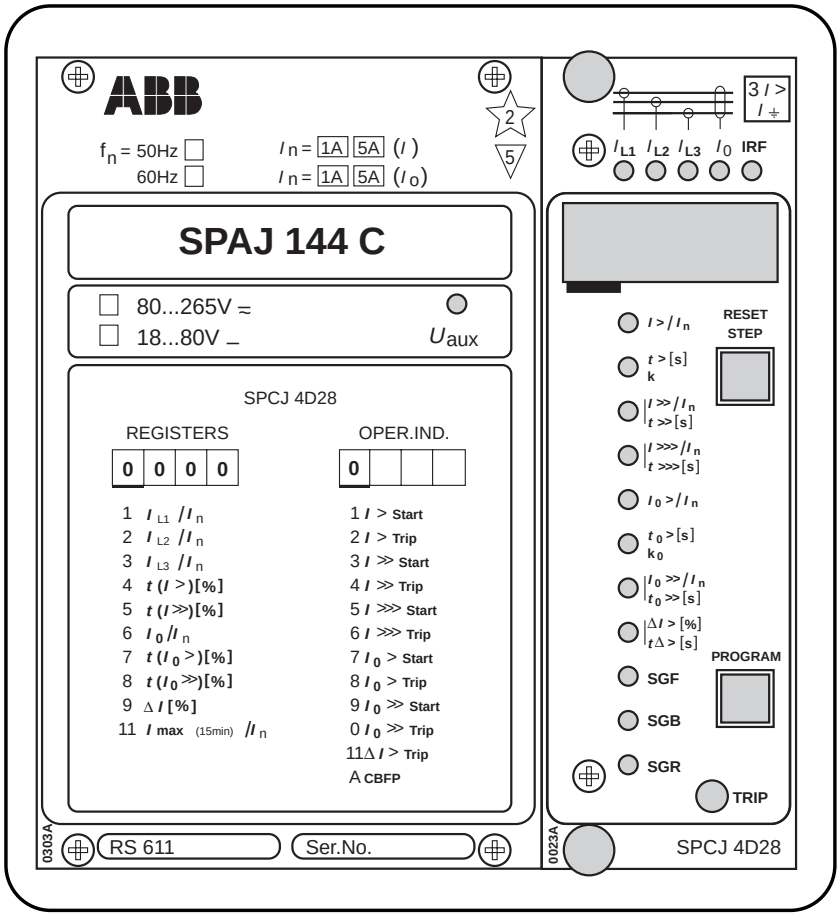
SPAJ 144 C
Combined overcurrent and earth-fault relay

User´s manual and Technical description



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SPAJ 144 C
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Contents

The complete manual for the relay SPAJ 144 C contains the following submanuals:

General relay description for SPAJ 144 C	1MRS 750043-MUM EN
Combined overcurrent and earth-fault relay module SPCJ 4D28	1MRS 750093-MUM EN
General characteristics of D-type relay modules	1MRS 750066-MUM EN

Features

Three-phase, low-set phase overcurrent unit with definite time or inverse definite minimum time (IDMT) characteristic

Three-phase, high-set phase overcurrent unit with instantaneous or definite time operation characteristic

Three-phase, superhigh-set phase overcurrent unit with instantaneous or definite time operation characteristic

Low-set earth-fault unit with definite time or inverse definite minimum time (IDMT) characteristic

High-set earth-fault unit with instantaneous or definite time function

Phase discontinuity stage with definite time characteristic. The phase discontinuty stage can be set out of operation

Built-in circuit breaker failure protection

Two heavy-duty and four signal output relays with field-selectable configuration

Output relay matrix allowing any start or trip signal from the protection stages to be routed to the desired output relay.

Local display of measured and set values and data recorded at the moment of a fault.
Reading and writing of setting values either via local display and front panel push buttons or from higher-level systems over the serial interface and the fibre-optic bus.

Self-supervision system continuously monitoring the operation of the electronics and the mircoprocessor. When a permanent fault is detected the alarm output relay operates and the other relay outputs are blocked.

Description of operation

The combined overcurrent and earth-fault relay is a secondary relay to be connected to the current transformers of the protected object. The three-phase overcurrent unit and the earth-fault unit continuously measure the phase currents and the neutral current of the protected object. On detection of a fault the relay starts, trips the circuit breaker, provides an alarm signal, records fault data, etc. in accordance with the application and the relay configuration.

When the phase current exceeds the set start current of the low-set stage I>, the overcurrent unit starts and it delivers, after a preset start time, a start signal. When the set operate time at definite time operation, or the calculated operate time, at inverse time operation elapses, the overcurrent unit operates. In the same way, the high-set stage I>> of the overcurrent unit starts when the set start current is exceeded and delivers a start signal after a preset (~40 ms) start time. When the set operate time elapses, the overcurrent unit operates. The second high-set stage I>>> of the overcurrent unit operates in the same way as the above stages. It starts when the set start current is exceeded and delivers a start signal when a preset start time has elapsed.

When the earth-fault current exceeds the set start current of the low-set stage I_0>, the earth-fault unit starts and it delivers, after a preset start time, a start signal. When the set operate time at definite time operation, or the calculated operate time, at inverse time operation, elapses, the earth-fault unit operates. In the same way, the high-set stage I_0>> of the earth-fault unit starts when the set start current is exceeded and delivers a start signal after a preset (~50 ms) start time. At the moment the set operate time elapses, the earth-fault unit operates. In the same way the phase discontinuity stage starts and delivers a start signal after a preset (~150 ms) start time, when the set start value is exceeded. At the moment the set operate time elapses, the stage operates.

The low-set stage of the overcurrent unit and the low-set stage of the earth-fault unit may be given definite time or inverse definite minimum time (IDMT) characteristic. When the IDMT characteristic is chosen six time/current curves are available. Four of the curves comply with the BS 142 and IEC 60255 and are named "Normal inverse", "Very inverse", "Extremely inverse" and "Long-time inverse". The two additional inverse time curves are called "RI" and "RXIDG".

By appropriate configuration of the output relay matrix, the start signals of the overcurrent and earth-fault units are obtained as contact functions. The start signals can be used for blocking co-operating protection relays, and for signalling.

The relay includes one external binary input, which is controlled by an external control voltage. The function of the control input is determined by the switch SGB1 of the protection relay module. The control input can be used for blocking the operation of one or more protection stages, for resetting a latched output relay in the manual reset mode or for switching between main and second setting banks.

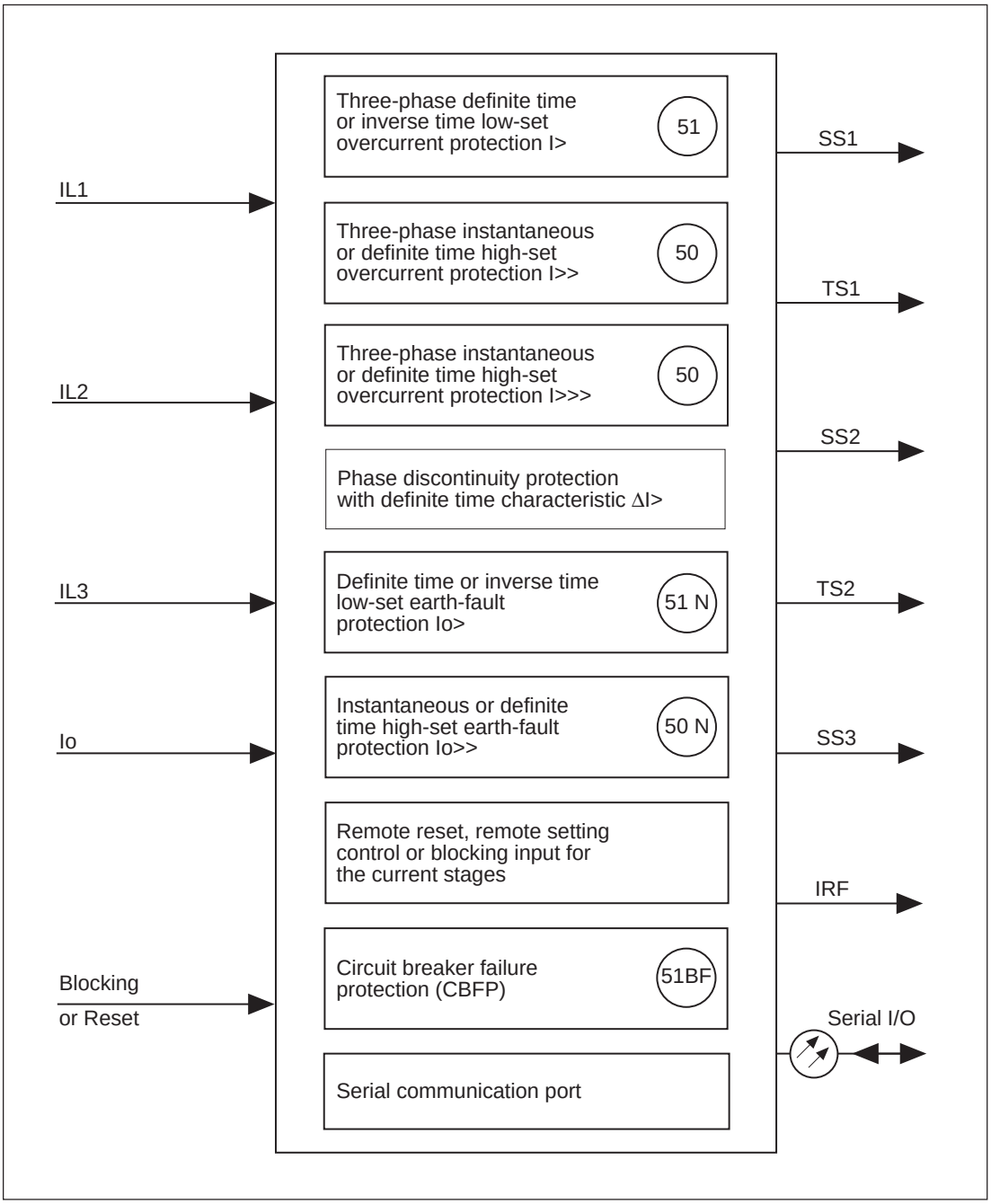


Fig. 1. Protection functions of the combined overcurrent and earth-fault relay type SPAJ 144 C

Connections

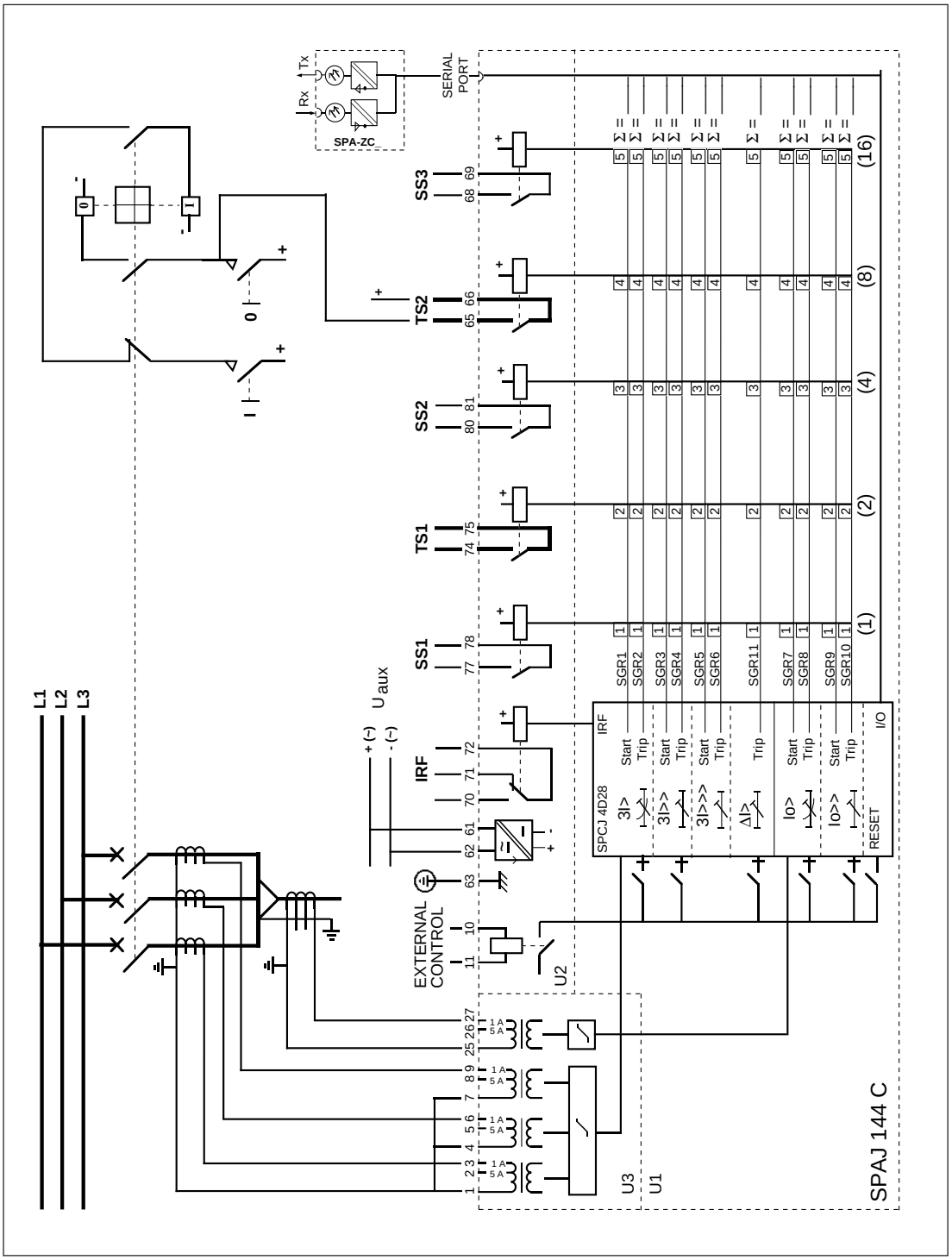


Fig. 2. Connection diagram for the combined overcurrent and earth-fault relay type SPAJ 144 C

U_{aux}	Auxiliary voltage
IRF	Self-supervision
SGR	Switchgroups for the configuration of output relays
SGB	Switchgroup for the configuration of blocking or control signals
TS1, TS2	Trip output relays
SS1, SS2, SS3	Signal ouput relays
U1	Overcurrent and earth-fault relay module SPCJ 4D28
U3	Input module SPTE 4E1
U2	Power supply and output relay module SPTU 240 R1 or SPTU 48 R1
SERIAL PORT	Serial communication port
SPA-ZC_	Bus connection module
Rx/Tx	Receiver bus terminal (Rx) and transmitter bus terminal (Tx) of the bus connection module

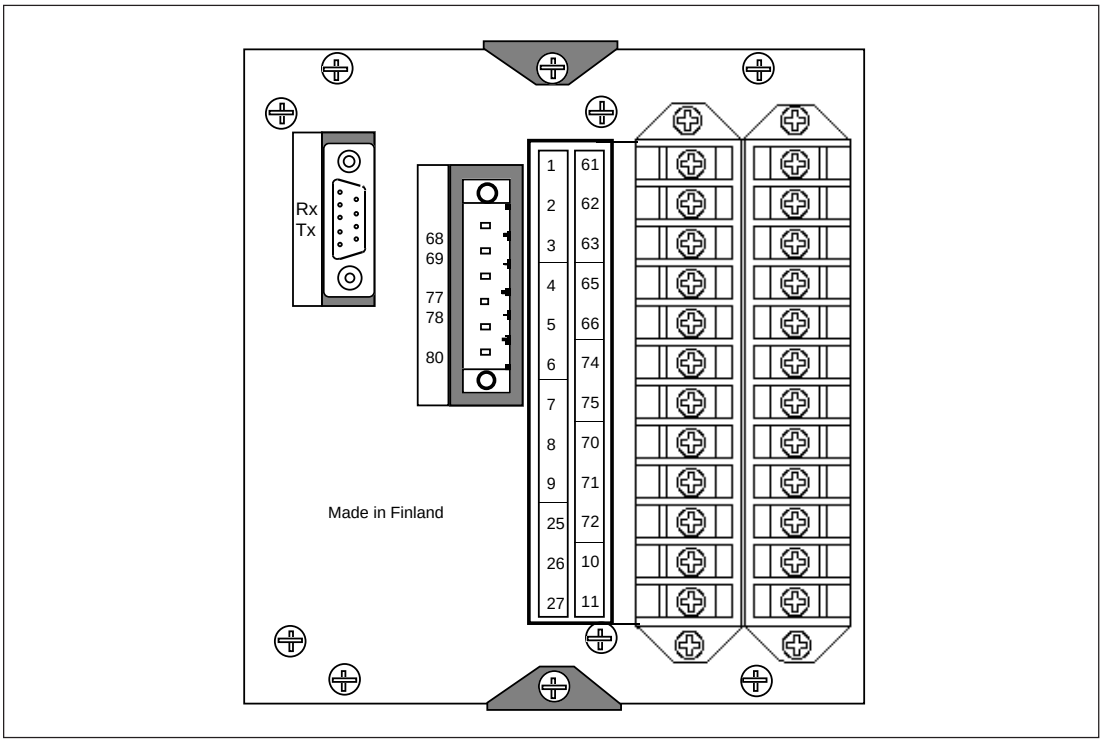


Fig. 3. Terminal arrangement of the overcurrent and earth-fault relay type SPAJ 144 C

The energizing currents of the overcurrent unit are connected to terminals 1-2, 4-5 and 7-8, when the rated current of the CT secondary circuits is I_n = 5 A. When the rated current of the CT secondary circuits is I_n = 1 A, terminals 1-3, 4-6 and 7-9 are used. The relay can also be used in single-phase or two-phase applications, by leaving one or two energizing inputs unoccupied. In single-phase applications the same energizing current can be routed through two energizing inputs, this may increase the operating speed of the overcurrent unit, especially, at instantaneous operation.

The energizing current of the earth-fault unit is connected to terminals 25-26 when the rated current I_n = 5 A and to terminals 25-27 when the rated current I_n = 1 A.

The control input 10-11 can be used in three ways: 1) as the control input for an external blocking signal, 2) as the control input for unlatching a trip relay, or 3) as the control input for the remote control of main/second settings of the relay. The required function is selected using switchgroup SGB of the protection relay module.

The auxiliary supply voltage of the relay is connected to terminals 61-62. At d.c. supply the positive lead is connected to terminal 61. The level of the voltage to be applied to the terminals depends on the type of power supply and output relay module used in the relay. For further details, see the description of the power supply module. The permitted auxiliary voltage range of the relay is marked on the relay front panel.

Output relays TS1 and TS2 are heavy-duty trip relays capable of controlling most circuit breakers. The operate signals of the protection stages are routed to the trip relay with the SGR switches. When the relay is delivered from the factory all the protection stages are routed to the trip relays. Switchgroup SGF4 is used to select latching of the heavy-duty output relays.

The relay module is also provided with a circuit breaker failure protection (CBFP), which provides a tripping signal via TS1 after the set operation time 0.1...1 s counted from the normal tripping signal TS2, if the fault has not been cleared within that time. The operation time of the circuit breaker failure protection is set in Register A, submenu 5.The output contact of the circuit breaker failure protection is normally used for tripping an upstream circuit breaker. The CBFP can also be used for establishing a redundant trip system by providing the circuit breaker with two tripping coils one being controlled by TS2 and the other by TS1. Output relay TS1 is used as a trip relay for the circuit breaker failure protection (CBFP), when the CBFP function is used. In this case the trip signal can be used either to control a circuit breaker upstream or to control a second trip coil on the main circuit breaker to increase the redundancy of the circuit breaker.

Output relay IRF functions as the output relay for the self-supervision system of the protection relay. Under normal operating conditions the IRF relay is energized and the contact gap 70-72 is closed. If a fault is detected by the self-supervision system, or on loss of auxiliary supply, the output relay drops off and the NO contact 71-72 closes.

The relay connects to the fibre-optic SPA bus via a bus connection module type SPA -ZC 17 or SPA-ZC 21 and the 9-pole, D-type subminiature connector located at the rear panel of the relay. The fibre-optic cables are linked from one relay to another and to the substation level communication unit.

Signal diagram

The figure below schematically illustrates how the start, trip, control and blocking signals can be configured to obtain the required protection functions.

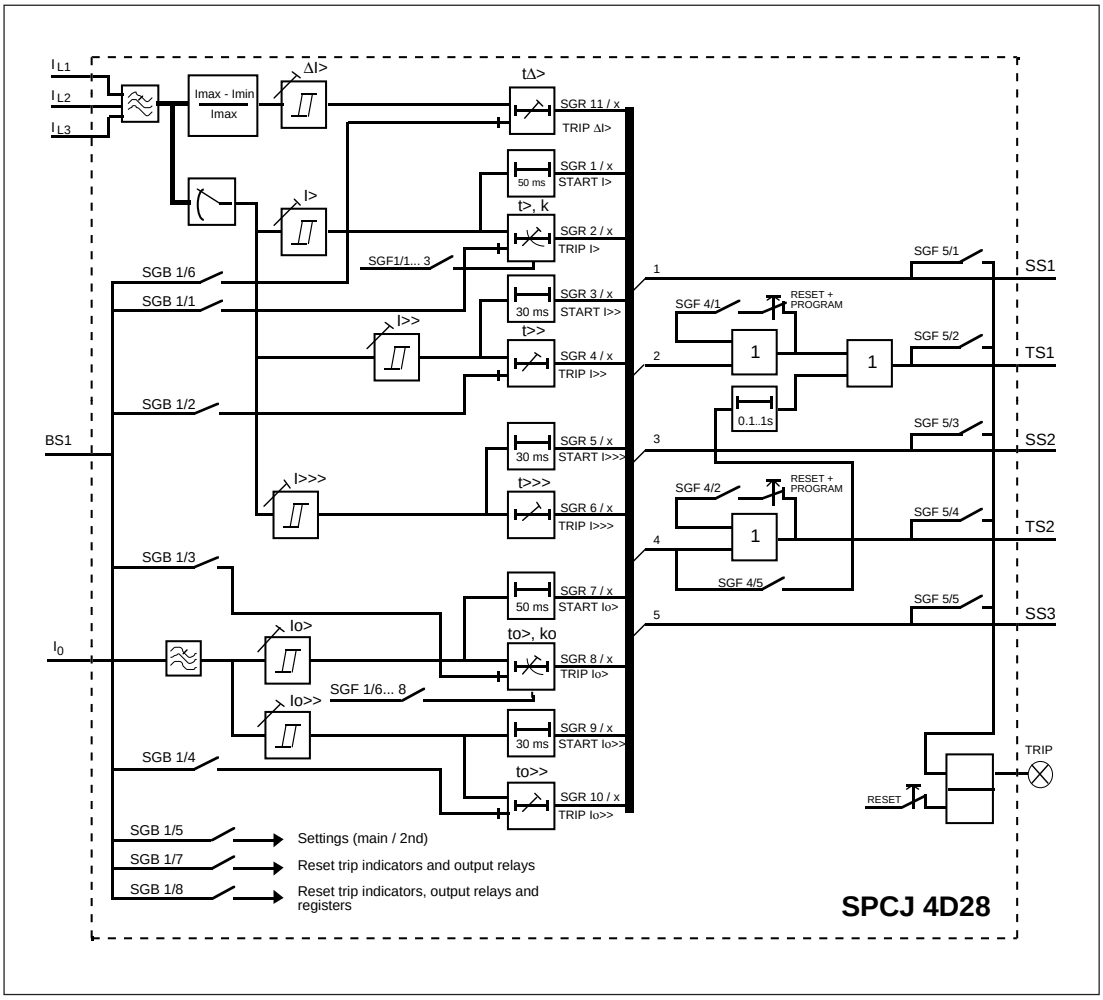


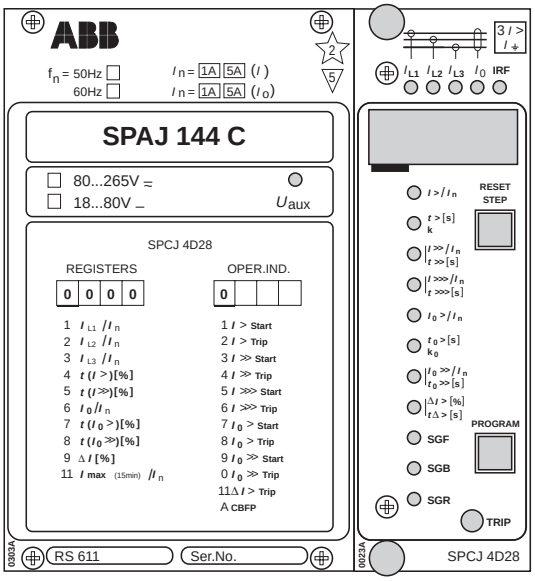
Fig. 4. Signal diagram of the combined overcurrent and earth-fault relay type SPAJ 144 C

The functions of the blocking and operation signals are selected with the switches of switchgroups SGB and SGR. The checksums of the switchgroups are found in the setting menu of the protection relay module. The functions of the switches are explained in detail in the user´s manual of the protection relay module SPCJ 4D28.

Signal abbreviations

I_{L1}, I_{L2}, I_{L3}	Phase currents
I_0	Neutral current
BS1	Blocking or control signal
SGF1..8	Selector switchgroups for relay functions
SGB1...3	Selector switchgroups for external control signals
SGR1...11	Selector switchgroups for output relays configuration
SS1...SS4, TS1...TS4	Output signals
TRIP	Red operation indicator

Operation indicators



A) The indicator TRIP is lit when one of the protection stages operates. When the protection stage resets, the red indicator remains lit. The TRIP indicator is configured with switchgroup SGF 5.

B) If the display is dark when one of the protection stages I>, I>>, I>>>,I_0>, I_0>> or ΔI>, operates, the faulty phase or the earth-fault is indicated with a yellow LED. If, for instance, the TRIP indicator glows red, and at the same time are the indicators I_{L1} and I_{L2} lit, overcurrent has occurred on phase L1 and L2.

C) Besides operating as a code number at data presentation, the leftmost red digit in the display serves as a visual operation indicator. An operation indicator is identified by the red digit alone being lit. The following table explains the code numbers used.

