SIPROTEC Compact
Generator and Motor Protection 7SK81
for Low-Power CT and VT Applications

SIEMENS

Generator and Motor Protection 7SK81

for Low-Power CT and VT Applications

You will find a detailed overview of the technical data
(extract of the manual) under:
http://www.siemens.com/siprotec

Description

The SIPROTEC Compact 7SK81 provides 4 low-power current transformer inputs and optionally 3 low-power voltage transformer inputs. With the same low-power current transformer (LPCT) a wide range of primary rated line currents can be covered. Objects with rated currents in the range of 40 A to 5000 A can be protected when using low-power current transformers. The following low-power current transformer ratios are suitable for the following primary current operating ranges:

- 100A/225mV for a primary operating current range of 40A ... 600A
- 50A/22.5mV for a primary operating current range of 200A ... 3000A
- 400A/225mV for a primary operating current range of 200A ... 2500A
- 100A/22.5mV for a primary operating current range of 400A ... 5000A

Resistive dividers are provided as low-power voltage transformers (LPVT).

Please refer to page 4/5 for a list of available low-power current transformers, low-power voltage transformers (voltage dividers) and a combined low-power current transformer with an integrated voltage divider from TRENCH.

The SIPROTEC Compact 7SK81 is a multi-functional motor protection relay. It is designed for protection of asynchronous motors of all sizes.

The SIPROTEC Compact 7SK81 offers highest reliability at major functionality by the synergy of reliable algorithms with newly developed hardware. The reliability is proven by the experience in the field of almost 1,000,000 SIPROTEC devices.

The relay provides numerous functions to respond flexibly to the system requirements and to deploy the invested capital economically. Examples for this are: exchangeable interfaces, flexible protection functions and the integrated automation level (CFC).

Freely assignable LEDs and a six-line display ensure a unique and clear display of the process states. In combination with up to 9 function keys, the operating personnel can react quickly and safely in any situation.

This guarantees a high operational reliability.

Fig. 4/1 7SK81 front view

Fig. 4/2 7SK81 rear view

Highlights

- Inputs for low power VTs and CTs according IEC 61869-6 (formerly IEC 60044-7 and IEC 60044-8)
- Removable terminal blocks
- Binary input thresholds settable using DIGSI (3 stages)
- 9 programmable function keys
- 6-line display
- Buffer battery exchangeable from the front
- USB front port
- 2 additional communication ports
- IEC 61850 with integrated redundancy (electrical or optical)
- Relay-to-relay communication through Ethernet with IEC 61850 GOOSE
- Millisecond-accurate time synchronization through Ethernet with SNTP.

Generator and Motor Protection 7SK81

for Low-Power CT and VT Applications - Function overview

Protection functions	IEC	ANSI
Instantaneous and definite time-overcurrent protection (phase/neutral)	I>, I>>, I>>>, I_E>, I_E>>, I_E>>>; I_p, I_{Ep}	50, 50N; 51, 51N
Directional time-overcurrent protection, ground	$I_{E\ dir}$>, $I_{E\ dir}$>>, $I_{Ep\ dir}$	67N
Directional overcurrent protection, ground (definite/inverse)	I_{EE}>, I_{EE}>>, I_{EEp}	67Ns, 50Ns
Displacement voltage, zero-sequence voltage	V_E, V_0>	59N
Undercurrent monitoring	I<	37
Temperature monitoring		38
Thermal overload protection	ϑ>	49
Load jam protection		51M
Locked rotor protection		14
Restart inhibit		66/86
Undervoltage/overvoltage protection	V<, V>	27/59
Forward-power, reverse-power protection	P<>, Q<>	32
Power factor	cos φ	55
Overfrequency/underfrequency protection	f<, f>	81O/U
Breaker failure protection		50BF
Phase-balance current protection (negative-sequence protection)	I_2>	46
Unbalance-voltage protection and/or phase-sequence monitoring	V_2>, phase sequence	47
Start-time supervision		48
Lockout		86
Rate-of-frequency-change protection	df/dt	81R

Table 4/1 Function overview

Control functions/programmable logic

- Commands for the ctrl. of CB, disconnect switches (isolators/isolating switches)
- Control through keyboard, binary inputs, DIGSI 4 or SCADA system
- User-defined PLC 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
- Minimum and maximum values
- Trip circuit supervision
- Fuse failure monitor
- 8 oscillographic fault records
- Motor statistics.

Communication interfaces

- System/service interface
  – IEC 61850
  – IEC 60870-5-103
  – PROFIBUS-DP
  – DNP 3.0
  – MODBUS RTU
- Ethernet interface for DIGSI 4, RTD box
- USB front interface for DIGSI 4.

Hardware

- 4 current inputs
- 0/3 voltage inputs
- 3/7 binary inputs (thresholds configurable using software)
- 5/8 binary outputs (2 changeover)
- 0/5 RTD inputs
- 1 live-status contact
- Pluggable voltage terminals.

Type	Order No.	Ratio	Type	Order No.
lopo CT	16 100 008	100A/225mV	LPCT 25-A (D120) with CAT.5 cable and RJ45 connector	3-16100000
lopo CT	16 100 005	50A/22.5mV	LPCT 25-A (D120) with CAT.5 cable and RJ45 connector	3-16100000
lopo CT	16 110 005	50A/22.5mV	LPCT 25-B (D108) with CAT.5 cable and RJ45 connector	3-16110000
lopo CT	16 120 005	50A/22.5mV	LPCT 25-C (D300) with CAT.5 cable and RJ45 connector	3-16120000
lopo CT	16 130 005	50A/22.5mV	LPCT 25-D (D55) with CAT.5 cable and RJ45 connector	3-16130000
split-core lopo CT	16 140 005	60A/7.07V	LPCT K-60 (D120) with CAT.5 cable and RJ45 connector	3-16140000
lopo CT	16 150 005	50A/22.5mV	LPCT 25-E (oval) with CAT.5 cable and RJ45 connector	3-16150003
lopo VT (resistive divider)	see table below		LPVT-A with CAT.5 cable and RJ45 connector	3-16300000
lopo VT (resistive divider)	see table below		LPVT-I with CAT.5 cable and RJ45 connector (size 2)	3-16320000
lopo VT (resistive divider)	see table below		LPVT-I with CAT.5 cable and RJ45 connector (size 3)	3-16320010
lopo VT (resistive divider)	see table below		LPVT-G with CAT.5 cable and RJ45 connector	3-16340000
lopo VT (resistive divider)	see table below		LPVT-P with CAT.5 cable and RJ45 connector	3-16360000
lopo VT (resistive divider)	see table below		LPVT-F with CAT.5 cable and RJ45 connector	3-16380000
lopo VT (resistive divider)	see table below		LPVT-S with CAT.5 cable and RJ45 connector	3-16380101
combined (lopo CT with integrated resistive divider)	16 401 202	CT: 50A/22.5mV VT: prim: 10kV/√3 sec: 3.25V/√3	LPVCT-12 with CAT.5 cable and RJ45 connector; 4 x M12	3-16400002

Table 4/2 Available low-power transformers from TRENCH

CAT.5 cable length: Standard 6.5 m
Contact partner: Rolf.Fluri@siemens.com

Trench Switzerland AG, Lehenmattstraße 353, CH-4028 Basel

LOPO Voltage Transformers

				4	5	6	7 8									
	Order No.:		16 3	□	□	2	□ □									
								01	02	03	04	05	06	07	08	
Highest voltage for equipment [kV] →								7.2	12	15.5	24	36	38	40	52	
		Ratio →						$\frac{6kV}{\sqrt{3}} / \frac{3.25V}{\sqrt{3}}$	$\frac{10kV}{\sqrt{3}} / \frac{3.25V}{\sqrt{3}}$	$\frac{15kV}{\sqrt{3}} / \frac{3.25V}{\sqrt{3}}$	$\frac{20kV}{\sqrt{3}} / \frac{3.25V}{\sqrt{3}}$	$\frac{30kV}{\sqrt{3}} / \frac{3.25V}{\sqrt{3}}$	$\frac{34.5kV}{\sqrt{3}} / \frac{3.25V}{\sqrt{3}}$	$\frac{36kV}{\sqrt{3}} / \frac{3.25V}{\sqrt{3}}$	$\frac{45kV}{\sqrt{3}} / \frac{3.25V}{\sqrt{3}}$	Drawing No.
Type	LPVT-A			0	0		→	✓	✓	✓	✓	X	X	X	X	3-16300000
Type	LPVT-I	size2		2	0		→	✓	✓	✓	✓	✓	X	X	X	3-16320000
Type	LPVT-I	size3		2	1		→	X	X	X	X	✓	✓	✓	✓	3-16320010
Type	LPVT-G			4	0		→	✓	✓	✓	✓	✓	✓	X	X	3-16340000
Type	LPVT-P			6	0		→	✓	✓	✓	✓	✓	X	X	X	3-16360000
Type	LPVT-F			8	0		→	✓	✓	✓	✓	X	X	X	X	3-16380000
Type	LPVT-S			8	1		→	✓	✓	✓	✓	✓	X	X	X	3-16380101
	RJ45 connector					2										

Table 4/3 Order no. for LOPO voltage transformers

Generator and Motor Protection 7SK81

for Low-Power CT and VT Applications - Applications

The SIPROTEC Compact 7SK81 unit is a numerical motor protection relay for low power CT and VT inputs. It can perform control and monitoring functions and therefore provide the user with a cost-effective platform for power system management, that ensures reliable supply of electrical power to the customers. The ergonomic design makes control easy from the relay front panel. A large, easy-to-read display was a key design factor.

Control

The integrated control function permits control of disconnect devices, grounding switches or circuit-breakers through the integrated operator panel, binary inputs, DIGSI 4 or the control or automation system (e.g. SICAM).

Programmable logic

The integrated logic characteristics (CFC) allow the user to add own functions for automation of switchgear (e.g. interlocking) or switching sequence. The user can also generate user-defined messages. This functionality can form the base to create extremely flexible transfer schemes.

Operational measured value

Extensive measured values (e.g. I, V), metered values (e.g.W_p,W_q) and limit values (e.g. for voltage, frequency) provide improved system management.

