** (ANSI 81)*	
Number of frequency elements	4
Setting ranges	
Pickup thresholds for f_{nom} = 50 Hz	40 to 60 Hz (in steps of 0.01 Hz)
Pickup thresholds for f_{nom} = 60 Hz	50 to 70 Hz (in steps of 0.01 Hz)
Dropout differential = |pickup threshold - dropout threshold|	0.02 Hz to 1.00 Hz (in steps of 0.01 Hz)
Delay times	0 to 100 s or ∞ (in steps of 0.01 s)
Undervoltage blocking, with positive-sequence voltage V_1	10 to 150 V (in steps of 1 V)
Times	
Pickup times	Approx. 150 ms
Dropout times	Approx. 150 ms
Dropout	
Ratio undervoltage blocking	Approx. 1.05
Tolerances	
Pickup thresholds	
Frequency	5 mHz (at $V = V_N$, $f = f_N$) 10 mHz (at $V = V_N$)
Undervoltage blocking	3 % of setting value or 1 V
Delay times	3 % of the setting value or 10 ms
***Fault locator** (ANSI 21FL)*	
Output of the fault distance	in Ω primary and secondary, in km or miles line length, in % of line length
Starting signal	Trip command, dropout of a protection element, via binary input
Setting ranges	
Reactance (secondary)	0.001 to 1.9 Ω/km[1)] (in steps of 0.0001) 0.001 to 3 Ω/mile[1)] (in steps of 0.0001)
Tolerances	
Measurement tolerance acc. to VDE 0435, Part 303 for sinusoidal measurement quantities	2.5 % fault location, or 0.025 Ω (without intermediate infeed) for 30 ° ≤ φK ≤ 90 ° and $V_K/V_{nom} \geq 0.1$ and $I_K/I_{nom} \geq 1$
Additional functions	
Operational measured values	
Currents I_{L1}, I_{L2}, I_{L3} Positive-sequence component I_1 Negative-sequence component I_2 I_E or $3I_0$	In A (kA) primary, in A secondary or in % I_{nom}
Range	10 to 200 % I_{nom}
Tolerance[2)]	1 % of measured value or 0.5 % I_{nom}
Phase-to-earth voltages V_{L1-E}, V_{L2-E}, V_{L3-E} Phase-to-phase voltages V_{L1-L2}, V_{L2-L3}, V_{L3-L1}, V_E or V_0 Positive-sequence component V_1 Negative-sequence component V_2	In kV primary, in V secondary or in % V_{nom}
Range	10 to 120 % V_{nom}
Tolerance[2)]	1 % of measured value or 0.5 % of V_{nom}
S, apparent power	In kVAr (MVAr or GVAr) primary and in % of S_{nom}
Range	0 to 120 % S_{nom}
Tolerance[2)]	1 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 %
P, active power	With sign, total and phase-segregated in kW (MW or GW) primary and in % S_{nom}

2) At rated frequency.

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Technical data

Operational measured values (cont'd)	
Range Tolerance[2]	0 to 120 % S_{nom} 1 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 % and $\lvert\cos\varphi\rvert$ = 0.707 to 1 with $S_{nom} = \sqrt{3} \cdot V_{nom} \cdot I_{nom}$
Q, reactive power	With sign, total and phase-segregated in kVAr (MVAr or GVAr)primary and in % S_{nom}
Range Tolerance[2]	0 to 120 % S_{nom} 1 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 % and $\lvert\sin\varphi\rvert$ = 0.707 to 1 with $S_{nom} = \sqrt{3} \cdot V_{nom} \cdot I_{nom}$
cos φ, power factor (p.f.)	Total and phase segregated
Range Tolerance[2]	- 1 to + 1 2 % for $\lvert\cos\varphi\rvert \geq 0.707$
Frequency f	In Hz
Range Tolerance[2]	$f_{nom} \pm 5$ Hz 20 mHz
Temperature overload protection Θ/Θ_{Trip}	In %
Range Tolerance[2]	0 to 400 % 5 % class accuracy per IEC 60255-8
Temperature restart inhibit $\Theta_L/\Theta_{L\ Trip}$	In %
Range Tolerance[2]	0 to 400 % 5 % class accuracy per IEC 60255-8
Restart threshold $\Theta_{Restart}/\Theta_{L\ Trip}$	In %
Reclose time $T_{Reclose}$	In min
Currents of sensitive ground fault detection (total, real, and reactive current) I_{EE}, $I_{EE\ real}$, $I_{EE\ reactive}$	In A (kA) primary and in mA secondary
Range Tolerance[2]	0 mA to 1600 mA 2 % of measured value or 1 mA
RTD-box	See section "Temperature monitoring box"
Long-term averages	
Time window	5, 15, 30 or 60 minuets
Frequency of updates	Adjustable
Long-term averages of currents of real power of reactive power of apparent power	 I_{L1dmd}, I_{L2dmd}, I_{L3dmd}, I_{1dmd} in A (kA) P_{dmd} in W (kW, MW) Q_{dmd} in VAr (kVAr, MVAr) S_{dmd} in VAr (kVAr, MVAr)
Max. / Min. report	
Report of measured values	With date and time
Reset, automatic	Time of day adjustable (in minutes, 0 to 1439 min) Time frame and starting time adjustable (in days, 1 to 365 days, and ∞)
Reset, manual	Using binary input, using keypad, via communication
Min./Max. values for current	I_{L1}, I_{L2}, I_{L3}, I_1 (positive-sequence component)
Min./Max. values for voltages	V_{L1-E}, V_{L2-E}, V_{L3-E} V_1 (positive-sequence component) V_{L1-L2}, V_{L2-L3}, V_{L3-L1}
Min./Max. values for power	S, P, Q, cos φ, frequency
Min./Max. values for overload protection	Θ/Θ_{Trip}
Min./Max. values for mean values	I_{L1dmd}, I_{L2dmd}, I_{L3dmd} I_1 (positive-sequence component); S_{dmd}, P_{dmd}, Q_{dmd}
Local measured values monitoring	
Current asymmetry	I_{max}/I_{min} > balance factor, for $I>I_{balance\ limit}$
Voltage asymmetry	V_{max}/V_{min} > balance factor, for $V>V_{lim}$
Current phase sequence	Clockwise (ABC) / counter-clockwise (ACB)
Voltage phase sequence	Clockwise (ABC) / counter-clockwise (ACB)
Limit value monitoring	Predefined limit values, user-defined expansions via CFC
Fuse failure monitor	
For all network types	With the option of blocking affected protection functions
Fault recording	
Recording of indications of the last 8 power system faults	
Recording of indications of the last 3 power system ground faults	
Time stamping	
Resolution for event log (operational annunciations)	1 ms
Resolution for trip log (fault annunciations)	1 ms
Maximum time deviation (internal clock)	0.01 %
Battery	Lithium battery 3 V/1 Ah, type CR 1/2 AA, message "Battery Fault" for insufficient battery charge
Oscillographic fault recording	
Maximum 8 fault records saved, memory maintained by buffer battery in case of loss of power supply	
Recording time	Total 20 s Pre-trigger and post-fault recording and memory time adjustable
Sampling rate for 50 Hz Sampling rate for 60 Hz	1 sample/1.25 ms (16 samples/cycle) 1 sample/1.04 ms (16 samples/cycle)
Energy/power	
Meter values for power Wp, Wq (real and reactive power demand)	in kWh (MWh or GWh) and kVARh (MVARh or GVARh)
Tolerance[1]	≤ 2 % for $I > 0.1\ I_{nom}$, $V > 0.1\ V_{nom}$ and $\lvert\cos\varphi\rvert$ (p.f.) ≥ 0.707
Statistics	
Saved number of trips	Up to 9 digits
Number of automatic reclosing commands (segregated according to 1st and ≥ 2nd cycle)	Up to 9 digits

1) At I_{nom} = 1 A, all limits multiplied with 5.

2) At rated frequency.

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Technical data

Circuit-breaker wear	
Methods	• ΣI^x with x = 1 .. 3 • 2-point method (remaining service life) • $\Sigma i^2 t$
Operation	Phase-selective accumulation of measured values on TRIP command, up to 8 digits, phase-selective limit values, monitoring indication
Motor statistics	
Total number of motor start-ups	0 to 9999 (resolution 1)
Total operating time	0 to 99999 h (resolution 1 h)
Total down-time	0 to 99999 h (resolution 1 h)
Ratio operating time/down-time	0 to 100 % (resolution 0.1 %)
Active energy and reactive energy	See operational measured values
Motor start-up data:	Of the last 5 start-ups
– Start-up time	0.30 s to 9999.99 s (resolution 10 ms)
– Start-up current (primary)	0 A to 1000 kA (resolution 1 A)
– Start-up voltage (primary)	0 V to 100 kV (resolution 1 V)
Operating hours counter	
Display range	Up to 7 digits
Criterion	Overshoot of an adjustable current threshold (BkrClosed I_{MIN})
Trip circuit monitoring	
With one or two binary inputs	
Commissioning aids	
Phase rotation field check, operational measured values, circuit-breaker/switching device test, creation of a test measurement report	
Clock	
Time synchronization	DCF77/IRIG-B signal (telegram format IRIG-B000), binary input, communication
Setting group switchover of the function parameters	
Number of available setting groups	4 (parameter group A, B, C and D)
Switchover performed	Via keypad, DIGSI, system (SCADA) interface or binary input
Control	
Number of switching units	Depends on the binary inputs and outputs
Interlocking	Programmable
Circuit-breaker signals	Feedback, close, open, intermediate position
Control commands	Single command / double command 1, 1 plus 1 common or 2 trip contacts
Programmable controller	CFC logic, graphic input tool
Local control	Control via menu, assignment of a function key
Remote control	Via communication interfaces, using a substation automation and control system (e.g. SICAM), DIGSI 4 (e.g. via modem)

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 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 conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

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

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Selection and ordering data

Description	Order No.
7SJ62 multifunction protection relay	7SJ62□□ – □□□□□ – □□□□

Housing, inputs, outputs

Description	
Housing 1/3 19", 4 line text display, 3 x *U*, 4 x *I*, 8 BI, 8 BO, 1 live status-contact	1
Housing 1/3 19", 4 line text display, 3 x *U*, 4 x *I*, 11 BI, 6 BO, 1 live status-contact	2
Housing 1/3 19", 4 line text display, 4 x *U*, 4 x *I*, 8 BI, 8 BO, 1 live status-contact	3
Housing 1/3 19", 4 line text display, 4 x *U*, 4 x *I*, 11 BI, 6 BO, 1 live status-contact	4
Housing 1/2 19", graphic display, 4 x *U*, 4 x *I*, 8 BI, 8 BO, 1 live status contact 7)	5
Housing 1/2 19", graphic display, 4 x *U*, 4 x *I*, 11 BI, 6 BO, 1 live status contact 7)	6

see next page

Measuring inputs (3 x V / 4 x V, 4 x I)

Description	
I_{ph} = 1 A 1), I_e = 1 A 1) (min. = 0.05 A) Position 15 only with *A, C, E, G*	1
I_{ph} = 1 A 1), I_e = sensitive (min. = 0.001 A) Position 15 only with *B, D, F, H*	2
I_{ph} = 5 A 1), I_e = 5 A 1) (min. = 0.25 A) Position 15 only with *A, C, E, G*	5
I_{ph} = 5 A 1), I_e = sensitive (min. = 0.001 A) Position 15 only with *B, D, F, H*	6
I_{ph} = 5 A 1), I_e = 1 A 1) (min. = 0.05 A) Position 15 only with *A, C, E, G*	7

Rated auxiliary voltage (power supply, indication voltage)

Description	
24 to 48 V DC, threshold binary input 19 DC 3)	2
60 to 125 V DC 2), threshold binary input 19 DC 3)	4
110 to 250 V DC 2), 115 to 230 V 4) AC, threshold binary input 88 V DC 3)	5
110 to 250 V DC 2), 115 to 230 V 4) AC, threshold binary input 176 V DC 3)	6

Unit version

Description	
For panel surface mounting, two-tier terminal top/bottom	B
For panel flush mounting, plug-in terminal, (2/3 pin connector)	D
For panel flush mounting, screw-type terminal (direct connection/ring-type cable lugs)	E

Region-specific default settings/function versions and language settings

Description	
Region DE, 50 Hz, IEC, language: German, selectable	A
Region World, 50/60 Hz, IEC/ANSI, language: English (GB), selectable	B
Region US, 60 Hz, ANSI, language: English (US), selectable	C
Region FR, 50/60 Hz, IEC/ANSI, language: French, selectable	D
Region World, 50/60 Hz, IEC/ANSI, language: Spanish, selectable	E
Region IT, 50/60 Hz, IEC/ANSI, language: Italian (language selectable)	F
Region RU, 50/60 Hz, IEC/ANSI, language: Russian(language can be changed)	G

System interface (Port B): Refer to page 5/114

Description	
No system interface	0
Protocols see page 5/114	

Service interface (Port C)

Description	
No interface at rear side	0
DIGSI 4/modem, electrical RS232	1
DIGSI 4/modem/RTD-box 5), electrical RS485	2
DIGSI 4/modem/RTD-box 5)6), optical 820 nm wave length, ST connector	3

Measuring/fault recording

Description	
Fault recording	1
Slave pointer, mean values, min/max values, fault recording	3

1) Rated current can be selected by means of jumpers.
2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.
3) The binary input thresholds can be selected per binary input by means of jumpers.
4) 230 V AC, starting from device version …/EE.
5) Temperature monitoring box 7XV5662-□AD10, refer to "Accessories".
6) When using the temperature monitoring box at an optical interface, the additional RS485 fiber-optic converter 7XV5650-0□A00 is required.
7) starting from device version .../GG and FW-Version V4.82

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Selection and ordering data

Description	Order No.
7SJ62 multifunction protection relay	*7SJ62□□ – □□□□□ – □□□□*

Designation				ANSI No.	Description	Order code
Basic version					Control	
				50/51	Time-overcurrent protection $I>$, $I>>$, $I>>>$, I_p	
				50N/51N	Earth-fault protection $I_E>$, $I_E>>$, $I_E>>>$, I_{Ep}	
				50N/51N	Insensitive earth-fault protection via IEE function: $I_{EE}>$, $I_{EE}>>$, I_{EEp} [1)]	
				50/50N	Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I_2>$, $I>>>>$, $I_E>>>>$	
				51 V	Voltage-dependent inverse-time overcurrent protection	
				49	Overload protection (with 2 time constants)	
				46	Phase balance current protection (negative-sequence protection)	
				37	Undercurrent monitoring	
				47	Phase sequence	
				59N/64	Displacement voltage	
				50BF	Breaker failure protection	
				74TC	Trip circuit supervision	
					4 setting groups, cold-load pickup	
					Inrush blocking	
				86	Lockout	
■			*V, P, f*	27/59 81O/U 27/47/59(N) 32/55/81R	Under-/overvoltage Under-/overfrequency Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	*F E*
■		IEF	*V, P, f*	27/59 81O/U 27/47/59(N) 32/55/81R	Under-/overvoltage Under-/overfrequency Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection Intermittent earth fault	*P E*
■	Dir			67/67N	Direction determination for overcurrent, phases and earth	*F C*
■	Dir		*V, P, f*	67/67N 27/59 81O/U 27/47/59(N) 32/55/81R	Direction determination for overcurrent, phases and earth Under-/overvoltage Under-/overfrequency Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	*F G*
■	Dir	IEF		67/67N	Direction determination for overcurrent, phases and earth Intermittent earth fault	*P C*
Directional earth-fault detection ■	Dir			67/67N 67Ns 87N	Direction determination for overcurrent, phases and earth Directional sensitive earth-fault detection High-impedance restricted earth fault	*F D* [2)]
Directional earth-fault detection ■			*V, P, f*	67Ns 87N 27/59 81O/U 27/47/59(N) 32/55/81R	Directional sensitive earth-fault detection High-impedance restricted earth fault Under-/overvoltage Under-/overfrequency Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	*F F* [2)]
Directional earth-fault detection ■	Dir	IEF		67/67N 67Ns 87N	Direction determination for overcurrent, phases and earth Directional sensitive earth-fault detection High-impedance restricted earth fault Intermittent earth fault	*P D* [2)]

■ Basic version included

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

Dir = Directional overcurrent protection

IEF = Intermittent earth fault

1) Only with insensitive earth-current transformer when position 7 = *1, 5, 7*.

2) For isolated/compensated networks only with sensitive earth-current transformer when position 7 = *2, 6*.

Continued on next page

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Selection and ordering data

Description	Order No.	Order code
7SJ62 multifunction protection relay	*7SJ62□□ – □□□□□ – □□□□–□□□□*	

Designation	ANSI No.	Description	Order code
Basic version		Control	
	50/51	Time-overcurrent protection $I>$, $I>>$, $I>>>$, I_p	
	50N/51N	Earth-fault protection $I_E>$, $I_E>>$, $I_E>>>$, I_{Ep}	
	50N/51N	Insensitive earth-fault protection via IEE function: $I_{EE}>$, $I_{EE}>>$, I_{EEp} 1)	
	50/50N	Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I_2>$, $I>>>>$, $I_E>>>>$	
	51 V	Voltage-dependent inverse-time overcurrent protection	
	49	Overload protection (with 2 time constants)	
	46	Phase balance current protection (negative-sequence protection)	
	37	Undercurrent monitoring	
	47	Phase sequence	
	59N/64	Displacement voltage	
	50BF	Breaker failure protection	
	74TC	Trip circuit supervision	
		4 setting groups, cold-load pickup	
		Inrush blocking	
	86	Lockout	
Directional earth-fault detection ■	67Ns	Directional sensitive earth-fault detection	
	87N	High-impedance restricted earth fault	F B 2)
Directional earth-fault detection ■ Motor *V, P, f*	67Ns	Directional sensitive earth-fault detection	
	87N	High-impedance restricted earth fault	
	48/14	Starting time supervision, locked rotor	
	66/86	Restart inhibit	
	51M	Load jam protection, motor statistics	
	27/59	Under-/overvoltage	
	81O/U	Under-/overfrequency	
	27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	H F 2)
Directional earth-fault detection Motor Dir *V, P, f*	67/67N	Direction determination for overcurrent, phases and earth	
	67Ns	Directional sensitive earth-fault detection	
	87N	High-impedance restricted earth fault	
	48/14	Starting time supervision, locked rotor	
	66/86	Restart inhibit	
	51M	Load jam protection, motor statistics	
	27/59	Under-/overvoltage	
	81O/U	Under-/overfrequency	
	27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	H H 2)
Directional earth-fault detection ■ Motor IEF Dir *V, P, f*	67/67N	Direction determination for overcurrent, phases and earth	
	67Ns	Directional sensitive earth-fault detection	
	87N	High-impedance restricted earth fault	
		Intermittent earth fault	
	48/14	Starting time supervision, locked rotor	
	66/86	Restart inhibit	
	51M	Load jam protection, motor statistics	
	27/59	Undervoltage/overvoltage	
	81O/U	Underfrequency/overfrequency	
	27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	R H 2)

■ Basic version included

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

Dir = Directional overcurrent protection

IEF = Intermittent earth fault

1) Only with insensitive earth-current transformer when position 7 = *1, 5, 7*.

2) For isolated/compensated networks only with sensitive earth-current transformer when position 7 = *2, 6*.

Continued on next page

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Selection and ordering data

Description			Order No.	Order code
7SJ62 multifunction protection relay			7SJ62□□ – □□□□□ – □□□□–□□□□	

Designation		ANSI No.	Description	Order code
Basic version			Control	
		50/51	Time-overcurrent protection $I>$, $I>>$, $I>>>$, I_p	
		50N/51N	Earth-fault protection $I_E>$, $I_E>>$, $I_E>>>$, I_{Ep}	
		50N/51N	Insensitive earth-fault protection via IEE function: $I_{EE}>$, $I_{EE}>>$, I_{EEp} 1)	
		50/50N	Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I_2>$, $I>>>>$, $I_E>>>>$	
		51 V	Voltage-dependent inverse-time overcurrent protection	
		49	Overload protection (with 2 time constants)	
		46	Phase balance current protection (negative-sequence protection)	
		37	Undercurrent monitoring	
		47	Phase sequence	
		59N/64	Displacement voltage	
		50BF	Breaker failure protection	
		74TC	Trip circuit supervision	
			4 setting groups, cold-load pickup	
			Inrush blocking	
		86	Lockout	
■	Motor V, P, f Dir	67/67N	Direction determination for overcurrent, phases and earth	
		48/14	Starting time supervision, locked rotor	
		66/86	Restart inhibit	
		51M	Load jam protection, motor statistics	
		27/59	Under-/overvoltage	
		81O/U	Under-/overfrequency	
		27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	*H G*
■	Motor	48/14	Starting time supervision, locked rotor	
		66/86	Restart inhibit	
		51M	Load jam protection, motor statistics	*H A*
ARC, fault locator, synchro-check			Without	*0*
		79	With auto-reclosure	*1*
		21FL	With fault locator	*2*
		79, 21FL	With auto-reclosure, with fault locator	*3*
		25	With synchro-check 4)	*4* 5)
		25, 79, 21FL	With synchro-check 4), auto-reclosure, fault locator	*7* 5)
ATEX100 Certification For protection of explosion-protected motos (increased-safety type of protection "e"				*Z X 9 9* 3)

■ Basic version included

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

Dir = Directional overcurrent protection
IEF = Intermittent earth fault

1) Only with insensitive earth-current transformer when position 7 = *1, 5, 7*.

2) For isolated/compensated networks only with sensitive earth-current transformer when position 7 = *2, 6*.

3) This variant will be supplied with a previous firmware version.

4) Synchro-check (no asynchronous switching), one function group; available only with devices 7SJ623 and 7SJ624

5) Ordering option only available for devices 7SJ623 and 7SJ624

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Order number for system port B

Description	Order No.	Order code
7SJ62 multifunction protection relay	*7SJ62☐☐ – ☐☐☐☐☐ – ☐☐☐☐–☐☐☐*	
System interface (on rear of unit, Port B)		
No system interface	0	
IEC 60870-5-103 protocol, RS232	1	
IEC 60870-5-103 protocol, RS485	2	
IEC 60870-5-103 protocol, 820 nm fiber, ST connector	3	
PROFIBUS-FMS Slave, RS485	4	
PROFIBUS-FMS Slave, 820 nm wavelength, single ring, ST connector 1)	5	
PROFIBUS-FMS Slave, 820 nm wavelength, double ring, ST connector 1)	6	
PROFIBUS-DP Slave, RS485	9	L 0 A
PROFIBUS-DP Slave, 820 nm wavelength, double ring, ST connector 1)	9	L 0 B
MODBUS, RS485	9	L 0 D
MODBUS, 820 nm wavelength, ST connector 2)	9	L 0 E
DNP 3.0, RS485	9	L 0 G
DNP 3.0, 820 nm wavelength, ST connector 2)	9	L 0 H
IEC 60870-5-103 protocol, redundant, RS485, RJ45 connector 2)	9	L 0 P
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector (EN 100)	9	L 0 R
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector (EN 100) 2)	9	L 0 S

1) Not with position 9 = "B"; if 9 = "B", please order 7SJ6 unit with RS485 port and separate fiber-optic converters.
For single ring, please order converter 6GK1502-2CB10, not available with position 9 = "B".
For double ring, please order converter 6GK1502-3CB10, not available with position 9 = "B".
The converter requires a 24 V AC power supply (e.g. power supply 7XV5810-0BA00)

2) Not available with position 9 = "B"

Sample order

Position		Order No. + Order code
		7SJ6225-5EC91-3FC1+L0G
6	I/O's: 11 BI/6 BO, 1 live status contact	2
7	Current transformer: 5 A	5
8	Power supply: 110 to 250 V DC, 115 V AC to 230 V AC	5
9	Unit version: Flush-mounting housing, screw-type terminals	E
10	Region: US, English language (US); 60 Hz, ANSI	C
11	Communication: System interface: DNP 3.0, RS485	9 L 0 G
12	Communication: DIGSI 4, electric RS232	1
13	Measuring/fault recording: Extended measuring and fault records	3
14/15	Protection function package: Basic version plus directional TOC	F C
16	With auto-reclosure	1

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Accessories

Description		Order No.
DIGSI 4		
Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition		
Basis	Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional	DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	*7XS5402-0AA00*
Professional + IEC 61850	Complete version: DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	*7XS5403-0AA00*
IEC 61850 System configurator		
Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM		*7XS5460-0AA00*
SIGRA 4		
Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000 or XP Professional Edition. (generally contained in DIGSI Professional, but can be ordered additionally) Authorization by serial number. On CD-ROM.		*7XS5410-0AA00*
Temperature monitoring box		
24 to 60 V AC/DC		*7XV5662-2AD10*
90 to 240 V AC/DC		*7XV5662-5AD10*
Varistor/Voltage arrester		
Voltage arrester for high-impedance REF protection		
125 Vrms; 600 A; 1S/S 256		*C53207-A401-D76-1*
240 Vrms; 600 A; 1S/S 1088		*C53207-A401-D77-1*
Connecting cable		
Cable between PC/notebook (9-pin con.) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)		*7XV5100-4*
Cable between temperature monitoring box and SIPROTEC 4 unit		
- length 5 m /16.4 ft		*7XV5103-7AA05*
- length 25 m /82 ft		*7XV5103-7AA25*
- length 50 m /164 ft		*7XV5103-7AA50*
Manual for 7SJ62		
English		*C53000-G1140-C207-x* [1)]

1) x = please inquire for latest edition (exact Order No.).

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Accessories

Mounting rail

2-pin connector

3-pin connector

Short-circuit links for current terminals

Short-circuit links for other terminals

Description	Order No.	Size of package	Supplier
Terminal safety cover			
Voltage/current terminal 18-pole/12-pole	C73334-A1-C31-1	1	Siemens
Voltage/current terminal 12-pole/8-pole	C73334-A1-C32-1	1	Siemens
Connector 2-pin	C73334-A1-C35-1	1	Siemens
Connector 3-pin	C73334-A1-C36-1	1	Siemens
Crimp connector CI2 0.5 to 1 mm^2	0-827039-1	4000 taped on reel	AMP 1)
Crimp connector CI2 0.5 to 1 mm^2	0-827396-1	1	AMP 1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	0-163084-2	1	AMP 1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	0-163083-7	4000 taped on reel	AMP 1)
Crimping tool for Type III+	0-539635-1	1	AMP 1)
and matching female	0-539668-2	1	AMP 1)
Crimping tool for CI2	0-734372-1	1	AMP 1)
and matching female	1-734387-1	1	AMP 1)
Short-circuit links			
for current terminals	C73334-A1-C33-1	1	Siemens
for other terminals	C73334-A1-C34-1	1	Siemens
Mounting rail for 19" rack	C73165-A63-D200-1	1	Siemens

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

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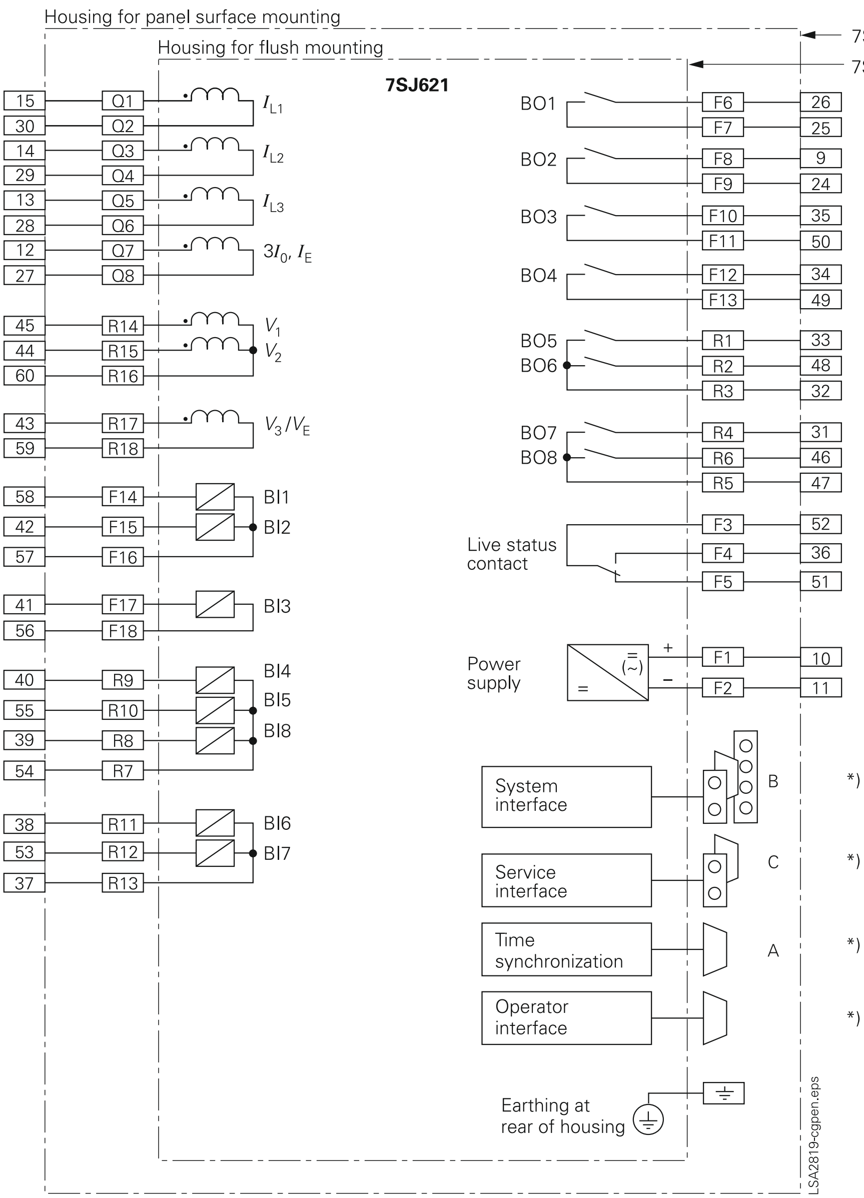
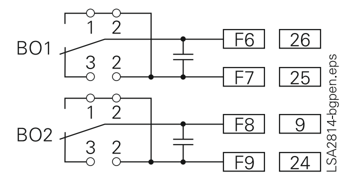
Connection diagram





As of unit version .../EE

Fig. 5/101 7SJ621 connection diagram

*) For pinout of communication ports see part 15 of this catalog.
For the allocation of the terminals of the panel surface mounting version refer to the manual (http://www.siemens.com/siprotec).

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Connection diagram

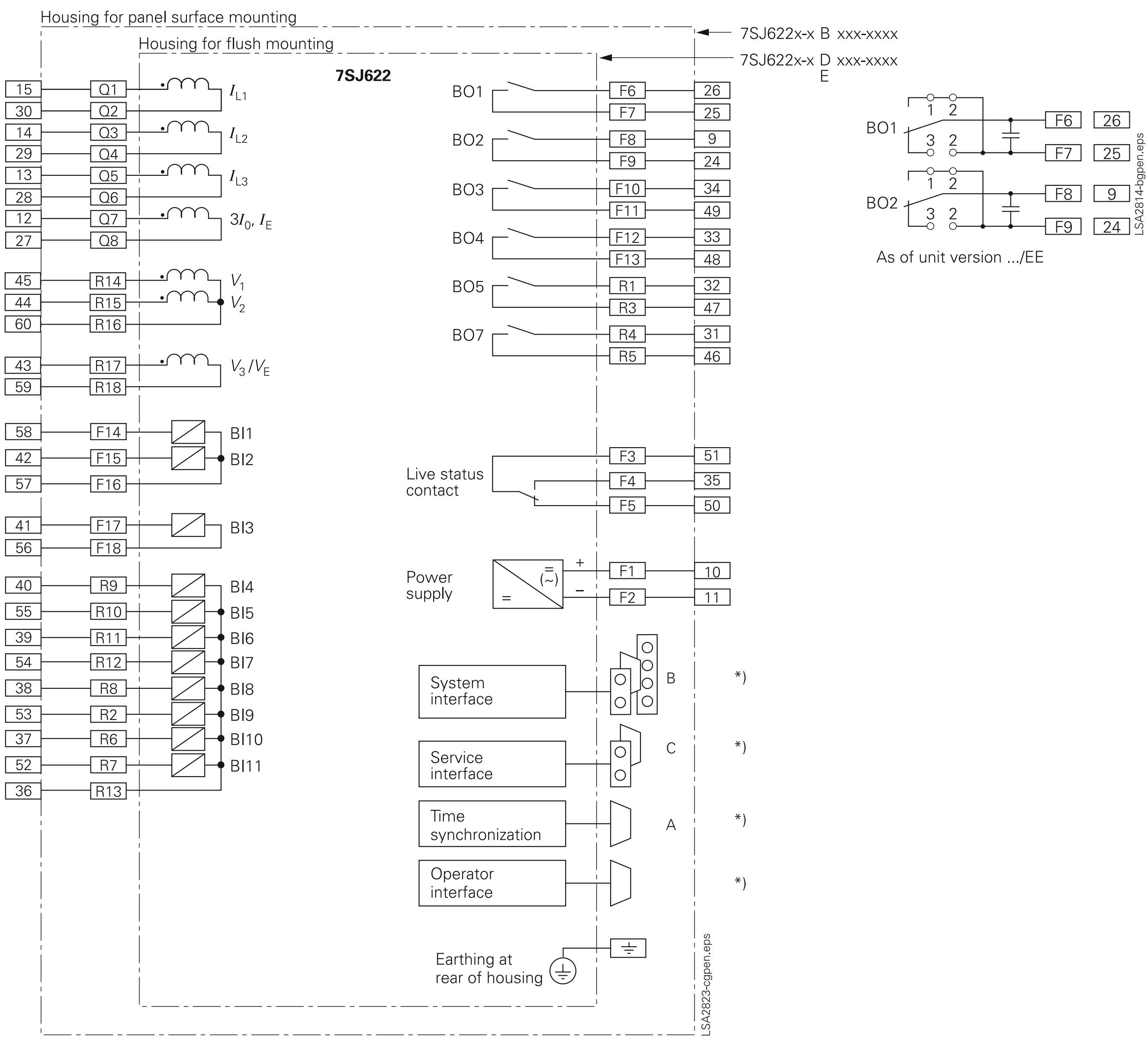

Fig. 5/102 7SJ622 connection diagram

*) For pinout of communication ports see part 15 of this catalog.
For the allocation of the terminals of the panel surface mounting version refer to the manual (http://www.siemens.com/siprotec).

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Connection diagram

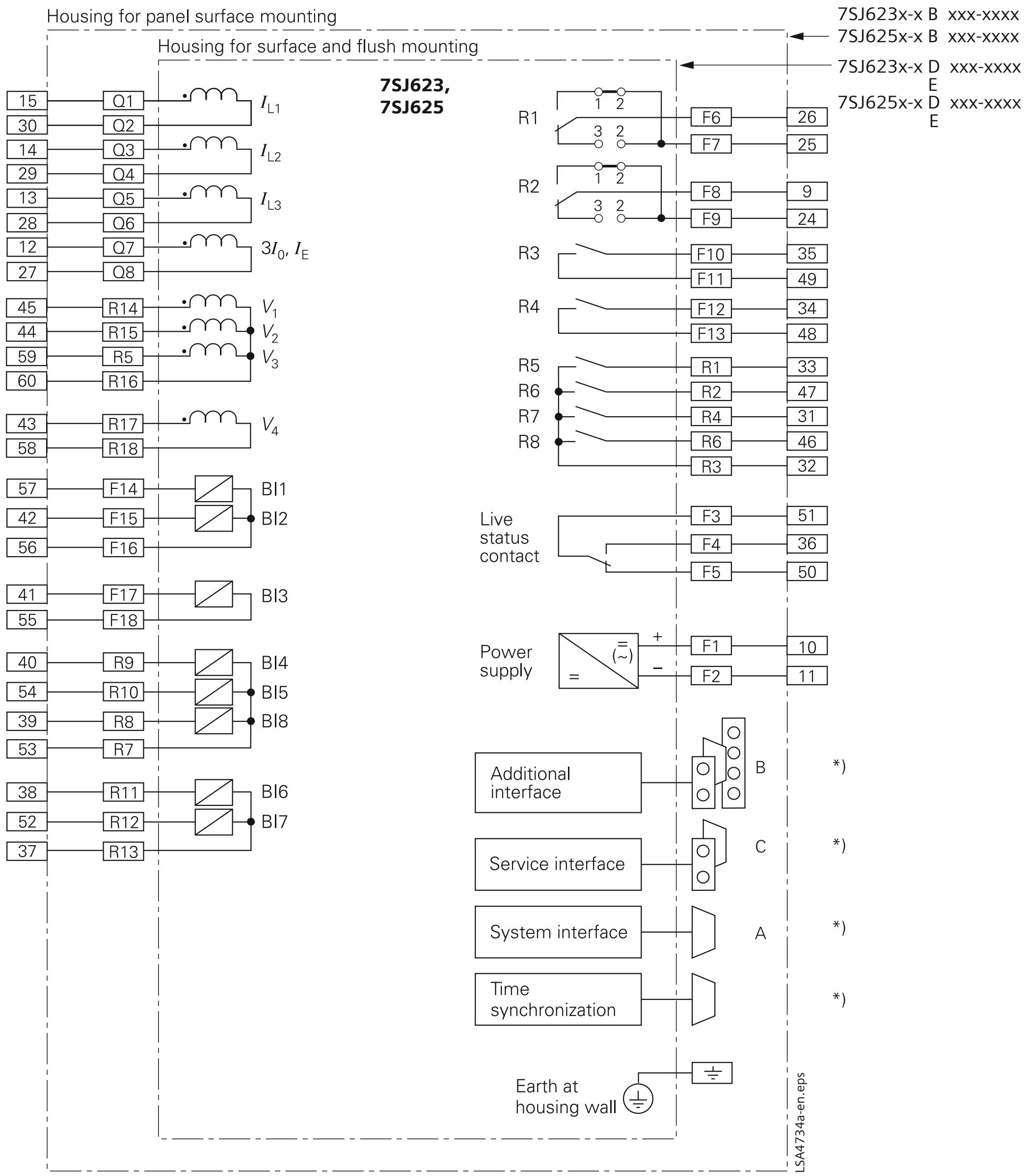

Fig. 5/103 7SJ623, 7SJ625 connection diagram

*) For pinout of communication ports see part 15 of this catalog.
For the allocation of the terminals of the panel surface mounting version refer to the manual (http://www.siemens.com/siprotec).