Indication	Parameter V9	Symbol	Explanation
1	1	I> START	= Start of overcurrent stage I>
2	2	I> TRIP	= Operation of overcurrent stage I>
3	3	I>> START	= Start of overcurrent stage I>>
4	4	I>> TRIP	= Operation of overcurrent I>>
5	5	I>>> START	= Start of overcurrent stage I>>>
6	6	I>>> TRIP	= Operation of overcurrent stage I>>>
6	7	I_0> START	= Start of earth-fault stage I_0>
7	8	I_0> TRIP	= Operation of earth-fault stage I_0>
8	9	I_0>> START	= Start of earth-fault stage I_0>>
0	0	I_0>> TRIP	= Operation of earth-fault stage I_0>>
11	11	ΔI> TRIP	= Operation of phase discontinuity protection stage ΔI>
A	12	CBFP	= Operation of circuit breaker failure protection

D) The TRIP indications persist when the protection stage returns to normal. The indicator is reset by pushing the RESET/STEP push-button.

Further, the indicators may be reset by applying a control voltage to the external control input 10-11, provided switch SGB1/7 is in position 1.

The basic protection relay functions are not depending on whether the operation indicators are reset or not. The relay is always alert.

If a protection stage starts, but does not operate, because the energizing quantity falls below the set start current before the operate time circuit times out, the start indicators are normally switched off automatically. When required, manual resetting of the start indications is obtained through the following switch settings:

SGF2/1 = 1 manual reset of I> start indication
SGF2/2 = 1 manual reset of I>> start indication
SGF2/3 = 1 manual reset of I>>> start indication
SGF2/4 = 1 manual reset of I_0> start indication
SGF2/5 = 1 manual reset of I_0>> start indication

On delivery of the relay from the factory the switches SGF2/1…5 are preset at 0.

E) Once the internal self-supervision system has detected a permanent relay fault the red IRF indicator is lit and the output relay of the self-supervision system operates. Further, in most fault situations, an autodiagnostic fault code is shown in the display. The fault code is composed of a red figure 1 and a green code number which indicates the fault type. The code number should always be recorded for maintenance purposes.

Power supply and output relay module

To be able to operate the relay needs a secured auxiliary voltage supply. The power supply module forms the voltages required by the protection relay module and the auxiliary relays. The withdrawable power supply and output relay module is located behind the system front panel, which is fixed by means of four cross-slotted screws. The power supply and output relay module contains the power supply unit, the output relays, the control circuits of the output relays and the electronic circuitry of the external control inputs.

The power supply and output relay module can be withdrawn after removing the system front panel. The primary side of the power supply module is protected with a fuse, F1, located on the PCB of the module.

The power supply unit is a pulse-width modulated (PWM) dc/dc converter with galvanically isolated primary and secondary sides. It forms the dc secondary voltages required by the protection relay module; that is +24 V, ±12 V and +8 V. The output voltages ±12 V and +24 V are stabilized in the power supply module, while the +5 V logic voltage required by the protection relay module is stabilized in the protection relay module.

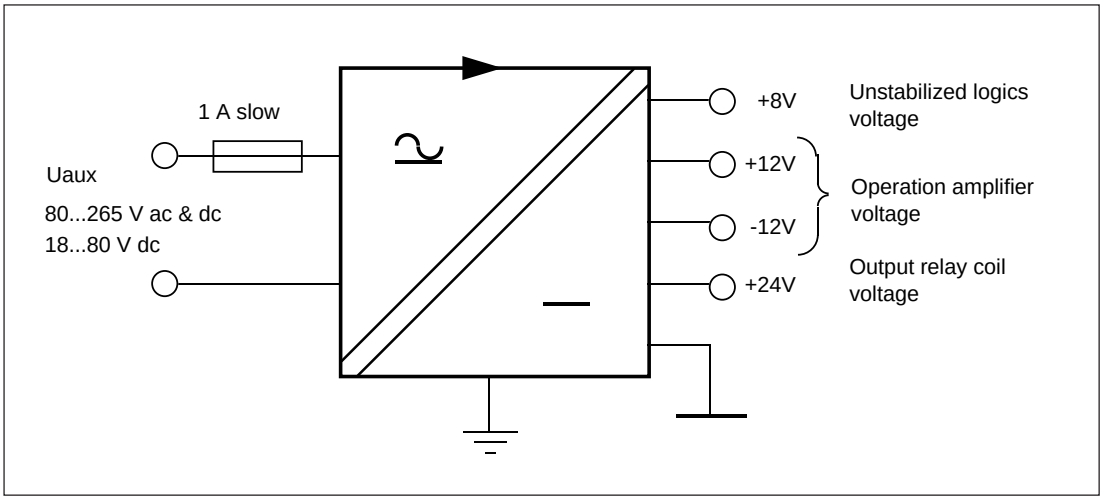


Fig. 5. Voltage levels of the power supply unit

A green LED indicator U_{aux} on the system front panel is lit when the power supply module is in operation. The supervision of the voltages supplying the electronics is integrated into the protection relay module. If a secondary voltage differs too much from its rated value, a self-supervision alarm will be generated. An alarm signal is also issued when the power supply module is withdrawn from the relay case, or on loss of auxiliary supply.

There are two versions of power supply and output relay modules available. The secondary sides and the relay configurations are identical, but the input voltage ranges differ.

Insulation test voltage between the primary and secondary side and protective earth

2 kV, 50 Hz, 1 min

Voltage ranges of the power supply modules:
- SPTU 240 R1 U_{aux} = 80...265 V dc/ac
- SPTU 48 R1 U_{aux} = 18...80 V dc

The SPTU 240 R1 module can be fed from an ac source or a dc source. SPTU 48 R1 is designed for dc supply only. The permitted auxiliary voltage range of the relay is marked on the relay system front panel.

Technical data

(modified 2002-04)

Energizing inputs

Rated current I_n	1 A	5 A
Thermal withstand capability		
- continuously	4 A	20 A
- for 10 s	25 A	100 A
- for 1 s	100 A	500 A
Dynamic current withstand, half-wave value	250 A	1250 A
Input impedance	<100 mΩ	<20 mΩ
Rated frequency f_n, on request	50 Hz or 60 Hz	

Output contact ratings

Trip contacts	
Terminal numbers	65-66, 74-75
- rated voltage	250 V dc/ac
- continuous carry	5 A
- make and carry for 0.5 s	30 A
- make and carry for 3.0 s	15 A
Breaking capacity for dc, when the trip circuit time-constant L/R ≤ 40 ms, at 48/110/220 V dc	5 A/3 A/1 A
Signal contacts	
Terminals	70-71-72, 68-69, 77-78, 80-81
- rated voltage	250 V dc/ac
- continuous	5 A
- make and carry for 0.5 s	10 A
- make and carry for 3.0 s	8 A
Breaking capacity for dc, when the signal circuit time-constant L/R ≤ 40 ms, at 48/110/220 V dc signal circuit voltage	1 A/0.25 A/0.15 A

External control inputs

Blocking, remote reset or remote setting input (BS1)	
- terminal numbers	10-11
Control voltage level	18...265 V dc or 80...265 V ac
Control current of activated input	2…20 mA

Auxiliary power supply and output relay module

Voltage ranges of power supply modules:	
SPTU 240R1:	
- rated voltage	U_n = 110/120/230/240 V ac U_n = 110/125/220 V dc
- operative range	U = 80...265 V ac/d
SPTU 48R1	
- rated voltage	U_n = 24/48/60 V dc
- operative range	U = 18...80 V dc
Power consumption, under quiescent/ operation conditions	~4W /~8W

Combined overcurrent and earth-fault relay module SPCJ 4D28

- see "Technical data" in the manual for the module. (1MRS 750093-MUM EN)

Data communication

Transmission mode	Fibre-optic serial bus
Data code	ASCII
Data transfer rate, selectable	4800 Bd or 9600 Bd
Electrical/optical bus connection module powered from the host relay	
- for plastic core cables	SPA-ZC 21BB
- for glass fibre cables	SPA-ZC 21 MM
Electrical/optical bus connection module powered from the host relay or from an external power source	
- for plastic core cables	SPA-ZC 17BB
- for glass fibre cables	SPA-ZC 17 MM

Insulation Tests *)

Dielectric test IEC 60255-5	2 kV, 50 Hz, 1 min
Impulse voltage test IEC 60255-5	5 kV, 1.2/50 μs, 0.5 J
Insulation resistance measurement IEC 60255-5	>100 MΩ, 500 Vdc

Electromagnetic Compatibility Tests *)

High-frequency (1 MHz) burst disturbance test IEC 60255-22-1	
- common mode	2.5 kV
- differential mode	1.0 kV
Electrostatic discharge test IEC 60255-22-2 and IEC 61000-4-2	
- contact discharge	6 kV
- air discharge	8 kV
Fast transient disturbance test IEC 60255-22-4 and IEC 61000-4-4	
- power supply	4 kV
- I/O ports	2 kV

Mechanical environmental test

Vibration test (IEC 60255-21-1)	class 1
Chock/bump test (IEC 60255-21-2)	class 1

Environmental conditions

Service temperature range	-10...+55°C
Transport and storage temperature range	-40...+70°C
Temperature influence	0.2%/°C
Damp heat test (IEC 60068-2-30)	93...95%, +55°C, 6 cycles
Degree of protection by enclosure of flush mounting relay case (IEC 60529)	IP 54
Weight of fully equipped relay	3.5 kg

*) The tests do not apply to the serial port, which is used exclusively for the bus connection module.

Examples of application

The combined overcurrent and earth-fault relay SPAJ 144 C is intended to be used for the selective short-circuit and earth-fault protection of radial feeders in solidly earthed, resistance earthed or impedance earthed power systems. The integrated protection relay includes an overcurrent unit and an earth-fault unit with flexible tripping and signalling facilities. The overcurrent and earth-fault relays can also be used for other applications requiring single-, two-, or three-phase overcurrent protection. The combined overcurrent and earth-fault relay also includes a phase discontinuity stage and circuit breaker failure protection.

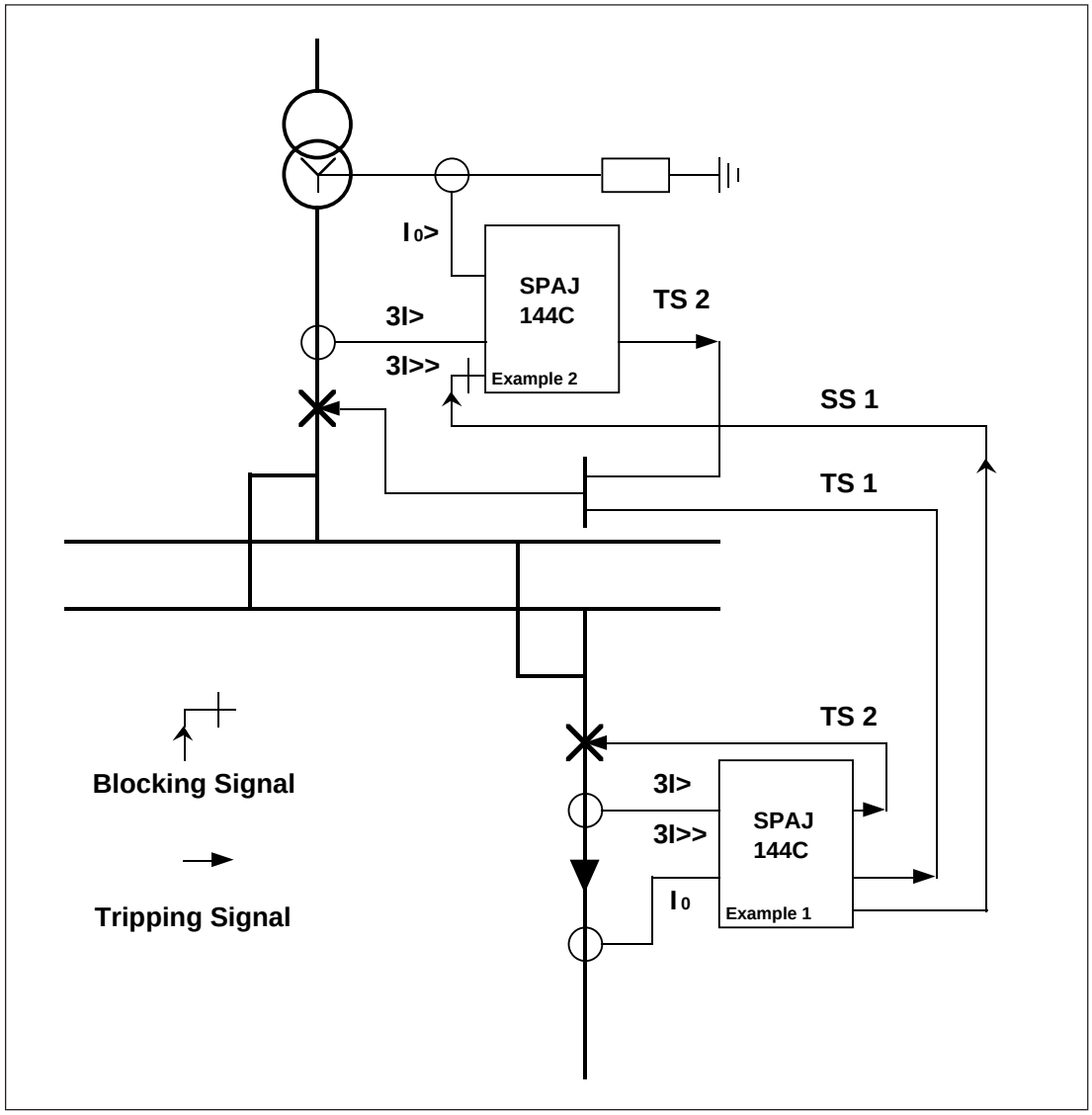


Fig. 6. The combined overcurrent and earth-fault relay SPAJ 144 C used for substation protection. For reasons of clarity remote control equipment and other protection relays have been omitted.

The short circuit protection is based on blockings between successive protection stages. In such an arrangement the relay located nearest to the fault gives, when starting, a blocking signal backwards to the relay that is closest to the object supplying the short-circuit current. If there is no blocking, the relay perceives the fault as being within its own protection area and trips the circuit breaker. When required the blocking can be extended to include the transformer feeding the busbar system.

Current asymmetry, if any, does not have to be allowed for in the current settings, because due to the peak-to-peak measurement method employed by the SPACOM relays asymmetry does not affect the operation of the protection.

Example 1. Overcurrent and earth-fault protection of an outgoing feeder

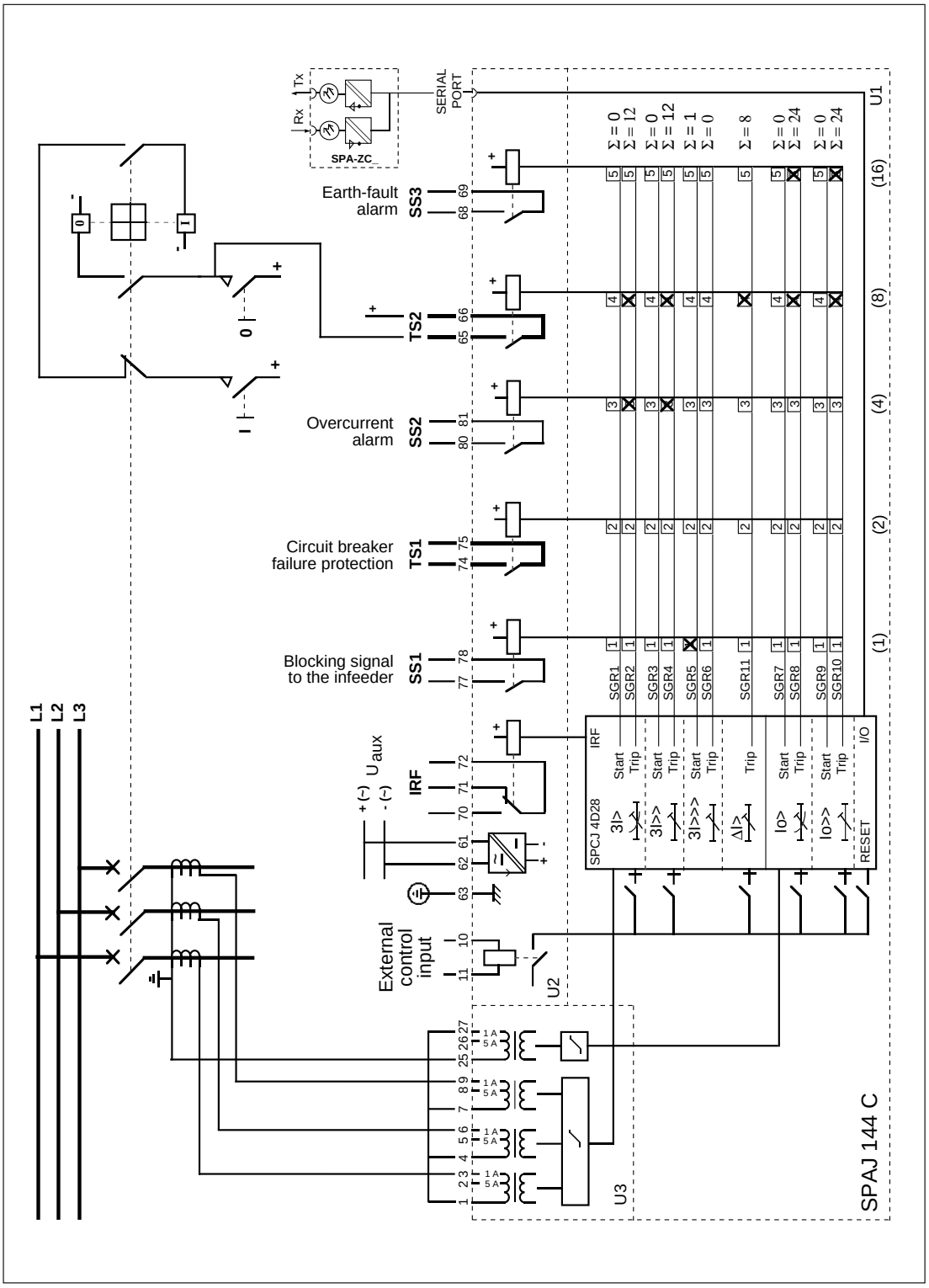


Fig. 7. The combined overcurrent and earth-fault relay SPAJ 144 C used for protecting an outgoing feeder

Overcurrent protection

The overcurrent relay module SPCJ 4D28 includes three overcurrent stages. By using all three stages and giving each overcurrent stage its own operate value and operate time good selectivity with short operate times can be obtained. Normally, two-stage overcurrent protection is sufficient. However, when the short-circuit protection is based on blockings between the successive protection stages, the high-set stage I>>> can be used for blocking purpose and so the blocking level can be freely selected. This means that when starting, the I>>> stage of the overcurrent relay module of the feeder provides a blocking signal to the I>> stage of the overcurrent relay module of the infeeder. When no blocking signal is received, the infeeder overcurrent relay module perceives the fault as being within its own protection zone and trips the circuit breaker. When required, the blocking functions can be extended to include the relay of the infeeder.

The operation of the low-set stage of the overcurrent relay can be based on definite time characteristic or inverse time characteristic. The operation characteristic is selected with the SGF1 switchgroup. When definite time characteristic has been selected, the operate time of the relay is current independent. At inverse time characteristic, on the contrary, the operate time is a function of the fault current level; the greater the fault current, the shorter the operate time. Therefore, the operate time is short at close faults.

In this example the definite time characteristic is used. Definite time characteristic can be used to obtain constant time grading steps over a wide current range and it offers faster tripping times than inverse time protection at low multiples of current settings.

Earth-fault protection

The earth-fault relay provides two-stage earth-fault protection. The neutral current can be measured either via a set of three phase current transformers in a residual connection or a core-balance current transformer. The above application can be used in cases with high earth-fault currents, moderate sensitivity requirements and small current transformer ratios. In solidely earthed networks or networks earthed over a low-resistance resistor or low-impedance coil, the earth-fault current is high enough to guarantee sufficient accuracy of the residual current connection for measuring the earth-fault current. The accuracy of the residual current connection depends on electrical similarity of the current transformers. To secure selectivity and stability at high fault current levels, current transformers with high accuracy limit factors are recommended, especially, if the high-set stage is to operate instantaneously.

The earth-fault relay is provided with two stages, a high-set stage and a low-set stage. The low-set stage satisfies the sensitivity requirements of the protection and the high-set stage the operate time requirements. The two-stage relay also enables selective protection in such cases, where the fault current generated by the feeder during a fault somewhere else in the network exceeds the set start current of the low-set stage but not that of the high-set stage. Definite time operation has been used in this example, but inverse time characteristic can be selected for the stage $I_0>$ as well.

The operation of a non-directional neutral overcurrent relay can be stabilised with a residual voltage relay. During a no-fault situation the residual voltage relay provides a blocking signal which is routed to the non-directional earth-fault relay. At an earthfault the residual voltage relay starts, the blocking signal disappears and the neutral overcurrent relays are allowed to operate.

Earth-fault current measured with a core-balance transformer

In figure 2, a core-balance current transformer is used instead of the residual current connection. In isolated neutral networks and in networks earthed over a resistor the core-balance current transformer is preferred to ensure stable and sensitive earth-fault protection. At an earth-fault situation, the healthy network supplies fault current to the faulty feeder. Therefore, non-directional earth-fault relays like SPAJ 144 C are best suited for the earth-fault protection of networks with rather short feeders, for instance, motor and transformer feeders of industrial switchgear.

The advantage with the core-balance current transformer is that only one CT core is used in place of three phase current transformers. In this way the CTmagnetizing current at relay operation is reduced by approximately three-to-one, an important consideration in sensitive earth-fault protection. Furthermore the number of secondary turns does not need to be related to the cable rated current because no secondary current would flow under normal balanced conditions. This allows the CT to be choosen such as to optimize the effective primary pick up current.

Phase discontinuity protection

The phase discontinuity stage ΔI> has a tripping function when used for protecting overhead lines. In cable networks, where phase discontinuity does not cause dangerous situations, the ΔI stage can be given an alarming function. The phase discontinuity protection can be used irrespective of earthing principle.

Health and safety is an important consideration for protecting against phase discontinuity faults. An example can be a broken phase wire, that has fallen down on such a place that the resistance towards earth is very high, for example, a dry road. the earth-fault protection alone is not able to detect the fault and thus the voltage is not disconnected. The phase discontinuity protection is of special importance in overhead lines and in overhead lines with isolated phase wires.

The start setting value of the stage ΔI> is the difference between the minimum and the maximum phase current measured, expressed as percentage ($\Delta I=(I_{max}-I_{min})/I_{max}$ x 100%). The set start value of the stage depends on the normal unbalance in the network. This has to be considered when selecting the setting value. Since this type of protection cannot be graded with other systems, it is confined to a supplementary role by the use of a long time delay, adjustable from 1s up to 300s.

Configuration

In the case described in example 1 the switches of feeder protection relay SPAJ 144 C can be configured as follows:

Switch-group	Serial comm. parameter	Checksum	Operation
SGF1	S53	000	Definite time operation
SGF2	S54	000	All stages used, automatic resetting of start indicators
SGF3	S55	000	ΔI stage operates, resetting time of I> & I_0> = 40 ms
SGF4	S56	016	No self-holding for TS signals, the TS2 signal starts the circuit-beaker failure protection
SGF5	S57	008	Signal TS2 controls the TRIP LED
SGF6	S58	000	Not used in SPAJ 144 C
SGF7	S59	000	Not used in SPAJ 144 C
SGF8	S60	000	Not used in SPAJ 144 C
SGB1	S61	000	No blocking/control by the BS1 signal
SGB2	S62	000	Not used in SPAJ 144 C
SGB3	S63	000	Not used in SPAJ 144 C
SGR1	S64	000	I> start not linked to the output contacts
SGR2	S65	012	I> trip linked to contacts TS2 and SS2
SGR3	S66	000	I>> start not linked to the output contacts
SGR4	S67	012	I>> trip linked to contacts TS2 and SS2
SGR5	S68	001	I>>> start linked to alarm contact SS1
SGR6	S69	000	I>>> trip not linked to output contacts
SGR7	S70	000	I_0> start not linked to output contacts
SGR8	S71	024	I_0> trip linked to contacts TS2 and SS3
SGR9	S72	000	I_0>> start not linked to output contacts
SGR10	S73	024	I_0>> trip linked to contacts TS2 and SS3
SGR11	S74	008	ΔI> trip linked to output contacts TS2

Example 2.
Overcurrent and earth-fault protection of an infeeder

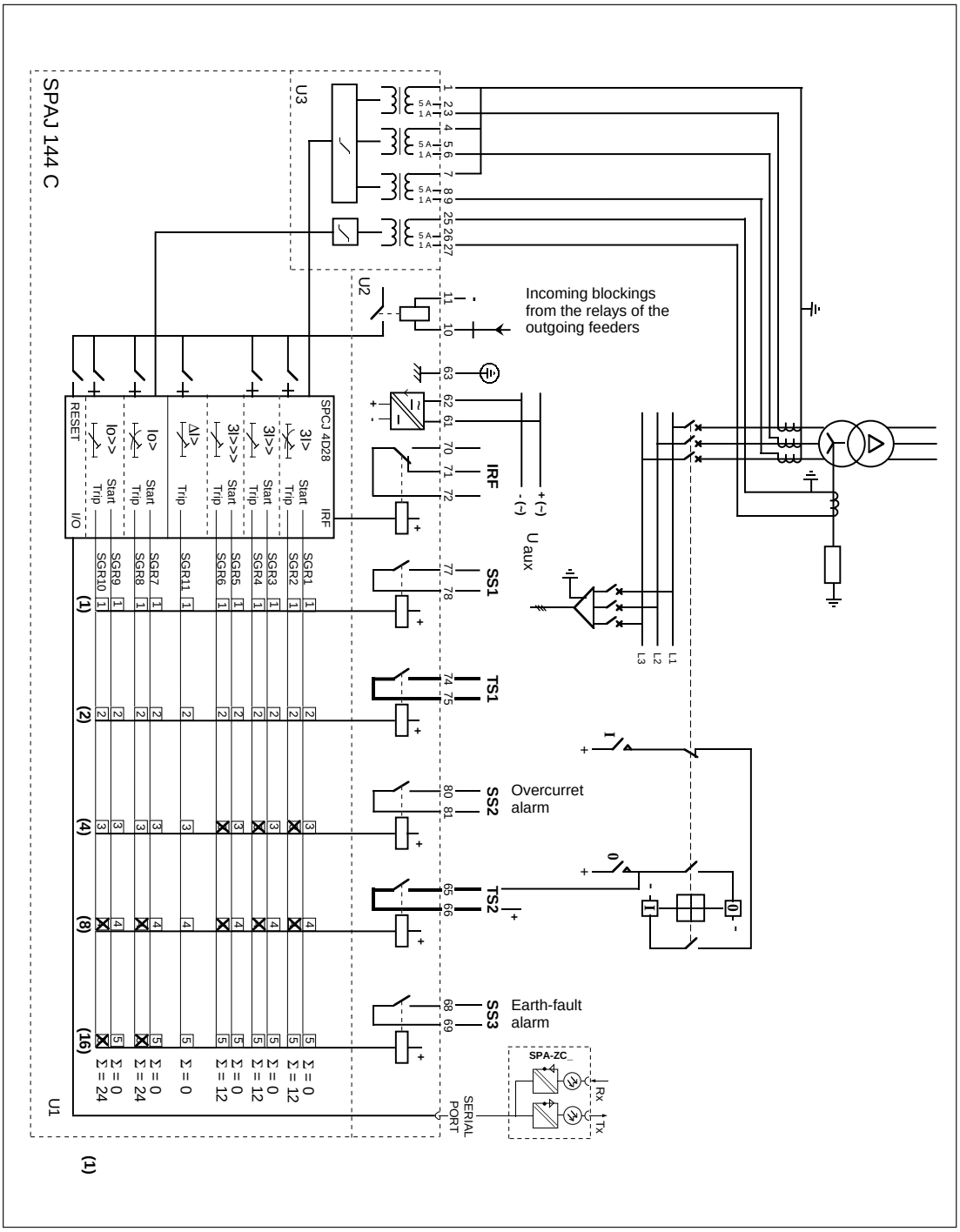


Fig. 8. The combined overcurrent and earth-fault relay SPAJ 144 C used for protecting an infeeder

Overcurrent protection

In the application example 2, the stages I> and I>>> of the overcurrent relay module SPCJ 4D28 operate as back-up protection for the outgoing feeders and the busbar system and the I>> stage is used for the short-circuit protection of the busbar system. In this way the back-up protection has two stages and the current settings can be the same as those used on the outgoing feeders. The set operate time of a back-up protection stage is calculated from; the fault current interrupting time of the circuit breaker (~150ms) plus a safety margin (~100ms), plus the operate time of the protection relay of the outgoing feeder.