Operational indication

Event logs, trip logs, fault records and statistics documents are stored in the relay to provide the user or operator with all the key data required to operate modern substations.

Motor protection

The 7SK81 relay is specifically designed to protect induction-type asynchronous motors.

Line protection

The 7SK81 units can be used for line protection of high and medium-voltage networks with grounded, low-resistance grounded, isolated or a compensated neutral point.

Transformer protection

The 7SK81 relay provides all the functions for backup protection for transformer differential protection. The inrush suppression effectively prevents unwanted trips that can be caused by inrush currents.

Backup protection

As a backup protection the 7SK81 devices are universally applicable.

Switchgear cubicles for high/medium voltage

All units are designed specifically to meet the requirements of high/medium-voltage applications. In general, no separate measuring instruments (e.g., for current, voltage, frequency, ...) or additional control components are necessary.

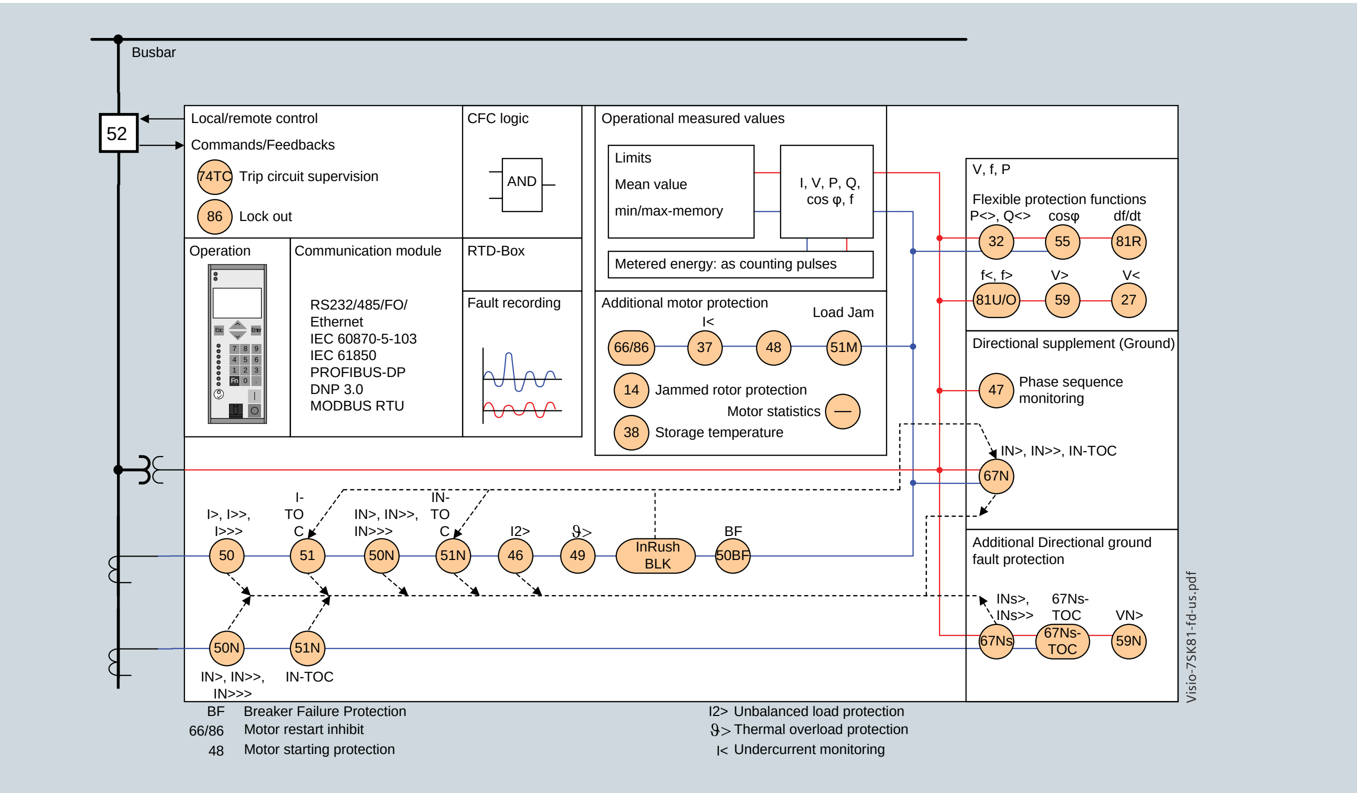


Fig. 4/3 Function diagram

Protection functions

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

This function is based on the phase selective measurement of the three phase currents and the ground current (four transformers). Three definite-time overcurrent protection elements (DMT) are available both for the phase and the ground elements. The current threshold and the delay time can be set in a wide range.

Inverse-time overcurrent protection characteristics (IDMTL) can also be selected and activated.

Reset characteristics

Time coordination with electromechanical relays are made easy with the inclusion of the reset characteristics according to ANSI C37.112 and IEC 60255-3 /BS 142 standards. When using the reset characteristic (disk emulation), the 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 (disk emulation).

Available inverse-time characteristics

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

Table 4/4 Available inverse-time characteristics

Inrush restraint

If second harmonic content is detected during the energization of a transformer, the pickup of stages I>, I_p, $I>_{dir}$ and $I_{p\ dir}$ is blocked.

Dynamic settings group switching

In addition to the static parameter changeover, the pickup thresholds and the tripping times for the directional and non-directional time-overcurrent protection functions can be changed over dynamically. As changeover criterion, the circuit-breaker position, the prepared auto-reclosure, or a binary input can be selected.

Directional overcurrent protection, ground (ANSI 67N)

Directional ground protection is a separate function. It operates in parallel to the non-directional ground overcurrent elements. Their pickup values and delay times can be set separately. Definite-time and inverse-time characteristics aroffered. The tripping characteristic can be rotated by 0 to ± 180 degrees.

For ground protection, users can choose whether the direction is to be calculated using the zero-sequence or negative-sequence system quantities (selectable). If the zero-sequence voltage tends to be very low due to the zero-sequence impedance it will be better to use the negative-sequence quantities.

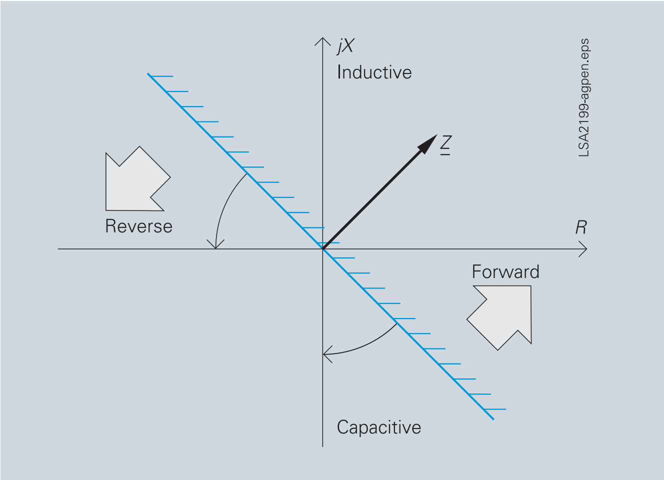


Fig. 4/4 Directional characteristic of the directional time-overcurrent protection, ground

(Sensitive) directional ground-fault detection (ANSI 59N/64, 67Ns, 67N)

For isolated-neutral and compensated networks, the direction of power flow in the zero sequence is calculated from the zero-sequence current I_0 and zero-sequence voltage V_0. For networks with an isolated neutral, the reactive current component is evaluated; for compensated networks, the active current component or residual resistive current is evaluated. For special network conditions, e.g. high-resistance grounded networks with ohmic-capacitive ground-fault current or low-resistance grounded networks with ohmic-inductive current, the tripping characteristics can be rotated approximately ± 45 degrees (see Fig. 4/5).

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 to forward, reverse or non-directional
- The function can also be operated in the insensitive mode as an additional short-circuit protection.

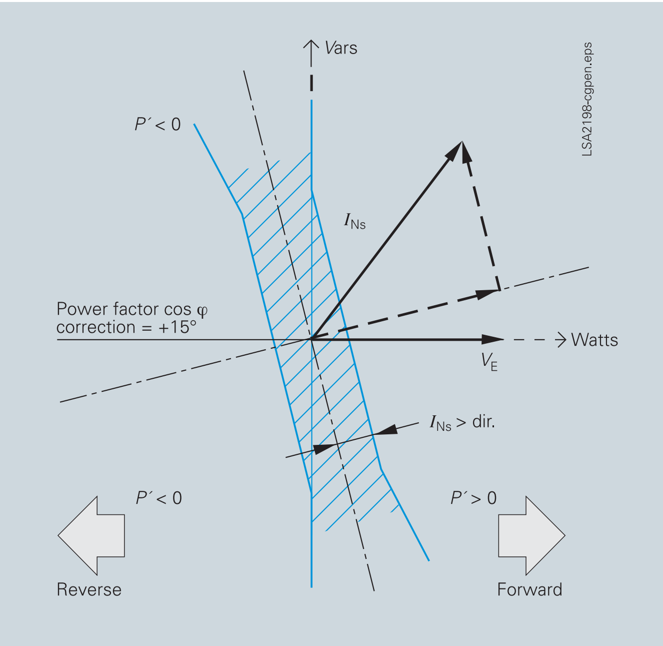


Fig. 4/5 Directional determination using cosine measurements for compensated networks

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

For high-resistance grounded networks, a sensitive input transformer is connected to a split-core low-power current transformer (also called core-balance CT). The function can also be operated in the normal mode as an additional short-circuit protection for neutral or residual ground protection.

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

By measuring current on the high side of the transformer, the two-element phase-balance current/negative-sequence protection detects high-resistance phase-to-phase faults and phase-to-ground faults on the low side of a transformer (e.g. Dy 5). This function provides backup protection for high-resistance faults through the transformer.

