



Fig. 5/142 SIPROTEC 4 7SJ64 multifunction protection relay

### Description

The SIPROTEC 4 7SJ64 can be used as a protective control and monitoring relay for distribution feeders and transmission lines of any voltage in networks that are earthed (grounded), low-resistance grounded, ungrounded, or of a compensated neutral point structure. The relay is suited for networks that are radial or looped, and for lines with single or multi-terminal feeds. The SIPROTEC 4 7SJ64 is equipped with a synchronization function which provides the operation modes 'synchronization check' (classical) and 'synchronous/asynchronous switching' (which takes the CB mechanical delay into consideration). Motor protection comprises undercurrent monitoring, starting time supervision, restart inhibit, locked rotor, load jam protection as well as motor statistics.

The 7SJ64 is featuring the "flexible protection functions". Up to 20 protection functions can be added according to individual requirements. Thus, for example, rate-of-frequency-change protection or reverse power protection can be implemented.

The relay provides easy-to-use local control and automation functions. The number of controllable switchgear depends only on the number of available inputs and outputs. The integrated programmable logic (CFC) allows the user to implement their own functions, e.g. for the automation of switchgear (interlocking). CFC capacity is much larger compared to 7SJ63 due to extended CPU power. The user is able to generate user-defined messages as well.

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

### Function overview

#### Protection functions

- Overcurrent protection
- Directional overcurrent protection
- Sensitive dir./non-dir. ground-fault detection
- Displacement voltage
- Intermittent ground-fault protection
- Directional intermittent ground fault protection
- High-impedance restricted ground fault
- Inrush restraint
- Motor protection
- Overload protection
- Temperature monitoring
- Under-/overvoltage protection
- Under-/overfrequency protection
- Rate-of-frequency-change protection
- Power protection (e.g. reverse, factor)
- Undervoltage-controlled reactive power protection
- Breaker failure protection
- Negative-sequence protection
- Phase-sequence monitoring
- Synchronization
- Auto-reclosure
- Fault locator
- Lockout

#### Control functions/programmable logic

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

#### Monitoring functions

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

#### Communication interfaces

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

# Overcurrent Protection/7SJ64

## Application

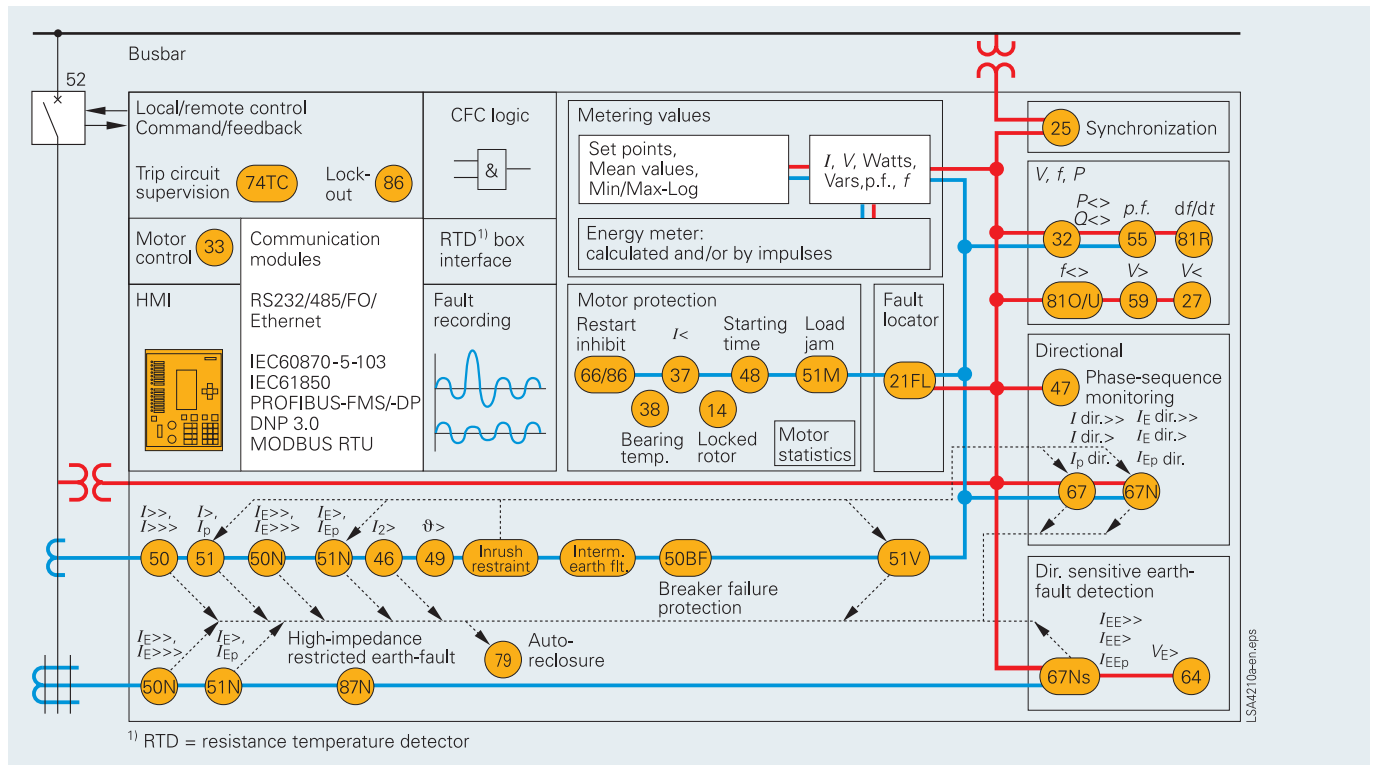


Fig. 5/143 Function diagram

### Application

The SIPROTEC 4 7SJ64 unit is a numerical protection relay that also performs control and monitoring functions and therefore supports the user in cost-effective power system management, and ensures reliable supply of electric power to the customers. Local operation has been designed according to ergonomic criteria. A large, easy-to-read graphic display was a major design aim.

### Control

The integrated control function permits control of disconnect devices (electrically operated/motorized switches) or circuit-breakers via the integrated operator panel, binary inputs, DIGSI 4 or the control and protection system (e.g. SICAM). The present status (or position) of the primary equipment can be displayed. 7SJ64 supports substations with single and duplicate busbars. The number of elements that can be controlled (usually 1 to 5) is only restricted by the number of inputs and outputs available. A full range of command processing functions is provided.

### Programmable logic

The integrated logic characteristics (CFC) allow users to implement their own functions for automation of switchgear (interlocking) or a substation via a graphic user interface. Due to extended CPU power, the programmable logic capacity is much larger compared to 7SJ63. The user can also generate user-defined messages.

### Line protection

The 7SJ64 units can be used for line protection of high and medium-voltage networks with grounded, low-resistance grounded, isolated or compensated neutral point.

### Synchronization

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

The synchronization function provides the operation modes 'synchro-check' (classical) and 'synchronous/asynchronous switching' (which takes the c.-b. mechanical delay into consideration).

### Motor protection

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

### Transformer protection

The 7SJ64 units perform all functions of backup protection supplementary to transformer differential protection. The inrush suppression effectively prevents tripping by inrush currents.

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

### Backup protection

The relays can be used universally for backup protection.

### Flexible protection functions

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

### Metering values

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

ANSI	IEC	Protection functions
50, 50N	$I>$ , $I>>$ , $I>>>$ $I_{E>}$ , $I_{E>>}$ , $I_{E>>>}$	Definite-time overcurrent protection (phase/neutral)
50, 50N	$I>>>>$ , $I_2>$ $I_{E>>>>}$	Additional definite-time overcurrent protection stages (phase/neutral) via flexible protection functions
51, 51V, 51N	$I_p$ , $I_{Ep}$	Inverse overcurrent protection (phase/neutral), phase function with voltage-dependent option
67, 67N	$I_{dir>}$ , $I_{dir>>}$ , $I_{p\ dir}$ $I_{Edir>}$ , $I_{Edir>>}$ , $I_{Ep\ dir}$	Directional overcurrent protection (definite/inverse, phase/neutral), Directional comparison protection
67Ns/50Ns	$I_{EE>}$ , $I_{EE>>}$ , $I_{EEp}$	Sensitive ground-fault protection
–		Cold load pick-up (dynamic setting change)
59N/64	$V_E$ , $V_{0>}$	Displacement voltage, zero-sequence voltage
–	$I_{IE>}$	Intermittent ground fault
67Ns	$I_{IE\ dir>}$	Directional intermittent ground fault protection
87N		High-impedance restricted ground-fault protection
50BF		Breaker failure protection
79M		Auto-reclosure
25		Synchronization
46	$I_2>$	Phase-balance current protection (negative-sequence protection)
47	$V_{2>}$ , phase seq.	Unbalance-voltage protection and/or phase-sequence monitoring
49	$\vartheta>$	Thermal overload protection
48		Starting time supervision
51M		Load jam protection
14		Locked rotor protection
66/86		Restart inhibit
37	$I<$	Undercurrent monitoring
38		Temperature monitoring via external device (RTD-box), e.g. bearing temperature monitoring
27, 59	$V<$ , $V>$	Undervoltage/overvoltage protection
59R	$dV/dt$	Rate-of-voltage-change protection
32	$P<>$ , $Q<>$	Reverse-power, forward-power protection
27/Q	$Q>/V<$	Undervoltage-controlled reactive power protection
35	$\cos \varphi$	Power factor protection
81O/U	$f>$ , $f<$	Overfrequency/underfrequency protection
81R	$df/dt$	Rate-of-frequency-change protection
21FL		Fault locator

# Overcurrent Protection/7SJ64

## Construction

### Construction

#### Connection techniques and housing with many advantages

$\frac{1}{3}$ ,  $\frac{1}{2}$  and  $\frac{1}{4}$ -rack sizes

These are the available housing widths of the 7SJ64 relays, referred to a 19" module frame system. This means that previous models can always be replaced. The height is a uniform 244 mm for flush-mounting housings and 266 mm for surface-mounting housings for all housing widths. All cables can be connected with or without ring lugs. Plug-in terminals are available as an option.

It is thus possible to employ prefabricated cable harnesses. In the case of surface mounting on a panel, the connection terminals are located above and below the housing. The communication interfaces are located in a sloped case at the top and bottom of the housing. The housing can also be supplied optionally with a detached operator panel (refer to Fig. 5/146), or without operator panel, in order to allow optimum operation for all types of applications.

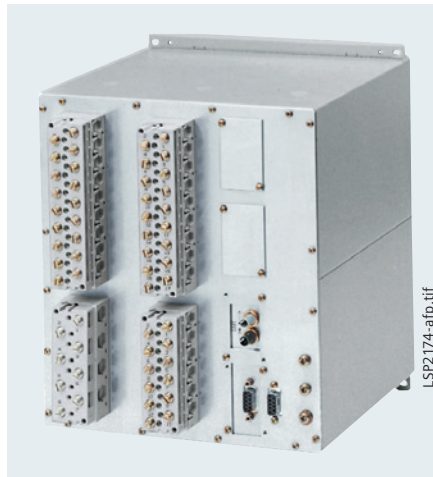


Fig. 5/144 Flush-mounting housing with screw-type terminals



Fig. 5/145 Front view of 7SJ64 with  $\frac{1}{3} \times 19$ " housing

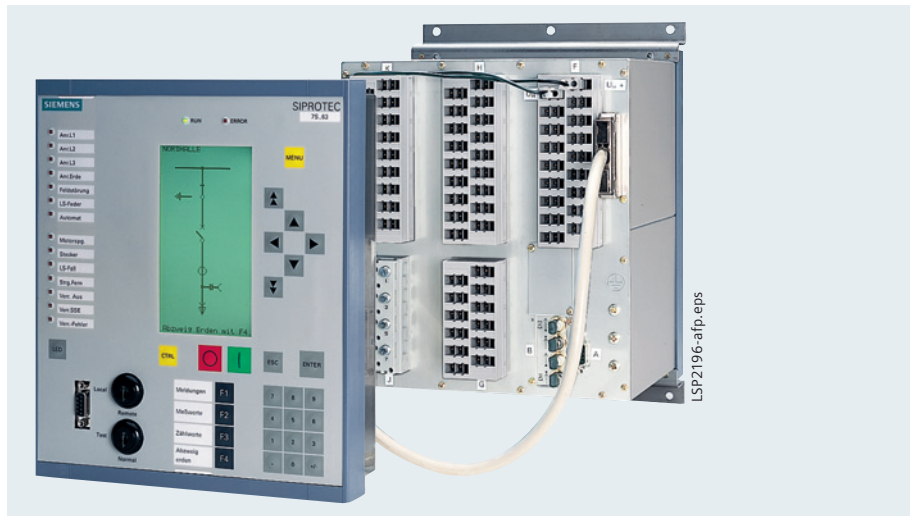


Fig. 5/146 Housing with plug-in terminals and detached operator panel



Fig. 5/147 Surface-mounting housing with screw-type terminals



Fig. 5/148 Communication interfaces in a sloped case in a surface-mounting housing

### Protection functions

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

This function is based on the phase-selective measurement of the three phase currents and the ground current (four transformers). Three definite-time overcurrent protection elements (DMT) exist both for the phases and for the ground. The current threshold and the delay time can be set in a wide range. In addition, inverse-time overcurrent protection characteristics (IDMTL) can be activated. The inverse-time function provides – as an option – voltage-restraint or voltage-controlled operating modes. With the "flexible protection functions", further definite-time overcurrent stages can be implemented in the 7SJ64 unit.

#### Reset characteristics

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

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

#### User-definable characteristics

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

#### Inrush restraint

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

#### Cold load pickup/dynamic setting change

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

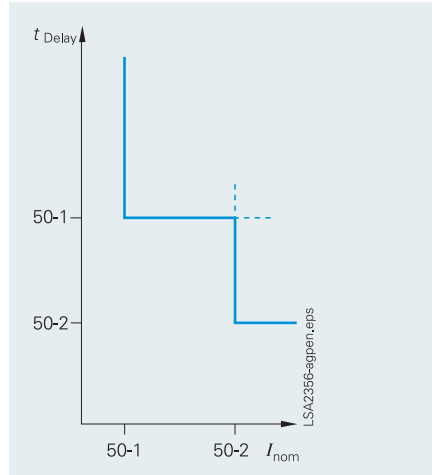


Fig. 5/149 Definite-time overcurrent protection

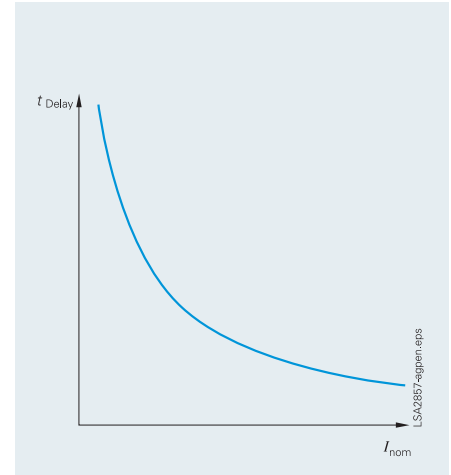


Fig. 5/150 Inverse-time overcurrent protection

#### Available inverse-time characteristics

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



## Protection functions

### Directional overcurrent protection (ANSI 67, 67N)

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

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

For ground protection, users can choose whether the direction is to be determined via zero-sequence system or negative-sequence system quantities (selectable).

Using negative-sequence variables can be advantageous in cases where the zero voltage tends to be very low due to unfavorable zero-sequence impedances.

### Directional comparison protection (cross-coupling)

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

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

For isolated-neutral and compensated networks, the direction of power flow in the zero sequence is calculated from the zero-sequence current  $I_0$  and zero-sequence voltage  $V_0$ . For networks with an isolated neutral, the reactive current component is evaluated; for compensated networks, the active current component or residual resistive current is evaluated.

For special network conditions, e.g. high-resistance grounded networks with ohmic-capacitive ground-fault current or low-resistance grounded networks with ohmic-inductive current, the tripping characteristics can be rotated approximately  $\pm 45$  degrees.

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

It has the following functions:

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

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

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

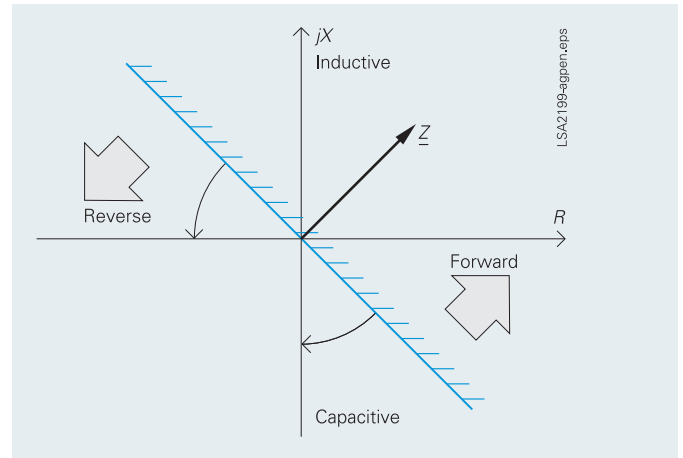


Fig. 5/151 Directional characteristic of the directional overcurrent protection

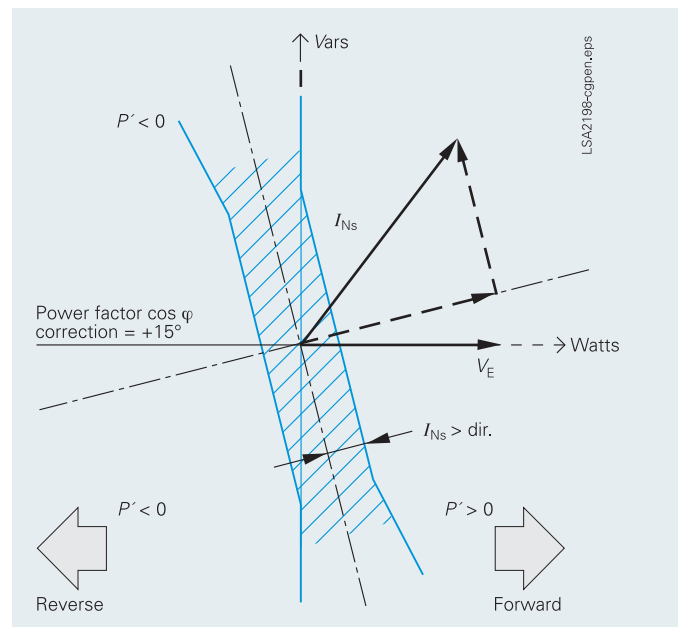


Fig. 5/152 Directional determination using cosine measurements for compensated networks

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

### Intermittent ground-fault protection

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

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

### Directional intermittent ground fault protection (ANSI 67Ns)

The directional intermittent ground fault protection has to detect intermittent ground faults in resonant grounded cable systems selectively. Intermittent ground faults in resonant grounded cable systems are usually characterized by the following properties:

- A very short high-current ground current pulse (up to several hundred amperes) with a duration of under 1 ms
- They are self-extinguishing and re-ignite within one halfperiod up to several periods, depending on the power system conditions and the fault characteristic.
- Over longer periods (many seconds to minutes), they can develop into static faults.

