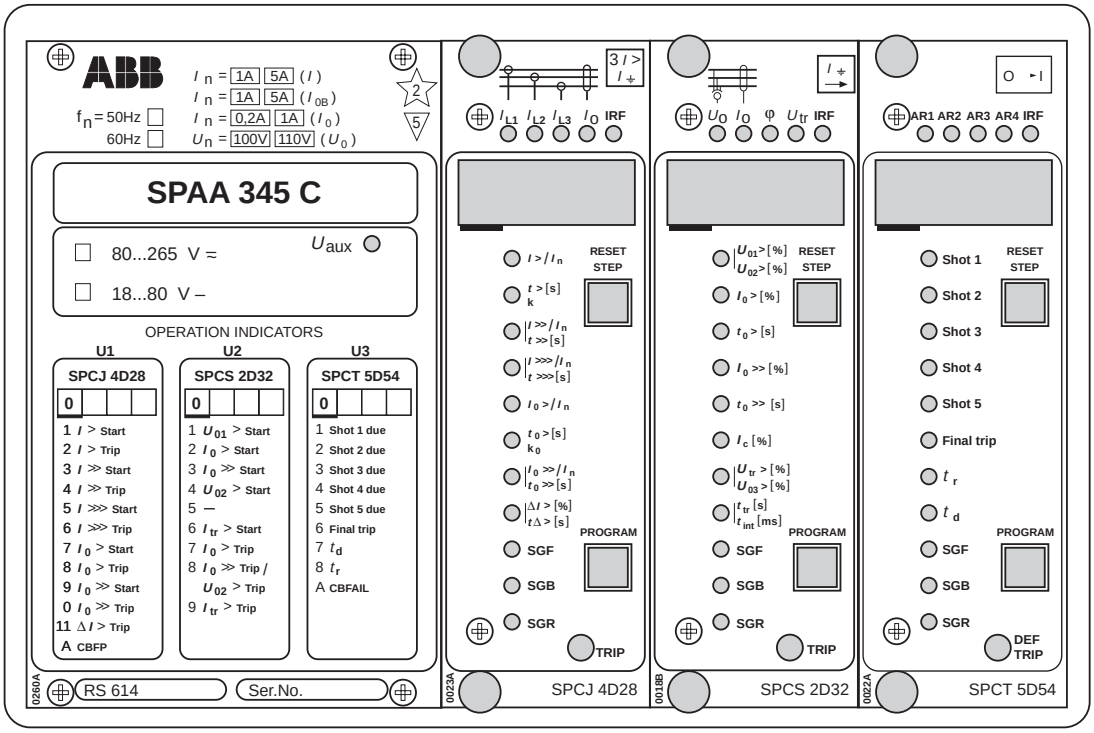
SPAA 345 C
Feeder Protection Relay

User´s manual and Technical description



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SPAA 345 C
Feeder Protection Relay

Contents

In addition to this general part the following descriptions of the individual modules are included in the complete manual of the feeder terminal relay SPAA 345 C:

Combined overcurrent and earth-fault module SPCJ 4D28	1MRS 750093-MUM EN
Transient measuring directional earth-fault relay module SPCS 2D32	1MRS 750094-MUM EN
Auto-reclose relay module SPCT 5D54	1MRS 750095-MUM EN
General characteristics of D-type SPC relay modules	1MRS 750066-MUM EN

Features

- Three-phase overcurrent protection with three stages
- Two-stage non-directional earth-fault protection and phase discontinuity protection
- Transient measuring earth-fault protection
- Intermittent earth-fault protection
- Two-stage sensitive directional earth-fault protection
- Two parallel measurements of neutral current: sensitive and normal
- Automatic reclosing allowing from one to five auto-reclosures
- Remote control of circuit breaker via auto-reclose module
- Five external control inputs enabling, for example, external initiation of auto-reclosing
- Seven freely configurable output relays and output relays for self-supervision and circuit breaker closing
- Four trip contacts for double-pole CB opening and double-pole CB closing
- Recording of measured data which can be used for analyzing the network condition
- Transfer of data over serial communication bus
- Continuous self-supervision and internal fault diagnosis
- Reading and writing of setting values via the display and front panel push-buttons, a PC with setting software, or from higher systems levels over the serial bus

Application

The feeder protection relay SPAA 345 C is designed to be used for selective short-circuit and earth-fault protection of radial isolated neutral networks, resonant earthed networks and partially earthed networks. The integrated protection includes short-circuit and earth-fault protection for one feeder, automatic reclosing and signalling logic. In addition, the feeder protection relay SPAA 345 C can be used for applications requiring special-type earth-fault protection: transient measuring earth-fault protection and intermittent earth-fault protection.

Description of operation

The feeder protection relay SPAA 345 C is a secondary relay system to be connected to the current and voltage transformers of the network section to be protected. The feeder protection relay includes three protection relay modules: a three-phase combined overcurrent and earth-fault relay module type SPCJ 4D28, a transient measuring directional earth-fault relay module type SPCS 2D32 and an auto-reclose relay module type SPCT 5D54.

Combined overcurrent and earth-fault relay module SPCJ 4D28

The overcurrent unit of the combined overcurrent and earth-fault relay module SPCJ 4D28 is intended to be used for single-phase, two-phase or three-phase overcurrent protection. It includes three overcurrent stages: I>, I>> and I>>>. An overcurrent stage starts, as soon as the current on one of the phases exceeds the setting value of the stage concerned. Should the stage still be started when the operate time selected for the stage elapses, it trips the circuit breaker by delivering the configured trip signal.

The earth-fault unit of the combined overcurrent and earth-fault relay module SPCJ 4D28 is intended to be used for non-directional earth-fault protection. It includes two stages: a low-set stage I_0> and a high-set stage I_0>>. When starting the stage provides a start signal which can be programmed to operate as the desired output signal. Should the earth-fault persist when the operate time elapses, the stage delivers a trip signal.

The low-set stages (I> and I_0>) may have a definite or an inverse time characteristic, whereas the high-set stages operate according to the definite time characteristic only. The operation of the stages can be totally blocked by means of the configuration switches.

The overcurrent and earth-fault relay module SPCJ 4D28 also provides protection against phase discontinuity. This phase discontinuity protection stage monitors the minimum and maximum phase current and calculates the differential current ΔI between the phases. The stage provides a trip signal if the differential current is greater than the setting value when the set operate time elapses.

Transient measuring directional earth-fault relay module SPCS 2D32

An earth fault occurring in the network can be detected by the transient measuring earth-fault relay module as follows: by using the traditional method of determining the direction of the earth fault, by measuring the earth fault transient or using a method for detecting an intermittent earth fault.

The directional earth-fault protection includes two stages: a low-set stage I_0> and a high-set stage I_0>>. In addition, the high-set stage can be configured to operates as a residual voltage stage or a non-directional earth-fault stage. The operation of the protection can be based on measuring either I_0, U_0 and φ, or U_0 and Iφ (= $I_0\cos\varphi$ or $I_0 \sin\varphi$). The stage starts once the neutral current and residual voltage exceed the set values and the phase angle is within the specified operating area. If these conditions are fulfilled when the set operate elapses, the stage provides a trip signal.

The transient measuring earth-fault protection operates in parallel with the intermittent earth-fault protection, with common settings and protection stages.

The operation of the transient measuring protection is based on measuring the neutral current and residual voltage transient at the moment an earth fault occurs and calculating the capacitive current of the background network. Further, a permanent increase in the residual voltage is required for tripping. The intermittent earth-fault protection has mainly been designed for the detection of low-impedance faults occurring in underground cables. The protection monitors the fundamental frequency or high-frequency I_0 pulses and starts, if all fault conditions (regular I_0 pulses, phase criterion and U_0 value) are fulfilled.

Auto-reclose relay module SPCT 5D54

The auto-reclose relay module SPCT 5D54 is capable of performing from one to five auto-reclose shots and tripping the circuit breaker finally. The auto-reclose shots are freely programmable to be initiated by short circuit, overcurrent, earth fault or via an external control input. When required, the initiation of an auto-reclose sequence can be blocked by a short circuit.

An auto-reclose shot can be initiated by starting and tripping of the protection. When initiated by a start signal of one of the protection relay modules, the auto-reclose module opens the circuit breaker, and when the dead time set for the concerned AR shot elapses, it closes the circuit breaker. Should the fault still persist when the auto-reclosure has been carried out, the protection relay module operates again initiating the next shot until the whole AR sequence has been completed. Then, if the fault proves permanent, definite tripping will follow. Definite trip can be carried out either by one of the protection relay modules or by the auto-reclose module (final trip function). At definite tripping the red DEF TRIP indicator on the auto-reclose module is lit and information about which of the protection functions that initiated the unsuccessful AR sequence is available via the output signals.

The auto-reclose module is provided with a maintenance monitor that records the operations of the circuit breaker. Each CB opening decrements the value of the monitor according to the stress factors. The alarm signal of the maintenance monitor can be used to block auto-reclose operations. The maintenance monitor also allows a pre-alarm level to be set.

Different types of information, e.g., information about an auto-reclosure in progress, alarm on definite tripping, and circuit breaker failure alarm, can also be received as contact information from the auto-reclose module.

The external control inputs of the auto-reclose module can be used to initiate an auto-reclose sequence, to prevent or interrupt an auto-reclosure and to prevent CB closing.

Circuit-breaker failure protection

The circuit-breaker failure protection (CBFP) is integrated into the relay module SPCJ 4D28. The circuit-breaker failure protection can be used to obtain a circuit-breaker back-trip system. The breaker fail function is linked to the output relay TS1 so that in the event of the local circuit breaker failing to trip, the trip signal can be rerouted directly to the upstream circuit breaker.

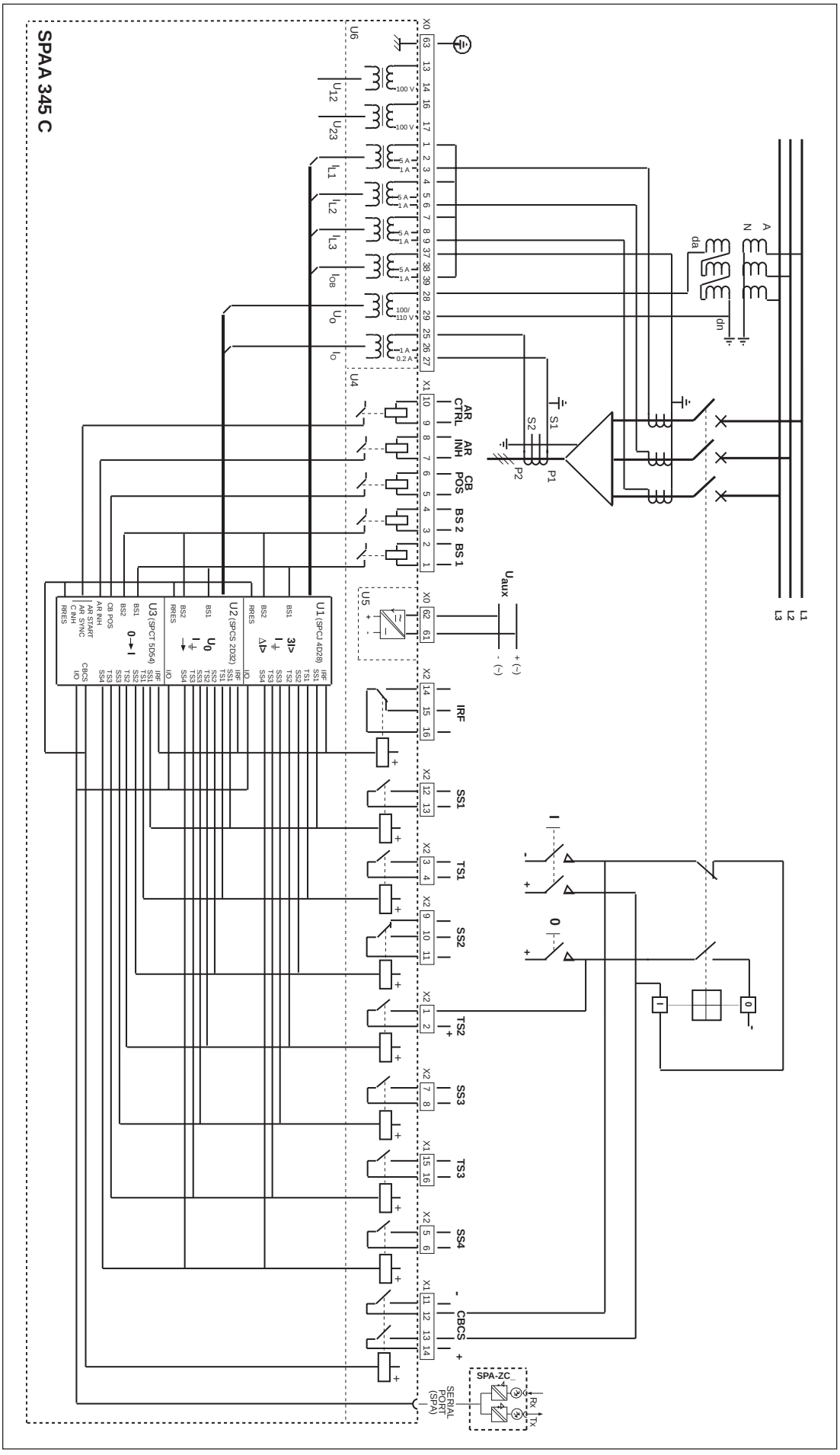

Fig. 1. Connection diagram for feeder protection relay SPAA 345 C

U_{aux}	Auxiliary voltage
TS1...TS3, CBCS	Output relays (heavy-duty)
SS1...SS4	Output relays
IRF	Self-supervision output relay
BS1, BS2	Control signals 1 and 2
CBPOS	Circuit breaker status data
ARINH	Signal for AR interruption and inhibition
ARCTRL	Control signal for auto-reclosing
SS1...SS4, TS1...TS3, IRF	Output signals
CBCS	Signal for circuit breaker closing
U1	Combined overcurrent and earth-fault relay module SPCJ 4D28
U2	Transient measuring directional earth-fault relay module SPCS 2D32
U3	Auto-reclose relay module SPCT 5D54
U4	I/O module
U5	Power supply module
U6	Energizing input module
SERIAL PORT	Serial communication port
SPA-ZC	Bus connection module
Rx/Tx	Fibre-optic cable connections