If a fault occurs on the feeder, the overcurrent relay module of the outgoing feeder provides a blocking signal to the overcurrent relay module of the infeeder. Should the fault occur on the busbar system no blocking signal will be issued and the I>> stage of the overcurrent module of the infeeder provides a trip signal to the infeeder circuit breaker. Thus it is possible to use a minimum operate time of 100 ms at busbar system faults. The blocking arrangement can be extended to include the HV side overcurrent relay of the main transformer.

Busbar protection and the co-operation of the relays between the different protection levels can be arranged in many ways and varies quite a lot between different applications. Below a few examles of how the application described can be changed using some of the features of the relay SPAJ 144 C.

The back-up protection can also be made with the circuit breaker failure protection function of the protection relay of the outgoing feeder. Then a faster back-up function can be achived as since the safety margin can be omitted when setting the CBFP time. Furthermore, different time settings on the outgoing feeders do not affect the operation, because each relay has a separate CBFP function. The disadvantage of the CBFP function is that it requires external wiring from the protection relays of the outgoing feeders to the relay of the infeeder.

If an operate time of less than 100 ms is required on the busbar protection system and non-selective operation can be allowed, one possibility is to use the second high-set stage I>>> with an instantaneous operate time. Then the start current value shall be set to such a level that the fault most probably is within the busbar system. The second high-set stage I>>> can be given a set value up to 40 times the rated current. The advantage is that a fault on the busbar system does not cause serious damage due to the instantaneous trip of the busbar system. On the other hand, it is difficult to find the right setting value since a close-up fault on a feeder can cause the circuit breaker of the infeed to trip instead of the feeder protection relay.

In a double busbar system where the busbar circuit breaker is closed and two main transformers are connected in parallel, the breaking capacity of the circuit breakers of the feeders may not be sufficient and so tripping should be carried out by the circuit breaker of the infeeder. Then the current setting of the second high-set stage I>>> is set to the the same level as the breaking capacity of the feeders. This means that if the fault current exceeds the breaking capacity if the outgoing feeders the tripping is performed by the protection of the infeeder. An external control signal can be used for shifting to the second settings when the transformers are used in parallel operation. Then the stage I>>> is active in parallel operation and inhibited or has other settings when parallel operation not is used.

Eart-fault protection

The earth-fault stages can be used in different ways dependig of the earthing principle used. In this example with a low-resistance earthed network the two stages are used as back-up earth-fault protection and earth-fault protection of the busbar system. The low-set stage of the earth-fault protection serves as back-up protection for the outgoing feeders and the high-set stage as the primary earth-fault protection of the busbar system.

In networks with arc supression coil compensated neutral point the earth-fault stages can be used to protect the coil. Should the coil not be dimensioned for continuous service, the protection can be designed so that the low-set stage I_0> is alarming and stage I_0>> is tripping.

Configuration

In the case described in example 2 the switches of feeder protection relay SPAJ 144 C can be configured as follows:

Switch-group	Serial comm. parameter	Checksum	Operation
SGF1	S53	000	Definite time operation
SGF2	S54	000	Automatic resetting of start indicators
SGF3	S55	000	Stage ΔI operates, resetting time of I> & I_0> = 40 ms
SGF4	S56	016	No self-holding or CBFP
SGF5	S57	008	Signal TS2 controls the TRIP LED
SGB1	S61	002	The BS1 signal blocks stage I>>
SGR1	S64	000	I> start not linked to the output contacts
SGR2	S65	012	I> trip linked to contacts TS2 and SS2
SGR3	S66	000	I>> start not linked to the output contacts
SGR4	S67	012	I>> trip linked to contacts TS2 and SS2
SGR5	S68	000	I>>> start not linked to the output contacts
SGR6	S69	012	I>>> trip not linked to output contacts
SGR7	S70	000	I_0> start not linked to output contacts
SGR8	S71	024	I_0> trip linked to contacts TS2 and SS3
SGR9	S72	000	I_0>> start not linked to output contacts
SGR10	S73	024	I_0>> trip linked to contacts TS2 and SS3
SGR11	S74	000	ΔI>trip not linked to output contacts

Commissioning

Settings

When commissioning a SPAJ 144 C all settings can be entered either via the push buttons on the front panel or via the serial communication using a PC program, e.g. SMS 010. An advantage of using a PC is that the settings are more easily entered and the final settings can be saved to a file on a disk for future reference, or a permanent record can be printed on paper.

Inspection

Examine the relay case carefully to see that no damage has occurred since installation. Check that the external wiring is correct to the relevant relay diagram. Ensure that the case earthing connection (terminal 63) is used for connecting the relay to the local earth bar.

Wiring

In the trip test mode the outputs can be activated one by one to test the circuit breaker operation etc. The external wiring of the blocking circuits is also easily tested. To test the blocking circuit, the stage of the relay module issuing the blocking signal is activated (see section "General characteristics of D-type SPC relay modules") and then it is checked from the display (register 0) of the relay module to receive the blocking signal that it arrives properly. When the I>>> stage of the overcurrent module of the outgoing feeder is started (signal SS1), the rightmost digit of register 0 will be 1 (= blocking signal BS1 is activated) on the relay of the infeeder.

Testing

Periodic maintenance tests

The relay should be subjected to regular tests in accordance with national regulations and instructions. The manufacturer recommends an interval of five years between the tests.

The test should be carried out as a primary test, which includes the whole protection arrangement from the instrument transformers to the circuit breakers.

The test can also be carried out as a secondary injection test. Then the relay has to be disconnected during the test procedure. However, it is recommended to check the condition of the signal and trip circuits as well.

Note!
Make sure that the secondary circuits of the current transformers under no condition open or are open, when the relay is disconnected and during the test procedure.

The test is recommended to be carried out using the normal setting values of the relay and the energizing inputs used. When required, the test can be extended to include additional setting values.

As the settings of the relay modules vary in different applications, these instructions present the general features of the test procedure. Ordinary current and voltage supply units and instruments for measuring current, voltage and time can be used for the tests.

During the test procedure the relay records currents, voltages and relay operations. If the recorded data are used for the collection of information for longer time periods (for example, AR counters), these registers should be read before the test is started. After the test the registers are reset and, if required, the readings of the AR counters can be restored.

The relay settings may have to be changed during testing. A PC program is recommended to be used to read the relay settings before starting the test to make sure that the original settings are being restored when the test has been completed.

Testing of overcurrent and earth-fault relay module SPCJ 4D28

General

The protection stages used (I>, I>>, I>>>, I_0>, I_0>> and ΔI>) are tested as follows:

- start value (the high-set stages for all three phases)
- start time
- trip time
- trip indication, output relay operation and signalling
- circuit breaker failure protection (CBFP)

Start value

Test the start value by raising the current, starting from zero, until the relay starts. Record the current value required for starting. The value should be within the permitted tolerances.

To test the resetting value, if required, raise the current until the relay starts and then reduce the voltage, until the relay resets.

When multi-stage protection relays are tested, it is often necessary to inhibit or delay the operation of the low-set stages, to be able to test the operation of a high-set stage. In such a case it is recommended to start from the highest stage and then proceed to the lower stages. The advantage of this method is that the original settings of the stages really are restored, because otherwise the test cannot be carried out successfully.

Start and trip times

Switch a current 2...2.5 times the setting value of the protection stage to the relay. Measure the operate time, i.e. the time from the closing of the switch until the relay operates. The operate time should be within the permitted tolerances, except when the injected current is below 2 times the setting value. In such a case the protective algorithm adds about 20 ms to the operate times.

When inverse times are measured the measurement can be made with different supply currents, for example, 2 times and 10 times the setting value, if required. The resetting time can be measured from opening of the current switch until resetting of the relay.

Maintenance and repairs

When the feeder protection relay is used under the conditions specified in "Technical data", the relay requires practically no maintenance. The feeder protection includes no parts or components that are sensitive to physical or electrical wear under normal operating conditions.

Should the temperature and humidity at the operating site differ from the values specified, or the atmosphere contain chemically active gases or dust, the relay should be visually inspected in association with the secondary testing of the relay. This visual inspection should focus on:

- Signs of mechanical damage to relay case and terminals
- Collection of dust inside the relay case; remove with compressed air
- Signs of corrosion on terminals, case or inside the relay

If the relay malfunctions or the operating values differ from those specified, the relay should be overhauled. Minor measures can be taken by the customer but any major repair involving the electronics has to be carried out by the manufacturer. Please contact the manufacturer or his nearest representative for further information about checking, overhaul and recalibration of the relay.

The protection relay contains circuits sensitive to electrostatic discharge. If you have to withdraw a relay module, ensure that you are at the same potential as the module, for instance, by touching the case.

Note!
Protective relays are measuring instruments and should be handled with care and protected against moisture and mechanical stress, especially during transport.

Spare parts

Three-phase overcurrent and earth-faultmodule	SPCJ 4D28
Power supply and output relay module	
U_{aux} = 80...265 V ac/dc	SPTU 240 R1
U_{aux} = 18...80 V dc	SPTU 48 R1

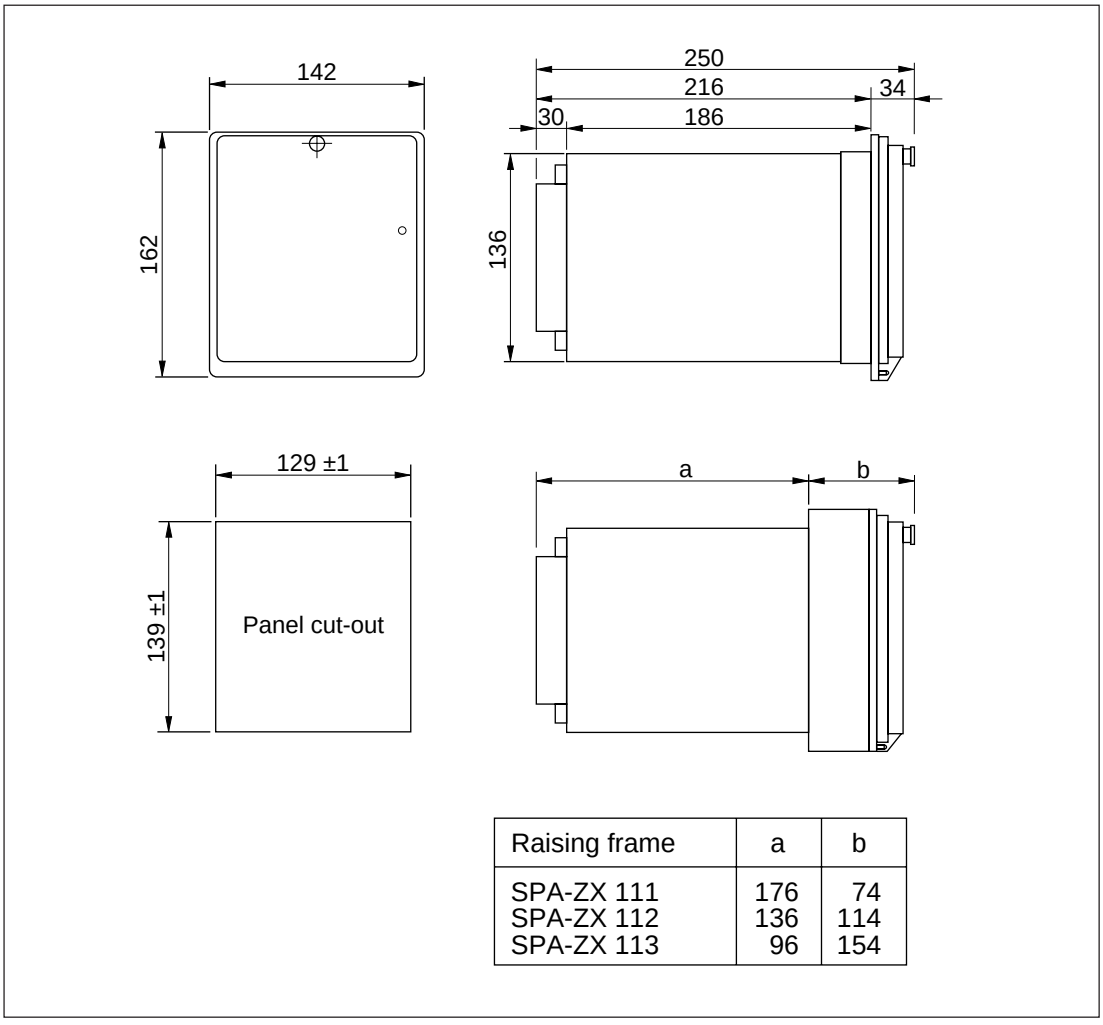
Dimensions for mounting

The relay is housed in a normally flush-mounted case. The case is made of an extruded, beige aluminium profile. When semi-flush mounting is required, raisings frames can be used to reduce the mounting depth. Three types of raising frames are available:
SPA-ZX 111, 40 mm
SPA-ZX 112, 80 mm
SPA-ZX 113, 120 mm

For surface mounting a case SPA-ZX 110 is available.

A cast aluminium alloy mounting collar with a rubber gasket provides a degree of protection by enclosure to IP 54 between the relay case and the panel surface, when the relay is panel mounted. The relay case is complete with a hinged gasketed, clear, UV-stabilized polycarbonate cover with a sealable fastening screw. The degree of protection by enclosure of the cover is IP 54 as well.

A terminal strip and two multi-pole connectors are mounted on the back of the relay case to facilitate input and output connections. To each heavy-duty terminal, i.e. measuring input, power supply or trip output, one 6 mm^2, one 4 mm^2 or one or two 2.5 mm^2 wires can be connected. No terminal lugs are needed. The signalling outputs are available on a six-pole detachable connector and the serial bus connection is using a 9-pin D-type connnector.



Raising frame	a	b
SPA-ZX 111	176	74
SPA-ZX 112	136	114
SPA-ZX 113	96	154

Order information

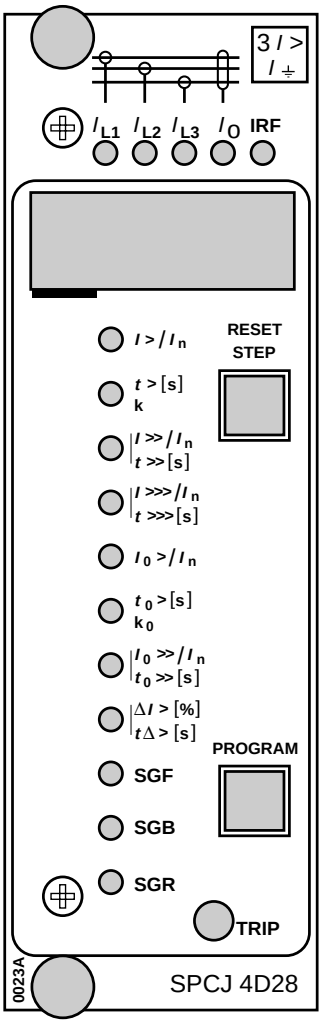
1. Quantity and type designation
2. Rated frequency
3. Auxiliary voltage
4. Accessories

5. Special requirements

Example
15 relays type SPAJ 144 C
f_n = 50 Hz
U_{aux} = 110 V dc
15 bus connection modules SPA-ZC17 MM
2 fibre optical cables SPA-ZF MM 100
14 fibre optical cables SPA-ZF MM 5
—

SPCJ 4D28
Overcurrent and earth-fault relay module

User´s manual and Technical description



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SPCJ 4D28
Overcurrent and earth-fault relay module

Contents

Characteristics

Low-set overcurrent stage I> with definite time or inverse definite time characteristic, the latter with six selectable inverse-time curves.

High-set overcurrent stage I>> with definite time characteristic. The high-set stage can be set out of operation.

Superhigh-set overcurrent stage I>>> with definite time characteristic. The superhigh-set stage can be set out of operation.

Low-set neutral overcurrent stage I_0> with definite time or inverse definite time characteristic, the latter with six selectable inverse-time curves.

High-set neutral current stage I_0>> with definite time characteristic. The high-set stage can be set out of operation.

Phase discontinuity stage with definite time characteristic. The phase discontinuity stage can be set out of operation.

Output relay matrix allowing any start or trip signal from the protection stages to be routed to the desired output relay.

Flexible configuration of auto-reclose start initiation signals.

Local display of measured and set values and data recorded at the moment of a fault. Reading and writing of setting values either via local display and front panel push-buttons or from higher-level systems over the serial interface and the fibre-optic bus.

Self-supervision system continuously monitoring the operation of the electronics and the microprocessor. When a permanent fault is detected the alarm output relay operates and the other relay outputs are blocked.

Description of operation

Overcurrent unit

The overcurrent unit of the combined overcurrent and earth-fault relay module SPCJ 4D28 is designed to be used for single-phase, two-phase and three-phase overcurrent protection. The overcurrent unit includes three overcurrent stages: a low-set stage I>, a high-set stage I>> and a superhigh-set stage I>>>.

An overcurrent stage starts if the current on one or more of the phases exceeds the set start value of the concerned stage. On starting the stage provides a start signal which can be routed to the desired output relay. At the same time a numerical code indicating starting appears on the display. Should the duration of the overcurrent situation exceed the set operate time of the stage at definite time operation or, at inverse time operation of stage I>, a time depending on the level of the measured current, the stage operates issuing an operate signal, which can be routed to the desired output relay.

The operation of the overcurrent stages I> and I>> can be inhibited by an external control signal BS1, BS2 or RRES(BS3) applied to the relay module. The external blocking signals are configured with switchgroups SGB1...3.

The operation of the overcurrent stage I> can be based on definite time or inverse time characteristic. When inverse time characteristic is selected four internationally standardized and two special type time/current curves are available. Both the mode of operation and the desired time/current curve is selected with switchgroup SGF1.

Note! At inverse time characteristic the effective setting range of the low-set overcurrent stage is 0.5…2.5 x I_n, although start current settings within the range 2.5…5.0 x I_n can be set on the relay. At inverse time characteristic any start current setting above 2.5 x I_n of the low-set stage will be regarded as being equal to 2.5 x I_n.

If the high-set stage I>> is given a setting from the lower part of the the setting range, the relay module will contain two nearly identical operation stages. In this case the relay module SPCJ 4D28 can be used in two-stage load shedding applications.

The set start current value I>>/I_n of stage I>> can be automatically doubled in a start situation, i.e. when the object to be protected is connected to the network. Thus a set start current value below the connection inrush current level may be selected for the overcurrent stage I>>. A start situation is defined as a situation where the phase currents rise from a value below 0.12 x I> to a value above 1.5 x I> in less than 60 ms. The start situation ends when the currents fall below 1.25 x I>.

The I>> stage or the I>>> stage can be set out of operation completely, if not needed. When an overcurrent stage is set out of operation the set start current of the stage is displayed with three dashes "- - -".

The inverse time function of stage I> can be inhibited, when stage I>> or stage I>>> is starting, in which case the operate time is determined by these stages.

Earth-fault unit

The earth-fault unit of the combined overcurrent and earth-fault relay module SPCJ 4D28 is provided with two protection stages: a low-set neutral overcurrent stage I_0> and a high-set neutral overcurrent stage I_0>>.

The low-set stage or the high-set stage starts, if the neutral or residual current measured exceeds the set start current of the concerned stage. On starting the stage provides a start signal, which can be routed to the desired output relay. At the same time a numerical code indicating starting appears on the display. Should the duration of the neutral overcurrent situation exceed the set operate time of the stage at definite time operation or, at inverse time operation of stage I_0>, a time depending on the level of the measured current, the stage operates issuing an operate signal, which can be routed to the desired output relay.

The operation of the overcurrent stages I_0> and I_0>> can be inhibited by an external control signal BS1, BS2 or RRES(BS3) applied to the relay module. The external blocking signals are configured with switchgroups SGB1...3.

The operation of the low-set stage I_0> can be based on definite time or inverse time characteristic. When inverse time characteristic is selected four internationally standardized and two special type time/current curves are available. Both the mode of operation and the desired time/current curve is selected with switchgroup SGF1.

The I_0>> stage can be set out of operation completely, if not needed. When a neutral overcurrent stage is set out of operation the set start current of the stage is displayed with three dashes "- - -".

The inverse time function of stage I_0> can be inhibited, when stage I_0>> is starting, in which case the operate time is determined by stage I_0>>.

Filter characteristics of the measuring inputs

A low-pass filter suppresses the harmonics of the phase currents and the earth-fault current measured by the module. Figure 1 shows the signal suppression as a function of the frequency.

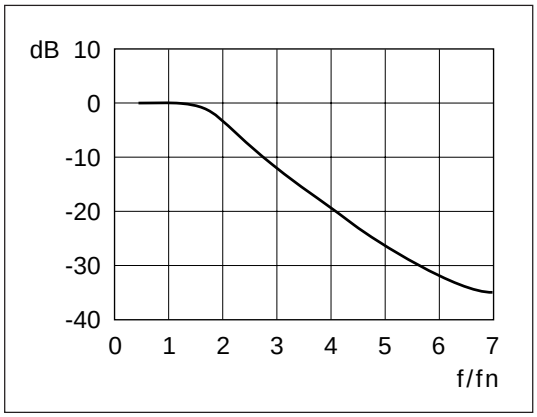


Fig. 1. Filter characteristics of the measuring inputs of the module SPCJ 4D28

Phase discontinuity protection unit

The overcurrent and earth-fault relay module SPCJ 4D28 is provided with a phase discontinuity protection unit which monitors the minimum and maximum phase currents. The difference between these currents is calculated from the expression $\Delta I = (I_{max}-I_{min})/I_{max} \times 100\%$. The phase discontinuity protection is not in use when the measured currents fall below $0.1 \times I_n$.

The phase discontinuity protection stage starts, if the current difference exceeds the set start current ΔI of the stage. Should the duration of the phase discontinuity situation exceed the set operate time tΔ> of the stage the stage operates issuing an operate signal, which can be routed to the desired output relay. At the same time a red operation indicator code is lit on the display.

The phase discontinuity protection stage can be set out of operation completely, if not needed. When the stage is set out of operation the set start current is displayed with three dashes "- - -".

The operation of the phase discontinuity protection stage can be inhibited by an external control signal BS1 applied to the relay module. The external blocking signal is configured with switch SGB1/6.

Circuit breaker failure protection unit

The overcurrent and earth-fault relay module SPCJ 4D28 is provided with a circuit breaker failure protection unit (CBFP) which provides a trip signal TS1 within 0.1...1 s after the trip signal TS2, TS3 or TS4 has been delivered, provided the fault still persists after the time has elapsed. The CBFP normally controls the circuit breaker which precedes the circuit breaker in question. The CBFP can also be used to establish a redundant trip system by using two trip coils in the circuit breaker and controlling one of the coils with TS2, TS3 or TS4 and the other with TS1. The switches SGF4/5...7 are used for activating the circuit breaker failure protection. The operate time is set in submenu 5 of register A.

Output signals

Switchgroups SGR1...11 are used for routing the start or trip signals of any protection stage to the desired start outputs SS1...SS4 or trip outputs TS...TS4.

The output signals TS1…TS4 can be assigned a self-holding function with switches SGF4/1…4. In this case the output signal remains active, although the signal that caused the operation resets. The resetting functions are explained in paragraph "Resetting". The TRIP indicator on the front panel can be set to be lit on activation of any of the output signals. The operation indicator remains lit after the output signal has disappeared. The functions are selected with switchgroup SGF5.

Auto-reclose start initiation signals

The start signals AR1, AR2 and AR3 can be used as start initiation signals for the desired autoreclose shots. The initiation signal AR2 can be programmed to be activated by the desired start and operate signals of the overcurrent module. The start signal AR3 can be programmed to be activated by the desired start and operate signals of the earth-fault module and the initiation signal AR1 by the start and operate signals of both the overcurrent module and the earth-fault module.