Breaker failure protection (ANSI 50BF)

If a faulted portion of the electrical circuit is not disconnected when a trip command is issued to a circuit-breaker, another trip command can be initiated using the breaker failure protection which trips the circuit-breaker of an upstream feeder. Breaker failure is detected if, after a trip command is issued and the current keeps on flowing into the faulted circuit. It is also possible to make use of the circuit-breaker position contacts (52a or 52b) for indication as opposed to the current flowing through the circuit-breaker.

Flexible protection functions

The 7SK81 enables the user to easily add up to 20 additional protection functions. Parameter definitions are used to link standard protection logic with any chosen characteristic quantity (measured or calculated quantity). The standard logic consists of the usual protection elements such as the pickup set point, the set delay time, the TRIP command, a block function, etc. The mode of operation for current, voltage, power and power factor quantities can be three-phase or phase-selective. Almost all quantities can be operated with ascending or descending pickup stages (e.g. under and over-voltage). All stages operate with protection priority or speed.

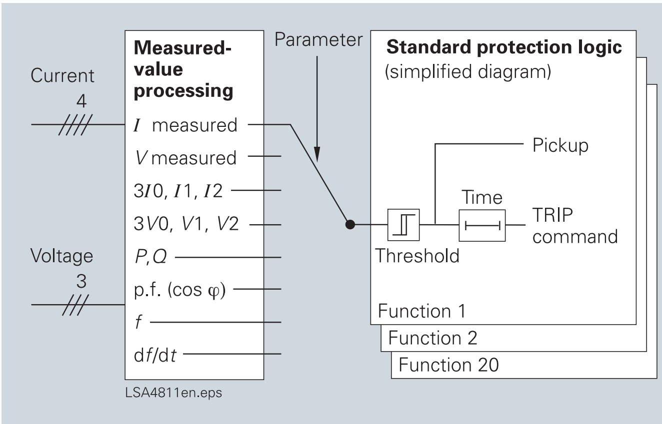


Fig. 4/6 Flexible protection functions

Protection functions/stages available are based on the available measured analog quantities:

Function	ANSI
$I>$, $I_E>$	50, 50N
$V<$, $V>$, $V_E>$	27, 59, 59N
$3I_0>$, $I_1>$, $I_2>$, $I_2/I_1>$, $3V_0>$, $V_1><$, $V_2><$	50N, 46, 59N, 47
$P><$, $Q><$	32
cos φ	55
$f><$	81O, 81U
$df/dt><$	81R

Tabelle 4/5 Available flexible protection functions

For example, the following can be implemented:

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

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 is generated whenever the circuit is interrupted.

Lockout (ANSI 86)

All binary output statuses can be memorized. The LED reset key is used to reset the lockout state. The lockout state is also stored in the event of supply voltage failure. Reclosure can only occur after the lockout state is reset.

Thermal overload protection (ANSI 49)

To protect cables and transformers, an overload protection function with an integrated warning/alarm element for temperature and current can be used. The temperature is calculated using a thermal homogeneous body model (per IEC 60255-8), it considers the energy entering the equipment and the energy losses. The calculated temperature is constantly adjusted according to the calculated losses. The function considers loading history and fluctuations in load.

Protection of motors requires an additional time constant. This is used to accurately determine the thermal heating of the stator during the running and motor stopped conditions. The ambient temperature or the temperature of the coolant can be detected either through internal RTD inputs or via an external RTD-box.The thermal replica of the overload function is automatically adapted to the ambient conditions. If neither internal RTD inputs nor an external RTD-box exist, it is assumed that the ambient temperatures are constant.

Settable dropout delay times

If the relays are used in conjunction with electromechanical relays, in networks with intermittent faults, the long dropout times of the electromechanical relay (several hundred milliseconds) can lead to problems in terms of time coordination/grading. Proper time coordination/grading is only possible if the dropout or reset time is approximately the same. This is why the parameter for dropout or reset 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 subjected to many successive starts, the rotor windings or rotor bars can be heated up to a point where the electrical connections between the rotor bars and the end rings are damaged. As it is not possible to physically measure the heat of the rotor we need to determine the heat by measuring the current the rotor is drawing through the stator to excite the rotor. A thermal replica of the rotor is established using a I^2t curve. The restart inhibit will block the user from starting the motor if the relay determined that the rotor reached a temperature that will damage the rotor should a start be attempted. The relay will thus only allow a restart if the rotor has a sufficient thermal reserve to start (see Fig.).

Emergency start-up

If the relay determines that a restart of the motor is not allowed, the relay will issue a block signal to the closing command, effectively blocking any attempt to start the motor. The emergency startup will defeat this block signal if activated through a binary input. The thermal replica can also be reset to allow an emergency restart of the motor.

Temperature monitoring (ANSI 38)

Either 5 internal RTD inputs or up to 12 RTD inputs through an external RTD box can be applied for temperature detection. Example for the application with 5 internal RTD inputs: Two RTDs can be applied to each bearing (the cause of 50% of typical motor failures). The remaining RTD is used to measure the ambient temperature. Stator temperature is calculated by the current flowing through the stator windings. Alternatively up to 12 RTDs can be applied using an external RTD box connected either through RS485 on Port B or through Ethernet on Port A. The RTDs can also be used to monitor the thermal status of transformers or other pieces of primary equipment.

Starting time supervision/Locked rotor protection (ANSI 48/14)

Starting time supervision protects the motor against unwanted prolonged starts 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:

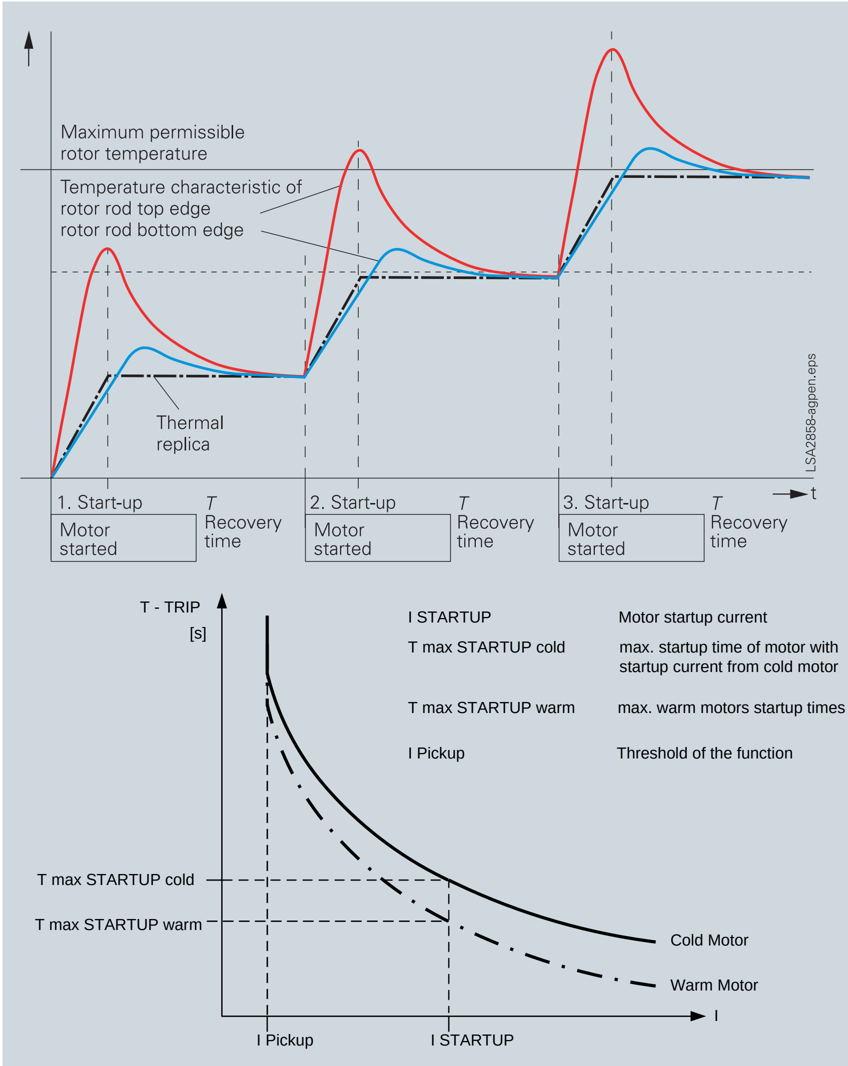


Fig. 4/7 Starting time supervision characteristics

$$t_{TRIP} \quad \frac{I_A{}^2}{I} \; t_{Amax}$$

t_{TRIP} = Tripping time I_A= Motor starting current
t_{Amax} = Max. permissible starting time
I = Actual current flowing

Because the flow of current is the cause of the heating of the motor windings, this equation will accurately calculate the starting supervision time. The accuracy will not be affected by reduced terminal voltage that could cause a prolonged start. The trip time is an inverse current dependant characteristic (I^2t).

Block rotor can also be detected using a speed sensor connected to a binary input of the relay. If activated it will cause an instantaneous trip.

Load jam protection (ANSI 51M)

Load jam is activated when a sudden high load is applied to the motor because of mechanical failure of a pump for example. The sudden rise in current is detected by this function and can initiate an alarm or a trip. The overload function is too slow and thus not suitable.

Unbalanced load protection (ANSI 46)

The unbalanced load protection detects a phase failure or load unbalance due to system asymmetry, and protects the rotor from impermissible overheating.

Undercurrent monitoring (ANSI 37)

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

Motor statistics

Essential statistical information is saved by the relay during a start. This includes the duration, current and voltage. The relay will also provide data on the number of starts, total operating time, total down time, etc. This data is saved as statistics in the relay.

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 conditions 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). Even when falling below this frequency range the function continues to work, however, with decreased accuracy. 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 overfrequency and underfrequency protection. Electric machines and parts of the system are protected from unwanted frequency 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 (for 50 Hz), 50 to 70 (for 60 Hz)). There are four elements (individually set as overfrequency, underfrequency or OFF) and each element can be delayed separately. Blocking of the frequency protection can be performed by activating a binary input or by using an undervoltage element.

Customized functions (ANSI 51V, 55 etc.)