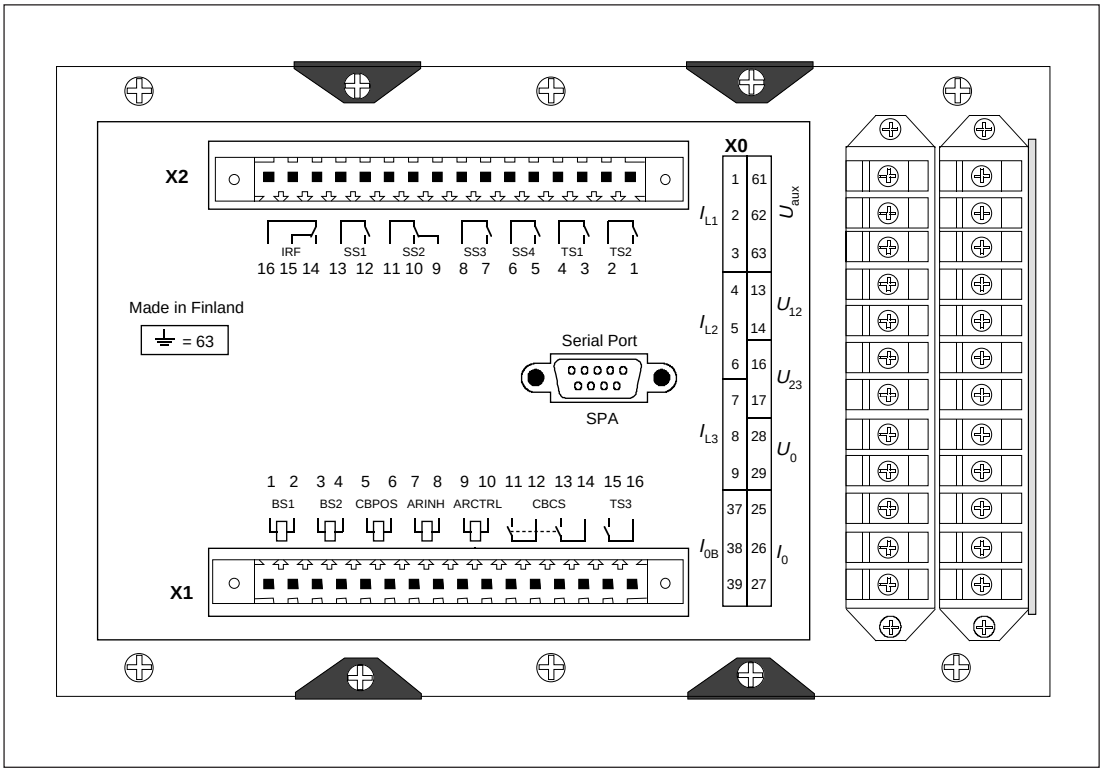

Fig. 2. Terminals of feeder protection relay SPAA 345 C.

Specification of input and output terminals

(modified 96-11)

Terminal group	Terminal interval	Function
X0	1–2	Phase current I_{L1} (5 A). Overcurrent protection
	1–3	Phase current I_{L1} (1 A). Overcurrent protection
	4–5	Phase current I_{L2} (5 A). Overcurrent protection
	4–6	Phase current I_{L2} (1 A). Overcurrent protection
	7–8	Phase current I_{L3} (5 A). Overcurrent protection
	7–9	Phase current I_{L3} (1 A). Overcurrent protection
	13–14	Phase-to-phase voltage U_{12} (100 V). (Not used in SPAA 345 C)
	16–17	Phase-to-phase voltage U_{23} (100 V). (Not used in SPAA 345 C)
	37–38	Neutral current I_{0B} (5 A). Earth-fault protection. (SPCJ 4D28)
	37–39	Neutral current I_{0B} (1 A). Earth-fault protection. (SPCJ 4D28)
	25–26	Neutral current I_0 (1 A). Earth-fault protection. (SPCS 2D32)
	25–27	Neutral current I_0 (0.2 A). Earth-fault protection. (SPCS 2D32)
	28–29	Residual voltage U_0 (100 V). Earth-fault protection. (Selection of rated voltage 110 V- possible)
	61–62	Auxiliary voltage supply. The positive pole of the DC supply is connected to terminal 61. Auxiliary voltage range marked on the front plate.
	63	Protective earth
X1	1–2	External control signal BS1
	3–4	External control signal BS2
	5–6	Circuit breaker position input CBPOS. The input is energized when the circuit breaker is open.
	7–8	Auto-reclose inhibition signal ARINH
	9–10	Auto-reclose control signal ARCTRL
	11–12–13–14	Output relay CBCS (heavy-duty, see "double-pole circuit breaker control")
	15–16	Output relay TS3 (heavy-duty)
X2	1–2	Output relay TS2 (heavy-duty)
	3–4	Output relay TS1 (heavy-duty)
	5–6	Output relay SS4
	7–8	Output relay SS3
	9–10–11	Output relay SS2
	12–13	Output relay SS1
	14–15–16	Output relay IRF

The protection relay is connected to the fibre-optic data bus via a bus connection module type SPA-ZC 17 or SPA-ZC 21 that is fitted to the D connector on the rear panel of the relay. The optical fibres are connected to the counter contacts Rx and Tx of the module. The selector switches of the bus connection module are set to the position "SPA".

Double-pole circuit breaker control

The circuit breaker closing can be implemented as one-pole or double-pole connection. At double-pole circuit breaker operation the control voltage is applied to both sides of the circuit breaker tripping coil: the negative and the positive polarity of the control circuit are separately connected over the terminals 11–12 and 13–14 of the output relay CBCS.

Note!
When the CBCS relay is used with one-pole connection, the terminals 12 and 13 have to be connected together.

Should double-pole circuit breaker opening be required as well, two heavy-duty output relays can be used for this purpose (e.g. TS2 and TS3).

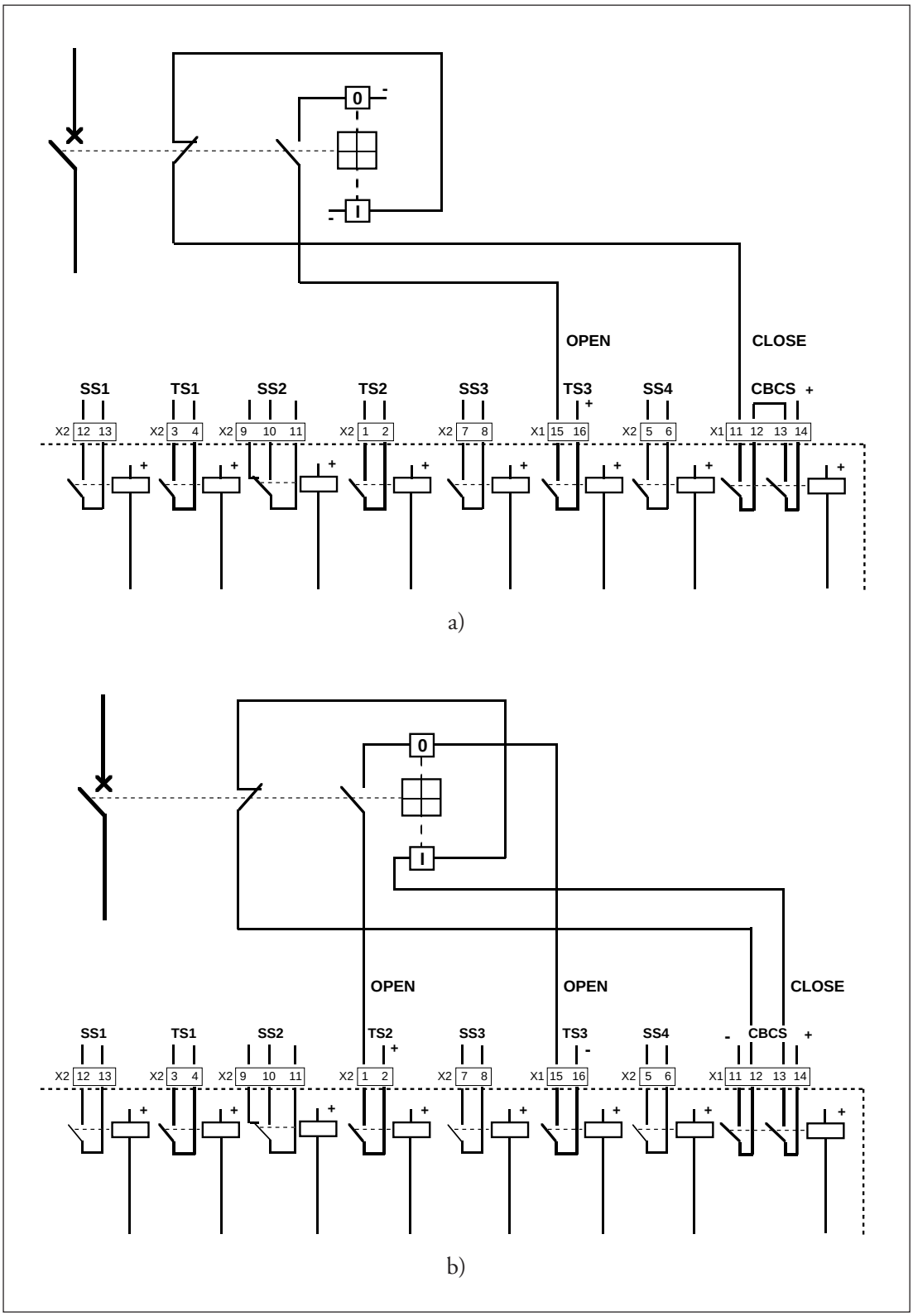

Fig. 3. Principle of one-pole (a) and double-pole (b) operation.

Signal flow diagram

(modified 96-11)

The internal signals of the feeder protection relay and their configuration are illustrated in Fig. 4. The numbers given in the small squares refer to the configuration switches to be used for connecting the control signals to the required functions and configuring the start and trip signals to operate as desired output signals or AR initiation signals.

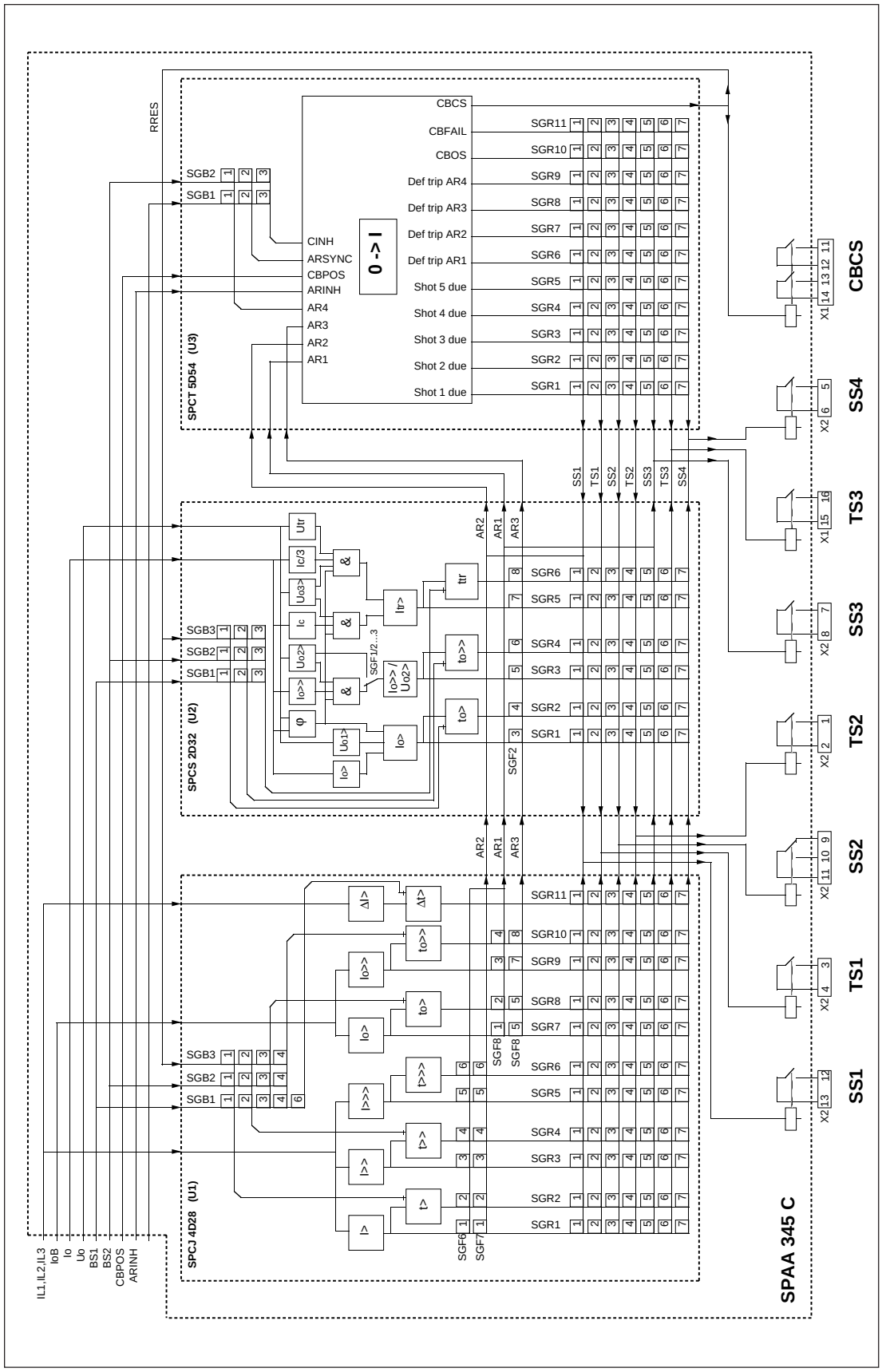

Fig. 4. Internal signals of feeder protection relay SPAA 345 C.