Second settings

Either the main settings or the second settings can be selected as currently used settings. Switching between the main settings and the second settings can be done in three different ways:

1) By command V150 over the serial communication bus
2) By an external control signal BS1, BS2 or RRES (BS3)
3) Via the push-buttons of the relay module, see submenu 4 of register A. When the value of submenu 4 is 0 the main settings are used and when the value of submenu 4 is 1 the second settings are used.

The main and second settings can be read and set via the serial bus using the S parameters. Those settings only, which currently are used, can be read and set with the push-buttons and the display on the front panel. When the second settings are used the indicators of the settings are flashing.

Note!
If external control signals have been used for selecting the main or second settings, it is not possible to switch between the settings over the serial bus or using the push-buttons on the front panel.

Resettings

The LED operation indicators, the operation code numbers of the display, the latched output relays and the registers of the module can be reset with the push-buttons on the front panel, with an external control signal or by a command via the serial bus, see table below.

Way of resetting	Resetting of indicators	Unlatching of output relays	Erasing of registers
RESET	x		
PROGRAM (dark display)	x	x	
RESET & PROGRAM	x	x	x
External control signal BS1, BS2 or RRES (BS3), when			
SGB2…3/6 = 1	x		
SGB_7/ = 1	x	x	
SGB_8/ = 1	x	x	x
Parameter V101	x	x	
Parameter V102	x	x	x

Block diagram

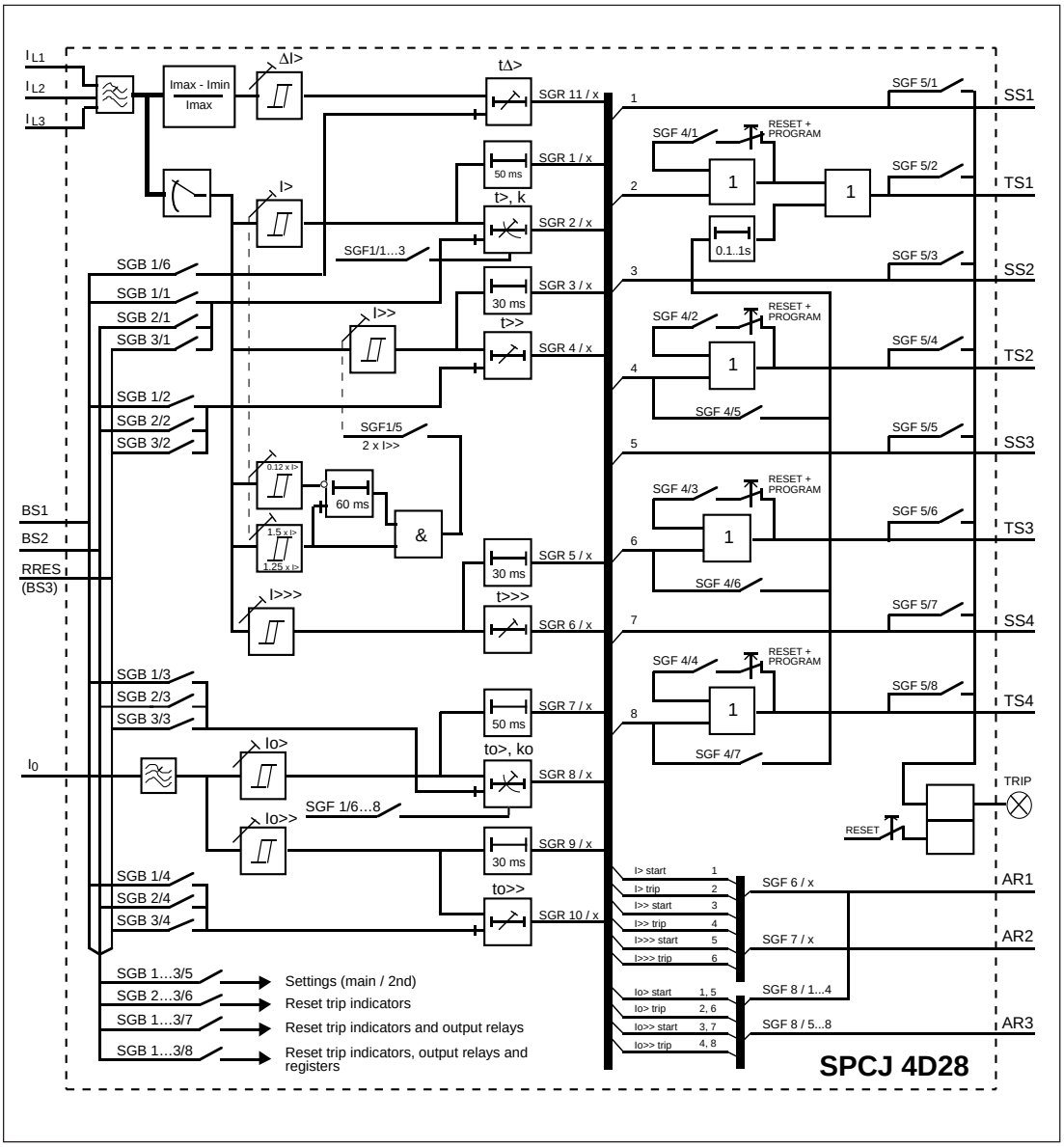
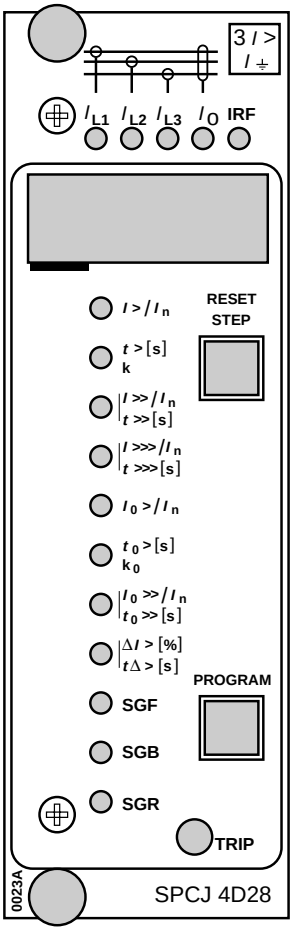


Fig. 2. Block diagram for overcurrent and earth-fault relay module SPCJ 4D28

I_{L1}, I_{L2}, I_{L3}	Phase currents
I_0	Neutral current
BS1, BS2, RRES (BS3)	External signals for blocking or resetting
SGF1..8	Selector switchgroups for relay functions
SGB1...3	Selector switchgroups for external control signals
SGR1...11	Selector switchgroups for configuration of output relays
SS1...SS4, TS1...TS4	Output signals
AR1, AR2, AR3	AR start initiation signal
TRIP	Red operation indicator

Note!
All input and output signals of the relay module are not necessarily wired to the terminals of each protection relay containing the SPCJ 4D28 module. The signals wired to the terminals are shown in the signal diagram of the concerned protection relay.



Phase current and residual current indicators during current measurement and phase fault indicators at relay operation

Indicator for the start current of stage I>

Indicator for the operate time t> or time multiplier k

Indicator for the start current of stage I>> and the operate time t>>

Indicator for the start current of stage I>>> and the operate time t>>>

Indicator for the start current of stage I_0>

Indicator for the operate time t_0> and the time multiplier k_0

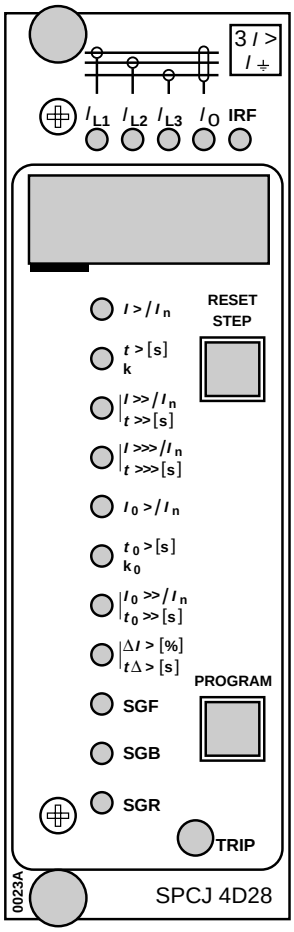
Indicator for the start current of stage I_0>> and the operate time t_0>>

Indicator for the start current of stage ΔI> and the operate time tΔ>

Indicator for the checksums of switchgroups SGF1...8

Indicator for the checksums of switchgroups SGB1...3

Indicator for the checksums of switchgroups SGR1...11



Device symbol

Indicator for self-supervision alarm

Display window

Reset and display step push-button

Setting push-button

Operation indicator

Type designation of relay module

Fig. 3. Front panel of the combined overcurrent and earth-fault relay module SPCJ 4D28

Operation indicators

Each protection stage has its own red start and trip code shown as a number on the display. The TRIP indicator at the bottom right corner is shared by the different protection stages. Switchgroup SGF5 is used for defining the mode of function of the TRIP indicator.

The code numbers indicating tripping and the red TRIP indicator remain lit, when the protection relay has issued a trip signal. Thus it is easy to identify the tripping stage. The indicators remain lit even though the stage that caused the indication resets, and they have to be separately reset. On the other hand, the code numbers indication starting automatically turned off when the protection stage resets. If the stage that started also operates the code number indicating starting turns into a code number indicating operation. When desired, the code numbers indicating starting can be set to remain lit, by giving switches SGF2/1...5 proper settings.

Operation indicators that remain lit are reset either by pressing the RESET push-button on the front panel or by command V101 over the SPA bus. Unreset operation indicators do not affect the operation of the relay module.

The table below shows the code numbers of the display or the corresponding code numbers readable with parameter V9 indicating starting or operation of the relay module.

Indication	Parameter V9	Symbol	Explanation
1	1	I> START	Staring of overcurrent stage I>
2	2	I> TRIP	Operation of overcurrent I>
3	3	I>> START	Staring of overcurrent stage I>>
4	4	I>> TRIP	Operation of overcurrent stage I>>
5	5	I>>> START	Staring of overcurrent stage I>>>
6	6	I>>> TRIP	Operation of overcurrent stage I>>>
7	7	I_0> START	Starting of earth-fault stage I_0>
8	8	I_0> TRIP	Operation of earth-fault stage I_0>
9	9	I_0>> START	Starting of earth-fault stage I_0>>
0	0	I_0>> TRIP	Operation of earth-fault stage I_0>>
11	11	ΔI> TRIP	Operation of phase discontinuity protection stage ΔI>
A	12	CBFP	Operation of circuit breaker failure protection unit

When one of the protection stages of the module operates, the yellow LEDs on the upper part of the front panel show on which phase the current exceeded the set start current of the stage, named phase fault indication. If, for instance, code number 2 and indicators I_{L1} and I_{L2} are lit, operation was caused by overcurrent on the phases L1 and L2. The phase fault indication is reset with the RESET push-button.

The self-supervision alarm indicator IRF indicates that the self-supervision system of the relay module has detected a permanent fault. Once a fault has been detected the red indicator is lit. At the same time the relay module delivers a control signal to the self-supervision system output relay of the protection relay. In addition, in most fault cases, a fault code appears on the display to indicate the type of fault. This fault code, which consists of a red figure one (1) and a green 1…3 digit code number cannot be removed by resetting. The code number should be recorded after a fault situation and stated when service is ordered.

Settings

Numerical settings
(modified 99-10)

The setting values are indicated by the three rightmost digits on the display.The LED indicators adjacent to the symbols of the quantities to be set indicates the quantity currently being displayed.

Setting	Explanation	Setting range (factory default)
$I>/I_n$	Start current of stage I> as a multiple of the energizing input used.	0.5…5.0 x I_n *) (0.5 x I_n)
t>	Operate time of stage I>, in seconds at definite time characteristic.	0.05...300 s (0.05 s)
k	Time multiplier k of stage I> at inverse time characteristic.	0.05...1.00 (0.05)
$I>>/I_n$	Start current of stage I>> as a multiple of the energizing input used.	0.5...40.0 x I_n and ∞ **) (0.5 x I_n)
t>>	Operate time of stage I>>, in seconds.	0.04...300 s (0.04 s)
$I>>>/I_n$	Start current of stage I>>> as a multiple of the energizing input used.	0.5...40.0 x I_n and ∞ **) (0.5 x I_n)
t>>>	Operate time of stage I>>>, in seconds.	0.04...30 s (0,04 s)
I_0/I_n	Start current of stage I_0> as a multiple of the energizing input used.	0.1...0.8 x I_n (0.1 x I_n)
$t_0>$	Operate time of stage I_0>, in seconds, at definite time characteristic.	0.05...300 s (0.05 s)
k_0	Time multiplier k_0 of stage I_0> at inverse time characteristic.	0.05...1.00 (0.05)
$I_0>>/I_n$	Start current of stage I_0>> as a multiple of the energizing input used.	0.1...10.0 x I_n and ∞ **) (0.1 x I_n)
$t_0>>$	Operate time of stage I_0>>, in seconds.	0.05...300 s (0.05 s)
ΔI> [%]	Start current of stage ΔI> as the difference between the minimum and maximum phase current measured, expressed as percentage of the measured current of the energizing input used. 10...100%.	10...100% and ∞ **) (10%)
tΔ>	Operate time of stage ΔI>, in seconds.	1...300 s (1 s)
CBFP	Operate time in seconds of the circuit breaker failure protection	0.1…1.0 s (0.2 s)

*) At inverse time characteristic the relay allows setting above 2.5 x I_n, but regards any setting >2.5 x I_n as being equal to 2.5 x I_n.

**) The stage can be set out of operation with SGF switches. This state is indicated as "- - -" on the display.

Note!
The continuous current carrying capacity of the energizing inputs is 4.0 x I_n.

Switch settings

Additional functions required for individual applications are selected with switchgroups SGF1...8, SGB1...3 and SGR1...11. The switch numbers, 1...8, and the switch positions, 0 and 1, are displayed when the switches are being set manually. Normally, the checksums of the switchgroups are displayed, see the main menu in section "Menu chart".

The tables below indicates the factory default settings of the switches and the corresponding checksums. The method for manual calculation of the checksum is shown at the end of this section.

The switchgroups SGF1...8 are used for configuring the desired functions as follows:

<table>
<tr><th>Switch</th><th>Function</th><th>Factory default</th></tr>
<tr><td>SGF1/1
SGF1/2
SGF1/3</td><td>Definite time or inverse time characteristic for stage I>.
When the inverse time has been selected, the desired current/time characteristic is selected as follows:
<table>
<tr><th>SGF1/1</th><th>SGF1/2</th><th>SGF1/3</th><th>Characteristic</th><th>Operate time t> or time/current curve</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>Definite time</td><td>0.05...300 s</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>Inverse time</td><td>Extremely inverse</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>"</td><td>Very inverse</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>"</td><td>Normal inverse</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>"</td><td>Long-time inverse</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>"</td><td>RI type characteristic</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>"</td><td>RXIDG type characteristic</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>---</td><td>(Long-time inverse)</td></tr>
</table></td><td>0
0
0</td></tr>
<tr><td>SGF1/4</td><td>Not in use</td><td>0</td></tr>
<tr><td>SGF1/5</td><td>Automatic doubling of the set start current of stage I>>, when the object to be protected is connected to the network.

When SGF1/5 = 0, the doubling function is out of use.
When SGF1/5 = 1, the set start current of stage I>> is automatically doubled. This feature allows the start current of stage I>> to be set below the level of the connection inrush current.</td><td>0</td></tr>
<tr><td>SGF1/6
SGF1/7
SGF1/8</td><td>Definite time or inverse time characteristic for stage I_0>.
When the inverse time has been selected, the desired current/time characteristic is selected as follows:
<table>
<tr><th>SGF1/6</th><th>SGF1/7</th><th>SGF1/8</th><th>Characteristic</th><th>Operate time t_0> or time/current curve</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>Definite time</td><td>0.05...300 s</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>Inverse time</td><td>Extremely inverse</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>"</td><td>Very inverse</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>"</td><td>Normal inverse</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>"</td><td>Long-time inverse</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>"</td><td>RI type characteristic</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>"</td><td>RXIDG type characteristic</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>---</td><td>(Long-time inverse)</td></tr>
</table></td><td>0
0
0</td></tr>
<tr><td>∑ SGF1</td><td></td><td>0</td></tr>
</table>

<table>
<tr><th>Switch</th><th>Function</th><th>Factory default</th></tr>
<tr><td>SGF2/1
SGF2/2
SGF2/3
SGF2/4
SGF2/5</td><td>Mode of operation of the start indicating code numbers of the different stages. When the switches are in position 0, the start indication code number automatically resets, once the fault disappears. When the switch is in position 1, the code number remains lit, although the fault disappears.
<table>
<tr><th>Switch</th><th>Stage</th><th colspan="2">Switch position
Code resets | Code remains</th></tr>
<tr><td>SGF2/1
SGF2/2
SGF2/3
SGF2/4
SGF2/5</td><td>I>
I>>
I>>>
I_0>
I_0>></td><td>0
0
0
0
0</td><td>1
1
1
1
1</td></tr>
</table></td><td>0
0
0
0
0</td></tr>
<tr><td>SGF2/6
SGF2/7
SGF2/8</td><td>Inhibition of the operation of stage I>>, stage I>>> and stage I_0>>. When the operation is inhibited the display shows "- - -", when the set value is displayed
<table>
<tr><th>Switch</th><th>Stage</th><th colspan="2">Switch position
Not inhibited | Inhibited</th></tr>
<tr><td>SGF2/6
SGF2/7
SGF2/8</td><td>I>>
I>>>
I_0>></td><td>0
0
0</td><td>1
1
1</td></tr>
</table></td><td>0
0
0</td></tr>
<tr><td>∑ SGF2</td><td></td><td>0</td></tr>
</table>

<table>
<tr><td>SGF3/1</td><td>Phase discontinuity protection stage ΔI> to be set out of use.
When SGF3/1 = 1, the phase discontinuity protection stage is out of use. The out of use state is indicated as "- - -" on the display.</td><td>1</td></tr>
<tr><td>SGF3/2
SGF3/3
SGF3/4
SGF3/5</td><td>Resetting times of stage I> and I_0>.
<table>
<tr><th>Switch</th><th>Stage</th><th colspan="4">Switch position
40 ms | 100 ms | 500 ms | 1000 ms</th></tr>
<tr><td>SGF3/2
SGF3/3
SGF3/4
SGF3/5</td><td>I>

I_0>
</td><td>0
0
0
0</td><td>1
0
1
0</td><td>0
1
0
1</td><td>1
1
1
1</td></tr>
</table></td><td>0
0
0
0</td></tr>
<tr><td>SGF3/6</td><td>Inverse time operation of stage I> to be inhibited by the starting of stage I>>.
When SGF3/6 = 1, the inverse time operation is inhibited.</td><td>0</td></tr>
<tr><td>SGF3/7</td><td>Inverse time operation of stage I> to be inhibited by the starting of stage I>>>.
When SGF3/7 = 1, the inverse time operation is inhibited.</td><td>0</td></tr>
<tr><td>SGF3/8</td><td>Inverse time operation of stage I_0> to be inhibited by the starting of stage I_0>>.
When SGF3/8 = 1, the inverse time operation is inhibited.</td><td>0</td></tr>
<tr><td>∑ SGF3</td><td></td><td>1</td></tr>
</table>

Switch	Function	Factory default
SGF4/1	Selection of self-holding for output signal TS1	0
SGF4/2	Selection of self-holding for output signal TS2	0
SGF4/3	Selection of self-holding for output signal TS3	0
SGF4/4	Selection of self-holding for output signal TS4 When the switch is in position 0, the output signal returns to its initial state, when the measuring signal that caused operation falls below the set start level. When the switch is in position 1 the output signal remains high although the measuring signal that caused operation falls below the set start level. At self-holding the output signal is reset with the push-buttons on the front panel, via an external control input or the serial bus, see section "Description of function".	0
SGF4/5	Starting of the circuit breaker failure protection (CBFP) by signal TS2	0
SGF4/6	Starting of the circuit breaker failure protection (CBFP) by signal TS3	0
SGF4/7	Starting of the circuit breaker failure protection (CBFP) by signal TS4 When the switch is in position 1, the output signal TS_ starts the circuit breaker failure protection. If the operate time of the CBFP expires while the output signal is active, the CBFP generates an operate signal TS1. When the switch is in position 0, the CBFP is set out of use.	0
SGF4/8	Not in use	0
∑ SGF4		0

SGF5/1 SGF5/2 SGF5/3 SGF5/4 SGF5/5 SGF5/6 SGF5/7 SGF5/8	Selection of the signal to control the TRIP indicator on the front panel. When the switch corresponding to a certain output signal is in position 1, the TRIP indicator is lit on activation of the output signal.			0 1 0 1 0 1 0 1
	Switch	Output signal	Switch position TRIP indicator not lit	Switch position TRIP indicator lit
	SGF5/1	SS1	0	1
	SGF5/2	TS1	0	1
	SGF5/3	SS2	0	1
	SGF5/4	TS2	0	1
	SGF5/5	SS3	0	1
	SGF5/6	TS3	0	1
	SGF5/7	SS4	0	1
	SGF5/8	TS4	0	1
∑SGF5				170

Switchgroups SGF6…8

(modified 96-02)

Using the different start and operation signals as autoreclose start initiation signals AR1, AR2 or AR3. The signal selection possibilities are shown in Fig. 4 below.

In the figure the start and operate signals of the different protection stages are connected to the desired autoreclose start line AR1, AR2 or AR3, for instance, by encircling the signal crossing point. The numbers of the different switches and their weight factors are marked near the crossing points. The checksums for the different switch groups are obtained by adding the weight factors of the selected switches.

Switches SGF6/7…8 and SGF7/7…8 are not in use.

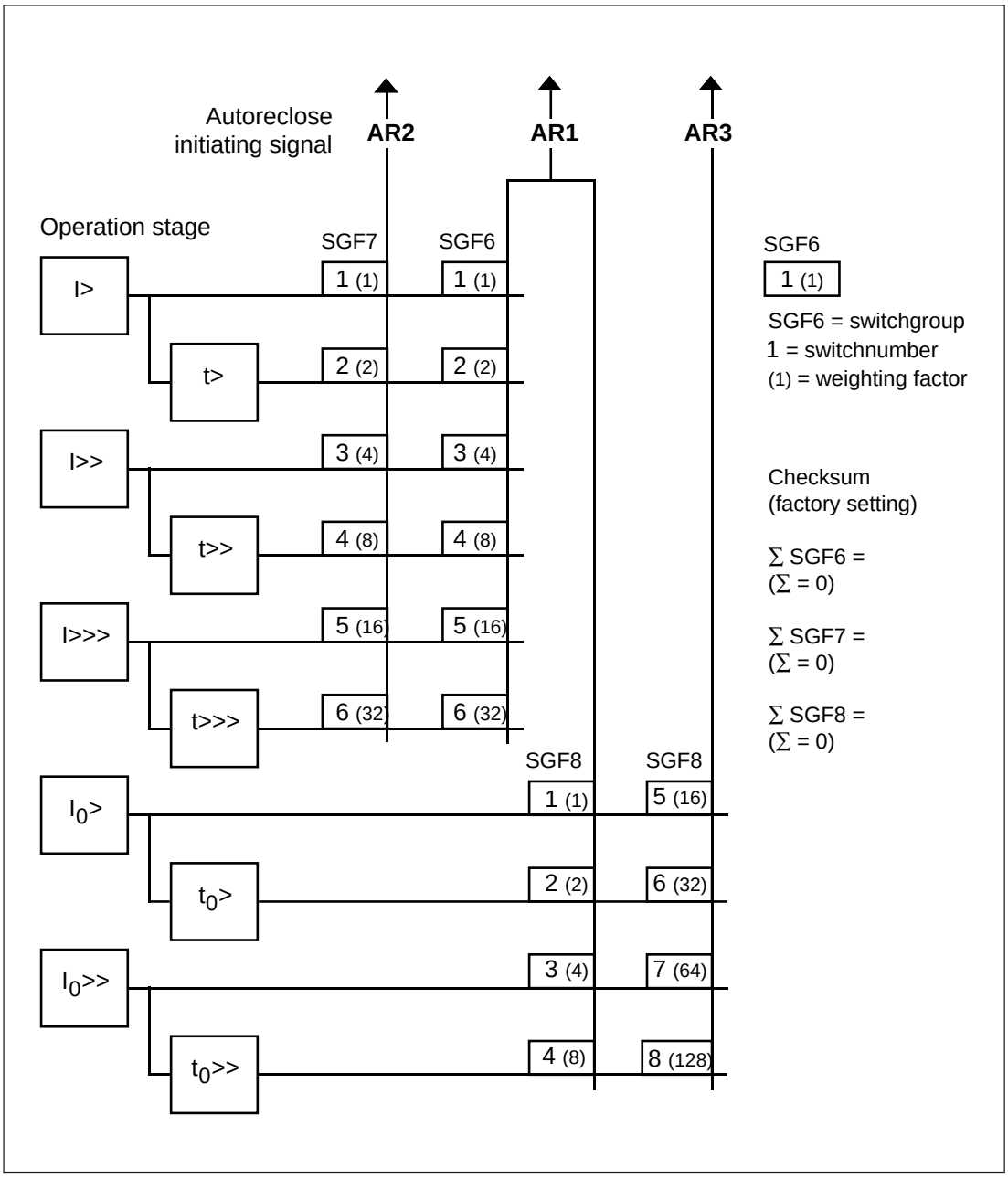


Fig. 4. Selection matrix for the autoreclose initiation signals

Switchgroups SGB1…3

The functions of the control signals BS1, BS2 and RRES (BS3) are defined with switchgroups SGB1…3. The matrix shown below can be used as an aid for making the desired selections. The control signals at the left side in the matrix can be combined with the functions at the upper side by encircling the desired intersection points. Each intersection point is marked with a switch number and the corresponding weight factor of the switch is shown at the bottom row of the matrix. By horizontally adding the weight factors of all the selected switches of a switchgroup the switchgroup checksums is obtained.

Note!
Check if all the control signals of the relay module SPCJ 4D28 are available in the protection relay in question.