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

Further functions

Measured values

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

- Currents I_{L1}, I_{L2}, I_{L3}, I_N, I_{EE}
- Voltages V_{L1}, V_{L2}, V_{L3}, V_{12}, V_{23}, V_{31}
- Symmetrical components I_1, I_2, 3 I_0; V_1, V_2, $3V_0$
- Power Watts, Vars, VA/P, Q, S (P, Q: total and phase selective)
- Power factor cos φ (total and phase selective)
- Frequency
- Energy ± kWh, ± kVarh, forward and reverse power flow
- Mean as well as minimum and maximum current and voltage values
- Operating hours counter
- Mean operating temperature of the overload function
- Limit value monitoring
  Limit values can be 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 7SK81 can obtain and process metering pulses through an indication input. The metered values can be displayed and passed on to a control center as an accumulated value with reset. A distinction is made between forward, reverse, active and reactive energy.

Circuit-breaker wear monitoring/ circuit-breaker remaining service life

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 exact mathematical method to calculate the wear or the remaining service life of a circuit-breaker that takes arc-chamber's physical conditions into account 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 relay offers several methods:

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

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

- Two-point method

The CB manufacturers double-logarithmic switching cycle diagram (see Fig. 4/8) and the breaking current at the time of contact opening serve as the basis for this method. After CB opening, the two-point method calculates the remaining number of possible switching cycles. 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.

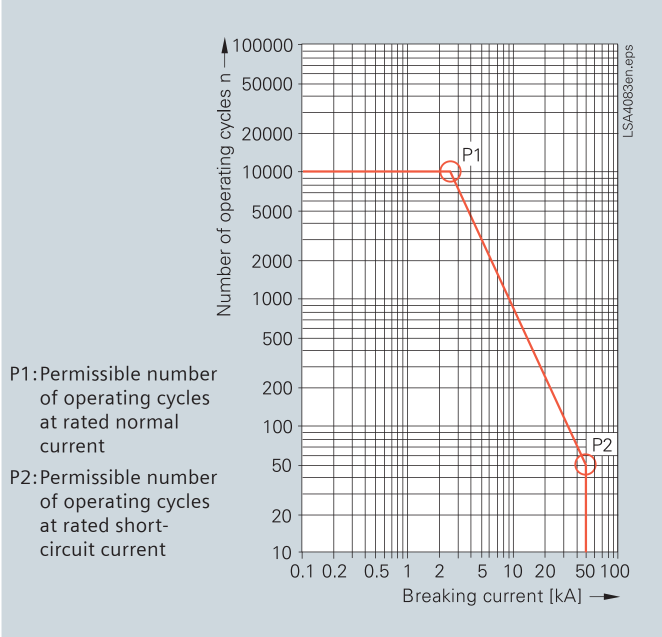


Fig. 4/8 Permissible number of operating cycles as a function of breaking current

Commissioning

Commissioning could not be easier and is 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 relay. The analog measured values are represented as wide-ranging operational measured values. To prevent transmission of information to the control center during maintenance, the communications can be disabled to prevent unnecessary data from being transmitted. During commissioning, all indications with test tag for test purposes can be connected to a control and protection system.

Test operation

During commissioning, all indications with test tag can be passed to a control system for test purposes.

Radial systems

General hints:
The relay at the far end (D) from the infeed has the shortest tripping time. Relays further upstream have to be time-graded against downstream relays in steps of about 0.3 s.

1) Unbalanced load protection (ANSI 46) as backup protection against asymmetrical faults

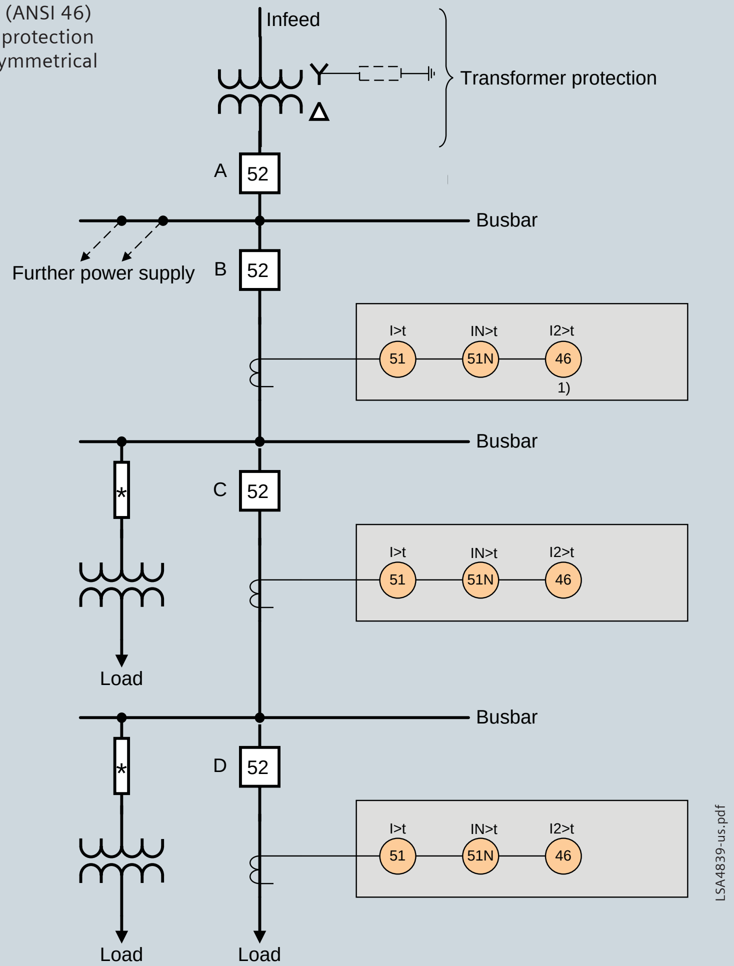


Fig. 4/9 Protection concept with overcurrent-time protection

Earth-fault detection in isolated or compensated systems

In isolated or compensated systems, an occurred earth fault can be easily found by means of sensitive directional earth-fault detection.

1) The sensitive current measurement of the earth current should be made by a zero-sequence low-power current transformer, e.g. LPCT K-60 from TRENCH

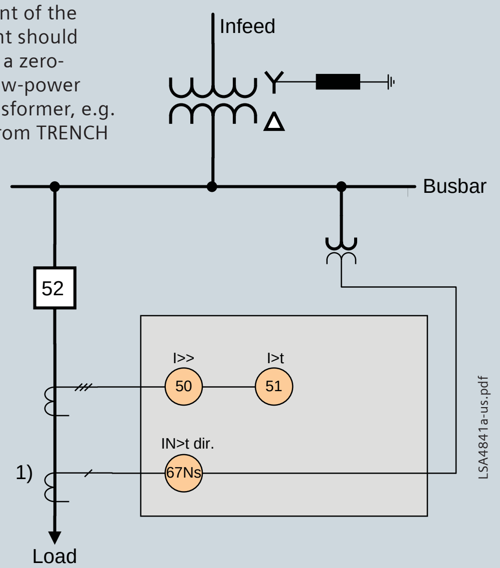


Fig. 4/10 Protection concept for directional earth-fault detection

Small and medium-sized motors < 1MW

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

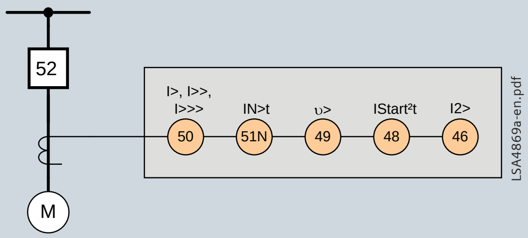


Fig. 4/11 Protection concept for small motors

High-resistance infeed

($I_E \leq I_{N,\ Motor}$)

1) The sensitive current measurement of the earth current should be made by a zero-sequence low-power current transformer, e.g. LPCT K-60 from TRENCH

2) The sensitive directional earth-fault detection (ANSI 67Ns) is only applicable with the infeed from an isolated system or a system earthed via Petersen coil.

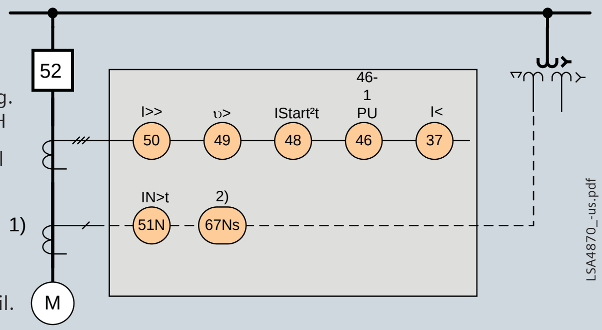


Fig. 4/12

Generators < 500 kW

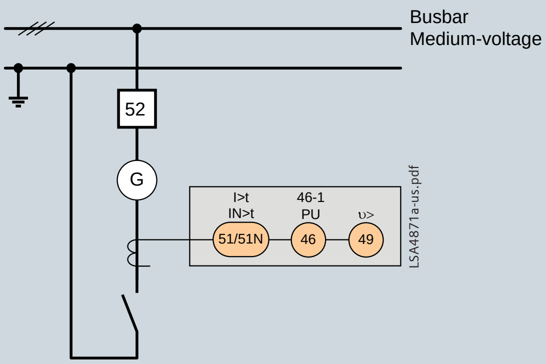
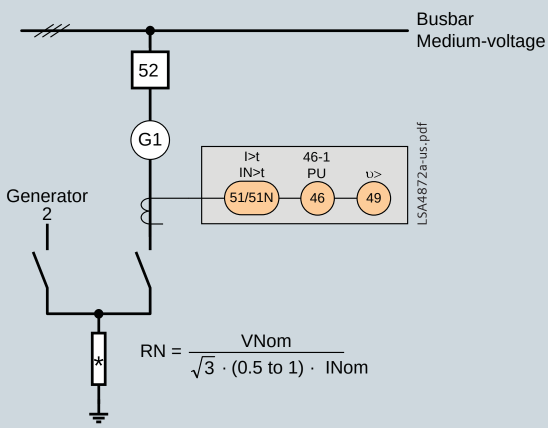