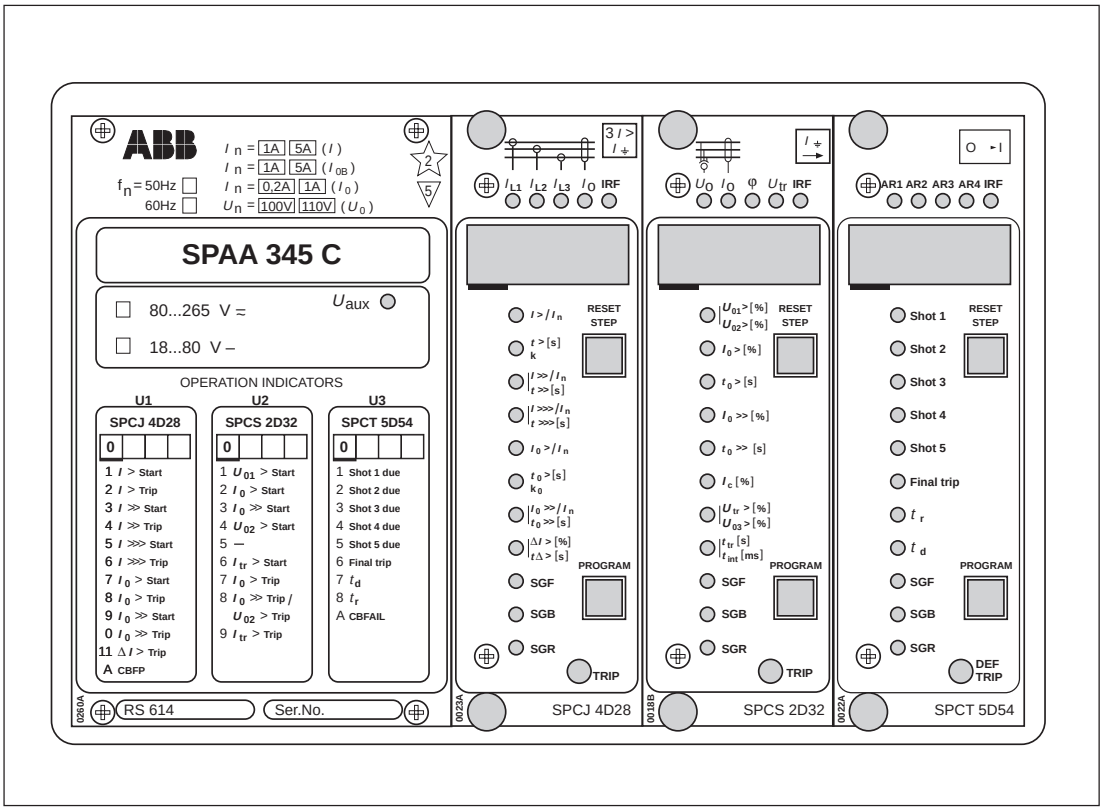

Fig. 5. Front panel of feeder protection relay SPAA 345 C.

1. The green LED U_{aux} on the system panel is lit when the power supply unit is operating.

2. Measured values, settings and start and trip data are indicated on the displays of the relay modules. Starting and tripping are indicated by the red operation code to the left of the display. The operation codes are explained in the manuals of the separate protection relay modules and on the system panel of the feeder protection relay.

   The start indications can be programmed to remain on even though the stage resets. Normally, the numbers indicating start are automatically reset, whereas the trip codes have to be reset by pressing the RESET push-button. The TRIP indicator at the bottom part of the front panel can be set to indicate tripping. The BS1, BS2 and RRES signals can be configured to automatically reset the trip indicators. The closing signal of the auto-reclose relay module is linked to the RRES input, which can be used to reset the operation indicators after a successful auto-reclose sequence. An unreset operation indicator does not affect the operation of the relay module.

3. Measured values and settings presented on the display are identified by yellow LEDs on the front panel.

4. A permanent fault detected by the self-supervision system is indicated by the IRF indicator of the concerned relay module. The fault code appearing on the display when a fault occurs should be recorded to facilitate maintenance and repair.

The operation indicators are described in detail in the manuals of the individual relay modules.

I/O module

The I/O module of the feeder protection relay SPAA 345 C is fitted in the rear part of the relay, in the same direction as the mother PC board. The module can be withdrawn after undoing the fixing screws and disconnecting the protective earth conductor of the cover and the flat cable connected to the mother PC board.

The I/O module contains the output relays (8 pcs + IRF), the control circuits of the relays, the electronic circuits for the five external control inputs and the D connector required for serial communications. The input and output signals of the I/O module are linked to the mother board over a flat cable. The relay module locations U1 and U2 are identical. The location U3 is intended for the auto-reclose module.

The output signals SS1...SS4, TS1...TS3 and CBCS control an output relay with the same designation. The operation of the stages is not fixed to a particular output relay but can be programmed for the desired output relays. It should, however, be noted that the output relays TS1, TS2, TS3 and CBCS can be used for circuit breaker control. The configuration of the switchgroups is described in detail in the manuals of the relay modules.

The operation of the external control inputs is determined by the setting of the configuration switchgroups of the relay modules. The control inputs can be used for blocking one or several protection stages, for resetting latched output relays, selecting second settings, etc.

Power supply module

The power supply module forms the voltages required for the relay modules and the auxiliary relay module. The power supply module is located behind the system panel of the protection relay and can be withdrawn after removal of the system panel.

The power supply module is available in two versions as follows:

SPGU 240A1:
- rated voltage U_n = 110/120/230/240 V ac
  U_n = 110/125/220 V dc
- operative range U = 80...265 V ac/dc

SPGU 48B2
- rated voltage U_n = 24/48/60 V dc
- operative range U = 18...80 V dc

The voltage range of the power supply module fitted in the relay is marked on the system panel of the relay.

The power supply module is transformer connected, i.e. the primary side and the secondary circuits are galvanically isolated. The primary side is protected by a fuse F1, located on the PC board of the module. The fuse used in SPGU 240A1 is 1 A (slow) and that one used in SPGU 48B2 is 4 A (slow).

The green LED U_{aux} on the front panel is lit when the power supply module is in operation. The supervision of the voltages supplying the electronic circuits are integrated into the relay modules. A self-supervision alarm is received, if a secondary voltage deviates from its rated value by more than 25%.

Technical data
(modified 2002-04)

Energizing inputs

Rated current I_n	0.2 A	1 A	5 A
Terminal numbers	X0/25-27	X0/1-3,4-6 X0/7-9,37-39 X0/25-26	X0/1-2,4-5 X0/7-8, 37-38
Thermal current withstand			
- continuously	1.5 A	4 A	20 A
- for 10 s	5 A	25 A	100 A
- for 1 s	20 A	100 A	500 A
Dynamic current withstand			
- half-wave value	50 A	250 A	1250 A
Input impedance	<750 mΩ	<100 mΩ	<20 mΩ

Voltage inputs

Rated voltage U_n, selectable	100 V (110 V)
Terminal numbers	X0/13-14, 16-17, 28-29
Continuous voltage withstand	2 x U_n
Rated burden of voltage input at U_n	<0.5 VA

Output contacts

Trip contacts	
Terminal numbers	X1/15-16, 11-12-13-14 X2/1-2, 3-4
- rated voltage	250 V ac/dc
- continuous current carrying capacity	5 A
- make and carry for 0.5 s	30 A
- make and carry for 3 s	15 A
Breaking capacity for dc when the control circuit time constant L/R ≤40 ms at the control voltage levels	
- 220 V dc	1 A
- 110 V dc	3 A
- 48 V dc	5 A
Signalling contacts	
Terminal numbers	X2/5-6, 7-8, 9-10-11 X2/12-13, 14-15-16 X2/1-2, 3-4
- rated voltage	250 V ac/dc
- continuous current carrying capacity	5 A
- make and carry for 0.5 s	10 A
- make and carry for 3 s	8 A
Breaking capacity for dc when the control circuit time constant L/R ≤40 ms at the control voltage levels	
- 220 V dc	0.15 A
- 110 V dc	0.25 A
- 48 V dc	1 A

External control inputs

Blocking/control (BS1, BS2)	
- terminal numbers	X1/1-2, 3-4
Circuit breaker position data	
- terminal number	X1/5-6
Auto-reclose control	
- terminal number	X1/7-8, 9-10
External control voltage	
- operative range	18...250 V dc or 80...250 V ac
Current drain of activated control input	2...20 mA

Auxiliary power supply

Voltage ranges of power supply modules:	
- SPGU 240A1:	
- rated voltage	U_n = 110/120/230/240 V ac
	U_n = 110/125/220 V dc
- operative range	U = 80...265 V ac/dc
- SPGU 48B2	
- rated voltage	U_n = 24/48/60 V dc
- operative range	U = 18...80 V dc
Power consumption, under quiescent/ operation conditions	10 W/15 W

Combined overcurrent and earth-fault relay module SPCJ 4D28

- see "Technical data" in the manual for the module.

Transient measuring directional earth-fault relay module SPCS 2D32

- see "Technical data" in the manual for the module.

Auto-reclose module SPCT 5D54

- see "Technical data" in the manual for the module.

Data communication

Transmission mode	Fibre-optic serial bus
Coding	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 21 BB
- 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 17 BB
- 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

Environmental Conditions

Specified service temperature range	-10...+55°C
Transport and storage temperature range	-40...+70°C
Temperature influence on the operating values of the relay over the specified service temperature range	<0.2%/°C
Damp heat test, cyclic IEC 60068-2-30	+25...55°C, r.h. > 93%, 6 cycles
Degree of protection by enclosure of the relay case when panel mounted	IP 54
Weight of fully equipped relay	6 kg

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

Applications

Example 1. Overcurrent and earth-fault protection of a feeder, resonant earthed system.

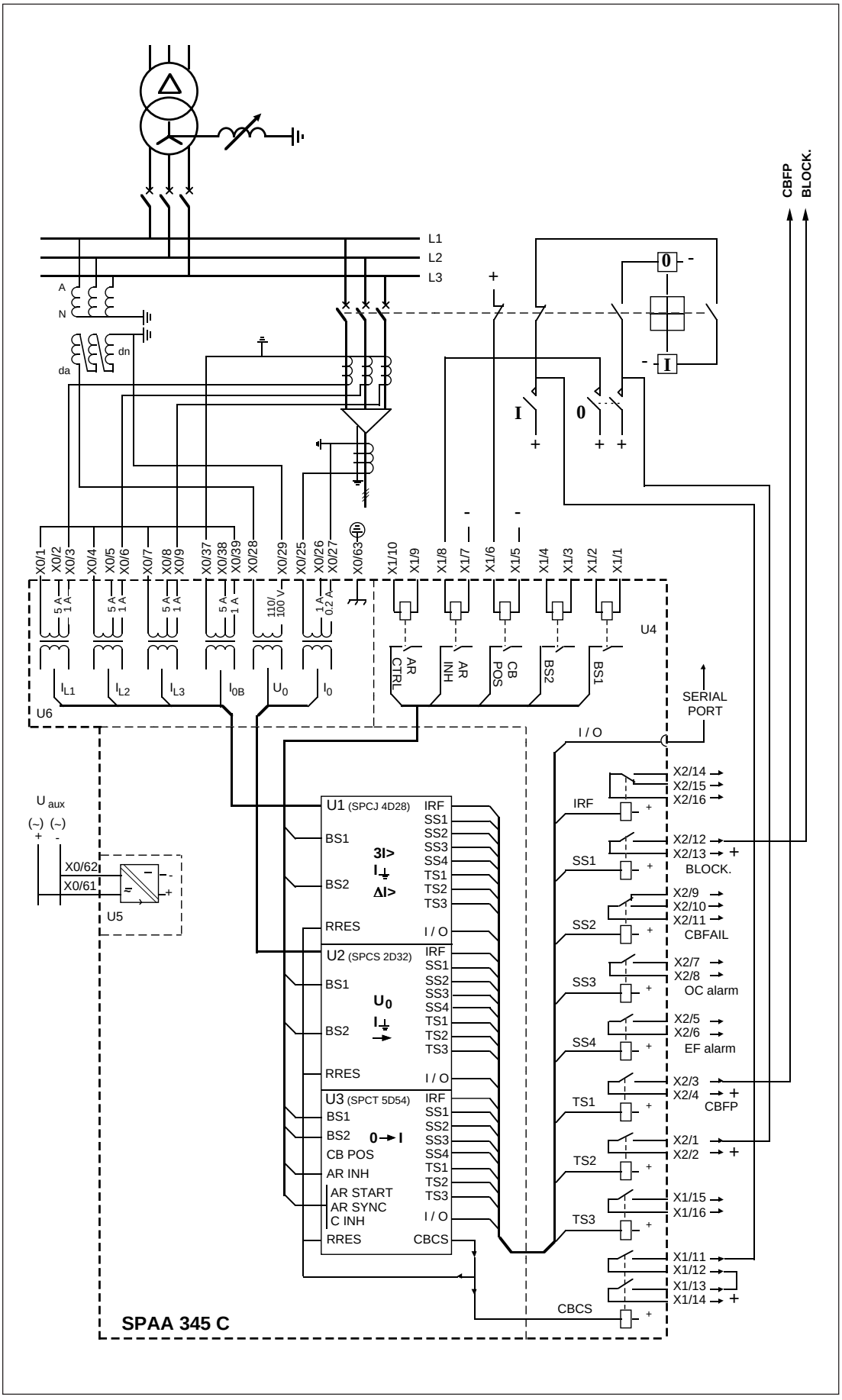

Fig. 6. Feeder protection relay SPAA 345 C used for protecting a feeder in a resonant earthed network.