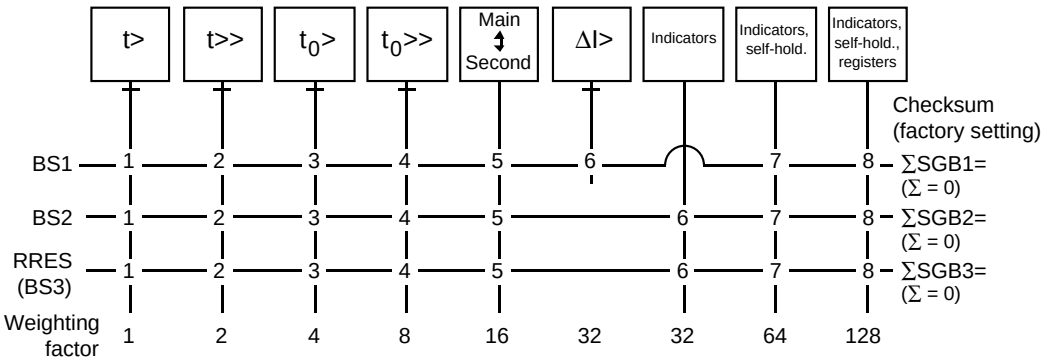


Fig. 5. Control signal matrix of the combined overcurrent and earth-fault relay module SPCJ 4D28.

Switch	Function
SGB_/1...4	Configuration of blocking signals to be applied to one or more protection stages via the external control signals BS1, BS2 and RRES (BS3). When a switch is in position 1, the operation of the concerned protection stage is blocked as long as the control signal is high.
SGB_/5	Switching between main setting values and second settings, either via the serial bus using command V 150, or using an external control signal. When SGB_/5 = 0, the setting values cannot be switched with an external control signal. When SGB1/5 = 1, the currently used setting values are determined exclusively by the state of the external control signal. Note! When the relay is provided with second settings in addition to the main settings, it is important that switch SGB_/5 has the same setting in the main settings and the second settings.
SGB1/6	Blocking of stage ΔI> via the external control signal BS1. The principle of operation is the same as for switches SGB_/1…4.
SGB2…3/6	Resetting of the operation indicators on the front panel, see section "Resetting"
SGB_/7	Resetting of the operation indicators and the latched output relays, see section "Resetting"
SGB_/8	Resetting of the operation indicators, the latched output relays and the registers, see section "Resetting"

Switchgroups SGR1…11

(modified 96-02)

The start and operate signals of the protection stages are combined with the outputs SS1… SS4 and TS1…TS4 with the switches of switchgroups SGR1…11.

The matrix shown below can be used as an aid for making the desired selections. The start and operate signals of the different protection stages can be combined with the output signals SS1…SS4 and TS1…TS4 by encircling the desired intersection points. Each intersection point is marked with a switch number and the corresponding weight factor of the switch is shown at the bottom row of the matrix. By horizontally adding the weight factors of all the selected switches of a switchgroup the switchgroup checksums is obtained.

Note!
Check if all the start and operate signals of the relay module SPCJ 4D28 are available in the protection relay in question.

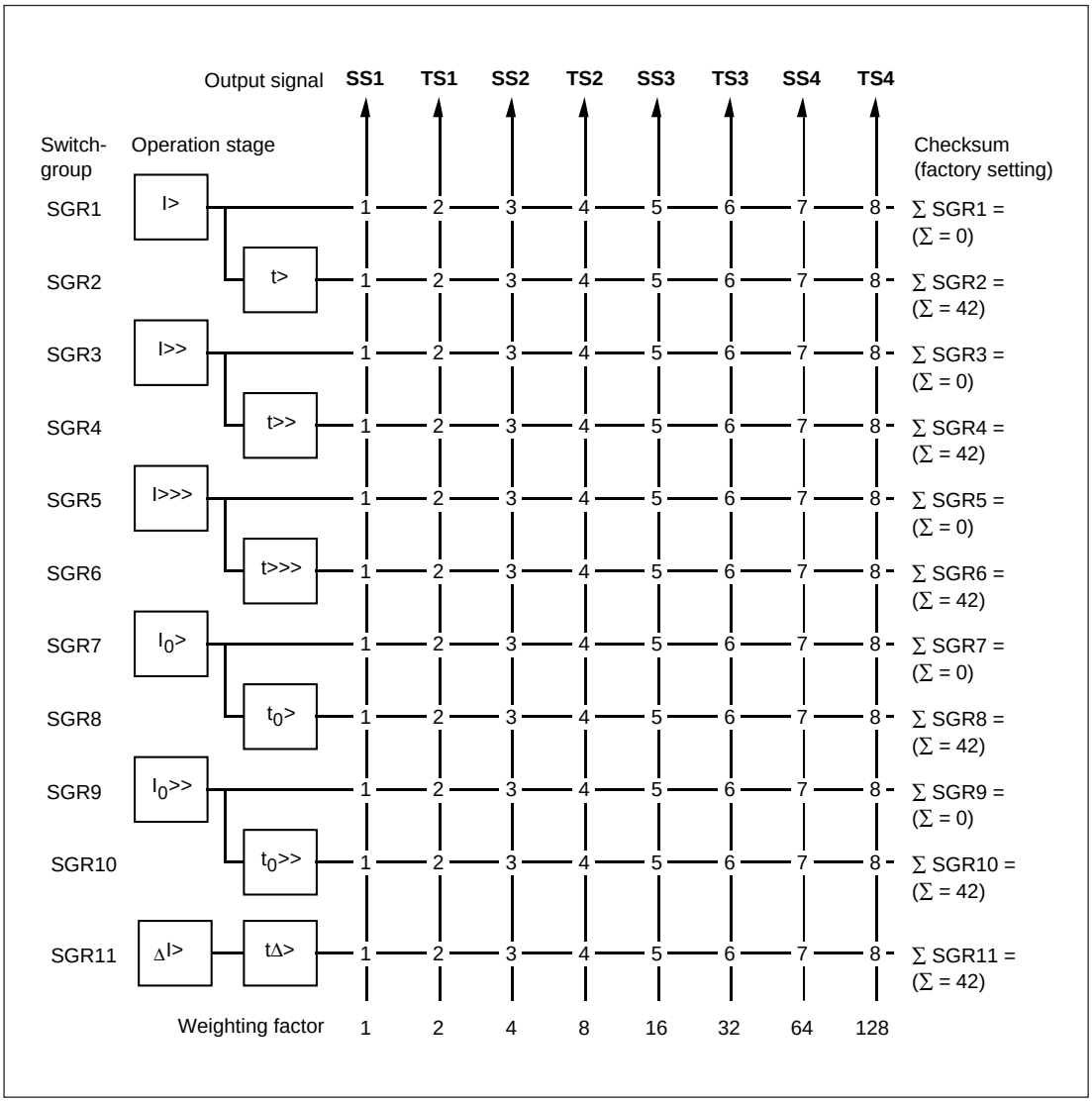


Fig. 6. Output signal matrix of the combined overcurrent and earth-fault relay module SPCJ 4D28.

Manual checksum calculation

Switch	Weight factor		Position		Value
SGF1/1	1	x	1	=	1
SGF1/2	2	x	0	=	0
SGF1/3	4	x	1	=	4
SGF1/4	8	x	0	=	0
SGF1/5	16	x	0	=	0
SGF1/6	32	x	0	=	0
SGF1/7	64	x	1	=	64
SGF1/8	128	x	0	=	0
Checksum of switchgroup SGF1			Σ	=	69

Measured data

The measured values are indicated by the three right-most digits on the display. The measured value currently presented is indicated by a yellow LED above the display.

Indicator	Measured data	Measuring range
I_{L1}	Measured line current on phase L1 as a multiple of the rated current I_n of the energizing input used.	0…63 x I_n
I_{L2}	Measured line current on phase L2 as a multiple of the rated current I_n of the energizing input used.	0…63 x I_n
I_{L3}	Measured line current on phase L3 as a multiple of the rated current I_n of the energizing input used.	0…63 x I_n
I_0	Residual current as a multiple of the rated current I_n of the energizing input used.	0…21 x I_n
I_0	In the submenu of the residual current the difference ΔI between the minimum phase current and the maximum phase current is available, expressed as a percentage.	0…100%

Recorded information

The left-most digit of the display shows the register address and the other three digits the recorded information. The structure of the registers is presented in the section "Main menus and submenus of settings and registers".

Register/ STEP	Recorded information
1	Current measured on phase L1, expressed as a multiple of the rated current I_n. The register is updated when one of the overcurrent stages (I>, I>> or I>>>) starts or operates. Then the previous current values will be pushed forwards one step in the stack while the oldest value is lost. The last five current values recorded are memorized so that the most recent value is stored in the main register and the other four values are stored in the subregisters. When the relay starts but does not operate, the relay module memorizes the maximum current measured on phase L1 during the start situation. When the stage operates, the value of the current measured at the moment of operation is recorded.
2	Register 2 records the events of phase L2. The operation principle is the same as that of register 1.
3	Register 3 records the events of phase L3. The operation principle is the same as that of register 1.
4	Duration of the latest start situation of stage I>, expressed as a percentage of the set operate time or, at IDMT mode of operation, of the calculated operate time. The register is updated, once the I> stage starts. Then the previously recorded values will be pushed forwards one step in the stack while the oldest value is lost. The last five current values recorded are memorized so that the most recently recorded value is stored in the main register and the other four values are stored in the subregisters. When the overcurrent stage operates, the counter reading is 100. Subregister 5 states the number of times stage I> has started, i.e. how many times the start value of the stage was exceeded, n(I>) = 0...255.
5	Duration of the latest start situation of stage I>>, expressed as a percentage of the set operate time. The operation principle is the same as that of register 4. Subregister 5 states the number of times stage I>> has started, i.e. how many times the set start current of the stage were exceeded, n(I>>) = 0...255.
6	Residual current I_0 measured, expressed as a multiple of the rated current I_n. The register is updated each time one of the residual current stages (I_0> or I_0>>) starts or operates. Then the previous current values will be pushed forwards one step in the stack while the oldest value is lost. The last five current values recorded are memorized in such a way that the most recent value is stored in the main register and the other four values in the subregisters. When the relay starts but does not operate, the relay module memorizes the maximum residual current measured during the start situation. When the stage operates, the value of the current measured at the moment of operation is recorded.

<table>
<tr><th>Register/
STEP</th><th>Recorded information</th></tr>
<tr><td>7</td><td>Duration of the latest start situation of stage I_0>, expressed as a percentage of the set operate time or, at IDMT mode of operation, of the calculated operate time. The register is updated each time the I_0> stage starts. Then the previous values recorded will be pushed forwards one step in the stack while the oldest value is lost. The last five current values recorded are memorized so that the most recent value is stored in the main register and the other four values are stored in the subregisters. When the stage operates, the counter reading is 100.

Subregister 5 states the number of times stage I_0> has started, i.e. how many times the set start current of the stage was exceeded, n(I_0>) = 0...255.</td></tr>
<tr><td>8</td><td>Duration of the latest start situation of stage I_0>>, expressed as a percentage of the set operate time. The operation principle is the same as that of register 7.

Subregister 5 states the number of times stage I_0>> has started, i.e. how many times the set start current of the stage was exceeded, n(I>>) = 0...255.</td></tr>
<tr><td>9</td><td>Unbalance ratio ΔI expressed as a percentage, i.e. the difference between the minimum phase current and the maximum phase current. When the phase discontinuity protection unit operates, the register is updated with the value at the moment of operation. Then the values recorded previously will be pushed forwards one step in the memory stack while the oldest value is lost. The last five current values recorded are available in the memory stack.</td></tr>
<tr><td>11</td><td>Continuous 15 min maximum demand current, updated once a minute.

Submenu 1 contains the highest maximum demand current value recorded after the last relay reset.</td></tr>
<tr><td>0</td><td>Display of external blocking and control signals.

The right-most digit indicates the status of the external control signals of the relay module as follows:

<table>
<tr><th rowspan="2">Displayed figure</th><th colspan="3">Activated signal</th></tr>
<tr><th>BS1</th><th>BS2</th><th>RRES (BS3)</th></tr>
<tr><td>0</td><td></td><td></td><td></td></tr>
<tr><td>1</td><td>x</td><td></td><td></td></tr>
<tr><td>2</td><td></td><td>x</td><td></td></tr>
<tr><td>3</td><td>x</td><td>x</td><td></td></tr>
<tr><td>4</td><td></td><td></td><td>x</td></tr>
<tr><td>5</td><td>x</td><td></td><td>x</td></tr>
<tr><td>6</td><td></td><td>x</td><td>x</td></tr>
<tr><td>7</td><td>x</td><td>x</td><td>x</td></tr>
</table>

The functions of the external control signals are defined with the switches of switchgroups SGB1...3.</td></tr>
</table>

Register/ STEP	Recorded information
	From register 0 it is possible to enter the TEST mode, in which the start and operate signals of the module can be activated one by one. The table below shows the activation order and the corresponding indicator lit when a signal is tested. Indicator — Signal activated I> — start signal of stage I> t> — operate signal of stage I> I>> — start and operate signal of stage I>> I>>> — start and operate signal of stage I>>> I_0> — start signal of stage I_0> t_0> — operate signal of stage I_0> I_0>> — start and operate signal of stage I_0>> ΔI> — operate signal of stage ΔI> activated For further information about the operation, see description "General characteristics of D-type SPC relay modules".
A	Address code of the relay module, required by the serial communication system. In addition, the following submenus are available in register A: 1. Selection of the data transfer rate, 4.8 kBd or 9.6 kBd, of the relay module. Default setting 9.6 kBd. 2. Bus traffic counter indicating the operating state of the serial communication system. If the relay module is connected to a system including a control data communicator and the communication system is operating, the counter reading is 0. Otherwise the numbers 0...255 are continuously scrolling in the counter. 3. Password required for remote setting. Settings cannot be changed over the serial communication system unless a password (remote setting parameter V160) has been given. 4. Selection of main and second settings (0 = main settings, 1 = second settings). Default setting 0. 5. Selection of operate time for the circuit breaker failure protection, setting range 0.1...1.0 s. Default setting 0.2 s

When the display is dark, press the STEP push-button for 1 second to go to the beginning of the display menu. To go to the end of the display menu, press the STEP push-button for a short moment only (<0.5 s).

The values stored in registers 1...11 are cleared by pressing the push-buttons RESET and PROGRAM simultaneously, by a command V102 over the serial communication system or by an external control signal BS1, BS2 or RRES. The registers are cleared by failures in the auxiliary power supply to the module. The setting values, the address code, the data transfer rate and the password of the relay module are not affected by supply voltage failures. Instructions for specifying the address code and the data transfer rate of the relay module are given in the description "General characteristics of D-type SPC relay modules".

Menu chart

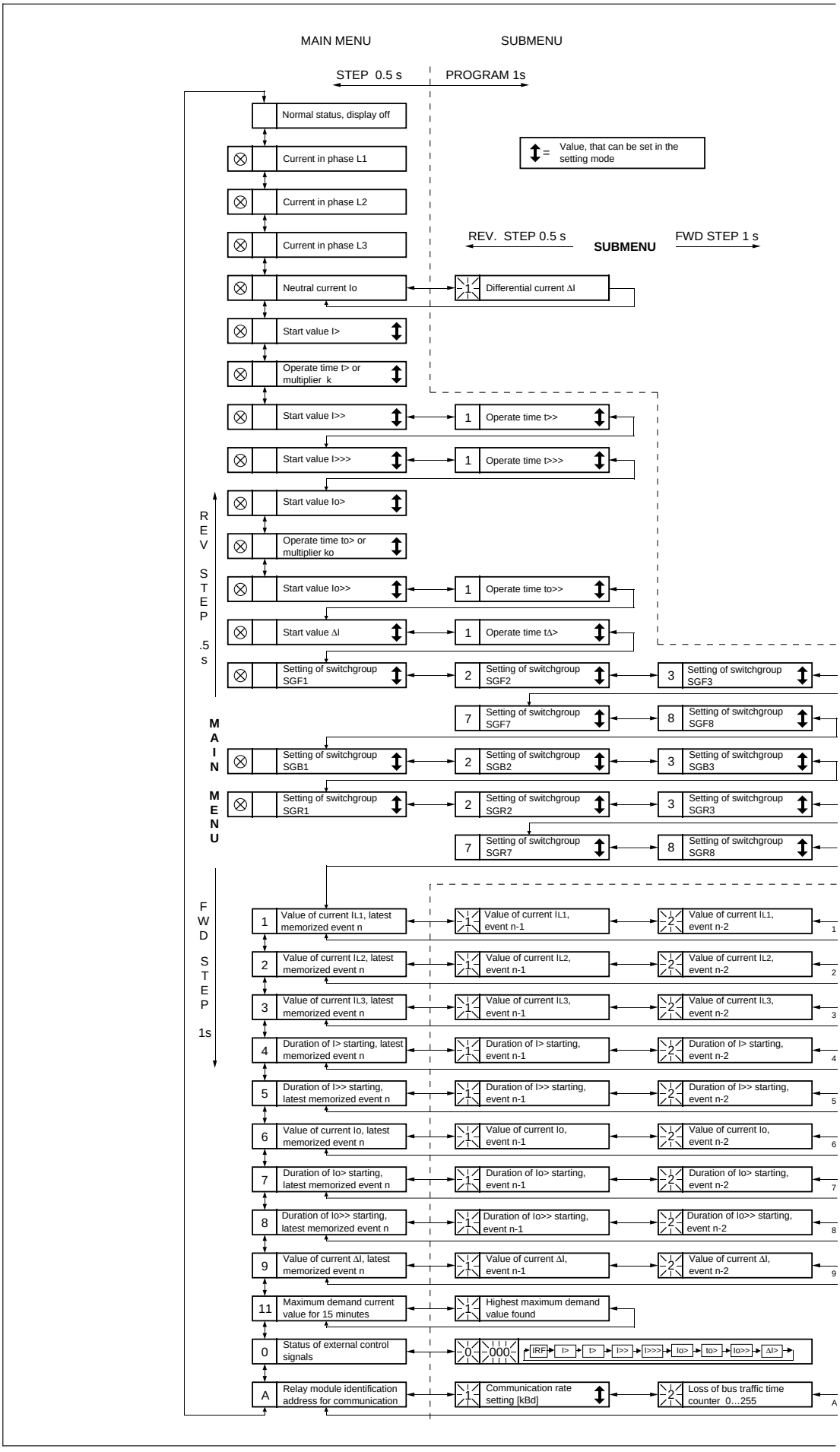
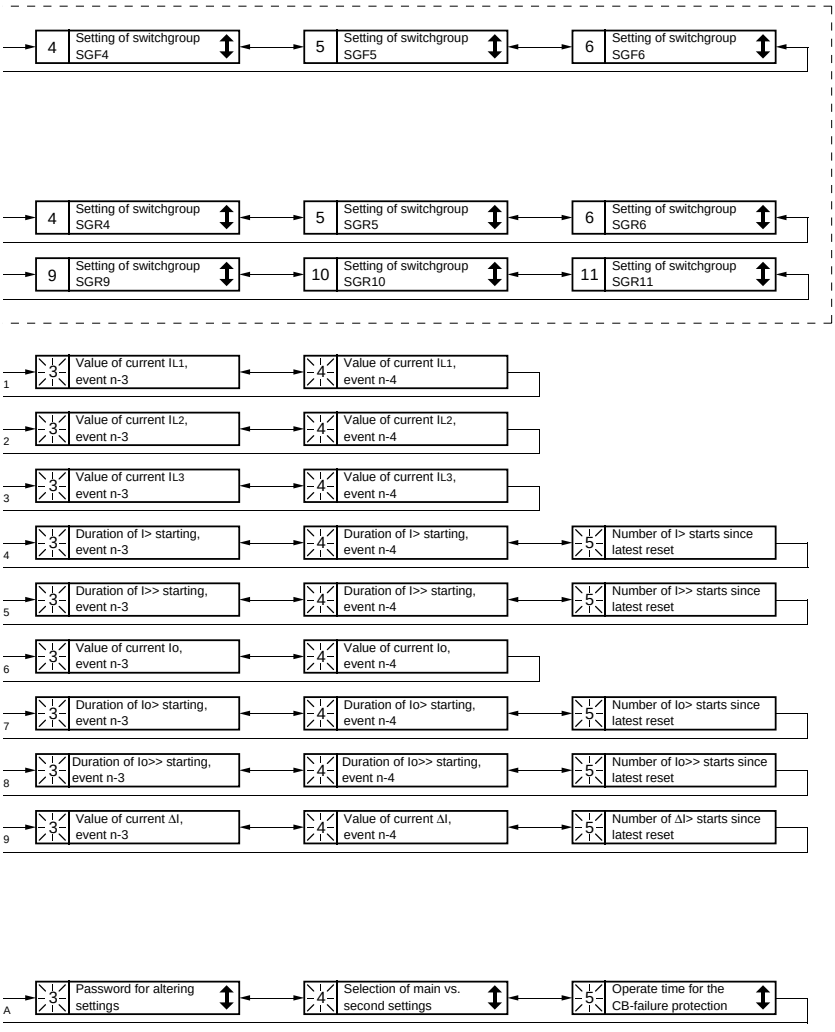


Fig. 7. Main and submenus of the combined overcurrent and earth-fault relay module SPCJ 4D28.

The procedure for entering a submenu or a setting mode, setting a value and entering the TEST mode is described in detail in the manual 1MRS 750066-MUM EN: "General characteristics of D-type SPC relay modules". A short guide follows:

Desired step	Push-button	Action
Forward step in main menu or submenu	STEP	Press for more than 0.5 s
Rapid scan forward in main menu	STEP	Keep depressed
Backward step in main or submenu	STEP	Press less than 0.5 s
Entering a submenu from the main menu	PROGRAM	Press for 1 s (activated when released)
Entering or leaving a setting mode	PROGRAM	Press for 5 s
Incrementation of value in setting mode	STEP	
Moving cursor in setting mode	PROGRAM	Press for about 1 s
Storing a setting value in setting mode	STEP and PROGRAM	Press simultaneously
Erasing of memorized values and re-setting of latched output relays	STEP and PROGRAM	
Resetting of latched output relays	PROGRAM	Note! Display must be dark



Time/current characteristics

(modified 2002-05)

The overcurrent stage I> and the low-set residual current stage I_0> can be given definite time or an inverse definite time operation characteristic. The settings of the switches SGF1/1...3 determine the mode of operation of stage I> and the switches SGF1/6…8 that of the stage I_0>. See section "Setting switches".

At the IDMT characteristic, the operate time of the stage will be a function of the current: the higher the current, the shorter is the operate time. Six time/current curve groups are available. Four of these comply with the BS 142 and IEC 255 standards and two curve groups, the RI and the RXIDG curve groups are special type curve groups according to ABB praxis.

Characteristics according to IEC 60255 and BS 142

The relay module incorporates four internationally standardized time/current curve groups named "extremely inverse", "very inverse", "normal inverse" and "long-time inverse". The relationship between time and current is in accordance with the standards BS 142 and IEC 60255-3, and can be expressed as follows:

$$t\,[s] = \frac{k \times \beta}{\left(\frac{I}{I>}\right)^{\alpha} - 1}$$

where t = operate time
k = time multiplier
I = phase current value
I> = set current value

The values of the constants α and β determine the slope as follows:

Time/current curve group	α	β
Normal inverse	0.02	0.14
Very inverse	1.0	13.5
Extremely inverse	2.0	80.0
Long-time inverse	1.0	120.0

The standard BS 142.1966 defines the normal current range to be 2...20 times the setting value. In addition, the relay has to start at the latest when the current exceeds the setting value by 1.3 times, if the time/current characteristic is normal inverse, very inverse or extremely inverse. For the long-time inverse characteristic the normal current range is specified to be 2...7 times the setting and the relay is to start when the current exceeds the setting value by 1.1 times.

The operate time tolerances specified by the standard are as follows (E denotes accuracy in per cent, - = not specified):

I/I>	Normal	Very	Extremely	Long time
2	2,22E	2,34E	2,44E	2,34E
5	1,13E	1,26E	1,48E	1,26E
7	-	-	-	1,00E
10	1,01E	1,01E	1,02E	-
20	1,00E	1,00E	1,00E	-

In the normal current ranges specified above the inverse time stages of the overcurrent and earth-fault relay module SPCJ 4D28 fulfil the tolerance requirements of class 5 at all degrees of inversity.

The time/current characteristics according to the IEC and BS standards are illustrated in Fig. 8…11.

Note.
The actual operate time of the relay, presented in the graphs in Fig. 8…11, includes an additional filter and detection time plus the operate time of the trip output relay. When the operate time of the relay is calculated using the mathematical expression above, these additional times of about 30 ms in total have to be added to the time received.

RI-type characteristic

The RI-type characteristic is a special characteristic that is principally used to obtain time grading with mechanical relays. The characteristic can be expressed by the mathematical expression

$$t\,[s] = \frac{k}{0.339 - 0.236 \times \frac{I>}{I}}$$

where t = operate time in seconds
k = time multiplier
I = phase current
I> = set start current

The characteristic is illustrated in Fig. 12.

RXIDG-type characteristic

The RXIDG-type characteristic is a special characteristic that is principally used in earth-fault protection, in which a high degree of selectivity is required also at high-resistance faults. In this case the protection can operate in a selective way, even if they are not directional.

Mathematically, the time/current characteristic can be expressed as follows:

$$t\,[s] = 5.8\text{-}1.35 \times \log_e \left(\frac{I}{k \times I>}\right)$$

where t = operate time in seconds
k = time multiplier
I = phase current
I> = set start current

The characteristic is illustrated in Fig. 13.