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Connection diagram

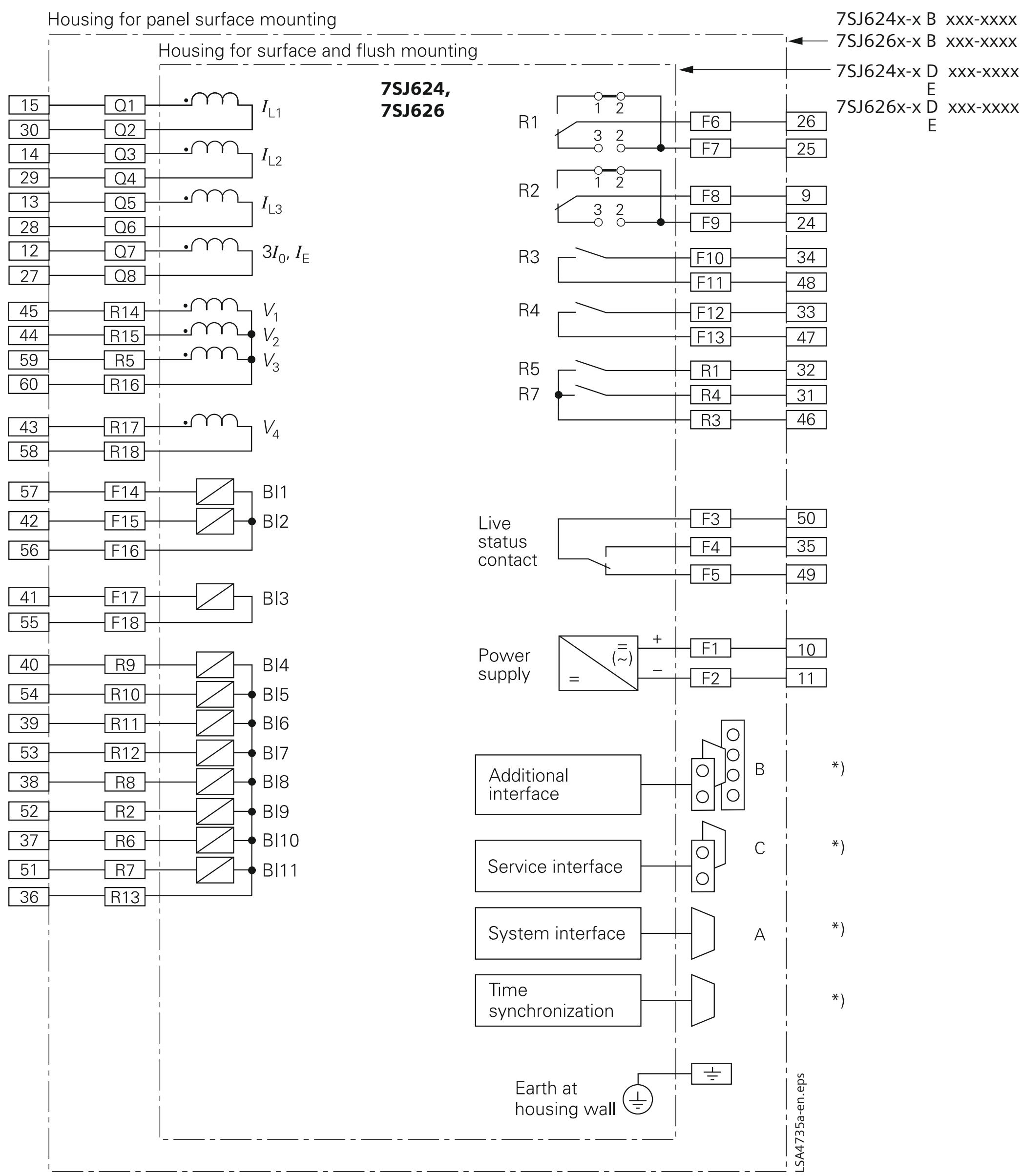

Fig. 5/104 7SJ624, 7SJ626 connection diagram

*) For pinout of communication ports see part 15 of this catalog.
For the allocation of the terminals of the panel surface mounting version refer to the manual (http://www.siemens.com/siprotec).

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SIPROTEC 4 7SJ63
Multifunction Protection Relay

LSP2316-afpen.tif

Fig. 5/105
SIPROTEC 4 7SJ63 multifunction protection relay

Description

The SIPROTEC 4 7SJ63 can be used as a protective control and monitoring relay for distribution feeders and transmission lines of any voltage in networks that are earthed (grounded), low-resistance earthed, unearthed, or of a compensated neutral point structure. The relay is suited for networks that are radial or looped, and for lines with single or multi-terminal feeds. Regarding the time-overcurrent/directional time-overcurrent protection the characteristics can be either definite time, inverse time or user-defined.

The SIPROTEC 4 7SJ63 is equipped with motor protection applicable for asynchronous machines of all sizes. Motor protection comprises undercurrent monitoring, starting time supervision, restart inhibit, locked rotor.

The relay provides easy-to-use local control and automation functions. The number of controllable switchgear depends only on the number of available inputs and outputs. The integrated programmable logic (CFC) allows the user to implement their own functions, e.g. for the automation of switchgear (interlocking). The user is able to generate user-defined messages as well.

Function overview

Protection functions

- Time-overcurrent protection (definite-time/inverse-time/user-def.)
- Directional time-overcurrent protection (definite-time/inverse-time/user-def.)
- Sensitive dir./non-dir. earth-fault detection
- Displacement voltage
- Intermittent earth-fault protection
- High-impedance restricted earth fault
- Inrush restraint
- Motor protection
- Overload protection
- Temperature monitoring
- Under-/overvoltage protection
- Under-/overfrequency protection
- Breaker failure protection
- Negative-sequence protection
- Phase-sequence monitoring
- Auto-reclosure
- Fault locator
- Lockout

Control functions/programmable logic

- Flexible number of switching devices
- Position of switching elements is shown on the graphic display
- Local/remote switching via key-operated switch
- Control via keyboard, binary inputs, DIGSI 4 or SCADA system
- Extended user-defined logic with CFC (e.g. interlocking)

Monitoring functions

- Operational measured values V, I, f,...
- Energy metering values W_p, W_q
- Circuit-breaker wear monitoring
- Slave pointer
- Trip circuit supervision
- Fuse failure monitor
- 8 oscillographic fault records

Communication interfaces

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

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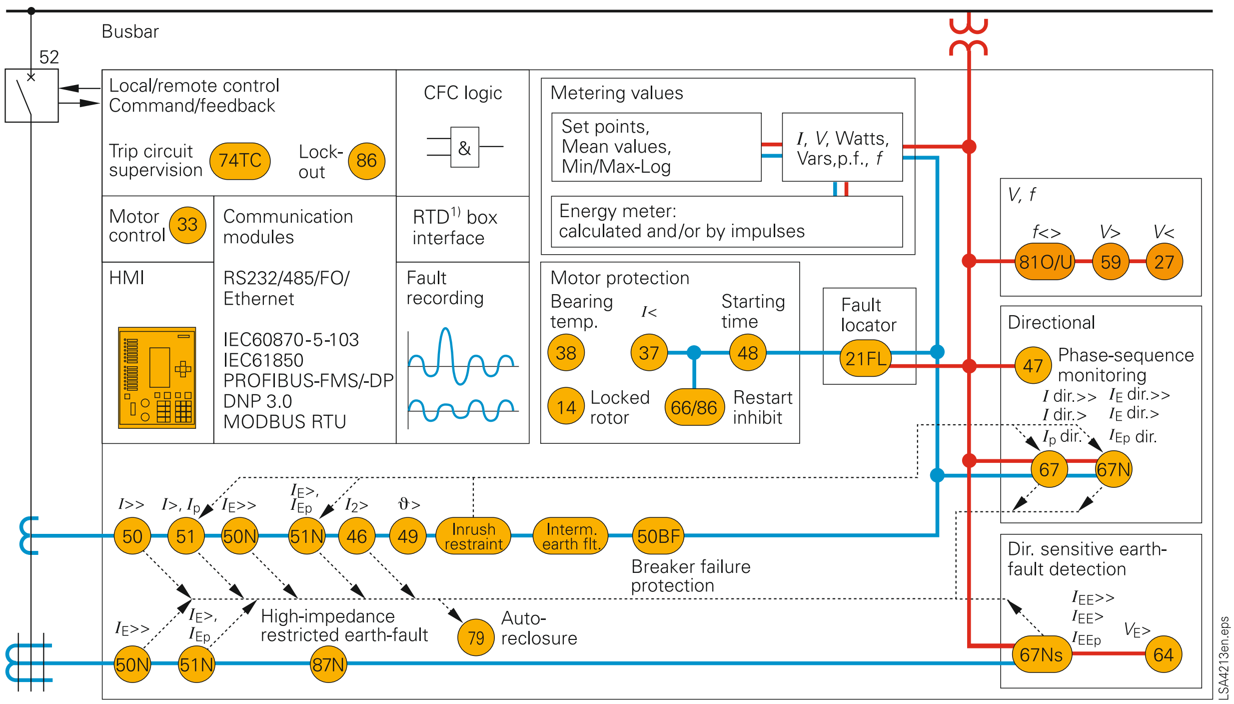
Application



1) RTD = resistance temperature detector

Fig. 5/106 Function diagram

The SIPROTEC 4 7SJ63 unit is a numerical protection relay that also performs control and monitoring functions and therefore supports the user in cost-effective power system management, and ensures reliable supply of electric power to the customers. Local operation has been designed according to ergonomic criteria. A large, easy-to-read graphic display was a major design aim.

Control

The integrated control function permits control of disconnect devices (electrically operated/motorized switches) or circuit-breakers via the integrated operator panel, binary inputs, DIGSI 4 or the control and protection system (e.g. SICAM). The present status (or position) of the primary equipment can be displayed. 7SJ63 supports substations with single and duplicate busbars. The number of elements that can be controlled (usually 1 to 5) is only restricted by the number of inputs and outputs available. A full range of command processing functions is provided.

Programmable logic

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

Line protection

The 7SJ63 units can be used for line protection of high and medium-voltage networks with earthed (grounded), low-resistance earthed, isolated or compensated neutral point.

Motor protection

When protecting motors, the 7SJ63 relays are suitable for asynchronous machines of all sizes.

Transformer protection

The 7SJ63 units perform all functions of backup protection supplementary to transformer differential protection. The inrush suppression effectively prevents tripping by inrush currents.

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

Backup protection

The relays can be used universally for backup protection.

Metering values

Extensive measured values, limit values and metering values permit improved systems management.

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Application

ANSI No.	IEC	Protection functions
50, 50N	$I>$, $I>>$ $I_E>$, $I_E>>$	Definite-time overcurrent protection (phase/neutral)
51, 51N	I_p, I_{Ep}	Inverse-time overcurrent protection (phase/neutral)
67, 67N	$I_{dir}>$, $I_{dir}>>$, $I_{p\,dir}$ $I_{Edir}>$, $I_{Edir}>>$, $I_{Ep\,dir}$	Directional time-overcurrent protection (definite/inverse, phase/neutral), Directional comparison protection
67Ns/50Ns	$I_{EE}>$, $I_{EE}>>$, I_{EEp}	Directional/non-directional sensitive earth-fault detection
–		Cold load pick-up (dynamic setting change)
59N/64	$V_E/V_0>$	Displacement voltage, zero-sequence voltage
–	$I_{IE}>$	Intermittent earth fault
87N		High-impedance restricted earth-fault protection
50BF		Breaker failure protection
79		Auto-reclosure
46	$I_2>$	Phase-balance current protection (negative-sequence protection)
47	$V_2>$, phase seq.	Unbalance-voltage protection and/or phase-sequence monitoring
49	$\vartheta>$	Thermal overload protection
48		Starting time supervision
14		Locked rotor protection
66/86		Restart inhibit
37	$I<$	Undercurrent monitoring
38		Temperature monitoring via external device (RTD-box) e.g. bearing temperature monitoring
27, 59	$V<$, $V>$	Undervoltage/overvoltage protection
81O/U	$f>$, $f<$	Overfrequency/underfrequency protection
21FL		Fault locator

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Construction

Connection techniques and housing with many advantages

1/2 and 1/1-rack sizes

These are the available housing widths of the 7SJ63 relays, referred to a 19" module frame system. This means that previous models can always be replaced. The height is a uniform 244 mm for flush-mounting housings and 266 mm for surface-mounting housings for all housing widths. All cables can be connected with or without ring lugs. Plug-in terminals are available as an option.
It is thus possible to employ prefabricated cable harnesses. In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located in a sloped case at the top and bottom of the housing. The housing can also be supplied optionally with a detached operator panel (refer to Fig. 5/109), or without operator panel, in order to allow optimum operation for all types of applications.

Fig. 5/107
Flush-mounting housing with screw-type terminals

Fig. 5/108
Rear view of flush-mounting housing with covered connection terminals and wirings

Fig. 5/109
Housing with plug-in terminals and detached operator panel

Fig. 5/110
Surface-mounting housing with screw-type terminals

Fig. 5/111
Communication interfaces in a sloped case in a surface-mounting housing

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Protection functions

Time-overcurrent protection (ANSI 50, 50N, 51, 51N)

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

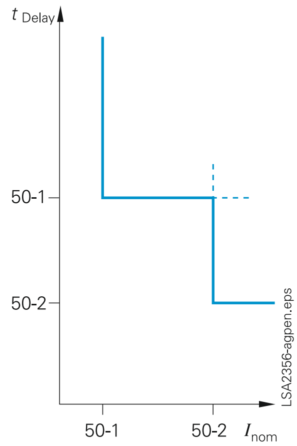

Fig. 5/112
Definite-time overcurrent protection

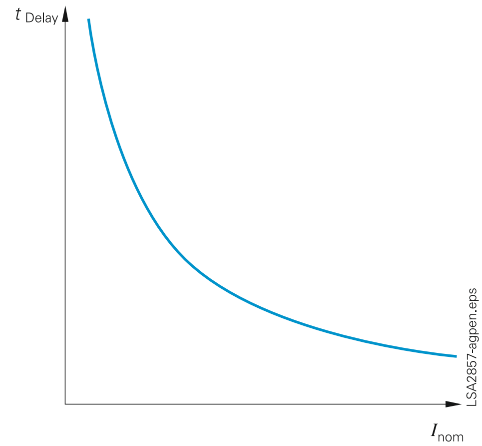

Fig. 5/113
Inverse-time overcurrent protection

Available inverse-time characteristics

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

Reset characteristics

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

User-definable characteristics

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

Inrush restraint

The relay features second harmonic restraint. If the second harmonic is detected during transformer energization, pickup of non-directional and directional normal elements are blocked.

Cold load pickup/dynamic setting change

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

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Protection functions

Directional time-overcurrent protection (ANSI 67, 67N)

Directional phase and earth protection are separate functions. They operate in parallel to the non-directional overcurrent elements. Their pickup values and delay times can be set separately. Definite-time and inverse-time characteristic is offered. The tripping characteristic can be rotated about ± 180 degrees.

By means of voltage memory, directionality can be determined reliably even for close-in (local) faults. If the switching device closes onto a fault and the voltage is too low to determine direction, directio- nality (directional decision) is made with voltage from the voltage memory. If no voltage exists in the memory, tripping occurs according to the coordination schedule.

For earth protection, users can choose whether the direction is to be determined via zero-sequence system or negative-sequence system quantities (selectable). Using negative-sequence variables can be advantageous in cases where the zero voltage tends to be very low due to unfavorable zero-sequence impedances.

Directional comparison protection (cross-coupling)

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

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

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

Two modes of earth-fault direction detection can be implemented: tripping or “signalling only mode”.

It has the following functions:

- TRIP via the displacement voltage V_E.
- Two instantaneous elements or one instantaneous plus one user-defined characteristic.
- Each element can be set in forward, reverse, or non-directional.
- The function can also be operated in the insensitive mode as an additional short-circuit protection.

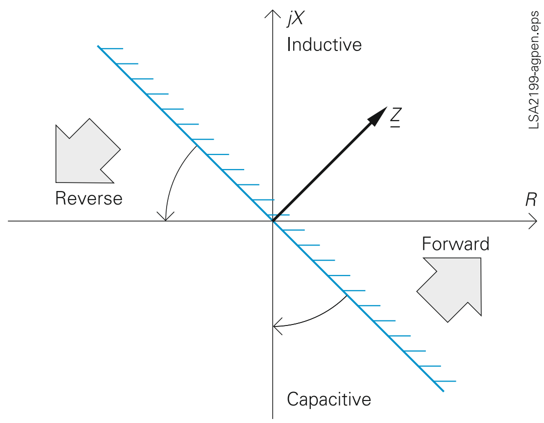

Fig. 5/114
Directional characteristic of the directional time-overcurrent protection

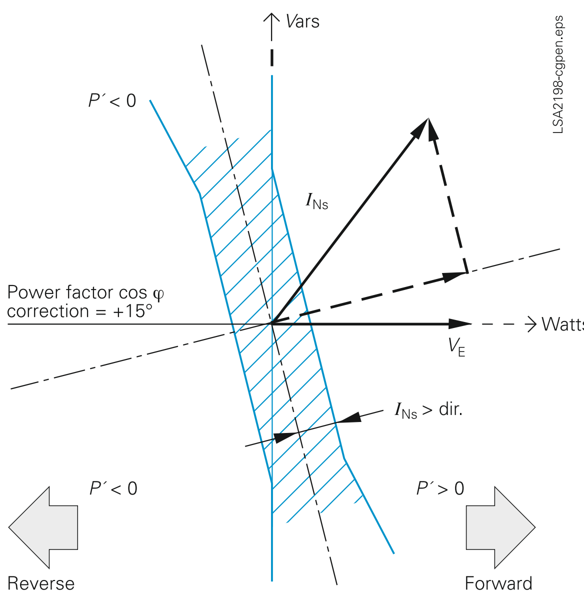

Fig. 5/115
Directional determination using cosine measurements for compensated networks

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

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

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

Protection functions

Intermittent earth-fault protection

Intermittent (re-striking) faults occur due to insulation weaknesses in cables or as a result of water penetrating cable joints. Such faults either simply cease at some stage or develop into lasting short-circuits. During intermittent activity, however, star-point resistors in networks that are impedance-earthed may undergo thermal overloading. The normal earth-fault protection cannot reliably detect and interrupt the current pulses, some of which can be very brief.
The selectivity required with intermittent earth faults is achieved by summating the duration of the individual pulses and by triggering when a (settable) summed time is reached. The response threshold I_{IE}> evaluates the r.m.s. value, referred to one systems period.

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

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

Breaker failure protection (ANSI 50BF)

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

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

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

When the high-impedance measurement principle is applied, all current transformers in the protected area are connected in parallel and operated on one common resistor of relatively high *R* whose voltage is measured (see Fig. 5/116). In the case of 7SJ6 units, the voltage is measured by detecting the current through the (external) resistor *R* at the sensitive current measurement input I_{EE}. The varistor *V* serves to limit the voltage in the event of an internal fault. It cuts off the high momentary voltage spikes occurring at transformer saturation. At the same time, this results in smoothing of the voltage without any noteworthy reduction of the average value.
If no faults have occurred and in the event of external faults, the system is at equilibrium, and the voltage through the resistor is approximately zero. In the event of internal faults, an imbalance occurs which leads to a voltage and a current flow through the resistor *R*.

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

Auto-reclosure (ANSI 79)

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

- 3-pole ARC for all types of faults
- Separate settings for phase and earth faults
- Multiple ARC, one rapid auto-reclosure (RAR) and up to nine delayed auto-reclosures (DAR)
- Starting of the ARC depends on the trip command selection (e.g. 46, 50, 51, 67)
- Blocking option of the ARC via binary inputs
- ARC can be initiated externally or via CFC
- The directional and non-directional elements can either be blocked or operated non-delayed depending on the auto-reclosure cycle
- Dynamic setting change of the directional and non-directional elements can be activated depending on the ready AR

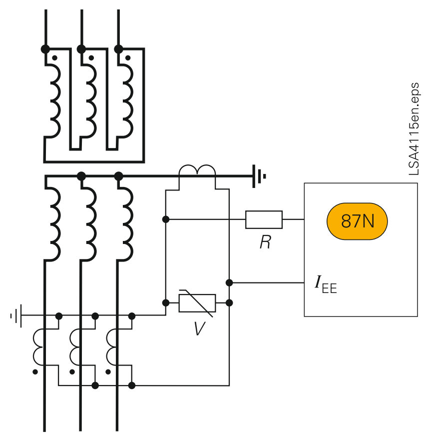

Fig. 5/116 High-impedance restricted earth-fault protection

Thermal overload protection (ANSI 49)

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

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

Settable dropout delay times

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

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Protection functions

Motor protection

Restart inhibit (ANSI 66/86)

If a motor is started up too many times in succession, the rotor can be subject to thermal overload, especially the upper edges of the bars. The rotor temperature is calculated from the stator current. The reclosing lockout only permits start-up of the motor if the rotor has sufficient thermal reserves for a complete start-up (see Fig. 5/117).

Emergency start-up

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

Temperature monitoring (ANSI 38)

Up to two temperature monitoring boxes with a total of 12 measuring sensors can be used for temperature monitoring and detection by the protection relay. The thermal status of motors, generators and transformers can be monitored with this device. Additionally, the temperature of the bearings of rotating machines are monitored for limit value violation. The temperatures are being measured with the help of temperature detectors at various locations of the device to be protected. This data is transmitted to the protection relay via one or two temperature monitoring boxes (see "Accessories", page 5/153).

Starting time supervision (ANSI 48/14)

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

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

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

I = Actual current flowing

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

t = Tripping time

I_A = Rated motor starting current

T_A = Tripping time at rated motor starting current

1) The 45 to 55, 55 to 65 Hz range is available for f_N = 50/60 Hz.

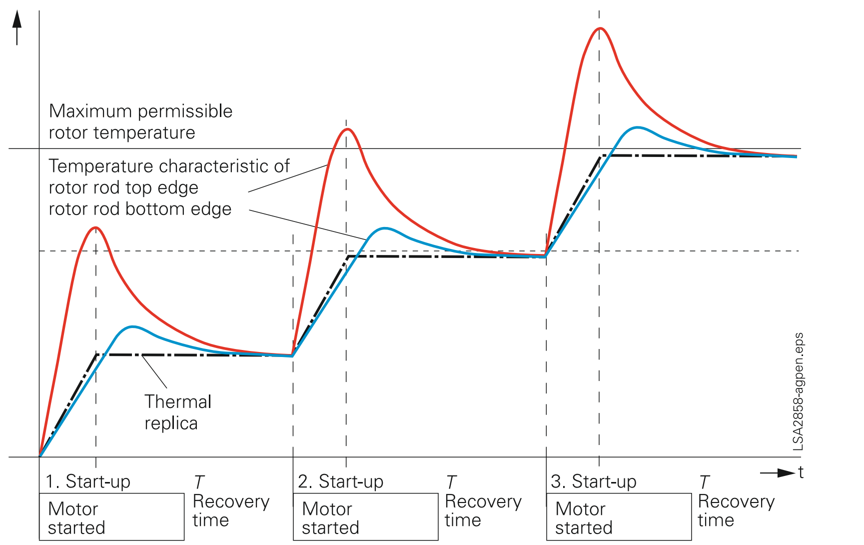

Fig. 5/117

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

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

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

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

Undercurrent monitoring (ANSI 37)

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

Voltage protection

Overvoltage protection (ANSI 59)

The two-element overvoltage protection detects unwanted network and machine overvoltage conditions. The function can operate either with phase-to-phase voltage (default) or with the negative phase-sequence system voltage. Three-phase and single-phase connections are possible.

Undervoltage protection (ANSI 27)

The two-element undervoltage protection provides protection against dangerous voltage drops (especially for electric machines). Applications include the isolation of generators or motors from the network to avoid undesired operating states and a possible loss of stability. Proper operating conditions of electrical machines are best evaluated with the positive-sequence quantities. The protection function is active over a wide frequency range (45 to 55, 55 to 65 Hz)[1]. Even when falling below this frequency range the function continues to work, however, with a greater tolerance band.

The function can operate either with the positive phase-sequence system voltage (default) or with the phase-to-phase voltages, and can be monitored with a current criterion. Three-phase and single-phase connections are possible.

Frequency protection (ANSI 81O/U)

Frequency protection can be used for overfrequency and underfrequency protection. Electric machines and parts of the system are protected from unwanted speed deviations. Unwanted frequency changes in the network can be detected and the load can be removed at a specified frequency setting. Frequency protection can be used over a wide frequency range (45 to 55, 55 to 65 Hz)[1]. There are four elements (selectable as overfrequency or underfrequency) and each element can be delayed separately. Blocking of the frequency protection can be performed if using a binary input or by using an undervoltage element.

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Protection functions/Functions

Fault locator (ANSI 21FL)

The fault locator specifies the distance to a fault location in kilometers or miles or the reactance of a second fault operation.

Circuit-breaker wear monitoring

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

There is no mathematically exact method of calculating the wear or the remaining service life of circuit-breakers that takes into account the arc-chamber's physical conditions when the CB opens. This is why various methods of determining CB wear have evolved which reflect the different operator philosophies. To do justice to these, the devices offer several methods:

- ΣI
- ΣI^x, with x = 1... 3

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

- Two-point method

The CB manufacturers double-logarithmic switching cycle diagram (see Fig. 5/118) and the breaking current at the time of contact opening serve as the basis for this method. After CB opening, the two-point method calculates the number of still possible switching cycles. To this end, the two points P1 and P2 only have to be set on the device. These are specified in the CB's technical data.

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

Customized functions (ANSI 32, 51V, 55, etc.)

Additional functions, which are not time critical, can be implemented via the CFC using measured values. Typical functions include reverse power, voltage controlled overcurrent, phase angle detection, and zero-sequence voltage detection.

1) The 45 to 55, 55 to 65 Hz range is available for f_N= 50/60 Hz

Commissioning

Commissioning could hardly be easier and is fully supported by DIGSI 4. The status of the binary inputs can be read individually and the state of the binary outputs can be set individually. The operation of switching elements (circuit-breakers, disconnect devices) can be checked using the switching functions of the bay controller. The analog measured values are represented as wide-ranging operational measured values. To prevent transmission of information to the control center during maintenance, the bay controller communications can be disabled to prevent unnecessary data from being transmitted. During commissioning, all indications with test marking for test purposes can be connected to a control and protection system.

Test operation

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

■ Control and automatic functions

Control

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

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

The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated to the 7SJ63 via binary inputs. Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a fault or intermediate circuit-breaker or auxiliary contact position.

The switchgear or circuit-breaker can be controlled via:

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

Automation / user-defined logic

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

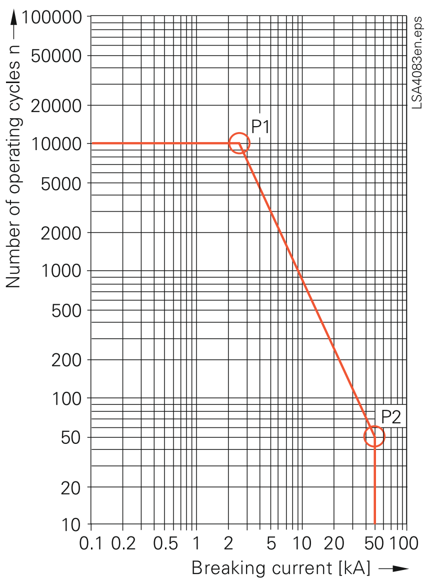

Fig. 5/118 CB switching cycle diagram

Switching authority

Switching authority is determined according to parameters, communication or by key-operated switch (when available).
If a source is set to “LOCAL”, only local switching operations are possible. The following sequence of switching authority is laid down: “LOCAL”; DIGSI PC program, “REMOTE”.

Key-operated switch

7SJ63 units are fitted with key-operated switch function for local/remote changeover and changeover between interlocked switching and test operation.

Command processing

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

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable bay interlocks
- Operating sequences combining several switching operations such as control of circuit-breakers, disconnectors and earthing switches
- Triggering of switching operations, indications or alarm by combination with existing information

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Functions

Motor control

The SIPROTEC 4 7SJ63 with high performance relays is well-suited for direct activation of the circuit-breaker, disconnector and earthing switch operating mechanisms in automated substations.

Interlocking of the individual switching devices takes place with the aid of programmable logic. Additional auxiliary relays can be eliminated. This results in less wiring and engineering effort.

Assignment of feedback to command

The positions of the circuit-breaker or switching devices and transformer taps are acquired by feedback. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication change is a consequence of switching operation or whether it is a spontaneous change of state.

Chatter disable

Chatter disable feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

Indication filtering and delay

Binary indications can be filtered or delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time. In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

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

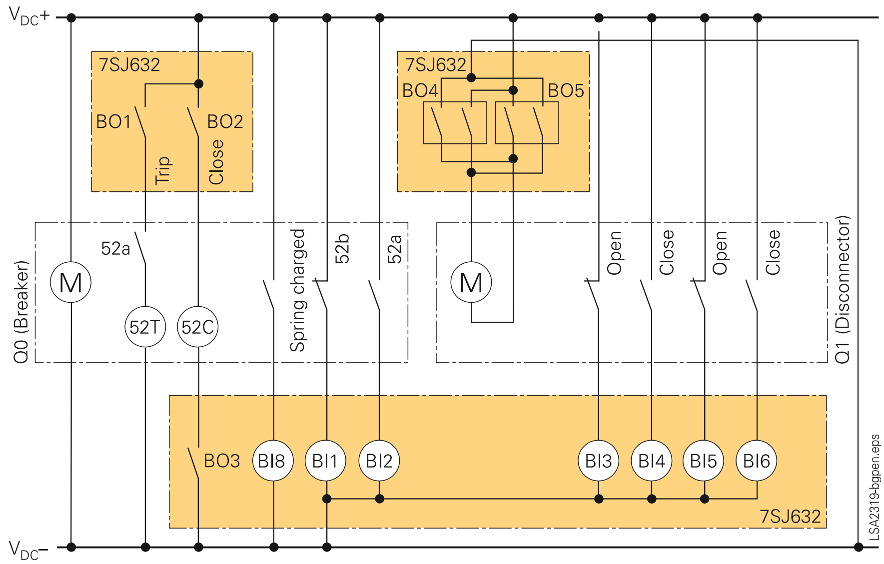

Fig. 5/119
Typical wiring for 7SJ632 motor direct control (simplified representation without fuses)
Binary output BO4 and BO5 are interlocked so that only one set of contacts are closed at a time.

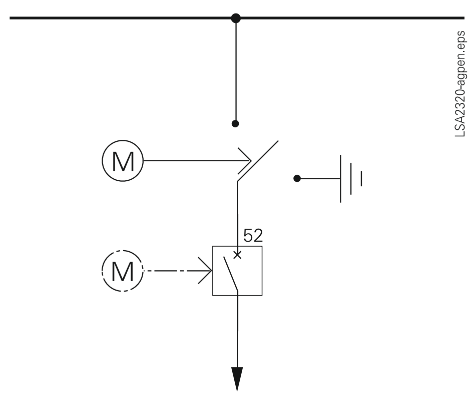

Fig. 5/120 Example: Single busbar with circuit-breaker and motor-controlled three-position switch

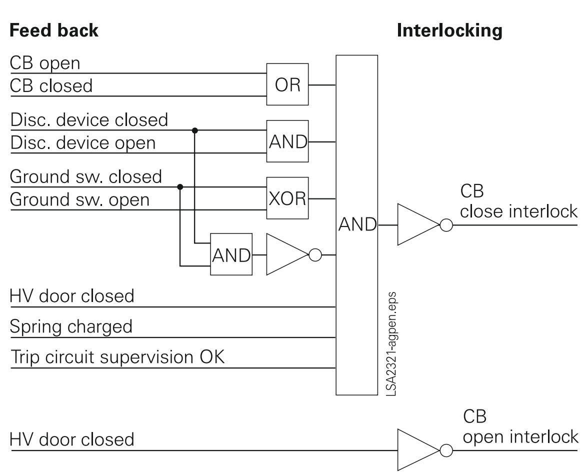

Fig. 5/121 Example: Circuit-breaker interlocking

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Functions

Measured values

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

- Currents I_{L1}, I_{L2}, I_{L3}, I_E, I_{EE} (67Ns)
- Voltages V_{L1}, V_{L2}, V_{L3}, V_{L1L2}, V_{L2L3}, V_{L3L1}
- Symmetrical components
  I_1, I_2, $3I_0$; V_1, V_2, V_0
- Power Watts, Vars, VA/P, Q, S
  (P, Q: total and phase-selective)
- Power factor (cos φ)
  (total and phase-selective)
- Frequency
- Energy ± kWh, ± kVarh, forward and reverse power flow
- Mean as well as minimum and maximum current and voltage values
- Operating hours counter
- Mean operating temperature of overload function
- Limit value monitoring
  Limit values are monitored using programmable logic in the CFC. Commands can be derived from this limit value indication.
- Zero suppression
  In a certain range of very low measured values, the value is set to zero to suppress interference.

Metered values

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

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

Measuring transducers

- Characteristic with knee
  For measuring transducers it sometimes makes sense to extend a small range of the input value, e.g. for the frequency that is only relevant in the range 45 to 55, 55 to 65 Hz. This can be achieved by using a knee characteristic.
- Live-zero monitoring
  4 - 20 mA circuits are monitored for open-circuit detection.

Switchgear cubicles for high/medium voltage

All units are designed specifically to meet the requirements of high/medium-voltage applications.

In general, no separate measuring instruments (e.g. for current, voltage, frequency measuring transducer ...) or additional control components are necessary.

Fig. 5/122
NX PLUS panel (gas-insulated)

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Communication

In terms of communication, the units offer substantial flexibility in the context of connection to industrial and power automation standards. Communication can be extended or added on thanks to modules for retrofitting on which the common protocols run. Therefore, also in the future it will be possible to optimally integrate units into the changing communication infrastructure, for example in Ethernet networks (which will also be used increasingly in the power supply sector in the years to come).

Serial front interface

There is a serial RS232 interface on the front of all the units. All of the unit's functions can be set on a PC by means of the DIGSI 4 protection operation program. Commissioning tools and fault analysis are also built into the program and are available through this interface.

Rear-mounted interfaces[1)]

A number of communication modules suitable for various applications can be fitted in the rear of the flush-mounting housing. In the flush-mounting housing, the modules can be easily replaced by the user.
The interface modules support the following applications:

- Time synchronization interface
  All units feature a permanently integrated electrical time synchronization interface. It can be used to feed timing telegrams in IRIG-B or DCF77 format into the units via time synchronization receivers.
- System interface
  Communication with a central control system takes place through this interface. Radial or ring type station bus topologies can be configured depending on the chosen interface. Furthermore, the units can exchange data through this interface via Ethernet and IEC 61850 protocol and can also be operated by DIGSI.
- Service interface
  The service interface was conceived for remote access to a number of protection units via DIGSI. On all units, it can be an electrical RS232/RS485 or an optical interface. For special applications, a maximum of two temperature monitoring boxes (RTD-box) can be connected to this interface as an alternative.

1) For units in panel surface-mounting housings please refer to note on page 5/130.

System interface protocols (retrofittable)

IEC 61850 protocol

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

IEC 60870-5-103 protocol

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

PROFIBUS-DP protocol

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

MODBUS RTU protocol

This uncomplicated, serial protocol is mainly used in industry and by power supply corporations, and is supported by a number of unit manufacturers. SIPROTEC units function as MODBUS slaves, making their information available to a master or receiving information from it. A time-stamped event list is available.

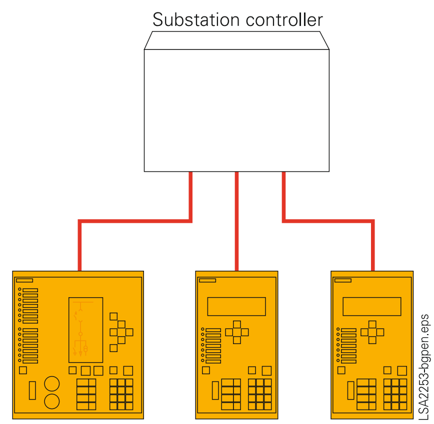

Fig. 5/123
IEC 60870-5-103: Radial fiber-optic connection

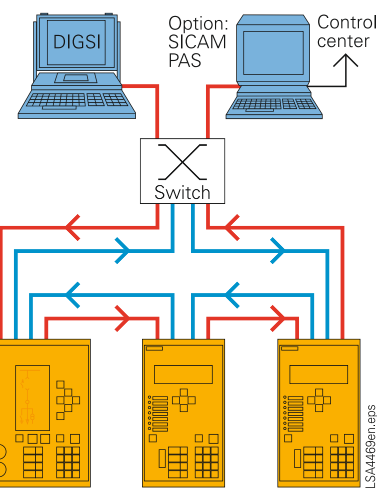

Fig. 5/124
Bus structure for station bus with Ethernet and IEC 61850, fiber-optic ring

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Communication

DNP 3.0 protocol

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

System solutions for protection and station control

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

Units featuring IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 5/123).

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

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 5/124).

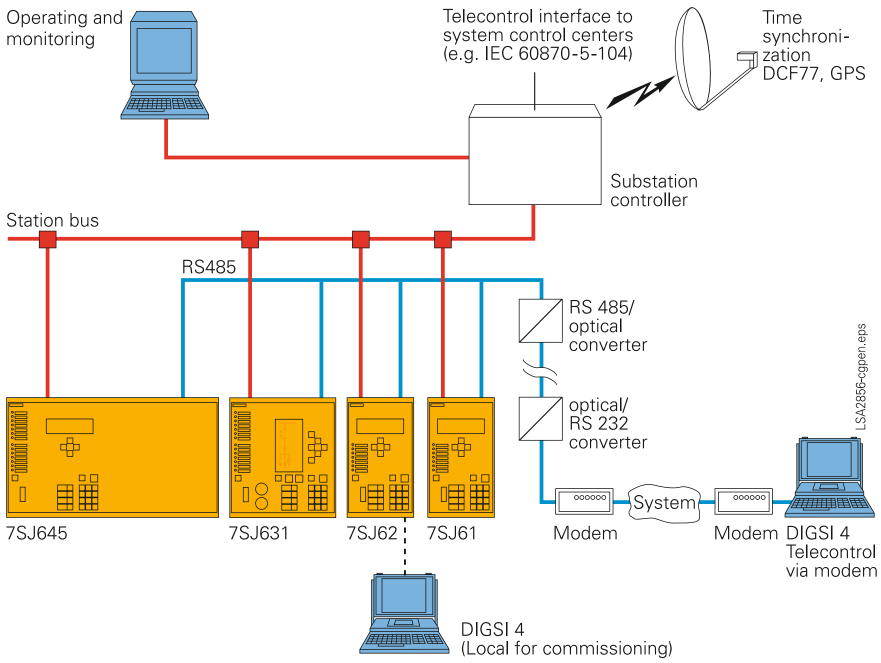

Fig. 5/125
System solution/communication

Fig. 5/126
Optical Ethernet communication module for IEC 61850 with integrated Ethernet-switch

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Typical connections

■ Connection of current and voltage transformers

Standard connection

For earthed networks, the earth current is obtained from the phase currents by the residual current circuit.

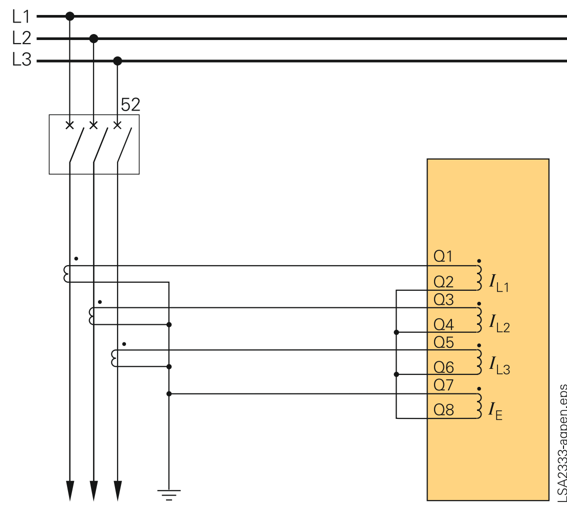

Fig. 5/127
Residual current circuit without directional element

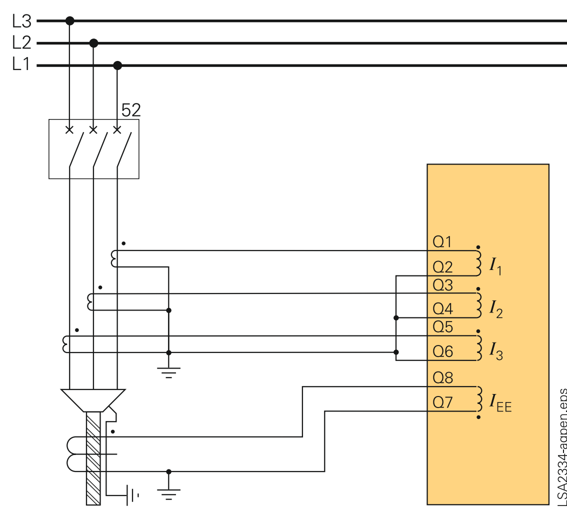

Fig. 5/128
Sensitive earth current detection without directional element

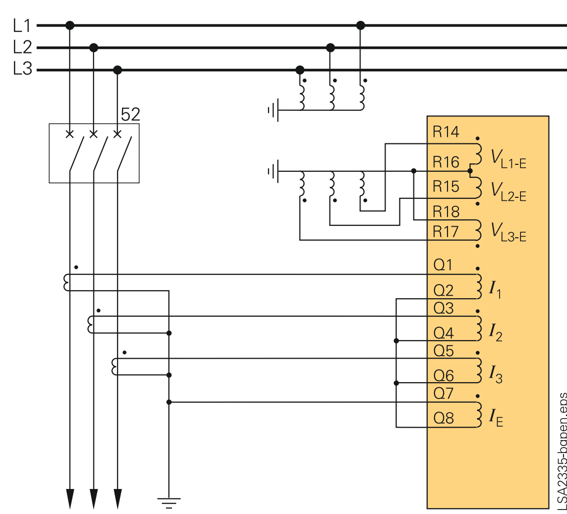

Fig. 5/129
Residual current circuit with directional element

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Typical connections

Connection for compensated networks

The figure shows the connection of two phase-to-earth voltages and the V_E voltage of the open delta winding and a phase-balance neutral current transformer for the earth current. This connection maintains maximum precision for directional earth-fault detection and must be used in compensated networks.
Figure 5/130 shows sensitive directional earth-fault detection.