Overcurrent relay module SPCJ 4D28

The overcurrent relay module SPCJ 4D28 includes three overcurrent stages. By using all three stages and giving each of them its own operate value and operate time good selectivity with short operate times can be obtained.

The operation of the short-circuit protection is based on blockings between the protection levels. 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 area and trips the circuit breaker. When required, the blocking functions can be extended beyond the relay of the infeeder.

In general, the I>>> stage is used for tripping, but in this example it is only used for providing a blocking signal. Then the start value (blocking level) is freely selectable.

The I_0> stage is used for protecting a separate feeder against a double short circuit. A double short circuit occurs when two phase conductors get in galvanic connection with earth. A double short circuit is generally a serious situation with dangerous voltages, because the fault currents through earth may be of the same level as the short circuit current. The protection is implemented as single-stage, tripping protection. Two-stage double short circuit protection is recommended to be used if the lines of the network are close to each other and the earth resistance is small.

A possible DC component does not have to be considered in the current setting, because due to the peak-to-peak measurement method used, asymmetry does not affect the sensitivity of the start operation.

Definite time operation has been used in the example, but inverse time characteristic can also be selected for the stages I> and I_0>, see example 3.

The phase discontinuity stage ΔI> operates with a tripping function when used for protecting the overhead lines of the network against phase discontinuity. 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. The earth-fault protection alone is not able to detect the fault and thus the voltage is not disconnected. In cable networks where phase discontinuity does not cause dangerous situations the ΔI stage can be given an alarming function. The phase discontinuity protection is of special importance in overhead lines.

Transient measuring directional earth-fault relay module SPCS 2D32

In the resonant earthed network illustrated in this example the relay module SPCS 2D32 has been used for the directional earth-fault protection of the feeders.

Directional earth-fault relays should also be used when the network is often changed or when high sensitivity is to be achieved. A directional earth-fault relay allows earth faults with fault resistances of several thousand ohms to be detected in overhead lines.

In the SPAA 345 type relay the directional earth-fault protection uses the sensitive neutral current input; rated values 0.2 A/1 A.

If the network to be protected is resonant earthed or earthed through a resistor, an operation characteristic corresponding to the basic angle φ_b = 0°, or a cosφ operation characteristic is used. In isolated neutral systems the protection is based on an operation characteristic corresponding to the basic angle φ_b = -90°, or a sinφ operation characteristic. When planning the settings of the earth-fault protection, it should be noticed that the operation sector will be ±80° when the angle criterion is used, and ±88° when cosφ operation characteristic is used. In practice, the use of angle criterions improves the sensitivity of the protection in the operation sector. The angle deviation of the current transformer may grow too much when the transformer is overloaded. This may lead to malfunction, because the directional angle of the neutral current of a healthy feeder is very close to the relay's operating range. An external control signal can also be used for selecting the basic angle (0°/-90°) so that it is automatically determined by the earthing situation of the network.

The BACTRL signal is not used in SPAA 345 C relay packages as in some 300 and 500 series relay packages. If required the BACTRL signal can be activated by setting switch SGF3/1 of the SPCS 2D32 relay module in position 1.

The start value of the low-set stage I_0> of the earth-fault relay module should be set low enough to fulfil the sensitivity requirements of the safety regulations. The requirements regarding operate times are primarily met by the high-set stage I_0>>.

The most convenient way of verifying the directional operation is by testing. Primary testing should be carried out when the relay is commissioned.

Transient measuring earth-fault protection

The operation of the transient measuring protection can be the same in resonant earthed systems and in isolated neutral systems, so changing the operation characteristics of the directional earth-fault protection has no effect on the operation of the protection.

The stages I_0> and I_0>> can be configured to affect the operation of the transient measuring protection of the SPCS 2D32 module. When SGF3/3 = 1, starting of stage I_0> or stage I_0>> inhibits the operation of the transient measuring protection. Then the transient measuring protection controls the output relays and provides event codes only if the neutral current remains below the setting values of the earth-fault stages I_0> and I_0>> during the fault situation. The relation between the operate time t_{tr} of the transient protection and the operate times of the stages I_0> and I_0>> are shown in the figures 7 and 8.

An exceptional situation regarding the priority of the earth-fault stages I_0> and I_0>> over the transient measuring protection occurs when the high-set stage is non-directional (SGF1/2 = 0 & SGF1/3 = 0) or operates as a residual voltage protection stage (SGF1/2 = 0 & SGF1/3 = 1), or the low-set stage is non-operational (SGF3/4 = 1). In such situations the transient measuring protection considers the operational stages and blocks its own operation, provided the I_0 stage fulfills the conditions for operating. However, the protection does not take into account the blockings of the I_0> and I_0>> stages.

The switches SGF3/4 and SGF3/5 can be used to control the operation speed of the transient measuring protection. A configuration where SGF3/5 = 1 and SGF3/4 = 0 gives the shortest (practical) operate time. Depending on the operate time selected, a start signal is activated after the time required for defining the transient; typical start time is t_{tr} - 200 ms, when the operate time of the transient measuring protection exceeds 1 s.

When selecting the operate time t_{tr} for the transient measuring protection it should be noticed that operate times in the range between t_{tr} - 1 s and t_{tr} should be avoided for the stages I_0> and I_0>>.

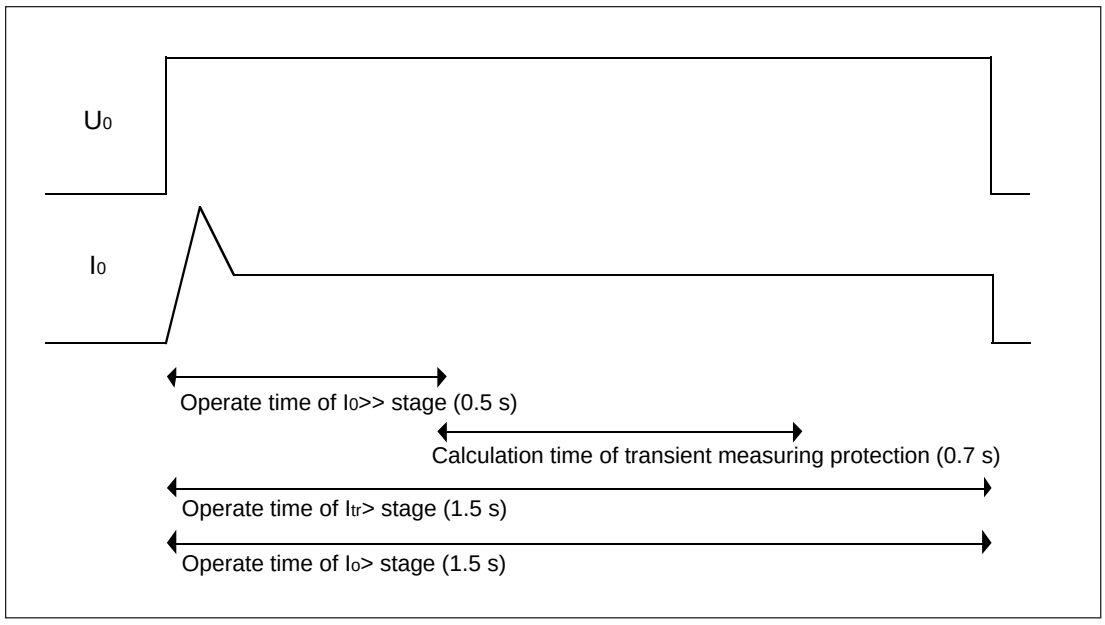

Fig. 7. Setting of operate times for stage I_{tr}> and stages I_0> and I_0>>.

The start signal of the transient measuring protection can be wired to block the residual voltage relay of the substation.

(modified 96-11)

Blocking of the transient measuring protection

When SGF1/1 = 1, the transient measuring protection is blocked. This blocking feature can be used for testing the operation of the other earth-fault stages. The blockings of the intermittent earth-fault protection do not interfere with the operation of the transient measuring protection.

Blocking of the operation of the $I_{tr}>$ stage using external blocking signals, by setting one of the switches SGB1...3/3 into position 1, has an effect both on the transient measuring protection and the intermittent earth-fault protection. Activated transient measuring protection or intermittent earth-fault protection cannot be reset (blocked) via blocking signals, but the protection resets when the residual voltage falls below the setting value.

Intermittent earth-fault protection

The operate time of the protection depends on the interval between the fault current pulses. Typically, the start signal is activated when about 40% of the operate time is left.

Blocking of the protection

As with the transient measuring earth-fault protection, when SGF3/3=1, starting of stage $I_0>$ or stage $I_0>>$ inhibits the operation of the intermittent earth-fault protection, irrespective of the settings.

The operation of the intermittent earth-fault protection is independent of the transient measuring protection. It can be disconnected by setting the switch SGF3/6 in position 1. The intermittent earth-fault protection is also non-operational, when "φ_b = -90°" or a sinφ operation characteristic has been selected for the directional earth-fault protection, because intermittent earth-faults do not occur in isolated neutral networks. Blocking of the transient measuring protection (SGF1/1=1) does not affect the operation of the intermittent earth-fault protection.

Stage $I_0>>$ of the module can be used together with the normal U_0 protection of the substation to obtain additional residual voltage protection. This function is obtained with the switch settings SGF1/2 = 0 and SGF1/3 = 1. Then the operation of the residual voltage protection of the separate feeders can be graded by giving each feeder its own operate time based on the anticipated failure rate and the requirements. The $I_0>$ stage can be used as a fast directional earth-fault protection stage in parallel with the transient measuring protection and the intermittent earth-fault protection.

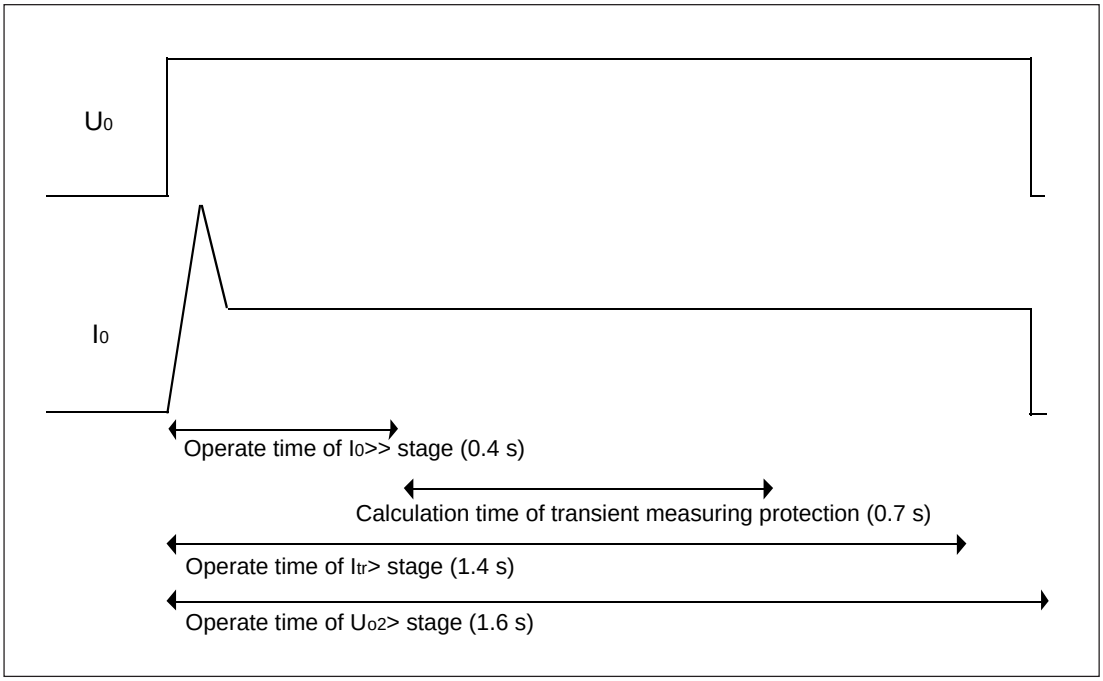

Fig. 8. Setting of operate times for stage $I_{tr}>$ and the earth-fault stages $I_0>$ and $I_0>>$, when the neutral current stage, the residual voltage stage, the transient measuring protection and the intermittent earth-fault protection are in use.