Such intermittent ground faults are frequently caused by weak insulation, e.g. due to decreased water resistance of old cables. Ground fault functions based on fundamental component measured values are primarily designed to detect static ground faults and do not always behave correctly in case of intermittent ground faults. The function described here evaluates specifically the ground current pulses and puts them into relation with the zero-sequence voltage to determine the direction.

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

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

### Breaker failure protection (ANSI 50BF)

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

### Auto-reclosures (ANSI 79)

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

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

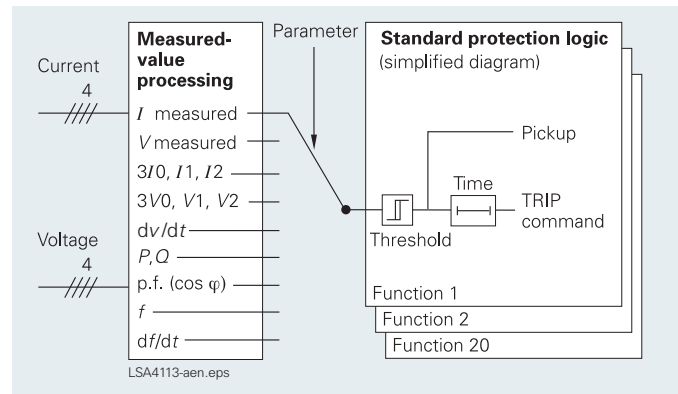


Fig. 5/153 Flexible protection functions

### Flexible protection functions

The 7SJ64 units enable the user to easily add on up to 20 protective functions. To this end, parameter definitions are used to link a standard protection logic with any chosen characteristic quantity (measured or derived quantity) (Fig. 5/153). The standard logic consists of the usual protection elements such as the pickup message, the parameter-definable delay time, the TRIP command, a blocking possibility, etc. The mode of operation for current, voltage, power and power factor quantities can be three-phase or single-phase. Almost all quantities can be operated as greater than or less than stages. All stages operate with protection priority.

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

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

For example, the following can be implemented:

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

### Undervoltage-controlled reactive power protection (ANSI 27/Q)

The undervoltage-controlled reactive power protection protects the system for mains decoupling purposes. To prevent a voltage collapse in energy systems, the generating side, e.g. a generator, must be equipped with voltage and frequency protection devices. An undervoltage-controlled reactive power protection is required at the supply system connection point. It detects critical power system situations and ensures that the power generation facility is disconnected from the mains. Furthermore, it ensures that reconnection only takes place under stable power system conditions. The associated criteria can be parameterized.

## Protection functions

### Synchronization (ANSI 25)

- In case of switching ON the circuit-breaker, the units can check whether the two subnetworks are synchronized (classic synchro-check). Furthermore, the synchronizing function may operate in the "Synchronous/asynchronous switching" mode. The unit then distinguishes between synchronous and asynchronous networks:  
In synchronous networks, frequency differences between the two subnetworks are almost non-existent. In this case, the circuit-breaker operating time does not need to be considered. Under asynchronous condition, however, this difference is markedly larger and the time window for switching is shorter. In this case, it is recommended to consider the operating time of the circuit-breaker.

The command is automatically pre-dated by the duration of the operating time of the circuit-breaker, thus ensuring that the contacts of the CB close at exactly the right time.

Up to 4 sets of parameters for the synchronizing function can be stored in the unit. This is an important feature when several circuit-breakers with different operating times are to be operated by one single relay.

### Thermal overload protection (ANSI 49)

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

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

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

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

When the high-impedance measurement principle is applied, all current transformers in the protected area are connected in parallel and operated on one common resistor of relatively high  $R$  whose voltage is measured (see Fig. 5/154). In the case of 7SJ6 units, the voltage is measured by detecting the current through the (external) resistor  $R$  at the sensitive current measurement input  $I_{EE}$ .

The varistor  $V$  serves to limit the voltage in the event of an internal fault. It cuts off the high momentary voltage spikes occurring at transformer saturation. At the same time, this results in smoothing of the voltage without any noteworthy reduction of the average value. If no faults have occurred and in the event of external faults, the system is at equilibrium, and the voltage through the resistor is approximately zero. In the

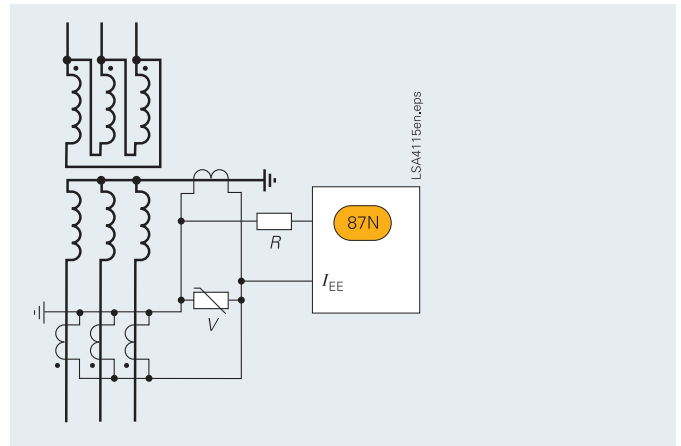


Fig. 5/154 High-impedance restricted ground-fault protection

event of internal faults, an imbalance occurs which leads to a voltage and a current flow through the resistor  $R$ .

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

### Settable dropout delay times

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

### ■ Motor protection

#### Restart inhibit (ANSI 66/86)

If a motor is started up too many times in succession, the rotor can be subject to thermal overload, especially the upper edges of the bars. The rotor temperature is calculated from the stator current. The reclosing lockout only permits start-up of the motor if the rotor has sufficient thermal reserves for a complete start-up (see Fig. 5/155).

#### Emergency start-up

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

#### Temperature monitoring (ANSI 38)

Up to two temperature monitoring boxes with a total of 12 measuring sensors can be used for temperature monitoring and detection by the protection relay. The thermal status of motors, generators and transformers can be monitored with this device. Additionally, the temperature of the bearings of rotating machines are monitored for limit value violation. The temperatures are being measured with the help of temperature



detectors at various locations of the device to be protected. This data is transmitted to the protection relay via one or two temperature monitoring boxes (see "Accessories", page 5/197).

### Starting time supervision (ANSI 48/14)

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

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

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

$I$  = Actual current flowing

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

$t$  = Tripping time

$I_A$  = Rated motor starting current

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

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

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

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

### Load jam protection (ANSI 51M)

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

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

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

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

### Undercurrent monitoring (ANSI 37)

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

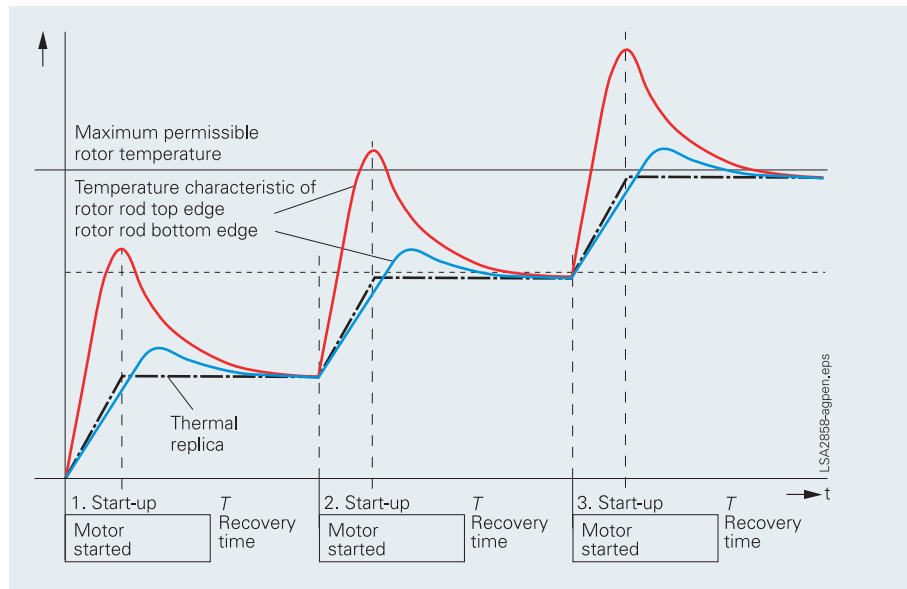


Fig. 5/155

### Motor statistics

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

### Voltage protection

#### Overvoltage protection (ANSI 59)

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

#### Undervoltage protection (ANSI 27)

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

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

#### Frequency protection (ANSI 81O/U)

Frequency protection can be used for over-frequency and under-frequency protection. Electric machines and parts of the system are protected from unwanted speed deviations. Unwanted frequency changes in the network can be detected and the load can be removed at a specified frequency setting. Frequency protection can be used over a wide frequency range (40 to 60, 50 to

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

# Overcurrent Protection / 7SJ64

## Protection functions, functions

70 Hz)<sup>1)</sup>. 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  $\Omega$ , 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:

- $\Sigma I$
- $\Sigma I^x$ , with  $x = 1 \dots 3$
- $\Sigma I^2 t$

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. 5/156) and the breaking current at the time of contact opening serve as the basis for this method. After CB opening, the two-point method calculates the number of still possible switching cycles. To this end, the two points P1 and P2 only have to be set on the device. These are specified in the CB's technical data. All of these methods are phase-selective and a limit value can be set in order to obtain an alarm if the actual value falls below or exceeds the limit value during determination of the remaining service life.

### Commissioning

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

### Test operation

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

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

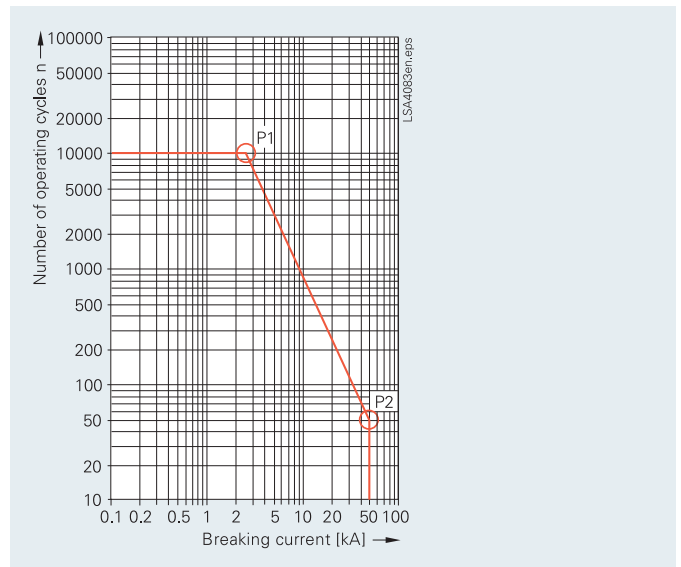


Fig. 5/156 CB switching cycle diagram

## Functions

### Control and automatic functions

#### Control

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

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

The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated to the 7SJ64 via binary inputs. Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a fault or intermediate circuit-breaker or auxiliary contact position.

The switchgear or circuit-breaker can be controlled via:

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

#### Automation / user-defined logic

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

#### Switching authority

Switching authority is determined according to parameters, communication or by key-operated switch (when available). If a source is set to "LOCAL", only local switching operations are possible. The following sequence of switching authority is laid down: "LOCAL"; DIGSI PC program, "REMOTE".

#### Key-operated switch

7SJ64 units are fitted with key-operated switch function for local/remote changeover and changeover between interlocked switching and test operation.

### Command processing

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

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

### Motor control

The SIPROTEC 4 7SJ64 with high performance relays is well-suited for direct activation of the circuit-breaker, disconnector and grounding switch operating mechanisms in automated substations.

Interlocking of the individual switching devices takes place with the aid of programmable logic. Additional auxiliary relays can be eliminated. This results in less wiring and engineering effort.

### Assignment of feedback to command

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

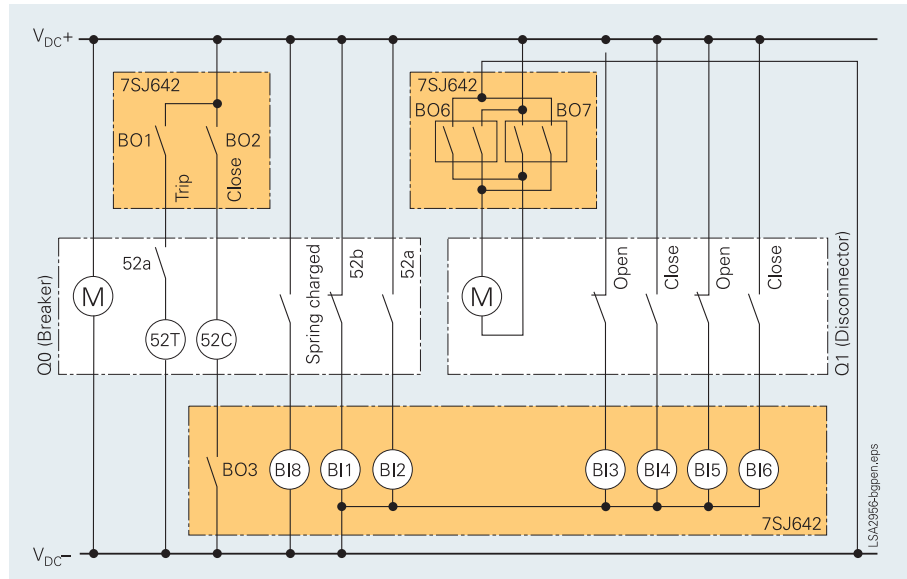
### Chatter disable

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

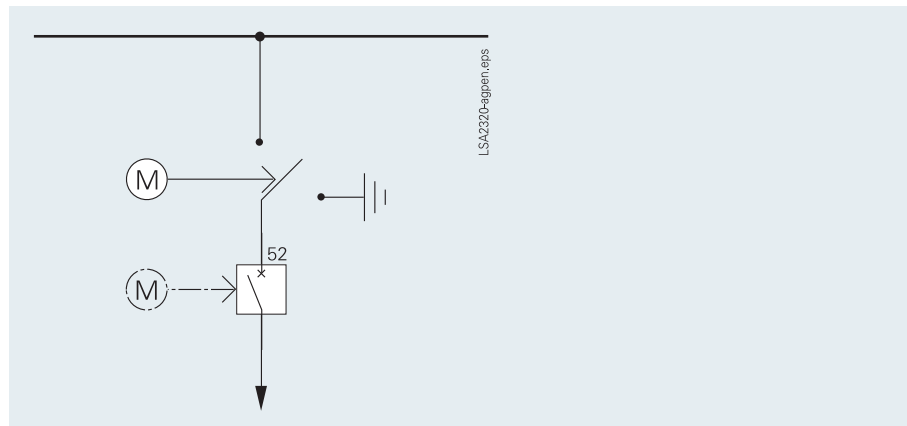
### Indication filtering and delay

Binary indications can be filtered or delayed.

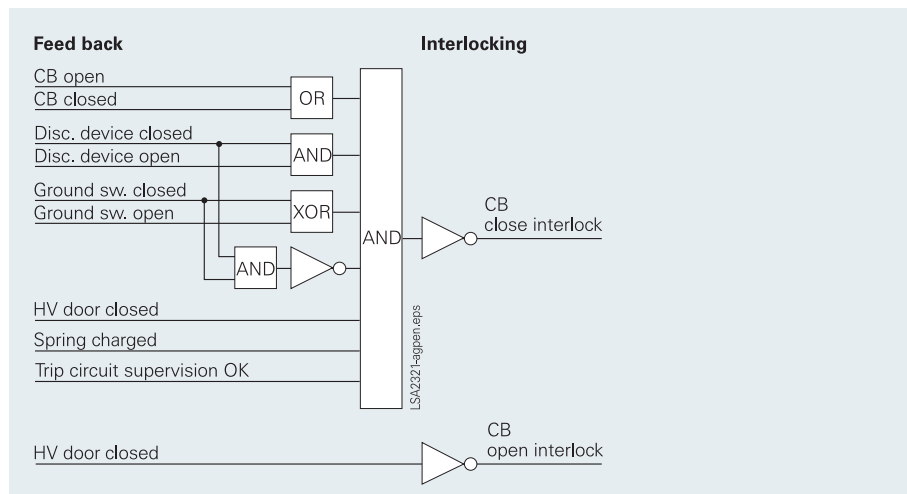
Filtering serves to suppress brief changes in potential at the indication input. The



**Fig. 5/157** Typical wiring for 7SJ642 motor direct control (simplified representation without fuses). Binary output BO6 and BO7 are interlocked so that only one set of contacts are closed at a time.



**Fig. 5/158** Example: Single busbar with circuit-breaker and motor-controlled three-position switch



**Fig. 5/159** Example: Circuit-breaker interlocking

## Functions

indication is passed on only if the indication voltage is still present after a set period of time.

In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

### Indication derivation

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

### Measured values

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

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

### Metered values

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

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

### Switchgear cubicles for high/medium voltage

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

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



Fig. 5/160 NX PLUS panel (gas-insulated)

### Communication

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

#### Serial front interface

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

#### Rear-mounted interfaces<sup>1)</sup>

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

The interface modules support the following applications:

- Time synchronization interface  
All units feature a permanently integrated electrical time synchronization interface. It can be used to feed timing telegrams in IRIG-B or DCF77 format into the units via time synchronization receivers.
- System interface  
Communication with a central control system takes place through this interface. Radial or ring type station bus topologies can be configured depending on the chosen interface. Furthermore, the units can exchange data through this interface via Ethernet and IEC 61850 protocol and can also be operated by DIGSI.
- Service interface  
The service interface was conceived for remote access to a number of protection units via DIGSI. It can be an electrical RS232/RS485 interface. For special applications, a maximum of two temperature monitoring boxes (RTD-box) can be connected to this interface as an alternative.
- Additional interface  
Up to 2 RTD-boxes can be connected via this interface.