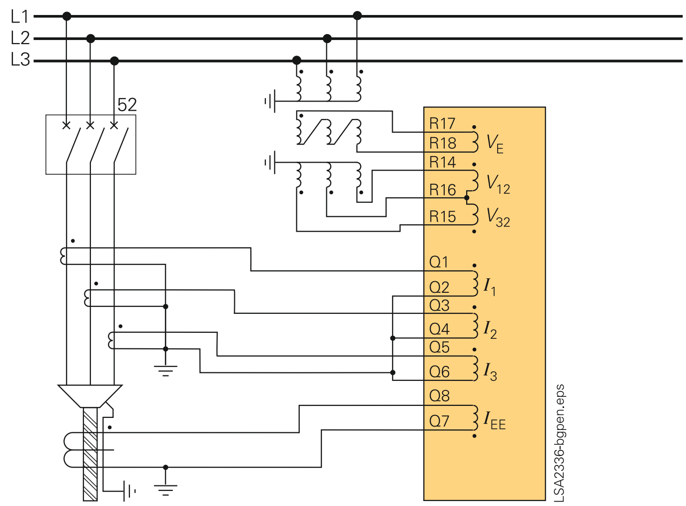

Fig. 5/130
Sensitive directional earth-fault detection with directional element for phases

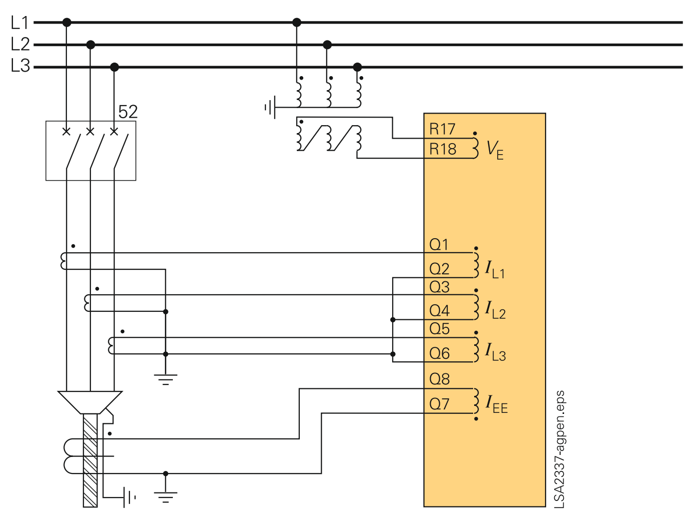

Fig. 5/131
Sensitive directional earth-fault detection

Connection for isolated-neutral or compensated networks only

If directional earth-fault protection is not used, the connection can be made with only two phase current transformers. Directional phase short-circuit protection can be achieved by using only two primary transformers.

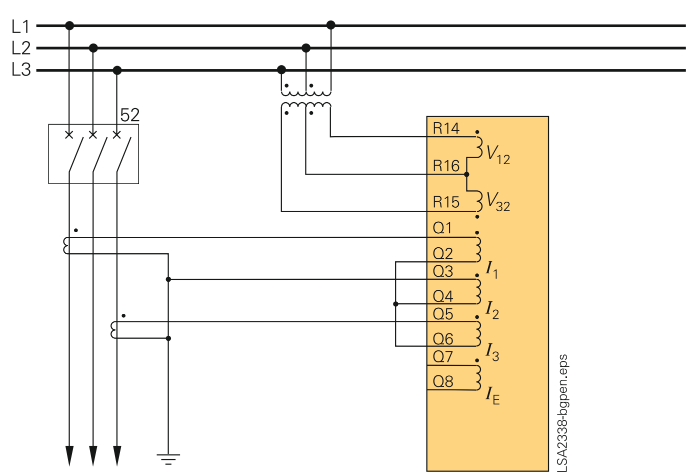

Fig. 5/132
Isolated-neutral or compensated networks

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Typical applications

Overview of connection types

Type of network	Function	Current connection	Voltage connection
(Low-resistance) earthed network	Time-overcurrent protection phase/earth non-directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformer possible	-
(Low-resistance) earthed networks	Sensitive earth-fault protection	Phase-balance neutral current transformers required	-
Isolated or compensated networks	Time-overcurrent protection phases non-directional	Residual circuit, with 3 or 2 phase current transformers possible	-
(Low-resistance) earthed networks	Time-overcurrent protection phases directional	Residual circuit, with 3 phase-current transformers possible	Phase-to-earth connection or phase-to-phase connection
Isolated or compensated networks	Time-overcurrent protection phases directional	Residual circuit, with 3 or 2 phase-current transformers possible	Phase-to-earth connection or phase-to-phase connection
(Low-resistance) earthed networks	Time-overcurrent protection earth directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformers possible	Phase-to-earth connection required
Isolated networks	Sensitive earth-fault protection	Residual circuit, if earth current $> 0.05\ I_N$ on secondary side, otherwise phase-balance neutral current transformers required	3 times phase-to-earth connection or phase-to-earth connection with open delta winding
Compensated networks	Sensitive earth-fault protection cos φ measurement	Phase-balance neutral current transformers required	Phase-to-earth connection with open delta winding required

■ Connection of circuit-breaker

Undervoltage releases

Undervoltage releases are used for automatic tripping of high-voltage motors.

Example:
DC supply voltage of control system fails and manual electric tripping is no longer possible.

Automatic tripping takes place when voltage across the coil drops below the trip limit. In Fig. 5/133, tripping occurs due to failure of DC supply voltage, by automatic opening of the live status contact upon failure of the protection unit or by short-circuiting the trip coil in event of a network fault.

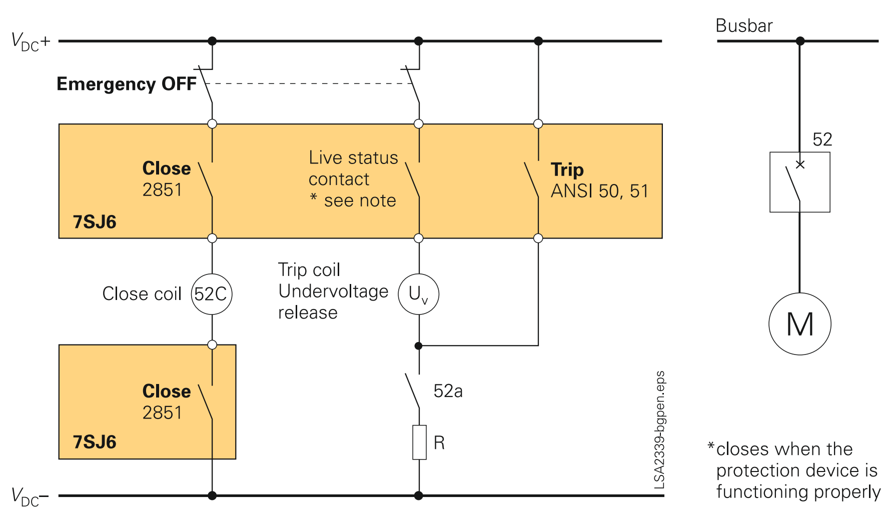

Fig. 5/133 Undervoltage release with make contact (50, 51)

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Typical applications

In Fig. 5/134 tripping is by failure of auxiliary voltage and by interruption of tripping circuit in the event of network failure. Upon failure of the protection unit, the tripping circuit is also interrupted, since contact held by internal logic drops back into open position.

Trip circuit supervision (ANSI 74TC)

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

Lockout (ANSI 86)

All binary outputs can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only occur after the lockout state is reset.

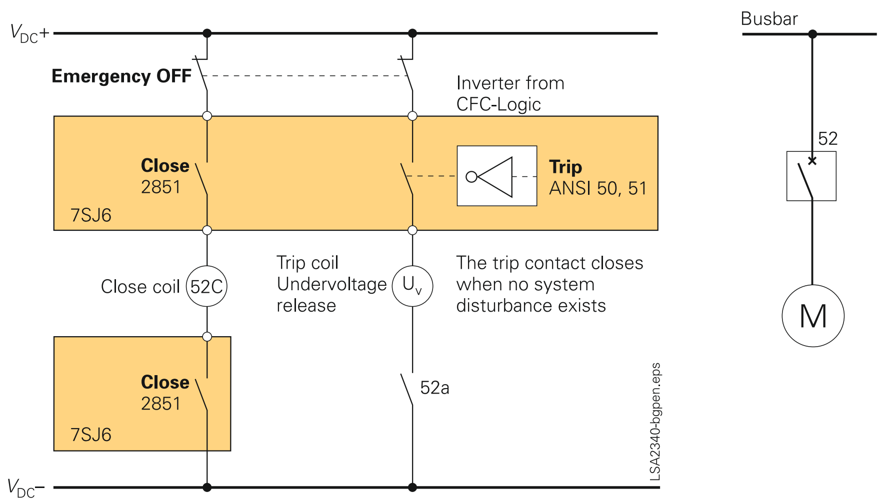
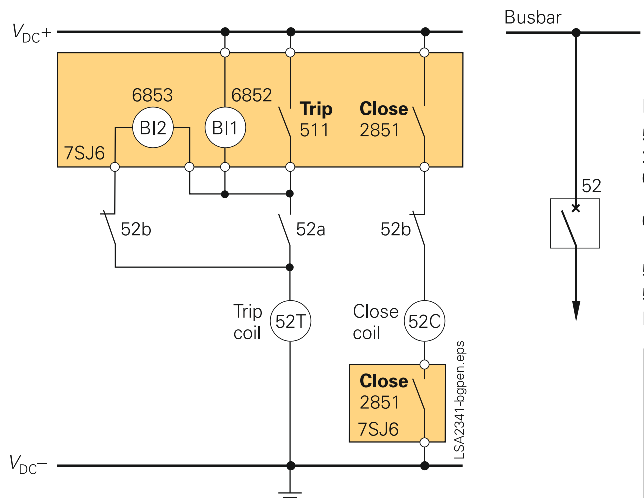


Fig. 5/134 Undervoltage release with locking contact (trip signal 50 is inverted)

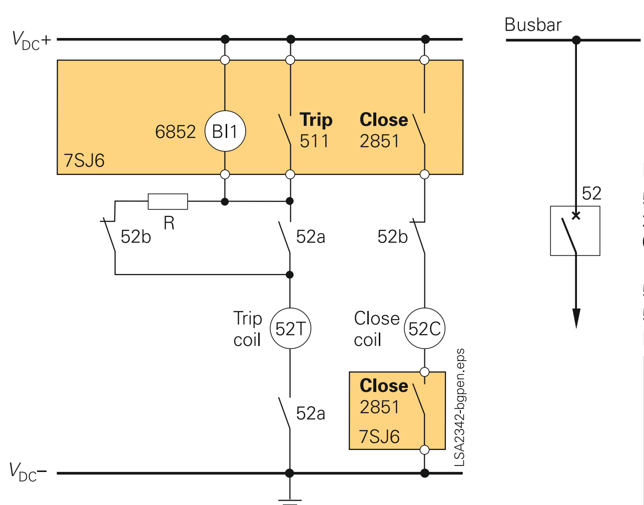


Protection indications
511* General trip
2851* CB close command
6852* Trip circuit supervision: Trip relay
6853* Trip circuit supervision: CB aux

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

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

Fig. 5/135 Trip circuit supervision with 2 binary inputs



Protection indications
511* General trip
2851* CB close command
6852* Trip circuit supervision: Trip relay

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

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

Fig. 5/136 Trip circuit supervision with 1 binary input

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Technical data

General unit data

Measuring circuits

System frequency	50 / 60 Hz (settable)	
Current transformer		
Rated current I_{nom}	1 or 5 A (settable)	
Option: sensitive earth-fault CT	I_{EE} < 1.6 A	
Power consumption at I_{nom} = 1 A at I_{nom} = 5 A for sensitive earth-fault CT at 1 A	 Approx. 0.05 VA per phase Approx. 0.3 VA per phase Approx. 0.05 VA	
Overload capability Thermal (effective) Dynamic (impulse current)	 100 x I_{nom} for 1 s 30 x I_{nom} for 10 s 4 x I_{nom} continuous 250 x I_{nom} (half cycle)	
Overload capability if equipped with sensitive earth-fault CT Thermal (effective) Dynamic (impulse current)	 300 A for 1 s 100 A for 10 s 15 A continuous 750 A (half cycle)	
Voltage transformer		
Rated voltage V_{nom}	100 V to 225 V	
Power consumption at V_{nom} = 100 V	< 0.3 VA per phase	
Overload capability in voltage path (phase-neutral voltage) Thermal (effective)	 230 V continuous	
Measuring transducer inputs		
Type	7SJ633	7SJ636
Number	2	2
Input current	DC 0 - 20 mA	
Input resistance	10 Ω	
Power consumption	5.8 mW at 24 mA	

Auxiliary voltage *(via integrated converter)*

Rated auxiliary voltage V_{aux}	DC	24/48 V	60/125 V	110/250 V
Permissible tolerance	DC	19 - 58 V	48 - 150 V	88 - 300 V
Ripple voltage, peak-to-peak		≤ 12 % of rated auxiliary voltage		
Power consumption		7SJ631	7SJ632 7SJ633	7SJ635 7SJ636
Quiescent Energized	Approx. Approx.	4 W 10 W	5.5 W 16 W	7 W 20 W
Backup time during loss/short-circuit of auxiliary direct voltage		≥ 50 ms at V > 110 V DC ≥ 20 ms at V > 24 V DC		
Rated auxiliary voltage V_{aux}	AC	115 V	230 V	
Permissible tolerance	AC	92 - 132 V	184 - 265 V	
Power consumption		7SJ631	7SJ632 7SJ633	7SJ635 7SJ636
Quiescent Energized	Approx. Approx.	3 W 12 W	5 W 18 W	7 W 23 W
Backup time during loss/short-circuit of auxiliary alternating voltage		≥ 200 ms		

Binary inputs/indication inputs

Type	7SJ631	7SJ632	7SJ633	7SJ635	7SJ636
Number (marshallable)	11	24	20	37	33
Voltage range	24 - 250 V DC				
Pickup threshold modifiable by plug-in jumpers					
Pickup threshold DC	19 V DC		88 V DC		
For rated control voltage DC	24/48/60/110/ 125 V DC		110/125/220/250 V DC		
Power consumption energized	0.9 mA (independent of operating voltage) for BI 1…6 / 8…19 / 25…36; 1.8 mA for BI 7 / 20…24 / 37				

Binary outputs/command outputs

Type	7SJ631	7SJ632	7SJ633	7SJ635	7SJ636
Command/indication relay	8	11	11	14	14
Contacts per command/ indication relay	1 NO / form A				
Live status contact	1 NO / NC (jumper) / form A / B				
Switching capacity Make	1000 W / VA				
Break	30 W / VA / 40 W resistive / 25 W at L/R ≤ 50 ms				
Switching voltage	≤ 250 V DC				
Permissible current	5 A continuous, 30 A for 0.5 s making current, 2000 switching cycles				

Power relay *(for motor control)*

Type	7SJ631	7SJ632 7SJ633 7SJ636	7SJ635
Number	0	2 (4)	4 (8)
Number of contacts/relay		2 NO / form A	
Switching capacity Make	1000 W / VA at 48 V … 250 V / 500 W at 24 V		
Break	1000 W / VA at 48 V … 250 V / 500 W at 24 V		
Switching voltage	≤ 250 V DC		
Permissible current	5 A continuous, 30 A for 0.5 s		

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Technical data

Electrical tests	
Specification	
Standards	IEC 60255 ANSI C37.90, C37.90.1, C37.90.2, UL508
Insulation tests	
Standards	IEC 60255-5; ANSI/IEEE C37.90.0
Voltage test (100 % test) all circuits except for auxiliary voltage and RS485/RS232 and time synchronization	2.5 kV (r.m.s. value), 50/60 Hz
Auxiliary voltage	3.5 kV DC
Communication ports and time synchronization	500 V AC
Impulse voltage test (type test) all circuits, except communication ports and time synchronization, class III	5 kV (peak value); 1.2/50 µs; 0.5 J 3 positive and 3 negative impulses at intervals of 5 s
***EMC tests for interference immunity;** type tests*	
Standards	IEC 60255-6; IEC 60255-22 (product standard) EN 50082-2 (generic specification) DIN 57435 Part 303
High-frequency test IEC 60255-22-1, class III and VDE 0435 Part 303, class III	2.5 kV (peak value); 1 MHz; τ =15 ms; 400 surges per s; test duration 2 s
Electrostatic discharge IEC 60255-22-2 class IV and EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air gap discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with radio-frequency field, non-modulated IEC 60255-22-3 (Report) class III	10 V/m; 27 to 500 MHz
Irradiation with radio-frequency field, amplitude-modulated IEC 61000-4-3; class III	10 V/m, 80 to 1000 MHz; AM 80 %; 1 kHz
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204; class III	10 V/m, 900 MHz; repetition rate 200 Hz, on duration 50 %
Fast transient interference/burst IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; test duration 1 min
High-energy surge voltages (Surge) IEC 61000-4-5; class III	
Auxiliary voltage	From circuit to circuit: 2 kV; 12 Ω; 9 µF across contacts: 1 kV; 2 Ω ;18 µF
Binary inputs/outputs	From circuit to circuit: 2 kV; 42 Ω; 0.5 µF across contacts: 1 kV; 42 Ω; 0.5 µF
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; AM 80 %; 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m; 50 Hz, continuous 300 A/m; 50 Hz, 3 s 0.5 mT, 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak value), 1 to 1.5 MHz damped wave; 50 surges per s; duration 2 s, R_i = 150 to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per s both polarities; duration 2 s, R_i = 80 Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz; amplitude and pulse-modulated
Damped wave IEC 60694 / IEC 61000-4-12	2.5 kV (peak value, polarity alternating) 100 kHz, 1 MHz, 10 and 50 MHz, R_i = 200 Ω
***EMC tests for interference emission;** type tests*	
Standard	EN 50081-* (generic specification)
Conducted interferences only auxiliary voltage IEC/CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC/CISPR 11	30 to 1000 MHz Limit class B
Units with a detached operator panel must be installed in a metal cubicle to maintain limit class B	

Mechanical stress tests	
Vibration, shock stress and seismic vibration	
During operation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz; +/- 0.075 mm amplitude; 60 to 150 Hz; 1 *g* acceleration frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 5 *g*, duration 11 ms; 3 shocks in both directions of 3 axes
Seismic vibration IEC 60255-21-3, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 perpendicular axes
During transportation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz; 2 *g* acceleration, frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, Class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 15 *g*, duration 11 ms 3 shocks in both directions of 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Semi-sinusoidal Acceleration 10 *g*, duration 16 ms 1000 shocks in both directions of 3 axes

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Climatic stress tests	
Temperatures	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C /-13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	-20 °C to +70 °C /-4 °F to +158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C /+131 °F)	-5 °C to +55 °C /+25 °F to +131 °F
– Limiting temperature during permanent storage	-25 °C to +55 °C /-13 °F to +131 °F
– Limiting temperature during transport	-25 °C to +70 °C /-13 °F to +158 °F
Humidity	
Permissible humidity It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average 75 % relative humidity; on 56 days a year up to 95 % relative humidity; condensation not permissible!

Unit design		
Housing	7XP20	
Dimensions	See dimension drawings, part 15 of this catalog	
Weight in kg	Housing width 1/2	Housing width 1/1
Surface-mounting housing	7.5	15
Flush-mounting housing	6.5	13
Housing for detached operator panel	8.0	15
Detached operator panel	2.5	2.5
Degree of protection acc. to EN 60529		
Surface-mounting housing	IP 51	
Flush-mounting housing	Front: IP 51, rear: IP 20;	
Operator safety	IP 2x with cover	

Serial interfaces	
Operating interface *(front of unit)*	
Connection	Non-isolated, RS232; front panel, 9-pin subminiature connector
Transmission rate	min. 4800 baud, max. 115200 baud
Service/modem interface *(rear of unit)*	
Isolated interface for data transfer	Port C: DIGSI 4/modem/RTD-box
Transmission rate	Factory setting 38400 baud min. 4800 baud, max. 115200 baud
RS232/RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location “C”
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	15 m /49.2 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth

System interface (rear of unit)	
IEC 60870-5-103 protocol	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Factory setting: 9600 baud, min. 9600 baud, max. 19200 baud
RS232/RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	Max. 15 m/49 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth
Fiber optic	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles
IEC 61850 protocol	
Isolated interface for data transfer: - to a control center - with DIGSI - between SIPROTEC 4 relays	Port B, 100 Base T acc. to IEEE802.3
Transmission rate	100 Mbit
Ethernet, electrical	
Connection	Two RJ45 connectors
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
Distance	Max. 20 m / 65.6 ft
Test voltage	500 V AC against earth
Ethernet, optical	
Connection	Intergr. LC connector for FO connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
Optical wavelength	1300 nmm
Distance	1.5 km/0.9 miles
PROFIBUS-FMS/DP	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 1.5 Mbaud

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Technical data

RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location "B"
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance	1000 m/3300 ft ≤ 93.75 kbaud; 500 m/1500 ft ≤ 187.5 kbaud; 200 m/600 ft ≤ 1.5 Mbaud; 100 m/300 ft ≤ 12 Mbaud
Test voltage	500 V AC against earth
Fiber optic	
Connection fiber-optic cable	Integr. ST connector for FO connection, mounting location "B"
For flush-mounting housing/ surface-mounting housing with detached operator panel	
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing Important: Please refer to footnotes 1) and 2) on page 5/174
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	500 kB/s 1.6 km/0.99 miles 1500 kB/s 530 m/0.33 miles
MODBUS RTU, ASCII, DNP 3.0	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 19200 baud
RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location "B"
For surface-mounting housing with two-tier terminal at the top/bottom part	At bottom part of the housing: shielded data cable
Distance	Max. 1 km/3300 ft max. 32 units recommended
Test voltage	500 V AC against earth
Fiber-optic	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing Important: Please refer to footnotes 1) and 2) on page 5/174
Optical wavelength	820 nm
Permissible path attenuation	Max 8 dB. for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles
Time synchronization DCF77/IRIG-B signal (Format IRIG-B000)	
Connection	9-pin subminiature connector (SUB-D) (terminal with surface-mounting housing)
Voltage levels	5 V, 12 V or 24 V (optional)

1) At I_{nom} = 1 A, all limits divided by 5.

Functions

Definite-time overcurrent protection, directional/non-directional (ANSI 50, 50N, 67, 67N)		
Operating mode non-directional phase protection (ANSI 50)	3-phase (standard) or 2-phase (L1 and L3)	
Setting ranges		
Pickup phase elements $I>$, $I>>$	0.5 to 175 A or ∞[1] (in steps of 0.01 A)	
Pickup earth elements $I_E>$, $I_E>>$	0.25 to 175 A or ∞[1] (in steps of 0.01 A)	
Delay times T	0 to 60 s or ∞ (in steps of 0.01 s)	
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)	
Times		
Pickup times (without inrush restraint, with inrush restraint + 10 ms)	Non-directional	Directional
With twice the setting value	Approx. 30 ms	45 ms
With five times the setting value	Approx. 20 ms	40 ms
Dropout times	Approx. 40 ms	
Dropout ratio	Approx. 0.95 for $I/I_{nom} \geq 0.3$	
Tolerances		
Pickup	2 % of setting value or 50 mA[1]	
Delay times T, T_{DO}	1 % or 10 ms	
Inverse-time overcurrent protection, directional/non-directional (ANSI 51, 51N, 67, 67N)		
Operating mode non-directional phase protection (ANSI 51)	3-phase (standard) or 2-phase (L1 and L3)	
Setting ranges		
Pickup phase element I_P	0.5 to 20 A or ∞ [1] (in steps of 0.01 A)	
Pickup earth element I_{EP}	0.25 to 20 A or ∞ [1] (in steps of 0.01 A)	
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)	
Time multiplier D (ANSI characteristics)	0.05 to 15 s or ∞ (in steps of 0.01 s)	
Trip characteristics		
IEC	Normal inverse, very inverse, extremely inverse, long inverse	
ANSI	Inverse, short inverse, long inverse moderately inverse, very inverse, extremely inverse, definite inverse	
User-defined characteristic	Defined by a maximum of 20 value pairs of current and time delay	
Dropout setting		
Without disk emulation	Approx. 1.05 · setting value I_p for $I_p/I_{nom} \geq 0.3$, corresponds to approx. 0.95 · pickup threshold	
With disk emulation	Approx. 0.90 · setting value I_p	
Tolerances		
Pickup/dropout thresholds I_p, I_{Ep}	2 % of setting value or 50 mA[1]	
Pickup time for $2 \leq I/I_p \leq 20$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms	
Dropout ratio for $0.05 \leq I/I_p \leq 0.9$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms	

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Technical data

Direction detection	
For phase faults	
Polarization	With cross-polarized voltages; With voltage memory for measurement voltages that are too low
Forward range Rotation of reference voltage $V_{ref,rot}$	$V_{ref,rot} \pm 86°$ - 180° to 180° (in steps of 1°)
Direction sensitivity	For one and two-phase faults unlimited; For three-phase faults dynamically unlimited; Steady-state approx. 7 V phase-to-phase
For earth faults	
Polarization	With zero-sequence quantities $3V_0$, $3I_0$ or with negative-sequence quantities $3V_2$, $3I_2$
Forward range Rotation of reference voltage $V_{ref,rot}$	$V_{ref,rot} \pm 86°$ - 180° to 180° (in steps of 1°)
Direction sensitivity	
Zero-sequence quantities $3V_0$, $3I_0$	$V_E \approx 2.5$ V displacement voltage, measured; $3V_0 \approx 5$ V displacement voltage, calculated
Negative -sequence quantities $3V_2$, $3I_2$	$3V_2 \approx 5$ V negative-sequence voltage; $3I_2 \approx 225$ mA negative-sequence current[1)]
Tolerances (phase angle error under reference conditions)	
For phase and earth faults	± 3 ° electrical
Inrush blocking	
Influenced functions	Time-overcurrent elements, I>, I_E>, I_p, I_{Ep} (directional, non-directional)
Lower function limit	1.25 A[1)]
Upper function limit (setting range)	1.5 to 125 A[1)] (in steps of 0.01 A)
Setting range I_{2f}/I	10 to 45 % (in steps of 1 %)
Crossblock (I_{L1}, I_{L2}, I_{L3})	ON/OFF
Dynamic setting change	
Controllable function	Directional and non-directional pickup, tripping time
Start criteria	Current criteria, CB position via aux. contacts, binary input, auto-reclosure ready
Time control	3 timers
Current criteria	Current threshold (reset on dropping below threshold; monitoring with timer)

(Sensitive) earth-fault detection *(ANSI 64, 50 Ns, 51Ns, 67Ns)*	
Displacement voltage starting *for all types of earth fault (ANSI 64)*	
Setting ranges	
Pickup threshold V_E> (measured)	1.8 to 170 V (in steps of 0.1 V)
Pickup threshold $3V_0$> (calculated)	10 to 225 V (in steps of 0.1 V)
Delay time $T_{Delay\ pickup}$	0.04 to 320 s or ∞ (in steps of 0.01 s)
Additional trip delay T_{VDELAY}	0.1 to 40000 s or ∞ (in steps of 0.01 s)
Times	
Pickup time	Approx. 60 ms
Dropout ratio	0.95 or (pickup value -0.6 V)
Tolerances	
Pickup threshold V_E (measured)	3 % of setting value or 0.3 V
Pickup threshold $3V_0$ (calculated)	3 % of setting value or 3 V
Delay times	1 % of setting value or 10 ms
Phase detection for earth fault in an unearthed system	
Measuring principle	Voltage measurement (phase-to-earth)
Setting ranges	
$V_{ph\ min}$ (earth-fault phase)	10 to 100 V (in steps of 1 V)
$V_{ph\ max}$ (unfaulted phases)	10 to 100 V (in steps of 1 V)
Measuring tolerance acc. to DIN 57435 part 303	3 % of setting value, or 1 V
Earth-fault pickup *for all types of earth faults*	
Definite-time characteristic *(ANSI 50Ns)*	
Setting ranges	
Pickup threshold I_{EE}>, I_{EE}>>	
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A[1)] (in steps of 0.01 A)
Delay times T for I_{EE}>, I_{EE}>>	0 to 320 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Times	
Pickup times	Approx. 60 ms (non-directional) Approx. 80 ms (directional
Dropout ratio	Approx. 0.95
Tolerances	
Pickup threshold I_{EE}>, I_{EE}>>	2 % of setting value or 1 mA
Delay times	1 % of setting value or 20 ms
Earth-fault pickup *for all types of earth faults*	
Inverse-time characteristic *(ANSI 51Ns)*	
User-defined characteristic	Defined by a maximum of 20 pairs of current and delay time values
Logarithmic inverse	$t = T_{IEEpmax} - T_{IEEp} \cdot \ln \frac{I}{I_{EEp}}$
Setting ranges	
Pickup threshold I_{EEp}	
For sensitive input	0.001 A to 1.4 A (in steps of 0.001 A)
For normal input	0.25 to 20 A[1)] (in steps of 0.01 A)
User defined	
Time multiplier T	0.1 to 4 s or ∞ (in steps of 0.01 s)
Logarithmic inverse	
Time multiplier $T_{IEEp\ mul}$	0.05 to 15 s or ∞ (in steps of 0.01 s)
Delay time T_{IEEp}	0.1 to 4 s or ∞ (in steps of 0.01 s)
Min time delay $T_{IEEpmin}$	0 to 32 s (in steps of 0.01 s)
Max. time delay $T_{IEEpmax}$	0 to 32 s (in steps of 0.01 s)

Note: Due to the high sensitivity the linear range of the measuring input IN with integrated sensitive input transformer is from 0.001 A to 1.6 A. For currents greater than 1.6 A, correct directionality can no longer be guaranteed.

1) For I_{nom} = 1 A, all limits divided by 5.

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Times	
Pickup times	Approx. 60 ms (non-directional) Approx 80 ms (directional)
Pickup threshold	Approx. 1.1 · I_{EEp}
Dropout ratio	Approx. 1.05 · I_{EEp}
Tolerances	
Pickup threshold I_{EEp}	2 % of setting value or 1 mA
Delay times in linear range	7 % of reference value for $2 \leq I/I_{EEp} \leq 20$ + 2 % current tolerance, or 70 ms
***Direction detection** for all types of earth-faults (ANSI 67Ns)*	
Direction measurement	I_E and V_E measured or $3I_0$ and $3V_0$ calculated
Measuring principle	Active/reactive power measurement
Setting ranges	
Measuring enable $I_{Release\ direct.}$	
For sensitive input	0.001 to 1.2 A (in steps of 0.001 A)
For normal input	0.25 to 150 A[1] (in steps of 0.01 A)
Measuring method	cos φ and sin φ
Direction phasor $\varphi_{Correction}$	- 45 ° to + 45 ° (in steps of 0.1 °)
Dropout delay $T_{Reset\ delay}$	1 to 60 s (in steps of 1 s)
Angle correction for cable CT	
Angle correction F1, F2	0 ° to 5 ° (in steps of 0.1 °)
Current value $I1$, $I2$	
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A[1] (in steps of 0.01 A)
Tolerances	
Pickup measuring enable	2 % of the setting value or 1 mA
Angle tolerance	3 °
***High-impedance restricted earth-fault protection** (ANSI 87N) / single-phase overcurrent protection*	
Setting ranges	
Pickup thresholds $I>$, $I>>$	
For sensitive input	0.003 to 1.5 A or ∞ (in steps of 0.001 A)
For normal input	0.25 to 175 A[1] or ∞ (in steps of 0.01 A)
Delay times $T_I>$, $T_I>>$	0 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
Minimum	Approx. 20 ms
Typical	Approx. 30 ms
Dropout times	Approx. 30 ms
Dropout ratio	Approx. 0.95 for $I/I_{nom} \geq 0.5$
Tolerances	
Pickup thresholds	3 % of setting value or 1 % rated current at I_{nom} = 1 or 5 A; 5 % of setting value or 3 % rated current at I_{nom} = 0.1 A
Delay times	1 % of setting value or 10 ms
Intermittent earth-fault protection	
Setting ranges	
Pickup threshold	
For I_E — $I_{IE}>$	0.25 to 175 A[1] (in steps of 0.01 A)
For $3I_0$ — $I_{IE}>$	0.25 to 175 A[1] (in steps of 0.01 A)
For I_{EE} — $I_{IE}>$	0.005 to 1.5 A (in steps of 0.001 A)
Pickup prolongation time — T_V	0 to 10 s (in steps of 0.01 s)
Earth-fault accumulation time — T_{sum}	0 to 100 s (in steps of 0.01 s)
Reset time for accumulation — T_{res}	1 to 600 s (in steps of 1 s)
Number of pickups for intermittent earth fault	2 to 10 (in steps of 1)

1) At I_{nom} = 1 A, all limits divided by 5.

Times	
Pickup times	
Current = 1.25 · pickup value	Approx. 30 ms
Current ≥ 2 · pickup value	Approx. 22 ms
Dropout time	Approx. 22 ms
Tolerances	
Pickup threshold $I_{IE}>$	3 % of setting value, or 50 mA[1]
Times T_V, T_{sum}, T_{res}	1 % of setting value or 10 ms
***Thermal overload protection** (ANSI 49)*	
Setting ranges	
Factor k	0.1 to 4 (in steps of 0.01)
Time constant	1 to 999.9 min (in steps of 0.1 min)
Warning overtemperature $\Theta_{alarm}/\Theta_{trip}$	50 to 100 % with reference to the tripping overtemperature (in steps of 1 %)
Current warning stage I_{alarm}	0.5 to 20 A (in steps of 0.01 A)
Extension factor when stopped k_τ factor	1 to 10 with reference to the time constant with the machine running (in steps of 0.1)
Rated overtemperature (for I_{nom})	40 to 200 °C (in steps of 1 °C)
Tripping characteristic For $(I/k \cdot I_{nom}) \leq 8$	$t = \tau_{th} \cdot \ln \frac{(I/k \cdot I_{nom})^2 - (I_{pre}/k \cdot I_{nom})^2}{(I/k \cdot I_{nom})^2 - 1}$ t = Tripping time τ_{th} = Temperature rise time constant I = Load current I_{pre} = Preload current k = Setting factor acc. to VDE 0435 Part 3011 and IEC 60255-8 I_{nom} = Rated (nominal) current of the protection relay
Dropout ratios	
Θ/Θ_{Trip}	Drops out with Θ_{Alarm}
Θ/Θ_{Alarm}	Approx. 0.99
I/I_{Alarm}	Approx. 0.97
Tolerances	
With reference to k · I_{nom}	Class 5 acc. to IEC 60255-8
With reference to tripping time	5 % +/- 2 s acc. to IEC 60255-8
***Auto-reclosure** (ANSI 79)*	
Number of reclosures	0 to 9 Shot 1 to 4 individually adjustable
Program for phase fault Start-up by	Time-overcurrent elements (dir., non-dir.), negative sequence, binary input
Program for earth fault Start-up by	Time-overcurrent elements (dir., non-dir.), sensitive earth-fault protection, binary input
Blocking of ARC	Pickup of protection functions, three-phase fault detected by a protective element, binary input, last TRIP command after the reclosing cycle is complete (unsuccessful reclosing), TRIP command by the breaker failure protection (50BF), opening the CB without ARC initiation, external CLOSE command

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Auto-reclosure *(ANSI 79) (cont'd)*

Setting ranges	
Dead time (separate for phase and earth and individual for shots 1 to 4)	0.01 to 320 s (in steps of 0.01 s)
Blocking duration for manual-CLOSE detection	0.5 s to 320 s or 0 (in steps of 0.01 s)
Blocking duration after reclosure	0.5 s to 320 s (in steps of 0.01 s)
Blocking duration after dynamic blocking	0.01 to 320 s (in steps of 0.01 s)
Start-signal monitoring time	0.01 to 320 s or ∞ (in steps of 0.01 s)
Circuit-breaker supervision time	0.1 to 320 s (in steps of 0.01 s)
Max. delay of dead-time start	0 to 1800 s or ∞ (in steps of 0.1 s)
Maximum dead time extension	0.5 to 320 s or ∞ (in steps of 0.01 s)
Action time	0.01 to 320 s or ∞ (in steps of 0.01 s)

The delay times of the following protection function can be altered individually by the ARC for shots 1 to 4 (setting value $T = T$, non-delayed $T = 0$, blocking $T = \infty$):
I>>, I>, I_p, I_{dir}>>, I_{dir}>, I_{pdir}
I_E>>, I_E>, I_{Ep}, I_{Edir}>>, I_{Edir}>, I_{Edir}

Additional functions	Lockout (final trip), delay of dead-time start via binary input (monitored), dead-time extension via binary input (monitored), co-ordination with other protection relays, circuit-breaker monitoring, evaluation of the CB contacts

Breaker failure protection *(ANSI 50 BF)*

Setting ranges	
Pickup threshold CB I>	0.2 to 5 A[1] (in steps of 0.01 A)
Delay time	0.06 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
with internal start	is contained in the delay time
start via control	is contained in the delay time
with external start	is contained in the delay time
Dropout times	Approx. 25 ms
Tolerances	
Pickup value	2 % of setting value (50 mA)[1]
Delay time	1 % or 20 ms

Negative-sequence current detection *(ANSI 46)*

Definite-time characteristic *(ANSI 46-1 and 46-2)*

Setting ranges	
Pickup current I_2>, I_2>>	0.5 to 15 A or ∞ (in steps of 0.01 A)
Delay times	0 to 60 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Functional limit	All phase currents ≤ 20 A[1]
Times	
Pickup times	Approx. 35 ms
Dropout times	Approx. 35 ms
Dropout ratio	Approx. 0.95 for $I_2 / I_{nom} > 0.3$
Tolerances	
Pickup thresholds	3 % of the setting value or 50 mA[1]
Delay times	1 % or 10 ms

1) At I_{nom} = 1 A, all limits divided by 5.