Auto-reclose relay module SPCT 5D54

The auto-reclose relay module SPCT 5D54 enables different types of auto-reclosing. An auto-reclose sequence is initiated either by a start signal or by a trip signal.

In this example two auto-reclosures initiated by the start of the protection are carried out. The auto-reclosures are subject to a preset start delay time starting from the start of the protection relay module. The first auto-reclosure is delayed only slightly to avoid unwanted auto-reclosures. Shot 1 is a high-speed auto-reclosure (short dead time) mainly used for extinguishing the arc at the fault place. Before the second AR shot is initiated, a longer start delay time is used to attempt to burn the fault. The dead time of shot 2 is long, a so called slow-speed auto-reclosure that typically lasts minutes. Should the fault still persist when shot 2 has been performed, final CB tripping (6) will follow and a DEF.TRIP alarm signal is received (red indicator + contact alarms).

The operate time of the protection relay module is longer than the start times of the auto-reclose module and the final trip time. Thus the relay module operates as a back-up for the auto-reclose module, if the tripping carried out by the auto-reclose module fails.

An auto-reclose sequence can also be initiated by the trip signal of a protection relay module, see example 3.

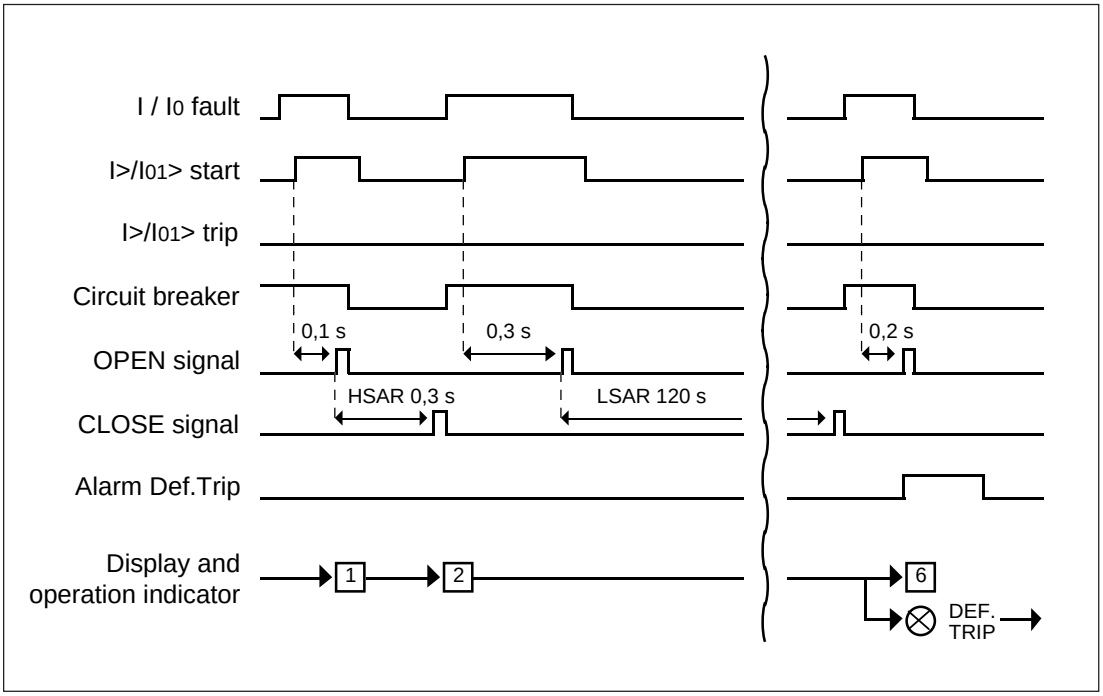

Fig. 9. Auto-reclose sequence when AR initiated by the start signal.

Information about the status of the arc-suppression coil circuit breaker can be wired to the relay as contact data and then, for instance, switching to the second settings is possible when the status changes.

The freely programmable output relay matrix of the relay modules of the SPAA 345 C feeder protection relay enables separate contact alarms for overcurrent and earth fault.

The CBCS output contact can be used for implementing two-pole CB closing. Should two-pole CB opening be required as well, the trip contacts TS2 and TS3 can be used for this purpose. Single-pole circuit breaker control is used in the example.

When operating, the circuit-breaker failure protection (CBFP) trips the circuit breaker of the infeeder. The operation of the circuit-breaker failure protection is described in the section "Circuit breaker failure protection".

In the case described in example 1 the switches of feeder protection relay SPAA 345 C can be configured as follows:

Configuration of SPCJ 4D28

Switch-group	Serial comm. parameter	Check-sum	Operation
SGF1	S53	000	Definite time operation
SGF2	S54	000	All stages operate, 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	004	Auto-reclosure (AR1) initiated by the I>> start signal
SGF7	S59	001	Auto-reclosure (AR2) initiated by the I> start signal
SGF8	S60	000	No auto-reclosures from the I_0 stages
SGB1	S61	000	No blocking/control by the BS1 signal
SGB2	S62	000	No blocking/control by the BS2 signal
SGB3	S63	032	Operation indicators reset by CB closing
SGR1	S64	000	I> start not linked to the output contacts
SGR2	S65	008	I> trip linked to trip contact TS2
SGR3	S66	000	I>> start not linked to the output contacts
SGR4	S67	008	I>> trip linked to trip contact TS2
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	008	I_0> trip linked to trip contact TS2
SGR9	S72	000	I_0>> start not linked to output contacts
SGR10	S73	008	I_0>> trip linked to trip contact TS2
SGR11	S74	008	ΔI>trip linked to output contacts TS2

Configuration of SPCS 2D32

Switch-group	Serial comm. parameter	Check-sum	Operation
SGF1	S50	002	Transient measuring protection operational Stage I_0>> operates in forward direction.
SGF2	S51	020	Basic angle φ_b = 0°, AR3 initiated by the start of I_0> and I_0>>
SGF3	S52	016	Speed-up of transient measuring earth-fault protection
SGB1	S53	000	No blocking/control by the BS1 signal
SGB2	S54	000	No blocking/control by the BS2 signal
SGB3	S55	016	Operation indicators reset by CB closing
SGR1	S56	000	I_0> start not linked to output contacts
SGR2	S57	008	I_0> trip linked to trip contacts TS2
SGR3	S58	000	I_0>> start not linked to output contacts
SGR4	S59	008	I_0>> trip linked to trip contact TS2
SGR5	S60	000	I_{tr}> start not linked to output contacts
SGR6	S61	008	I_{tr}> trip linked to trip contact TS2

Configuration of SPCT 5D54

Setting	Serial comm. parameter	Value	Operation
Shot 1	1S2, 1S3, 1S4	1, 1, 1	AR1 - AR3 initiates shot 1
	1S6, 1S7, 1S8	0,1 s	Start delay times of shot 1
	1S1	0,3 s	Dead time shot 1
Shot 2	2S2, 2S3, 2S4	1, 1, 1	AR1 - AR3 initiates shot 2
	2S6, 2S7, 2S8	0,3 s	Start delay times of shot 2
	2S1	120 s	Dead time shot 2
Final trip	6S2, 6S3, 6S4	1, 1, 1	Final trip initiated by AR1 - AR3
	6S6, 6S7, 6S8	0,2 s	Operates time of final trip

Switch-group	Serial comm. parameter	Check-sum	Operation
SGF1	S2	007	Shot1 & 2 initiated by the start of the protection
SGF2	S3	000	No synchrocheck function, maintenance monitor alarming
SGF3	S4	039	DEF.TRIP indicator is lit, when DEF.TRIP AR1, AR2&AR3 or CBFAIL are activated
SGB1	S7	000	No blockings in use
SGB2	S8	000	No blockings in use
SGB3	S9	000	No blockings in use
SGR1	S10	000	Signal "AR1 in progress" not linked to output contact
SGR2	S11	000	Signal "AR2 in progress" not linked to output contact
SGR3	S12	000	Signal "AR3 in progress" not linked to output contact
SGR4	S13	000	Signal "AR4 in progress" not linked to output contact
SGR5	S14	000	Signal "AR5 in progress" not linked to output contact
SGR6	S15	016	Def trip AR1 linked to SS3
SGR7	S16	016	Def trip AR2 linked to SS3
SGR8	S17	064	Def trip AR3 linked to SS4
SGR9	S18	000	Def trip AR4 not linked to output contact
SGR10	S19	008	CB opening linked to TS2
SGR11	S20	004	CBFAIL linked to SS2

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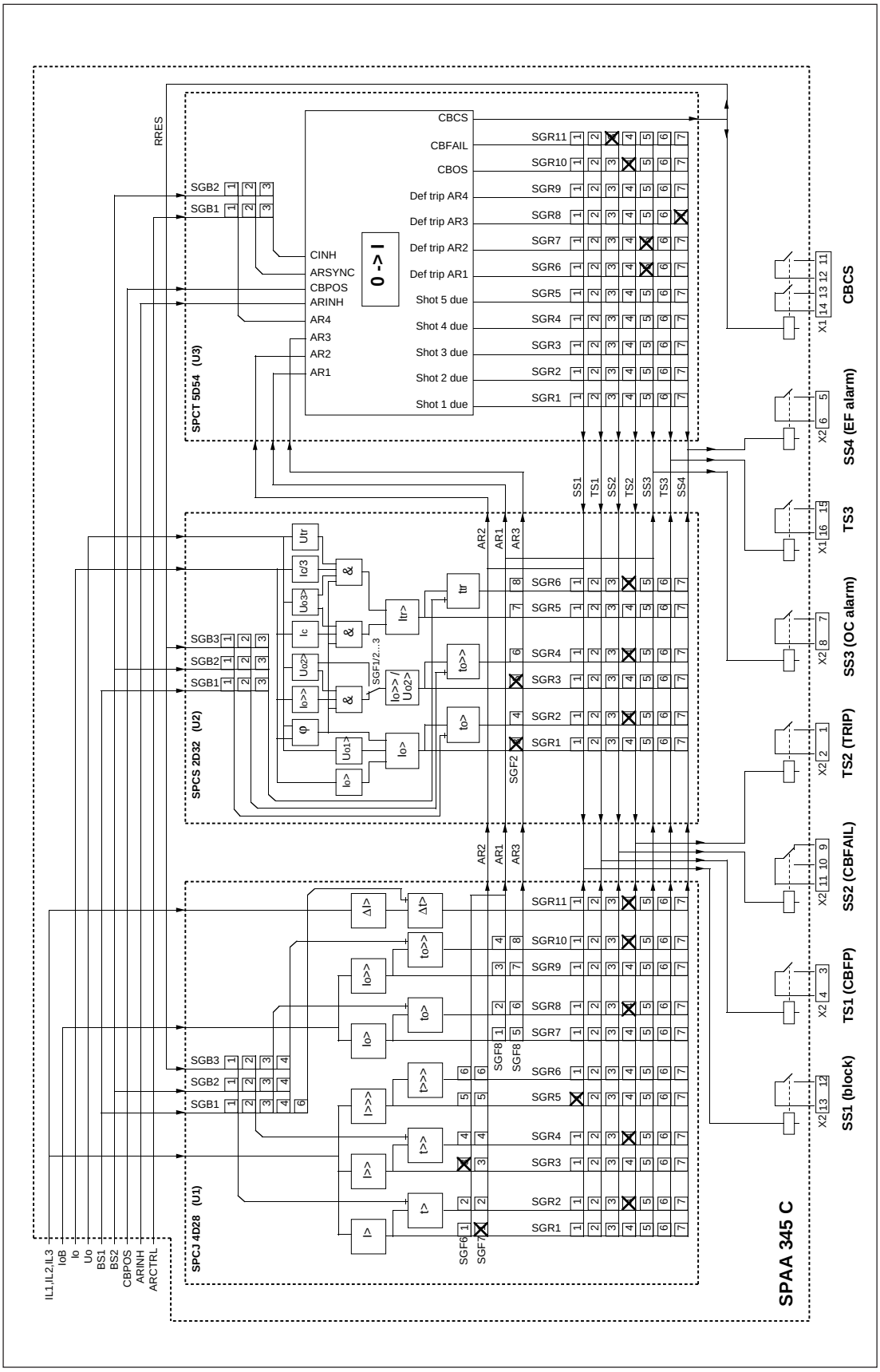


Fig. 10. Configuration of internal signals in the application example 1 of feeder protection relay SPAA 345 C.

Note !
The above configuration are not factory default settings.

Example 2.
Overcurrent and earth-fault protection of an outgoing feeder in an isolated neutral network.