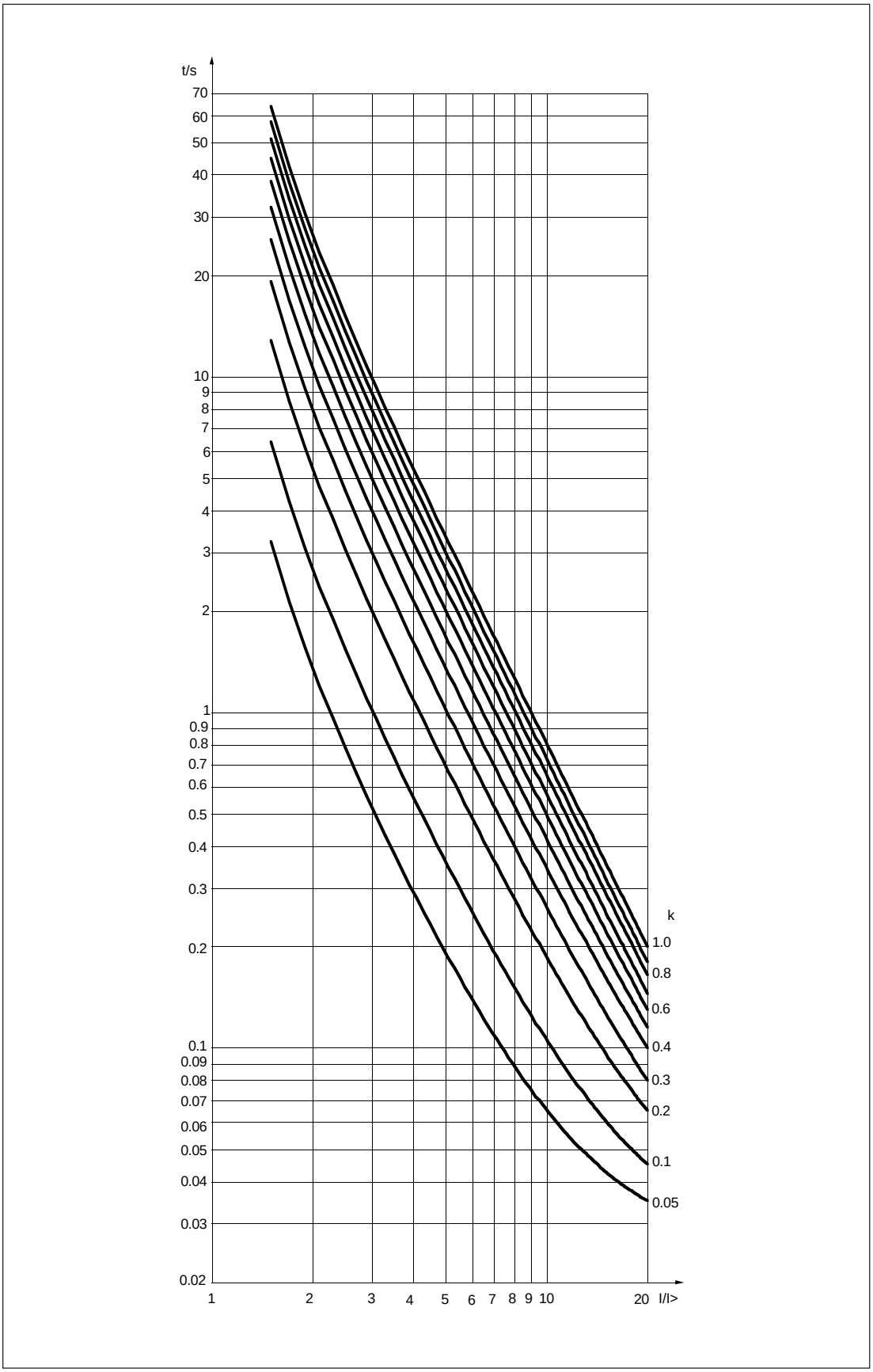


Fig. 8. Inverse-time characteristics of overcurrent and earth-fault relay module SPCJ 4D28

Extremely inverse

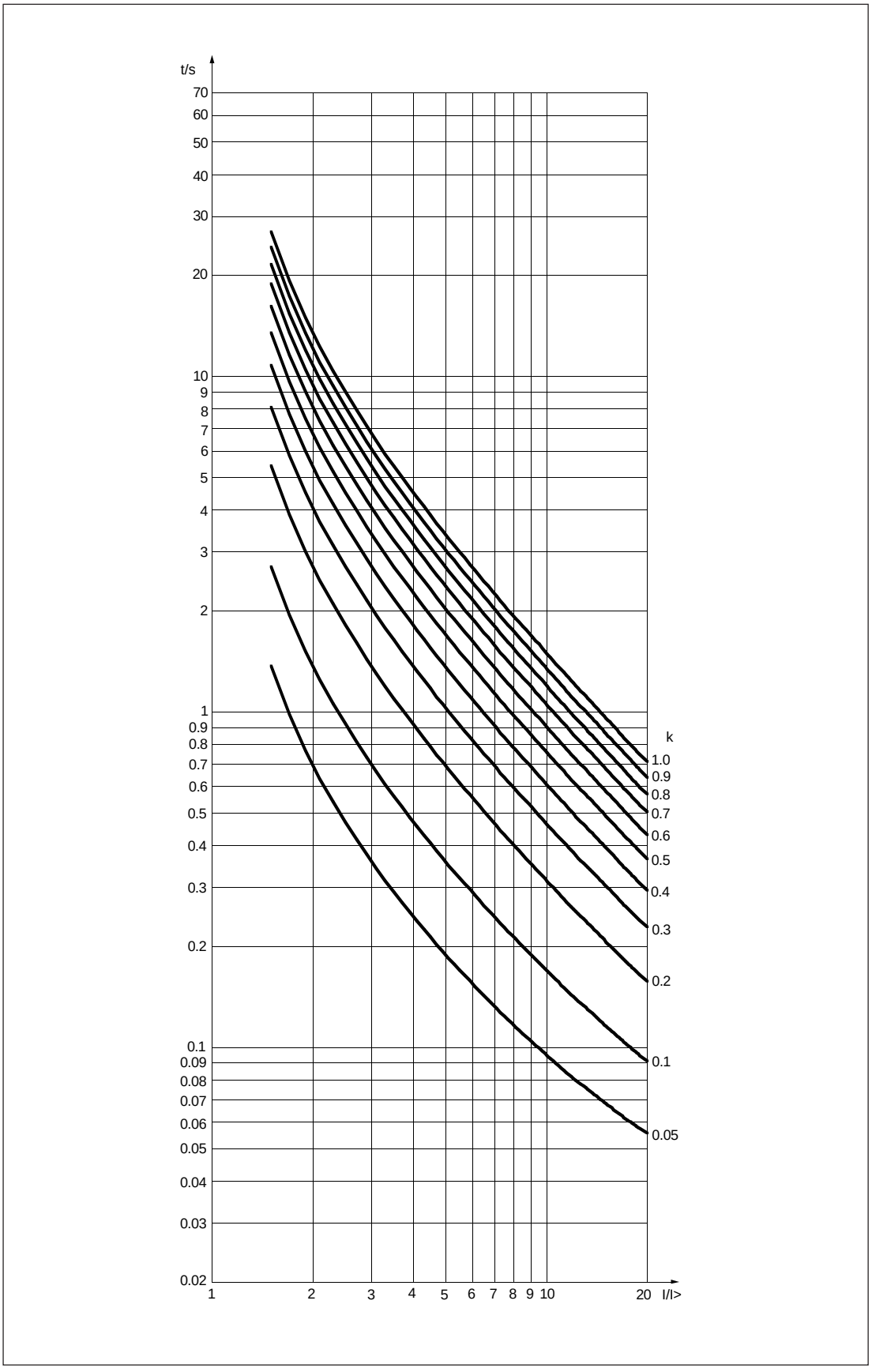


Fig. 9. Inverse-time characteristics of overcurrent and earth-fault relay module SPCJ 4D28

Very inverse

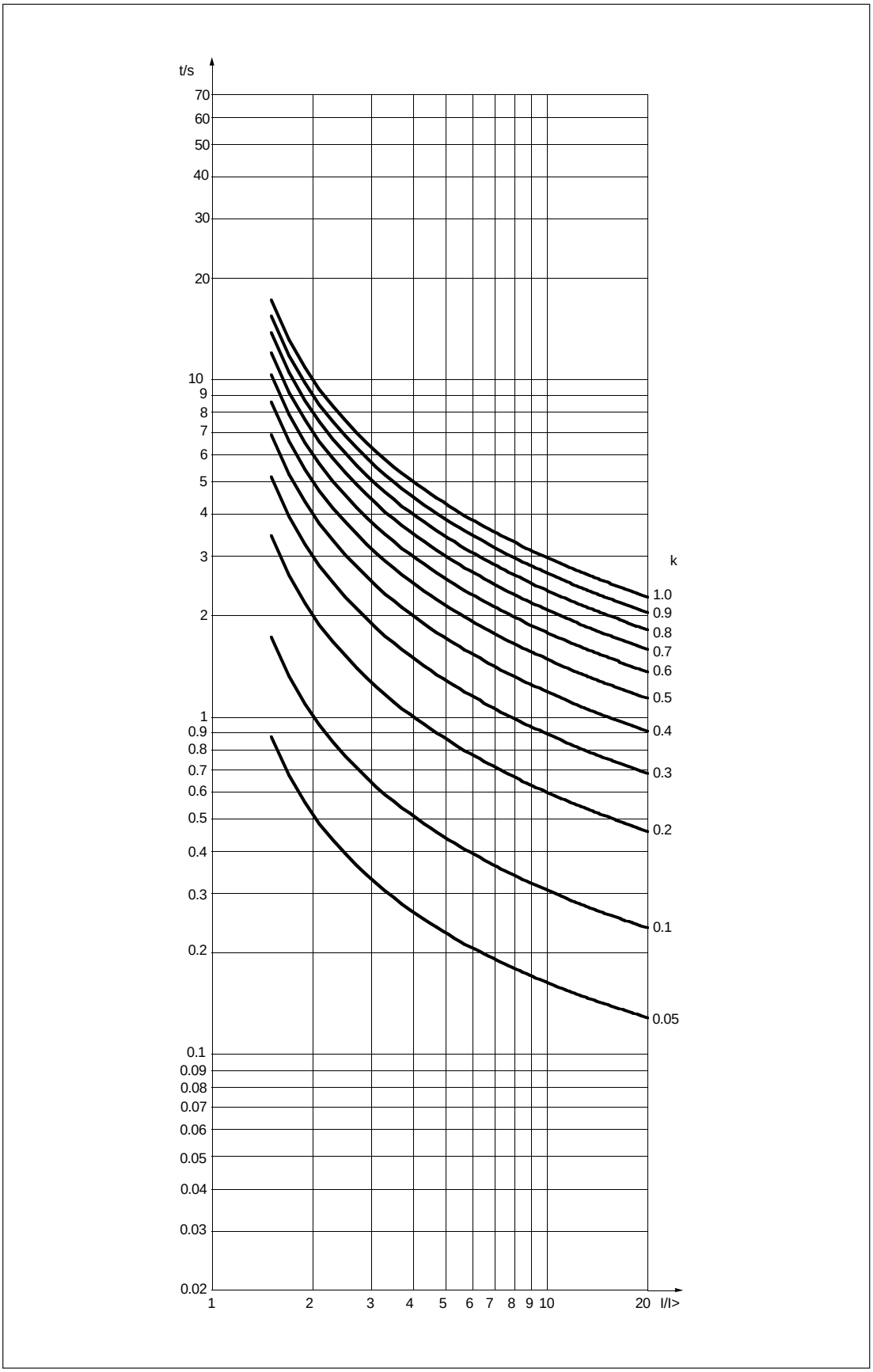


Fig. 10. Inverse-time characteristics of overcurrent and earth-fault relay module SPCJ 4D28

Normal inverse

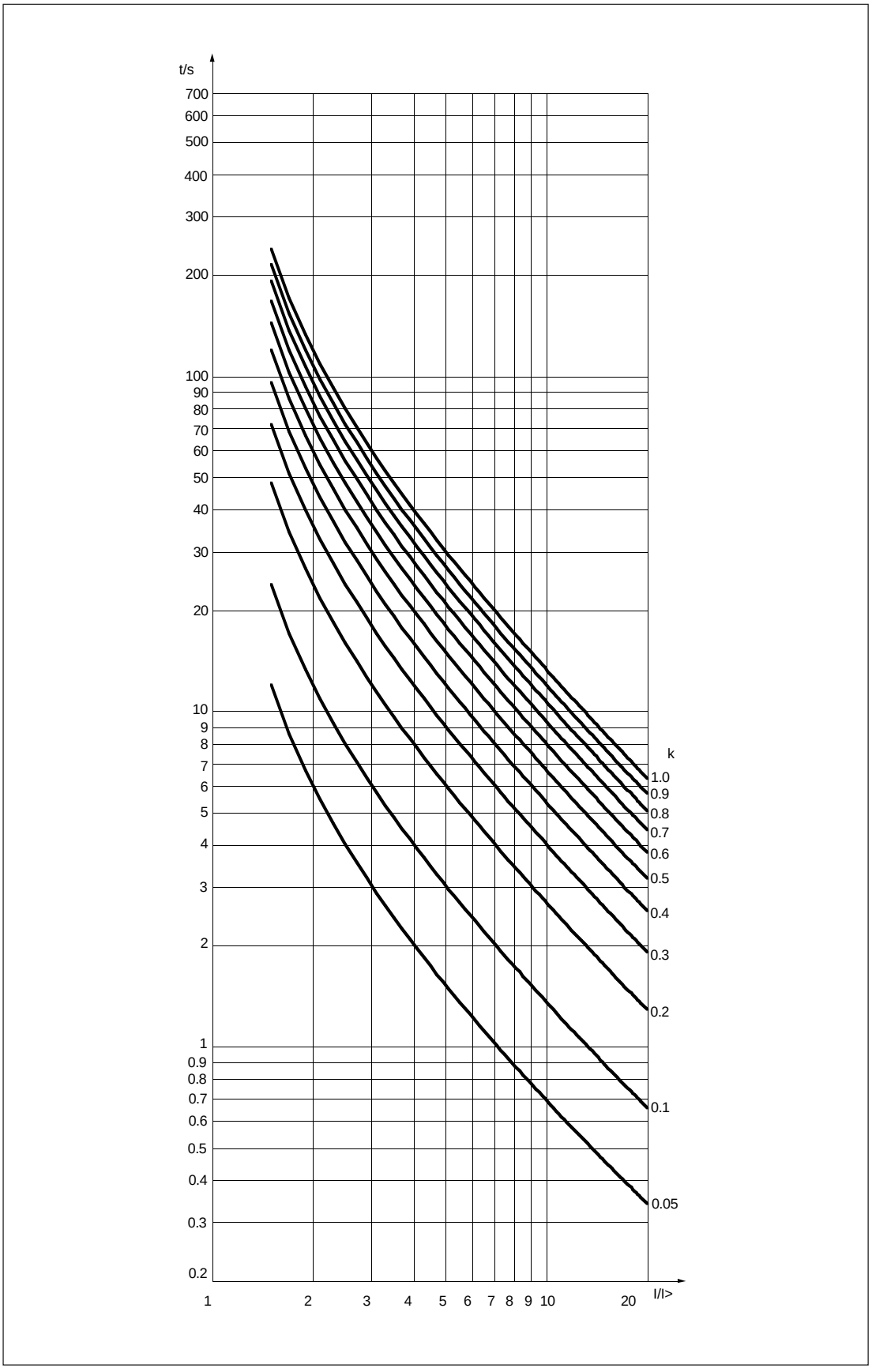


Fig. 11. Inverse-time characteristics of overcurrent and earth-fault relay module SPCJ 4D28

Long-time inverse

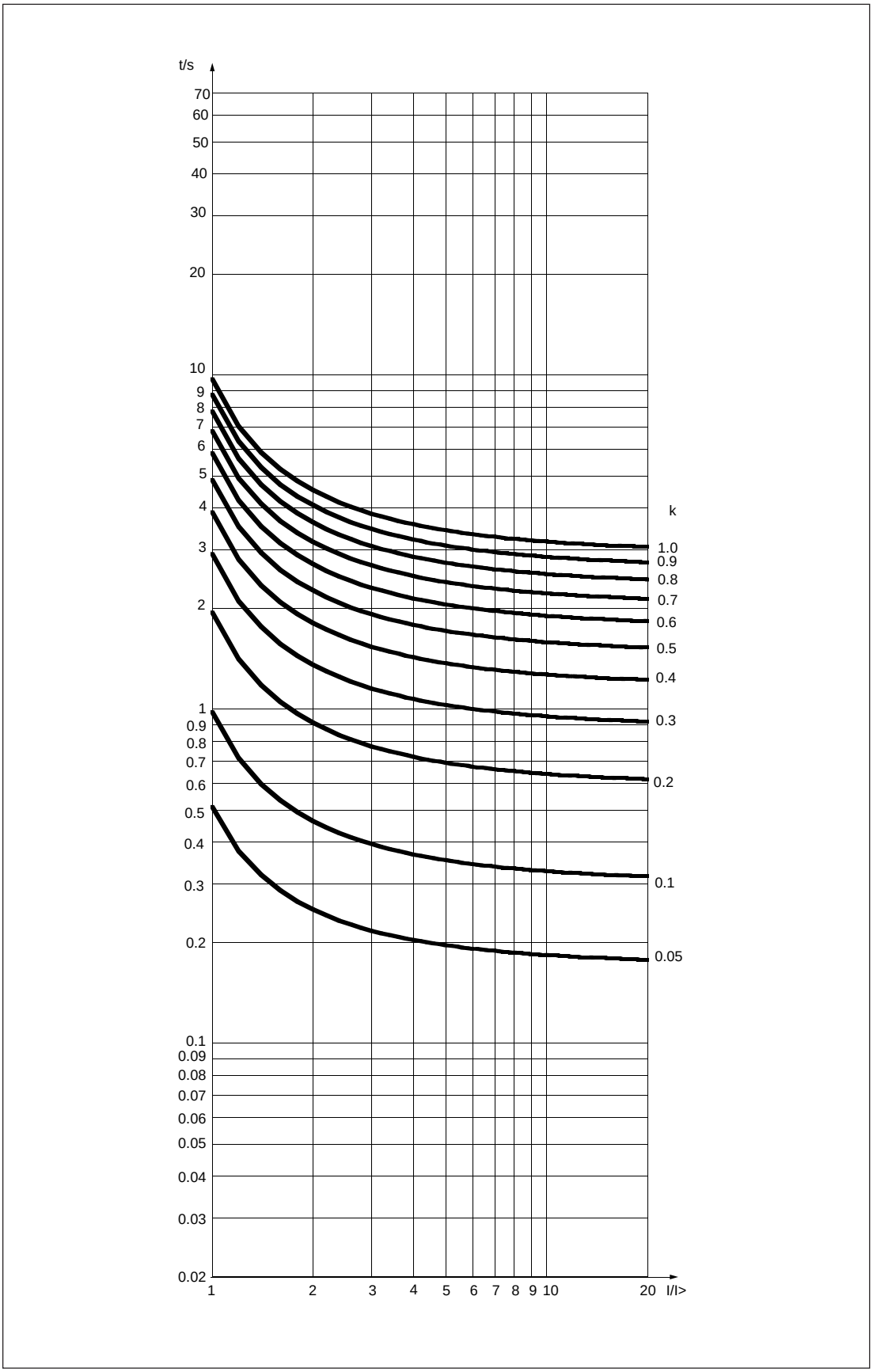


Fig. 12. Inverse-time characteristic of overcurrent and earth-fault relay module SPCJ 4D28

RI-type inverse

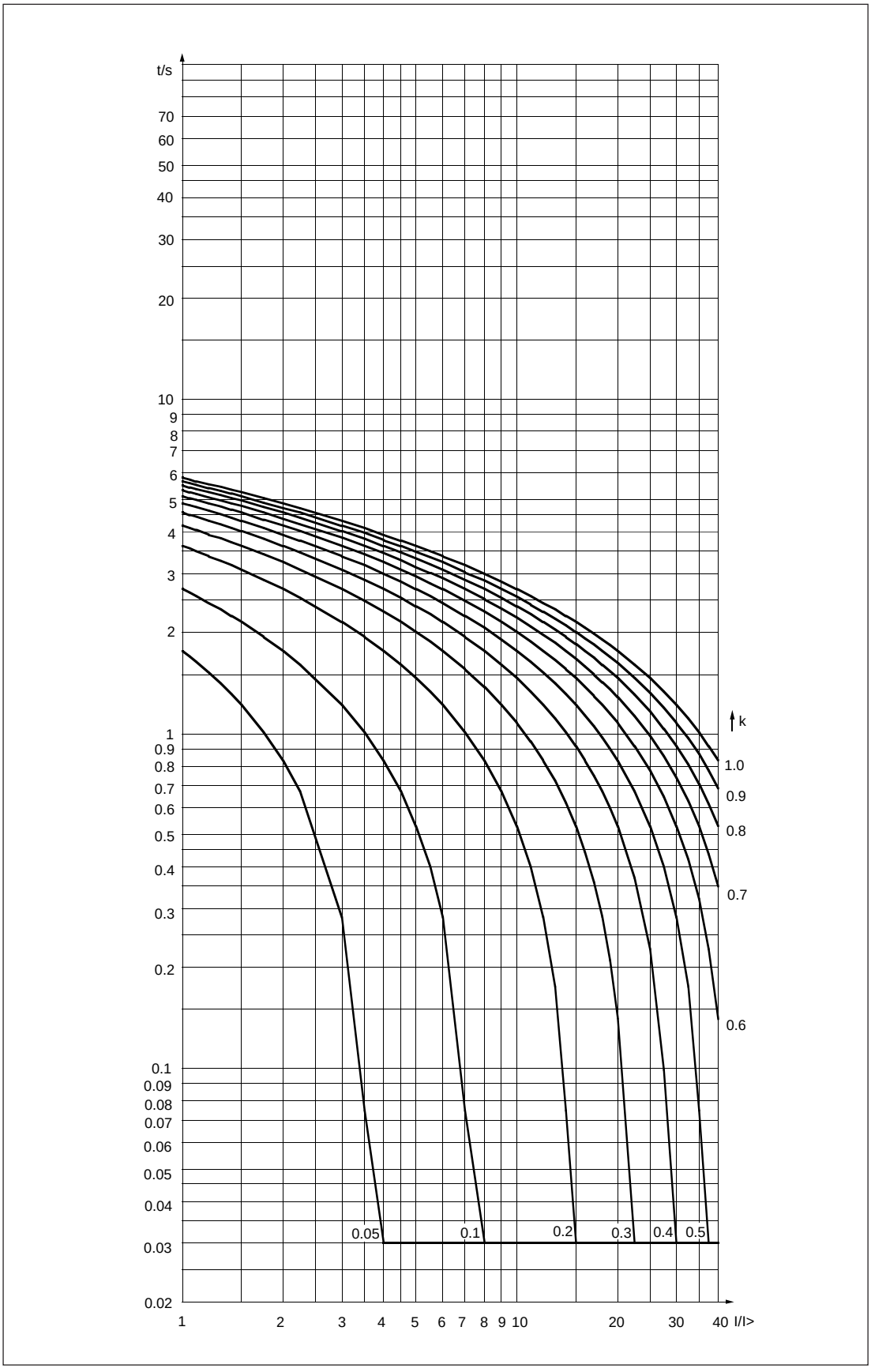


Fig. 13. Inverse-time characteristic of overcurrent and earth-fault relay module SPCJ 4D28

RXIDG-type inverse

Feature	Stage I>	Stage I>>	Stage I>>>
Start current			
- at definite time	0.5…5.0 x I_n	0.5…40.0 x I_n and ∞	0.5…40.0 x I_n and ∞
- at inverse time	0.5…2.5 x I_n		
Start time, typ.	70 ms	40 ms	40 ms
Operate time at definite time characteristic	0.05…300 s	0.04…300 s	0.04…30 s
Time/current characteristic at inverse mode	Extremely inv. Very inv. Normal inv. Long-time inv. RI type inv. RXIDG type inv.		
Time multiplier k	0.05…1.0		
Reset time, typ.	40 ms	40 ms	40 ms
Retardation time	<30 ms	<30 ms	<30 ms
Reset ratio, typ.	0.96	0.96	0.96
Operate time accuracy at definite time mode	±2% of set value or ±25 ms	±2% of set value or ±25 ms	±2% of set value or ±25 ms
Accuracy class index E at inverse time mode	5		
Operation accuracy	±3% of set value	±3% of set value	±3% of set value

Feature	Stage I_0>	Stage I_0>>	Stage ΔI>
Start current	0.1…0.8 x I_n	0.1…10.0 x I_n and ∞	10…100% and ∞
Start time, typ.	70 ms	50 ms	150 ms
Operate time at definite time characteristic	0.05…300 s	0.05…300 s	1…300 s
Time/current characteristic at inverse mode	Extremely inv. Very inv. Normal inv. Long-time inv. RI type inv. RXIDG type inv.		
Time multiplier k	0.05…1.0		
Reset time, typ.	40 ms	40 ms	80 ms
Retardation time	<30 ms	<30 ms	
Reset ratio, typ.	0.96	0.96	0.90
Operate time accuracy at definite time mode	±2% of set value or ±25 ms	±2% of set value or ±25 ms	±2% of set value or ±25 ms
Accuracy class index E at inverse time mode	5		
Operation accuracy	±3% of set value	±3% of set value	±1 unit ±3% of set value

Serial communication parameters

Event codes

The start and operate situations of the protection stages and the states of the output signals are defined as events and provided with event codes, which can be transmitted to higher system levels via the serial bus. An event, which is to be communicated, is marked with a multiplier 1. The event mask is formed by the sum of the weight factors of all those events, that are to be communicated.

Event mask	Code	Setting range	Default setting
V155	E1…E12	0…4095	1365
V156	E13…E24	0…4095	1365
V157	E25…E32	0…255	192
V158	E33…E42	0…1023	12

Event codes of the combined overcurrent and earth-fault relay module SPCJ 4D28

Code	Event	No. representing the event	Default value
E1	Starting of stage I>	1	1
E2	Starting of stage I> reset	2	0
E3	Tripping of stage I>	4	1
E4	Tripping of stage I> reset	8	0
E5	Starting of stage I>>	16	1
E6	Starting of stage I>> reset	32	0
E7	Tripping of stage I>>	64	1
E8	Tripping of stage I>> reset	128	0
E9	Starting of stage I>>>	256	1
E10	Starting of stage I>>> reset	512	0
E11	Tripping of stage I>>>	1024	1
E12	Tripping of stage I>>> reset	2048	0
	Default value of event mask V155		1365

E13	Starting of stage I_0>	1	1
E14	Starting of stage I_0> reset	2	0
E15	Tripping of stage I_0>	4	1
E16	Tripping of stage I_0> reset	8	0
E17	Starting of stage I_0>>	16	1
E18	Starting of stage I_0>> reset	32	0
E19	Tripping of stage I_0>>	64	1
E20	Tripping of stage I_0>> reset	128	0
E21	Starting of stage ΔI>	256	1
E22	Starting of stage ΔI> reset	512	0
E23	Tripping of stage ΔI>	1024	1
E24	Tripping of stage ΔI> reset	2048	0
	Default value of event mask V156		1365

Code	Event	No. representing the event	Default value
E25	Output signal SS1 activated	1	0
E26	Output signal SS1 reset	2	0
E27	Output signal TS1 activated	4	0
E28	Output signal TS1 reset	8	0
E29	Output signal SS2 activated	16	0
E30	Output signal SS2 reset	32	0
E31	Output signal TS2 activated	64	1
E32	Output signal TS2 reset	128	1
	Default value of event mask V157		192

E33	Output signal SS3 activated	1	0
E34	Output signal SS3 reset	2	0
E35	Output signal TS3 activated	4	1
E36	Output signal TS3 reset	8	1
E37	Output signal SS4 activated	16	0
E38	Output signal SS4 reset	32	0
E39	Output signal TS4 activated	64	0
E40	Output signal TS4 reset	128	0
E41	Circuit breaker failure protection operated	256	0
E42	Circuit breaker failure protection reset	512	0
	Default value of event mask V158		12

E50	Restart of microprocessor	*	-
E51	Overflow of event register	*	-
E52	Temporary interruption in data communication	*	-
E53	No response from the module over the data communication	*	-
E54	The module responds again over the data communication	*	-

Explanations:
0 not included in event reporting
1 included in event reporting
* no code number
- cannot be programmed

Note.
The event represented by the codes E52...E54 are generated by a higher-level control data communicator, for example type SRIO 1000M.