Inverse-time characteristic *(ANSI 46-TOC)*

Setting ranges	
Pickup current	0.5 to 10 A[1] (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.5 to 15 s or ∞ (in steps of 0.01 s)
Functional limit	All phase currents ≤ 20 A[1]
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse
ANSI	Inverse, moderately inverse, very inverse, extremely inverse
Pickup threshold	Approx. 1.1 · I_{2p} setting value
Dropout	
IEC and ANSI (without disk emulation)	Approx. 1.05 · I_{2p} setting value, which is approx. 0.95 · pickup threshold
ANSI with disk emulation	Approx. 0.90 · I_{2p} setting value
Tolerances	
Pickup threshold	3 % of the setting value or 50 mA[1]
Time for 2 ≤ M ≤ 20	5 % of setpoint (calculated) +2 % current tolerance, at least 30 ms

Starting time monitoring for motors *(ANSI 48)*

Setting ranges	
Motor starting current $I_{STARTUP}$	2.5 to 80 A[1] (in steps of 0.01)
Pickup threshold $I_{MOTOR\ START}$	2 to 50 A[1] (in steps of 0.01)
Permissible starting time $T_{STARTUP}$	1 to 180 s (in steps of 0.1 s)
Permissible blocked rotor time $T_{LOCKED\text{-}ROTOR}$	0.5 to 120 s or ∞ (in steps of 0.1 s)
Tripping time characteristic	
For $I > I_{MOTOR\ START}$	$t = \left(\frac{I_{STARTUP}}{I}\right)^2 \cdot T_{STARTUP}$
	$I_{STARTUP}$ = Rated motor starting current
	I = Actual current flowing
	$T_{STARTUP}$ = Tripping time for rated motor starting current
	t = Tripping time in seconds
Dropout ratio $I_{MOTOR\ START}$	Approx. 0.95
Tolerances	
Pickup threshold	2 % of setting value or 50 mA[1]
Delay time	5 % or 30 ms

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Restart inhibit for motors (ANSI 66)	
Setting ranges	
Motor starting current relative to rated motor current $I_{MOTOR\ START}/I_{Motor\ Nom}$	1.1 to 10 (in steps of 0.1)
Rated motor current $I_{Motor\ Nom}$	1 to 6 A[1] (in steps of 0.01 A)
Max. permissible starting time $T_{Start\ Max}$	3 to 320 s (in steps of 1 s)
Equilibrium time T_{Equal}	0 min to 320 min (in steps of 0.1 min)
Minimum inhibit time $T_{MIN.\ INHIBIT\ TIME}$	0.2 min to 120 min (in steps of 0.1 min)
Max. permissible number of warm starts	1 to 4 (in steps of 1)
Difference between cold and warm starts	1 to 2 (in steps of 1)
Extension k-factor for cooling simulations of rotor at zero speed $k_{\tau\ at\ STOP}$	0.2 to 100 (in steps of 0.1)
Extension factor for cooling time constant with motor running $k_{\tau\ RUNNING}$	0.2 to 100 (in steps of 0.1)
Restarting limit	$\Theta_{restart} = \Theta_{rot\ max\ perm} \cdot \frac{n_c - 1}{n_c}$ $\Theta_{restart}$ = Temperature limit below which restarting is possible $\Theta_{rot\ max\ perm}$ = Maximum permissible rotor overtemperature (= 100 % in operational measured value $\Theta_{rot}/\Theta_{rot\ trip}$) n_c = Number of permissible start-ups from cold state
Undercurrent monitoring (ANSI 37)	
Signal from the operational measured values	Predefined with programmable logic
Temperature monitoring box (ANSI 38)	
Temperature detectors	
Connectable boxes	1 or 2
Number of temperature detectors per box	Max. 6
Type of measuring	Pt 100 Ω or Ni 100 Ω or Ni 120 Ω
Mounting identification	“Oil” or “Environment” or “Stator” or “Bearing” or “Other”
Thresholds for indications	
For each measuring detector	
Stage 1	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)
Stage 2	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)

1) At I_{nom} = 1 A, all limits divided by 5.

Undervoltage protection (ANSI 27)	
Operating modes/measuring quantities	
3-phase	Positive-sequence component or smallest of the phase-to-phase voltages
1-phase	Single-phase phase-earth or phase-phase voltage
Setting ranges	
Pickup thresholds $V<$, $V<<$	
3-phase, phase-earth connection	10 to 210 V (in steps of 1 V)
3-phase, phase-phase connection	10 to 120 V (in steps of 1 V)
1-phase connection	10 to 120 V (in steps of 1 V)
Dropout ratio r	1.01 to 3 (in steps of 0.01)
Delay times T	0 to 100 s or ∞ (in steps of 0.01 s)
Current Criteria "Bkr Closed I_{MIN}"	0.2 to 5 A[1] (in steps of 0.01 A)
Dropout threshold $r \cdot V<(<)$	Max. 130 V for phase-phase voltages Max. 225 V phase-earth voltages
Times	
Pickup times $V<$, $V<<$, $V_1<$, $V_1<<$	Approx. 50 ms
Dropout times	As pickup times
Tolerances	
Pickup thresholds	3 % of setting value or 1 V
Times	1 % of setting value or 10 ms
Overvoltage protection (ANSI 59)	
Operating modes/measuring quantities	
3-phase	Negative-sequence component or largest of the phase-to-phase voltages
1-phase	Single-phase phase-earth or phase-phase voltage
Setting ranges	
Pickup thresholds $V>$, $V>>$	
3-phase, phase-earth connection, largest phase-phase voltage	40 to 260 V (in steps of 1 V)
3-phase, phase-phase connection, largest phase-phase voltage	40 to 150 V (in steps of 1 V)
3-phase, negative-sequence voltage	2 to 150 V (in steps of 1 V)
1-phase connection	40 to 150 V (in steps of 1 V)
Dropout ratio r	0.9 to 0.99 (in steps of 0.01)
Delay times T	0 to 100 s or ∞ (in steps of 0.01 s)
Times	
Pickup times $V>$, $V>>$	Approx. 50 ms
Pickup times $V_2>$, $V_2>>$	Approx. 60 ms
Dropout times	As pickup times
Tolerances	
Pickup thresholds	3 % of setting value or 1 V
Times	1 % of setting value or 10 ms

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Frequency protection *(ANSI 81)*	
Number of frequency elements	4
Setting ranges Pickup thresholds for f_{nom} = 50 Hz Pickup thresholds for f_{nom} = 60 Hz Delay times Undervoltage blocking, with positive-sequence voltage V_1	 45.5 to 54.5 Hz (in steps of 0.01 Hz) 55.5 to 64.5 Hz (in steps of 0.01 Hz) 0 to 100 s or ∞ (in steps of 0.01 s) 10 to 150 V (in steps of 1 V)
Times Pickup times Dropout times	 Approx. 150 ms Approx. 150 ms
Dropout Δf = pickup value - dropout value Ratio undervoltage blocking	 Approx. 20 mHz Approx. 1.05
Tolerances Pickup thresholds Frequency Undervoltage blocking Delay times	 10 mHz 3 % of setting value or 1 V 3 % of the setting value or 10 ms
Fault locator *(ANSI 21FL)*	
Output of the fault distance	In Ω secondary, in km / mile of line length
Starting signal	Trip command, dropout of a protection element, via binary input
Setting ranges Reactance (secondary)	 0.001 to 1.9 Ω/km[1)] (in steps of 0.0001) 0.001 to 3 Ω/mile[1)] (in steps of 0.0001)
Tolerances Measurement tolerance acc. to VDE 0435, Part 303 for sinusoidal measurement quantities	 2.5 % fault location, or 0.025 Ω (without intermediate infeed) for 30 ° ≤ φK ≤ 90 ° and $V_K/V_{nom} \geq 0.1$ and $I_K/I_{nom} \geq 1$

Additional functions	
Operational measured values	
Currents I_{L1}, I_{L2}, I_{L3} Positive-sequence component I_1 Negative-sequence component I_2 I_E or $3I_0$	In A (kA) primary, in A secondary or in % I_{nom}
Range Tolerance[2)]	10 to 200 % I_{nom} 1 % of measured value or 0.5 % I_{nom}
Phase-to-earth voltages V_{L1-E}, V_{L2-E}, V_{L3-E} Phase-to-phase voltages V_{L1-L2}, V_{L2-L3}, V_{L3-L1}, V_E or V_0 Positive-sequence component V_1 Negative-sequence component V_2	In kV primary, in V secondary or in % V_{nom}
Range Tolerance[2)]	10 to 120 % V_{nom} 1 % of measured value or 0.5 % of V_{nom}
S, apparent power	In kVAr (MVAr or GVAr) primary and in % of S_{nom}
Range Tolerance[2)]	0 to 120 % S_{nom} 1 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 %
P, active power	With sign, total and phase-segregated in kW (MW or GW) primary and in % S_{nom}
Range Tolerance[2)]	0 to 120 % S_{nom} 2 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 % and $\lvert\cos\varphi\rvert$ = 0.707 to 1 with $S_{nom} = \sqrt{3} \cdot V_{nom} \cdot I_{nom}$
Q, reactive power	With sign, total and phase-segregated in kVAr (MVAr or GVAr)primary and in % S_{nom}
Range Tolerance[2)]	0 to 120 % S_{nom} 2 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 % and $\lvert\sin\varphi\rvert$ = 0.707 to 1 with $S_{nom} = \sqrt{3} \cdot V_{nom} \cdot I_{nom}$
cos φ, power factor (p.f.)	Total and phase segregated
Range Tolerance[2)]	- 1 to + 1 3 % for $\lvert\cos\varphi\rvert \geq 0.707$
Frequency f	In Hz
Range Tolerance[2)]	f_{nom} ± 5 Hz 20 mHz
Temperature overload protection Θ/Θ_{Trip}	In %
Range Tolerance[2)]	0 to 400 % 5 % class accuracy per IEC 60255-8
Temperature restart inhibit $\Theta_L/\Theta_{L\,Trip}$	In %
Range Tolerance[2)]	0 to 400 % 5 % class accuracy per IEC 60255-8
Restart threshold $\Theta_{Restart}/\Theta_{L\,Trip}$	In %
Reclose time $T_{Reclose}$	In min
Currents of sensitive ground fault detection (total, real, and reactive current) I_{EE}, $I_{EE\,real}$, $I_{EE\,reactive}$	In A (kA) primary and in mA secondary
Range Tolerance[2)]	0 mA to 1600 mA 2 % of measured value or 1 mA
Measuring transducer Operating range Accuracy range	 0 to 24 mA 1 to 20 mA
Tolerance[2)]	1.5 %, relative to rated value of 20 mA
For standard usage of the measurement transducer for pressure and temperature monitoring	
Operating measured value Operating range (presetting) Operating measured value temperature Operating range (presetting)	Pressure in hPa 0 hPa to 1200 hPa Temp in °C / °F 0 °C to 240 °C or 32 °F to 464 °F
RTD-box	See section "Temperature monitoring box"
Long-term averages	
Time window	5, 15, 30 or 60 minuets
Frequency of updates	Adjustable
Long-term averages of currents of real power of reactive power of apparent power	 I_{L1dmd}, I_{L2dmd}, I_{L3dmd}, I_{1dmd} in A (kA) P_{dmd} in W (kW, MW) Q_{dmd} in VAr (kVAr, MVAr) S_{dmd} in VAr (kVAr, MVAr)

1) At I_{nom} = 1 A, all limits multiplied with 5.

1) At rated frequency.

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Max. / Min. report	
Report of measured values	With date and time
Reset, automatic	Time of day adjustable (in minutes, 0 to 1439 min) Time frame and starting time adjustable (in days, 1 to 365 days, and ∞)
Reset, manual	Using binary input, using keypad, via communication
Min./Max. values for current	I_{L1}, I_{L2}, I_{L3}, I_1 (positive-sequence component)
Min./Max. values for voltages	V_{L1-E}, V_{L2-E}, V_{L3-E} V_1 (positive-sequence component) V_{L1-L2}, V_{L2-L3}, V_{L3-L1}
Min./Max. values for power	S, P, Q, $\cos\varphi$, frequency
Min./Max. values for overload protection	Θ/Θ_{Trip}
Min./Max. values for mean values	I_{L1dmd}, I_{L2dmd}, I_{L3dmd} I_1 (positive-sequence component); S_{dmd}, P_{dmd}, Q_{dmd}
Local measured values monitoring	
Current asymmetry	I_{max}/I_{min} > balance factor, for $I>I_{balance\ limit}$
Voltage asymmetry	V_{max}/V_{min} > balance factor, for $V>V_{lim}$
Current sum	$\lvert i_{L1}+i_{L2}+i_{L3}+k_{iE}\cdot i_E\rvert$ > limit value, with $k_{iE}=\frac{I_{earth}\text{ CT PRIM}/I_{earth}\text{ CT SEC}}{\text{CT PRIM }/\text{CT SEC}}$
Current phase sequence	Clockwise (ABC) / counter-clockwise (ACB)
Voltage phase sequence	Clockwise (ABC) / counter-clockwise (ACB)
Limit value monitoring	Predefined limit values, user-defined expansions via CFC
Fault recording	
Recording of indications of the last 8 power system faults	
Recording of indications of the last 3 power system ground faults	
Time stamping	
Resolution for event log (operational annunciations)	1 ms
Resolution for trip log (fault annunciations)	1 ms
Maximum time deviation (internal clock)	0.01 %
Battery	Lithium battery 3 V/1 Ah, type CR 1/2 AA, message "Battery Fault" for insufficient battery charge
Oscillographic fault recording	
Maximum 8 fault records saved, memory maintained by buffer battery in case of loss of power supply	
Recording time	Total 5 s Pre-trigger and post-fault recording and memory time adjustable
Sampling rate for 50 Hz Sampling rate for 60 Hz	1 sample/1.25 ms (16 samples/cycle) 1 sample/1.04 ms (16 samples/cycle)

Energy/power	
Meter values for power Wp, Wq (real and reactive power demand)	in kWh (MWh or GWh) and kVARh (MVARh or GVARh)
Tolerance[1)]	≤ 5 % for $I > 0.5\ I_{nom}$, $V > 0.5\ V_{nom}$ and $\lvert\cos\varphi\rvert$ (p.f.) ≥ 0.707
Statistics	
Saved number of trips	Up to 9 digits
Number of automatic reclosing commands (segregated according to 1st and ≥ 2nd cycle)	Up to 9 digits
Circuit-breaker wear	
Methods	• ΣI^x with x = 1 .. 3 • 2-point method (remaining service life)
Operation	Phase-selective accumulation of measured values on TRIP command, up to 8 digits, phase-selective limit values, monitoring indication
Operating hours counter	
Display range	Up to 7 digits
Criterion	Overshoot of an adjustable current threshold (BkrClosed I_{MIN})
Trip circuit monitoring	
With one or two binary inputs	
Commissioning aids	
Phase rotation field check, operational measured values, circuit-breaker / switching device test, creation of a test measurement report	
Clock	
Time synchronization	DCF77/IRIG-B signal (telegram format IRIG-B000), binary input, communication
Control	
Number of switching units	Depends on the binary inputs and outputs
Interlocking	Programmable
Circuit-breaker signals	Feedback, close, open, intermediate position
Control commands	Single command / double command 1, 1 plus 1 common or 2 trip contacts
Programmable controller	CFC logic, graphic input tool
Local control	Control via menu, control with control keys
Remote control	Via communication interfaces, using a substation automation and control system (e.g. SICAM), DIGSI 4 (e.g. via modem)

1) At rated frequency.

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Technical data

Setting group switchover of the function parameters	
Number of available setting groups	4 (parameter group A, B, C and D)
Switchover performed	Via keypad, DIGSI, system (SCADA) interface or binary input

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 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 conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

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

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Selection and ordering data

Description	Order No.
7SJ63 multifunction protection relay	*7SJ63□□ – □□□□□ – □□□□*

Housing, binary inputs (BI) and outputs (BO), measuring transducer	
Housing 1/2 19", 11 BI, 8 BO, 1 live status contact	*1*
Housing 1/2 19", 24 BI, 11 BO, 4 (2) power relays, 1 live status contact	*2*
Housing 1/2 19", 20 BI, 11 BO, 2 measuring transducer inputs, 4 power relays, 1 live status contact	*3*
Housing 1/1 19", 37 BI, 14 BO, 8 (4) power relays, 1 live status contact	*5*
Housing 1/1 19", 33 BI, 14 BO, 2 measuring transducer inputs, 8 (4) power relays, 1 live status contact	*6*

Measuring inputs (3 x V, 4 x I)	
I_{ph} = 1 A[1)], I_e = 1 A[1)] (min. = 0.05 A) Position 15 only with *A, C, E, G*	*1*
I_{ph} = 1 A[1)], I_e = sensitive (min. = 0.001 A) Position 15 only with *B, D, F, H*	*2*
I_{ph} = 5 A[1)], I_e = 5 A[1)] (min. = 0.25 A) Position 15 only with *A, C, E, G*	*5*
I_{ph} = 5 A[1)], I_e = sensitive (min. = 0.001 A) Position 15 only with *B, D, F, H*	*6*
I_{ph} = 5 A[1)], I_e = 1 A[1)] (min. = 0.05 A) Position 15 only with *A, C, E, G*	*7*

Rated auxiliary voltage (power supply, indication voltage)	
24 to 48 V DC, threshold binary input 19 V DC[3)]	*2*
60 to 125 V DC[2)], threshold binary input 19 V DC[3)]	*4*
110 to 250 V DC[2)], 115 to 230 V[4)] AC, threshold binary input 88 V DC[3)]	*5*

Unit version	
For panel surface mounting, plug-in terminals, detached operator panel	*A*
For panel surface mounting, 2-tier terminals top/bottom	*B*
For panel surface mounting, screw-type terminals, detached operator panel	*C*
For panel flush mounting, plug-in terminals (2/3 pin connector)	*D*
For panel flush mounting , screw-type terminals (direct connection/ring-type cable lugs)	*E*
Surface-mounting housing, screw-type terminals (direct connection/ring-type cable lugs), without operator panel, panel mounting in low-voltage housing	*F*
Surface-mounting housing, plug-in terminals, without operator panel, panel mounting in low-voltage housing	*G*

Region-specific default settings/function versions and language settings	
Region DE, 50 Hz, IEC, language: German, selectable	*A*
Region World, 50/60 Hz, IEC/ANSI, language: English (GB), selectable	*B*
Region US, 60 Hz, ANSI, language: English (US), selectable	*C*
Region FR, IEC/ANSI language: French, selectable	*D*
Region World, IEC/ANSI language: Spanish, selectable	*E*

System interface (Port B): Refer to page 5/152	
No system interface	*0*
Protocols see page 5/152	

Service interface (Port C)	
No interface at rear side	*0*
DIGSI 4/modem, electrical RS232	*1*
DIGSI 4/modem/RTD-box[5)], electrical RS485	*2*
DIGSI 4/modem/RTD-box[5)6)], optical 820 nm wavelength, ST connector	*3*

Measuring/fault recording	
Slave pointer, mean values, min/max values, fault recording	*3*

see next page

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

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

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

4) 230 V AC, starting from unit version .../EE

5) Temperature monitoring box 7XV5662-□AD10, refer to "Accessories".

6) When using the temperature monitoring box at an optical interface, the additional RS485 fiber-optic converter 7XV5650-0□A00 is required.

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Selection and ordering data

Description	Order No.
7SJ63 multifunction protection relay	*7SJ63□□ – □□□□□ – □□□□*

Designation				ANSI No.	Description	Order code
Basic version					Control	
				50/51	Time-overcurrent protection $I>$, $I>>$, I_p, reverse interlocking	
				50N/51N	Earth-fault protection $I_E>$, $I_E>>$, I_{Ep}	
				50N/51N	Insensitive earth-fault protection via IEE function: $I_{EE}>$, $I_{EE}>>$, I_{EEp} 1)	
				49	Overload protection (with 2 time constants)	
				46	Phase balance current protection (negative-sequence protection)	
				37	Undercurrent monitoring	
				47	Phase sequence	
				59N/64	Displacement voltage	
				50BF	Breaker failure protection	
				74TC	Trip circuit supervision 4 setting groups, cold-load pickup Inrush blocking	
				86	Lockout	*F A*
■			V, f	27/59 81O/U	Under-/overvoltage Under-/overfrequency	*F E*
■		IEF	V, f	27/59 81O/U	Under-/overvoltage Under-/overfrequency Intermittent earth fault	*P E*
■	Dir			67/67N 47	Direction determination for overcurrent, phases and earth Phase sequence	*F C*
■	Dir		V, f	67/67N 27/59 81O/U	Direction determination for overcurrent, phases and earth Under-/overvoltage Under-/overfrequency	*F G*
■	Dir	IEF		67/67N	Direction determination for overcurrent, phases and earth Intermittent earth fault	*P C*
Directional earth-fault detection ■	Dir			67/67N 67Ns 87N	Direction determination for overcurrent, phases and earth Directional sensitive earth-fault detection High-impedance restricted earth fault	*F D* 2)
Directional earth-fault detection ■	Dir	IEF		67/67N 67Ns 87N	Direction determination for overcurrent, phases and earth Directional sensitive earth-fault detection High-impedance restricted earth fault Intermittent earth fault	*P D* 2)
Directional earth-fault detection ■				67Ns 87N	Directional sensitive earth-fault detection High-impedance restricted earth fault	*F B* 2)
Directional earth-fault detection ■	Motor		V, f	67Ns 87N 48/14 66/86 27/59 81O/U	Directional sensitive earth-fault detection High-impedance restricted earth fault Starting time supervision, locked rotor Restart inhibit Under-/overvoltage Under-/overfrequency	*H F* 2)

continued on next page

■ Basic version included

V, f = Voltage, frequency protection
Dir = Directional overcurrent protection
IEF = Intermittent earth fault

1) Only with insensitive earth-current transformer when position 7 = *1, 5, 7*.

2) For isolated/compensated networks only with sensitive earth-current transformer when position 7 = *2, 6*.

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Selection and ordering data

Description	Order No.	Order code
7SJ63 multifunction protection relay	*7SJ63□□ – □□□□□ – □□□□-□□□□*	

Designation				ANSI No.	Description	Order code
Basic version					Control	
				50/51	Time-overcurrent protection	
					$I>$, $I>>$, I_p, reverse interlocking	
				50N/51N	Earth-fault protection	
					$I_E>$, $I_E>>$, I_{Ep}	
				50N/51N	Earth-fault protection via insensitive	
					IEE function: $I_{EE}>$, $I_{EE}>>$, I_{EEp} 1)	
				49	Overload protection (with 2 time constants)	
				46	Phase balance current protection	
					(negative-sequence protection)	
				37	Undercurrent monitoring	
				47	Phase sequence	
				59N/64	Displacement voltage	
				50BF	Breaker failure protection	
				74TC	Trip circuit supervision	
					4 setting groups, cold-load pickup	
					Inrush blocking	
				86	Lockout	
Directional earth-fault detection ■	Motor Dir		V, f	67/67N	Direction determination for overcurrent, phases and earth	
				67Ns	Directional sensitive earth-fault detection	
				87N	High-impedance restricted earth fault	
				48/14	Starting time supervision, locked rotor	
				66/86	Restart inhibit	
				27/59	Under-/overvoltage	
				81O/U	Under-/overfrequency	*H H* 2)
Directional earth-fault detection ■	Motor Dir	IEF	V, f	67/67N	Direction determination for overcurrent, phases and earth	
				67Ns	Directional sensitive earth-fault detection	
				87N	High-impedance restricted earth fault	
					Intermittent earth fault	
				48/14	Starting time supervision, locked rotor	
				66/86	Restart inhibit	
				27/59	Under-/overvoltage	
				81O/U	Under-/overfrequency	*R H* 2)
■	Motor Dir		V, f	67/67N	Direction determination for overcurrent, phases and earth	
				48/14	Starting time supervision, locked rotor	
				66/86	Restart inhibit	
				27/59	Under-/overvoltage	
				81O/U	Under-/overfrequency	*H G*
■	Motor			48/14	Starting time supervision, locked rotor	
				66/86	Restart inhibit	*H A*
ARC, fault locator					Without	*0*
				79	With auto-reclosure	*1*
				21FL	With fault locator	*2*
				79, 21FL	With auto-reclosure, with fault locator	*3*
ATEX100 Certification For protection of explosion-protected motors (increased-safety type of protection "e")						*Z X 9 9* 3)

■ Basic version included

V, f = Voltage, frequency protection
Dir = Directional overcurrent protection
IEF = Intermittent earth fault

1) Only with insensitive earth-current transformer when position 7 = *1, 5, 7*.

2) For isolated/compensated networks only with sensitive earth-current transformer when position 7 = *2, 6*.

3) This variant might be supplied with a previous firmware version.

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Order number for system port B

Description	Order No.	Order code
7SJ63 multifunction protection relay	*7SJ63□□ – □□□□□ – □□□□–□□□*	
System interface (on rear of unit, Port B)		
No system interface	0	
IEC 60870-5-103 protocol, RS232	1	
IEC 60870-5-103 protocol, RS485	2	
IEC 60870-5-103 protocol, 820 nm fiber, ST connector	3	
PROFIBUS-FMS Slave, RS485	4	
PROFIBUS-FMS Slave, 820 nm wavelength, single ring, ST connector [1])	5	
PROFIBUS-FMS Slave, 820 nm wavelength, double ring, ST connector [1])	6	
PROFIBUS-DP Slave, RS485	9	L 0 A
PROFIBUS-DP Slave, 820 nm wavelength, double ring, ST connector [1])	9	L 0 B
MODBUS, RS485	9	L 0 D
MODBUS, 820 nm wavelength, ST connector [2])	9	L 0 E
DNP 3.0, RS485	9	L 0 G
DNP 3.0, 820 nm wavelength, ST connector [2])	9	L 0 H
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector (EN 100)	9	L 0 R
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector (EN 100)[2])	9	L 0 S

1) Not with position 9 = "B"; if 9 = "B", please order 7SJ6 unit with RS485 port and separate fiber-optic converters.
For single ring, please order converter 6GK1502-2CB10, not available with position 9 = "B".
For double ring, please order converter 6GK1502-3CB10, not available with position 9 = "B".
The converter requires a 24 V AC power supply (e.g. power supply 7XV5810-0BA00).

2) Not available with position 9 = "B".

Sample order

Position		Order No. + Order code
		7SJ6325-5EC91-3FC1+L0G
6	I/O's: 24 BI/11 BO, 1 live status contact	2
7	Current transformer: 5 A	5
8	Power supply: 110 to 250 V DC, 115 V AC to 230 V AC	5
9	Unit version: Flush-mounting housing, screw-type terminals	E
10	Region: US, English language (US); 60 Hz, ANSI	C
11	Communication: System interface: DNP 3.0, RS485	9 L 0 G
12	Communication: DIGSI 4, electrical RS232	1
13	Measuring/fault recording: Extended measuring and fault records	3
14/15	Protection function package: Basic version plus directional TOC	F C
16	With auto-reclosure	1

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Accessories

Description		Order No.
DIGSI 4		
Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition		
Basis	Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional	DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	*7XS5402-0AA00*
Professional + IEC 61850	Complete version: DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	*7XS5403-0AA00*
IEC 61850 System configurator		
Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional		
License for 10 PCs. Authorization by serial number. On CD-ROM		*7XS5460-0AA00*
SIGRA 4		
Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000 or XP Professional Edition. (generally contained in DIGSI Professional, but can be ordered additionally) Authorization by serial number. On CD-ROM.		*7XS5410-0AA00*
Temperature monitoring box		
24 to 60 V AC/DC		*7XV5662-2AD10*
90 to 240 V AC/DC		*7XV5662-5AD10*
Varistor/Voltage Arrester		
Voltage arrester for high-impedance REF protection		
125 Vrms; 600 A; 1S/S 256		*C53207-A401-D76-1*
240 Vrms; 600 A; 1S/S 1088		*C53207-A401-D77-1*
Connecting cable		
Cable between PC/notebook (9-pin con.) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)		*7XV5100-4*
Cable between temperature monitoring box and SIPROTEC 4 unit		
- length 5 m /16.4 ft		*7XV5103-7AA05*
- length 25 m /82 ft		*7XV5103-7AA25*
- length 50 m /164 ft		*7XV5103-7AA50*
Manual for 7SJ63		
English		*C53000-G1140-C147-x* 1)

1) x = please inquire for latest edition (exact Order No.).

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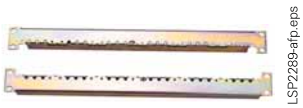
Accessories



Mounting rail

2-pin connector

3-pin connector

Short-circuit links for current terminals

Short-circuit links for other terminals

Description	Order No.	Size of package	Supplier
Terminal safety cover			
Voltage/current terminal 18-pole/12-pole	C73334-A1-C31-1	1	Siemens
Voltage/current terminal 12-pole/8-pole	C73334-A1-C32-1	1	Siemens
Connector 2-pin	C73334-A1-C35-1	1	Siemens
Connector 3-pin	C73334-A1-C36-1	1	Siemens
Crimp connector CI2 0.5 to 1 mm^2	0-827039-1	4000 taped on reel	AMP 1)
Crimp connector CI2 0.5 to 1 mm^2	0-827396-1	1	AMP 1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	0-163084-2	1	AMP 1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	0-163083-7	4000 taped on reel	AMP 1)
Crimping tool for Type III+	0-539635-1	1	AMP 1)
and matching female	0-539668-2	1	AMP 1)
Crimping tool for CI2	0-734372-1	1	AMP 1)
and matching female	1-734387-1	1	AMP 1)
Short-circuit links			
for current terminals	C73334-A1-C33-1	1	Siemens
for other terminals	C73334-A1-C34-1	1	Siemens
Mounting rail for 19" rack	C73165-A63-D200-1	1	Siemens

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

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Connection diagram

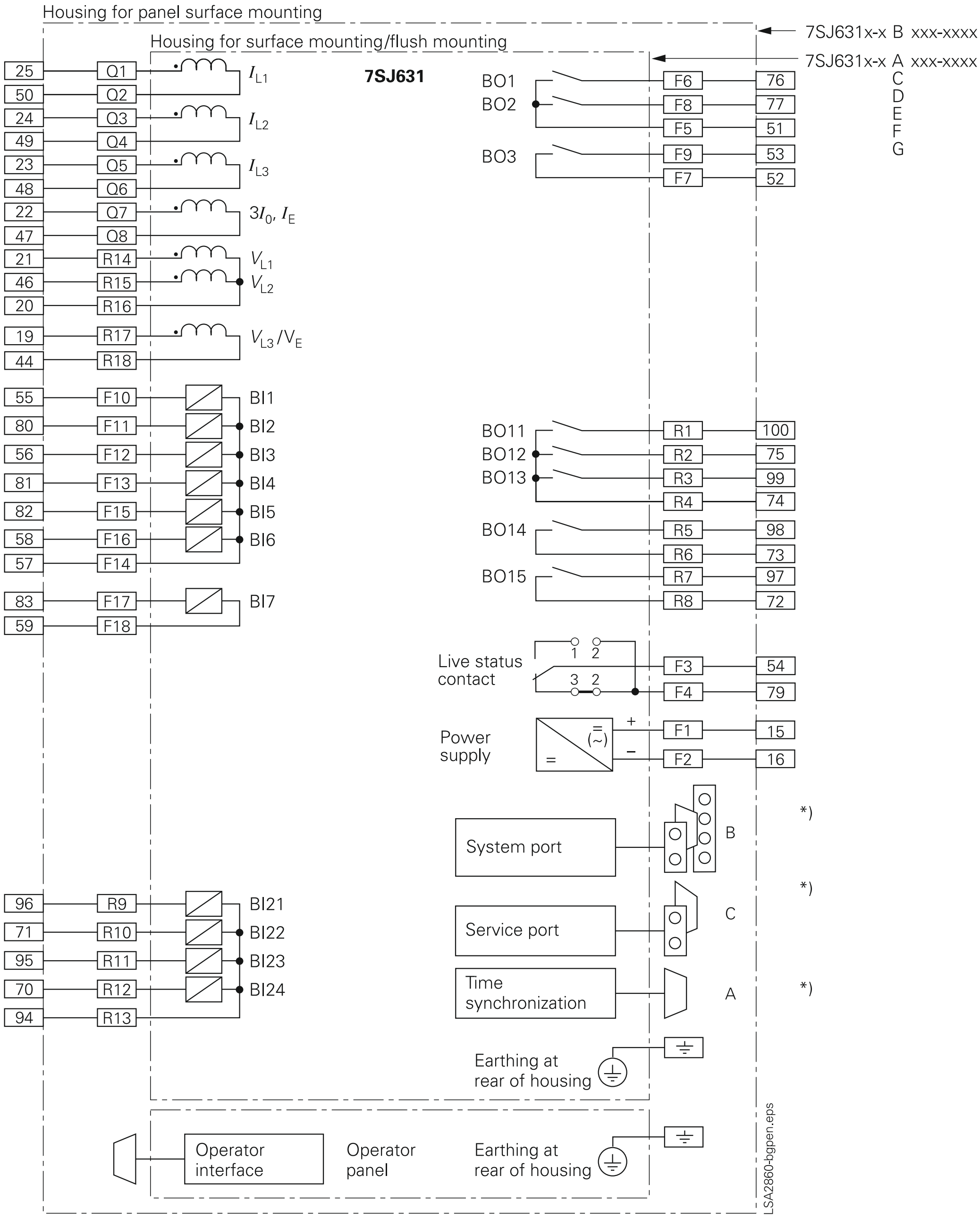

Fig. 5/137
7SJ631 connection diagram

*) For pinout of communication ports see part 15 of this catalog.

For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siemens.com/siprotec).

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Connection diagram

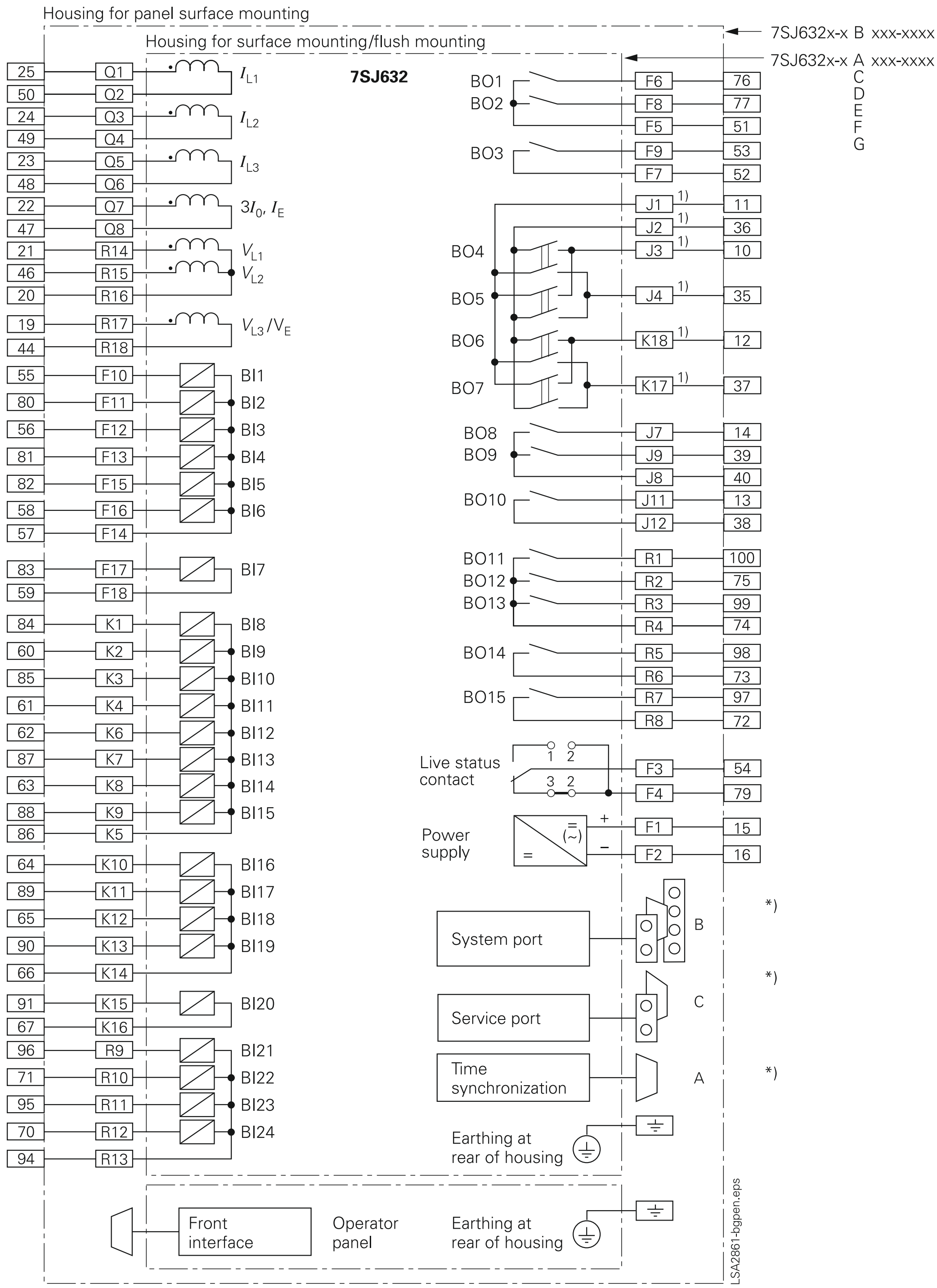

Fig. 5/138
7SJ632 connection diagram

*) For pinout of communication ports see part 15 of this catalog.

For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siemens.com/siprotec).

1) Power relays are intended to directly control motorized switches. The power relays are interlocked so only one relay of each pair can close at a time, in order to avoid shorting out the power supply. The power relay pairs are BO4/BO5, BO6/BO7. If used for protection purposes only one binary output of a pair can be used.

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Connection diagram

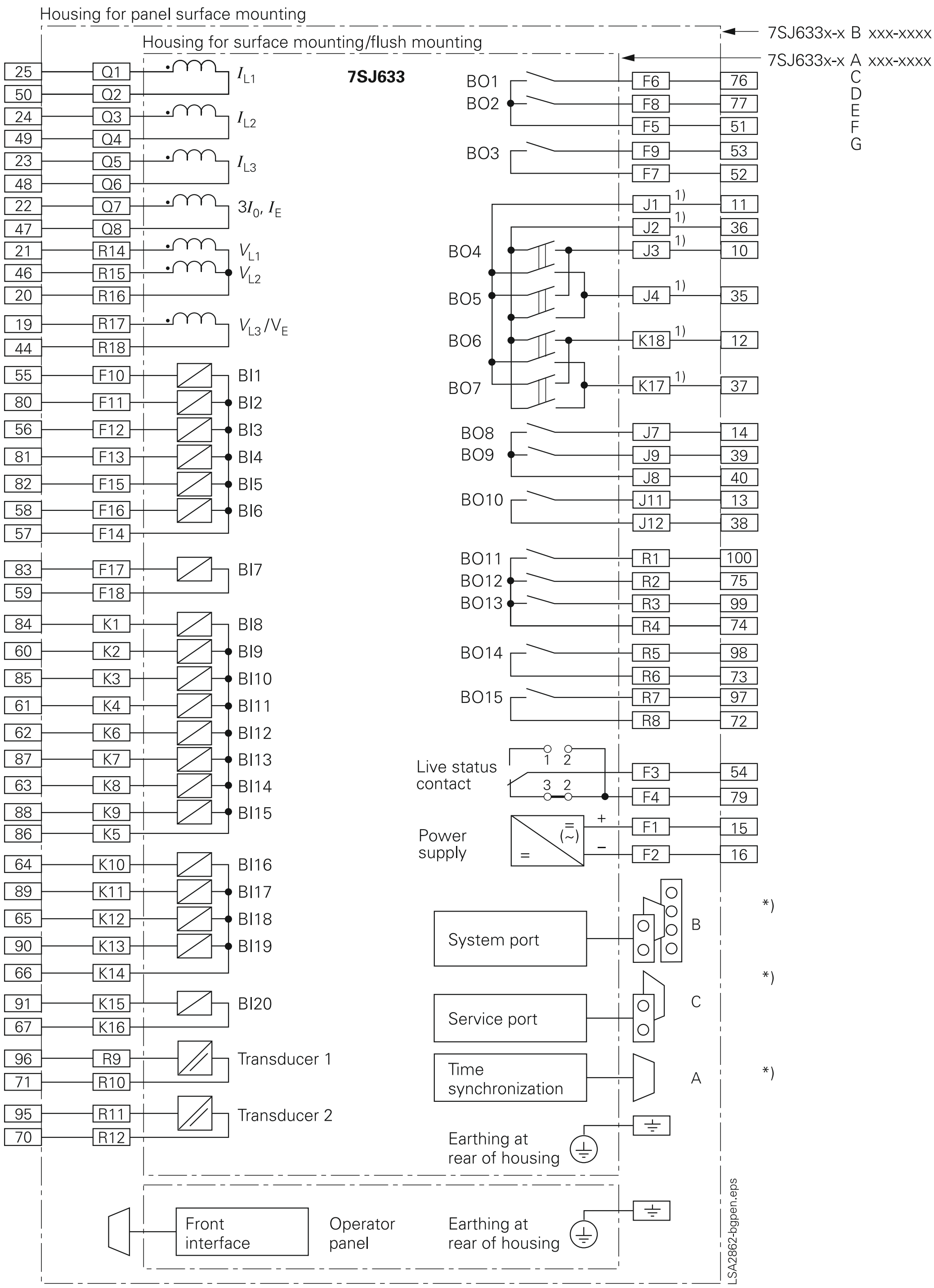

Fig. 5/139
7SJ633 connection diagram

*) For pinout of communication ports see part 15 of this catalog.