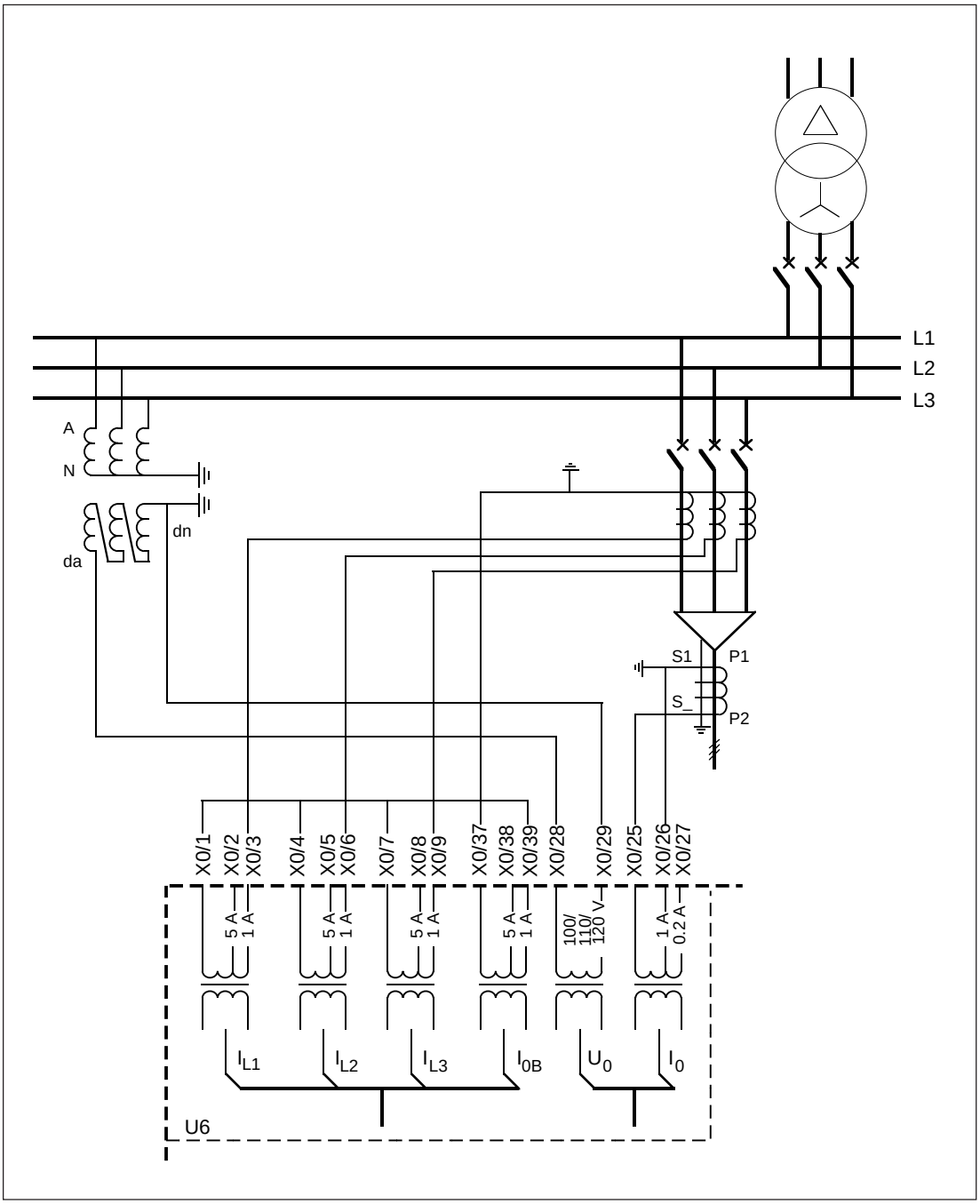


Fig. 11. Feeder protection relay SPAA 345 C for the protection of an outgoing feeder in an isolated neutral network

The protection of the outgoing feeder in the isolated neutral network illustrated in Fig. 11 is basically implemented in the same way as in the resonant earthed network described in example 1.

The operation characteristic to be selected for the directional earth-fault protection in an isolated neutral network is a characteristic corresponding to the basic angle φ_b = -90° or a sinφ characteristic. The operation sensitivity is the same for the two operation characteristics, because the phase angle between I_0 and U_0 is very close to -90°. The transient measuring protection is set in the same way as in example 1. The intermittent earth-fault protection is non-operational, as intermittent earth faults do not appear in isolated neutral networks. The rated current of the energizing input is 1 A.

The same arrangement of blocking between the protection levels as in example 1 can be used.

Example 3.
Overcurrent and earth-fault protection of a feeder in a low-resistance earthed network.

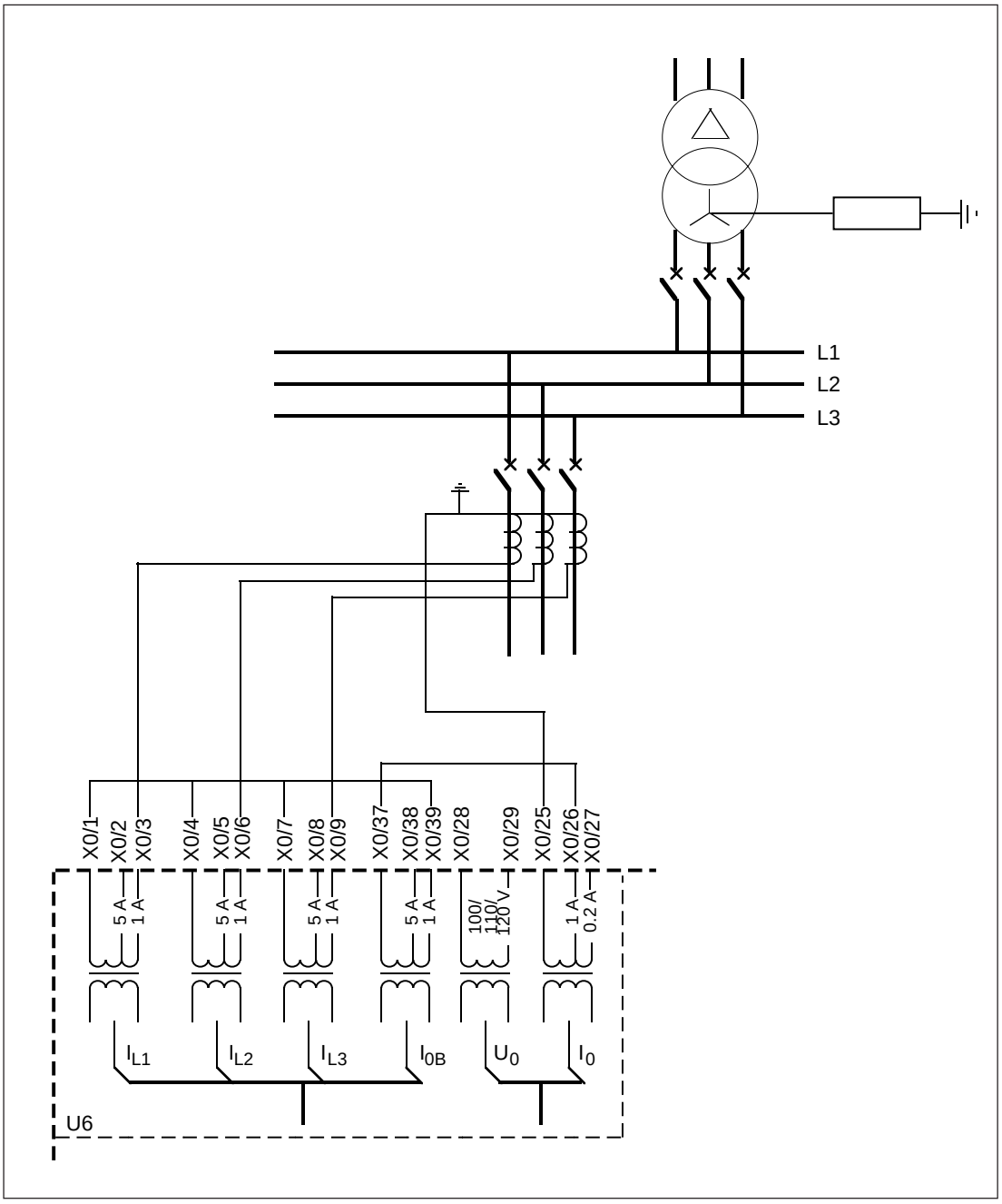


Fig. 12. Feeder protection relay SPAA 345 C used for the protection of a feeder in a network earthed through a resistor.

Both overcurrent protection and earth-fault protection are based on inverse time operation in the example. This means that the operate time is inversely proportional to the current.

The earth-fault protection has three protection stages: an inverse time stage and a definite time stage provided by the module SPCJ 4D28 and a sensitive earth-fault stage provided by the module SPCS 2D32.

A long operate time is selected (10...15 s) which means that the virtual neutral current occuring at a short circuit does not cause unwanted operations. The sensitive neutral current stage is not used for initiating auto-reclosing.

The high-set stage of the earth-fault relay module SPCS 2D32 can be used for non-directional operation, but in situations with high capacitive earth-fault currents the use of directional earth-fault protection should be considered (I_0>> stage directional as well). The transient measuring protection is set in the same way as in example 1. The intermittent earth-fault protection is non-operational.

The same blocking arrangement as in example 1 can be used between the different protection levels .

In example 3 auto-reclosing is initiated by the trip signal of the protection relay module. When the set dead time elapses, the auto-reclose module closes the circuit breaker and, simultaneously, a discriminating time (td) is started. Normally, this discriminating time is shorter than the operate time of the protection relay module, and so the sequence is allowed to continue with the second shot, the third shot, and so on, until selected sequence has been completed or the fault has disappeared. Should the fault become more serious during the sequence (the short circuit current or the earth fault current increases), the operate time of the protection relay module shortens. When the operate time is shorter than the discriminating time td, the auto-reclose sequence will not continue, but the circuit breaker remains open after the trip signal has been received from the protection relay module, and a DEF.TRIP alarm will be received from the auto-reclose module.

If the auto-reclose sequence is initiated by tripping of the I_{tr}> stage, it should be noticed when setting the discrimination time that the transient measuring protection does not detect faults occurring at intervals shorter than 10 seconds. This time delay will be activated every time when the transient measuring earth-fault protection will be triggered by some kind of transient pulse occuring in the network.

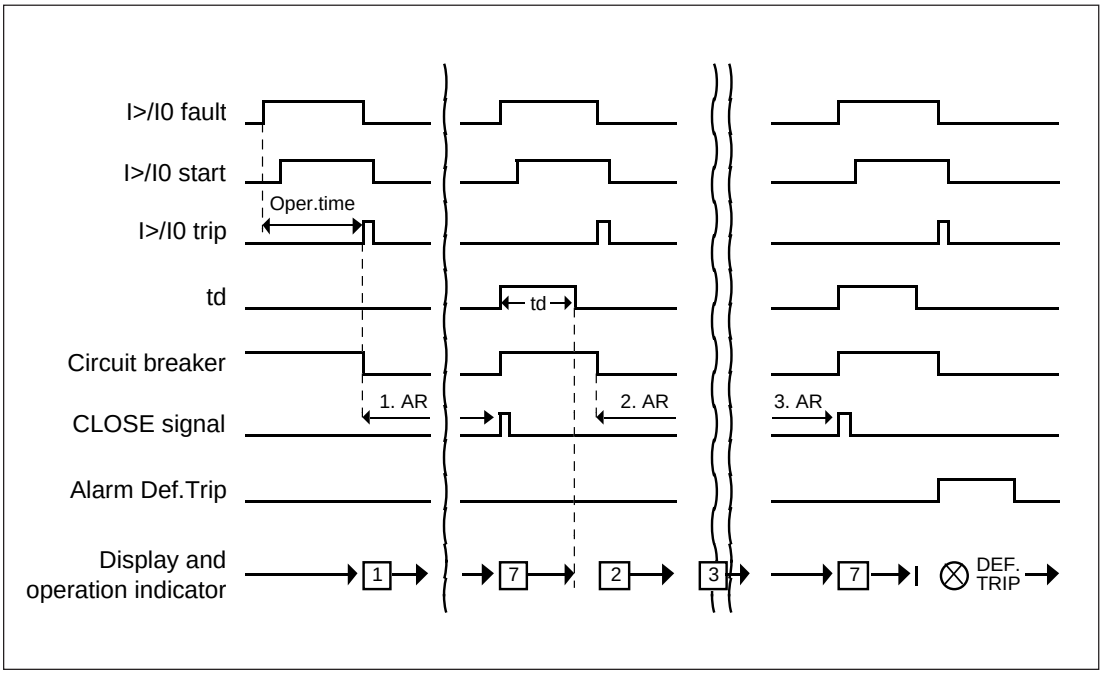


Fig. 13. An auto-reclose sequence, when auto-reclosing is initiated by a trip signal.

Testing

The relay should be subject 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 more 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 is used for the collection of information for longer time periods (for example, AR counters), these registers should be read before the test procedure 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 gradually 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.

If the resetting value is to be tested as well, start by raising the current until the relay starts and then reduce the current until the relay resets.

When multi-stage protection relays are tested, the operating of the low-set stages may be a problem when the high-set stages are tested. Then it is often necessary to block 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 ones. 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 smaller than 2 times the setting value. In such a case the protective algorithm adds about 20 ms to the operate times.

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

Testing of transient measuring directional earth-fault relay module SPCS 2D32

General

Since complex test arrangements are required for testing the transient measuring earth-fault stage and the intermittent earth-fault stage, testing of the stages I_0> and I_0>> will be enough.