#### System interface protocols (retrofittable)

##### IEC 61850 protocol

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens was the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus is also possible with DIGSI. It is also possible to retrieve operating and fault messages and fault recordings via a browser. This Web monitor also provides a few items of unit-specific information in browser windows.

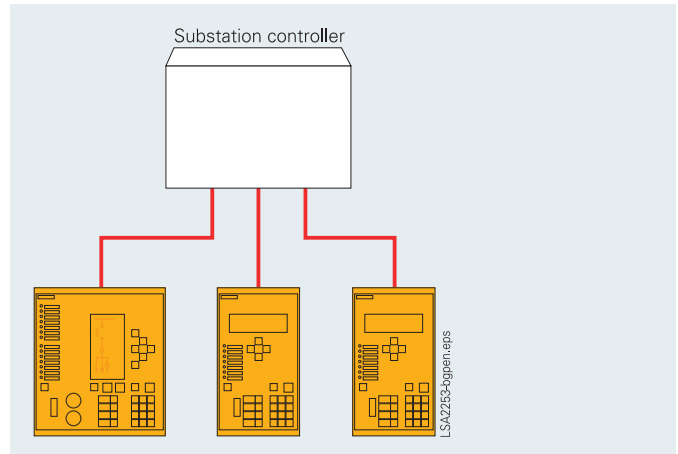


Fig. 5/161 IEC 60870-5-103: Radial fiber-optic connection

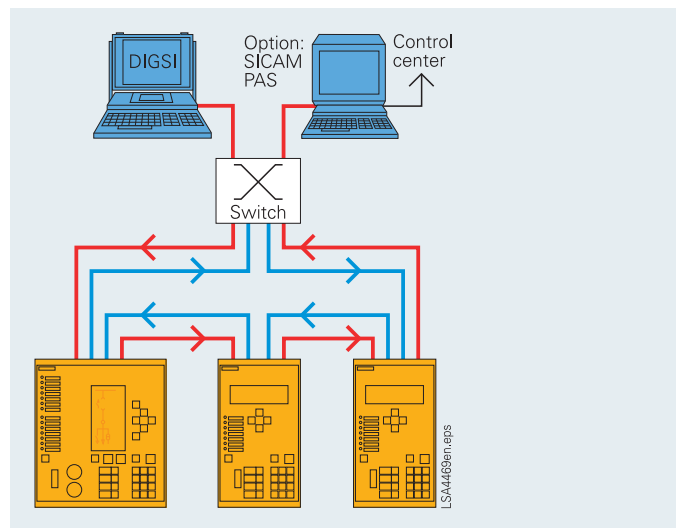


Fig. 5/162 Bus structure for station bus with Ethernet and IEC 61850, fiber-optic ring

#### IEC 60870-5-103 protocol

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

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

#### PROFIBUS-DP protocol

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

1) For units in panel surface-mounting housings please refer to note on page 5/193.



# Overcurrent Protection/7SJ64

## Communication

### MODBUS RTU protocol

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

### PROFINET

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

### DNP 3.0 protocol

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

### DNP3 TCP

The ethernet-based TCP variant of the DNP3 protocol is supported with the electrical and optical ethernet module. Two DNP3 TCP clients are supported. Redundant ring structures can be realized for DNP3 TCP with the help of the integrated switch in the module. For instance, a redundant optical ethernet ring can be constructed. Single-point indications, double-point indications, measured and metered values can be configured with DIGSI 4 and are transmitted to the DNPi client. Switching commands can be executed in the controlling direction. Fault records of the device are stored in

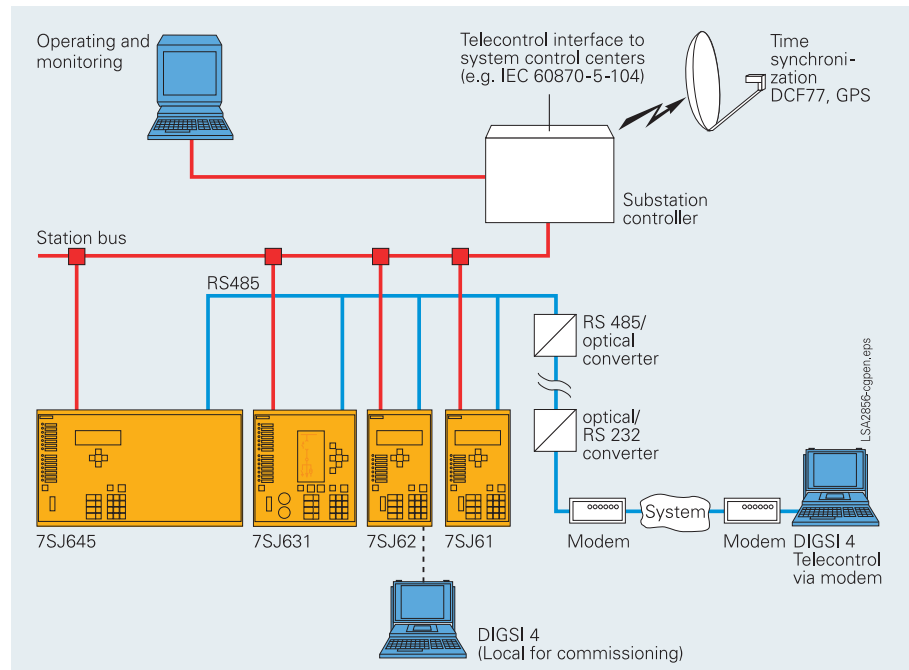


Fig. 5/163 System solution/communication

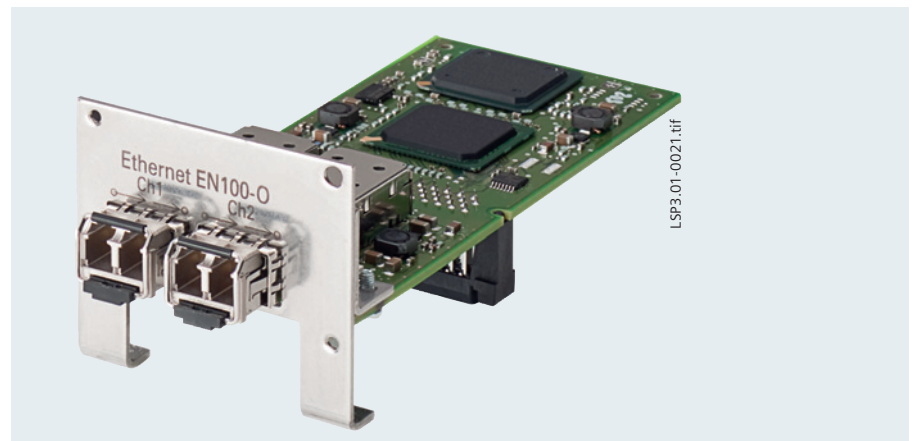


Fig. 5/164 Optical Ethernet communication module for IEC 61850 with integrated Ethernet-switch

the binary Comtrade format and can be retrieved via the DNP3 file transfer. The time synchronization is performed via the DNP3 TCP client or SNTP. The device can also be integrated into a network monitoring system via the SNMP V2 protocol. Parallel to the DNP3 TCP protocol the IEC 61850 protocol (the device works as a server) and the GOOSE messages of the IEC 61850 are available for the intercommunication between devices.

### System solutions for protection and station control

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

Units featuring IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or radially by fiber-optic link.

Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 5/161).

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

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 5/162).

### Typical connections

#### ■ Connection of current and voltage transformers

##### Standard connection

For grounded networks, the ground current is obtained from the phase currents by the residual current circuit.

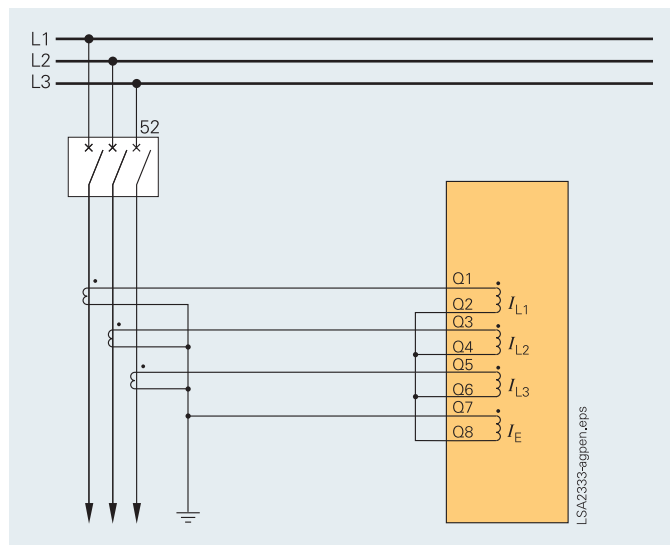


Fig. 5/165 Residual current circuit without directional element

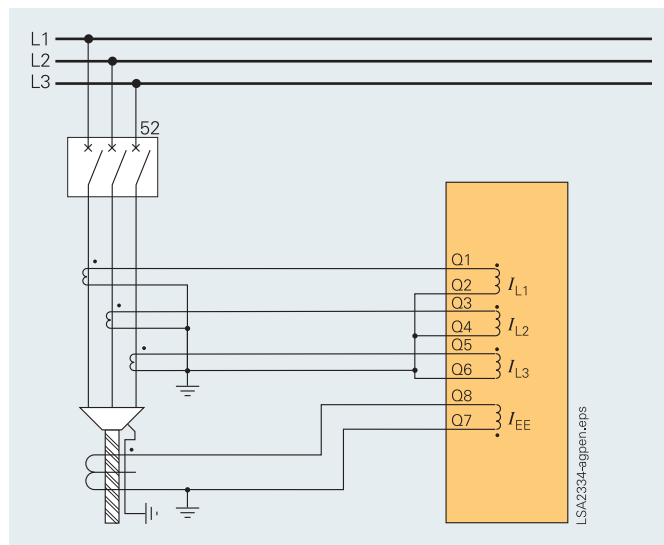


Fig. 5/166 Sensitive ground current detection without directional element

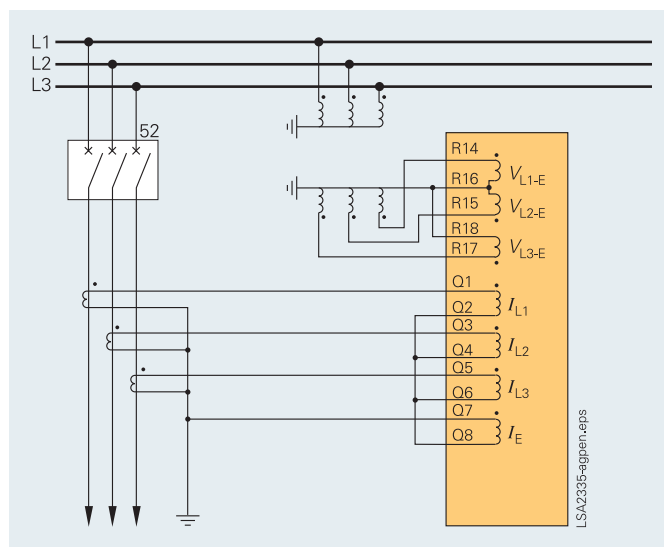


Fig. 5/167 Residual current circuit with directional element

# Overcurrent Protection / 7SJ64

## Typical connections

### Connection for compensated networks

The figure shows the connection of two phase-to-ground voltages and the  $V_E$  voltage of the open delta winding and a phase-ground neutral current transformer for the ground current. This connection maintains maximum precision for directional ground-fault detection and must be used in compensated networks. Fig. 5/168 shows sensitive directional ground-fault detection.

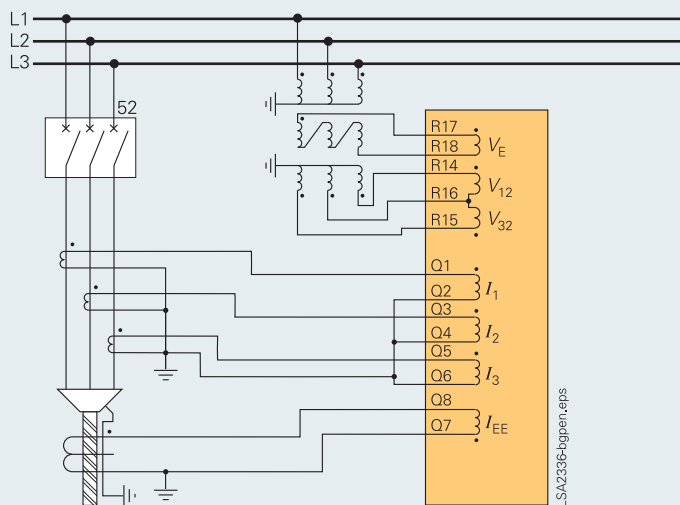


Fig. 5/168 Sensitive directional ground-fault detection with directional element for phases

### Connection for isolated-neutral or compensated networks only

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

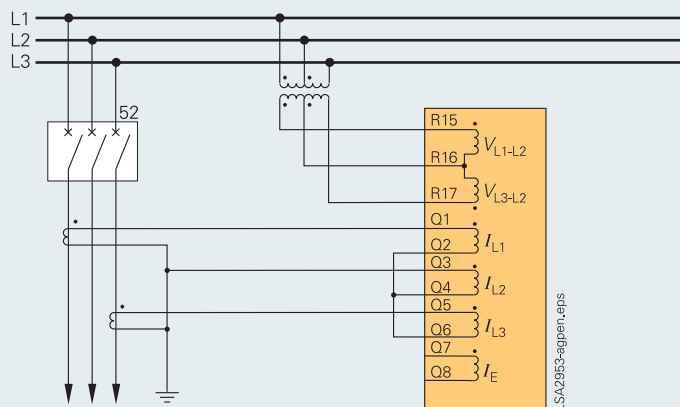


Fig. 5/169 Isolated-neutral or compensated networks

### Connection for the synchronization function

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

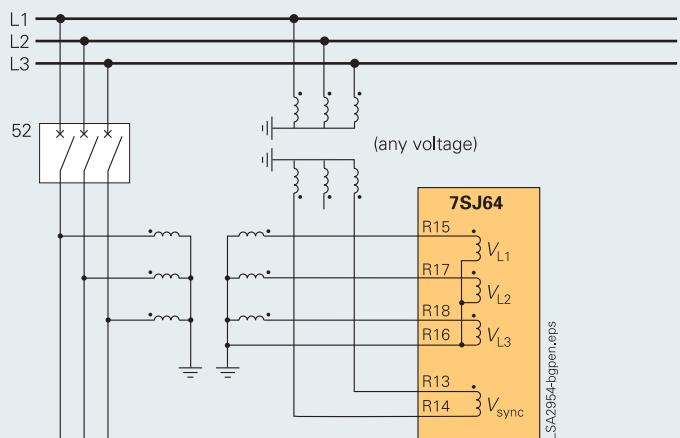


Fig. 5/170 Measuring of the busbar voltage and the outgoing feeder voltage for synchronization

Overview of connection types			
Type of network	Function	Current connection	Voltage connection
(Low-resistance) grounded network	Overcurrent protection phase/ground non-directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformer possible	–
(Low-resistance) grounded networks	Sensitive ground-fault protection	Phase-balance neutral current transformers required	–
Isolated or compensated networks	Overcurrent protection phases non-directional	Residual circuit, with 3 or 2 phase current transformers possible	–
(Low-resistance) grounded networks	Overcurrent protection phases directional	Residual circuit, with 3 phase-current transformers possible	Phase-to-ground connection or phase-to-phase connection
Isolated or compensated networks	Overcurrent protection phases directional	Residual circuit, with 3 or 2 phase-current transformers possible	Phase-to-ground connection or phase-to-phase connection
(Low-resistance) grounded networks	Overcurrent protection ground directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformers possible	Phase-to-ground connection required
Isolated networks	Sensitive ground-fault protection	Residual circuit, if ground current $> 0.05 I_N$ on secondary side, otherwise phase-balance neutral current transformers required	3 times phase-to-ground connection or phase-to-ground connection with open delta winding
Compensated networks	Sensitive ground-fault protection $\cos \varphi$ measurement	Phase-balance neutral current transformers required	Phase-to-ground connection with open delta winding required

### Typical applications

#### Application examples

##### Synchronization function

When two subnetworks must be interconnected, the synchronization function monitors whether the subnetworks are synchronous and can be connected without risk of losing stability.

As shown in Fig. 5/171, load is being fed from a generator to a busbar via a transformer. It is assumed that the frequency difference of the 2 subnetworks is such that the device determines asynchronous system conditions.

The voltages of the busbar and the feeder should be the same when the contacts are made; to ensure this condition the synchronism function must run in the "synchronous/asynchronous switching" mode. In this mode, the operating time of the CB can be set within the relay. Differences between angle and frequency can then be calculated by the relay while taking into account the operating time of the CB. From these differences, the unit derives the exact time for issuing the CLOSE command under asynchronous conditions. When the contacts close, the voltages will be in phase.