For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siemens.com/siprotec).

1) Power relays are intended to directly control motorized switches. The power relays are interlocked so only one relay of each pair can close at a time, in order to avoid shorting out the power supply. The power relay pairs are BO4/BO5, BO6/BO7. If used for protection purposes only one binary output of a pair can be used.

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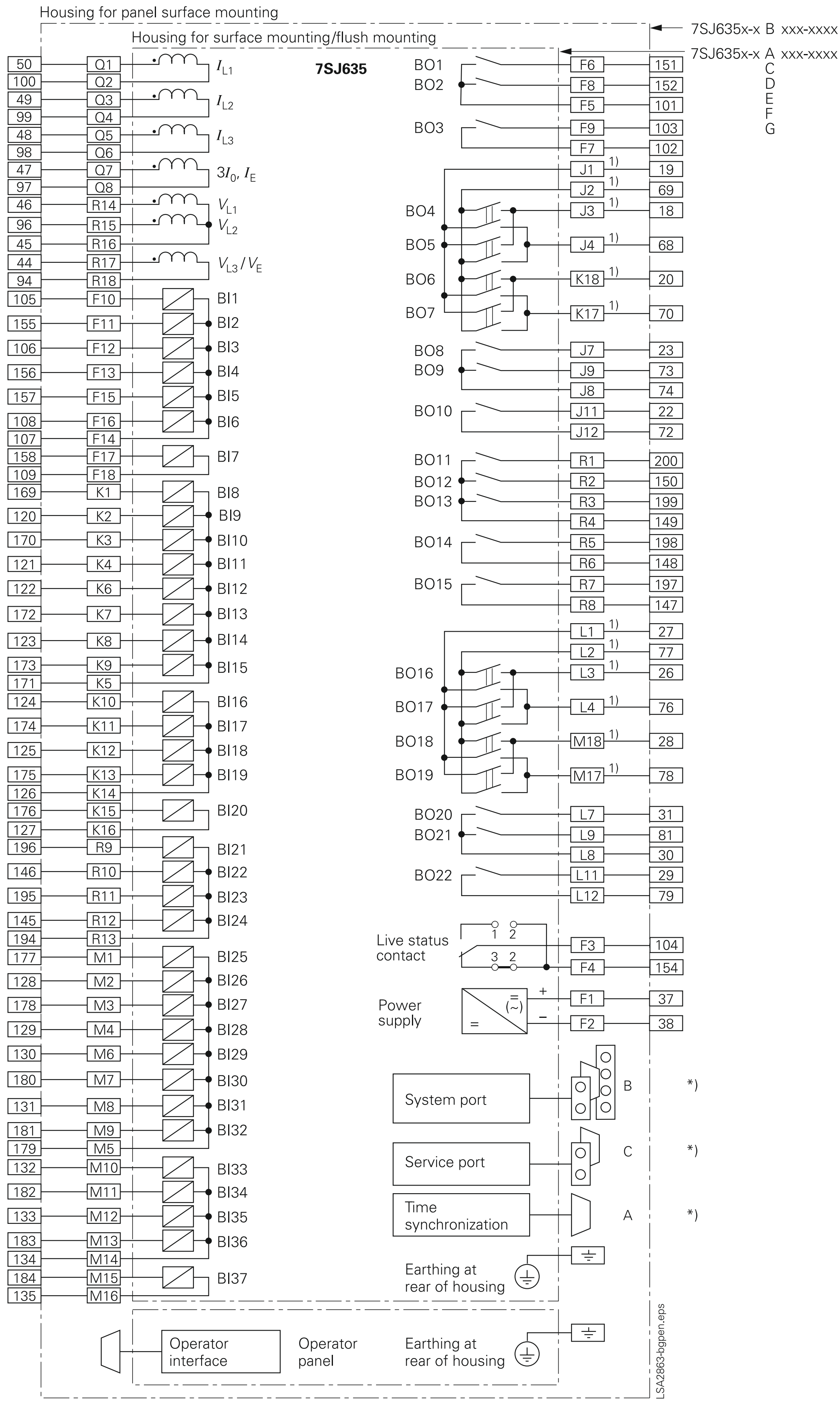
Connection diagram



*) For pinout of communication ports see part 15 of this catalog.

For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siemens.com/siprotec).

1) Power relays are intended to directly control motorized switches. The power relays are interlocked so only one relay of each pair can close at a time, in order to avoid shorting out the power supply. The power relay pairs are BO4/BO5, BO6/BO7, BO16/BO17 and BO18/BO19. If used for protection purposes only one binary output of a pair can be used.

Fig. 5/140
7SJ635 connection diagram

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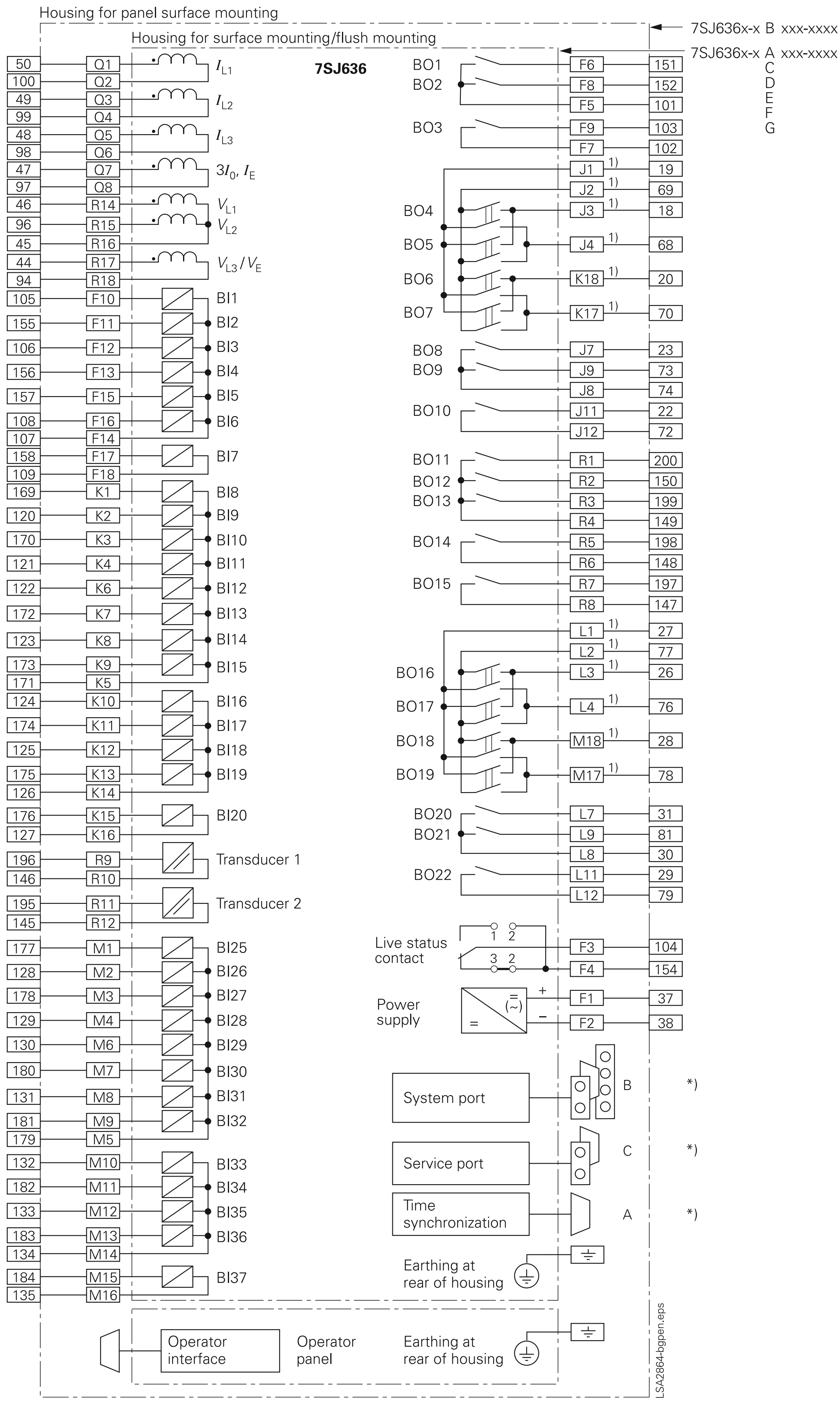
Connection diagram



*) For pinout of communication ports see part 15 of this catalog.

For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siemens.com/siprotec).

1) Power relays are intended to directly control motorized switches. The power relays are interlocked so only one relay of each pair can close at a time, in order to avoid shorting out the power supply. The power relay pairs are BO4/BO5, BO6/BO7, BO16/BO17 and BO18/BO19. If used for protection purposes only one binary output of a pair can be used.

Fig. 5/141
7SJ636 connection diagram

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SIPROTEC 4 7SJ64 Multifunction Protection Relay with Synchronization

LSP2316-afpen.tif

Fig. 5/142
SIPROTEC 4 7SJ64 multifunction protection relay

Description

The SIPROTEC 4 7SJ64 can be used as a protective control and monitoring relay for distribution feeders and transmission lines of any voltage in networks that are earthed (grounded), low-resistance earthed, unearthed, or of a compensated neutral point structure. The relay is suited for networks that are radial or looped, and for lines with single or multi-terminal feeds. The SIPROTEC 4 7SJ64 is equipped with a synchronization function which provides the operation modes 'synchronization check' (classical) and 'synchronous/asynchronous switching' (which takes the CB mechanical delay into consideration). Motor protection comprises undercurrent monitoring, starting time supervision, restart inhibit, locked rotor, load jam protection as well as motor statistics.

The 7SJ64 is featuring the "flexible protection functions". Up to 20 protection functions can be added according to individual requirements. Thus, for example, rate-of-frequency-change protection or reverse power protection can be implemented.

The relay provides easy-to-use local control and automation functions. The number of controllable switchgear depends only on the number of available inputs and outputs. The integrated programmable logic (CFC) allows the user to implement their own functions, e.g. for the automation of switchgear (interlocking). CFC capacity is much larger compared to 7SJ63 due to extended CPU power. The user is able to generate user-defined messages as well.

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

Function overview

Protection functions

- Time-overcurrent protection
- Directional time-overcurrent protection
- Sensitive dir./non-dir. earth-fault detection
- Displacement voltage
- Intermittent earth-fault protection
- High-impedance restricted earth fault
- Inrush restraint
- Motor protection
- Overload protection
- Temperature monitoring
- Under-/overvoltage protection
- Under-/overfrequency protection
- Rate-of-frequency-change protection
- Power protection (e.g. reverse, factor)
- Breaker failure protection
- Negative-sequence protection
- Phase-sequence monitoring
- Synchronization
- Auto-reclosure
- Fault locator
- Lockout

Control functions/programmable logic

- Flexible number of switching devices
- Position of switching elements is shown on the graphic display
- Local/remote switching via key-operated switch
- Control via keyboard, binary inputs, DIGSI 4 or SCADA system
- Extended user-defined logic with CFC (e.g. interlocking)

Monitoring functions

- Operational measured values V, I, f,...
- Energy metering values W_p, W_q
- Circuit-breaker wear monitoring
- Slave pointer
- Trip circuit supervision
- Fuse failure monitor
- 8 oscillographic fault records
- Motor statistics

Communication interfaces

- System interface
  – IEC 60870-5-103, IEC 61850
  – PROFIBUS-FMS / DP
  – DNP 3.0 / MODBUS RTU
- Service interface for DIGSI 4 (modem)
- Additional interface for temperature detection (RTD-box)
- Front interface for DIGSI 4
- Time synchronization via IRIG B/DCF77

5

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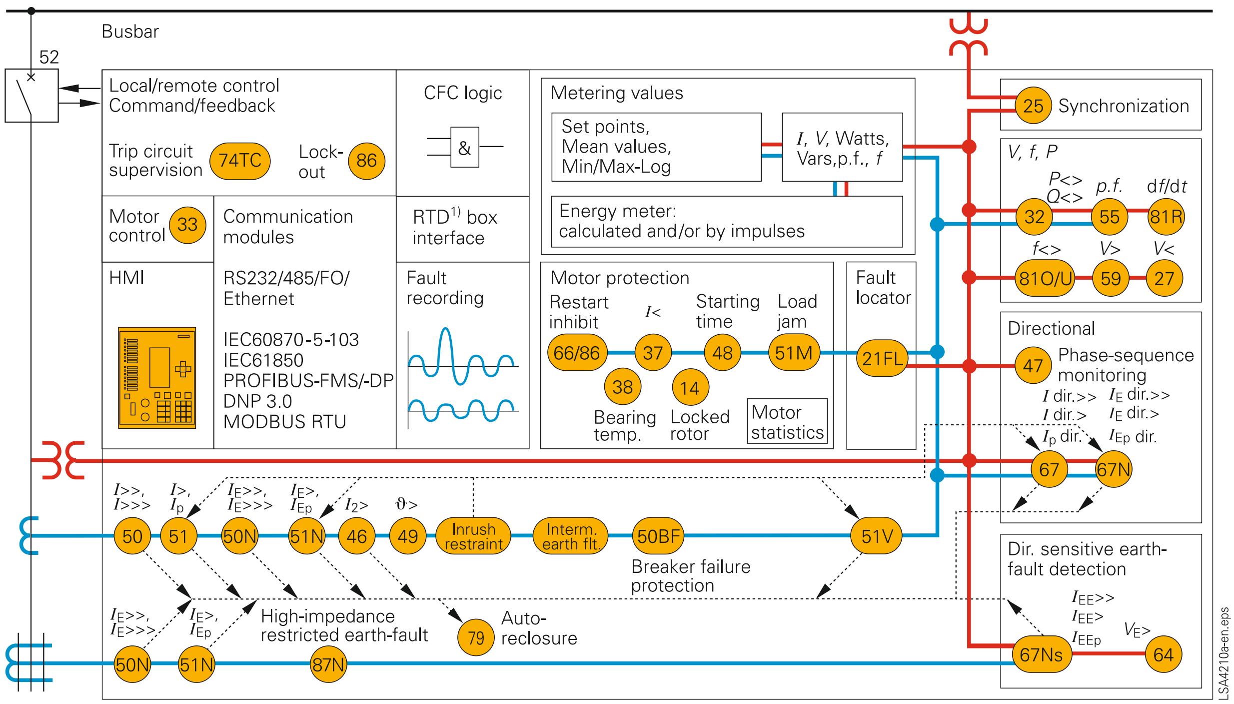
Application



[1] RTD = resistance temperature detector

Fig. 5/143 Function diagram

The SIPROTEC 4 7SJ64 unit is a numerical protection relay that also performs control and monitoring functions and therefore supports the user in cost-effective power system management, and ensures reliable supply of electric power to the customers. Local operation has been designed according to ergonomic criteria. A large, easy-to-read graphic display was a major design aim.

Control

The integrated control function permits control of disconnect devices (electrically operated/motorized switches) or circuit-breakers via the integrated operator panel, binary inputs, DIGSI 4 or the control and protection system (e.g. SICAM). The present status (or position) of the primary equipment can be displayed. 7SJ64 supports substations with single and duplicate busbars. The number of elements that can be controlled (usually 1 to 5) is only restricted by the number of inputs and outputs available. A full range of command processing functions is provided.

Programmable logic

The integrated logic characteristics (CFC) allow users to implement their own functions for automation of switchgear (interlocking) or a substation via a graphic user interface. Due to extended CPU power, the programmable logic capacity is much larger compared to 7SJ63. The user can also generate user-defined messages.

Line protection

The 7SJ64 units can be used for line protection of high and medium-voltage networks with earthed, low-resistance earthed, isolated or compensated neutral point.

Synchronization

In order to connect two components of a power system, the relay provides a synchronization function which verifies that switching ON does not endanger the stability of the power system.

The synchronization function provides the operation modes 'synchro-check' (classical) and 'synchronous/asynchronous switching' (which takes the c.-b. mechanical delay into consideration).

Motor protection

When protecting motors, the relays are suitable for asynchronous machines of all sizes.

Transformer protection

The 7SJ64 units perform all functions of backup protection supplementary to transformer differential protection. The inrush suppression effectively prevents tripping by inrush currents.

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

Backup protection

The relays can be used universally for backup protection.

Flexible protection functions

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

Metering values

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

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Application

ANSI No.	IEC	Protection functions
50, 50N	$I>$, $I>>$, $I>>>$ $I_E>$, $I_E>>$, $I_E>>>$	Definite-time overcurrent protection (phase/neutral)
50, 50N	$I>>>>$, $I_2>$ $I_E>>>>$	Additional definite-time overcurrent protection stages (phase/neutral) via flexible protection functions
51, 51V, 51N	I_p, I_{Ep}	Inverse-time overcurrent protection (phase/neutral), phase function with voltage-dependent option
67, 67N	$I_{dir}>$, $I_{dir}>>$, $I_{p\ dir}$ $I_{Edir}>$, $I_{Edir}>>$, $I_{Ep\ dir}$	Directional time-overcurrent protection (definite/inverse, phase/neutral) Directional comparison protection
67Ns/50Ns	$I_{EE}>$, $I_{EE}>>$, I_{EEp}	Directional/non-directional sensitive earth-fault detection
–		Cold load pick-up (dynamic setting change)
59N/64	V_E, $V_0>$	Displacement voltage, zero-sequence voltage
–	$I_{IE}>$	Intermittent earth fault
87N		High-impedance restricted earth-fault protection
50BF		Breaker failure protection
79M		Auto-reclosure
25		Synchronization
46	$I_2>$	Phase-balance current protection (negative-sequence protection)
47	$V_2>$, phase seq.	Unbalance-voltage protection and/or phase-sequence monitoring
49	$\vartheta>$	Thermal overload protection
48		Starting time supervision
51M		Load jam protection
14		Locked rotor protection
66/86		Restart inhibit
37	$I<$	Undercurrent monitoring
38		Temperature monitoring via external device, e.g. bearing temperature monitoring
27, 59	$V<$, $V>$	Undervoltage/overvoltage protection
59R	dV/dt	Rate-of-voltage-change protection
32	$P<>$, $Q<>$	Reverse-power, forward-power protection
55	$\cos\varphi$	Power factor protection
81O/U	$f>$, $f<$	Overfrequency/underfrequency protection
81R	df/dt	Rate-of-frequency-change protection
21FL		Fault locator

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Construction

Connection techniques and housing with many advantages

1/3, 1/2 and 1/1-rack sizes

These are the available housing widths of the 7SJ64 relays, referred to a 19” module frame system. This means that previous models can always be replaced. The height is a uniform 244 mm for flush-mounting housings and 266 mm for surface-mounting housings for all housing widths. All cables can be connected with or without ring lugs. Plug-in terminals are available as an option.
It is thus possible to employ prefabricated cable harnesses. In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located in a sloped case at the top and bottom of the housing. The housing can also be supplied optionally with a detached operator panel (refer to Fig. 5/146), or without operator panel, in order to allow optimum operation for all types of applications.

Fig. 5/144
Flush-mounting housing with screw-type terminals

Fig. 5/145
Front view of 7SJ64 with 1/3x19" housing

Fig. 5/146
Housing with plug-in terminals and detached operator panel

Fig. 5/147
Surface-mounting housing with screw-type terminals

Fig. 5/148
Communication interfaces in a sloped case in a surface-mounting housing

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Protection functions

Time-overcurrent protection (ANSI 50, 50N, 51,51V, 51N)

This function is based on the phase-selective measurement of the three phase currents and the earth current (four transformers). Three definite-time overcurrent protection elements (DMT) exist both for the phases and for the earth. The current threshold and the delay time can be set in a wide range. In addition, inverse-time overcurrent protection characteristics (IDMTL) can be activated. The inverse-time function provides – as an option – voltage-restraint or voltage-controlled operating modes.
With the "flexible protection functions", further definite-time overcurrent stages can be implemented in the 7SJ64 unit.

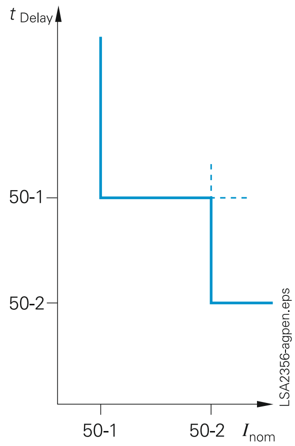

Fig. 5/149
Definite-time overcurrent protection

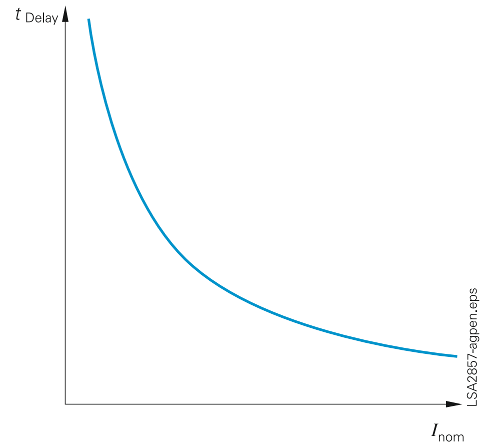

Fig. 5/150
Inverse-time overcurrent protection

Available inverse-time characteristics

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

Reset characteristics

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

User-definable characteristics

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

Inrush restraint

The relay features second harmonic restraint. If the second harmonic is detected during transformer energization, pickup of non-directional and directional normal elements are blocked.

Cold load pickup/dynamic setting change

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

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Protection functions

Directional time-overcurrent protection (ANSI 67, 67N)

Directional phase and earth protection are separate functions. They operate in parallel to the non-directional overcurrent elements. Their pickup values and delay times can be set separately. Definite-time and inverse-time characteristic is offered. The tripping characteristic can be rotated about ± 180 degrees.

By means of voltage memory, directionality can be determined reliably even for close-in (local) faults. If the switching device closes onto a fault and the voltage is too low to determine direction, directio- nality (directional decision) is made with voltage from the voltage memory. If no voltage exists in the memory, tripping occurs according to the coordination schedule.

For earth protection, users can choose whether the direction is to be determined via zero-sequence system or negative-sequence system quantities (selectable).
Using negative-sequence variables can be advantageous in cases where the zero voltage tends to be very low due to unfavorable zero-sequence impedances.

Directional comparison protection (cross-coupling)

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

(Sensitive) directional earth-fault detection (ANSI 64, 67Ns/67N)

For isolated-neutral and compensated networks, the direction of power flow in the zero sequence is calculated from the zero-sequence current I_0 and zero-sequence voltage V_0. For networks with an isolated neutral, the reactive current component is evaluated; for compensated networks, the active current component or residual resistive current is evaluated.

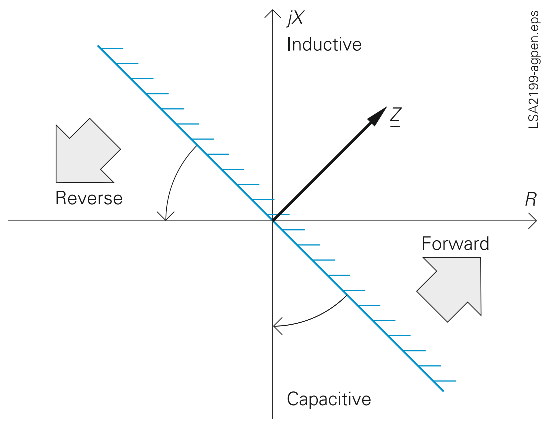

Fig. 5/151
Directional characteristic of the directional time-overcurrent protection

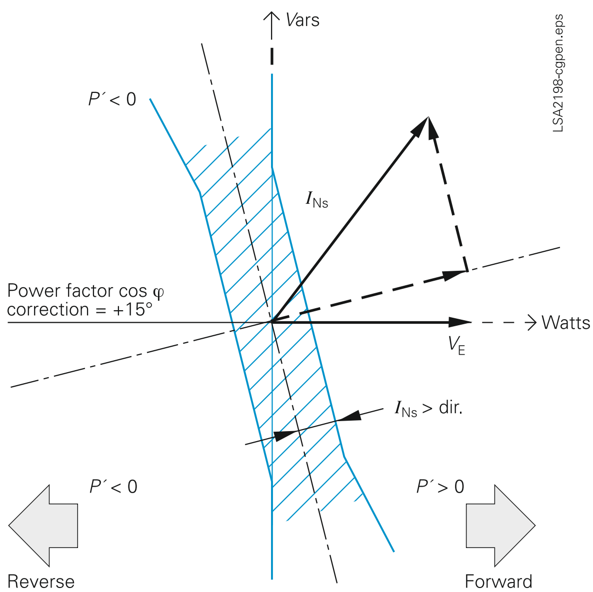

Fig. 5/152
Directional determination using cosine measurements for compensated networks

For special network conditions, e.g. high-resistance earthed networks with ohmic-capacitive earth-fault current or low-resistance earthed networks with ohmic-inductive current, the tripping characteristics can be rotated approximately ± 45 degrees.

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

It has the following functions:

- TRIP via the displacement voltage V_E.
- Two instantaneous elements or one instantaneous plus one user-defined characteristic.
- Each element can be set in forward, reverse, or non-directional.
- The function can also be operated in the insensitive mode, as an additional short-circuit protection.

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

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

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

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Protection functions

Intermittent earth-fault protection

Intermittent (re-striking) faults occur due to insulation weaknesses in cables or as a result of water penetrating cable joints. Such faults either simply cease at some stage or develop into lasting short-circuits. During intermittent activity, however, star-point resistors in networks that are impedance-earthed may undergo thermal overloading. The normal earth-fault protection cannot reliably detect and interrupt the current pulses, some of which can be very brief.
The selectivity required with intermittent earth faults is achieved by summating the duration of the individual pulses and by triggering when a (settable) summed time is reached. The response threshold I_{IE}> evaluates the r.m.s. value, referred to one systems period.

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

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

Breaker failure protection (ANSI 50BF)

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

Auto-reclosures (ANSI 79)

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

- 3-pole ARC for all types of faults
- Separate settings for phase and earth faults
- Multiple ARC, one auto-reclosure (RAR) and up to nine delayed auto-reclosures (DAR)
- Starting of the ARC depends on the trip command selection (e.g. 46, 50, 51, 67)
- Blocking option of the ARC via binary inputs
- ARC can be initiated externally or via CFC
- The directional and non-directional elements can either be blocked or operated non-delayed depending on the auto-reclosure cycle
- Dynamic setting change of the directional and non-directional elements can be activated depending on the ready AR
- The AR CLOSE command can be given synchronous by use of the synchronization function.

Flexible protection functions

The 7SJ64 units enable the user to easily add on up to 20 protective functions. To this end, parameter definitions are used to link a standard protection logic with any chosen characteristic quantity (measured or derived quantity) (Fig. 5/153). The standard logic consists of the usual protection elements such as the pickup message, the parameter-definable delay time, the TRIP command, a blocking possibility, etc. The mode of operation for current, voltage, power and power factor quantities can be three-phase or single-phase. Almost all quantities can be operated as greater than or less than stages. All stages operate with protection priority.

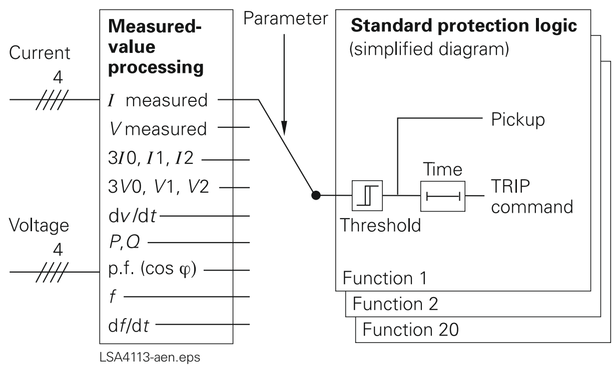

Fig. 5/153 Flexible protection functions

Protection stages/functions attainable on the basis of the available characteristic quantities:

Function	ANSI No.
I>, I_E>	50, 50N
V<, V>, V_E>, dV/dt	27, 59, 59R, 64
$3I_0$>, I_1>, I_2>, I_2/I_1 $3V_0$>, V_1><, V_2><	50N, 46 59N, 47
P><, Q><	32
cos φ (p.f.)><	55
f><	81O, 81U
df/dt><	81R

For example, the following can be implemented:

- Reverse power protection (ANSI 32R)
- Rate-of-frequency-change protection (ANSI 81R)

Synchronization (ANSI 25)

- In case of switching ON the circuit-breaker, the units can check whether the two subnetworks are synchronized (classic synchro-check). Furthermore, the synchronizing function may operate in the “Synchronous/asynchronous switching” mode. The unit then distinguishes between synchronous and asynchronous networks:
  In synchronous networks, frequency differences between the two subnetworks are almost non-existant. In this case, the circuit-breaker operating time does not need to be considered. Under asynchronous condition, however, this difference is markedly larger and the time window for switching is shorter. In this case, it is recommended to consider the operating time of the circuit-breaker.

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Protection functions

The command is automatically pre-dated by the duration of the operating time of the circuit-breaker, thus ensuring that the contacts of the CB close at exactly the right time.

Up to 4 sets of parameters for the synchronizing function can be stored in the unit. This is an important feature when several circuit-breakers with different operating times are to be operated by one single relay.

Thermal overload protection (ANSI 49)

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

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

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

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

When the high-impedance measurement principle is applied, all current transformers in the protected area are connected in parallel and operated on one common resistor of relatively high *R* whose voltage is measured (see Fig. 5/154). In the case of 7SJ6 units, the voltage is measured by detecting the current through the (external) resistor *R* at the sensitive current measurement input I_{EE}.

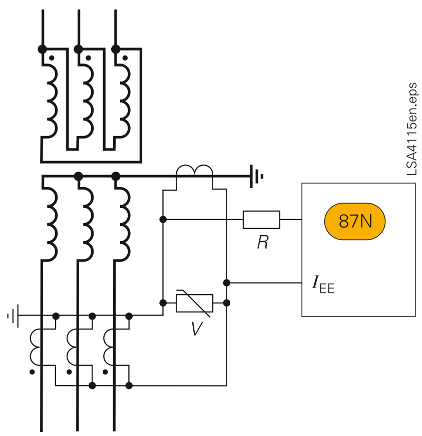

Fig. 5/154 High-impedance restricted earth- fault protection

The varistor *V* serves to limit the voltage in the event of an internal fault. It cuts off the high momentary voltage spikes occurring at transformer saturation. At the same time, this results in smoothing of the voltage without any noteworthy reduction of the average value. If no faults have occurred and in the event of external faults, the system is at equilibrium, and the voltage through the resistor is approximately zero. In the event of internal faults, an imbalance occurs which leads to a voltage and a current flow through the resistor *R*.

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

Settable dropout delay times

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

■ Motor protection

Restart inhibit (ANSI 66/86)

If a motor is started up too many times in succession, the rotor can be subject to thermal overload, especially the upper edges of the bars. The rotor temperature is calculated from the stator current. The reclosing lockout only permits start-up of the motor if the rotor has sufficient thermal reserves for a complete start-up (see Fig. 5/155).

Emergency start-up

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

Temperature monitoring (ANSI 38)

Up to two temperature monitoring boxes with a total of 12 measuring sensors can be used for temperature monitoring and detection by the protection relay. The thermal status of motors, generators and transformers can be monitored with this device. Additionally, the temperature of the bearings of rotating machines are monitored for limit value violation. The temperatures are being measured with the help of temperature detectors at various locations of the device to be protected. This data is transmitted to the protection relay via one or two temperature monitoring boxes (see "Accessories", page 5/175).

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Protection functions

Starting time supervision (ANSI 48/14)

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

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

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

I = Actual current flowing

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

t = Tripping time

I_A = Rated motor starting current

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

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

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

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

Load jam protection (ANSI 51M)

Sudden high loads can cause slowing down and blocking of the motor and mechanical damages. The rise of current due to a load jam is being monitored by this function (alarm and tripping).

The overload protection function is too slow and therefore not suitable under these circumstances.

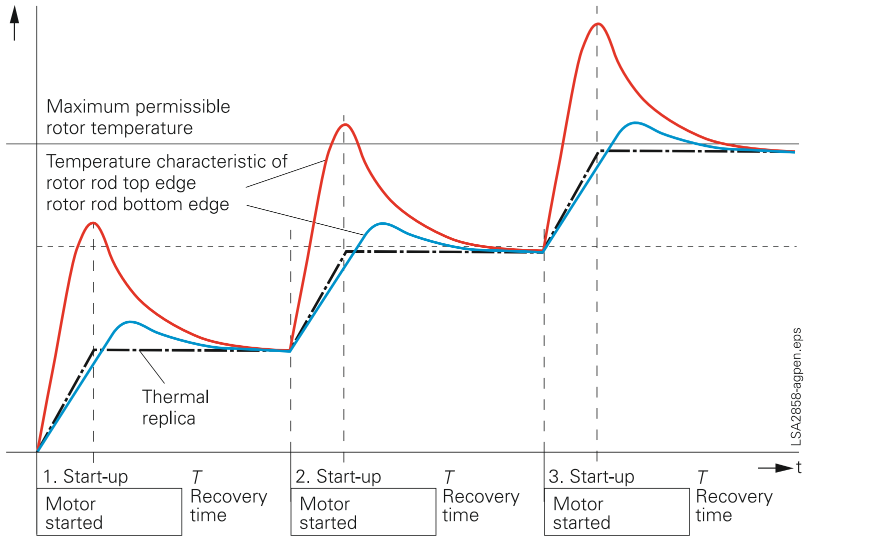

Fig. 5/155

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

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

Undercurrent monitoring (ANSI 37)

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

Motor statistics

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

■ Voltage protection

Overvoltage protection (ANSI 59)

The two-element overvoltage protection detects unwanted network and machine overvoltage conditions. The function can operate either with phase-to-phase, phase-to-earth, positive phase-sequence or negative phase-sequence voltage. Three-phase and single-phase connections are possible.

Undervoltage protection (ANSI 27)

The two-element undervoltage protection provides protection against dangerous voltage drops (especially for electric machines). Applications include the isolation of generators or motors from the network to avoid undesired operating states and a possible loss of stability. Proper operating conditions of electrical machines are best evaluated with the positive-sequence quantities. The protection function is active over a wide frequency range (45 to 55, 55 to 65 Hz)[1)]. Even when falling below this frequency range the function continues to work, however, with a greater tolerance band.

The function can operate either with phase-to-phase, phase-to-earth or positive phase-sequence voltage, and can be monitored with a current criterion.
Three-phase and single-phase connections are possible.

Frequency protection (ANSI 81O/U)

Frequency protection can be used for overfrequency and underfrequency protection. Electric machines and parts of the system are

1) The 45 to 55, 55 to 65 Hz range is available for f_N = 50/60 Hz.

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Protection functions/Functions

protected from unwanted speed deviations. Unwanted frequency changes in the network can be detected and the load can be removed at a specified frequency setting. Frequency protection can be used over a wide frequency range (40 to 60, 50 to 70 Hz)[1]. There are four elements (selectable as overfrequency or underfrequency) and each element can be delayed separately. Blocking of the frequency protection can be performed if using a binary input or by using an undervoltage element.

Fault locator (ANSI 21FL)

The integrated fault locator calculates the fault impedance and the distance-to-fault. The results are displayed in Ω, kilometers (miles) and in percent of the line length.

Circuit-breaker wear monitoring

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

There is no mathematically exact method of calculating the wear or the remaining service life of circuit-breakers that takes into account the arc-chamber's physical conditions when the CB opens. This is why various methods of determining CB wear have evolved which reflect the different operator philosophies. To do justice to these, the devices offer several methods:

- ΣI
- ΣI^x, with x = 1... 3
- $\Sigma i^2 t$

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

- Two-point method

The CB manufacturers double-logarithmic switching cycle diagram (see Fig. 5/181) and the breaking current at the time of contact opening serve as the basis for this method. After CB opening, the two-point method calculates the number of still possible switching cycles. To this end, the two points P1 and P2 only have to be set on the device. These are specified in the CB's technical data.

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

1) The 40 to 60, 50 to 70 Hz range is available for f_N = 50/60 Hz.

Commissioning

Commissioning could hardly be easier and is fully supported by DIGSI 4. The status of the binary inputs can be read individually and the state of the binary outputs can be set individually. The operation of switching elements (circuit-breakers, disconnect devices) can be checked using the switching functions of the bay controller. The analog measured values are represented as wide-ranging operational measured values. To prevent transmission of information to the control center during maintenance, the bay controller communications can be disabled to prevent unnecessary data from being transmitted. During commissioning, all indications with test marking for test purposes can be connected to a control and protection system.

Test operation

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

Control and automatic functions

Control

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

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

The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated to the 7SJ64 via binary inputs. Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a fault or intermediate circuit-breaker or auxiliary contact position.

The switchgear or circuit-breaker can be controlled via:

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

Automation / user-defined logic

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

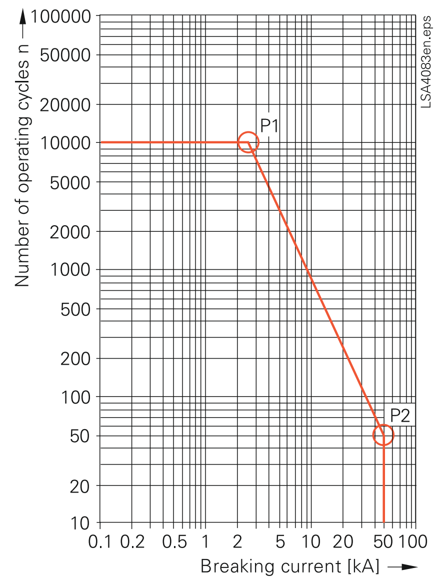

Fig. 5/156 CB switching cycle diagram

Switching authority

Switching authority is determined according to parameters, communication or by key-operated switch (when available).
If a source is set to "LOCAL", only local switching operations are possible. The following sequence of switching authority is laid down: "LOCAL"; DIGSI PC program, "REMOTE".

Key-operated switch

7SJ64 units are fitted with key-operated switch function for local/remote changeover and changeover between interlocked switching and test operation.