Testing of the protection stages I_0> and I_0>> includes:
- start value(s)
- start time
- trip time
- trip indication, output relay operation and signalling

Start value

Measure the start values for both residual voltage and neutral current. To measure the start value of the neutral current, set the residual voltage above the setting value and raise the neutral current until the relay starts. Record the value. Then set the neutral current above the setting value and raise the residual voltage, starting from zero, until the relay starts.

The operation of the I_0> stage is always directional, whereas the operation of the I_0>>/U_{02}> stage can be directional or non-directional. If directional operation has been selected for the stage, the phase angle between the current and voltage has to be equal to the basic angle selected for the relay, to enable relay operation. The directional operation can be tested by setting the current and voltage above their setting values and changing the phase angle until the relay starts and resets.

To measure the resetting values, start by raising the current and voltage applied to the relay above their setting values. Then decrease the current, voltage or phase angle until the relay resets.

Start and trip times

Switch a voltage and/or a current about 2...2.5 times the setting value of the protection stage to the relay. Measure the operate time, i.e. the time from closing the switch until the relay operates. The operate times 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. The resetting time is the time from the opening of the current switch until the relay resets.

Testing of auto-reclose relay module SPCT 5D54

General

Testing of the auto-reclose relay module includes:
- initiation of auto-reclosing
- output relay operation
- timers
- alarm indication

Testing of auto-reclose sequence

The operation of the auto-reclose module is recommended to be tested together with the overcurrent and earth-fault relay modules. Always when an overcurrent stage or an earth-fault stage has been tested, the operation of the same stage should be tested together with the auto-reclose module. The most convenient way is to use a circuit breaker for the testing and then connect the current to be applied to the relay over the contact of the circuit breaker. The test can also be carried out without using a circuit breaker. Then the required configuration is made in the auto-reclose relay module (SGF2/7=1).

Start the test by closing the circuit breaker and wait for the possible reclaim time to elapse. Connect the energizing current/voltage and allow the relay to complete the AR sequence. Depending on the configuration the sequence may include one or several AR shots and it ends in definite tripping performed by a protection relay module or the auto-reclose module (final trip function).

During the auto-reclose sequence no actions that could interrupt the sequence or cause an alarm signal are allowed. Definite tripping will produce an alarm signal (DEFTRIP), if this function has been selected.

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

Combined overcurrent and earth-fault relay module	SPCJ 4D28
Transient measuring directional earth-fault relay module	SPCS 2D32
Auto-reclose relay module	SPCT 5D54
Power supply modules	
- U = 80...265 V ac/dc (operative range)	SPGU 240A1
- U = 18...80 V dc (operative range)	SPGU 48B2
I/O module	SPTR 9B25
Case (including connection module)	SPTK 8B17
Bus connection module	SPA-ZC 17_ SPA-ZC 21_

Delivery alternatives

Type	Equipment	SPCJ 4D28	SPCS 2D32	SPCT 5D54
SPAA 345 C	Basic version, including all relay modules	x	x	x
SPAA 345 C1	Basic version excluding AR relay module	x	x	
SPAA 345 C2	Basic version excluding earth-fault relay module	x		x
SPAA 345 C3	Basic version excluding earth-fault relay module and AR relay module	x		
SPAA 345 C4	Basic version excluding overcurrent relay module		x	x
SPAA 345 C5	Basic version excluding overcurrent relay module and AR relay module		x	

Delivery alternatives of feeder protection relay SPAA 345 C

Order numbers

Feeder protection relay SPAA 345 C without test adapter: RS 614 090-AA, CA

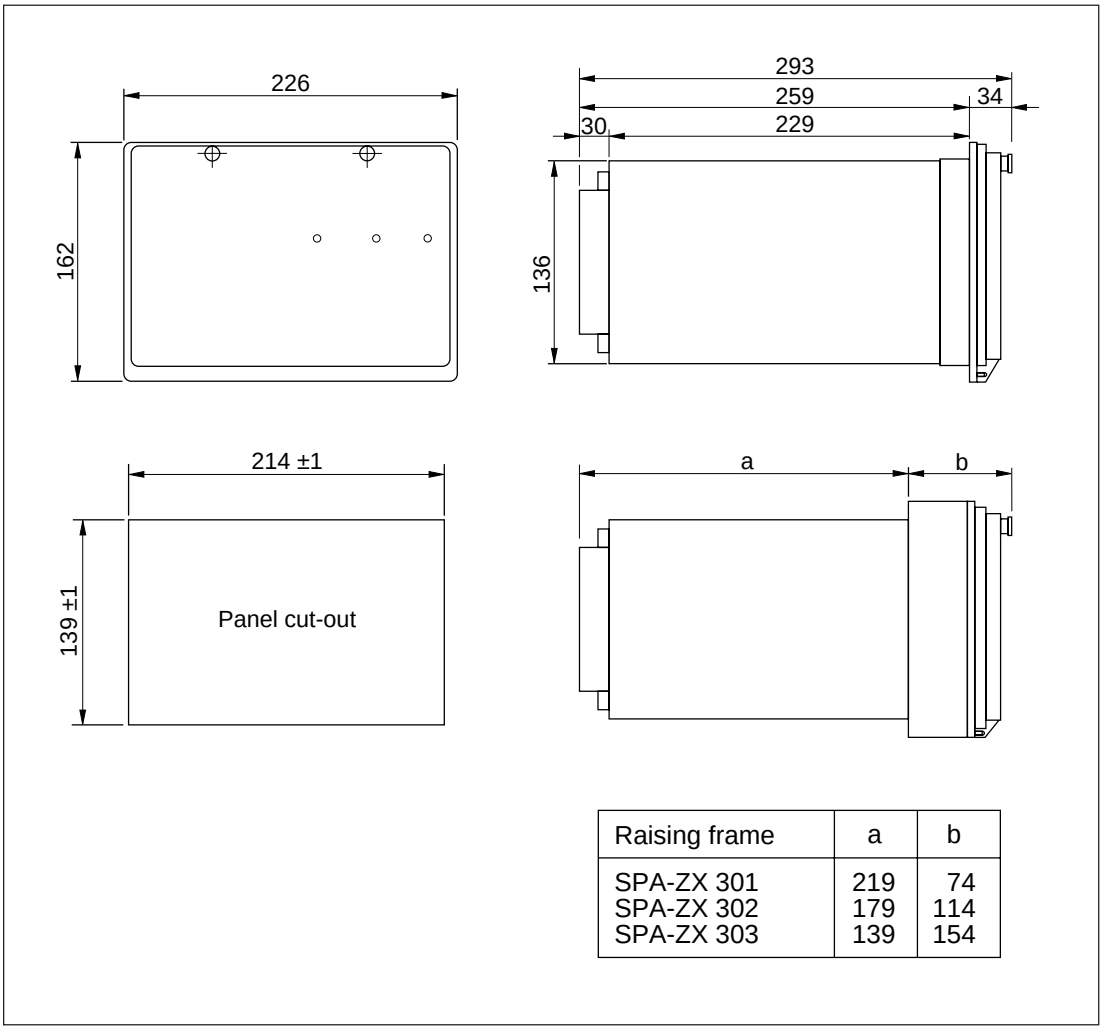
Feeder protection relay SPAA 345 C with test adapter RTXP 18: RS 614 290-AA, CA

The letter combinations of the order number denote the rated frequency f_n and auxiliary voltage U_{aux} of the protection relay:

AA: f_n = 50 Hz and U_{aux} = 80...265 V ac/dc
CA: f_n = 50 Hz and U_{aux} = 18...80 V dc

Dimension drawings and mounting

The basic model of the protection relay case is designed for flush-mounting. When required, the mounting depth of the case can be reduced by using raising frames: type SPA-ZX 301 reduces the depth by 40 mm, type SPA-ZX 302 by 80 mm and type SPA-ZX 303 by 120 mm. When projecting mounting is preferred a relay case type SPA-ZX 317 is used. The relay case for projecting mounting is provided with front connectors.



Raising frame	a	b
SPA-ZX 301	219	74
SPA-ZX 302	179	114
SPA-ZX 303	139	154

Fig. 14. Dimension and mounting drawings for feeder protection relay SPAA 345 C.

The relay case is made of profile aluminium and finished in beige.

The rubber gasket fitted to the mounting collar provides an IP 54 degree of protection by enclosure between the relay case and the mounting base.

The hinged cover of the case is made of transparent, UV-stabilized polycarbonate polymer and provided with two sealable locking screws. The rubber gasket of the cover provides an IP 54 degree of protection between the case and the cover.

The required input and output connections are made to the screw terminals on the rear panel. Terminal block X0 consists of screw terminals fitted to the rear panel of the relay. The terminal blocks X1 and X2 are provided with disconnectable multi-pole screw terminals. The male parts of the disconnectable terminal blocks are attached to the I/O module. The female parts are included in the delivery. The female part can be locked to the male part with fixing accessories and screws.

Measured data, auxiliary voltage and protective earth are wired to the terminal block X0. Each terminal screw is dimensioned for one wire of maximum 6 mm^2 or two wires of maximum 2.5 mm^2.

Binary input and output signals are connected to the multi-pole terminal blocks X1 and X2. Each screw terminal is dimensioned for one wire of maximum 1.5 mm^2 or two wires of maximum 0.75 mm^2.

The 9-pole D-type connector is intended for serial communication.

The bus connection modules (SPA-ZC 17, -21 and -22) and fibre-optic cables recommended by the manufacturer should always be used for the serial communication.

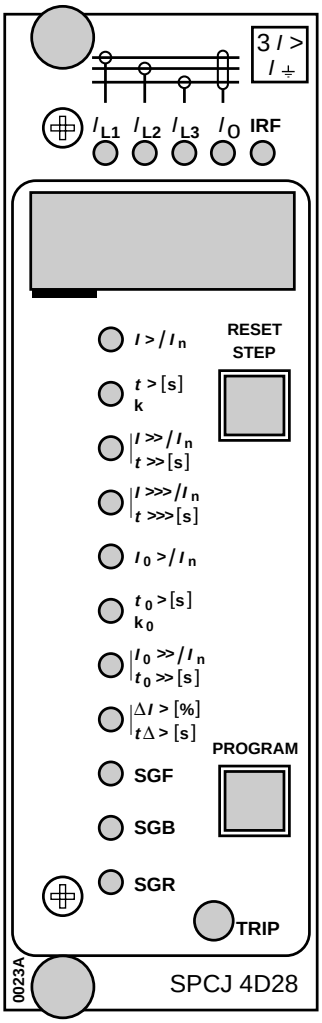
Ordering information

1. Number and type designation
2. Order number
3. Rated frequency
4. Auxiliary voltage
5. Accessories
6. Special requirements

Example
10 SPAA 345 C units
RS 614 090 -AA
f_n = 50 Hz
U_{aux} = 110 V dc
10 bus connection modules SPA-ZC 17 MM2A
–

SPCJ 4D28
Overcurrent and earth-fault relay module

User´s manual and Technical description



1MRS 750093-MUM EN

Issued 1995-05-04
Modified 2002-05-15
Version E (replaces 34 SPCJ 18 EN1)
Checked MK
Approved OL

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.