Fig. 4/13 Protection concept for smallest generators with solidly earthed neutral



$$RN = \frac{VNom}{\sqrt{3} \cdot (0.5 \text{ to } 1) \cdot INom}$$

Fig. 4/14 Protection concept for smallest generators with low-resistance neutral earthing

Generators up to 1MW

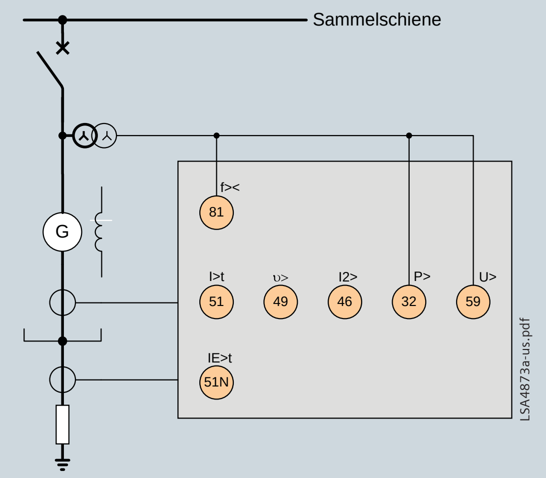


Fig. 4/15 Protection concept for small generators

Busbar protection by overcurrent relays with reverse interlocking

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

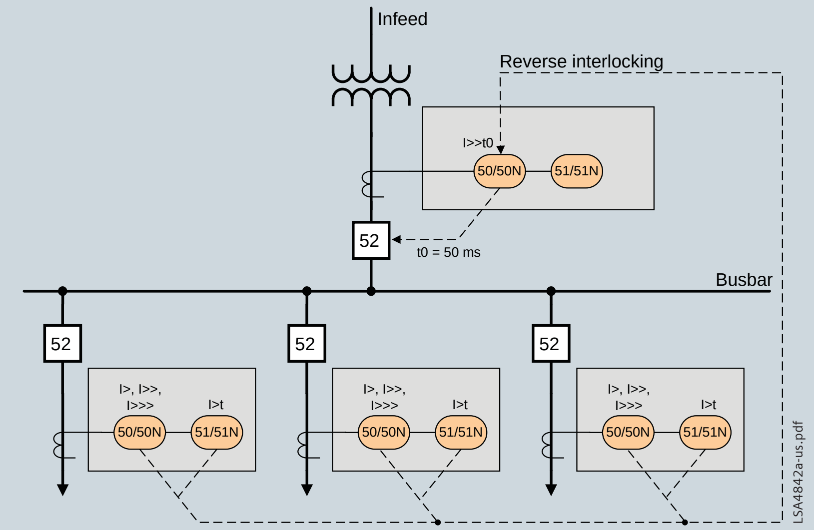


Fig. 4/16 Busbar protection with reverse interlocking

Line feeder with load shedding

In unstable power systems (e.g. solitary systems, emergency power supply in hospitals), it may be necessary to isolate selected consumers from the power system in order to protect the overall system. The overcurrent-time protection functions are effective only in the case of a short-circuit. Overloading of the generator can be measured as a frequency or voltage drop.

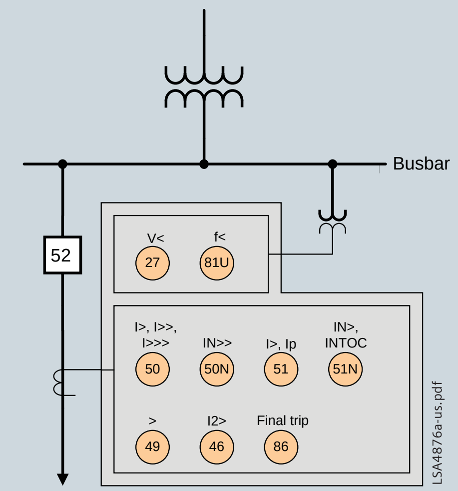


Fig. 4/17 Line feeder with load shedding

Motor protection

For short-circuit protection, the stages I>> and I_E>> are available, for example. Sudden load variations in running operation are acquired by the I_{load}> function. For isolated systems, the sensitive earth-fault detection (I_{EE}>>, V_0>) can be used. The stator is protected against thermal overload by ϑs, the rotor by I_2>, start-time supervision and restart inhibit. A locked rotor is detected via a binary input, and shut down as fast as required. The restart inhibit can be deactivated by an “emergency start”.

The undervoltage function prevents a start when the voltage is too low; the overvoltage function prevents insulation damages.

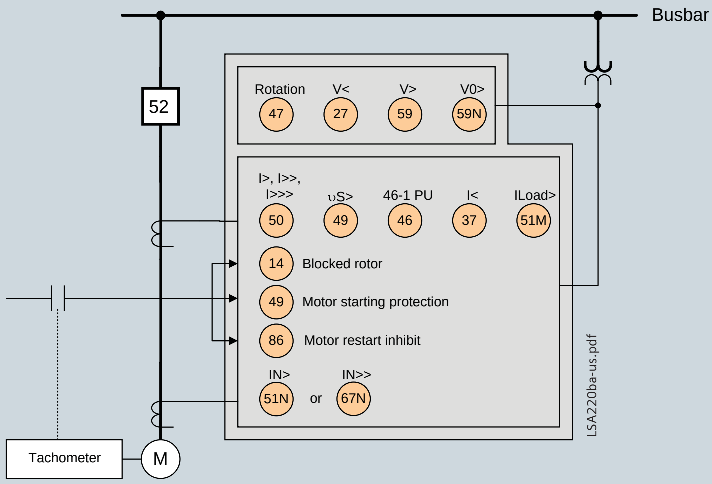


Fig. 4/18 Typical protection concept for an asynchronous high-voltage motor

for Low-Power CT and VT Applications - Selection and ordering data

Product description	Order No.	Short code
	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 7SK81□ 3-□□□□□- 3□□□+□□□	
Measuring inputs, binary inputs and outputs		
Housing 1/6 19"; 4 x I, 3 BI, 5 BO, 1 live status contact	1	
Housing 1/6 19"; 4 x I, 7 BI, 8 BO, 1 live status contact	2	
Housing 1/6 19"; 4 x I, 3 x *V*, 3 BI, 5 BO, 1 live status contact	3	
Housing 1/6 19"; 4 x I, 3 x *V*, 7 BI, 8 BO, 1 live status contact	4	
Housing 1/6 19"; 4 x I, 3 BI, 5 BO, 1 live status contact, 5 RTD inputs	5	
Housing 1/6 19"; 4 x I, 3 x *V*, 3 BI, 5 BO, 1 live status contact, 5 RTD inputs	6	
Low Power Measuring Inputs	3	
Auxiliary voltage		
DC 24V / 48V	1	
DC 60V / 110V / 125V / 220V / 250V, AC 115V, AC 230V	5	
Construction		
Flush mounting housing, screw-type terminal	E	
Region-specific default- and language settings		
Region DE, IEC, language German (language changeable)	A	
Region World, IEC/ANSI, language English (language changeable)	B	
Port B (at bottom of device)		
No port	0	
IEC 60870-5-103 or DIGSI 4/modem, electrical RS232	1	
IEC 60870-5-103 DIGSI 4/modem or RTD-box, electrical RS485	2	
IEC 60870-5-103 DIGSI 4/modem or RTD-box, optical 820 nm, ST connector	3	
Further protocols see supplement L	9	L 0 □
PROFIBUS DP slave, electrical RS485	9	A
PROFIBUS DP slave, optical, double ring, ST connector	9	B
MODBUS, electrical RS485	9	D
MODBUS, optical 820 nm, ST connector	9	E
DNP 3.0, electrical RS485	9	G
DNP 3.0, optical 820 nm, ST connector	9	H
IEC 60870-5-103, redundant, electrical RS485, RJ45 connector	9	P
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector	9	R
IEC 61850, 100 Mbit Ethernet, optical, double, LC connector	9	S
Port A (at bottom of device, in front)		
No port	0	
With Ethernet interface (DIGSI, RTD-box, not IEC 61850), RJ45 connector	6	
Measuring / fault recording		
With fault recording, average values, min/max values	3	

see next page

ANSI No.	Product description	Order No. 14 15 16
Motor protection device		H D 0 [2)]
	Basic functionality	
50/51	Overcurrent protection, phase $I>$, $I>>$, $I>>>$, I_p	
50N/51N	Overcurrent protection, ground $I_E>$, $I_E>>$, $I_E>>>$, I_{Ep}	
50N(s)/51N(s)[1)]	Sensitive ground fault protection $I_{EE}>$, $I_{EE}>>$, I_{EEp}	
49	Thermal overload protection	
74TC	Trip-circuit supervision, TCS	
50BF	Circuit-breaker failure protection,CBFP	
46	Negative sequence / unbalanced load protection, I2>	
86	Lockout	
48	Start-time supervision, I^2_{start}	
37	Undercurrent monitoring, I<	
66/86	Restart inhibit, I^2t	
14	Locked rotor protection	
51M	Load jam protection	
	Motor statistics	
	Parameter changeover	
	Monitoring functions	
	Control of circuit-breaker	
	Flexible protection functions (current parameters)	
	Inrush restraint	
	Basic version included	H E 0 [3)]
67N	Directional overcurrent protection for ground-faults, $I_E>$, $I_E>>$, I_{Ep}	
67N(s)[1)]	Senitive ground-fault detection for systems with resonant or isolated neutral, $I_{EE}>$, $I_{EE}>>$, I_{EEp}	
59N	Overvoltage protection	
27/59	Under-/overvoltage protection V<, V>	
81 U/O	Under-/overfrequency protection $f<$, $f>$	
47	Phase rotation	
32/55/81R	Flexible protection functions (current and voltage parameters) Protection function for voltage, power, power factor, frequency change	

1) Depending on the connected low-power current transformer the function will be either sensitive (IN_S) or non-sensitive (IN).
2) Only if position 6 = 1,2 or 5
3) Only if position 6 = 3,4 or 6