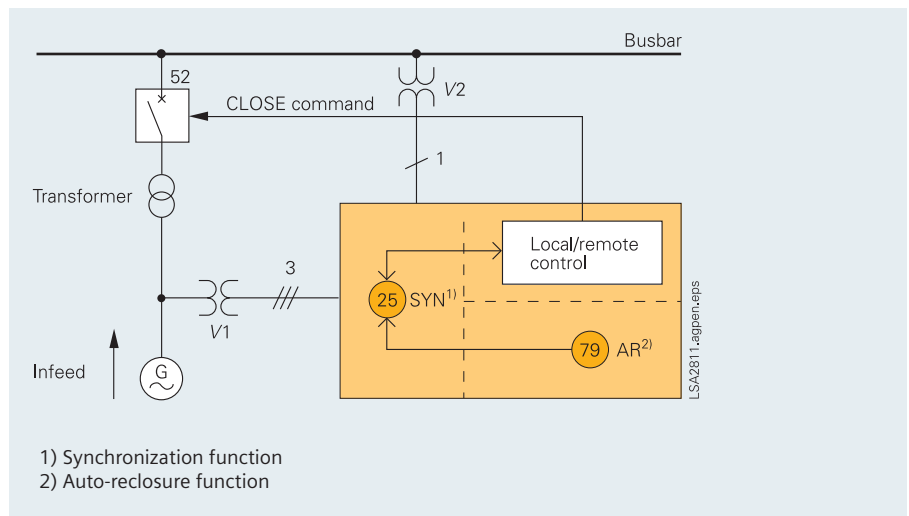


Fig. 5/171 Measuring of busbar and feeder voltages for synchronization

The vector group of the transformer can be considered by setting parameters. Thus no external circuits for vector group adaptation are required.

This synchronism function can be applied in conjunction with the auto-reclosure function as well as with the control function CLOSE commands (local/remote).

# Overcurrent Protection / 7SJ64

## 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.

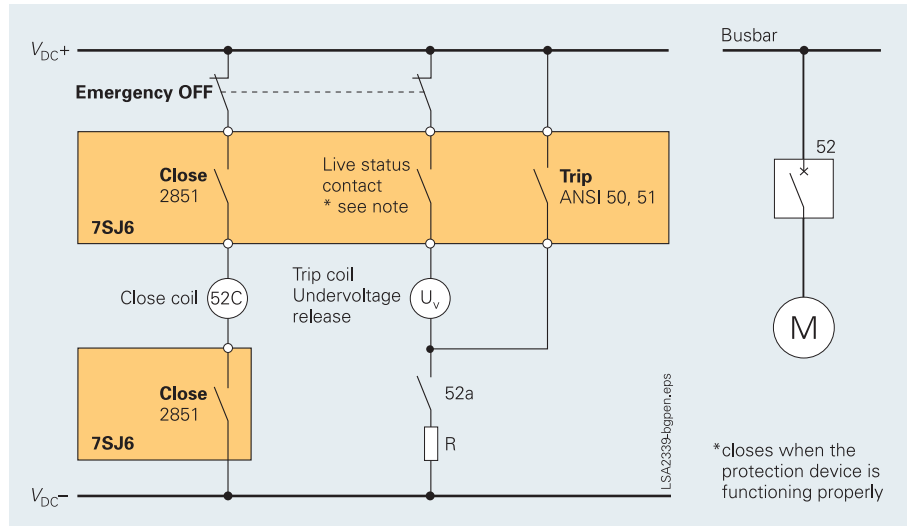


Fig. 5/172 Undervoltage release with make contact 50, 51

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.

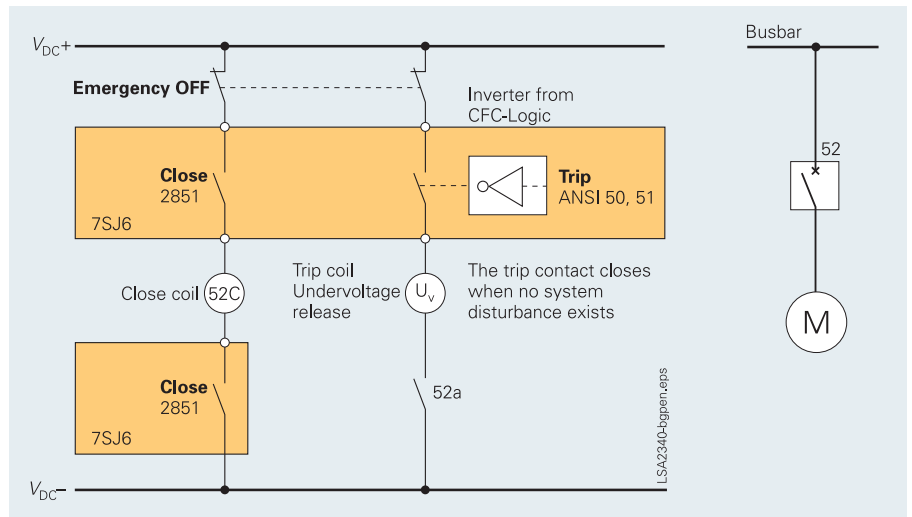


Fig. 5/173 Undervoltage release with locking contact (trip signal 50 is inverted)



### Trip circuit supervision (ANSI 74TC)

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

### Lockout (ANSI 86)

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

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

If power is fed to a busbar through two parallel infeeds, then in the event of any fault on one of the infeeds it should be selectively interrupted. This ensures a continued supply to the busbar through the remaining infeed. For this purpose, directional devices are needed which detect a short-circuit current or a power flow from the busbar in the direction of the infeed. The directional overcurrent protection is usually set via the load current. It cannot be used to deactivate low-current faults. Reverse-power protection can be set far below the rated power. This ensures that it also detects power feedback into the line in the event of low-current faults with levels far below the load current. Reverse-power protection is performed via the "flexible protection functions" of the 7SJ64.

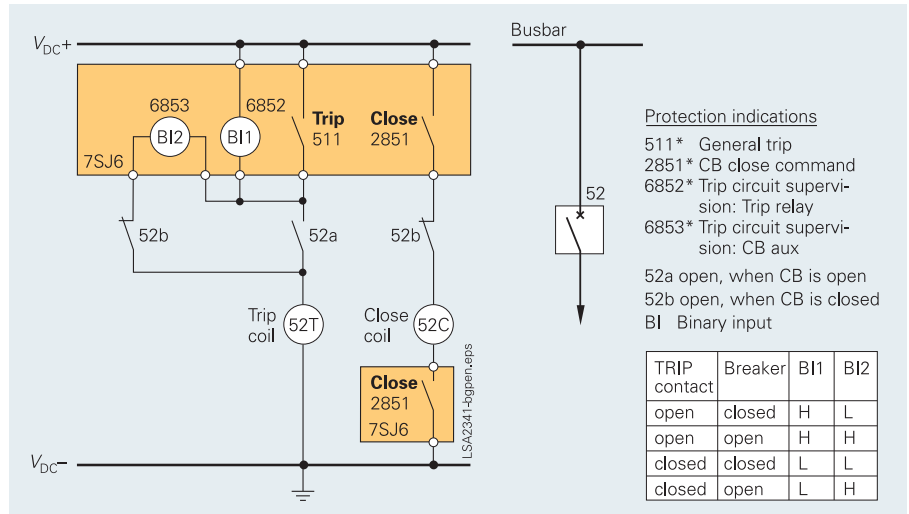


Fig. 5/174 Trip circuit supervision with 2 binary inputs

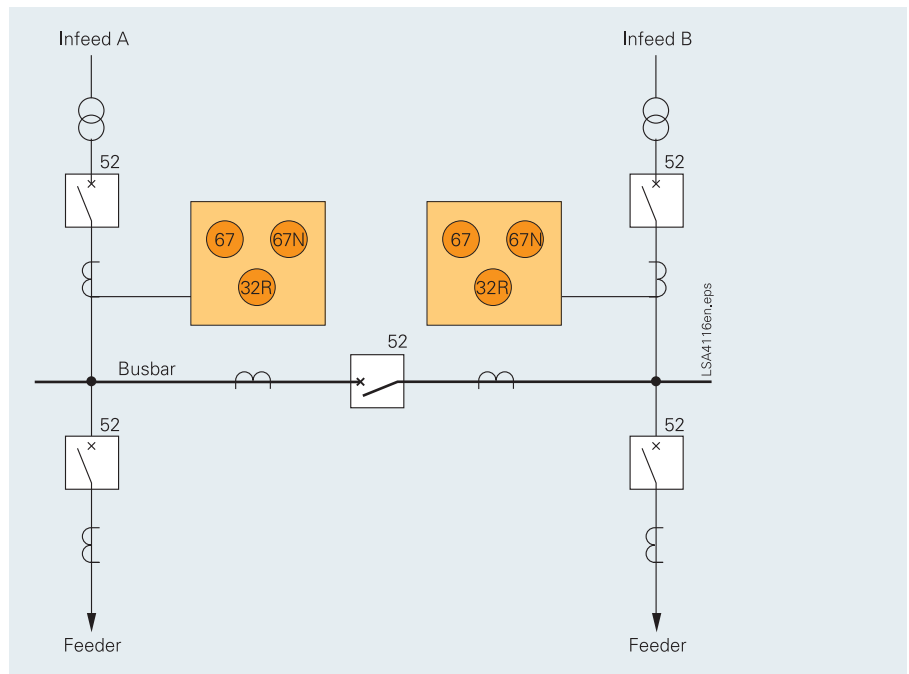


Fig. 5/175 Reverse-power protection for dual supply

# Overcurrent Protection / 7SJ64

## Technical data

5

General unit data	
<i>Measuring circuits</i>	
System frequency	50 / 60 Hz (settable)
<i>Current transformer</i>	
Rated current $I_{nom}$	1 or 5 A (settable)
Option: sensitive ground-fault CT	$I_{EE} < 1.6$ A
Power consumption at $I_{nom} = 1$ A at $I_{nom} = 5$ A for sensitive ground-fault CT at 1 A	Approx. 0.05 VA per phase Approx. 0.3 VA per phase Approx. 0.05 VA
Overload capability Thermal (effective)	500 A for 1 s 150 A for 10 s 20 A continuous
Dynamic (impulse current)	$250 \times I_{nom}$ (half cycle)
Overload capability if equipped with sensitive ground-fault CT Thermal (effective)	300 A for 1 s 100 A for 10 s 15 A continuous
Dynamic (impulse current)	750 A (half cycle)
<i>Voltage transformer</i>	
Rated voltage $V_{nom}$	100 V to 225 V
Measuring range	0 V to 200 V
Power consumption at $V_{nom} = 100$ V	< 0.3 VA per phase
Overload capability in voltage path (phase-neutral voltage) Thermal (effective)	230 V continuous
<i>Auxiliary voltage (via integrated converter)</i>	
Rated auxiliary voltage $V_{aux}$ DC	24/48 V 60/125 V 110/250 V
Permissible tolerance DC	19–58 V 48–150 V 88–300 V
Ripple voltage, peak-to-peak	≤ 12 % of rated auxiliary voltage
Power consumption	7SJ640 7SJ641 7SJ645 7SJ647 7SJ642
Quiescent Energized	Approx. 5 W 5.5 W 6.5 W 7.5 W Approx. 9 W 12.5 W 15 W 21 W
Backup time during loss/short-circuit of auxiliary direct voltage	≥ 50 ms at $V > DC 110$ V ≥ 20 ms at $V > DC 24$ V
Rated auxiliary voltage $V_{aux}$ AC	115 V / 230 V
Permissible tolerance AC	92–32 V / 184–265 V
Power consumption	7SJ640 7SJ641 7SJ645 7SJ647 7SJ642
Quiescent Energized	Approx. 7 W 9 W 12 W 16 W Approx. 12 W 19 W 23 W 33 W
Backup time during loss/short-circuit of auxiliary alternating voltage	≥ 200 ms

Binary outputs/command outputs					
Type	7SJ640	7SJ641	7SJ642	7SJ645	7SJ647
Number (marshallable)	7	15	20	33	48
Voltage range	DC 24 – 250 V				
Pickup threshold modifiable by plug-in jumpers					
Pickup threshold DC	DC 19 V		DC 88 V		
For rated control voltage DC	DC 24/48/60/110/ DC 110/125/220/250 V 125 V				
Power consumption energized	0.9 mA (independent of operating voltage) for BI 8...19 / 21...32; 1.8 mA for BI 1...7 / 20/33...48				
Binary outputs/command outputs					
Type	7SJ640	7SJ641	7SJ642	7SJ645	7SJ647
Command/indication relay	5	13	8	11	21
Contacts per command/ indication relay	1 NO / form A				
Live status contact	1 NO / NC (jumper) / form A / B				
Switching capacity					
Make	1000 W / VA				
Break	30 W / VA / 40 W resistive / 25 W at L/R ≤ 50 ms				
Switching voltage	≤ DC 250 V				
Permissible current	5 A continuous, 30 A for 0.5 s making current, 2000 switching cycles				
Power relay (for motor control)					
Type	7SJ640 7SJ641	7SJ642	7SJ645	7SJ647	
Number	0	2 (4)	4 (8)	4 (8)	
Number of contacts/relay	2 NO / form A				
Switching capacity					
Make	1000 W / VA at 48 V ... 250 V / 500 W at 24 V				
Break	1000 W / VA at 48 V ... 250 V / 500 W at 24 V				
Switching voltage	≤ DC 250 V				
Permissible current	5 A continuous, 30 A for 0.5 s				

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

Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz; amplitude and pulse-modulated
Damped wave IEC 60694 / IEC 61000-4-12	2.5 kV (peak value, polarity alternating) 100 kHz, 1 MHz, 10 and 50 MHz, $R_i = 200 \Omega$
EMC tests for interference emission; type tests	
Standard	EN 50081-* (generic specification)
Conducted interferences only auxiliary voltage IEC/CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC/CISPR 11	30 to 1000 MHz Limit class B
Units with a detached operator panel must be installed in a metal cubicle to maintain limit class B	

Mechanical stress tests	
Vibration, shock stress and seismic vibration	
During operation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz; $\pm 0.075$ 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: $\pm 3.5$ mm amplitude (horizontal axis) 1 to 8 Hz: $\pm 1.5$ mm amplitude (vertical axis) 8 to 35 Hz: 1 g acceleration (horizontal axis) 8 to 35 Hz: 0.5 g acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 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: $\pm 7.5$ 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			
Type	7SJ640 7SJ642	7SJ641	7SJ645 7SJ647
Housing	7XP20		
Dimensions	See dimension drawings, part 14 of this catalog		
Weight in kg	Housing width ⅓	Housing width ½	Housing width ⅙
Surface-mounting housing	8	11	15
Flush-mounting housing	5	6	10
Housing for detached operator operator panel	–	8	12
Detached operator panel	–	2.5	2.5
Degree of protection acc. to EN 60529	IP 51		
Surface-mounting housing	Front: IP 51, rear: IP 20;		
Flush-mounting housing	IP 2x with cover		
Operator safety			

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
For surface-mounting housing with two-tier terminal at the top / bottom part	9-pin subminiature connector, mounting location "C"
Distance RS232	At the bottom part of the housing: shielded data cable
Distance RS485	15 m / 49.2 ft
Test voltage	Max. 1 km / 3300 ft
	AC 500 V against ground
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
RS485	
Connection	For flush-mounting housing / surface-mounting housing with detached operator panel
For surface-mounting housing with two-tier terminal at the top / bottom part	9-pin subminiature connector, mounting location "D"
Distance	At the bottom part of the housing: shielded data cable
Test voltage	Max. 1 km / 3300 ft
	AC 500 V against ground
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 "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

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
<u>RS232/RS485</u>	
Connection For flush-mounting housing / surface-mounting housing with detached operator panel	Mounting location "B"
For surface-mounting housing with two-tier terminal on the top / bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	Max. 15 m / 49 ft
Distance RS485	Max. 1 km / 3300 ft
Test voltage	AC 500 V against ground
<u>Fiber optic</u>	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection Mounting location "B"
For flush-mounting housing / surface-mounting housing with detached operator panel	
For surface-mounting housing with two-tier terminal on the top / bottom part	At the bottom part of the housing
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	Max. 1.5 km / 0.9 miles
IEC 60870-5-103 protocol, redundant	
<u>RS485</u>	
Connection For flush-mounting housing / surface-mounting housing with detached operator panel	Mounting location "B"
For surface-mounting housing with two-tier terminal on the top / bottom part	(not available)
Distance RS485	Max. 1 km / 3300 ft
Test voltage	AC 500 V against ground
Ethernet (EN 100) for DIGSI, IEC 61850, DNP3 TCP, PROFINET	
<u>Electrical</u>	
Connection for flush-mounted casing	rear panel, mounting location "B" 2 x RJ45 socket contact 100BaseT acc. to IEEE802.3
Connection for surface-mounted casing	in console housing at case bottom
Test voltage (reg. socket)	500 V; 50 Hz
Transmission speed	100 Mbit/s
Bridgeable distance	65.62 feet (200 m)
<u>Optical</u>	
Connection for flush-mounted case	rear panel, slot position "B", duplex LC, 100BaseT acc. to IEEE802.3
Connection for surface-mounted case	(not available)
Transmission speed	100 Mbit/s
Optical wavelength	1300 nm
Bridgeable distance	max. 0.93 miles (1.5 km)

PROFIBUS-FMS/DP	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 1.5 Mbaud
<u>RS485</u>	
Connection For flush-mounting housing / surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location "B"
For surface-mounting housing with two-tier terminal on the top / bottom part	At the bottom part of the housing: shielded data cable
Distance	1000 m / 3300 ft ≤ 93.75 kbaud; 500 m / 1500 ft ≤ 187.5 kbaud; 200 m / 600 ft ≤ 1.5 Mbaud; 100 m / 300 ft ≤ 12 Mbaud
Test voltage	AC 500 V against ground
<u>Fiber optic</u>	
Connection fiber-optic cable For flush-mounting housing / surface-mounting housing with detached operator panel	Integr. ST connector for FO connection, mounting location "B"
For surface-mounting housing with two-tier terminal on the top / bottom part	At the bottom part of the housing <b>Important:</b> Please refer to footnotes <sup>1)</sup> and <sup>2)</sup> on page 5/215
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	500 kbit/s 1.6 km / 0.99 miles 1500 kbit/s 530 m / 0.33 miles
MODBUS RTU, ASCII, DNP 3.0	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 19200 baud
<u>RS485</u>	
Connection For flush-mounting housing / surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location "B"
For surface-mounting housing with two-tier terminal at the top / bottom part	At bottom part of the housing: shielded data cable
Distance	Max. 1 km / 3300 ft max. 32 units recommended
Test voltage	AC 500 V against ground
<u>Fiber-optic</u>	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection Mounting location "B"
For flush-mounting housing / surface-mounting housing with detached operator panel	
For surface-mounting housing with two-tier terminal at the top / bottom part	At the bottom part of the housing <b>Important:</b> Please refer to footnotes <sup>1)</sup> and <sup>2)</sup> on page 5/174
Optical wavelength	820 nm
Permissible path attenuation	Max 8 dB. for glass fiber 62.5/125 µm
Distance	Max. 1.5 km / 0.9 miles
1) At $I_{nom} = 1\text{ A}$ , all limits divided by 5.	