Command processing

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

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable bay interlocks
- Operating sequences combining several switching operations such as control of circuit-breakers, disconnectors and earthing switches
- Triggering of switching operations, indications or alarm by combination with existing information

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Functions

Motor control

The SIPROTEC 4 7SJ64 with high performance relays is well-suited for direct activation of the circuit-breaker, disconnector and earthing switch operating mechanisms in automated substations.

Interlocking of the individual switching devices takes place with the aid of programmable logic. Additional auxiliary relays can be eliminated. This results in less wiring and engineering effort.

Assignment of feedback to command

The positions of the circuit-breaker or switching devices and transformer taps are acquired by feedback. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication change is a consequence of switching operation or whether it is a spontaneous change of state.

Chatter disable

Chatter disable feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

Indication filtering and delay

Binary indications can be filtered or delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time.

In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

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

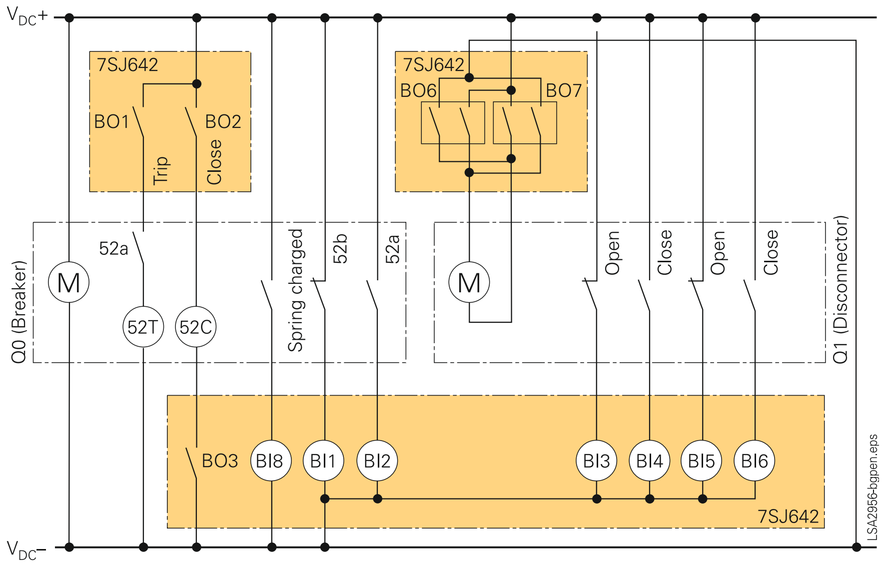

Fig. 5/157
Typical wiring for 7SJ642 motor direct control (simplified representation without fuses)
Binary output BO6 and BO7 are interlocked so that only one set of contacts are closed at a time.

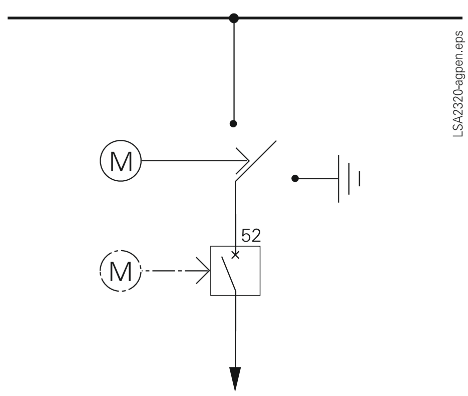

Fig. 5/158 Example: Single busbar with circuit-breaker and motor-controlled three-position switch

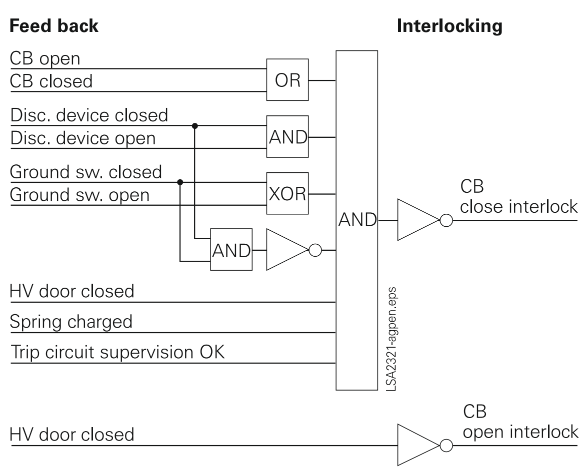

Fig. 5/159 Example: Circuit-breaker interlocking

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Functions

Measured values

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

- Currents I_{L1}, I_{L2}, I_{L3}, I_E, I_{EE} (67Ns)
- Voltages V_{L1}, V_{L2}, V_{L3}, V_{L1L2}, V_{L2L3}, V_{L3L1}, V_{syn}
- Symmetrical components I_1, I_2, $3I_0$; V_1, V_2, V_0
- Power Watts, Vars, VA/P, Q, S (P, Q: total and phase-selective)
- Power factor (cos φ) (total and phase-selective)
- Frequency
- Energy ± kWh, ± kVArh, forward and reverse power flow
- Mean as well as minimum and maximum current and voltage values
- Operating hours counter
- Mean operating temperature of overload function
- Limit value monitoring
- Limit values are monitored using programmable logic in the CFC. Commands can be derived from this limit value indication.
- Zero suppression
  In a certain range of very low measured values, the value is set to zero to suppress interference.

Metered values

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

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

Switchgear cubicles for high/medium voltage

All units are designed specifically to meet the requirements of high/medium-voltage applications.

In general, no separate measuring instruments (e.g. for current, voltage, frequency measuring transducer ...) or additional control components are necessary.

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Fig. 5/160
NX PLUS panel (gas-insulated)

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Communication

In terms of communication, the units offer substantial flexibility in the context of connection to industrial and power automation standards. Communication can be extended or added on thanks to modules for retrofitting on which the common protocols run. Therefore, also in the future it will be possible to optimally integrate units into the changing communication infrastructure, for example in Ethernet networks (which will also be used increasingly in the power supply sector in the years to come).

Serial front interface

There is a serial RS232 interface on the front of all the units. All of the unit's functions can be set on a PC by means of the DIGSI 4 protection operation program. Commissioning tools and fault analysis are also built into the program and are available through this interface.

Rear-mounted interfaces[1)]

A number of communication modules suitable for various applications can be fitted in the rear of the flush-mounting housing. In the flush-mounting housing, the modules can be easily replaced by the user.
The interface modules support the following applications:

- Time synchronization interface
  All units feature a permanently integrated electrical time synchronization interface. It can be used to feed timing telegrams in IRIG-B or DCF77 format into the units via time synchronization receivers.
- System interface
  Communication with a central control system takes place through this interface. Radial or ring type station bus topologies can be configured depending on the chosen interface. Furthermore, the units can exchange data through this interface via Ethernet and IEC 61850 protocol and can also be operated by DIGSI.
- Service interface
  The service interface was conceived for remote access to a number of protection units via DIGSI. It can be an electrical RS232/RS485 interface. For special applications, a maximum of two temperature monitoring boxes (RTD-box) can be connected to this interface as an alternative.
- Additional interface
  Up to 2 RTD-boxes can be connected via this interface.

1) For units in panel surface-mounting housings please refer to note on page 5/193.

System interface protocols (retrofittable)

IEC 61850 protocol

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens was the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus is also possible with DIGSI. It is also possible to retrieve operating and fault messages and fault recordings via a browser. This Web monitor also provides a few items of unit-specific information in browser windows.

IEC 60870-5-103 protocol

The IEC 60870-5-103 protocol is an international standard for the transmission of protective data and fault recordings. All messages from the unit and also control commands can be transferred by means of published, Siemens-specific extensions to the protocol.
Redundant solutions are also possible. Optionally it is possible to read out and alter individual parameters (only possible with the redundant module).

PROFIBUS-DP protocol

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

MODBUS RTU protocol

This uncomplicated, serial protocol is mainly used in industry and by power supply corporations, and is supported by a number of unit manufacturers. SIPROTEC units function as MODBUS slaves, making their information available to a master or receiving information from it. A time-stamped event list is available.

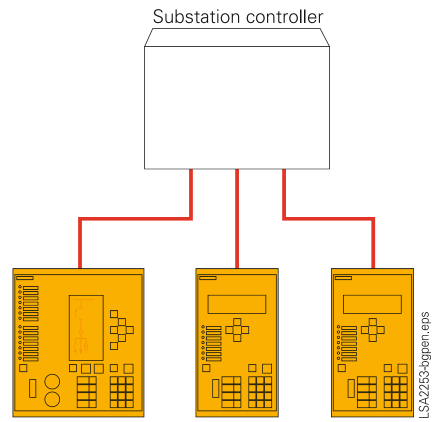

Fig. 5/161
IEC 60870-5-103: Radial fiber-optic connection

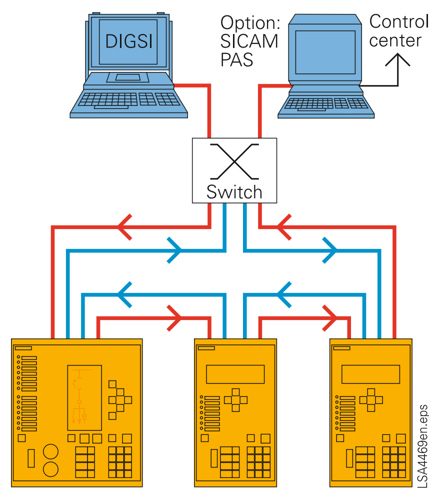

Fig. 5/162
Bus structure for station bus with Ethernet and IEC 61850, fiber-optic ring

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Communication

DNP 3.0 protocol

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

System solutions for protection and station control

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

Units featuring IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 5/161).

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

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 5/162).

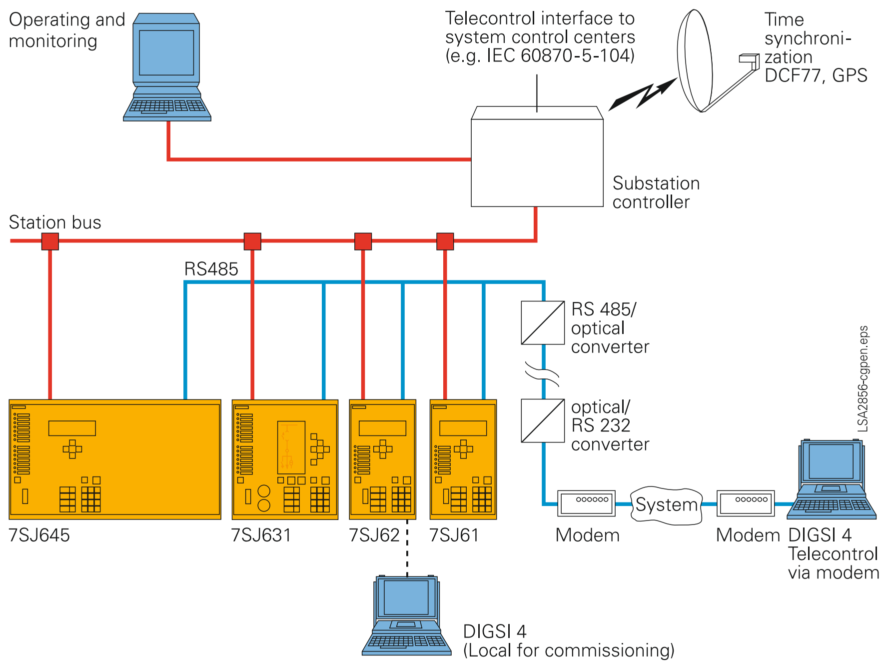

Fig. 5/163
System solution/communication

Fig. 5/164
Optical Ethernet communication module for IEC 61850 with integrated Ethernet-switch

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Typical connections

■ *Connection of current and voltage transformers*

Standard connection

For earthed networks, the earth current is obtained from the phase currents by the residual current circuit.

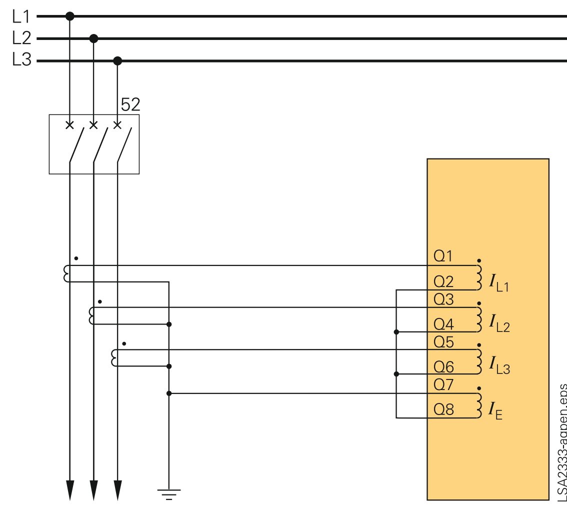

Fig. 5/165
Residual current circuit without directional element

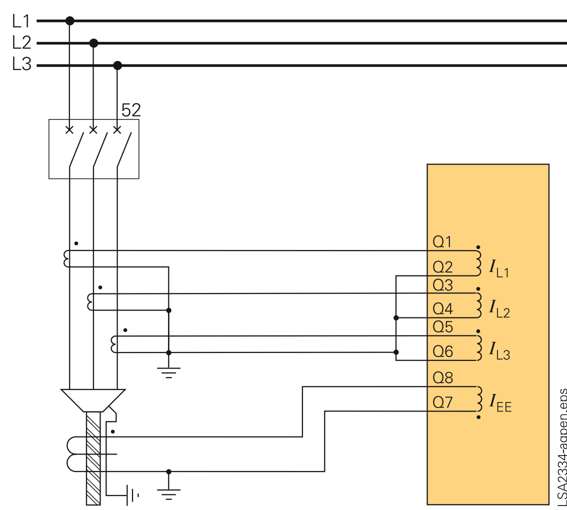

Fig. 5/166
Sensitive earth current detection without directional element

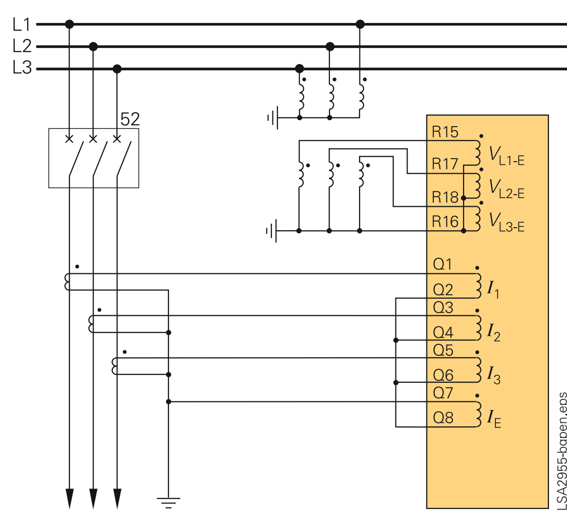

Fig. 5/167
Residual current circuit with directional element

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Typical connections

Connection for compensated networks

The figure shows the connection of two phase-to-earth voltages and the V_E voltage of the open delta winding and a phase-earth neutral current transformer for the earth current. This connection maintains maximum precision for directional earth- fault detection and must be used in compensated networks.
Fig. 5/168 shows sensitive directional earth-fault detection.

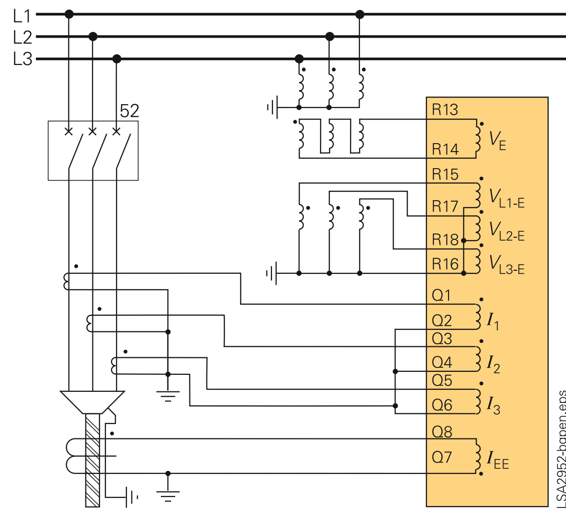

Fig. 5/168
Sensitive directional earth-fault detection with directional element for phases

Connection for isolated-neutral or compensated networks only

If directional earth-fault protection is not used, the connection can be made with only two phase current transformers. Directional phase short-circuit protection can be achieved by using only two primary transformers.

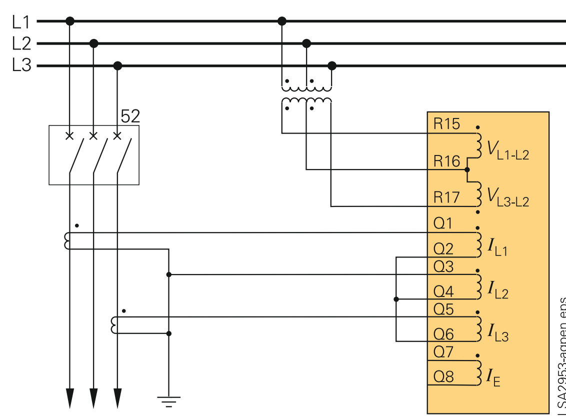

Fig. 5/169
Isolated-neutral or compensated networks

Connection for the synchronization function

The 3-phase system is connected as reference voltage, i. e. the outgoing voltages as well as a single-phase voltage, in this case a busbar voltage, that has to be synchronized.

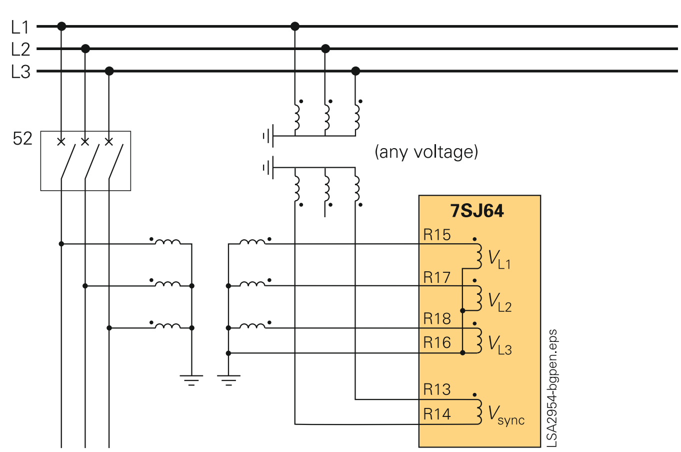

Fig. 5/170
Measuring of the busbar voltage and the outgoing feeder voltage for synchronization

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Typical applications

Overview of connection types

Type of network	Function	Current connection	Voltage connection
(Low-resistance) earthed network	Time-overcurrent protection phase/earth non-directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformer possible	-
(Low-resistance) earthed networks	Sensitive earth-fault protection	Phase-balance neutral current transformers required	-
Isolated or compensated networks	Time-overcurrent protection phases non-directional	Residual circuit, with 3 or 2 phase-current transformers possible	-
(Low-resistance) earthed networks	Time-overcurrent protection phases directional	Residual circuit, with 3 phase-current transformers possible	Phase-to-earth connection or phase-to-phase connection
Isolated or compensated networks	Time-overcurrent protection phases directional	Residual circuit, with 3 or 2 phase-current transformers possible	Phase-to-earth connection or phase-to-phase connection
(Low-resistance) earthed networks	Time-overcurrent protection earth directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformers possible	Phase-to-earth connection required
Isolated networks	Sensitive earth-fault protection	Residual circuit, if earth current $> 0.05\ I_N$ on secondary side, otherwise phase-balance neutral current transformers required	3 times phase-to-earth connection or phase-to-earth connection with open delta winding
Compensated networks	Sensitive earth-fault protection $\cos\varphi$ measurement	Phase-balance neutral current transformers required	Phase-to-earth connection with open delta winding required

5

■ Application examples

Synchronization function

When two subnetworks must be interconnected, the synchronization function monitors whether the subnetworks are synchronous and can be connected without risk of losing stability.

As shown in Fig. 5/171, load is being fed from a generator to a busbar via a transformer. It is assumed that the frequency difference of the 2 subnetworks is such that the device determines asynchronous system conditions.

The voltages of the busbar and the feeder should be the same when the contacts are made; to ensure this condition the synchronism function must run in the “synchronous/asynchronous switching” mode.
In this mode, the operating time of the CB can be set within the relay.
Differences between angle and frequency can then be calculated by the relay while taking into account the operating time of the CB.
From these differences, the unit derives the exact time for issuing the CLOSE command under asynchronous conditions.
When the contacts close, the voltages will be in phase.

The vector group of the transformer can be considered by setting parameters. Thus no external circuits for vector group adaptation are required.

This synchronism function can be applied in conjunction with the auto-reclosure function as well as with the control function CLOSE commands (local/remote).

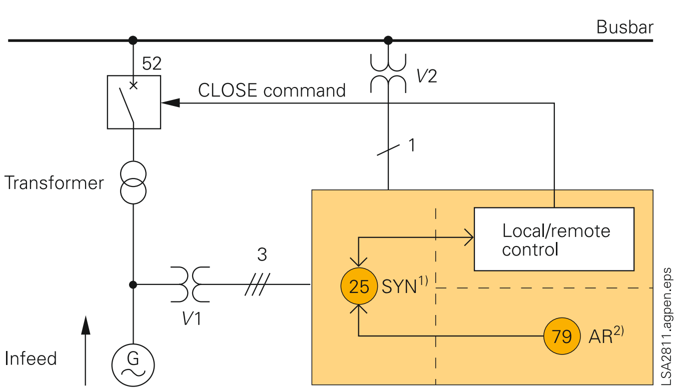

Fig. 5/171 Measuring of busbar and feeder voltages for synchronization

1) Synchronization function
2) Auto-reclosure function

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Typical applications

■ Connection of circuit-breaker

Undervoltage releases

Undervoltage releases are used for automatic tripping of high-voltage motors.

Example:
DC supply voltage of control system fails and manual electric tripping is no longer possible.

Automatic tripping takes place when voltage across the coil drops below the trip limit. In Figure 5/172, tripping occurs due to failure of DC supply voltage, by automatic opening of the live status contact upon failure of the protection unit or by short-circuiting the trip coil in event of a network fault.

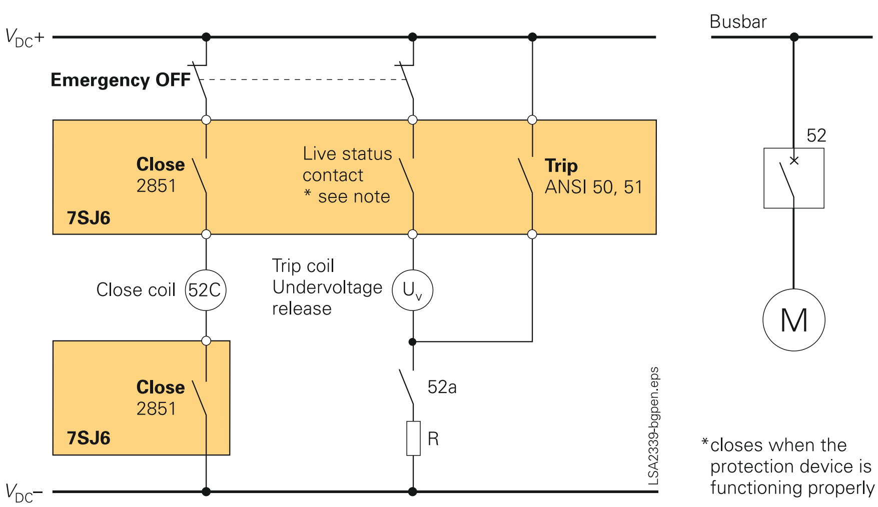

Fig. 5/172 Undervoltage release with make contact 50, 51

In Fig. 5/173 tripping is by failure of auxiliary voltage and by interruption of tripping circuit in the event of network failure. Upon failure of the protection unit, the tripping circuit is also interrupted, since contact held by internal logic drops back into open position.

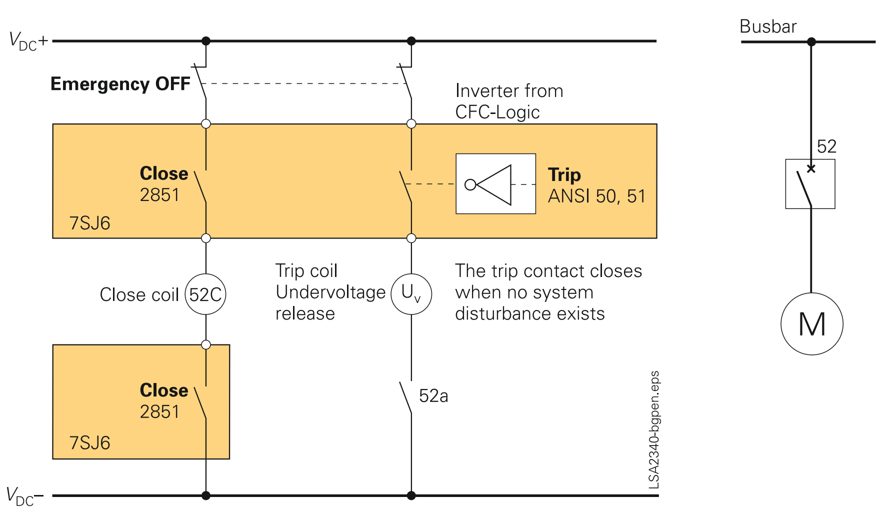

Fig. 5/173 Undervoltage release with locking contact (trip signal 50 is inverted)

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Typical applications

Trip circuit supervision (ANSI 74TC)

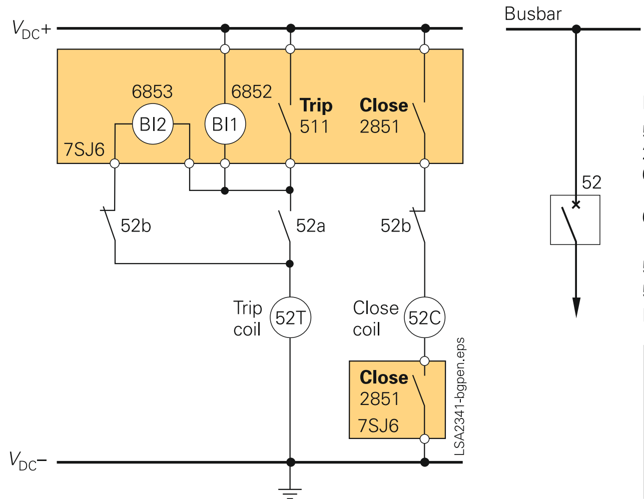
One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal occurs whenever the circuit is interrupted.

Lockout (ANSI 86)

All binary outputs can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only occur after the lockout state is reset.

Reverse-power protection for dual supply (ANSI 32R)

If power is fed to a busbar through two parallel infeeds, then in the event of any fault on one of the infeeds it should be selectively interrupted. This ensures a continued supply to the busbar through the remaining infeed. For this purpose, directional devices are needed which detect a short-circuit current or a power flow from the busbar in the direction of the infeed. The directional time-overcurrent protection is usually set via the load current. It cannot be used to deactivate low-current faults. Reverse-power protection can be set far below the rated power. This ensures that it also detects power feedback into the line in the event of low-current faults with levels far below the load current. Reverse-power protection is performed via the "flexible protection functions" of the 7SJ64.



Protection indications

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

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

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

Fig. 5/174 Trip circuit supervision with 2 binary inputs

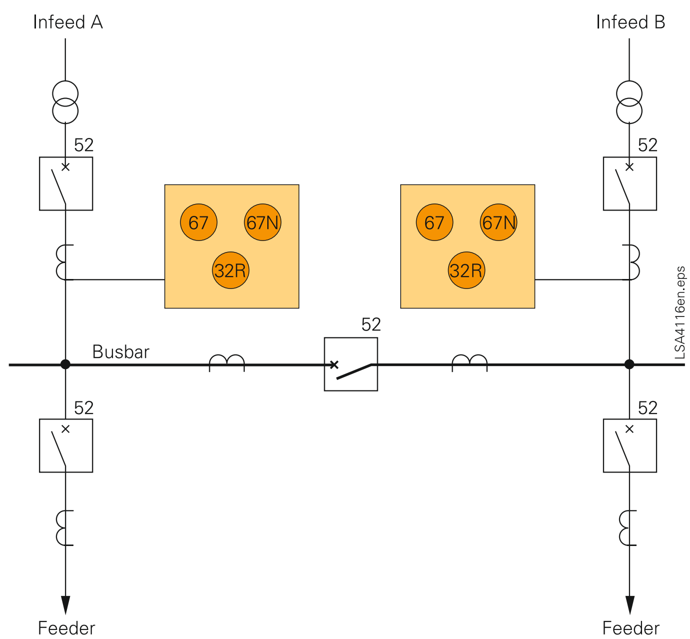


Fig. 5/175 Reverse-power protection for dual supply

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Technical data

General unit data

Measuring circuits	
System frequency	50 / 60 Hz (settable)
Current transformer	
Rated current I_{nom}	1 or 5 A (settable)
Option: sensitive earth-fault CT	I_{EE} < 1.6 A
Power consumption at I_{nom} = 1 A at I_{nom} = 5 A for sensitive earth-fault CT at 1 A	 Approx. 0.05 VA per phase Approx. 0.3 VA per phase Approx. 0.05 VA
Overload capability Thermal (effective)	 100 x I_{nom} for 1 s 30 x I_{nom} for 10 s 4 x I_{nom} continuous
Dynamic (impulse current)	250 x I_{nom} (half cycle)
Overload capability if equipped with sensitive earth-fault CT Thermal (effective)	 300 A for 1 s 100 A for 10 s 15 A continuous
Dynamic (impulse current)	750 A (half cycle)
Voltage transformer	
Rated voltage V_{nom}	100 V to 225 V
Measuring range	0 V to 200 V
Power consumption at V_{nom} = 100 V	< 0.3 VA per phase
Overload capability in voltage path (phase-neutral voltage) Thermal (effective)	 230 V continuous

Auxiliary voltage *(via integrated converter)*

Rated auxiliary voltage V_{aux}	DC	24/48 V	60/125 V	110/250 V	
Permissible tolerance	DC	19 - 58 V	48 - 150 V	88 - 300 V	
Ripple voltage, peak-to-peak		≤ 12 % of rated auxiliary voltage			
Power consumption		7SJ640	7SJ641 7SJ642	7SJ645	7SJ647
Quiescent	Approx.	5 W	5.5 W	6.5 W	7.5 W
Energized	Approx.	9 W	12.5 W	15 W	21 W
Backup time during loss/short-circuit of auxiliary direct voltage		≥ 50 ms at V > 110 V DC ≥ 20 ms at V > 24 V DC			
Rated auxiliary voltage V_{aux}	AC	115 / 230 V			
Permissible tolerance	AC	92 - 132 V / 184 - 265 V			
Power consumption		7SJ640	7SJ641 7SJ642	7SJ645	7SJ647
Quiescent	Approx.	7 W	9 W	12 W	16 W
Energized	Approx.	12 W	19 W	23 W	33 W
Backup time during loss/short-circuit of auxiliary alternating voltage		≥ 200 ms			

Binary inputs/indication inputs

Type	7SJ640	7SJ641	7SJ642	7SJ645	7SJ647
Number (marshallable)	7	15	20	33	48
Voltage range	24 - 250 V DC				
Pickup threshold modifiable by plug-in jumpers					
Pickup threshold DC	19 V DC		88 V DC		
For rated control voltage DC	24/48/60/110/ 125 V DC		110/125/220/250 V DC		
Power consumption energized	0.9 mA (independent of operating voltage) for BI 8…19 / 21…32; 1.8 mA for BI 1…7 / 20/33…48				

Binary outputs/command outputs

Type	7SJ640	7SJ641	7SJ642	7SJ645	7SJ647
Command/indication relay	5	13	8	11	21
Contacts per command/ indication relay	1 NO / form A				
Live status contact	1 NO / NC (jumper)/form A/B				
Switching capacity Make	1000 W / VA				
Break	30 W / VA / 40 W resistive/ 25 W at L/R ≤ 50 ms				
Switching voltage	≤ 250 V DC				
Permissible current	5 A continuous, 30 A for 0.5 s making current, 2000 switching cycles				

Power relay *(for motor control)*

Type	7SJ640 7SJ641	7SJ642	7SJ645	7SJ647
Number	0	2 (4)	4 (8)	4 (8)
Number of contacts/relay		2 NO / form A		
Switching capacity Make	1000 W / VA at 48 V … 250 V / 500 W at 24 V			
Break	1000 W / VA at 48 V … 250 V / 500 W at 24 V			
Switching voltage	≤ 250 V DC			
Permissible current	5 A continuous, 30 A for 0.5 s			

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Technical data

Electrical tests

Specification

Standards	IEC 60255 ANSI C37.90, C37.90.1, C37.90.2, UL508

Insulation tests

Standards	IEC 60255-5; ANSI/IEEE C37.90.0
Voltage test (100 % test) all circuits except for auxiliary voltage and RS485/RS232 and time synchronization	2.5 kV (r.m.s. value), 50/60 Hz
Auxiliary voltage	3.5 kV DC
Communication ports and time synchronization	500 V AC
Impulse voltage test (type test) all circuits, except communication ports and time synchronization, class III	5 kV (peak value); 1.2/50 µs; 0.5 J 3 positive and 3 negative impulses at intervals of 5 s

EMC tests for interference immunity; type tests

Standards	IEC 60255-6; IEC 60255-22 (product standard) EN 50082-2 (generic specification) DIN 57435 Part 303
High-frequency test IEC 60255-22-1, class III and VDE 0435 Part 303, class III	2.5 kV (peak value); 1 MHz; τ =15 ms; 400 surges per s; test duration 2 s
Electrostatic discharge IEC 60255-22-2 class IV and EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air gap discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with radio-frequency field, non-modulated IEC 60255-22-3 (Report) class III	10 V/m; 27 to 500 MHz
Irradiation with radio-frequency field, amplitude-modulated IEC 61000-4-3; class III	10 V/m, 80 to 1000 MHz; AM 80 %; 1 kHz
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204; class III	10 V/m, 900 MHz; repetition rate 200 Hz, on duration 50 %
Fast transient interference/burst IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; test duration 1 min
High-energy surge voltages (Surge) IEC 61000-4-5; class III	
Auxiliary voltage	From circuit to circuit: 2 kV; 12 Ω; 9 µF across contacts: 1 kV; 2 Ω ;18 µF
Binary inputs/outputs	From circuit to circuit: 2 kV; 42 Ω; 0.5 µF across contacts: 1 kV; 42 Ω; 0.5 µF
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; AM 80 %; 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m; 50 Hz, continuous 300 A/m; 50 Hz, 3 s 0.5 mT, 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak value), 1 to 1.5 MHz damped wave; 50 surges per s; duration 2 s, R_i = 150 to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per s both polarities; duration 2 s, R_i = 80 Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz; amplitude and pulse-modulated
Damped wave IEC 60694 / IEC 61000-4-12	2.5 kV (peak value, polarity alternating) 100 kHz, 1 MHz, 10 and 50 MHz, R_i = 200 Ω

EMC tests for interference emission; type tests

Standard	EN 50081-* (generic specification)
Conducted interferences only auxiliary voltage IEC/CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC/CISPR 11	30 to 1000 MHz Limit class B
Units with a detached operator panel must be installed in a metal cubicle to maintain limit class B	

Mechanical stress tests

Vibration, shock stress and seismic vibration

<u>During operation</u>	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz; +/- 0.075 mm amplitude; 60 to 150 Hz; 1 *g* acceleration frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 5 *g*, duration 11 ms; 3 shocks in both directions of 3 axes
Seismic vibration IEC 60255-21-3, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 perpendicular axes
<u>During transportation</u>	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz; 2 *g* acceleration, frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, Class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 15 *g*, duration 11 ms 3 shocks in both directions of 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Semi-sinusoidal Acceleration 10 *g*, duration 16 ms 1000 shocks in both directions of 3 axes

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Technical data

Climatic stress tests	
Temperatures	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C / -13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	-20 °C to +70 °C / -4 °F to -158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C / +131 °F)	-5 °C to +55 °C / +25 °F to +131 °F
– Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to +131 °F
– Limiting temperature during transport	-25 °C to +70 °C / -13 °F to +158 °F
Humidity	
Permissible humidity It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average 75 % relative humidity; on 56 days a year up to 95 % relative humidity; condensation not permissible!

Unit design			
Type	7SJ640 7SJ642	7SJ641	7SJ645 7SJ647
Housing	7XP20		
Dimensions	See dimension drawings, part 15 of this catalog		
Weight in kg	Housing width 1/3	Housing width 1/2	Housing width 1/1
Surface-mounting housing	8	11	15
Flush-mounting housing	5	6	10
Housing for detached operator panel	–	8	12
Detached operator panel	–	2.5	2.5
Degree of protection acc. to EN 60529			
Surface-mounting housing	IP 51		
Flush-mounting housing	Front: IP 51, rear: IP 20;		
Operator safety	IP 2x with cover		

Serial interfaces	
Operating interface *(front of unit)*	
Connection	Non-isolated, RS232; front panel, 9-pin subminiature connector
Transmission rate	Factory setting 115200 baud, min. 4800 baud, max. 115200 baud
Service/modem interface *(rear of unit)*	
Isolated interface for data transfer	Port C: DIGSI 4/modem/RTD-box
Transmission rate	Factory setting 38400 baud, min. 4800 baud, max. 115200 baud
<u>RS232/RS485</u>	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location "C"
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	15 m /49.2 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth
Additional interface *(rear of unit)*	
Isolated interface for data transfer	Port D: RTD-box
Transmission rate	Factory setting 38400 baud, min. 4800 baud, max. 115200 baud
<u>RS485</u>	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location "D"
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing: shielded data cable
Distance	Max. 1 km/3300 ft
Test voltage	500 V AC against earth
<u>Fiber optic</u>	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "D"
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles

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Technical data

***System interface** (rear of unit)*

IEC 60870-5-103 protocol

Isolated interface for data transfer to a control center	Port B
Transmission rate	Factory setting 9600 baud, min. 1200 baud, max. 115200 baud
RS232/RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	Max. 15 m/49 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth
Fiber optic	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles

IEC 60870-5-103 protocol, redundant

RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	(not available)
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth

IEC 61850 protocol

Isolated interface for data transfer: - to a control center - with DIGSI - between SIPROTEC 4 relays	Port B, 100 Base T acc. to IEEE802.3
Transmission rate	100 Mbit
Ethernet, electrical	
Connection For flush-mounting housing/ surface-mounting housing with detached operator panel	Two RJ45 connectors Mounting location "B"
Distance	Max. 20 m / 65.6 ft
Test voltage	500 V AC against earth
Ethernet, optical	
Connection For flush-mounting housing/ surface-mounting housing with detached operator panel	Intergr. LC connector for FO connection Mounting location "B"
Optical wavelength	1300 nmm
Distance	1.5 km/0.9 miles

PROFIBUS-FMS/DP

Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 1.5 Mbaud
RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance	1000 m/3300 ft ≤ 93.75 kbaud; 500 m/1500 ft ≤ 187.5 kbaud; 200 m/600 ft ≤ 1.5 Mbaud; 100 m/300 ft ≤ 12 Mbaud
Test voltage	500 V AC against earth
Fiber optic	
Connection fiber-optic cable For flush-mounting housing/ surface-mounting housing with detached operator panel	Integr. ST connector for FO connection, mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing Important: Please refer to footnotes [1] and [2] on page 5/215
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	500 kB/s 1.6 km/0.99 miles 1500 kB/s 530 m/0.33 miles

MODBUS RTU, ASCII, DNP 3.0

Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 19200 baud
RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location “B”
For surface-mounting housing with two-tier terminal at the top/bottom part	At bottom part of the housing: shielded data cable
Distance	Max. 1 km/3300 ft max. 32 units recommended
Test voltage	500 V AC against earth
Fiber-optic	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing Important: Please refer to footnotes [1] and [2] on page 5/215
Optical wavelength	820 nm
Permissible path attenuation	Max 8 dB. for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles

1) At I_{nom} = 1 A, all limits divided by 5.