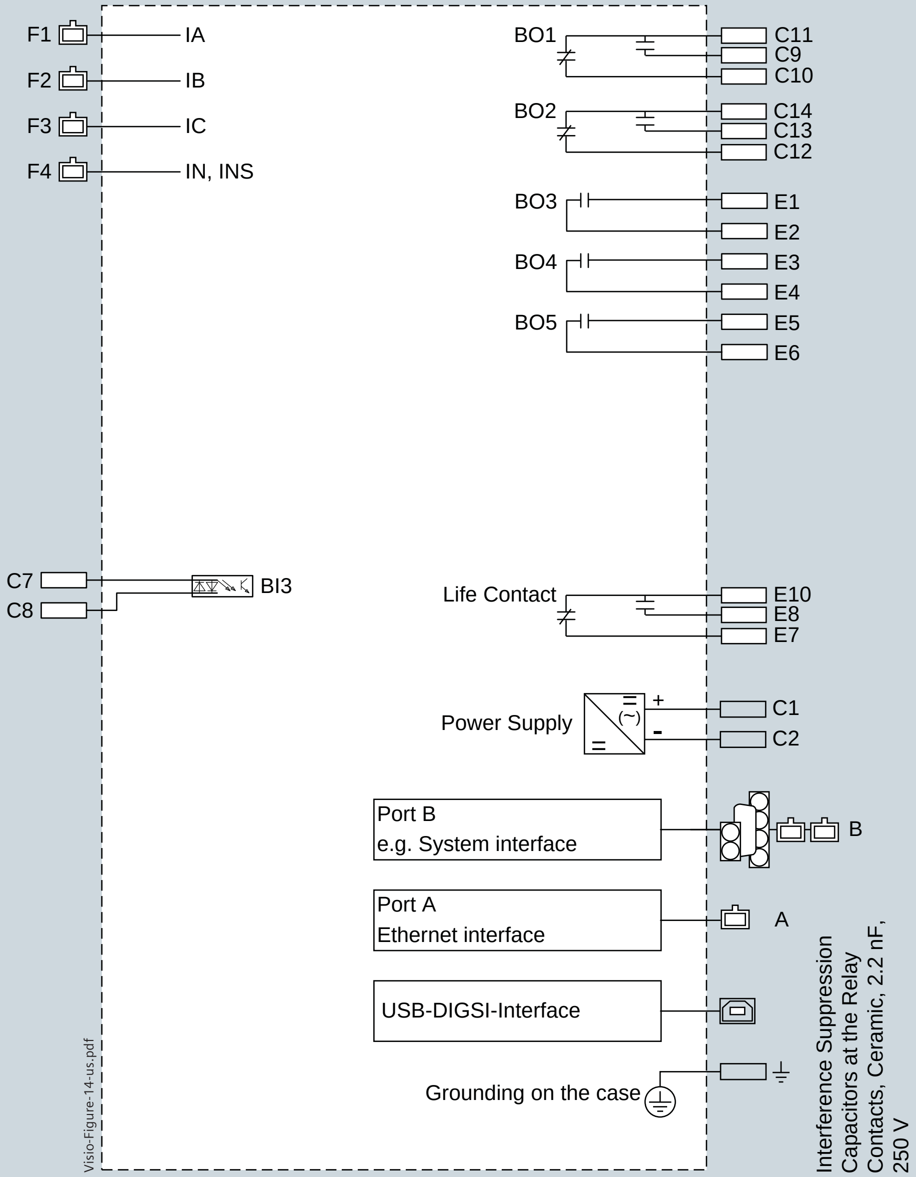


Fig. 4/19 Motor protection 7SK811

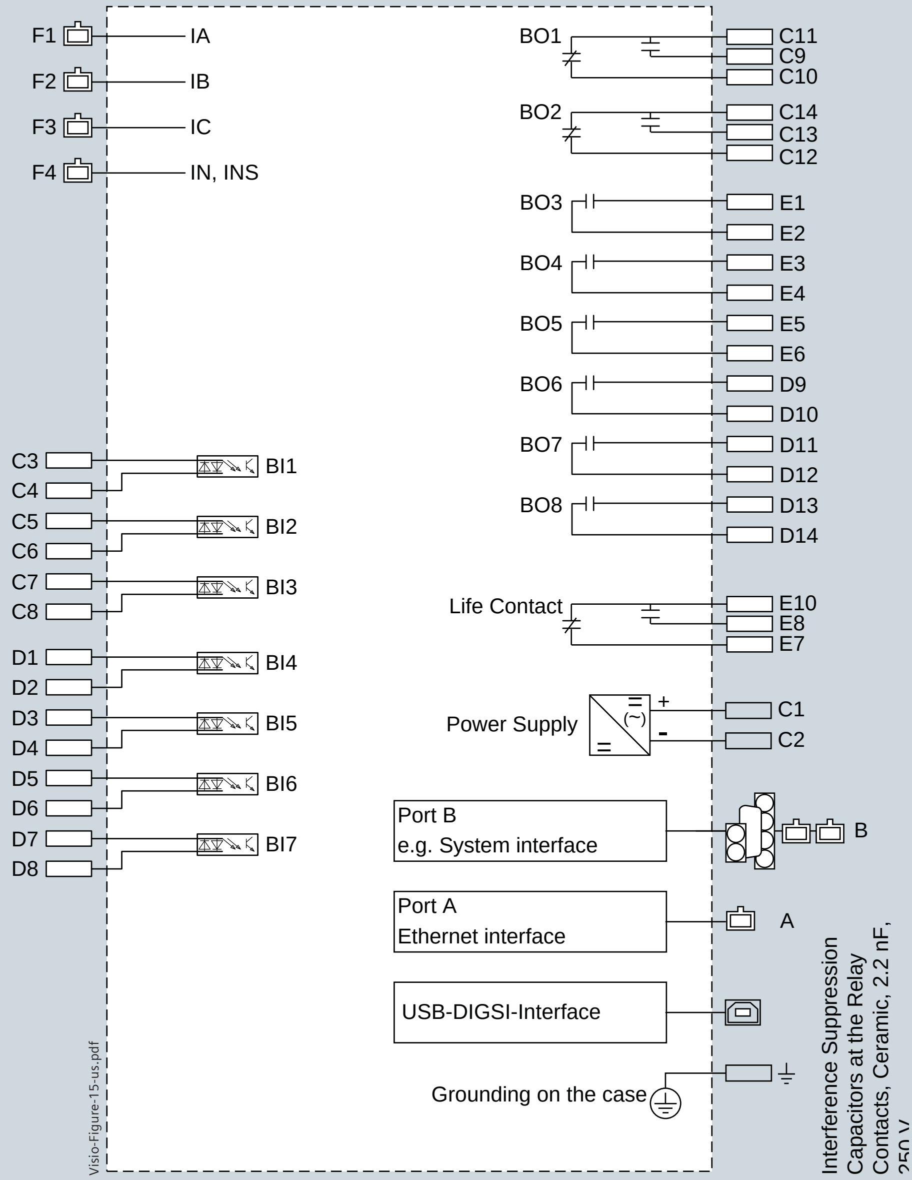


Fig. 4/20 Motor protection 7SK812

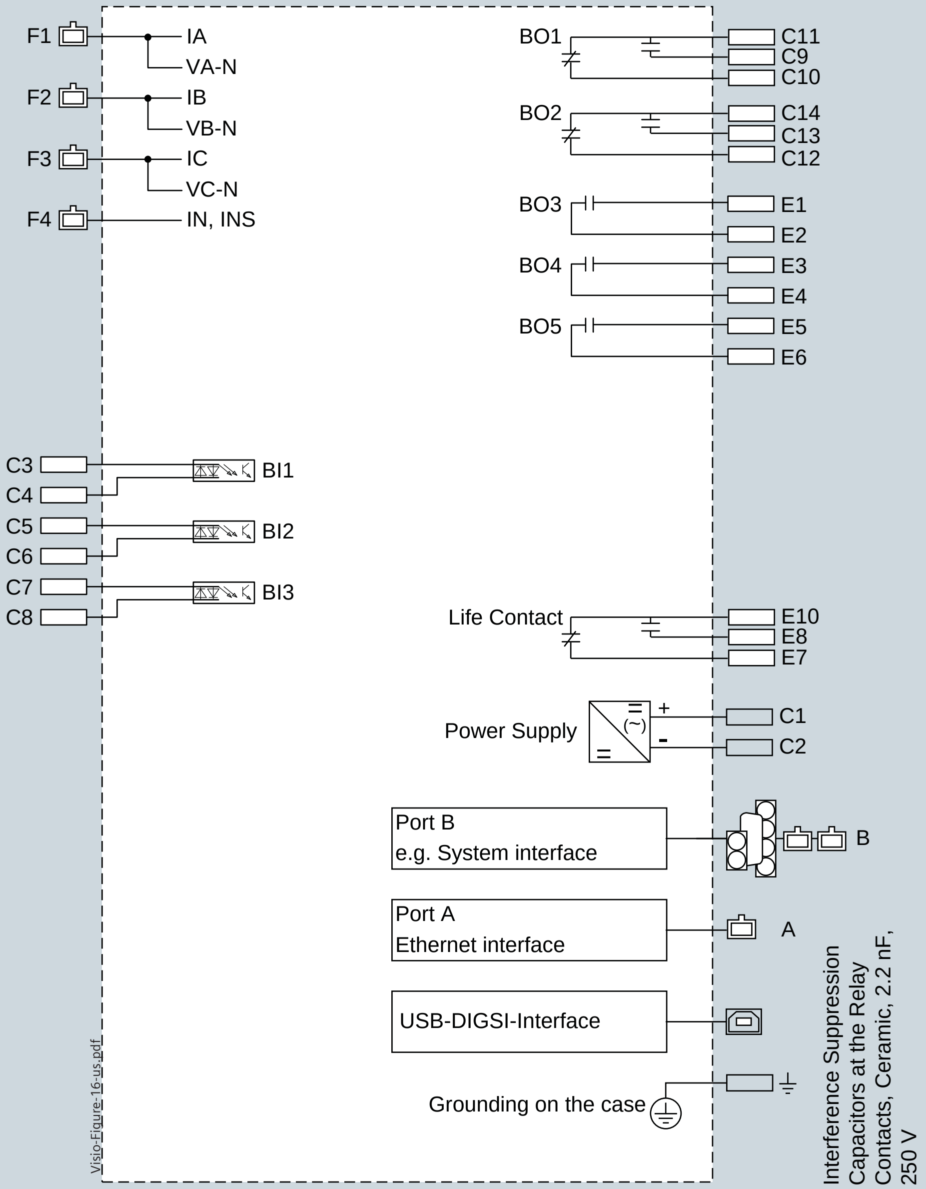


Fig. 4/21 Motor protection 7SK813