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Time synchronization DCF77/IRIG-B signal (Format IRIG-B000)	
Connection	9-pin subminiature connector (SUB-D) (terminal with surface-mounting housing)
Voltage levels	5 V, 12 V or 24 V (optional)

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

Inverse-time overcurrent protection, directional/non-directional (ANSI 51, 51N, 67, 67N)	
Operating mode non-directional phase protection (ANSI 51)	3-phase (standard) or 2-phase (L1 and L3)
Setting ranges	
Pickup phase element $I_p$	0.5 to 20 A or $\infty$ <sup>1)</sup> (in steps of 0.01 A)
Pickup ground element $I_{Ep}$	0.25 to 20 A or $\infty$ <sup>1)</sup> (in steps of 0.01 A)
Time multiplier $T$ (IEC characteristics)	0.05 to 3.2 s or $\infty$ (in steps of 0.01 s)
Time multiplier $D$ (ANSI characteristics)	0.05 to 15 s or $\infty$ (in steps of 0.01 s)
Undervoltage threshold $V<$ for release $I_p$	10.0 to 125.0 V (in steps of 0.1 V)
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse, long inverse
ANSI	Inverse, short inverse, long inverse moderately inverse, very inverse, extremely inverse, definite inverse
User-defined characteristic	Defined by a maximum of 20 value pairs of current and time delay
Dropout setting	
Without disk emulation	Approx. $1.05 \cdot$ setting value $I_p$ for $I_p/III_{nom} \geq 0.3$ , corresponds to approx. $0.95 \cdot$ pickup threshold
With disk emulation	Approx. $0.90 \cdot$ setting value $I_p$

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

Tolerances	
Pickup/dropout thresholds $I_p$ , $I_{Ep}$	2 % of setting value or 50 mA <sup>1)</sup>
Pickup time for $2 \leq III_p \leq 20$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms
Dropout ratio for $0.05 \leq III_p \leq 0.9$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms

Direction detection	
For phase faults	
Polarization	With cross-polarized voltages; With voltage memory for measurement voltages that are too low
Forward range	$V_{ref,rot} \pm 86^\circ$
Rotation of reference voltage $V_{ref,rot}$	- $180^\circ$ to $180^\circ$ (in steps of $1^\circ$ )
Direction sensitivity	For one and two-phase faults unlimited; For three-phase faults dynamically unlimited; Steady-state approx. 7 V phase-to-phase
For ground faults	
Polarization	With zero-sequence quantities $3V_0$ , $3I_0$ or with negative-sequence quantities $3V_2$ , $3I_2$
Forward range	$V_{ref,rot} \pm 86^\circ$
Rotation of reference voltage $V_{ref,rot}$	- $180^\circ$ to $180^\circ$ (in steps of $1^\circ$ )
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 <sup>1)</sup>
Tolerances (phase angle error under reference conditions)	
For phase and ground faults	$\pm 1^\circ$ electrical

Inrush blocking	
Influenced functions	Time-overcurrent elements, $I>$ , $I_E>$ , $I_p$ , $I_{Ep}$ (directional, non-directional)
Lower function limit phases	At least one phase current (50 Hz and 100 Hz) $\geq 125$ mA <sup>1)</sup>
Lower function limit ground	Ground current (50 Hz and 100 Hz) $\geq 125$ mA <sup>1)</sup>
Upper function limit (setting range)	1.5 to 125 A <sup>1)</sup> (in steps of 0.01 A)
Setting range $I_{2f}$ $II$	10 to 45 % (in steps of 1 %)
Crossblock ( $I_{L1}$ , $I_{L2}$ , $I_{L3}$ )	ON/OFF

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

<i>(Sensitive) ground-fault detection (ANSI 64, 50 Ns, 51Ns, 67Ns)</i>	
<i>Displacement voltage starting for all types of ground fault (ANSI 64)</i>	
Setting ranges	
Pickup threshold $V_E >$ (measured)	1.8 to 170 V (in steps of 0.1 V)
Pickup threshold $3V_0 >$ (calculated)	10 to 225 V (in steps of 0.1 V)
Delay time $T_{\text{Delay pickup}}$	0.04 to 320 s or $\infty$ (in steps of 0.01 s)
Additional trip delay $T_{\text{VDELAY}}$	0.1 to 40000 s or $\infty$ (in steps of 0.01 s)
Times	
Pickup time	Approx. 50 ms
Dropout ratio	0.95 or (pickup value -0.6 V)
Tolerances	
Pickup threshold $V_E$ (measured)	3 % of setting value or 0.3 V
Pickup threshold $3V_0$ (calculated)	3 % of setting value or 3 V
Delay times	1 % of setting value or 10 ms
<i>Phase detection for ground fault in an ungrounded system</i>	
Measuring principle	Voltage measurement (phase-to-ground)
Setting ranges	
$V_{\text{ph min}}$ (ground-fault phase)	10 to 100 V (in steps of 1 V)
$V_{\text{ph max}}$ (unfaulted phases)	10 to 100 V (in steps of 1 V)
Measuring tolerance acc. to DIN 57435 part 303	3 % of setting value, or 1 V
<i>Ground-fault pickup for all types of ground faults</i>	
<i>Definite-time characteristic (ANSI 50Ns)</i>	
Setting ranges	
Pickup threshold $I_{EE} >$ , $I_{EE} >>$	
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A <sup>1)</sup> (in steps of 0.01 A)
Delay times $T$ for $I_{EE} >$ , $I_{EE} >>$	0 to 320 s or $\infty$ (in steps of 0.01 s)
Dropout delay time $T_{\text{DO}}$	0 to 60 s (in steps of 0.01 s)
Times	
Pickup times	Approx. 50 ms
Dropout ratio	Approx. 0.95
Tolerances	
Pickup threshold	
For sensitive input	2 % of setting value or 1 mA
For normal input	2 % of setting value or 50mA <sup>1)</sup>
Delay times	1 % of setting value or 20 ms
<i>Ground-fault pickup for all types of ground faults</i>	
<i>Inverse-time characteristic (ANSI 51Ns)</i>	
User-defined characteristic	Defined by a maximum of 20 pairs of current and delay time values
Setting ranges	
Pickup threshold $I_{EEp}$	
For sensitive input	0.001 A to 1.4 A (in steps of 0.001 A)
For normal input	0.25 to 20 A <sup>1)</sup> (in steps of 0.01 A)
User defined	
Time multiplier $T$	0.1 to 4 s or $\infty$ (in steps of 0.01 s)
Times	
Pickup times	Approx. 50 ms
Pickup threshold	Approx. $1.1 \cdot I_{EEp}$
Dropout ratio	Approx. $1.05 \cdot I_{EEp}$
Tolerances	
Pickup threshold	
For sensitive input	2 % of setting value or 1 mA
For normal input	2 % of setting value or 50mA <sup>1)</sup>
Note: Due to the high sensitivity the linear range of the measuring input IN with integrated sensitive input transformer is from 0.001 A to 1.6 A. For currents greater than 1.6 A, correct directionality can no longer be guaranteed.	
1) For $I_{\text{nom}} = 1$ A, all limits divided by 5.	

Delay times in linear range	7 % of reference value for $2 \geq III_{EEp}$ $\geq 20 + 2$ % current tolerance, or 70 ms
Logarithmic inverse	Refer to the manual
Logarithmic inverse with knee point	Refer to the manual
<i>Direction detection for all types of ground-faults (ANSI 67Ns)</i>	
<i>Measuring method "cos <math>\varphi</math> / sin <math>\varphi</math>"</i>	
Direction measurement	$I_E$ and $V_E$ measured or $3I_0$ and $3V_0$ calculated
Measuring principle	Active/reactive power measurement
Setting ranges	
Measuring enable $I_{\text{Release direct}}$	
For sensitive input	0.001 to 1.2 A (in steps of 0.001 A)
For normal input	0.25 to 150 A <sup>1)</sup> (in steps of 0.01 A)
Direction phasor $\varphi_{\text{Correction}}$	- 45 ° to + 45 ° (in steps of 0.1 °)
Dropout delay $T_{\text{Reset delay}}$	1 to 60 s (in steps of 1 s)
Tolerances	
Pickup measuring enable	
For sensitive input	2 % of setting value or 1 mA
For normal input	2 % of setting value or 50 mA <sup>1)</sup>
Angle tolerance	3 °
<i>Measuring method "<math>\varphi</math> (<math>V_0/I_0</math>)"</i>	
Direction measurement	$I_E$ and $V_E$ measured or $3I_0$ and $3V_0$ calculated
Minimum voltage $V_{\text{min}}$ , measured	0.4 to 50 V (in steps of 0.1 V)
Minimum voltage $V_{\text{min}}$ , calculated	10 to 90 V (in steps of 1 V)
Phase angle $\varphi$	-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 °
<i>Angle correction for cable CT</i>	
Angle correction F1, F2	0 ° to 5 ° (in steps of 0.1°)
Current value $I_1$ , $I_2$	
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A <sup>1)</sup> (in steps of 0.01 A)
<i>High-impedance restricted ground-fault protection (ANSI 87N) / single-phase overcurrent protection</i>	
Setting ranges	
Pickup thresholds $I_>$ , $I_>>$	
For sensitive input	0.003 to 1.5 A or $\infty$ (in steps of 0.001 A)
For normal input	0.25 to 175 A <sup>1)</sup> or $\infty$ (in steps of 0.01 A)
Delay times $T_1$ , $T_1$ >>	0 to 60 s or $\infty$ (in steps of 0.01 s)
Times	
Pickup times	
Minimum	Approx. 20 ms
Typical	Approx. 30 ms
Dropout times	Approx. 30 ms
Dropout ratio	Approx. 0.95 for $III_{\text{nom}} \geq 0.5$
Tolerances	
Pickup thresholds	
	3 % of setting value or
	1 % rated current at $I_{\text{nom}} = 1$ or 5 A;
	5 % of setting value or
	3 % rated current at $I_{\text{nom}} = 0.1$ A
Delay times	1 % of setting value or 10 ms

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Intermittent ground-fault protection	
Setting ranges	
Pickup threshold	
For $I_E$ $I_{IE>}$	0.25 to 175 A <sup>1)</sup> (in steps of 0.01 A)
For $3I_0$ $I_{IE>}$	0.25 to 175 A <sup>1)</sup> (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)
Ground-fault accumulation time	$T_{sum}$ 0 to 100 s (in steps of 0.01 s)
Reset time for accumulation	$T_{res}$ 1 to 600 s (in steps of 1 s)
Number of pickups for intermittent ground fault	2 to 10 (in steps of 1)
Times	
Pickup times	
Current = 1.25 · pickup value	Approx. 30 ms
Current ≥ 2 · pickup value	Approx. 22 ms
Dropout time	Approx. 22 ms
Tolerances	
Pickup threshold $I_{IE>}$	3 % of setting value, or 50 mA <sup>1)</sup>
Times $T_V$ , $T_{sum}$ , $T_{res}$	1 % of setting value or 10 ms
Directional intermittent ground fault protection (ANSI 67Ns)	
Setting ranges / Increments	
Pickup threshold	
$V_{gnd> / 3V0>}$	2.0 V to 100.0 V Increments 1 V
Monitoring time after pickup detected	0.04 s ... 10.00 s Increments 0.01 s
Pulse no. for detecting the interm. E/F	2 ... 50 Increments 1
Dropout ratio	
Dropout ratio $V_{gnd> / 3V0>}$	0,95 or (pickup value - 0,6 V)
Tolerances	
Measurement tolerance	
$V_{gnd> / 3V0>}$	3 % of setting value
Times	1 % of setting value or 10 ms
Influencing Variables	
Power supply direct voltage in range	$0.8 \leq VPS/VPSNom \leq 1.15$ <1 %
Temperature in range	$23.00\text{ °F} (-5\text{ °C}) \leq \Theta_{amb} \leq 131.00\text{ °F} (55\text{ °C})$ <0.5 %/K
Thermal overload protection (ANSI 49)	
Setting ranges	
Factor k	0.1 to 4 (in steps of 0.01)
Time constant	1 to 999.9 min (in steps of 0.1 min)
Warning overtemperature	50 to 100 % with reference to the tripping overtemperature (in steps of 1 %)
Current warning stage $I_{alarm}$	0.5 to 20 A (in steps of 0.01 A)
Extension factor when stopped $k_t$ factor	1 to 10 with reference to the time constant with the machine running (in steps of 0.1)
Rated overtemperature (for $I_{nom}$ )	40 to 200 °C (in steps of 1 °C)
Tripping characteristic	
For $(I/k \cdot I_{nom}) \leq 8$	$t = \tau_{th} \cdot \ln \frac{(I/k \cdot I_{nom})^2 - (I_{pre}/k \cdot I_{nom})^2}{(I/k \cdot I_{nom})^2 - 1}$
	$t$ = Tripping time
	$\tau_{th}$ = Temperature rise time constant
	$I$ = Load current
	$I_{pre}$ = Preload current
	$k$ = Setting factor acc. to VDE 0435 Part 3011 and IEC 60255-8
	$I_{nom}$ = Rated (nominal) current of the protection relay
1) At $I_{nom} = 1$ A, all limits divided by 5.	
Dropout ratios	
$\Theta/\Theta_{Trip}$	
$\Theta/\Theta_{Alarm}$	Drops out with $\Theta_{Alarm}$
$III/I_{Alarm}$	Approx. 0.99
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.), sensitive ground-fault protection, binary input
Blocking of ARC	Pickup of protection functions, three-phase fault detected by a protective element, binary input, last TRIP command after the reclosing cycle is complete (unsuccessful reclosing), TRIP command by the breaker failure protection (50BF), opening the CB without ARC initiation, external CLOSE command
Setting ranges	
Dead time (separate for phase and ground and individual for shots 1 to 4)	0.01 to 320 s (in steps of 0.01 s)
Blocking duration for manual-CLOSE detection	0.5 s to 320 s or 0 (in steps of 0.01 s)
Blocking duration after reclosure	0.5 s to 320 s (in steps of 0.01 s)
Blocking duration after dynamic blocking	0.01 to 320 s (in steps of 0.01 s)
Start-signal monitoring time	0.01 to 320 s or ∞ (in steps of 0.01 s)
Circuit-breaker supervision time	0.1 to 320 s (in steps of 0.01 s)
Max. delay of dead-time start	0 to 1800 s or ∞ (in steps of 0.1 s)
Maximum dead time extension	0.5 to 320 s or ∞ (in steps of 0.01 s)
Action time	0.01 to 320 s or ∞ (in steps of 0.01 s)
The delay times of the following protection function can be altered individually by the ARC for shots 1 to 4 (setting value $T = T$ , non-delayed $T = 0$ , blocking $T = \infty$ ):	
$I>>>, I>>, I>, I_p, I_{dir>>>}, I_{dir>}, I_{pdir}$	
$I_E>>>, I_E>>, I_E>, I_{Ep}, I_{Edir>>>}, I_{Edir>}, I_{Edir}$	
Additional functions	Lockout (final trip), delay of dead-time start via binary input (monitored), dead-time extension via binary input (monitored), co-ordination with other protection relays, circuit-breaker monitoring, evaluation of the CB contacts
Breaker failure protection (ANSI 50 BF)	
Setting ranges	
Pickup threshold	0.2 to 5 A <sup>1)</sup> (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) <sup>1)</sup>
Delay time	1 % or 20 ms
Synchro- and voltage check (ANSI 25)	
Operating modes	<ul style="list-style-type: none"> <li>• Synchrocheck</li> <li>• Asynchronous/synchronous</li> </ul>
Additional release conditions	<ul style="list-style-type: none"> <li>• Live-bus / dead line</li> <li>• Dead-bus / live-line</li> <li>• Dead-bus and dead-line</li> <li>• Bypassing</li> </ul>

<b>Voltages</b>	
Max. operating voltage $V_{\max}$	20 to 140 V (phase-to-phase) (in steps of 1 V)
Min. operating voltage $V_{\min}$	20 to 125 V (phase-to-phase) (in steps of 1 V)
$V<$ for dead-line / dead-bus check	1 to 60 V (phase-to-phase) (in steps of 1 V)
$V>$ for live-line / live-bus check	20 to 140 V (phase-to-phase) (in steps of 1 V)
Primary rated voltage of transformer $V_{2\text{nom}}$	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 ( $V<$ )
<b><math>\Delta V</math>-measurement</b>	
Voltage difference	0.5 to 50 V (phase-to-phase) (in steps of 1 V)
Tolerance	1 V
<b><math>\Delta f</math>-measurement</b>	
$\Delta f$ -measurement ( $f_2 > f_1$ ; $f_2 < f_1$ )	0.01 to 2 Hz (in steps of 0.01 Hz)
Tolerance	15 mHz
<b><math>\Delta \alpha</math>-measurement</b>	
$\Delta \alpha$ -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 $\leftrightarrow$ SYN	
Threshold synchronous / asynchronous	0.01 to 0.04 Hz (in steps of 0.01 Hz)
<b>Adaptation</b>	
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)
<b>Times</b>	
Minimum measuring time	Approx. 80 ms
Max. duration $T_{\text{SYN DURATION}}$	0.01 to 1200 s; $\infty$ (in steps of 0.01 s)
Supervision time $T_{\text{SUP VOLTAGE}}$	0 to 60 s (in steps of 0.01 s)
Closing time of CB $T_{\text{CB close}}$	0 to 60 s (in steps of 0.01 s)
Tolerance of all timers	1 % of setting value or 10 ms
<b>Measuring values of synchro-check function</b>	
Reference voltage $V_1$	In kV primary, in V secondary or in % $V_{\text{nom}}$
Range	10 to 120 % $V_{\text{nom}}$
Tolerance*)	$\leq 1$ % of measured value or 0.5 % of $V_{\text{nom}}$
Voltage to be synchronized $V_2$	In kV primary, in V secondary or in % $V_{\text{nom}}$
Range	10 to 120 % $V_{\text{nom}}$
Tolerance*)	$\leq 1$ % of measured value or 0.5 % of $V_{\text{nom}}$
Frequency of $V_1$ and $V_2$	$f_1, f_2$ in Hz
Range	$f_N \pm 5$ Hz
Tolerance*)	20 mHz
Voltage difference ( $V_2 - V_1$ )	In kV primary, in V secondary or in % $V_{\text{nom}}$
Range	10 to 120 % $V_{\text{nom}}$
Tolerance*)	$\leq 1$ % of measured value or 0.5 % of $V_{\text{nom}}$
Frequency difference ( $f_2 - f_1$ )	In mHz
Range	$f_N \pm 5$ Hz
Tolerance*)	20 mHz
Angle difference ( $\alpha_2 - \alpha_1$ )	In °
Range	0 to 180 °
Tolerance*)	0.5 °