Remote transfer data

In addition to the event data all input data (I data), setting values (S values), recorded information (V data) and certain other data of the overcurrent module can be read via the SPA bus. Parameters marked with a W letter can be altered via the SPA bus.

When setting values are altered via the MMI on the front panel or via the serial bus, the module checks that the entered parameter values are within the permitted setting range. The relay module refuses to accept a too high or a too low setting value, but keeps the old setting value unchanged.

Altering parameter values via the serial bus usually requires the use of a password. The password is a number within the range 1…999. The default password is 1.

The password is opened by writing the password number to parameter V160 and closed by writing the password number to parameter V161. The password is also closed on loss of auxiliary supply to the relay module.

The password can be changed via the serial bus or via the MMI of the module. When the password is to be changed via the serial bus, the password must be opened first. The new password is written to parameter V161. The change of the password via the MMI of the module is carried out in register A, subregister 3, in which case the new password is written over the old one.

If an incorrect password is given seven times in a row via the serial bus, the password is automatically set to zero and after this it cannot be opened via the serial bus. Now the password can be opened only via the MMI of the module.

R = readable data
W = writable data
(P) = writing enabled with password

Inputs

The measured currents and the status of the external control signals can be read (R) with parameters I1…I8.

When the value of parameters I6…I8 is 1, the corresponding control inputs are energized.

Information	Parameter	Value
Current measured on phase L1	I1	0...63 x I_n
Current measured on phase L2	I2	0...63 x I_n
Current measured on phase L3	I3	0...63 x I_n
Residual current measured	I4	0...21 x I_n
Maximum phase current difference	I5	10...100%
Control signal BS1	I6	0 or 1
Control signal BS2	I7	0 or 1
Control signal RRES (BS3)	I8	0 or 1

The state information indicates the state of a signal at a certain moment. The recorded functions indicate such activations of signals, that happen after the last reset of the registers of the module. When the value = 0, the signal has not been activated and when the value = 1, the signal has been activated.

Output stages

States of the protection stages	State of stage (R)	Recorded functions (R)	Value
Starting of stage I>	O1	O21	0 or 1
Tripping of stage I>	O2	O22	0 or 1
Starting of stage I>>	O3	O23	0 or 1
Tripping of stage I>>	O4	O24	0 or 1
Starting of stage I>>>	O5	O25	0 or 1
Tripping of stage I>>>	O6	O26	0 or 1
Starting of stage I_0>	O7	O27	0 or 1
Tripping of stage I_0>	O8	O28	0 or 1
Starting of stage I_0>>	O9	O29	0 or 1
Tripping of stage I_0>>	O10	O30	0 or 1
Tripping of stage ΔI>	O11	O31	0 or 1

Output signals

Operation of output signals	State of output (R, W, P)	Recorded functions (R)	Value
Output signal SS1	O12	O32	0 or 1
Output signal TS1	O13	O33	0 or 1
Output signal SS2	O14	O34	0 or 1
Output signal TS2	O15	O35	0 or 1
Output signal SS3	O16	O36	0 or 1
Output signal TS3	O17	O37	0 or 1
Output signal SS4	O18	O38	0 or 1
Output signal TS4	O19	O39	0 or 1
Enable of output signals SS1…TS4	O41		0 or 1

Variable	Used settings (R)	Main setting (R, W, P)	Second setting (R, W, P)	Setting range
Start current of stage I>	S1	S41	S81	0.5…5.0 x I_n
Operate time or	S2	S42	S82	0.05…300 s
time multiplier k of stage I>				0.05…1.0
Start current of stage I>>	S3 *)	S43	S83	0.5…40 x I_n
Operate time of stage I>>	S4	S44	S84	0.04…300 s
Start current of stage I>>>	S5 *)	S45	S85	0.5…40 x I_n
Operate time of stage I>>>	S6	S46	S86	0.04…30 s
Start current of stage I_0>	S7	S47	S87	0.1…0.8 x I_n
Operate time or	S8	S48	S88	0.05…300 s
time multiplier k of stage I_0>				0.05…1.0
Start current of stage I_0>>	S9 *)	S49	S89	0.1…10 x I_n
Operate time of stage I_0>>	S10	S50	S90	0.05…300 s
Start value of stage ΔI>	S11 *)	S51	S91	10…100%
Operate time of stage ΔI>	S12	S52	S92	1…300 s
Checksum, SGF 1	S13	S53	S93	0…255
Checksum, SGF 2	S14	S54	S94	0…255
Checksum, SGF 3	S15	S55	S95	0…255
Checksum, SGF 4	S16	S56	S96	0…255
Checksum, SGF 5	S17	S57	S97	0…255
Checksum, SGF 6	S18	S58	S98	0…255
Checksum, SGF 7	S19	S59	S99	0…255
Checksum, SGF 8	S20	S60	S100	0…255
Checksum, SGB 1	S21	S61	S101	0…255
Checksum, SGB 2	S22	S62	S102	0…255
Checksum, SGB 3	S23	S63	S103	0…255
Checksum, SGR 1	S24	S64	S104	0…255
Checksum, SGR 2	S25	S65	S105	0…255
Checksum, SGR 3	S26	S66	S106	0…255
Checksum, SGR 4	S27	S67	S107	0…255
Checksum, SGR 5	S28	S68	S108	0…255
Checksum, SGR 6	S29	S69	S109	0…255
Checksum, SGR 7	S30	S70	S110	0…255
Checksum, SGR 8	S31	S71	S111	0…255
Checksum, SGR 9	S32	S72	S112	0…255
Checksum, SGR 10	S33	S73	S113	0…255
Checksum, SGR 11	S34	S74	S114	0…255
Operate time of the circuit breaker failure protection	-	S121	S121	0.1…1.0 s

*) If the protection stage has been set out of function, the display shows 999 for the currently used value.

Measured value	Parameter	Data direction	Value
Last 15 min maximum demand current	V1	R	0…2.5 x I_n
Number of starts of stage I>	V2	R	0…255
Number of starts of stage I>>	V3	R	0…255
Number of starts of stage I_0>	V4	R	0…255
Number of starts of stage I_0>>	V5	R	0…255
Number of starts of stage ΔI>	V6	R	0…255
Stage/phase that caused operation	V7	R	1 = I_{L3}>, 2 = I_{L2}>, 4 = I_{L1}>, 8 = I_0>, 16 = I_{L3}>>, 32 = I_{L2}>>, 64 = I_{L1}>>, 128 = I_0>>
Stage/phase that caused operation	V8	R	1 = I_{L3}>>>, 2 = I_{L2}>>>, 4 = I_{L1}>>>
Operation indication code on the display	V9	R	0…12
Maximum 15 min demand current	V10	R	0…2.55 x I_n

The last five recorded values can be read (R) with parameters V11…V59. Event n denotes the youngest recorded value and n-1 the next youngest and so forth.

Registered value	Event					Measuring range
	n	n-1	n-2	n-3	n-4	
Phase current I_{L1} (register 1)	V11	V21	V31	V41	V51	0…63 x I_n
Phase current I_{L2} (register 2)	V12	V22	V32	V42	V52	0…63 x I_n
Phase current I_{L3} (register 3)	V13	V23	V33	V43	V53	0…63 x I_n
Earth-fault current I_0 (register 6)	V14	V24	V34	V44	V54	0…21 x I_n
Difference current ΔI (register 9)	V15	V25	V35	V45	V55	0…100%
Start duration, stage I> (register 4)	V16	V26	V36	V46	V56	0…100%
Start duration, stage I>> (register 5)	V17	V27	V37	V47	V57	0…100%
Start duration, stage I_0> (register 7)	V18	V28	V38	V48	V58	0…100%
Start duration, stage I_0>> (register 8)	V19	V29	V39	V49	V59	0…100%

Information	Para-meter	Data direction	Value
Resetting of operation indicators and latched output relay	V101	W	1 = reset perfomed
Resetting of indicators and latched output relay and clearing of registers	V102	W	1 = reset perfomed
Remote control of setting	V150	R,W	0 = main settings enforced 1 = second settings enforced
Overcurrent even mask	V155	R,W	0...4096, see section "Event codes"
Residual/unbalance current event mask	V156	R,W	0...4096, see section "Event codes"
Output signal event mask	V157	R,W	0...255, see section "Event codes"
Output signal event mask	V158	R,W	0...1023, see section "Event codes"
Opening of password for remote setting	V160	W	1...999
Changing and closing of password for remote setting	V161	W, P	0...999
Activation of self-supervision system	V165	W	1 = self-supervision system activated and IRF LED lit
Formatting of EEPROM	V167	W, P	2 = formatting
Fault code	V169	R	0…255
Data communication address of relay module	V200	R,W	1...254
Data transfer rate	V201	R,W	4800 or 9600 Bd (R) 4.8 or 9.6 kBd (W)
Program version	V205	R	116 _
Reading of event register	L	R	Time, channel number and event code
Rereading of event register	B	R	Time, channel number and event code
Type designation of relay module	F	R	SPCJ 4D28
Reading of module state data	C	R	0 = normal state 1 = module been subject to automatic reset 2 = event register overflow 3 = events 1 and 2 together
Resetting of module state data	C	W	0 = resetting
Time reading and setting	T	R,W	00.000...59.999 s

The maximum capacity of the event register is 65 events. The content of the register can be read by the L command, 5 events at a time, only once. Should a fault occur, say, in the data communication, the B command can be used to re-read the contents of the register. When required, the B command can be repeated. In general, the control data communicator reads the event data and forwards the information to an output device. Under normal conditions the event register of the relay module is empty. The control data communicator also resets abnormal status data, so this data is normally zero.

Fault codes

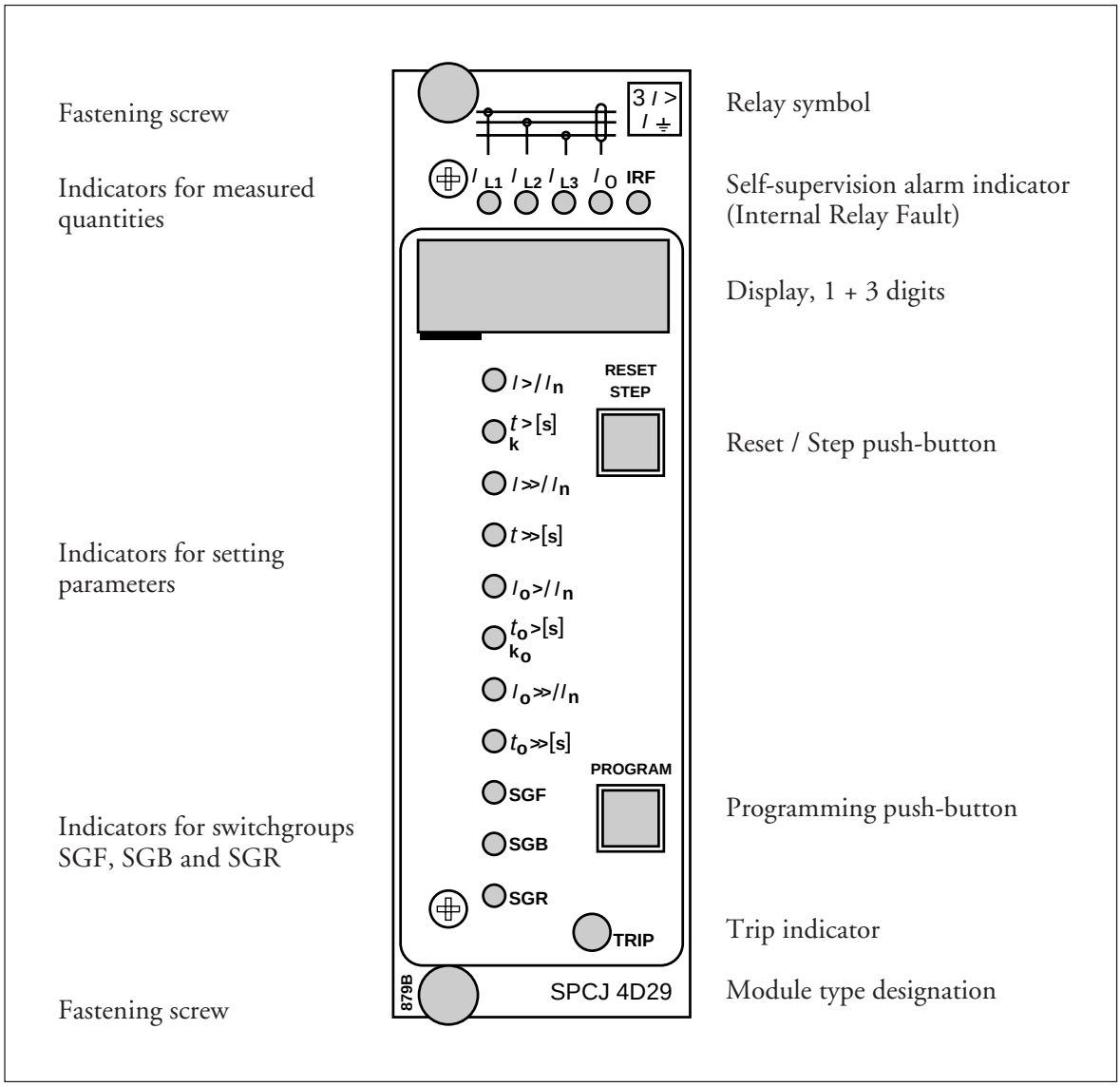
Once the self-supervision system has detected an internal relay fault, the IRF indicator on the front panel of the relay module is lit. At the same time the self-supervision alarm relay that is normally picked up, drops off. In most situations a fault code appears on the display of the relay module. This fault code consists of a red number one (1) and a green code number that identifies the fault type. The fault codes should be recorded and stated when service is ordered.

The table below lists some of the fault codes of the combined overcurrent and earth-fault relay module SPCJ 4D28.

Fault code	Type of fault
4	Relay control circuit faulty or missing
30	Read Only Memory (ROM) faulty
50	Random Access Memory (RAM) faulty
51	Parameter memory (EEPROM) faulty, block 1
52	Parameter memory (EEPROM) faulty, block 2
53	Parameter memory (EEPROM) faulty, blocks 1 and 2
54	Parameter memory (EEPROM) faulty, blocks 1 and 2 have different checksums
56	Parameter memory (EEPROM) key faulty. Formatting by writing V167 = 2
195	Too low a value on the reference channel with multiplier 1
131	Too low a value on the reference channel with multiplier 5
67	Too low a value on the reference channel with multiplier 25
203	Too high a value on the reference channel with multiplier 1
139	Too high a value on the reference channel with multiplier 5
75	Too high a value on the reference channel with multiplier 25
252	Filter of I0 channel faulty
253	No interruption from the A/D converter

General characteristics of D-type relay modules

User´s manual and Technical description



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General characteristics of D type relay modules

Contents

Control push-buttons

The front panel of the relay module contains two push buttons. The RESET / STEP push button is used for resetting operation indicators and for stepping forward or backward in the display main menu or submenus. The PROGRAM push button is used for moving from a certain position in the main menu to the corresponding submenu, for entering the setting mode of a certain parameter and together with the STEP push button for storing the set values. The different operations are described in the subsequent paragraphs in this manual.

Display

The measured and set values and the recorded data are shown on the display of the protection relay module. The display consists of four digits. The three green digits to the right show the measured, set or recorded value and the leftmost red digit shows the code number of the register. The measured or set value displayed is indicated by the adjacent yellow LED indicator on the front panel. When a recorded fault value is being displayed the red digit shows the number of the corresponding register. When the display functions as an operation indicator the red digit alone is shown.

When the auxiliary voltage of a protection relay module is switched on the module initially tests the display by stepping through all the segments of the display for about 15 seconds. At first the corresponding segments of all digits are lit one by one clockwise, including the decimal points. Then the center segment of each digit is lit one by one. The complete sequence is carried out twice. When the test is finished the display turns dark. The testing can be interrupted by pressing the STEP push button. The protection functions of the relay module are alerted throughout the testing.

Display main menu

Any data required during normal operation are accessible in the main menu i.e. present measured values, present setting values and recorded parameter values.

The data to be shown in the main menu are sequentially called up for display by means of the STEP push button. When the STEP push button is pressed for about one second, the display moves forward in the display sequence. When the push button is pressed for about 0.5 seconds, the display moves backward in the display sequence.

From a dark display only forward movement is possible. When the STEP push button is pushed constantly, the display continuously moves forward stopping for a while in the dark position.

Unless the display is switched off by stepping to the dark point, it remains lit for about 5 minutes from the moment the STEP push button was last pushed. After the 5 minutes' time-out the dispaly is switched off.

Display submenus

Less important values and values not very often set are displayed in the submenus. The number of submenus varies with different relay module types. The submenus are presented in the description of the concerned protection relay module.

A submenu is entered from the main menu by pressing the PROGRAM push button for about one second. When the push button is released, the red digit of the display starts flashing, indicating that a submenu has been entered. Going from one submenu to another or back to the main menu follows the same principle as when moving from the main menu display to another; the display moves forward when the STEP push button is pushed for one second and backward when it is pushed for 0.5 seconds. The main menu has been re-entered when the red display turns dark.

When a submenu is entered from a main menu of a measured or set value indicated by a LED indicator, the indicator remains lit and the address window of the display starts flashing. A submenu position is indicated by a flashing red address number alone on the dispaly without any lit set value LED indicator on the front panel.

Selector switch-groups SGF, SGB and SGR

Part of the settings and the selections of the operation characteristic of the relay modules in various applications are made with the selector switchgroups SG_ . The switchgroups are software based and thus not physically to be found in the hardware of the relay module. The indicator of the switchgroup is lit when the checksum of the switchgroup is shown on the display. Starting from the displayed checksum and by entering the setting mode, the switches can be set one by one as if they were real physical switches. At the end of the setting procedure, a checksum for the whole switchgroup is shown. The checksum can be used for verifying that the switches have been properly set. Fig. 2 shows an example of a manual checksum calculation.

When the checksum calculated according to the example equals the checksum indicated on the display of the relay module, the switches in the concerned switchgroup are properly set.

Switch No	Pos.		Weigth		Value
1	1	x	1	=	1
2	0	x	2	=	0
3	1	x	4	=	4
4	1	x	8	=	8
5	1	x	16	=	16
6	0	x	32	=	0
7	1	x	64	=	64
8	0	x	128	=	0
	Checksum		Σ	=	93

Fig. 2. Example of calculating the checksum of a selector switchgroup SG_.

The functions of the selector switches of the different protection relay modules are described in detail in the manuals of the different relay modules.

Settings

Most of the start values and operate times are set by means of the display and the push buttons on the front panel of the relay modules. Each setting has its related indicator which is lit when the concerned setting value is shown on the display.

In addition to the main stack of setting values most D type relay modules allow a second stack of settings. Switching between the main settings and the second settings can be done in three different ways:

1) By command V150 over the serial communication bus
2) By an external control signal BS1, BS2 or RRES (BS3)
3) Via the push-buttons of the relay module, see submenu 4 of register A.

Setting mode

Generally, when a large number of settings is to be altered, e.g. during commissioning of relay systems, it is recommended that the relay settings are entered with the keyboard of a personal computer provided with the necessary software. When no computer nor software is available or when only a few setting values need to be altered the procedure described below is used.

The registers of the main menu and the submenus contain all parameters that can be set. The settings are made in the so called setting mode, which is accessible from the main menu or a submenu by pressing the PROGRAM push button, until the whole display starts flashing. This position indicates the value of the parameter before it has been altered. By pressing the PROGRAM push button the programming sequence moves forward one step. First the rightmost digit starts flashing while the rest of the display is steady. The flashing digit is set by means of the STEP push button. The flashing cursor is moved on from digit to digit by pressing the PROGRAM push button and in each stop the setting is performed with the STEP push button. After the parameter values have been set, the decimal point is put in place. At the end the position with the whole display flashing is reached again and the data is ready to be stored.

A set value is recorded in the memory by pressing the push buttons STEP and PROGRAM simultaneously. Until the new value has been recorded a return from the setting mode will have no effect on the setting and the former value will still be valid. Furthermore *any attempt to make a setting outside the permitted limits for a particular parameter will cause the new value to be disqualified and the former value will be maintained.* Return from the setting mode to the main menu or a submenu is possible by pressing the PROGRAM push button until the green digits on the display stop flashing.

NOTE! During any local man-machine communication over the push buttons and the display on the front panel a five minute time-out function is active. Thus, if no push button has been pressed during the last five minutes, the relay returns to its normal state automatically. This means that the display turns dark, the relay escapes from a display mode, a programming routine or any routine going on, when the relay is left untouched. This is a convenient way out of any situation when the user does not know what to do.

Before a relay module is inserted into the relay case, one must assure that the module has been given the correct settings. If there however is any doubt about the settings of the module to be inserted, the setting values should be read using a spare relay unit or with the relay trip circuits disconnected. If this cannot be done the relay can be sett into a non-tripping mode by pressing the PROGRAM push button and powering up the relay module simultaneously. The display will show three dashes "- - -" to indicate the non-tripping mode. The serial communication is operative and all main and submenues are accessible. In the non-tripping mode unnecessary trippings are avoided and the settings can be checked. *The normal protection relay mode is entered automatically after a timeout of five minutes or ten seconds after the dark display position of the main menu has been entered.*

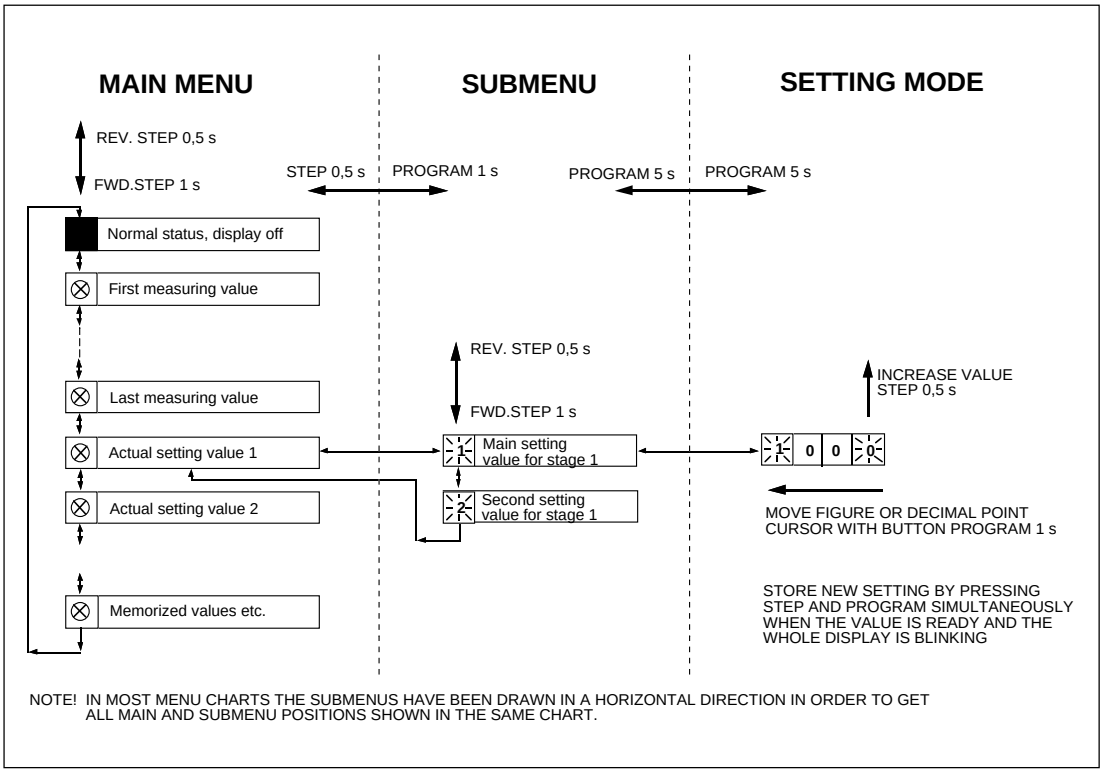


Fig.3. Basic principles of entering the main menus and submenus of a relay module.