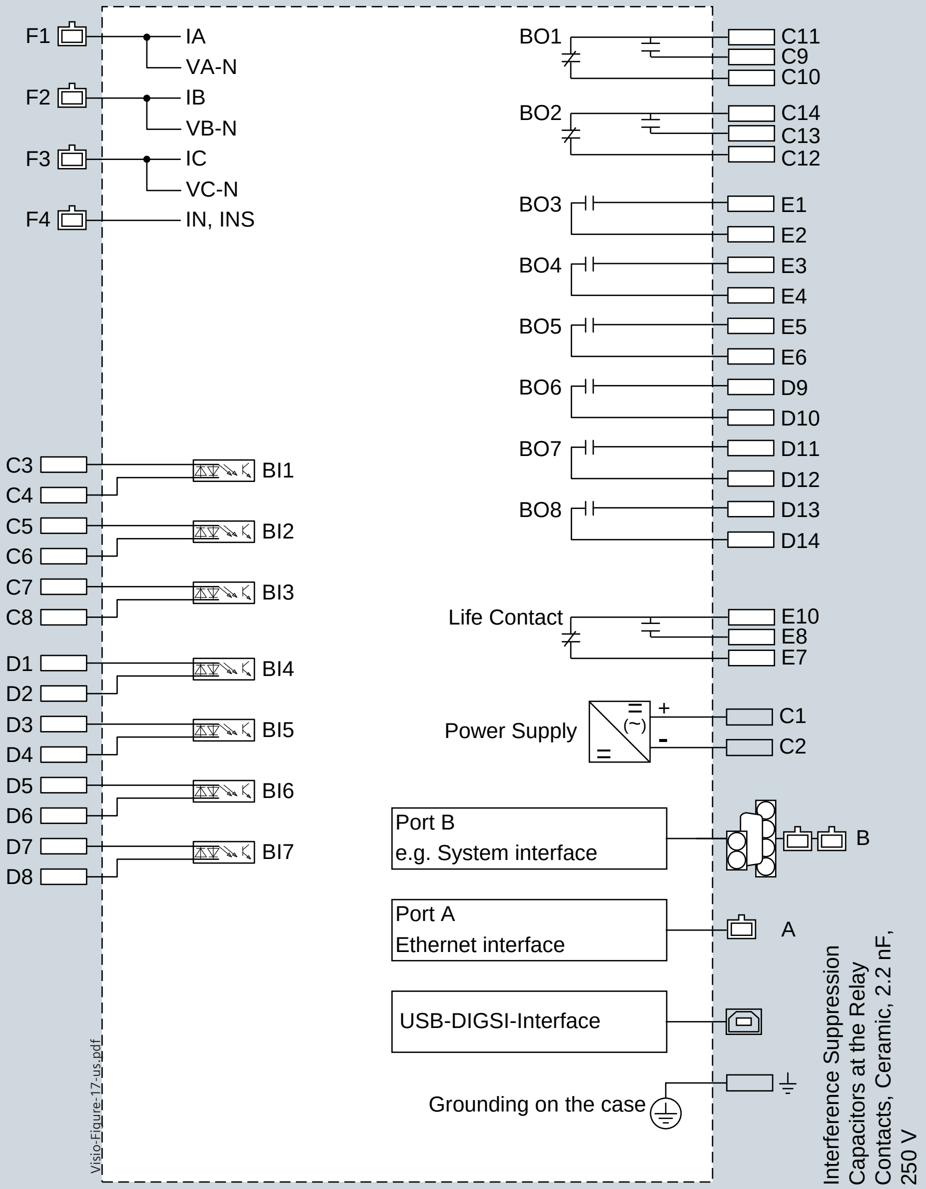


Fig. 4/22 Motor protection 7SK814

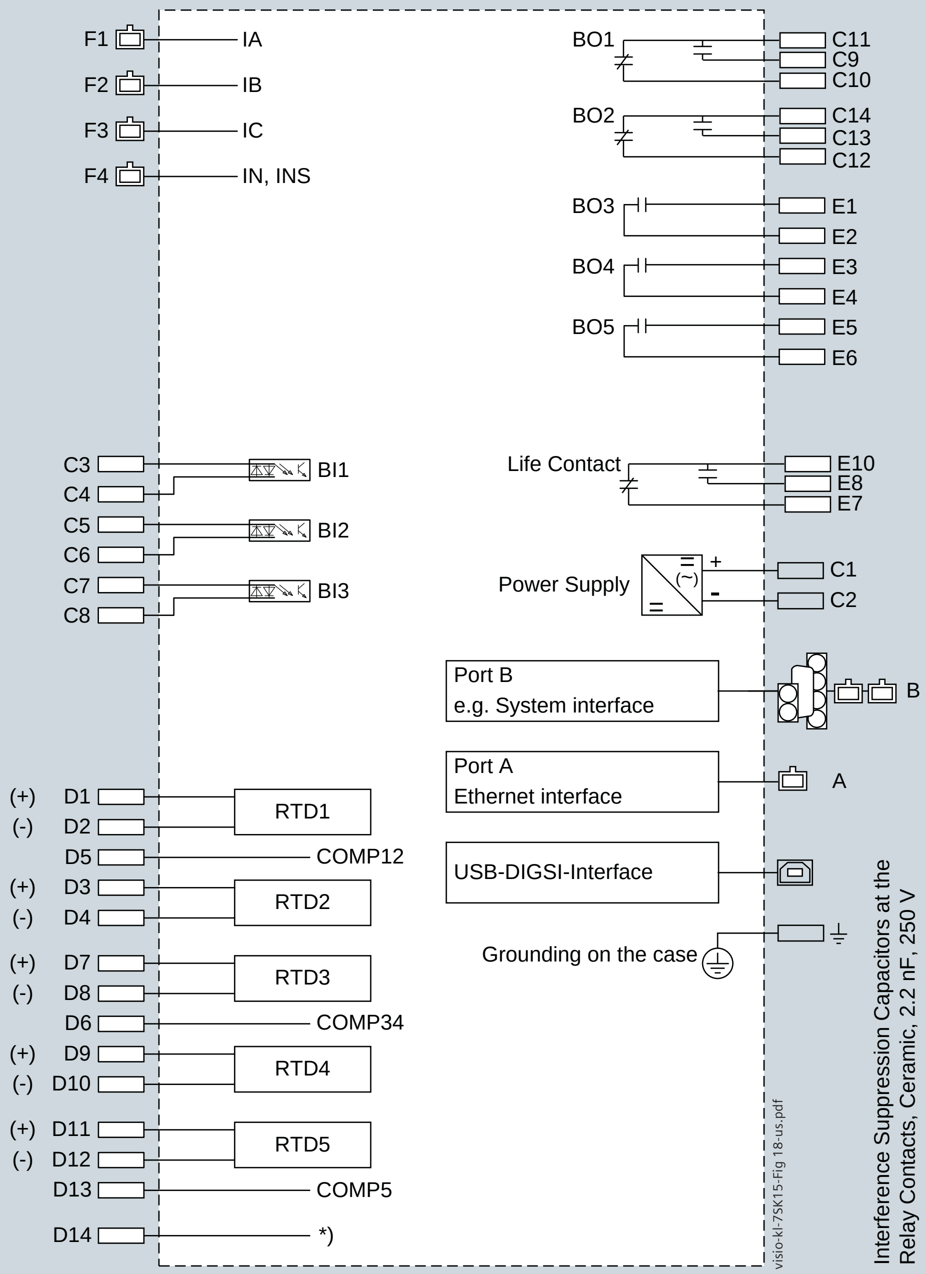


Fig. 4/23 Motor protection 7SK815

*) The shielding of the connecting cable is connected directly to the shield cap.