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Technical data

Time synchronization DCF77/IRIG-B signal (Format IRIG-B000)	
Connection	9-pin subminiature connector (SUB-D) (terminal with surface-mounting housing)
Voltage levels	5 V, 12 V or 24 V (optional)
Functions	
Definite-time overcurrent protection, directional/non-directional (ANSI 50, 50N, 67, 67N)	
Operating mode non-directional phase protection (ANSI 50)	3-phase (standard) or 2-phase (L1 and L3)
Number of elements (stages)	I>, I>>, I>>> (phases) I_E>, I_E>>, I_E>>> (earth)
Setting ranges	
Pickup phase elements Pickup earth elements	0.5 to 175 A or ∞ 1) (in steps of 0.01 A) 0.25 to 175 A or ∞ 1) (in steps of 0.01 A)
Delay times T Dropout delay time T_{DO}	0 to 60 s or ∞ (in steps of 0.01 s) 0 to 60 s (in steps of 0.01 s)
Times Pickup times (without inrush restraint, with inrush restraint + 10 ms)	
	Non-directional / Directional
With twice the setting value With five times the setting value	Approx. 30 ms / 45 ms Approx. 20 ms / 40 ms
Dropout times	Approx. 40 ms
Dropout ratio	Approx. 0.95 for I/I_{nom} ≥ 0.3
Tolerances Pickup Delay times T, T_{DO}	 2 % of setting value or 50 mA 1) 1 % or 10 ms
Inverse-time overcurrent protection, directional/non-directional (ANSI 51, 51N, 67, 67N)	
Operating mode non-directional phase protection (ANSI 51)	3-phase (standard) or 2-phase (L1 and L3)
Setting ranges Pickup phase element I_P Pickup earth element I_{EP} Time multiplier T (IEC characteristics) Time multiplier D (ANSI characteristics)	 0.5 to 20 A or ∞ 1) (in steps of 0.01 A) 0.25 to 20 A or ∞ 1) (in steps of 0.01 A) 0.05 to 3.2 s or ∞ (in steps of 0.01 s) 0.05 to 15 s or ∞ (in steps of 0.01 s)
Undervoltage threshold V< for release I_p	10.0 to 125.0 V (in steps of 0.1 V)
Trip characteristics IEC ANSI	 Normal inverse, very inverse, extremely inverse, long inverse Inverse, short inverse, long inverse moderately inverse, very inverse, extremely inverse, definite inverse
User-defined characteristic	Defined by a maximum of 20 value pairs of current and time delay
Dropout setting Without disk emulation	 Approx. 1.05 · setting value I_p for I_p/I_{nom} ≥ 0.3, corresponds to approx. 0.95 · pickup threshold
With disk emulation	Approx. 0.90 · setting value I_p

1) At I_{nom} = 1 A, all limits divided by 5.

Tolerances Pickup/dropout thresholds I_p, I_{Ep} Pickup time for 2 ≤ I/I_p ≤ 20	 2 % of setting value or 50 mA 1) 5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms
Dropout ratio for 0.05 ≤ I/I_p ≤ 0.9	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms
Direction detection	
For phase faults	
Polarization	With cross-polarized voltages; With voltage memory for measurement voltages that are too low
Forward range Rotation of reference voltage $V_{ref,rot}$	$V_{ref,rot}$ ± 86° - 180° to 180° (in steps of 1°)
Direction sensitivity	For one and two-phase faults unlimited; For three-phase faults dynamically unlimited; Steady-state approx. 7 V phase-to-phase
For earth faults	
Polarization	With zero-sequence quantities $3V_0$, $3I_0$ or with negative-sequence quantities $3V_2$, $3I_2$
Forward range Rotation of reference voltage $V_{ref,rot}$	$V_{ref,rot}$ ± 86° - 180° to 180° (in steps of 1°)
Direction sensitivity Zero-sequence quantities $3V_0$, $3I_0$	 V_E ≈ 2.5 V displacement voltage, measured; $3V_0$ ≈ 5 V displacement voltage, calculated
Negative -sequence quantities $3V_2$, $3I_2$	$3V_2$ ≈ 5 V negative-sequence voltage; $3I_2$ ≈ 225 mA negative-sequence current 1)
Tolerances (phase angle error under reference conditions) For phase and earth faults	 ± 3 ° electrical
Inrush blocking	
Influenced functions	Time-overcurrent elements, I>, I_E>, I_p, I_{Ep} (directional, non-directional)
Lower function limit phases	At least one phase current (50 Hz and 100 Hz) ≥ 125 mA 1)
Lower function limit earth	Earth current (50 Hz and 100 Hz) ≥ 125 mA 1)
Upper function limit (setting range)	1.5 to 125 A 1) (in steps of 0.01 A)
Setting range I_{2f}/I	10 to 45 % (in steps of 1 %)
Crossblock (I_{L1}, I_{L2}, I_{L3})	ON/OFF
Dynamic setting change	
Controllable function	Directional and non-directional pickup, tripping time
Start criteria	Current criteria, CB position via aux. contacts, binary input, auto-reclosure ready
Time control	3 timers
Current criteria	Current threshold (reset on dropping below threshold; monitoring with timer)

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***(Sensitive) earth-fault detection** (ANSI 64, 50 Ns, 51Ns, 67Ns)*	
***Displacement voltage starting** for all types of earth fault (ANSI 64)*	
Setting ranges	
Pickup threshold V_E> (measured)	1.8 to 200 V (in steps of 0.1 V)
Pickup threshold $3V_0$> (calculated)	10 to 225 V (in steps of 0.1 V)
Delay time $T_{Delay\ pickup}$	0.04 to 320 s or ∞ (in steps of 0.01 s)
Additional trip delay T_{VDELAY}	0.1 to 40000 s or ∞ (in steps of 0.01 s)
Times Pickup time	Approx. 50 ms
Dropout ratio	0.95 or (pickup value -0.6 V)
Tolerances	
Pickup threshold V_E (measured)	3 % of setting value or 0.3 V
Pickup threshold $3V_0$ (calculated)	3 % of setting value or 3 V
Delay times	1 % of setting value or 10 ms
Phase detection for earth fault in an unearthed system	
Measuring principle	Voltage measurement (phase-to-earth)
Setting ranges	
$V_{ph\ min}$ (earth-fault phase)	10 to 100 V (in steps of 1 V)
$V_{ph\ max}$ (unfaulted phases)	10 to 100 V (in steps of 1 V)
Measuring tolerance acc. to DIN 57435 part 303	3 % of setting value, or 1 V
***Earth-fault pickup** for all types of earth faults*	
***Definite-time characteristic** (ANSI 50Ns)*	
Setting ranges	
Pickup threshold I_{EE}>, I_{EE}>>	
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A[1)] (in steps of 0.01 A)
Delay times T for I_{EE}>, I_{EE}>>	0 to 320 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Times Pickup times	Approx. 50 ms
Dropout ratio	Approx. 0.95
Tolerances	
Pickup threshold	
For sensitive input	2 % of setting value or 1 mA
For normal input	2 % of setting value or 50 mA[1)]
Delay times	1 % of setting value or 20 ms
***Earth-fault pickup** for all types of earth faults*	
***Inverse-time characteristic** (ANSI 51Ns)*	
User-defined characteristic	Defined by a maximum of 20 pairs of current and delay time values
Setting ranges	
Pickup threshold I_{EEp}	
For sensitive input	0.001 A to 1.4 A (in steps of 0.001 A)
For normal input	0.25 to 20 A[1)] (in steps of 0.01 A)
User defined Time multiplier T	0.1 to 4 s or ∞ (in steps of 0.01 s)
Times Pickup times	Approx. 50 ms
Pickup threshold	Approx. 1.1 · I_{EEp}
Dropout ratio	Approx. 1.05 · I_{EEp}
Tolerances	
Pickup threshold	
For sensitive input	2 % of setting value or 1 mA
For normal input	2 % of setting value or 50 mA[1)]

Note: Due to the high sensitivity the linear range of the measuring input IN with integrated sensitive input transformer is from 0.001 A to 1.6 A. For currents greater than 1.6 A, correct directionality can no longer be guaranteed.

1) For I_{nom} = 1 A, all limits divided by 5.

Delay times in linear range	7 % of reference value for 2 ≥ I/I_{EEp} ≥ 20 + 2 % current tolerance, or 70 ms
Logarithmic inverse	Refer to the manual
Logarithmic inverse with knee point	Refer to the manual
***Direction detection** for all types of earth-faults (ANSI 67Ns)*	
Measuring method "cos φ/sin φ"	
Direction measurement	I_E and V_E measured or $3I_0$ and $3V_0$ calculated
Measuring principle	Active/reactive power measurement
Setting ranges	
Measuring enable $I_{Release\ direct.}$	
For sensitive input	0.001 to 1.2 A (in steps of 0.001 A)
For normal input	0.25 to 150 A[1)] (in steps of 0.01 A)
Direction phasor $\varphi_{Correction}$	- 45 ° to + 45 ° (in steps of 0.1 °)
Reduction of dir. area $\alpha_{Red.dir.area}$	1 ° to 15 ° (in steps of 1 °)
Dropout delay $T_{Reset\ delay}$	1 to 60 s (in steps of 1 s)
Tolerances	
Pickup measuring enable	
For sensitive input	2 % of setting value or 1 mA
For normal input	2 % of setting value or 50 mA[1)]
Angle tolerance	3 °
Measuring method "φ (V_0/I_0)"	
Direction measurement	I_E and V_E measured or $3I_0$ and $3V_0$ calculated
Minimum voltage $V_{min.}$ measured	0.4 to 50 V (in steps of 0.1 V)
Minimum voltage $V_{min.}$ calculated	10 to 90 V (in steps of 1 V)
Phase angle φ	-180° to 180° (in steps of 0.1°)
Delta phase angle $\Delta\varphi$	0° to 180° (in steps of 0.1°)
Tolerances	
Pickup threshold V_E (measured)	3 % of setting value or 0.3 V
Pickup threshold 3 V_0 (calculated)	3 % of setting value or 3 V
Angle tolerance	3 °
Angle correction for cable CT	
Angle correction F1, F2	0° to 5° (in steps of 0.1°)
Current value $I1$, $I2$	
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A[1)] (in steps of 0.01 A)
***High-impedance restricted earth-fault protection** (ANSI 87N) / single-phase overcurrent protection*	
Setting ranges	
Pickup thresholds I>, I>>	
For sensitive input	0.003 to 1.5 A or ∞ (in steps of 0.001 A)
For normal input	0.25 to 175 A[1)] or ∞ (in steps of 0.01 A)
Delay times T_I>, T_I>>	0 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
Minimum	Approx. 20 ms
Typical	Approx. 30 ms
Dropout times	Approx. 30 ms
Dropout ratio	Approx. 0.95 for I/I_{nom} ≥ 0.5
Tolerances	
Pickup thresholds	3 % of setting value or 1 % rated current at I_{nom} = 1 or 5 A; 5 % of setting value or 3 % rated current at I_{nom} = 0.1 A
Delay times	1 % of setting value or 10 ms

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Intermittent earth-fault protection		
Setting ranges		
Pickup threshold		
For I_E	$I_{IE}>$	0.25 to 175 A[1] (in steps of 0.01 A)
For $3I_0$	$I_{IE}>$	0.25 to 175 A[1] (in steps of 0.01 A)
For I_{EE}	$I_{IE}>$	0.005 to 1.5 A (in steps of 0.001 A)
Pickup prolongation time	T_V	0 to 10 s (in steps of 0.01 s)
Earth-fault accumulation time	T_{sum}	0 to 100 s (in steps of 0.01 s)
Reset time for accumulation	T_{res}	1 to 600 s (in steps of 1 s)
Number of pickups for intermittent earth fault		2 to 10 (in steps of 1)
Times		
Pickup times		
Current = 1.25 · pickup value		Approx. 30 ms
Current ≥ 2 · pickup value		Approx. 22 ms
Dropout time		Approx. 22 ms
Tolerances		
Pickup threshold $I_{IE}>$		3 % of setting value, or 50 mA[1]
Times T_V, T_{sum}, T_{res}		1 % of setting value or 10 ms

Thermal overload protection (ANSI 49)	
Setting ranges	
Factor k	0.1 to 4 (in steps of 0.01)
Time constant	1 to 999.9 min (in steps of 0.1 min)
Warning overtemperature $\Theta_{alarm}/\Theta_{trip}$	50 to 100 % with reference to the tripping overtemperature (in steps of 1 %)
Current warning stage I_{alarm}	0.5 to 20 A (in steps of 0.01 A)
Extension factor when stopped k_τ factor	1 to 10 with reference to the time constant with the machine running (in steps of 0.1)
Rated overtemperature (for I_{nom})	40 to 200 °C (in steps of 1 °C)
Tripping characteristic For $(I/k \cdot I_{nom}) \leq 8$	$t = \tau_{th} \cdot \ln \frac{(I/k \cdot I_{nom})^2 - (I_{pre}/k \cdot I_{nom})^2}{(I/k \cdot I_{nom})^2 - 1}$ t = Tripping time τ_{th} = Temperature rise time constant I = Load current I_{pre} = Preload current k = Setting factor acc. to VDE 0435 Part 3011 and IEC 60255-8 I_{nom} = Rated (nominal) current of the protection relay
Dropout ratios	
Θ/Θ_{Trip}	Drops out with Θ_{Alarm}
Θ/Θ_{Alarm}	Approx. 0.99
I/I_{Alarm}	Approx. 0.97
Tolerances	
With reference to $k \cdot I_{nom}$	Class 5 acc. to IEC 60255-8
With reference to tripping time	5 % +/- 2 s acc. to IEC 60255-8

Auto-reclosure (ANSI 79)	
Number of reclosures	0 to 9 Shot 1 to 4 individually adjustable
Program for phase fault Start-up by	Time-overcurrent elements (dir., non-dir.), negative sequence, binary input
Program for earth fault Start-up by	Time-overcurrent elements (dir., non-dir.), sensitive earth-fault protection, binary input
Blocking of ARC	Pickup of protection functions, three-phase fault detected by a protective element, binary input, last TRIP command after the reclosing cycle is complete (unsuccessful reclosing), TRIP command by the breaker failure protection (50BF), opening the CB without ARC initiation, external CLOSE command
Setting ranges	
Dead time (separate for phase and earth and individual for shots 1 to 4)	0.01 to 320 s (in steps of 0.01 s)
Blocking duration for manual-CLOSE detection	0.5 s to 320 s or 0 (in steps of 0.01 s)
Blocking duration after reclosure	0.5 s to 320 s (in steps of 0.01 s)
Blocking duration after dynamic blocking	0.01 to 320 s (in steps of 0.01 s)
Start-signal monitoring time	0.01 to 320 s or ∞ (in steps of 0.01 s)
Circuit-breaker supervision time	0.1 to 320 s (in steps of 0.01 s)
Max. delay of dead-time start	0 to 1800 s or ∞ (in steps of 0.1 s)
Maximum dead time extension	0.5 to 320 s or ∞(in steps of 0.01 s)
Action time	0.01 to 320 s or ∞ (in steps of 0.01 s)

1) At I_{nom} = 1 A, all limits divided by 5.

The delay times of the following protection function can be altered individually by the ARC for shots 1 to 4 (setting value $T = T$, non-delayed $T = 0$, blocking $T = \infty$):
$I>>>$, $I>>$, $I>$, I_p, $I_{dir}>>$, $I_{dir}>$, I_{pdir}
$I_E>>>$, $I_E>>$, $I_E>$, I_{Ep}, $I_{Edir}>>$, $I_{Edir}>$, I_{Edir}

Additional functions	Lockout (final trip), delay of dead-time start via binary input (monitored), dead-time extension via binary input (monitored), co-ordination with other protection relays, circuit-breaker monitoring, evaluation of the CB contacts

Breaker failure protection (ANSI 50 BF)	
Setting ranges	
Pickup thresholds	0.2 to 5 A[1] (in steps of 0.01 A)
Delay time	0.06 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
with internal start	is contained in the delay time
with external start	is contained in the delay time
Dropout times	Approx. 25 ms
Tolerances	
Pickup value	2 % of setting value (50 mA)[1]
Delay time	1 % or 20 ms

Synchro- and voltage check (ANSI 25)	
Operating modes	• Synchro-check • Asynchronous/synchronous
Additional release conditions	• Live-bus / dead line • Dead-bus / live-line • Dead-bus and dead-line • Bypassing

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Voltages	
Max. operating voltage V_{max}	20 to 140 V (phase-to-phase) (in steps of 1 V)
Min. operating voltage V_{min}	20 to 125 V (phase-to-phase) (in steps of 1 V)
V< for dead-line / dead-bus check	1 to 60 V (phase-to-phase) (in steps of 1 V)
V> for live-line / live-bus check	20 to 140 V (phase-to-phase) (in steps of 1 V)
Primary rated voltage of transformer $V2_{nom}$	0.1 to 800 kV (in steps of 0.01 kV)
Tolerances	2 % of pickup value or 2 V
Drop-off to pickup ratios	approx. 0.9 (V>) or 1.1 (V<)
ΔV-measurement	
Voltage difference	0.5 to 50 V (phase-to-phase) (in steps of 1 V)
Tolerance	1 V
Δf-measurement	
Δf-measurement ($f2>f1$; $f2<f1$)	0.01 to 2 Hz (in steps of 0.01 Hz)
Tolerance	15 mHz
$\Delta \alpha$-measurement	
$\Delta \alpha$-measurement ($\alpha 2>\alpha 1$; $\alpha 2>\alpha 1$)	2 ° to 80 ° (in steps of 1 °)
Tolerance	2 °
Max. phase displacement	5 ° for $\Delta f \leq 1$ Hz 10 ° for $\Delta f > 1$ Hz
Circuit-breaker operating time	
CB operating time	0.01 to 0.6 s (in steps of 0.01 s)
Threshold ASYN ⇔ SYN	
Threshold synchronous / asynchronous	0.01 to 0.04 Hz (in steps of 0.01 Hz)
Adaptation	
Vector group adaptation by angle	0 ° to 360 ° (in steps of 1 °)
Different voltage transformers V_1/V_2	0.5 to 2 (in steps of 0.01)
Times	
Minimum measuring time	Approx. 80 ms
Max. duration $T_{SYN\ DURATION}$	0.01 to 1200 s; ∞ (in steps of 0.01 s)
Supervision time $T_{SUP\ VOLTAGE}$	0 to 60 s (in steps of 0.01 s)
Closing time of CB $T_{CB\ close}$	0 to 60 s (in steps of 0.01 s)
Tolerance of all timers	1 % of setting value or 10 ms
Measuring values of synchro-check function	
Reference voltage $V1$	In kV primary, in V secondary or in % V_{nom}
Range	10 to 120 % V_{nom}
Tolerance*)	≤1 % of measured value or 0.5 % of V_{nom}
Voltage to be synchronized $V2$	In kV primary, in V secondary or in % V_{nom}
Range	10 to 120 % V_{nom}
Tolerance*)	≤1 % of measured value or 0.5 % of V_{nom}
Frequency of $V1$ and $V2$	$f1$, $f2$ in Hz
Range	f_N ± 5 Hz
Tolerance*)	20 mHz
Voltage difference ($V2 - V1$)	In kV primary, in V secondary or in % V_{nom}
Range	10 to 120 % V_{nom}
Tolerance*)	≤1 % of measured value or 0.5 % of V_{nom}
Frequency difference ($f2 - f1$)	In mHz
Range	f_N ± 5 Hz
Tolerance*)	20 mHz
Angle difference ($\alpha 2 - \alpha 1$)	In °
Range	0 to 180 °
Tolerance*)	0.5 °

Negative-sequence current detection (ANSI 46)

Definite-time characteristic (ANSI 46-1 and 46-2)

Setting ranges	
Pickup current I_2>, I_2>>	0.5 to 15 A or ∞ (in steps of 0.01 A)
Delay times	0 to 60 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Functional limit	All phase currents ≤ 50 A[1)]
Times	
Pickup times	Approx. 35 ms
Dropout times	Approx. 35 ms
Dropout ratio	Approx. 0.95 for $I_2 / I_{nom} > 0.3$
Tolerances	
Pickup thresholds	3 % of the setting value or 50 mA[1)]
Delay times	1 % or 10 ms

Inverse-time characteristic (ANSI 46-TOC)

Setting ranges	
Pickup current	0.5 to 10 A[1)] (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.5 to 15 s or ∞ (in steps of 0.01 s)
Functional limit	All phase currents ≤ 50 A[1)]
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse
ANSI	Inverse, moderately inverse, very inverse, extremely inverse
Pickup threshold	Approx. 1.1 · I_{2p} setting value
Dropout	
IEC and ANSI (without disk emulation)	Approx. 1.05 · I_{2p} setting value, which is approx. 0.95 · pickup threshold
ANSI with disk emulation	Approx. 0.90 · I_{2p} setting value
Tolerances	
Pickup threshold	3 % of the setting value or 50 mA[1)]
Time for 2 ≤ M ≤ 20	5 % of setpoint (calculated) +2 % current tolerance, at least 30 ms

Flexible protection functions (ANSI 27, 32, 47, 50, 55, 59, 81R)

Operating modes / measuring quantities	
3-phase	I, I_1, I_2, I_2/I_1, $3I_0$, V, V_1, V_2, $3V_0$, dV/dt, P, Q, cos φ
1-phase	I, I_E, $I_{E\ sens.}$, V, V_E, P, Q, cos φ
Without fixed phase relation	f, df/dt, binary input
Pickup when	Exceeding or falling below threshold value
Setting ranges	
Current I, I_1, I_2, $3I_0$, I_E	0.15 to 200 A[1)] (in steps of 0.01 A)
Current ratio I_2/I_1	15 to 100 % (in steps of 1 %)
Sens. earth curr. $I_{E\ sens.}$	0.001 to 1.5 A (in steps of 0.001 A)
Voltages V, V_1, V_2, $3V_0$	2 to 260 V (in steps of 0.1 V)
Displacement voltage V_E	2 to 200 V (in steps of 0.1 V)
Power P, Q	0.5 to 10000 W (in steps of 0.1 W)
Power factor (cos φ)	- 0.99 to + 0.99 (in steps of 0.01)
Frequency f_N = 50 Hz	40 to 60 Hz (in steps of 0.01 Hz)
f_N = 60 Hz	50 to 70 Hz (in steps of 0.01 Hz)
Rate-of-frequency change df/dt	0.1 to 20 Hz/s (in steps of 0.01 Hz/s)
Voltage change dV/dt	4 V/s to 100 V/s (in steps of 1 V/s)
Dropout ratio >- stage	1.01 to 3 (in steps of 0.01)
Dropout ratio <- stage	0.7 to 0.99 (in steps of 0.01)
Dropout differential f	0.02 to 1.00 Hz (in steps of 0.01 Hz)
Pickup delay time	0 to 60 s (in steps of 0.01 s)
Trip delay time	0 to 3600 s (in steps of 0.01 s)
Dropout delay time	0 to 60 s (in steps of 0.01 s)

*) With rated frequency.

1) At I_{nom} = 1 A, all limits divided by 5.

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Flexible protection functions *(ANSI 27, 32, 47, 50, 55, 59, 81R) (cont'd)*	
Times	
Pickup times	
Current, voltage (phase quantities)	
With 2 times the setting value	Approx. 30 ms
With 10 times the setting value	Approx. 20 ms
Current, voltages (symmetrical components)	
With 2 times the setting value	Approx. 40 ms
With 10 times the setting value	Approx. 30 ms
Power	
Typical	Approx. 120 ms
Maximum (low signals and thresholds)	Approx. 350 ms
Power factor	300 to 600 ms
Frequency	Approx. 100 ms
Rate-of-frequency change with 1.25 times the setting value	Approx. 220 ms
Voltage change dV/dt for 2 times pickup value	Approx. 220 ms
Binary input	Approx. 20 ms
Dropout times	
Current, voltage (phase quantities)	< 20 ms
Current, voltages (symmetrical components)	< 30 ms
Power	
Typical	< 50 ms
Maximum	< 350 ms
Power factor	< 300 ms
Frequency	< 100 ms
Rate-of-frequency change	< 200 ms
Voltage change	< 220 ms
Binary input	< 10 ms
Tolerances	
Pickup threshold	
Current	0.5 % of setting value or 50 mA[1)]
Current (symmetrical components)	1 % of setting value or 100 mA[1)]
Voltage	0.5 % of setting value or 0.1 V
Voltage (symmetrical components)	1 % of setting value or 0.2 V
Power	1 % of setting value or 0.3 W
Power factor	2 degrees
Frequency	5 mHz (at $V = V_N$, $f = f_N$) 10 mHz (at $V = V_N$)
Rate-of-frequency change	5 % of setting value or 0.05 Hz/s
Voltage change dV/dt	5 % of setting value or 2 V/s
Times	1 % of setting value or 10 ms

Starting time monitoring for motors *(ANSI 48)*	
Setting ranges	
Motor starting current $I_{STARTUP}$	2.5 to 80 A[1)] (in steps of 0.01)
Pickup threshold $I_{MOTOR\ START}$	2 to 50 A[1)] (in steps of 0.01)
Permissible starting time $T_{STARTUP,\ COLD\ MOTOR}$	1 to 180 s (in steps of 0.1 s)
Permissible starting time $T_{STARTUP,\ WARM\ MOTOR}$	0.5 to 180 s (in steps of 0.1 s)
Temperature threshold cold motor	0 to 80 % (in steps of 1 %)
Permissible blocked rotor time $T_{BLOCKED\text{-}ROTOR}$	0.5 to 120 s or ∞ (in steps of 0.1 s)

1) At I_{nom} = 1 A, all limits divided by 5.

Tripping time characteristic for $I > I_{MOTOR\ START}$	$t = \left(\frac{I_{STARTUP}}{I}\right)^2 \cdot T_{STARTUP}$ $I_{STARTUP}$ = Rated motor starting current I = Actual current flowing $T_{STARTUP}$ = Tripping time for rated motor starting current t = Tripping time in seconds
Dropout ratio $I_{MOTOR\ START}$	Approx. 0.95
Tolerances	
Pickup threshold	2 % of setting value or 50 mA[1)]
Delay time	5 % or 30 ms

Load jam protection for motors *(ANSI 51M)*	
Setting ranges	
Current threshold for alarm and trip	0.25 to 60 A[1)] (in steps of 0.01 A)
Delay times	0 to 600 s (in steps of 0.01 s)
Blocking duration after CLOSE signal detection	0 to 600 s (in steps of 0.01 s)
Tolerances	
Pickup threshold	2 % of setting value or 50 mA[1)]
Delay time	1 % of setting value or 10 ms

Restart inhibit for motors *(ANSI 66)*	
Setting ranges	
Motor starting current relative to rated motor current $I_{MOTOR\ START}/I_{Motor\ Nom}$	1.1 to 10 (in steps of 0.1)
Rated motor current $I_{Motor\ Nom}$	1 to 6 A[1)] (in steps of 0.01 A)
Max. permissible starting time $T_{Start\ Max}$	1 to 320 s (in steps of 1 s)
Equilibrium time T_{Equal}	0 to 320 min (in steps of 0.1 min)
Minimum inhibit time $T_{MIN.\ INHIBIT\ TIME}$	0.2 to 120 min (in steps of 0.1 min)
Max. permissible number of warm starts	1 to 4 (in steps of 1)
Difference between cold and warm starts	1 to 2 (in steps of 1)
Extension k-factor for cooling simulations of rotor at zero speed $k_{\tau\ at\ STOP}$	0.2 to 100 (in steps of 0.1)
Extension factor for cooling time constant with motor running $k_{\tau\ RUNNING}$	0.2 to 100 (in steps of 0.1)
Restarting limit	$\Theta_{restart} = \Theta_{rot\ max\ perm} \cdot \frac{n_c - 1}{n_c}$ $\Theta_{restart}$ = Temperature limit below which restarting is possible $\Theta_{rot\ max\ perm}$ = Maximum permissible rotor overtemperature (= 100 % in operational measured value $\Theta_{rot}/\Theta_{rot\ trip}$) n_c = Number of permissible start-ups from cold state

Undercurrent monitoring *(ANSI 37)*	
Signal from the operational measured values	Predefined with programmable logic

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Technical data

Temperature monitoring box *(ANSI 38)*	
Temperature detectors	
Connectable boxes	1 or 2
Number of temperature detectors per box	Max. 6
Type of measuring	Pt 100 Ω or Ni 100 Ω or Ni 120 Ω
Mounting identification	"Oil" or "Environment" or "Stator" or "Bearing" or "Other"
Thresholds for indications	
For each measuring detector	
Stage 1	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)
Stage 2	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)

Undervoltage protection *(ANSI 27)*	
Operating modes/measuring quantities	
3-phase	Positive phase-sequence voltage or phase-to-phase voltages or phase-to-earth voltages
1-phase	Single-phase phase-earth or phase-phase voltage
Setting ranges	
Pickup thresholds $V<$, $V<<$ dependent on voltage connection and chosen measuring quantity	10 to 120 V (in steps of 1 V) 10 to 210 V (in steps of 1 V)
Dropout ratio r	1.01 to 3 (in steps of 0.01)
Delay times T	0 to 100 s or ∞ (in steps of 0.01 s)
Current Criteria "Bkr Closed I_{MIN}"	0.2 to 5 A[1)] (in steps of 0.01 A)
Times	
Pickup times	Approx. 50 ms
Dropout times	As pickup times
Tolerances	
Pickup thresholds	0.5 % of setting value or 1 V
Times	1 % of setting value or 10 ms

Overvoltage protection *(ANSI 59)*	
Operating modes/measuring quantities	
3-phase	Positive phase-sequence voltage or negative phase-sequence voltage or phase-to-phase voltages or phase-to-earth voltages
1-phase	Single-phase phase-earth or phase-phase voltage
Setting ranges	
Pickup thresholds $V>$, $V>>$ dependent on voltage connection and chosen measuring quantity	40 to 260 V (in steps of 1 V) 40 to 150 V (in steps of 1 V) 2 to 150 V (in steps of 1 V)
Dropout ratio r	0.9 to 0.99 (in steps of 0.01)
Delay times T	0 to 100 s or ∞ (in steps of 0.01 s)
Times	
Pickup times V	Approx. 50 ms
Pickup times V_1, V_2	Approx. 60 ms
Dropout times	As pickup times
Tolerances	
Pickup thresholds	0.5 % of setting value or 1 V
Times	1 % of setting value or 10 ms

1) At I_{nom} = 1 A, all limits divided by 5.

2) At I_{nom} = 1 A, all limits multiplied with 5.

3) At rated frequency.

Frequency protection *(ANSI 81)*	
Number of frequency elements	4
Setting ranges	
Pickup thresholds for f_{nom} = 50 Hz	40 to 60 Hz (in steps of 0.01 Hz)
Pickup thresholds for f_{nom} = 60 Hz	50 to 70 Hz (in steps of 0.01 Hz)
Dropout differential = |pickup threshold - dropout threshold|	0.02 Hz to 1.00 Hz (in steps of 0.01 Hz)
Delay times	0 to 100 s or ∞ (in steps of 0.01 s)
Undervoltage blocking, with positive-sequence voltage V_1	10 to 150 V (in steps of 1 V)
Times	
Pickup times	Approx. 80 ms
Dropout times	Approx. 75 ms
Dropout	
Ratio undervoltage blocking	Approx. 1.05
Tolerances	
Pickup thresholds	
Frequency	5 mHz (at $V = V_N$, $f = f_N$) 10 mHz (at $V = V_N$)
Undervoltage blocking	3 % of setting value or 1 V
Delay times	3 % of the setting value or 10 ms

Fault locator *(ANSI 21FL)*	
Output of the fault distance	In Ω primary or secondary, in km / miles of line length, in % of line length
Starting signal	Trip command, dropout of a protection element, via binary input
Setting ranges	
Reactance (secondary)	0.001 to 1.9 Ω/km[2)] (in steps of 0.0001) 0.001 to 3 Ω/mile[2)] (in steps of 0.0001)
Tolerances	
Measurement tolerance acc. to VDE 0435, Part 303 for sinusoidal measurement quantities	2.5 % fault location, or 0.025 Ω (without intermediate infeed) for $30° \leq \varphi K \leq 90°$ and $V_K/V_{nom} \geq 0.1$ and $I_K/I_{nom} \geq 1$

Additional functions

Operational measured values	
Currents I_{L1}, I_{L2}, I_{L3} Positive-sequence component I_1 Negative-sequence component I_2 I_E or $3I_0$	In A (kA) primary, in A secondary or in % I_{nom}
Range	10 to 200 % I_{nom}
Tolerance[3)]	1 % of measured value or 0.5 % I_{nom}
Phase-to-earth voltages V_{L1-E}, V_{L2-E}, V_{L3-E} Phase-to-phase voltages V_{L1-L2}, V_{L2-L3}, V_{L3-L1}, V_{SYN}, V_E or V_0 Positive-sequence component V_1 Negative-sequence component V_2	In kV primary, in V secondary or in % V_{nom}
Range	10 to 120 % V_{nom}
Tolerance[3)]	1 % of measured value or 0.5 % of V_{nom}
S, apparent power	In kVAr (MVAr or GVAr) primary and in % of S_{nom}
Range	0 to 120 % S_{nom}
Tolerance[3)]	1 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 %

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Technical data

Operational measured values *(cont'd)*	
P, active power	With sign, total and phase-segregated in kW (MW or GW) primary and in % S_{nom}
Range Tolerance[1]	0 to 120 % S_{nom} 1 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 % and $\lvert \cos \varphi \rvert$ = 0.707 to 1 with $S_{nom} = \sqrt{3} \cdot V_{nom} \cdot I_{nom}$
Q, reactive power	With sign, total and phase-segregated in kVAr (MVAr or GVAr)primary and in % S_{nom}
Range Tolerance[1]	0 to 120 % S_{nom} 1 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 % and $\lvert \sin \varphi \rvert$ = 0.707 to 1 with $S_{nom} = \sqrt{3} \cdot V_{nom} \cdot I_{nom}$
$\cos \varphi$, power factor (p.f.)	Total and phase segregated
Range Tolerance[1]	- 1 to + 1 2 % for $\lvert \cos \varphi \rvert \geq 0.707$
Frequency f	In Hz
Range Tolerance[1]	$f_{nom} \pm 5$ Hz 20 mHz
Temperature overload protection Θ/Θ_{Trip}	In %
Range Tolerance[1]	0 to 400 % 5 % class accuracy per IEC 60255-8
Temperature restart inhibit $\Theta_L/\Theta_{L\,Trip}$	In %
Range Tolerance[1]	0 to 400 % 5 % class accuracy per IEC 60255-8
Restart threshold $\Theta_{Restart}/\Theta_{L\,Trip}$	In %
Reclose time $T_{Reclose}$	In min
Currents of sensitive ground fault detection (total, real, and reactive current) I_{EE}, $I_{EE\,real}$, IEE reactive	In A (kA) primary and in mA secondary
Range Tolerance[1]	0 mA to 1600 mA 2 % of measured value or 1 mA
RTD-box	See section "Temperature monitoring box"
Synchronism and voltage check	See section "Synchronism and voltage check"

Long-term averages	
Time window	5, 15, 30 or 60 minutes
Frequency of updates	Adjustable
Long-term averages of currents of real power of reactive power of apparent power	 I_{L1dmd}, I_{L2dmd}, I_{L3dmd}, I_{1dmd} in A (kA) P_{dmd} in W (kW, MW) Q_{dmd} in VAr (kVAr, MVAr) S_{dmd} in VAr (kVAr, MVAr)

1) At rated frequency.

Max. / Min. report	
Report of measured values	With date and time
Reset, automatic	Time of day adjustable (in minutes, 0 to 1439 min) Time frame and starting time adjustable (in days, 1 to 365 days, and ∞)
Reset, manual	Using binary input, using keypad, via communication
Min./Max. values for current	I_{L1}, I_{L2}, I_{L3}, I_1 (positive-sequence component)
Min./Max. values for voltages	$V_{L1\text{-}E}$, $V_{L2\text{-}E}$, $V_{L3\text{-}E}$ V_1 (positive-sequence component) $V_{L1\text{-}L2}$, $V_{L2\text{-}L3}$, $V_{L3\text{-}L1}$
Min./Max. values for power	S, P, Q, $\cos \varphi$, frequency
Min./Max. values for overload protection	Θ/Θ_{Trip}
Min./Max. values for mean values	I_{L1dmd}, I_{L2dmd}, I_{L3dmd} I_1 (positive-sequence component); S_{dmd}, P_{dmd}, Q_{dmd}

Local measured values monitoring	
Current asymmetry	I_{max}/I_{min} > balance factor, for $I>I_{balance\,limit}$
Voltage asymmetry	V_{max}/V_{min} > balance factor, for $V>V_{lim}$
Current phase sequence	Clockwise (ABC) / counter-clockwise (ACB)
Voltage phase sequence	Clockwise (ABC) / counter-clockwise (ACB)
Limit value monitoring	Predefined limit values, user-defined expansions via CFC

Fuse failure monitor	
For all types of networks	With the option of blocking affected protection functions

Fault recording	
Recording of indications of the last 8 power system faults	
Recording of indications of the last 3 power system ground faults	

Time stamping	
Resolution for event log (operational annunciations)	1 ms
Resolution for trip log (fault annunciations)	1 ms
Maximum time deviation (internal clock)	0.01 %
Battery	Lithium battery 3 V/1 Ah, type CR 1/2 AA, message "Battery Fault" for insufficient battery charge

Oscillographic fault recording	
Maximum 8 fault records saved, memory maintained by buffer battery in case of loss of power supply	
Recording time	Total 20 s Pre-trigger and post-fault recording and memory time adjustable
Sampling rate for 50 Hz Sampling rate for 60 Hz	1 sample/1.25 ms (16 samples/cycle) 1 sample/1.04 ms (16 samples/cycle)

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Energy/power

Meter values for power Wp, Wq (real and reactive power demand)	in kWh (MWh or GWh) and kVARh (MVARh or GVARh)
Tolerance[1)]	≤ 2 % for $I > 0.1\ I_{nom}$, $V > 0.1\ V_{nom}$ and $\lvert \cos \varphi \rvert$ (p.f.) ≥ 0.707

Statistics

Saved number of trips	Up to 9 digits
Number of automatic reclosing commands (segregated according to 1st and ≥ 2nd cycle)	Up to 9 digits

Circuit-breaker wear

Methods	• ΣI^x with x = 1 .. 3 • 2-point method (remaining service life) • $\Sigma i^2 t$
Operation	Phase-selective accumulation of measured values on TRIP command, up to 8 digits, phase-selective limit values, monitoring indication

Motor statistics

Total number of motor start-ups	0 to 9999	(resolution 1)
Total operating time	0 to 99999 h	(resolution 1 h)
Total down-time	0 to 99999 h	(resolution 1 h)
Ratio operating time/down-time	0 to 100 %	(resolution 0.1 %)
Active energy and reactive energy	See operational measured values	
Motor start-up data:	Of the last 5 start-ups	
– Start-up time	0.30 s to 9999.99 s	(resolution 10 ms)
– Start-up current (primary)	0 A to 1000 kA	(resolution 1 A)
– Start-up voltage (primary)	0 V to 100 kV	(resolution 1 V)

Operating hours counter

Display range	Up to 7 digits
Criterion	Overshoot of an adjustable current threshold (BkrClosed I_{MIN})

Trip circuit monitoring

With one or two binary inputs

Commissioning aids

Phase rotation field check, operational measured values, circuit-breaker / switching device test, creation of a test measurement report

Clock

Time synchronization	DCF77/IRIG-B signal (telegram format IRIG-B000), binary input, communication

Setting group switchover of the function parameters

Number of available setting groups	4 (parameter group A, B, C and D)
Switchover performed	Via keypad, DIGSI, system (SCADA) interface or binary input

1) At rated frequency.