<b>Negative-sequence current detection (ANSI 46)</b>	
<b>Definite-time characteristic (ANSI 46-1 and 46-2)</b>	
Setting ranges	
Pickup current $I_{2>}, I_{2>>}$	0.25 to 15 A <sup>1)</sup> or $\infty$ (in steps of 0.01 A)
Delay times	0 to 60 s or $\infty$ (in steps of 0.01 s)
Dropout delay time $T_{\text{DO}}$	0 to 60 s (in steps of 0.01 s)
Functional limit	All phase currents $\leq 20$ A <sup>1)</sup>
Times	
Pickup times	Approx. 35 ms
Dropout times	Approx. 35 ms
Dropout ratio	Approx. 0.95 for $I_2/I_{\text{nom}} > 0.3$
Tolerances	
Pickup thresholds	3 % of the setting value or 50 mA <sup>1)</sup>
Delay times	1 % or 10 ms
<b>Inverse-time characteristic (ANSI 46-TOC)</b>	
Setting ranges	
Pickup current	0.25 to 10 A <sup>1)</sup> (in steps of 0.01 A)
Time multiplier $T'$ (IEC characteristics)	0.05 to 3.2 s or $\infty$ (in steps of 0.01 s)
Time multiplier $D$ (ANSI characteristics)	0.5 to 15 s or $\infty$ (in steps of 0.01 s)
Functional limit	All phase currents $\leq 50$ A <sup>1)</sup>
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse
ANSI	Inverse, moderately inverse, very inverse, extremely inverse
Pickup threshold	Approx. $1.1 \cdot I_{2p}$ setting value
Dropout	
IEC and ANSI (without disk emulation)	Approx. $1.05 \cdot I_{2p}$ setting value, which is approx. 0.95 · pickup threshold
ANSI with disk emulation	Approx. $0.90 \cdot I_{2p}$ setting value
Tolerances	
Pickup threshold	3 % of the setting value or 50 mA <sup>1)</sup>
Time for $2 \leq M \leq 20$	5 % of setpoint (calculated) +2 % current tolerance, at least 30 ms
<b>Flexible protection functions (ANSI 27, 32, 47, 50, 55, 59, 81R)</b>	
Operating modes / measuring quantities	
3-phase	$I, I_1, I_2, I_2/I_1, 3I_0, V, V_1, V_2, 3V_0, dV/dt, P, Q, \cos \varphi$
1-phase	$I, I_E, I_{E \text{ sens.}}, V, V_E, P, Q, \cos \varphi$
Without fixed phase relation	$f, df/dt$ , binary input
Pickup when	Exceeding or falling below threshold value
Setting ranges	
Current $I, I_1, I_2, 3I_0, I_E$	0.15 to 200 A <sup>1)</sup> (in steps of 0.01 A)
Current ratio $I_2/I_1$	15 to 100 % (in steps of 1 %)
Sens. ground curr. $I_{E \text{ sens.}}$	0.001 to 1.5 A (in steps of 0.001 A)
Voltages $V, V_1, V_2, 3V_0$	2 to 260 V (in steps of 0.1 V)
Displacement voltage $V_E$	2 to 200 V (in steps of 0.1 V)
Power $P, Q$	0.5 to 10000 W (in steps of 0.1 W)
Power factor ( $\cos \varphi$ )	- 0.99 to + 0.99 (in steps of 0.01)
Frequency $f_N = 50$ Hz	40 to 60 Hz (in steps of 0.01 Hz)
$f_N = 60$ Hz	50 to 70 Hz (in steps of 0.01 Hz)
Rate-of-frequency change $df/dt$	0.1 to 20 Hz/s (in steps of 0.01 Hz/s)
Voltage change $dV/dt$	4 V/s to 100 V/s (in steps of 1 V/s)
Dropout ratio >- stage	1.01 to 3 (in steps of 0.01)
Dropout ratio <- stage	0.7 to 0.99 (in steps of 0.01)
Dropout differential $f$	0.02 to 1.00 Hz (in steps of 0.01 Hz)
Pickup delay time	0 to 60 s (in steps of 0.01 s)
Trip delay time	0 to 3600 s (in steps of 0.01 s)
Dropout delay time	0 to 60 s (in steps of 0.01 s)
*) With rated frequency.	
1) At $I_{\text{nom}} = 1$ 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 <sup>1)</sup>
Current (symmetrical components)	1 % of setting value or 100 mA <sup>1)</sup>
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 <sup>1)</sup> (in steps of 0.01)
Pickup threshold $I_{MOTOR START}$	2 to 50 A <sup>1)</sup> (in steps of 0.01)
Permissible starting time $T_{STARTUP, COLD MOTOR}$	1 to 180 s (in steps of 0.1 s)
Permissible starting time $T_{STARTUP, WARM MOTOR}$	0.5 to 180 s (in steps of 0.1 s)
Temperature threshold cold motor	0 to 80 % (in steps of 1 %)
Permissible blocked rotor time $T_{BLOCKED-ROTOR}$	0.5 to 120 s or ∞ (in steps of 0.1 s)

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

### Tripping time characteristic

For  $I > I_{MOTOR START}$

$$t = \left( \frac{I_{STARTUP}}{I} \right)^2 \cdot T_{STARTUP}$$

$I_{STARTUP}$  = Rated motor starting current

$I$  = Actual current flowing

$T_{STARTUP}$  = Tripping time for rated motor starting current

$t$  = Tripping time in seconds

Dropout ratio  $I_{MOTOR START}$

Approx. 0.95

Tolerances

Pickup threshold

2 % of setting value or 50 mA<sup>1)</sup>

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<sup>1)</sup> (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<sup>1)</sup>

Delay time

1 % of setting value or 10 ms

### Restart inhibit for motors (ANSI 66)

Setting ranges

Motor starting current relative to rated motor current

1.1 to 10 (in steps of 0.1)

$I_{MOTOR START} / I_{Motor Nom}$

Rated motor current  $I_{Motor Nom}$

1 to 6 A<sup>1)</sup> (in steps of 0.01 A)

Max. permissible starting time

1 to 320 s (in steps of 1 s)

$T_{Start Max}$

Equilibrium time  $T_{Equal}$

0 min to 320 min (in steps of 0.1 min)

Minimum inhibit time

0.2 min to 120 min (in steps of 0.1 min)

$T_{MIN. INHIBIT TIME}$

Max. permissible number of warm starts

1 to 4 (in steps of 1)

Difference between cold and warm starts

1 to 2 (in steps of 1)

Extension k-factor for cooling simulations of rotor at zero speed  $k_T$  at STOP

0.2 to 100 (in steps of 0.1)

Extension factor for cooling time constant with motor running

0.2 to 100 (in steps of 0.1)

$k_T$  RUNNING

Restarting limit

0.2 to 100 (in steps of 0.1)

0.2 to 100 (in steps of 0.1)

0.2 to 100 (in steps of 0.1)

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0.2 to 100 (in steps of 0.1)

0.2 to 100 (in steps of 0.1)

### 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 $\Omega$ or Ni 100 $\Omega$ or Ni 120 $\Omega$
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 $\infty$ (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 $\infty$ (no indication)

### Undervoltage protection (ANSI 27)

Operating modes/measuring quantities	
3-phase	Positive phase-sequence voltage or phase-to-phase voltages or phase-to-ground voltages
1-phase	Single-phase phase-ground or phase-phase voltage
Setting ranges	
Pickup thresholds $V<$ , $V<<$ dependent on voltage connection and chosen measuring quantity	10 to 120 V (in steps of 1 V) 10 to 210 V (in steps of 1 V)
Dropout ratio $r$	1.01 to 3 (in steps of 0.01)
Delay times $T$	0 to 100 s or $\infty$ (in steps of 0.01 s)
Current Criteria "Bkr Closed $I_{MIN}$ "	0.2 to 5 A <sup>1)</sup> (in steps of 0.01 A)
Times	
Pickup times	Approx. 50 ms
Dropout times	As pickup times
Tolerances	
Pickup thresholds	1 % of setting value or 1 V
Times	1 % of setting value or 10 ms

### Overvoltage protection (ANSI 59)

Operating modes/measuring quantities	
3-phase	Positive phase-sequence voltage or negative phase-sequence voltage or phase-to-phase voltages or phase-to-ground voltages
1-phase	Single-phase phase-ground or phase-phase voltage
Setting ranges	
Pickup thresholds $V>$ , $V>>$ dependent on voltage connection and chosen measuring quantity	40 to 260 V (in steps of 1 V) 40 to 150 V (in steps of 1 V) 2 to 150 V (in steps of 1 V)
Dropout ratio $r$	0.9 to 0.99 (in steps of 0.01)
Delay times $T$	0 to 100 s or $\infty$ (in steps of 0.01 s)
Times	
Pickup times $V>$ , $V>>$	Approx. 50 ms
Pickup times $V_1>$ , $V_2>>$	Approx. 60 ms
Dropout times	As pickup times
Tolerances	
Pickup thresholds	1 % of setting value or 1 V
Times	1 % of setting value or 10 ms

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

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

### Frequency protection (ANSI 81)

Number of frequency elements	4
Setting ranges	
Pickup thresholds for $f_{nom} = 50$ Hz	40 to 60 Hz (in steps of 0.01 Hz)
Pickup thresholds for $f_{nom} = 60$ Hz	50 to 70 Hz (in steps of 0.01 Hz)
Dropout differential	0.02 Hz to 1.00 Hz (in steps of 0.01 Hz)
=  pickup threshold – dropout threshold	
Delay times	0 to 100 s or $\infty$ (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 $\Omega$ 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 $\Omega/\text{km}^2$ (in steps of 0.0001) 0.001 to 3 $\Omega/\text{mile}^2$ (in steps of 0.0001)
Tolerances	
Measurement tolerance acc. to VDE 0435, Part 303 for sinusoidal measurement quantities	2.0 % fault location, or 0.025 $\Omega$ (without intermediate infeed) for $30^\circ \leq \varphi_K \leq 90^\circ$ and $V_K/V_{nom} \geq 0.1$ and $I_K/I_{nom} \geq 1$

### Undervoltage-controlled reactive power protection (ANSI 27/Q)

Measured Values / Modes of Operation	
3-phase	I1, V, Q,
Measuring method for I, V	Fundamental wave, Pickup when Exceeding threshold value or falling below threshold value
Setting Ranges / Increments	
Pickup thresholds	
Current I1 for $I_{Nom} = 1$ A	0.01 to 0.20 A Increments 0.01 A
for $I_{Nom} = 5$ A	0.05 to 1.00 A
Voltage V	10.0 to 210.00 V Increments 0.1 V
Power Q for $I_{Nom} = 1$ A	1.0 to 100 VAR Increments 0.01
for I VAR $Nom = 5$ A	5.0 to 500 VAR
Pickup delay (standard)	0.00 to 60.00 s Increments 0.01 s
Command delay time	0.00 to 3600.00 s Increments 0.01 s
Dropout delay	0.00 to 60.00 s Increments 0.01 s
Function Limits	
Power measurement I1 for $I_{Nom} = 1$ A	Positive sequence system current > 0.03 A
for $I_{Nom} = 5$ A	Positive sequence system current > 0.15 A
Times	
Pickup times:	
QU protection typical maximum (small signals and thresholds)	approx. 120 ms
Binary input	approx. 20 ms
Dropout times:	
QU protection typical maximum	< 50 ms
Binary input	< 350 ms
	< 10 ms

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Tolerances	Pickup thresholds		cos $\varphi$ , power factor (p.f.)	Total and phase segregated
	Current I1 for INom = 1 A	1% of setting value or 10 mA at INom $\geq$ 0.03 A 2% of setting value or 20 mA at INom < 0.03 A	Range Tolerance <sup>1)</sup>	- 1 to + 1 2 % for $ \cos \varphi  \geq 0.707$
	for INom = 5 A	1% of setting value or 50 mA at INom $\geq$ 0.25 A 2% of setting value or 100 mA at INom < 0.25 A	Frequency $f$	In Hz
	Current I1 (symmetrical components) for INom = 1 A for INom = 5 A	2% of set value or 20 mA 2% of set value or 100 mA	Range Tolerance <sup>1)</sup>	$f_{nom} \pm 5$ Hz 20 mHz
	Voltage	1% of set value or 0.1 V	Temperature overload protection $\Theta/\Theta_{Trip}$	In %
	Voltage (symmetrical components)	2% of set value or 0.2 V	Range Tolerance <sup>1)</sup>	0 to 400 % 5 % class accuracy per IEC 60255-8
	Power	1% of setting value or 0.3 VAR	Temperature restart inhibit $\Theta_L/\Theta_{L Trip}$	In %
	Times	1% of setting value or 10 ms	Range Tolerance <sup>1)</sup>	0 to 400 % 5 % class accuracy per IEC 60255-8
Influencing Variables for Pickup Values	Auxiliary direct voltage in the range	from $0.8 \leq VPS/VPS_{nom} \leq 1.15$ 1 %	Restart threshold $\Theta_{Restart}/\Theta_{L Trip}$	In %
	Temperature in the range	from 23.00 °F (-5 °C) $\leq \Theta_{amb} \leq$ 131.00 °F (55 °C) 0.5 %/10 K	Reclose time $T_{Reclose}$	In min
	Frequency in the range	from 25 Hz to 70 Hz 1 %	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
	Harmonics		Range Tolerance <sup>1)</sup>	0 mA to 1600 mA 2 % of measured value or 1 mA
	up to 10 % 3rd harmonic	1 %	RTD-box	See section "Temperature monitoring box"
	up to 10 % 5th harmonic	1 %	Synchronism and voltage check	See section "Synchronism and voltage check"
<b>Additional functions</b>			<b>Long-term averages</b>	
<b>Operational measured values</b>			Time window	5, 15, 30 or 60 min
Currents $I_{L1}$ , $I_{L2}$ , $I_{L3}$ Positive-sequence component $I_1$ Negative-sequence component $I_2$ $I_E$ or $3I_0$	Range Tolerance <sup>1)</sup>	10 to 200 % $I_{nom}$ 1 % of measured value or 0.5 % $I_{nom}$	Frequency of updates	Adjustable
	Phase-to-ground voltages $V_{L1-E}$ , $V_{L2-E}$ , $V_{L3-E}$ Phase-to-phase voltages $V_{L1-L2}$ , $V_{L2-L3}$ , $V_{L3-L1}$ , $V_{SYN}$ , $V_E$ or $V_0$ Positive-sequence component $V_1$ Negative-sequence component $V_2$	In kV primary, in V secondary or in % $V_{nom}$	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)
S, apparent power	Range Tolerance <sup>1)</sup>	10 to 120 % $V_{nom}$ 1 % of measured value or 0.5 % of $V_{nom}$	<b>Max. /Min. report</b>	
		In kVAR (MVAR or GVAR) primary and in % of $S_{nom}$	Report of measured values	With date and time
	Range Tolerance <sup>1)</sup>	0 to 120 % $S_{nom}$ 1 % of $S_{nom}$ for $V/V_{nom}$ and $I/I_{nom} = 50$ to 120 %	Reset, automatic	Time of day adjustable (in minutes, 0 to 1439 min)
<b>Operational measured values (cont'd)</b>			Reset, manual	Time frame and starting time adjustable (in days, 1 to 365 days, and $\infty$ )
P, active power		With sign, total and phase-segregated in kW (MW or GW) primary and in % $S_{nom}$	Min./Max. values for current	Using binary input, using keypad, via communication
	Range Tolerance <sup>1)</sup>	0 to 120 % $S_{nom}$ 1 % of $S_{nom}$ for $V/V_{nom}$ and $I/I_{nom} = 50$ to 120 % and $ \cos \varphi  = 0.707$ to 1 with $S_{nom} = \sqrt{3} V_{nom} \cdot I_{nom}$	Min./Max. values for voltages	$I_{L1}$ , $I_{L2}$ , $I_{L3}$ , $I_1$ (positive-sequence component)
Q, reactive power		With sign, total and phase-segregated in kVAR (MVAR or GVAR) primary and in % $S_{nom}$	Min./Max. values for power	voltages $V_{L1-E}$ , $V_{L2-E}$ , $V_{L3-E}$ $V_1$ (positive-sequence component) $V_{L1-L2}$ , $V_{L2-L3}$ , $V_{L3-L1}$
	Range Tolerance <sup>1)</sup>	0 to 120 % $S_{nom}$ 1 % of $S_{nom}$ for $V/V_{nom}$ and $I/I_{nom} = 50$ to 120 % and $ \sin \varphi  = 0.707$ to 1 with $S_{nom} = \sqrt{3} V_{nom} \cdot I_{nom}$	Min./Max. values for overload protection	$S$ , $P$ , $Q$ , $\cos \varphi$ , frequency
			Min./Max. values for mean values	$\Theta/\Theta_{Trip}$
				$I_{L1dmd}$ , $I_{L2dmd}$ , $I_{L3dmd}$ $I_1$ (positive-sequence component); $S_{dmd}$ , $P_{dmd}$ , $Q_{dmd}$
			<b>Local measured values monitoring</b>	
			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
			1) At rated frequency.	