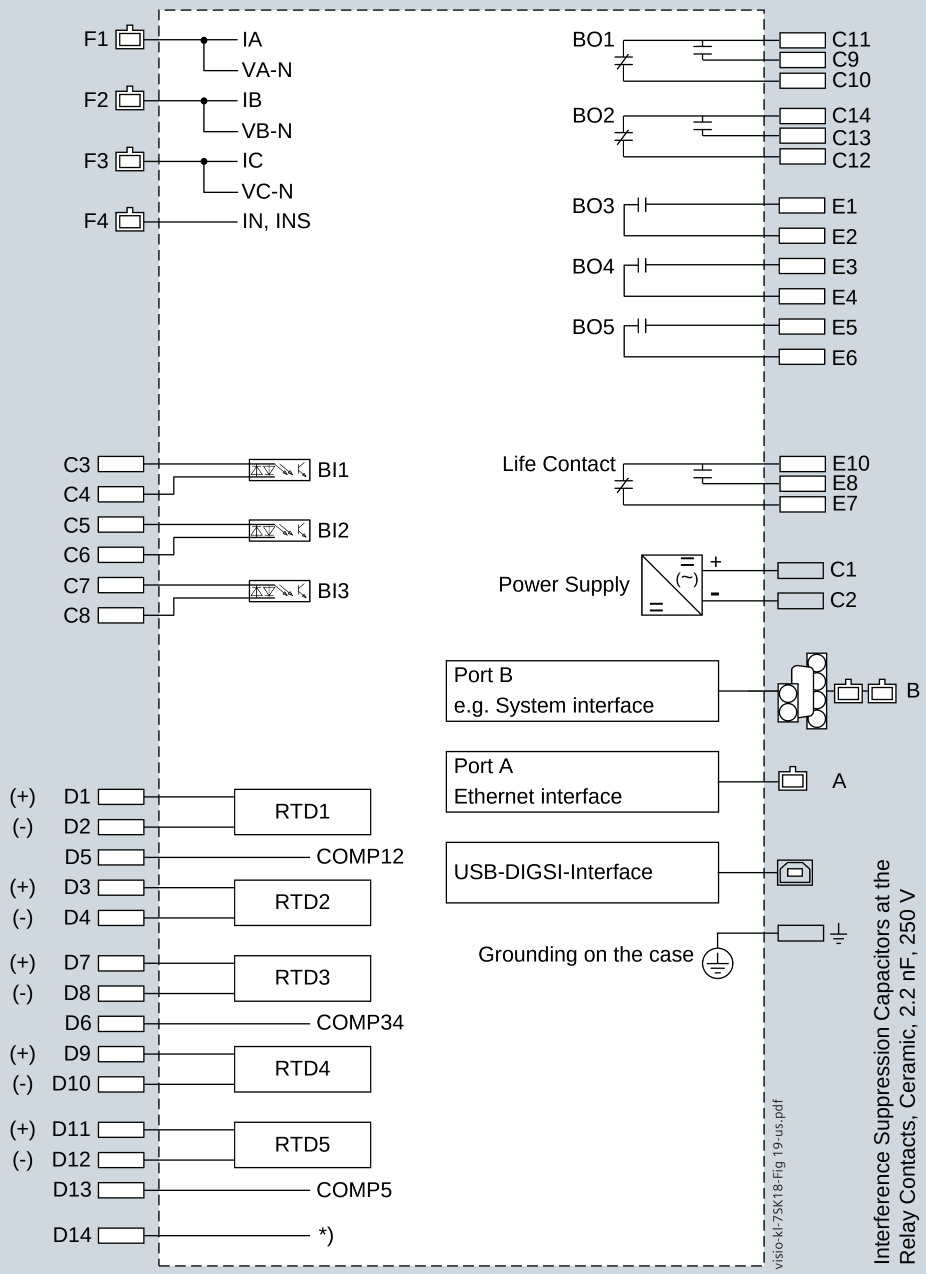


Fig. 4/24 Motor protection 7SK816

*) The shielding of the connecting cable is connected directly to the shield cap.

Standard connection capabilities

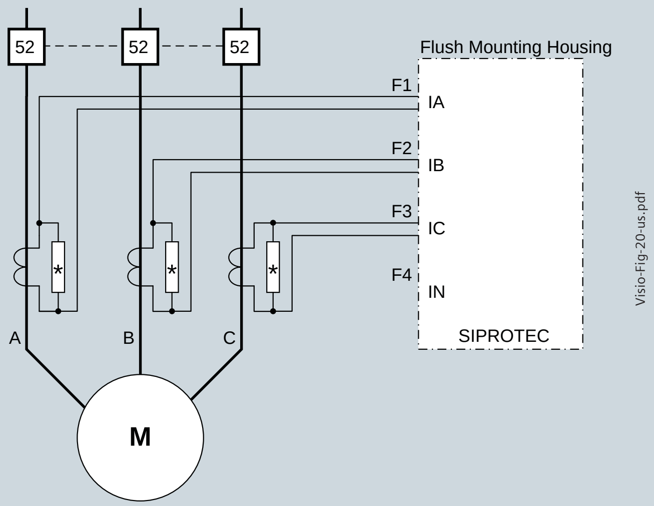


Fig. 4/25 Connection to 3 low-power CTs, normal circuit layout, appropriate for all networks

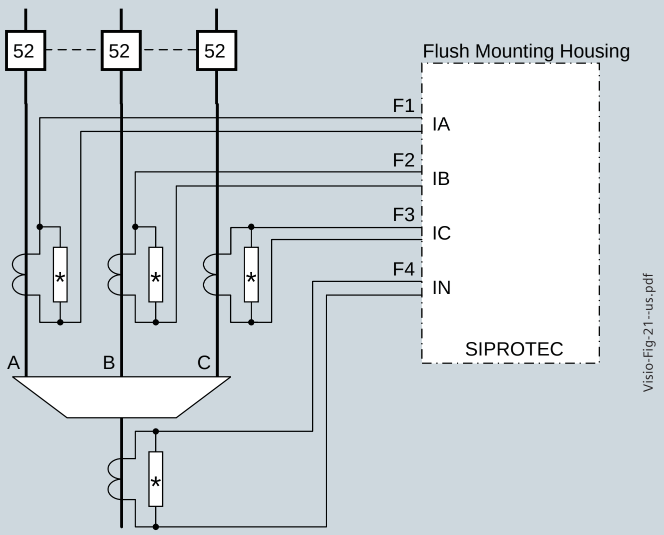


Fig. 4/26 Connection to 3 low-power CTs - additional low-power CT for sensitive ground fault detection INS - only for isolated or compensated networks

Standard connection capabilities

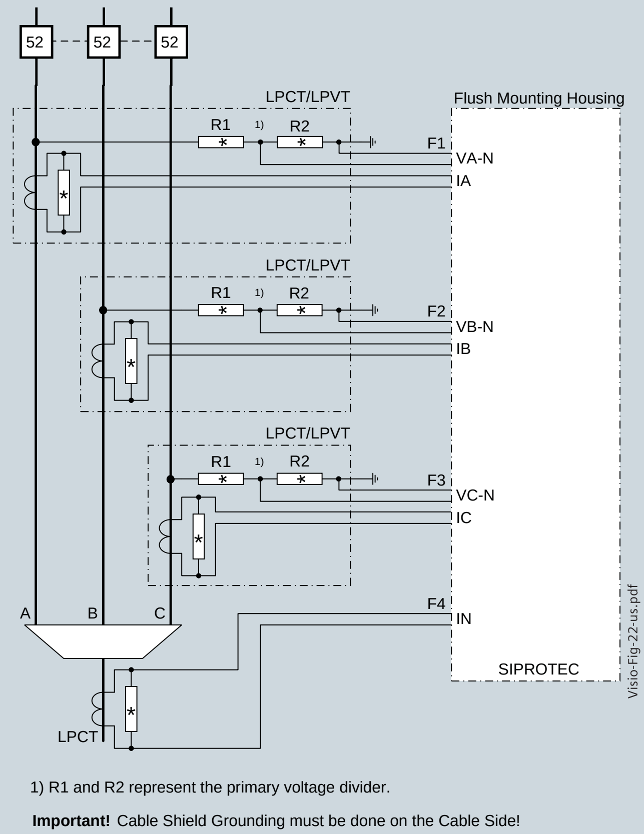
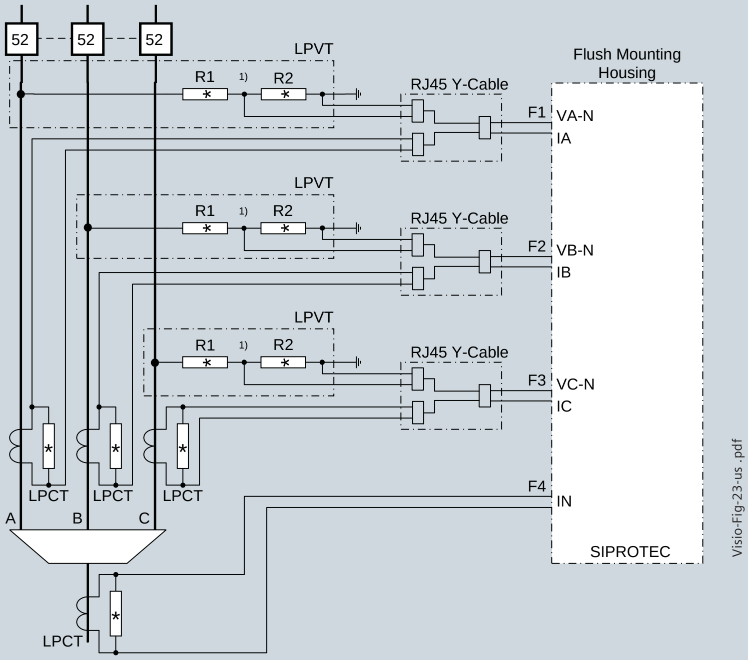


Fig. 4/27 Connection for combined low-power current and voltage transformers in phase L1, L2 and L3

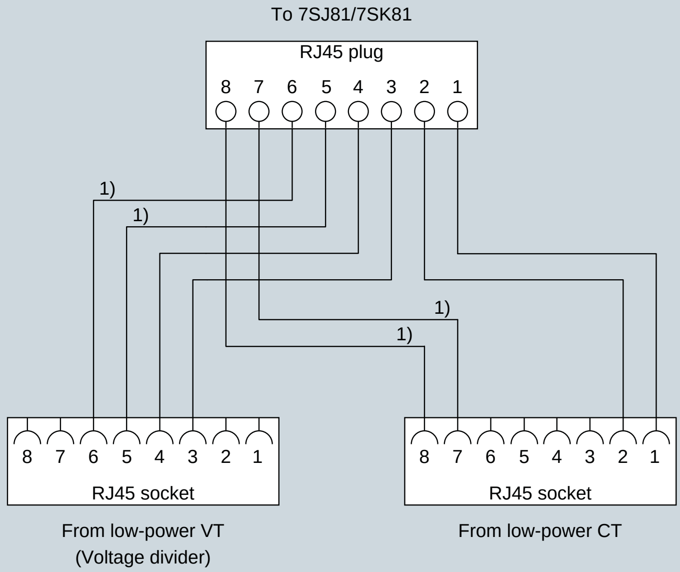
Standard connection capabilities



1) R1 and R2 represent the primary voltage divider.

Important! Cable Shield Grounding must be done on the Cable Side!

Fig. 4/28 Connection to low-power transformers for 3 phase currents, sensitive ground current INS and 3 phase-to-ground voltages.
The LPCT and the LPVT are connected to 7SK81 through a Y-cable (refer to Fig. 4/29)



1) The connections 5, 6, 7 and 8 are optional, but not mandatory.

Fig. 4/29 Y-cable for a connection of LPCT and LPVT with 7SK81