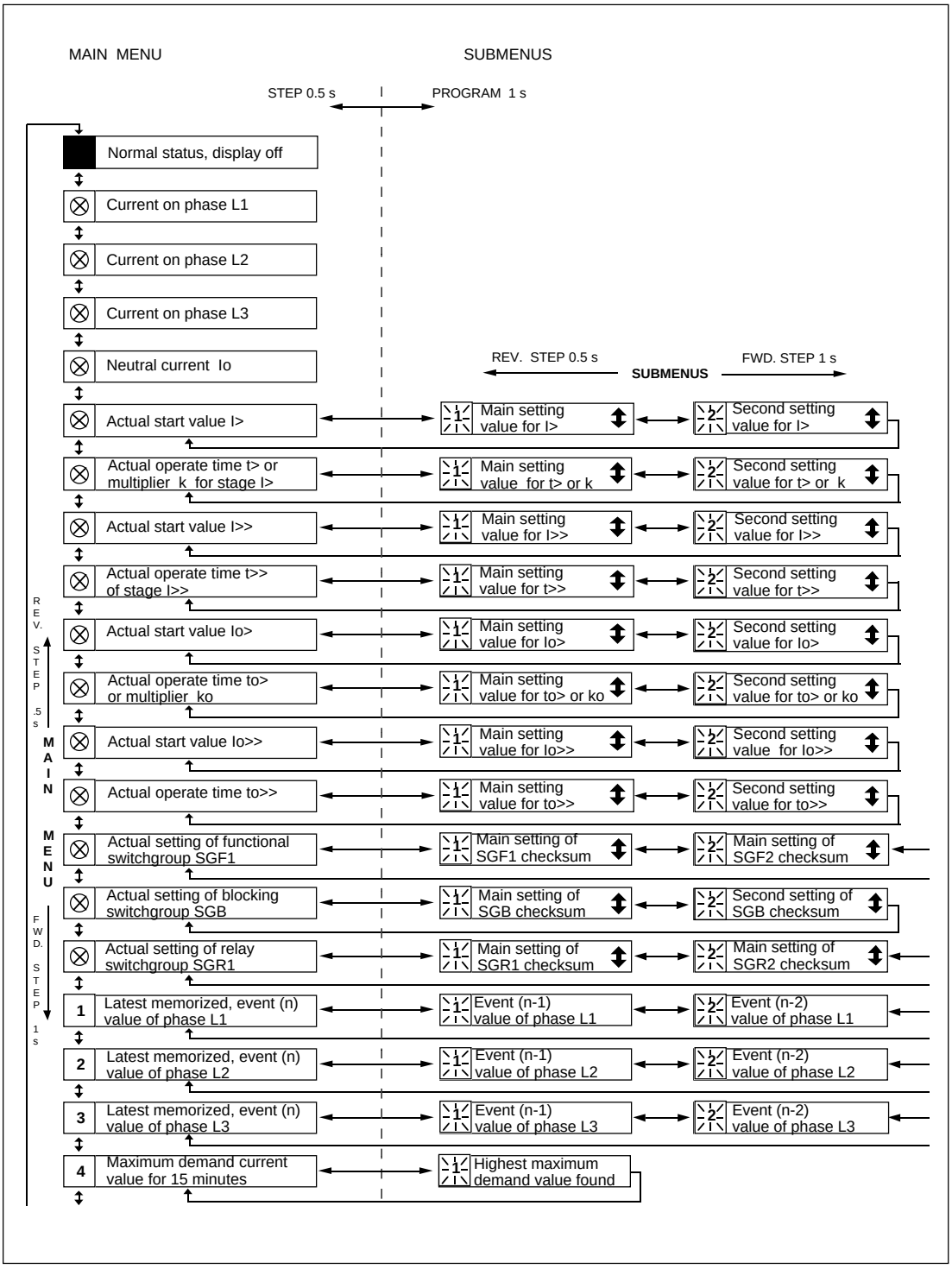
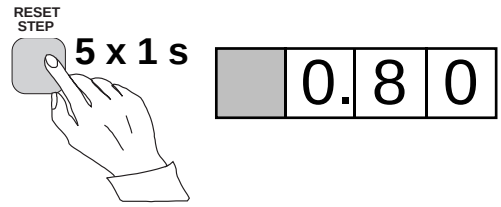


Fig. 4. Example of part of the main and submenus for the settings of the overcurrent and earth-fault relay module SPCJ 4D29. The settings currently in use are in the main manu and they are displayed by pressing the STEP push button. The main menu also includes the measured current values, the registers 1...9, 0 and A. The main and second setting values are located in the submenus and are called up on the display with the PROGRAM push button.

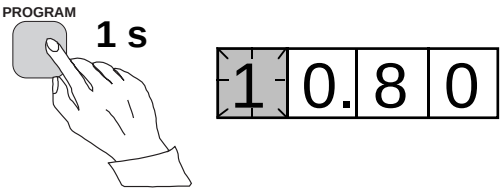
Example 1

Operation in the setting mode. Manual setting of the main setting of the start current value I> of an overcurrent relay module. The initial value for the main setting is 0.80 x I_n and for the second setting 1.00 x I_n. The desired main start value is 1.05 x I_n.

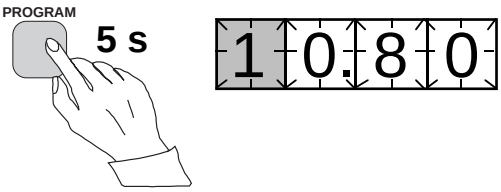
a)
Press push button STEP repeatedly until the LED close to the I> symbol is lit and the current start value appears on the display.



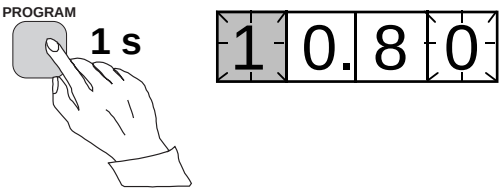
b)
Enter the submenu to get the main setting value by pressing the PROGRAM push button more than one second and then releasing it. The red display digit now shows a flashing number 1, indicating the first submenu position and the green digits show the set value.



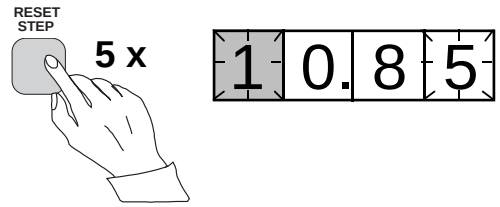
c)
Enter the setting mode by pressing the PROGRAM push button for five seconds until the display starts flashing.



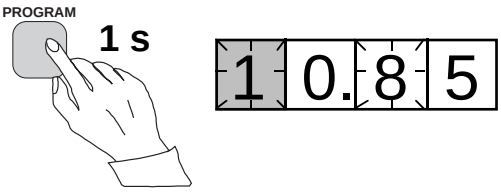
d)
Press the PROGRAM push button once again for one second to get the rightmost digit flashing.



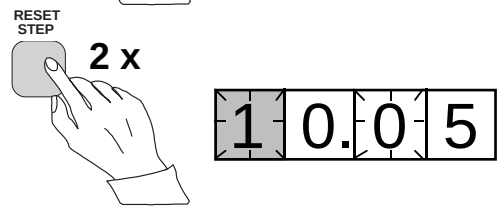
e)
Now the flashing digit can be altered. Use the STEP push button to set the digit to the desired value.



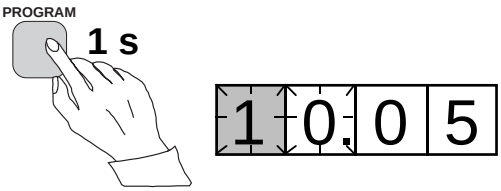
f)
Press the PROGRAM push button to make the middle one of the green digits flash.



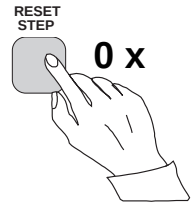
g)
Set the middle digit with of the STEP push button.

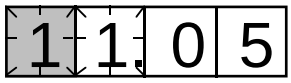


h)
Press the PROGRAM push button to make the leftmost green digit flash.

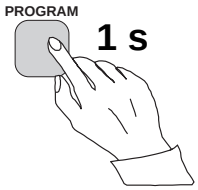


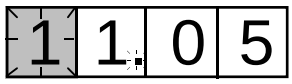
i)
Set the digit with the STEP push button.



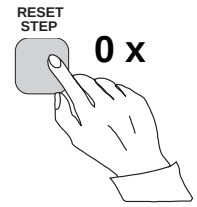


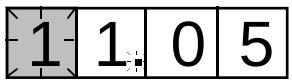
j)
Press the PROGRAM push button to make the decimal point flash.



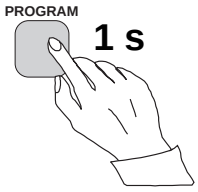


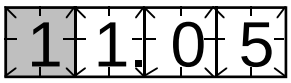
k)
If needed, move the decimal point with the STEP push button.



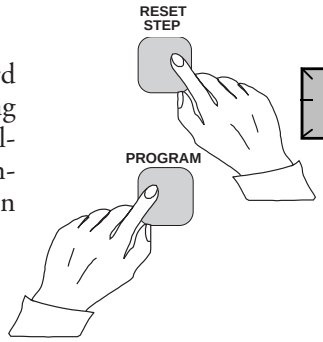


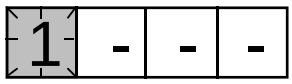
l)
Press the PROGRAM push button to make the whole display flash. In this position, corresponding to position c) above, one can see the new value before it is recorded. If the value needs changing, use the PROGRAM push button to alter the value.



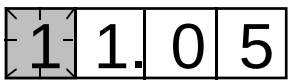


m)
When the new value has been corrected, record it in the memory of the relay module by pressing the PROGRAM and STEP push buttons simultaneously. At the moment the information enters the memory, the green dashes flash once in the display, i.e. 1 - - -.

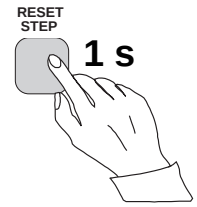


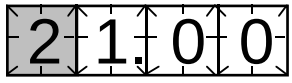


n)
Recording of the new value automatically initiates a return from the setting mode to the normal submenu. Without recording one can leave the setting mode any time by pressing the PROGRAM push button for about five seconds, until the green display digits stop flashing.



o)
If the second setting is to be altered, enter submenu position 2 of the setting I> by pressing the STEP push button for approx. one second. The flashing position indicator 1 will then be replaced by a flashing number 2 which indicates that the setting shown on the display is the second setting for I>.



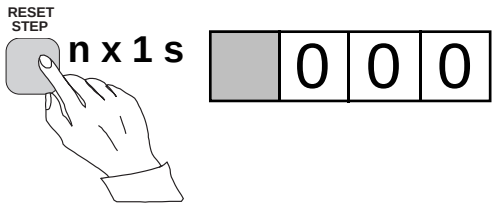


Enter the setting mode as in step c) and proceed in the same way. After recording of the requested values return to the main menu is obtained by pressing the STEP push button until the first digit is switched off. The LED still shows that one is in the I> position and the display shows the new setting value currently in use by the relay module.

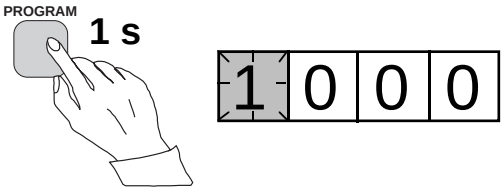
Example 2

Operation in the setting mode. Manual setting of the main setting of the checksum for the switchgroup SGF1 of a relay module. The initial value for the checksum is 000 and the switches SGF1/1and SGF1/3 are to be set in position 1. This means that a checksum of 005 should be the final result.

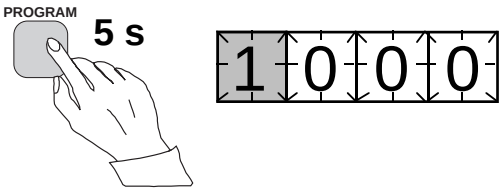
a)
Press push button STEP until the LED close to the SGF symbol is lit and the checksum appears on the display.



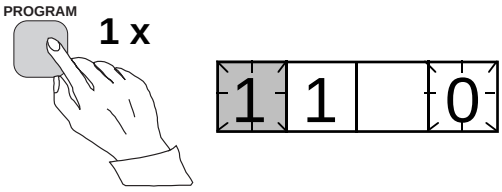
b)
Enter the submenu to get the main checksum of SGF1 by pressing the PROGRAM push button for more than one second and then releasing it. The red display now shows a flashing number 1 indicating the first submenu position and the green digits show the checksum.



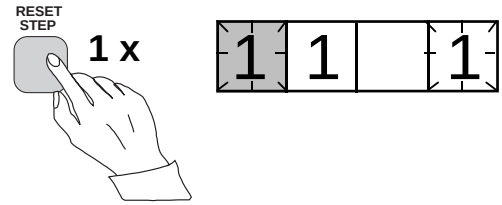
c)
Enter the setting mode by pressing the PROGRAM push button for five seconds until the display starts flashing.



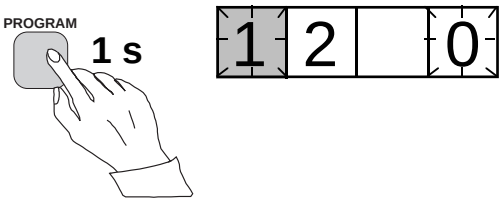
d)
Press the PROGRAM push button once again to get the first switch position. The first digit of the display now shows the switch number. The position of the switch is shown by the rightmost digit.



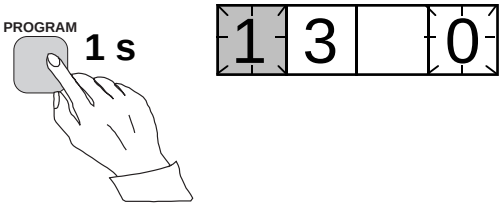
e)
The switch position can now be toggled between 1 and 0 by means of the STEP push button and it is left in the requested position 1.



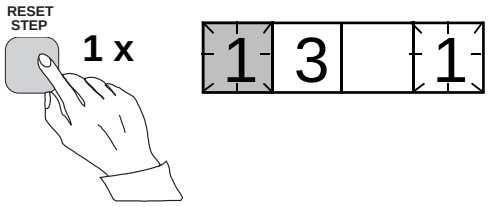
f)
When switch number 1 is in the requested position, switch number 2 is called up by pressing the PROGRAM push button for one second. As in step e), the switch position can be altered by using the STEP push button. As the desired setting for SGF1/2 is 0 the switch is left in the 0 position.



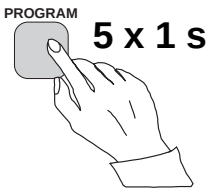
g)
Switch SGF1/3 is called up as in step f) by pressing the PROGRAM push button for about one second.



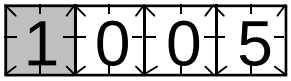
h)
The switch position is altered to the desired position 1 by pressing the STEP push button once.



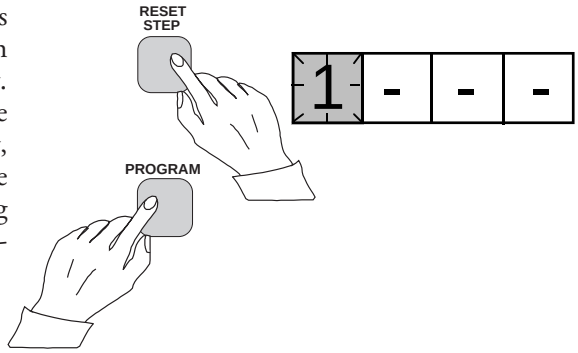
i)
Using the same procedure the switches SGF 1/ 4...8 are called up and, according to the example, left in position 0.



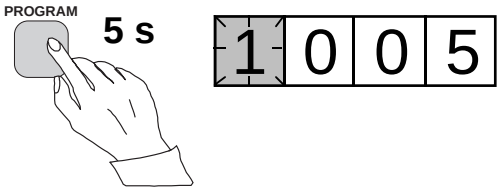
j)
In the final setting mode position, corresponding to step c), the checksum based on the set switch positions is shown.



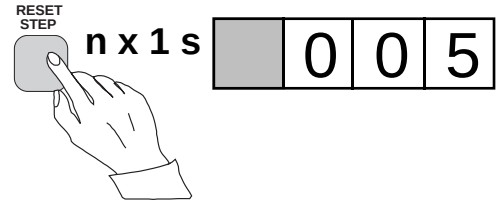
k)
If the correct checksum has been obtained, it is recorded in the memory by pressing the push buttons PROGRAM and STEP simultaneously. At the moment the information enters the memory, the green dashes flash in the display, i.e.1 - - -. If the checksum is incorrect, the setting of the separate switches is repeated using the PROGRAM and STEP push buttons starting from step d).



l)
Recording the new value automatically initiates a return from the setting mode to the normal menu. Without recording one can leave the setting mode any time by pressing the PROGRAM push button for about five seconds, until the green display digits stop flashing.



m)
After recording the desired values return to the main menu is obtained by pressing the STEP push button until the first digit is turned off. The LED indicator SGF still shows that one is in the SGF position and that the display shows the new checksum for SGF1 currently in use by the relay module.



Recorded information

The parameter values measured at the moment when a fault occurs or at the trip instant are recorded in the registers. The recorded data, except for some parameters, are set to zero by pressing the push buttons STEP and PROGRAM simultaneously. The data in normal registers are erased if the auxiliary voltage supply to the relay is interrupted, only the set values and certain other essential parameters are maintained in non-volatile registers during a voltage failure.

The number of registers varies with different relay module types. The functions of the registers are illustrated in the descriptions of the different relay modules. Additionally, the system front panel of the relay contains a simplified list of the data recorded by the various relay modules of the protection relay.

All D type relay modules are provided with two general registers: register 0 and register A.

Register 0 contains, in coded form, the information about e.g. external blocking signals, status information and other signals. The codes are explained in the manuals of the different relay modules.

Register A contains the address code of the relay modul which is reqiured by the serial communication system.

Submenu 1 of register A contains the data transfer rate value, expressed in kilobaud, of the serial communication.

Submenu 2 of register A contains a bus communication monitor for the SPAbus. If the protection relay, which contains the relay module, is linked to a system including a contol data communicatoe, for instance SRIO 1000M and the data communication system is operating, the counter reading of the monitor will be zero. Otherwise the digits 1...255 are continuously scrolling in the monitor.

Submenu 3 contains the password required for changing the remote settings. The address code, the data transfer rate of the serial communication and the password can be set manually or via the serial communication bus. For manual setting see example 1.

The default value is 001 for the address code, 9.6 kilobaud for the data transfer rate and 001 for the password.

In order to secure the setting values, all settings are recorded in two separate memory banks within the non-volatile memory. Each bank is complete with its own checksum test to verify the condition of the memory contents. If, for some reason, the contents of one bank is disturbed, all settings are taken from the other bank and the contents from here is transferred to the faulty memory region, all while the relay is in full operation condition. If both memory banks are simultaneously damaged the relay will be be set out of operation, and an alarm signal will be given over the serial port and the IRF output relay

Trip test function

Register 0 also provides access to a trip test function, which allows the output signals of the relay module to be activated one by one. If the auxiliary relay module of the protection assembly is in place, the auxiliary relays then will operate one by one during the testing.

When pressing the PROGRAM push button for about five seconds, the green digits to the right start flashing indicating that the relay module is in the test position. The indicators of the settings indicate by flashing which output signal can be activated. The required output function is selected by pressing the PROGRAM push button for about one second.

The indicators of the setting quantities refer to the following output signals:

Setting I>	Starting of stage I>
Setting t>	Tripping of stage I>
Setting I>>	Starting of stage I>>
Setting t>>	Tripping of stage I>>
etc.	
No indication	Self-supervision IRF

The selected starting or tripping is activated by simultaneous pressing of the push buttons STEP and PROGRAM. The signal remains activated as long as the two push butttons are pressed. The effect on the output relays depends on the configuration of the output relay matrix switches.

The self-supervision output is activated by pressing the STEP push button 1 second when no setting indicator is flashing. The IRF output is activated in about 1 second after pressing of the STEP push button.

The signals are selected in the order illustrated in Fig. 4.

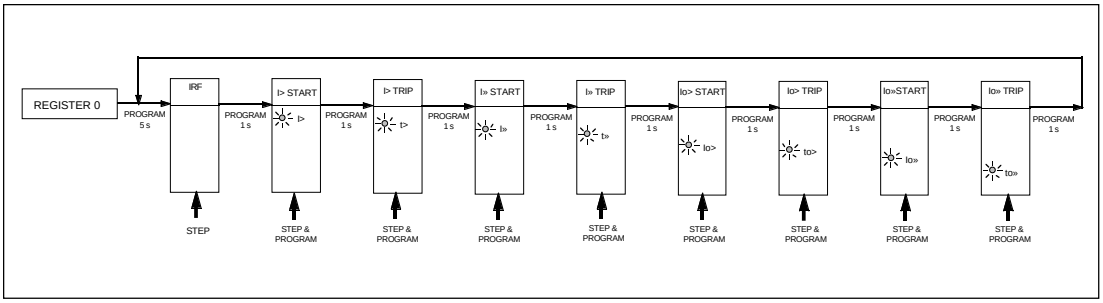


Fig. 5. Sequence order for the selection of output signals in the Trip test mode

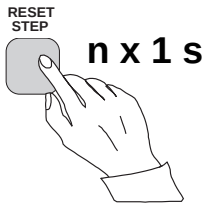
If, for instance, the indicator of the setting t> is flashing, and the push buttons STEP and PROGRAM are being pressed, the trip signal from the low-set overcurrent stage is activated. Return to the main menu is possible at any stage of the trip test sequence scheme, by pressing the PROGRAM push button for about five seconds.

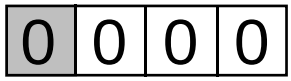
Note!
The effect on the output relays then depends on the configuration of the output relay matrix switchgroups SGR 1...3.

Example 3

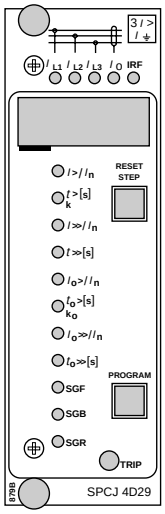
Trip test function. Forced activation of the outputs.

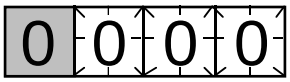
a)
Step forward on the display to register 0.





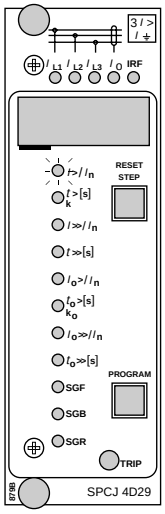
b)
Press the PROGRAM push button for about five seconds until the three green digits to the right.

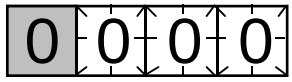




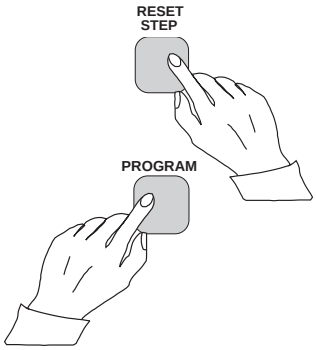
c)
Hold down the STEP push button. After one second the red IRF indicator is lit and the IRF output is activated. When the step push button is released the IRF indicator is switched off and the IRF output resets.

d)
Press the PROGRAM push button for one second and the indicator of the topmost setting start flashing.

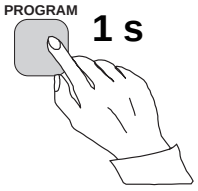


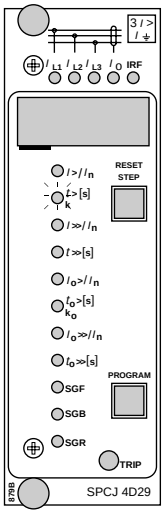


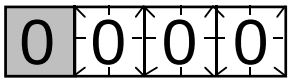
e)
If a start of the first stage is required, now press the push-buttons PROGRAM and STEP simultaneously. The stage output will be activated and the output relays will operate according to the actual programming of the relay output switchgroups SGR.



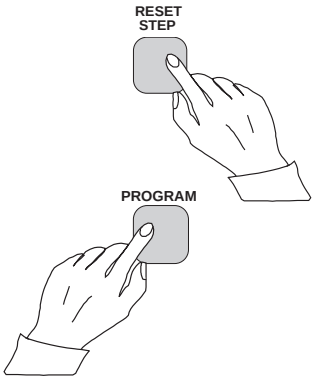
f)
To proceed to the next position press the PROGRAM push button for about 1 second until the indicator of the second setting starts flashing.

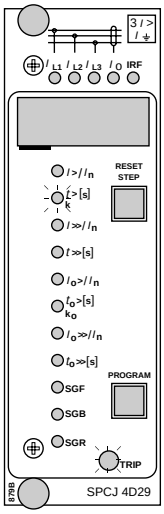


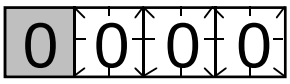




g)
Press the push buttons PROGRAM and STEP simultaneously to activate tripping of stage 1 (e.g. the I> stage of the overcurrent module SPCJ 4D29). The output relays will operate according to the actual programming of the relay switchgroups SGR. If the main trip relay is operated the trip indicator of the measuring module is lit.







h)
The starting and tripping of the remaining stages are activated in the same way as the first stage above. The indicator of the corresponding setting starts flashing to indicate that the concerned stage can be activated by pressing the STEP and PROGRAM buttons simultaneously. For any forced stage operation, the output relays will respond according to the setting of the relay output switchgroups SGR. Any time a certain stage is selected that is not wanted to operate, pressing the PROGRAM button once more will pass by this position and move to the next one without carrying out any operation of the selected stage.

It is possible to leave the trip test mode at any step of the sequence scheme by pressing the PROGRAM push button for about five seconds until the three digits to the right stop flashing.

Operation indication

A relay module is provided with a multiple of separate operation stages, each with its own operation indicator shown on the display and a common trip indicator on the lower part of the front plate of the relay module.

The starting of a relay stage is indicated with one number which changes to another number when the stage operates. The indicator remains glowing although the operation stage resets. The indicator is reset by means of the RESET push button of the relay module. An unreset operation indicator does not affect the function of the protection relay module.

In certain cases the function of the operation indicators may deviate from the above principles. This is described in detail in the descriptions of the separate modules.

Fault codes

In addition to the protection functions the relay module is provided with a self-supervision system which continuously supervises the function of the microprocessor, its program execution and the electronics.

Shortly after the self-supervision system detects a permanent fault in the relay module, the red IRF indicator on the front panel is lit . At the same time the module puts forward a control signal to the output relay of the self-supervision system of the protection relay.

In most fault situations a fault code, indicating the nature of the fault, appears on the display of the module. The fault code, which consists of a red figure "1" and a three digit green code number, cannot be removed from the display by resetting. When a fault occurs, the fault code should be recorded and stated when service is ordered. When in a fault mode, the normal relay menus are operative, i.e. all setting values and measured values can be accessed although the relay operation is inhibited. The serial communication is also operative making it possible to access the relay information also from a remote site. The internal relay fault code shown on the display remains active until the internal fault possibly disappears and can also be remotely read out as variable V 169.

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