<b>Fuse failure monitor</b>	
For all types of networks	With the option of blocking affected protection functions
<b>Fault recording</b>	
Recording of indications of the last 8 power system faults	
Recording of indications of the last 3 power system ground faults	
<b>Time stamping</b>	
Resolution for event log (operational annunciations)	1 ms
Resolution for trip log (fault annunciations)	1 ms
Maximum time deviation (internal clock)	0.01 %
Battery	Lithium battery 3 V/1 Ah, type CR ½ AA, message "Battery Fault" for insufficient battery charge
<b>Oscillographic fault recording</b>	
Maximum 8 fault records saved, memory maintained by buffer battery in case of loss of power supply	
Recording time	Total 20 s Pre-trigger and post-fault recording and memory time adjustable
Sampling rate for 50 Hz	1 sample/1.25 ms (16 samples/cycle)
Sampling rate for 60 Hz	1 sample/1.04 ms (16 samples/cycle)
<b>Energy/power</b>	
Meter values for power $W_p$ , $W_q$ (real and reactive power demand)	in kWh (MWh or GWh) and kVARh (MVARh or GVARh)
Tolerance <sup>1)</sup>	$\leq 2\%$ for $I > 0.1 I_{nom}$ , $V > 0.1 V_{nom}$ and $ \cos \phi  (p.f.) \geq 0.707$
<b>Statistics</b>	
Saved number of trips	Up to 9 digits
Number of automatic reclosing commands (segregated according to 1 <sup>st</sup> and $\geq 2^{nd}$ cycle)	Up to 9 digits
<b>Circuit-breaker wear</b>	
Methods	<ul style="list-style-type: none"> <li>• <math>\Sigma I^x</math> with <math>x = 1 \dots 3</math></li> <li>• 2-point method (remaining service life)</li> <li>• <math>\Sigma I^2 t</math></li> </ul>
Operation	Phase-selective accumulation of measured values on TRIP command, up to 8 digits, phase-selective limit values, monitoring indication
<b>Motor statistics</b>	
Total number of motor start-ups	0 to 9999 (resolution 1)
Total operating time	0 to 99999 h (resolution 1 h)
Total down-time	0 to 99999 h (resolution 1 h)
Ratio operating time/down-time	0 to 100 % (resolution 0.1 %)
Active energy and reactive energy	See operational measured values
Motor start-up data	Of the last 5 start-ups
– Start-up time	0.30 s to 9999.99 s (resolution 10 ms)
– Start-up current (primary)	0 A to 1000 kA (resolution 1 A)
– Start-up voltage (primary)	0 V to 100 kV (resolution 1 V)

1) At rated frequency.

<b>Operating hours counter</b>	
Display range	Up to 7 digits
Criterion	Overshoot of an adjustable current threshold (BkrClosed $I_{MIN}$ )
<b>Trip circuit monitoring</b>	
With one or two binary input	
<b>Commissioning aids</b>	
Phase rotation field check, operational measured values, circuit-breaker/switching device test, creation of a test measurement report	
<b>Clock</b>	
Time synchronization	DCF77/IRIG-B signal (telegram format IRIG-B000), binary input, communication
<b>Setting group switchover of the function parameters</b>	
Number of available setting groups	4 (parameter group A, B, C and D)
Switchover performed	Via keypad, DIGSI, system (SCADA) interface or binary input
<b>Control</b>	
Number of switching units	Depends on the binary inputs and outputs
Interlocking	Programmable
Circuit-breaker signals	Feedback, close, open, intermediate position
Control commands	Single command / double command 1, 1 plus 1 common or 2 trip contacts
Programmable controller	CFC logic, graphic input tool
Local control	
Units with small display	Control via menu, assignment of a function key
Units with large display	Control via menu, control with control keys
Remote control	Via communication interfaces, using a substation automation and control system (e.g. SICAM), DIGSI 4 (e.g. via modem)

### CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EG previous 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 2006/95/EG previous 73/23/EEC).

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

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1. The unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

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



## Selection and ordering data

See next page

5/192 Siemens SIP · Edition No. 7

Description	Order No.	Order code
<b>7SJ64 multifunction protection relay with synchronization</b>	7SJ64□□-□□□□□□-□□□□-□□□□	
<b>System interface (on rear of unit, Port B)</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 <sup>1)</sup>	5	
PROFIBUS-FMS Slave, 820 nm wavelength, double ring, ST connector <sup>1)</sup>	6	
PROFIBUS-DP Slave, RS485	9	L O A
PROFIBUS-DP Slave, 820 nm wavelength, double ring, ST connector <sup>1)</sup>	9	L O B
MODBUS, RS485	9	L O D
MODBUS, 820 nm wavelength, ST connector <sup>2)</sup>	9	L O E
DNP 3.0, RS485	9	L O G
DNP 3.0, 820 nm wavelength, ST connector <sup>2)</sup>	9	L O H
IEC 60870-5-103 protocol, redundant, RS485, RJ45 connector <sup>2)</sup>	9	L O P
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector (EN 100)	9	L O R
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector (EN 100) <sup>2)</sup>	9	L O S
DNP3 TCP + IEC 61850, 100Mbit Eth, electrical, double, RJ45 connector <sup>4)</sup>	9	L 2 R
DNP3 TCP + IEC 61850, 100Mbit Eth, optical, double, LC connector <sup>4)</sup>	9	L 2 S
PROFINET + IEC 61850, 100Mbit Eth, electrical, double, RJ45 connector <sup>4)</sup>	9	L 3 R
PROFINET + IEC 61850, 100Mbit Eth, optical, double, LC connector <sup>4)</sup>	9	L 3 S
<b>Only Port C (service interface)</b>		
DIGSI 4/modem, electrical RS232	1	
DIGSI 4/modem/RTD-box <sup>3)</sup> , electrical RS485	2	
<b>Port C and D (service and additional interface)</b>	9	M□□
<b>Port C (service interface)</b>		
DIGSI 4/modem, electrical RS232		1
DIGSI 4/modem/RTD-box <sup>3)</sup> , electrical RS485		2
<b>PortD(additional interface)</b>		
RTD-box <sup>3)</sup> , 820 nm fiber, ST connector <sup>5)</sup>		A
RTD-box <sup>3)</sup> , electrical RS485		F
<b>Measuring/fault recording</b>		
Fault recording	1	
Slave pointer,mean values, min/max values, fault recording	3	

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

2) Not available with position 9 = "B".

3) Temperature monitoring box 7XV5662-□AD10, refer to "Accessories".

4) Available with V4.9

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

# Overcurrent Protection / 7SJ64

## Selection and ordering data

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

Continued on next page

■ Basic version included

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

Dir = Directional overcurrent protection

IEF = Intermittent ground fault

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

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

3) available with V4.9



# Overcurrent Protection/7SJ64

## Selection and ordering data

5

Description			Order No.	Order code
<b>7SJ64 multifunction protection relay with synchronization</b>			<b>7SJ64</b> □□-□□□□□□-□□□□-□□□□	
Designation	ANSI No.	Description		
Basic version		Control		
	50/51	Overcurrent protection $I>$ , $I>>$ , $I>>>$ , $I_p$		
	50N/51N	Ground-fault protection $I_E>$ , $I_E>>$ , $I_E>>>$ , $I_{Ep}$		
	50N/51N	Insensitive ground-fault protection via IEE function: $I_{EE>}$ , $I_{EE>>}$ , $I_{EEp}^{1)}$		
	50/50N	Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I_2>$ , $I>>>$ , $I_E>>>$		
	51 V	Voltage-dependent inverse-time overcurrent protection		
	49	Overload protection (with 2 time constants)		
	46	Phase balance current protection (negative-sequence protection)		
	37	Undercurrent monitoring		
	47	Phase sequence		
	59N/64	Displacement volt		
	50BF	Breaker failure protection		
	74TC	Trip circuit supervision		
		4 setting groups, cold-load pickup		
		Inrush blocking		
	86	Lockout		
Sens. ground-f. det. Motor	67Ns	Directional sensitive ground-fault detection		
Dir V,P,f REF	67Ns	Directional intermittent ground fault protection <sup>3)</sup>		
■	87N	High-impedance restricted ground fault		
	27/59	Under-/overvoltage		
	81O/U	Under-/overfrequency		
	27/Q	Undervoltage-controlled reactive power protection <sup>3)</sup>		
	27/47/59(N)	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		F F <sup>2)</sup>
Sens. ground-f. det. Motor IEF	67/67N	Directional sensitive ground-fault detection, phases and ground		
Dir V,P,f REF	67Ns	Directional sensitive ground-fault detection		
■	67Ns	Directional intermittent ground fault protection <sup>3)</sup>		
	87N	High-impedance restricted ground fault		P D <sup>2)</sup>
		Intermittent ground fault		
Sens. ground-f. det. Motor	67Ns	Directional sensitive ground-fault detection		
Dir V,P,f REF	67Ns	Directional intermittent ground fault protection <sup>3)</sup>		
■	87N	High-impedance restricted ground fault		F B <sup>2)</sup>
Sens. ground-f. det. Motor	67Ns	Directional sensitive ground-fault detection		
Dir V,P,f REF	67Ns	Directional intermittent ground fault protection <sup>3)</sup>		
■	87N	High-impedance restricted ground fault		
	48/14	Starting time supervision, locked rotor		
	66/86	Restart inhibit		
	51M	Load jam protection, motor statistics		
	27/59	Under-/overvoltage		
	81O/U	Under-/overfrequency		
	27/Q	Undervoltage-controlled reactive power protection <sup>3)</sup>		
	27/47/59(N)	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		H F <sup>2)</sup>
Sens. ground-f. det. Motor	67/67N	Direction determination for overcurrent, phases and ground		
Dir V,P,f REF	67Ns	Directional sensitive ground-fault detection		
	67Ns	Directional intermittent ground fault protection <sup>3)</sup>		
	87N	High-impedance restricted ground fault		
	48/14	Starting time supervision, locked rotor		
	66/86	Restart inhibit		
	51M	Load jam protection, motor statistics		
	27/59	Under-/overvoltage		
	81O/U	Under-/overfrequency		
	27/Q	Undervoltage-controlled reactive power protection <sup>3)</sup>		
	27/47/59(N)	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		H H <sup>2)</sup>
■ Basic version included			1) Only with insensitive ground-current transformer when position 7 = 1, 5, 7.	
V, P, f = Voltage, power, frequency protection			2) For isolated/compensated networks only with sensitive ground-current transformer when position 7 = 2, 6.	
Dir = Directional overcurrent protection			3) available with V4.9	
IEF = Intermittent ground fault				

Continued on next page

## 5

Description				Order No.	Order code
7SJ64 multifunction protection relay with synchronization				7SJ64	□□-□□□□□-□□□□-□□□□
Designation	ANSI No.	Description			
Basic version		Control			
	50/51	Overcurrent protection $I>$ , $I>>$ , $I>>>$ , $I_p$			
	50N/51N	Ground-fault protection $I_E>$ , $I_E>>$ , $I_E>>>$ , $I_{Ep}$			
	50N/51N	Insensitive ground-fault protection via IEE function: $I_{EE>}$ , $I_{EE>>}$ , $I_{EEp}^{1)}$			
	50/50N	Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I_2>$ , $I>>>>$ , $I_E>>>>$			
	51 V	Voltage-dependent inverse-time overcurrent protection			
	49	Overload protection (with 2 time constants)			
	46	Phase balance current protection (negative-sequence protection)			
	37	Undercurrent monitoring			
	47	Phase sequence			
	59N/64	Displacement voltage			
	50BF	Breaker failure protection			
	74TC	Trip circuit supervision			
		4 setting groups, cold-load pickup			
		Inrush blocking			
	86	Lockout			
Sens. ground-f. det.	Motor	67/67N	Direction determination for overcurrent, phases and ground		
Dir V, P, f REF		67Ns	Directional sensitive ground-fault detection		
■		67Ns	Directional intermittent ground fault protection <sup>3)</sup>		
		87N	High-impedance restricted ground fault		
			Intermittent ground fault		
		48/14	Starting time supervision, locked rotor		
		66/86	Restart inhibit		
		51M	Load jam protection, motor statistics		
		27/59	Undervoltage/overvoltage		
		81O/U	Underfrequency/overfrequency		
		27/Q	Undervoltage-controlled reactive power protection <sup>3)</sup>		
		27/47/59(N)	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	R	H <sup>2)</sup>
		32/55/81R			
■	Motor Dir	V, P, f	67/67N		
			48/14		
			66/86		
			51M		
			27/59		
			81O/U		
			27/Q		
			27/47/59(N)		
			32/55/81R		
				H	G
■	Motor		48/14		
			66/86		
			51M		
				H	A
ARC, fault locator, synchronization					
			Without		0
			79		1
			21FL		2
			79, 21FL		3
			25		4
			25, 79, 21FL		7
ATEX100 Certification					
For protection of explosion-protected motors (increased-safety type of protection "e")					
				Z	X 9 9 <sup>2)</sup>






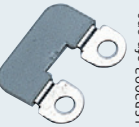

Dir = Directional overcurrent protection

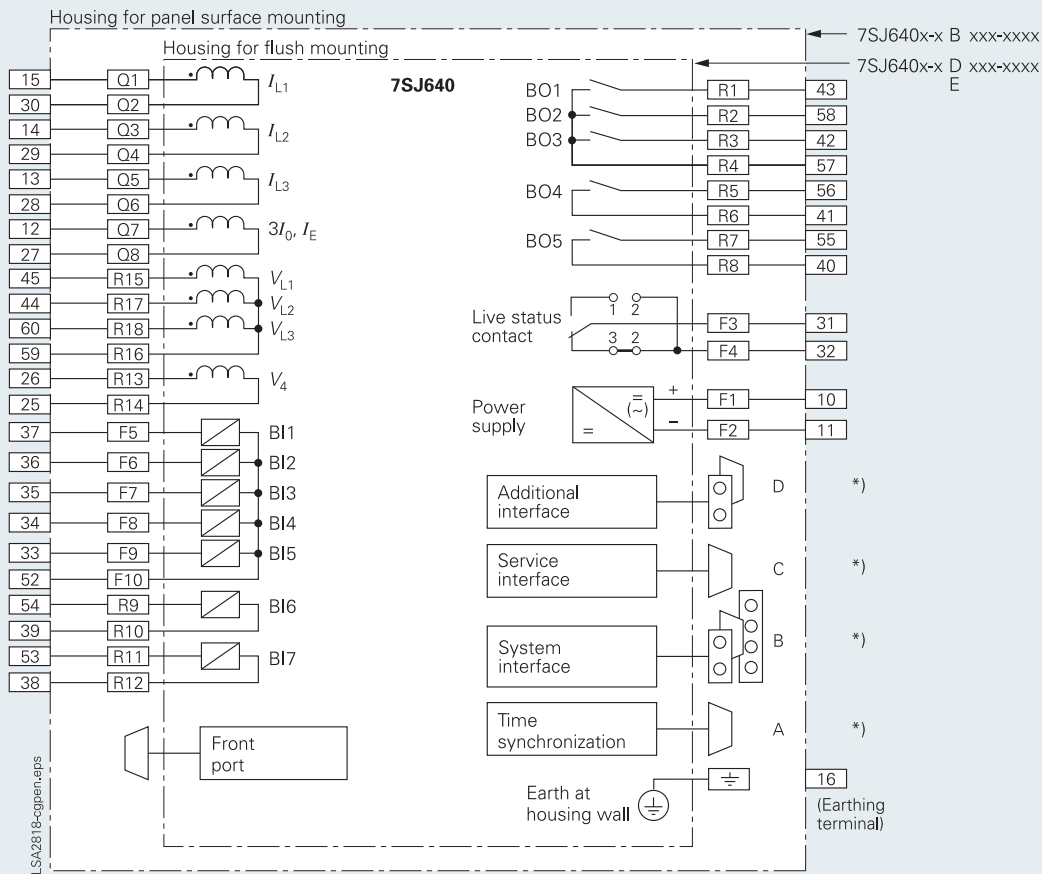
3) available with V4.9

Accessories	Description	Order No.
	<b>DIGSI 4</b> 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
	<b>IEC 61850 Systemconfigurator</b> 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
	<b>SIGRA 4</b> 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
	<b>Temperature monitoring box</b> AC/DC 24 to 60 V AC/DC 90 to 240 V	7XV5662-2AD10 7XV5662-5AD10
	<b>Varistor/VoltageArrester</b> Voltage arrester for high-impedance REF protection 125 Vrms; 600 A; 1S/S 256 240 Vrms; 600 A; 1S/S 1088	C53207-A401-D76-1 C53207-A401-D77-1
	<b>Connecting cable</b> Cable between PC/notebook (9-pin con.) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally) Cable between temperature monitoring box and SIPROTEC 4 unit - length 5 m / 16.4 ft - length 25 m / 82 ft - length 50 m / 164 ft	7XV5100-4 7XV5103-7AA05 7XV5103-7AA25 7XV5103-7AA50
	<b>Manual for 7SJ64</b> English /German	C53000-G1100-C147-x <sup>1)</sup>
	1) x = please inquire for latest edition (exact Order No.).	

# Overcurrent Protection / 7SJ64

## Selection and ordering data

Accessories	Description	Order No.	Size of package	Supplier
   <p>Mounting rail LSP2289-afp.eps</p>   <p>2-pin connector LSP2090-afp.eps 3-pin connector LSP2091-afp.eps</p>   <p>Short-circuit links for current terminals LSP2093-afp.eps Short-circuit links for current terminals LSP2092-afp.eps</p>	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 <sup>2</sup>	0-827039-1	4000 taped on reel	AMP <sup>1)</sup>
	Crimp connector CI2 0.5 to 1 mm <sup>2</sup>	0-827396-1	1	AMP <sup>1)</sup>
	Crimp connector: Type III+ 0.75 to 1.5 mm <sup>2</sup>	0-163084-2	1	AMP <sup>1)</sup>
	Crimp connector: Type III+ 0.75 to 1.5 mm <sup>2</sup>	0-163083-7	4000 taped on reel	AMP <sup>1)</sup>
	Crimping tool for Type III+ and matching female	0-539635-1	1	AMP <sup>1)</sup>
	Crimping tool for CI2 and matching female	0-539668-2	1	AMP <sup>1)</sup>
	Crimping tool for CI2 and matching female	0-734372-1	1	AMP <sup>1)</sup>
	Crimping tool for CI2 and matching female	1-734387-1	1	AMP <sup>1)</sup>
	Short-circuit links for current terminals	C73334-A1-C33-1	1	Siemens
	Short-circuit links for other terminals	C73334-A1-C34-1	1	Siemens
	Mounting rail for 19" rack	C73165-A63-D200-1	1	Siemens
	1) Your local Siemens representative can inform you on local suppliers.			