Control

Number of switching units	Depends on the binary inputs and outputs
Interlocking	Programmable
Circuit-breaker signals	Feedback, close, open, intermediate position
Control commands	Single command / double command 1, 1 plus 1 common or 2 trip contacts
Programmable controller	CFC logic, graphic input tool
Local control	
Units with small display	Control via menu, assignment of a function key
Units with large display	Control via menu, control with control keys
Remote control	Via communication interfaces, using a substation automation and control system (e.g. SICAM), DIGSI 4 (e.g. via modem)

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 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 conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

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

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Selection and ordering data

Description	Order No.
7SJ64 multifunction protection relay with synchronization	*7SJ64□□ – □□□□□ – □□□□*

Housing, binary inputs and outputs

Housing 1/3 19", 7 BI, 5 BO, 1 live status contact, text display 4 x 20 character (only for 7SJ640) 9th position only with: *B, D, E*	*0*
Housing 1/2 19", 15 BI, 13 BO (1 NO/NC or 1a/b contact), 1 live status contact, graphic display	*1*
Housing 1/2 19", 20 BI, 8 BO, 4 (2) power relays, 1 live status contact, graphic display	*2*
Housing 1/1 19", 33 BI, 11 BO, 8 (4) power relays, 1 live status contact, graphic display	*5*
Housing 1/1 19", 48 BI, 21 BO, 8 (4) power relays, 1 live status contact, graphic display	*7*

see next page

Measuring inputs (4 x V, 4 x I)

I_{ph} = 1 A 1), I_e = 1 A 1) (min. = 0.05 A) Position 15 only with *A, C, E, G*	*1*
I_{ph} = 1 A 1), I_e = sensitive (min. = 0.001 A) Position 15 only with *B, D, F, H*	*2*
I_{ph} = 5 A 1), I_e = 5 A 1) (min. = 0.25 A) Position 15 only with *A, C, E, G*	*5*
I_{ph} = 5 A 1), I_e = sensitive (min. = 0.001 A) Position 15 only with *B, D, F, H*	*6*
I_{ph} = 5 A 1), I_e = 1 A 1) (min. = 0.05 A) Position 15 only with *A, C, E, G*	*7*

Rated auxiliary voltage (power supply, binary inputs)

24 to 48 V DC, threshold binary input 19 V DC 3)	*2*
60 to 125 V DC 2), threshold binary input 19 V DC 3)	*4*
110 to 250 V DC 2), 115 to 230 V AC, threshold binary input 88 V DC 3)	*5*

Unit version

Surface-mounting housing, plug-in terminals, detached operator panel, panel mounting in low-voltage housing	*A*
Surface-mounting housing, 2-tier terminals on top/bottom	*B*
Surface-mounting housing, screw-type terminals (direct connection/ ring-type cable lugs), detached operator panel, panel mounting in low-voltage housing	*C*
Flush-mounting housing, plug-in terminals (2/3 pin connector)	*D*
Flush-mounting housing, screw-type terminals (direct connection/ring-type cable lugs)	*E*
Surface-mounting housing, screw-type terminals (direct connection/ring-type cable lugs), without operator panel, panel mounting in low-voltage housing	*F*
Surface-mounting housing, plug-in terminals, without operator panel, panel mounting in low-voltage housing	*G*

Region-specific default settings/function versions and language settings

Region DE, 50 Hz, IEC, language: German (language selectable)	*A*
Region World, 50/60 Hz, IEC/ANSI, language: English (GB) (language selectable)	*B*
Region US, 60 Hz, ANSI, language: English (US) (language selectable)	*C*
Region FR, 50/60 Hz, IEC/ANSI, language: French (language selectable)	*D*
Region World, 50/60 Hz, IEC/ANSI, language: Spanish (language selectable)	*E*
Region IT, 50/60 Hz, IEC/ANSI, language: Italian (language selectable)	*F*
Region RU, 50/60 Hz, IEC/ANSI, language: Russian(language can be changed)	*G*

1) Rated current can be selected by means of jumpers

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

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

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Selection and ordering data

Description	Order No.	Order code
7SJ64 multifunction protection relay with synchronization	*7SJ64□□ – □□□□□ – □□□□*	*□□□*
System interface (on rear of unit, Port B)		
No system interface	*0*	
IEC 60870-5-103 protocol, RS232	*1*	
IEC 60870-5-103 protocol, RS485	*2*	
IEC 60870-5-103 protocol, 820 nm fiber, ST connector	*3*	
PROFIBUS-FMS Slave, RS485	*4*	
PROFIBUS-FMS Slave, 820 nm wavelength, single ring, ST connector [1)]	*5*	
PROFIBUS-FMS Slave, 820 nm wavelength, double ring, ST connector [1)]	*6*	
PROFIBUS-DP Slave, RS485	*9*	*L 0 A*
PROFIBUS-DP Slave, 820 nm wavelength, double ring, ST connector [1)]	*9*	*L 0 B*
MODBUS, RS485	*9*	*L 0 D*
MODBUS, 820 nm wavelength, ST connector [2)]	*9*	*L 0 E*
DNP 3.0, RS485	*9*	*L 0 G*
DNP 3.0, 820 nm wavelength, ST connector [2)]	*9*	*L 0 H*
IEC 60870-5-103 protocol, redundant, RS485, RJ45 connector [2)]	*9*	*L 0 P*
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector (EN 100)	*9*	*L 0 R*
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector (EN 100) [2)]	*9*	*L 0 S*
Only Port C (service interface)		
DIGSI 4/modem, electrical RS232	*1*	
DIGSI 4/modem/RTD-box[3)], electrical RS485	*2*	
Port C and D (service and additional interface)	*9*	*M □□*
Port C (service interface)		
DIGSI 4/modem, electrical RS232		*1*
DIGSI 4/modem/RTD-box[3)], electrical RS485		*2*
Port D (additional interface)		
RTD-box[3)], 820 nm fiber, ST connector [4)]		*A*
RTD-box[3)], electrical RS485		*F*
Measuring/fault recording		
Fault recording	*1*	
Slave pointer, mean values, min/max values, fault recording	*3*	

(Further order number positions: see following pages)

1) Not with position 9 = "*B*"; if 9 = "*B*", please order 7SJ6 unit with RS485 port and separate fiber-optic converters.
For single ring, please order converter 6GK1502-2CB10, not available with position 9 = "*B*".
For double ring, please order converter 6GK1502-3CB10, not available with position 9 = "*B*".
The converter requires a 24 V AC power supply (e.g. power supply 7XV5810-0BA00).

2) Not available with position 9 = "*B*".

3) Temperature monitoring box 7XV5662-□AD10, refer to "Accessories".

4) When using the RTD-box at an optical interface, the additional RS485 fiber-optic converter 7XV5650-0□A00 is required.

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Selection and ordering data

Description	Order No.
7SJ64 multifunction protection relay with synchronization	*7SJ64□□ – □□□□□ – □□□□*

Designation				ANSI No.	Description	Order No.
Basic version				 50/51 50N/51N 50N/51N 50/50N 51 V 49 46 37 47 59N/64 50BF 74TC 86	Control Time-overcurrent protection $I>$, $I>>$, $I>>>$, I_p Earth-fault protection $I_E>$, $I_E>>$, $I_E>>>$, I_{Ep} Insensitive earth-fault protection through IEE function: $I_{EE}>$, $I_{EE}>>$, I_{EEp}[1] Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I_2>$, $I>>>>$, $I_E>>>>$ Voltage-dependent inverse-time overcurrent protection Overload protection (with 2 time constants) Phase balance current protection (negative-sequence protection) Undercurrent monitoring Phase sequence Displacement voltage Breaker failure protection Trip circuit supervision; 4 setting groups, cold-load pickup; inrush blocking Lockout	*F A*
■			*V*, *P*, *f*	27/59 81 O/U 27/47/59(N) 32/55/81R	Under-/overvoltage Under-/overfrequency Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	*F E*
■		IEF	*V*, *P*, *f*	27/59 81 O/U 27/47/59(N) 32/55/81R	Under-/overvoltage Under-/overfrequency Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection Intermittent earth fault	*P E*
■	Dir			67/67N	Direction determination for overcurrent, phases and earth	*F C*
■	Dir		*V*, *P*, *f*	67/67N 27/59 81O/U 27/47/59(N) 32/55/81R	Direction determination for overcurrent, phases and earth Under-/overvoltage Under-/overfrequency Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	*F G*
■	Dir	IEF		67/67N	Direction determination for overcurrent, phases and earth; intermittent earth fault	*P C*
Directional earth-fault detection ■	Dir			67/67N 67Ns 87N	Direction determination for overcurrent, phases and earth Directional sensitive earth-fault detection High-impedance restricted earth fault	*F D* [2]
Directional earth-fault detection ■			*V*, *P*, *f*	67Ns 87N 27/59 81O/U 27/47/59(N) 32/55/81R	Directional sensitive earth-fault detection High-impedance restricted earth fault Under-/overvoltage Under-/overfrequency Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	*F F* [2]
Directional earth-fault detection ■	Dir	IEF		67/67N 67Ns 87N	Direction determination for overcurrent, phases and earth Directional sensitive earth-fault detection High-impedance restricted earth fault Intermittent earth fault	*P D* [2]

■ Basic version included

V, *P*, *f* = Voltage, power, frequency protection
Dir = Directional overcurrent protection
IEF = Intermittent earth fault

1) Only with insensitive earth-current transformer when position 7 = *1, 5, 7*.

2) For isolated/compensated networks only with sensitive earth-current transformer when position 7 = *2, 6*.

Continued on next page

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Selection and ordering data

Description	Order No.
7SJ64 multifunction protection relay with synchronization	*7SJ64□□ – □□□□□ – □□□□*

Designation	ANSI No.	Description	Order code
Basic version		Control	
	50/51	Time-overcurrent protection $I>$, $I>>$, $I>>>$, I_p	
	50N/51N	Earth-fault protection $I_E>$, $I_E>>$, $I_E>>>$, I_{Ep}	
	50N/51N	Insensitive earth-fault protection via IEE function: $I_{EE}>$, $I_{EE}>>$, I_{EEp} 1)	
	50/50N	Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I_2>$, $I>>>>$, $I_E>>>>$	
	51 V	Voltage-dependent inverse-time overcurrent protection	
	49	Overload protection (with 2 time constants)	
	46	Phase balance current protection (negative-sequence protection)	
	37	Undercurrent monitoring	
	47	Phase sequence	
	59N/64	Displacement voltage	
	50BF	Breaker failure protection	
	74TC	Trip circuit supervision, 4 setting groups, cold-load pickup, inrush blocking	
	86	Lockout	
Directional earth-fault detection ■	67Ns 87N	Directional sensitive earth-fault detection, High-impedance restricted earth fault	*F B* 2)
Directional earth-fault detection ■ — Motor — *V, P, f*	67Ns 87N 48/14 66/86 51M 27/59 81O/U 27/47/59(N) 32/55/81R	Directional sensitive earth-fault detection, High-impedance restricted earth fault Starting time supervision, locked rotor Restart inhibit Load jam protection, motor statistics Under-/overvoltage Under-/overfrequency Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	*H F* 2)
Directional earth-fault detection — Motor — Dir — *V, P, f*	67/67N 67Ns 87N 48/14 66/86 51M 27/59 81O/U 27/47/59(N) 32/55/81R	Direction determination for overcurrent, phases and earth Directional sensitive earth-fault detection High-impedance restricted earth fault Starting time supervision, locked rotor Restart inhibit Load jam protection, motor statistics Under-/overvoltage Under-/overfrequency Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	*H H* 2)
Directional earth-fault detection ■ — Motor — Dir — IEF — *V, P, f*	67/67N 67Ns 87N 48/14 66/86 51M 27/59 81O/U 27/47/59(N) 32/55/81R	Direction determination for overcurrent, phases and earth Directional sensitive earth-fault detection High-impedance restricted earth fault Intermittent earth fault Starting time supervision, locked rotor Restart inhibit Load jam protection, motor statistics Undervoltage/overvoltage Underfrequency/overfrequency Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	*R H* 2)

■ Basic version included

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

1) Only with insensitive earth-current transformer when position 7 = *1, 5, 7*.

2) For isolated/compensated networks only with sensitive earth-current transformer when position 7 = *2, 6*.

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Selection and ordering data

Description	Order No.	Order code
7SJ64 multifunction protection relay with synchronization	*7SJ64□□ – □□□□□ – □□□□ – □□□□*	

Designation			ANSI No.	Description	Order No.	Order code
Basic version				Control		
			50/51	Time-overcurrent protection $I>, I>>, I>>>, I_p$		
			50N/51N	Earth-fault protection $I_E>, I_E>>, I_E>>>, I_{Ep}$		
			50N/51N	Insensitive earth-fault protection via IEE function: $I_{EE}>, I_{EE}>>, I_{EEp}$ [1)]		
			50/50N	Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I_2>, I>>>>, I_E>>>>$		
			51 V	Voltage-dependent inverse-time overcurrent protection		
			49	Overload protection (with 2 time constants)		
			46	Phase balance current protection (negative-sequence protection)		
			37	Undercurrent monitoring		
			47	Phase sequence		
			59N/64	Displacement voltage		
			50BF	Breaker failure protection		
			74TC	Trip circuit supervision		
				4 setting groups, cold-load pickup		
				Inrush blocking		
			86	Lockout		
■	Motor Dir	V, P, f	67/67N	Direction determination for overcurrent, phases and earth		
			48/14	Starting time supervision, locked rotor		
			66/86	Restart inhibit		
			51M	Load jam protection, motor statistics		
			27/59	Under-/overvoltage		
			81O/U	Under-/overfrequency		
			27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	*H G*	
■	Motor		48/14	Starting time supervision, locked rotor		
			66/86	Restart inhibit		
			51M	Load jam protection, motor statistics	*H A*	
ARC, fault locator, synchronization						
			Without		*0*	
			79	With auto-reclosure	*1*	
			21FL	With fault locator	*2*	
			79, 21FL	With auto-reclosure, with fault locator	*3*	
			25	With synchronization	*4*	
			25, 79, 21FL	With synchronization, auto-reclosure, fault locator	*7*	
ATEX100 Certification For protection of explosion-protected motos (increased-safety type of protection "e"						*Z X 9 9* [2)]

1) Only with insensitive earth-current transformer when position 7 = *1, 5, 7*.

2) This variant might be supplied with a previous firmware version.

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Accessories

Description		Order No.
DIGSI 4		
Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition		
Basis	Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional	DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	*7XS5402-0AA00*
Professional + IEC 61850	Complete version: DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	*7XS5403-0AA00*
IEC 61850 System configurator		
Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional		
License for 10 PCs. Authorization by serial number. On CD-ROM		*7XS5460-0AA00*
SIGRA 4		
Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000 or XP Professional Edition. (generally contained in DIGSI Professional, but can be ordered additionally) Authorization by serial number. On CD-ROM.		*7XS5410-0AA00*
Temperature monitoring box		
24 to 60 V AC/DC		*7XV5662-2AD10*
90 to 240 V AC/DC		*7XV5662-5AD10*
Varistor/Voltage Arrester		
Voltage arrester for high-impedance REF protection		
125 Vrms; 600 A; 1S/S 256		*C53207-A401-D76-1*
240 Vrms; 600 A; 1S/S 1088		*C53207-A401-D77-1*
Connecting cable		
Cable between PC/notebook (9-pin con.) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)		*7XV5100-4*
Cable between temperature monitoring box and SIPROTEC 4 unit		
- length 5 m /16.4 ft		*7XV5103-7AA05*
- length 25 m /82 ft		*7XV5103-7AA25*
- length 50 m /164 ft		*7XV5103-7AA50*
Manual for 7SJ64		
English		*C53000-G1140-C20 7-x* 1)

1) x = please inquire for latest edition (exact Order No.).

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Accessories

Mounting rail

2-pin connector

3-pin connector

Short-circuit links for current terminals

Short-circuit links for other terminals

Description	Order No.	Size of package	Supplier
Terminal safety cover			
Voltage/current terminal 18-pole/12-pole	C73334-A1-C31-1	1	Siemens
Voltage/current terminal 12-pole/8-pole	C73334-A1-C32-1	1	Siemens
Connector 2-pin		1	Siemens
Connector 3-pin	C73334-A1-C36-1	1	Siemens
Crimp connector CI2 0.5 to 1 mm^2	0-827039-1	4000 taped on reel	AMP 1)
Crimp connector CI2 0.5 to 1 mm^2	0-827396-1	1	AMP 1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	0-163084-2	1	AMP 1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	0-163083-7	4000 taped on reel	AMP 1)
Crimping tool for Type III+	0-539635-1	1	AMP 1)
and matching female	0-539668-2	1	AMP 1)
Crimping tool for CI2	0-734372-1	1	AMP 1)
and matching female	1-734387-1	1	AMP 1)
Short-circuit links			
for current terminals	C73334-A1-C33-1	1	Siemens
for other terminals	C73334-A1-C34-1	1	Siemens
Mounting rail for 19" rack	C73165-A63-D200-1	1	Siemens

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

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Connection diagram

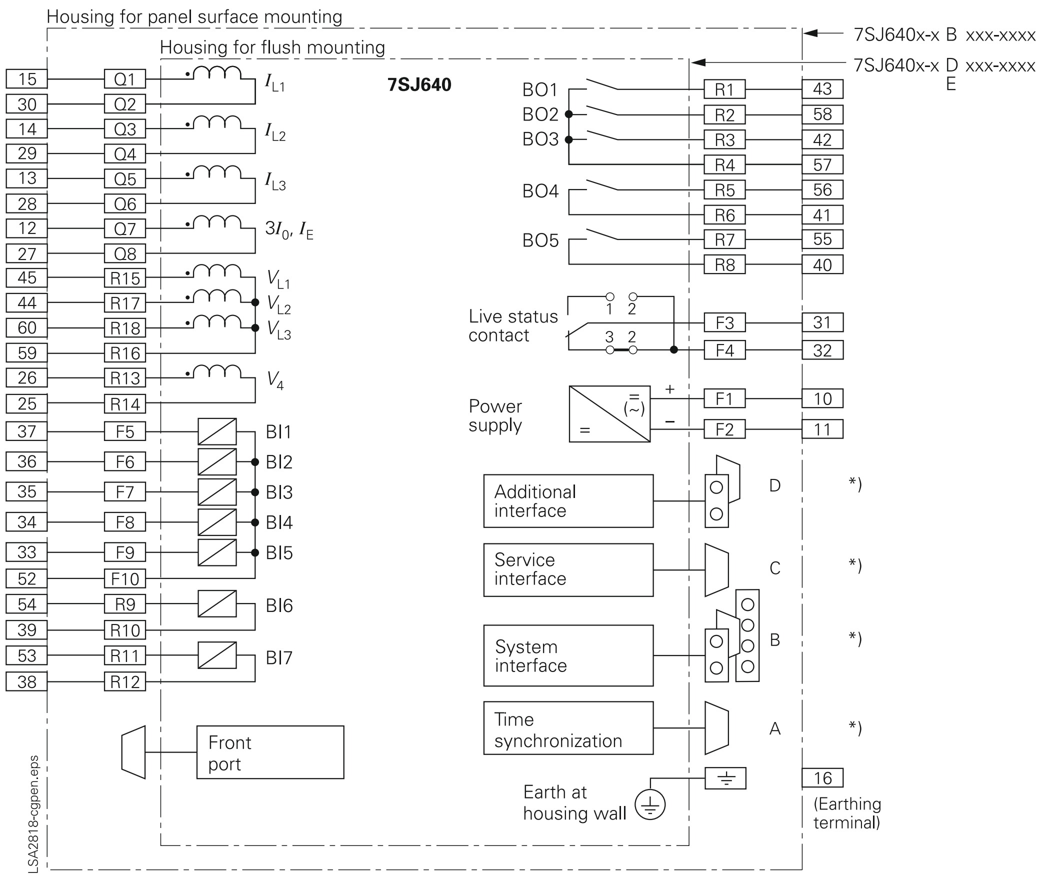

Fig. 5/176
7SJ640 connection diagram

*) For pinout of communication ports see part 15 of this catalog.
For allocation of terminals of the panel surface mounting version refer to the manual (http://www.siemens.com/siprotec).

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Connection diagram

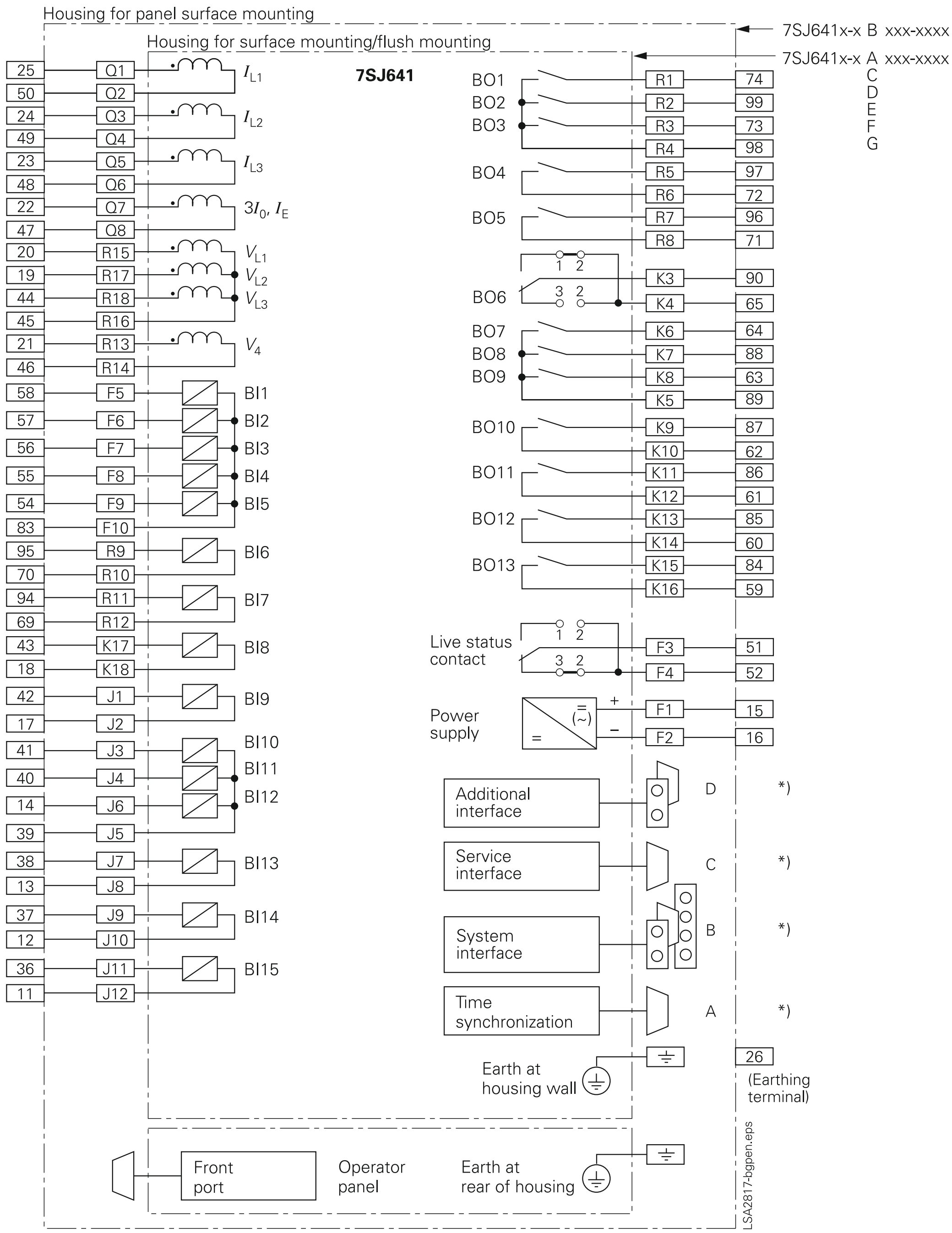

Fig. 5/177
7SJ641 connection diagram

*) For pinout of communication ports see part 15 of this catalog.
For allocation of terminals of the panel surface mounting version refer to the manual (http://www.siemens.com/siprotec).

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Connection diagram

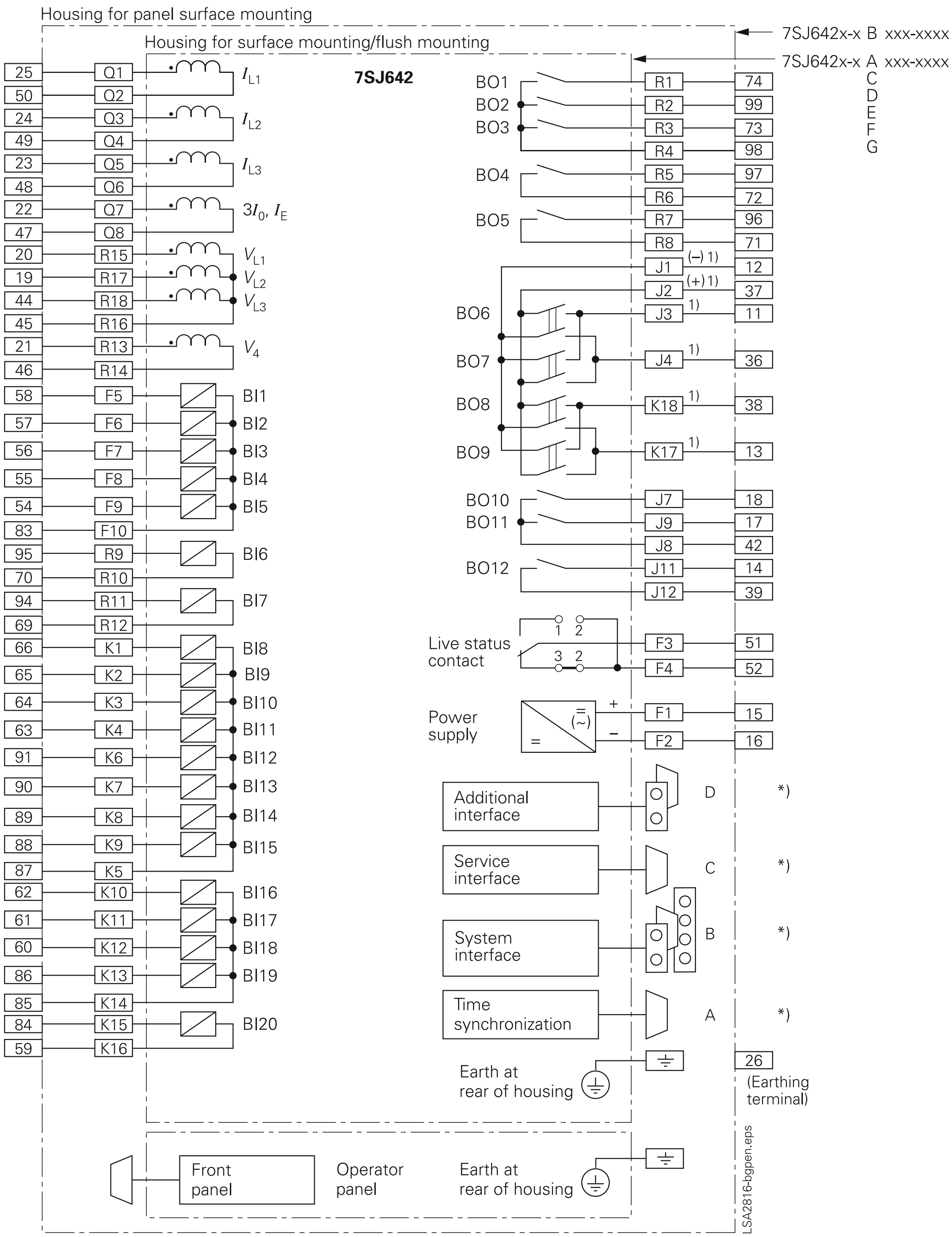

Fig. 5/178
7SJ642 connection diagram

*) For pinout of communication ports see part 15 of this catalog.
For allocation of terminals of the panel surface mounting version refer to the manual (http://www.siemens.com/siprotec).

1) Power relays are intended to directly control motorized switches. The power relays are interlocked so only one relay of each pair can close at a time, in order to avoid shorting out the power supply. The power relay pairs are BO6/BO7, BO8/BO9. If used for protection purposes only one binary output of a pair can be used.

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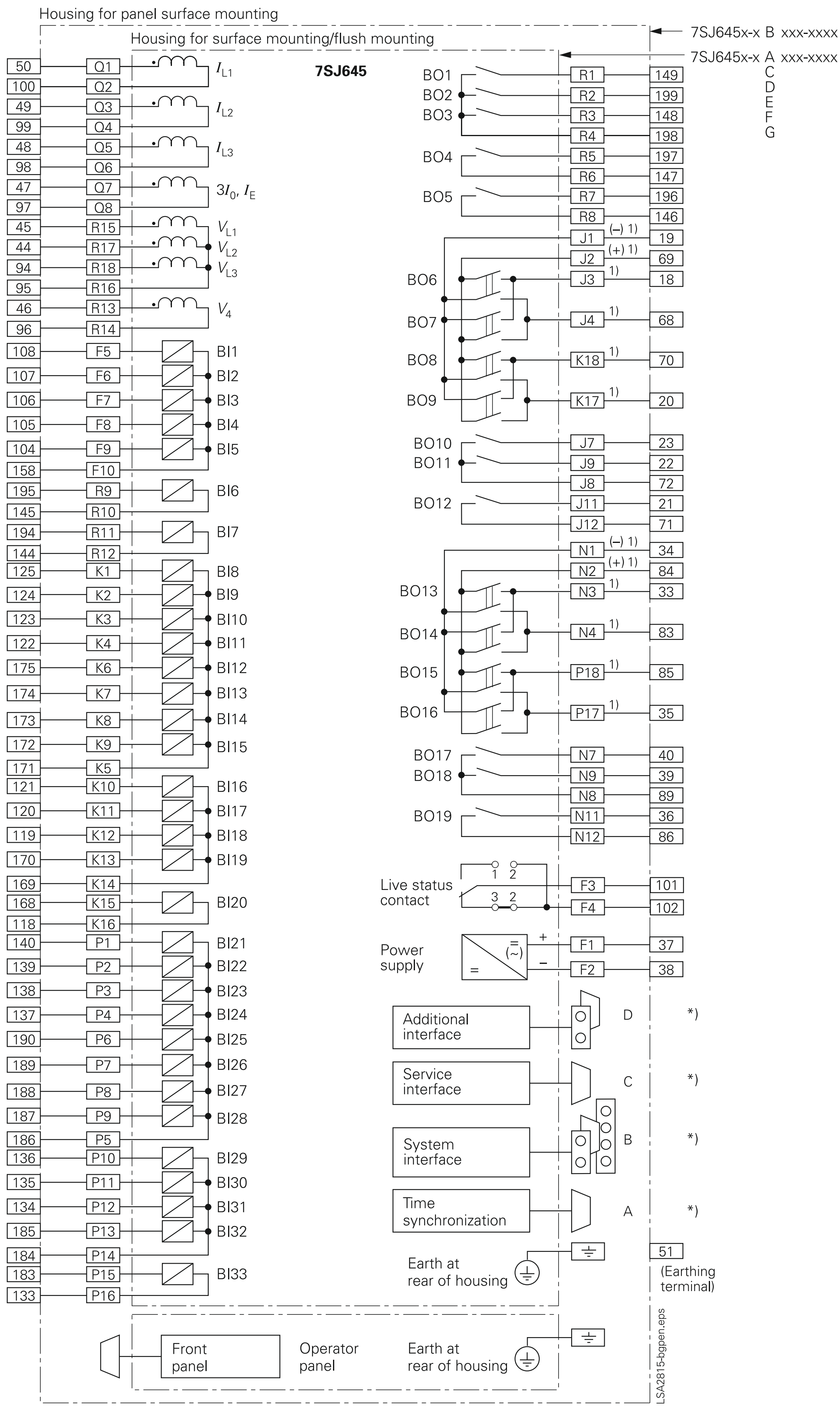
Connection diagram



*) For pinout of communication ports see part 15 of this catalog. For allocation of terminals of the panel surface mounting version refer to the manual (http://www.siemens.com/siprotec).

1) Power relays are intended to directly control motorized switches. The power relays are interlocked so only one relay of each pair can close at a time, in order to avoid shorting out the power supply. The power relay pairs are BO6/BO7, BO8/BO9, BO13/BO14, BO15/BO16. If used for protection purposes only one binary output of a pair can be used.

Fig. 5/179
7SJ645 connection diagram

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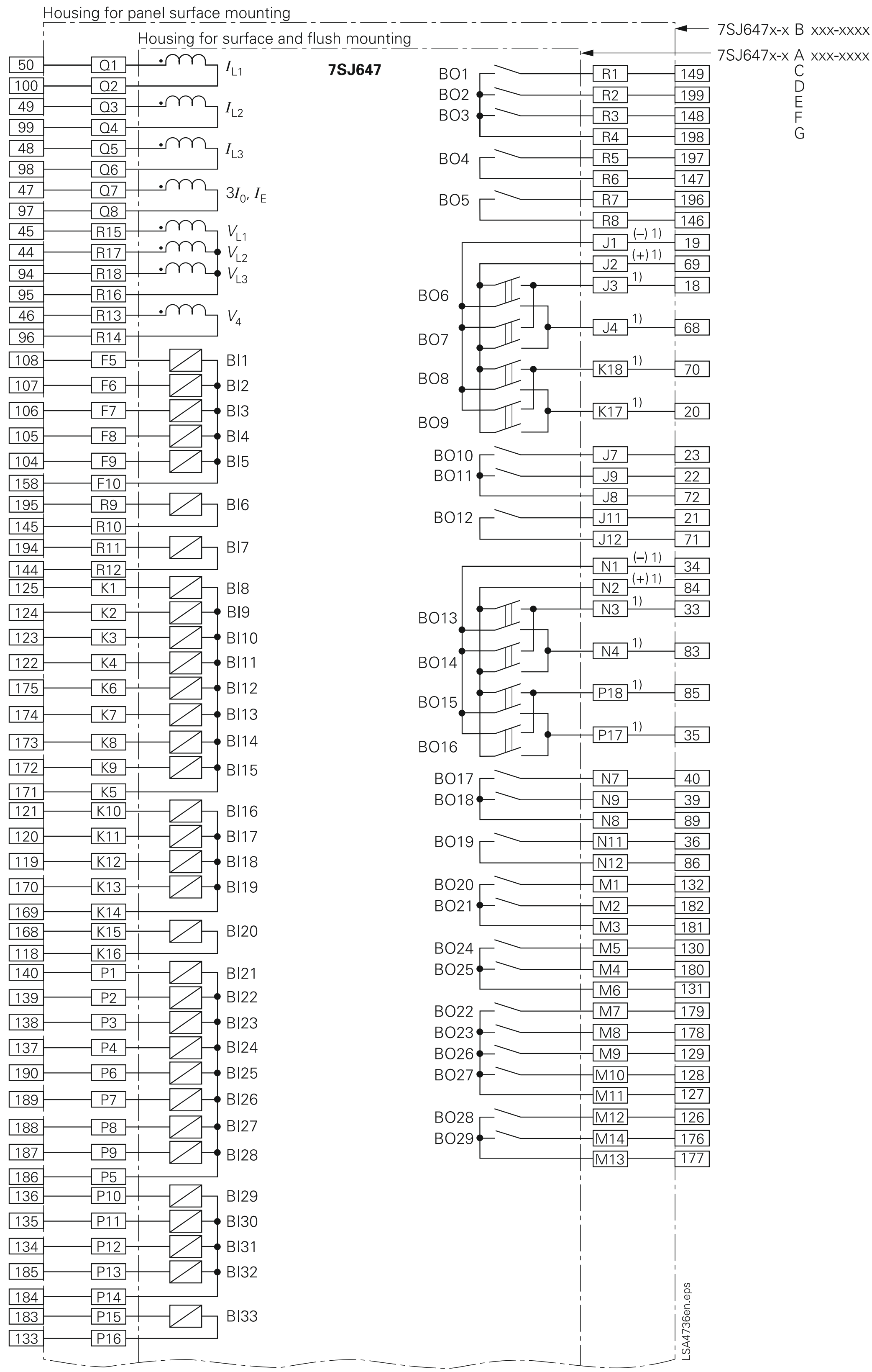
Connection diagram



1) Power relays are intended to directly control motorized switches. The power relays are interlocked so only one relay of each pair can close at a time, in order to avoid shorting out the power supply. The power relay pairs are BO6/BO7, BO8/BO9, BO13/BO14, BO15/BO16. If used for protection purposes only one binary output of a pair can be used.

Fig. 5/180
7SJ647 connection diagram part 1; continued on following page

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Connection diagram

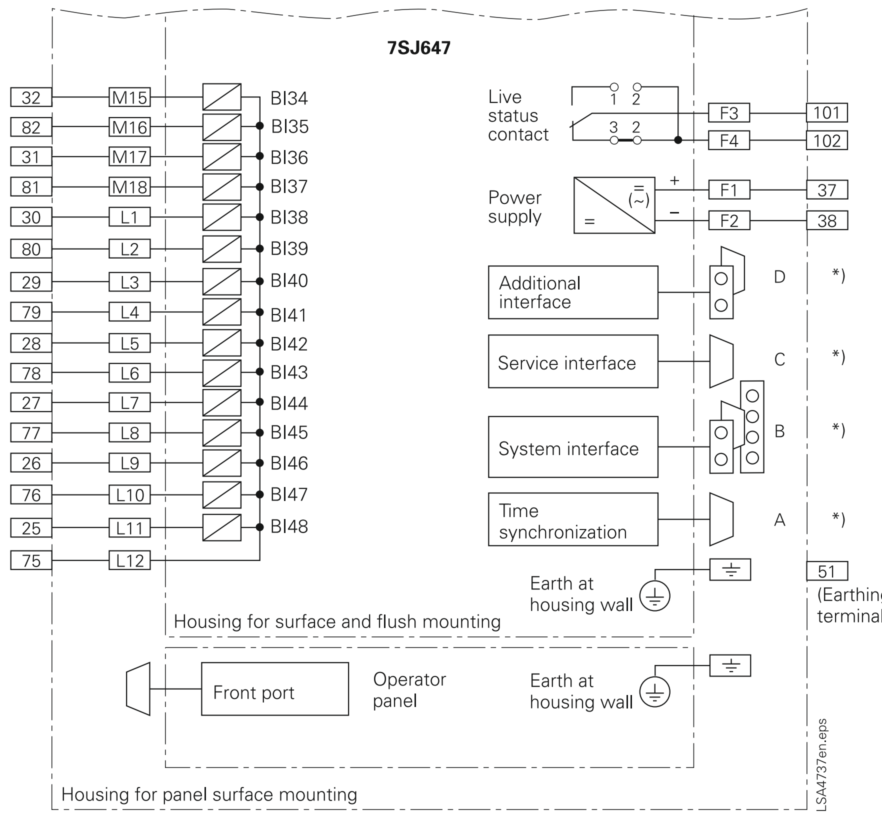

Fig. 5/181
7SJ647 connection diagram
part 2

*) For pinout of communication ports see part 15 of this catalog. For allocation of terminals of the panel surface mounting version refer to the manual (http://www.siemens.com/siprotec).

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