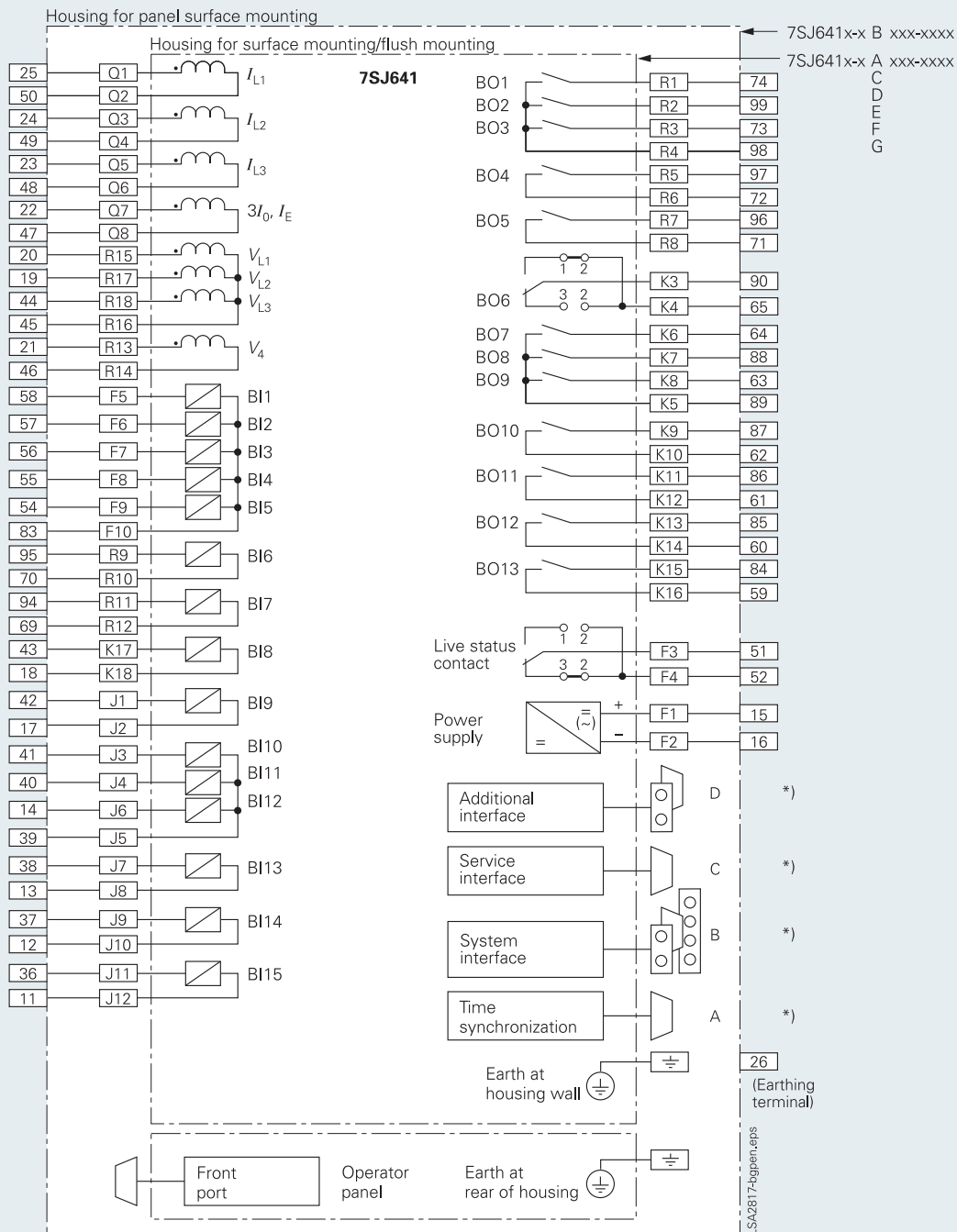


\*) For pinout of communication ports see part 14 of this catalog.  
For the allocation of the terminals of the panel surface-mounting version refer to the manual (<http://www.siemens.com/siprotec>).

Fig. 5/176 7SJ640 connection diagram

# Overcurrent Protection/7SJ64

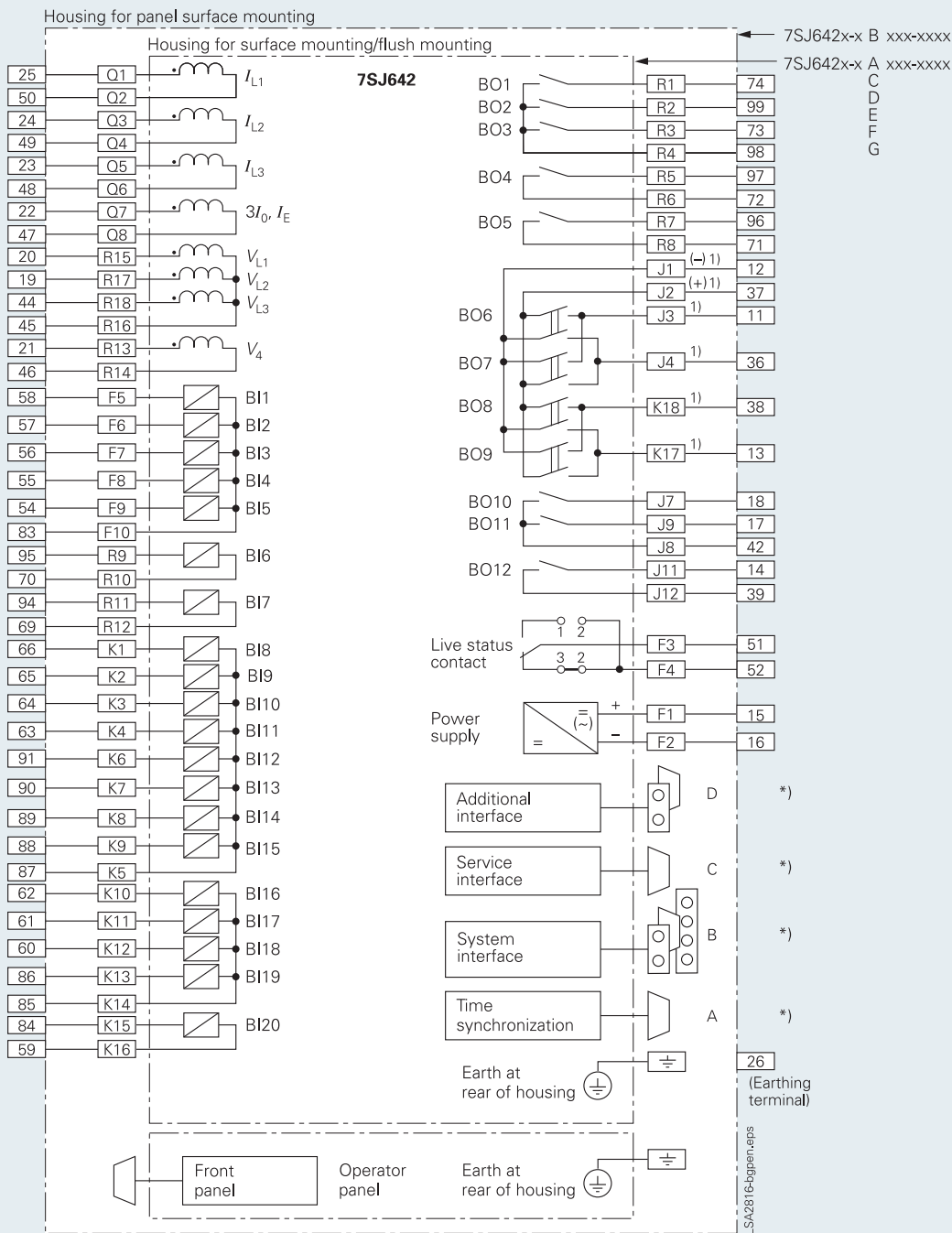
## Connection diagram



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

Fig. 5/177 7SJ641 connection diagram





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

1) Power relays are intended to directly control motorized switches. The power relays are interlocked so only one relay of each pair can close at a time, in order to avoid shorting out the power supply. The power relay pairs are BO6/BO7, BO8/BO9. If used for protection purposes only one binary output of a pair can be used.

Fig. 5/178 7SJ642 connection diagram

# Overcurrent Protection/7SJ64

## Connection diagram

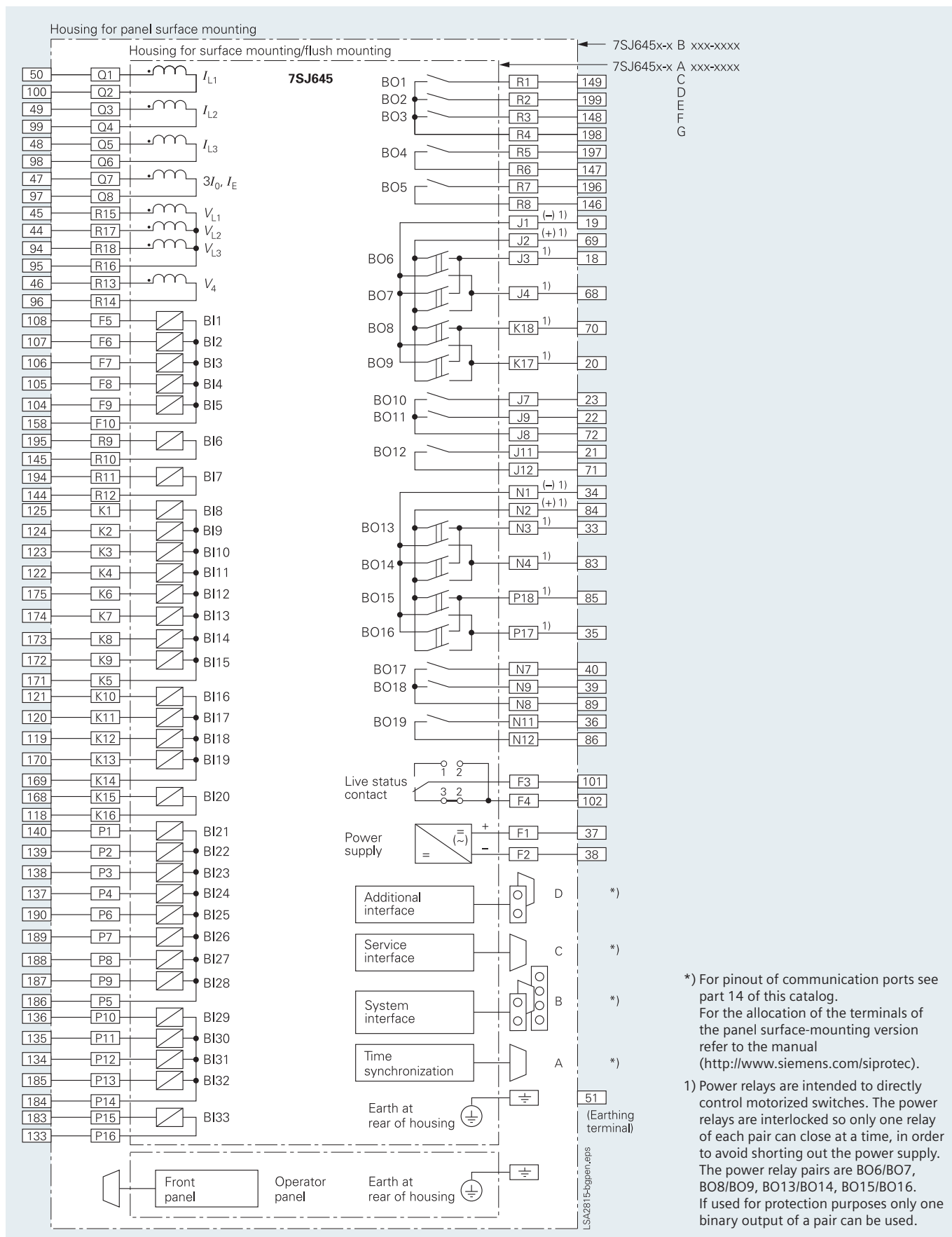


Fig. 5/179 7SJ645 connection diagram

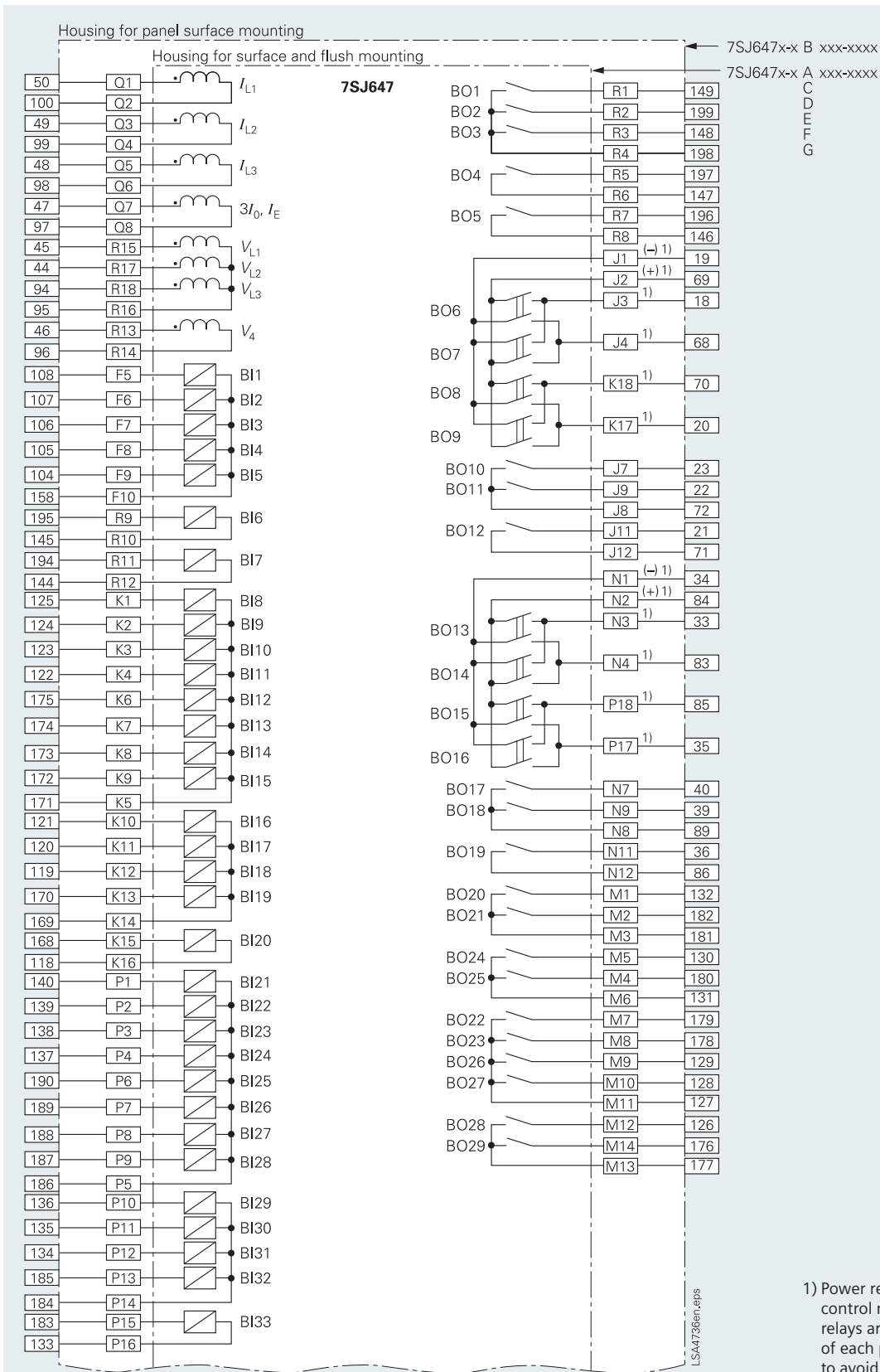
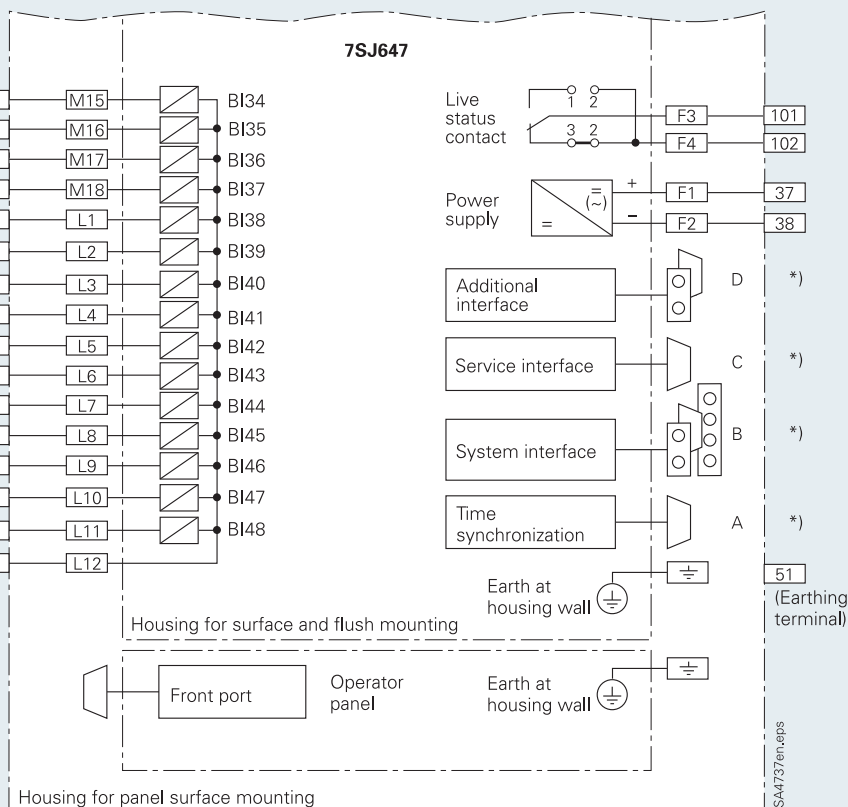


Fig. 5/180 7SJ647 connection diagram part 1; continued on following page

# Overcurrent Protection / 7SJ64

## Connection diagram



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

Fig. 5/181 7SJ647 connection diagram part 2