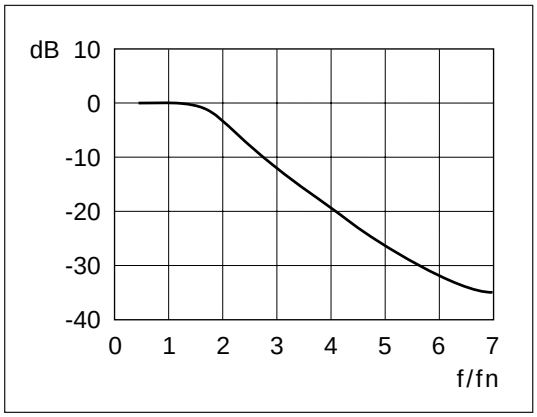


Fig. 1. Filter characteristics of the measuring inputs of the module SPCJ 4D28

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

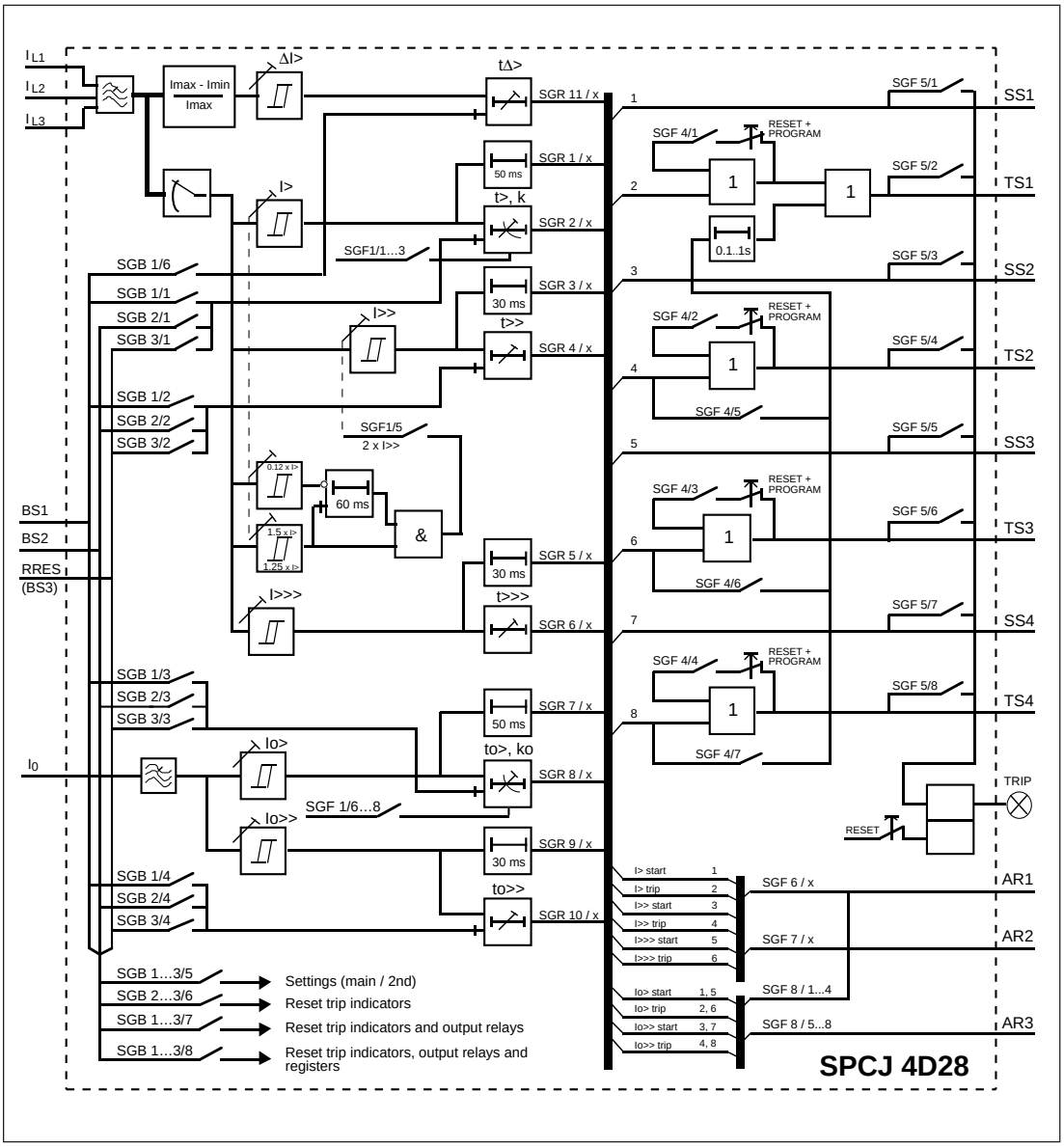
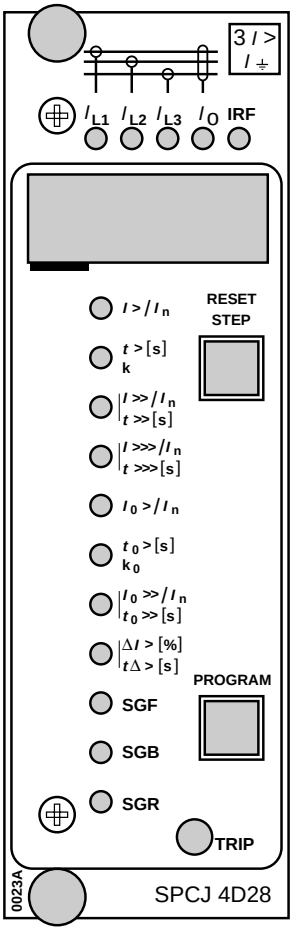


Fig. 2. Block diagram for overcurrent and earth-fault relay module SPCJ 4D28

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

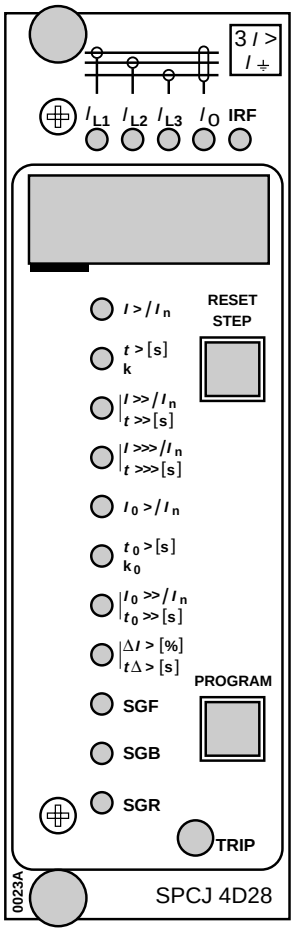
Indicator for the start current of stage I_0>> and the operate time t_0>>

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.

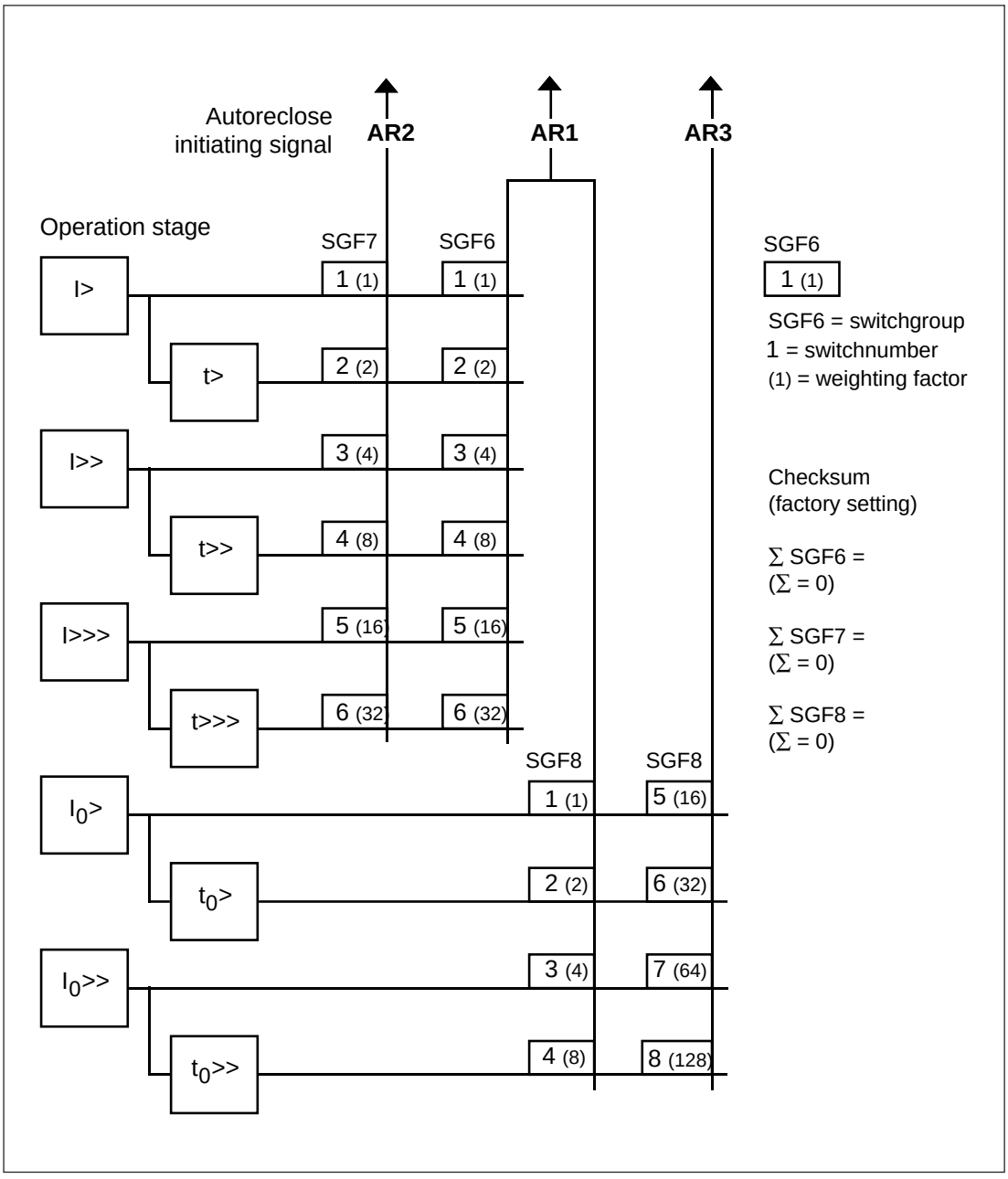


Fig. 4. Selection matrix for the autoreclose initiation signals

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.

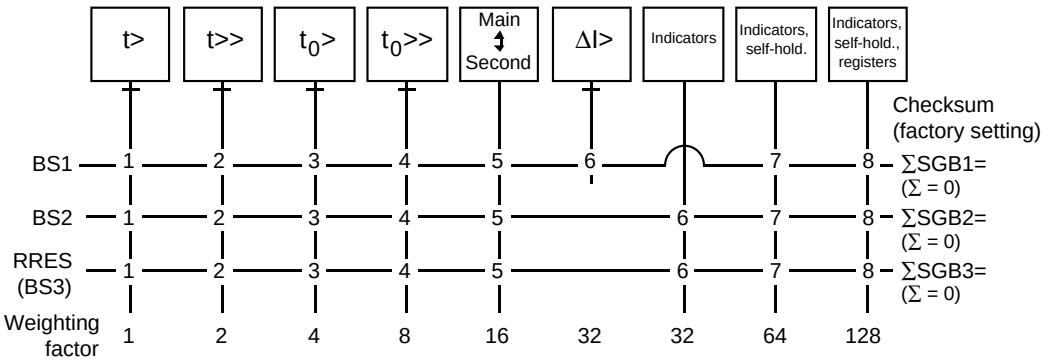


Fig. 5. Control signal matrix of the combined overcurrent and earth-fault relay module SPCJ 4D28.

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.

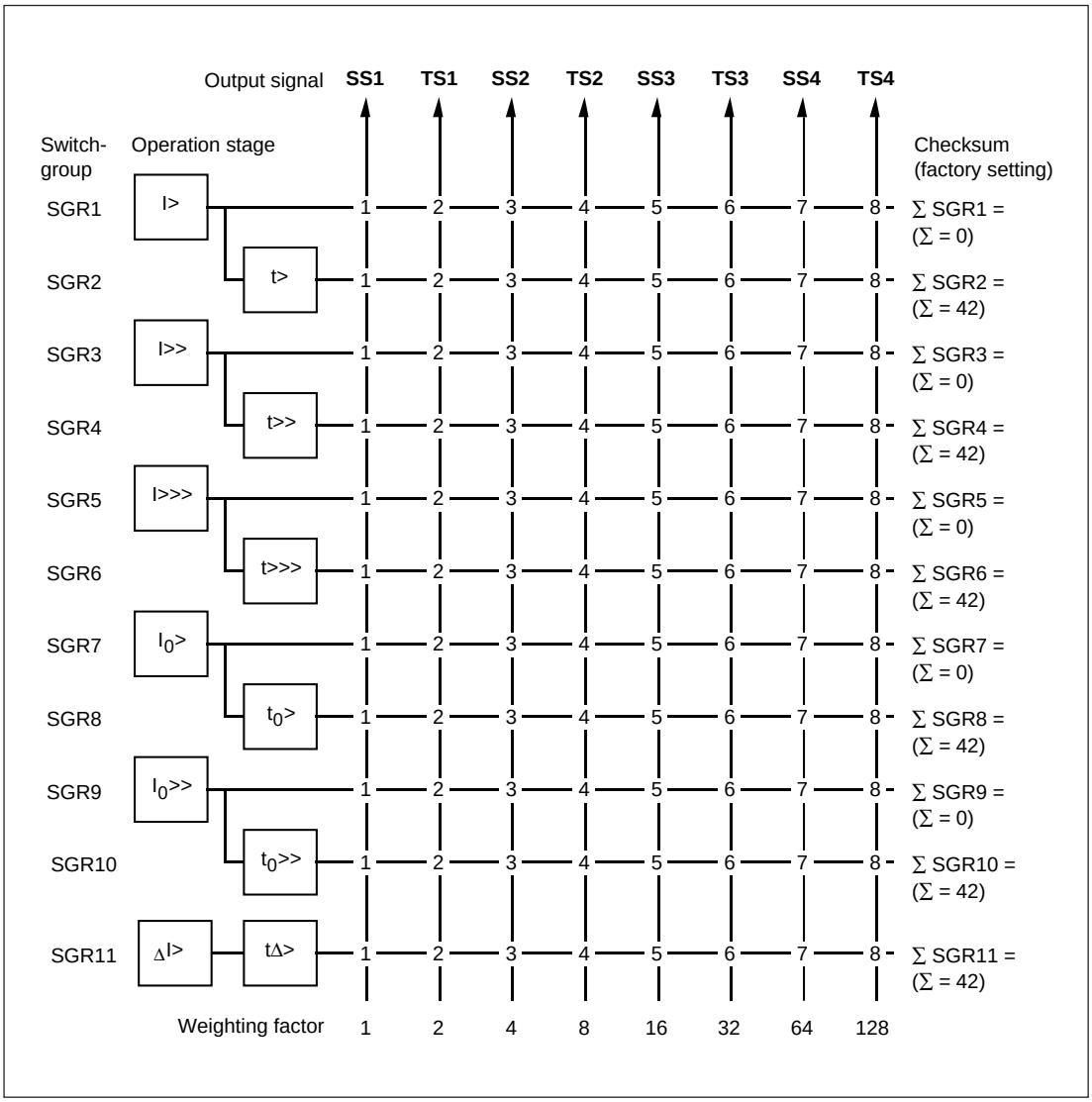


Fig. 6. Output signal matrix of the combined overcurrent and earth-fault relay module SPCJ 4D28.

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

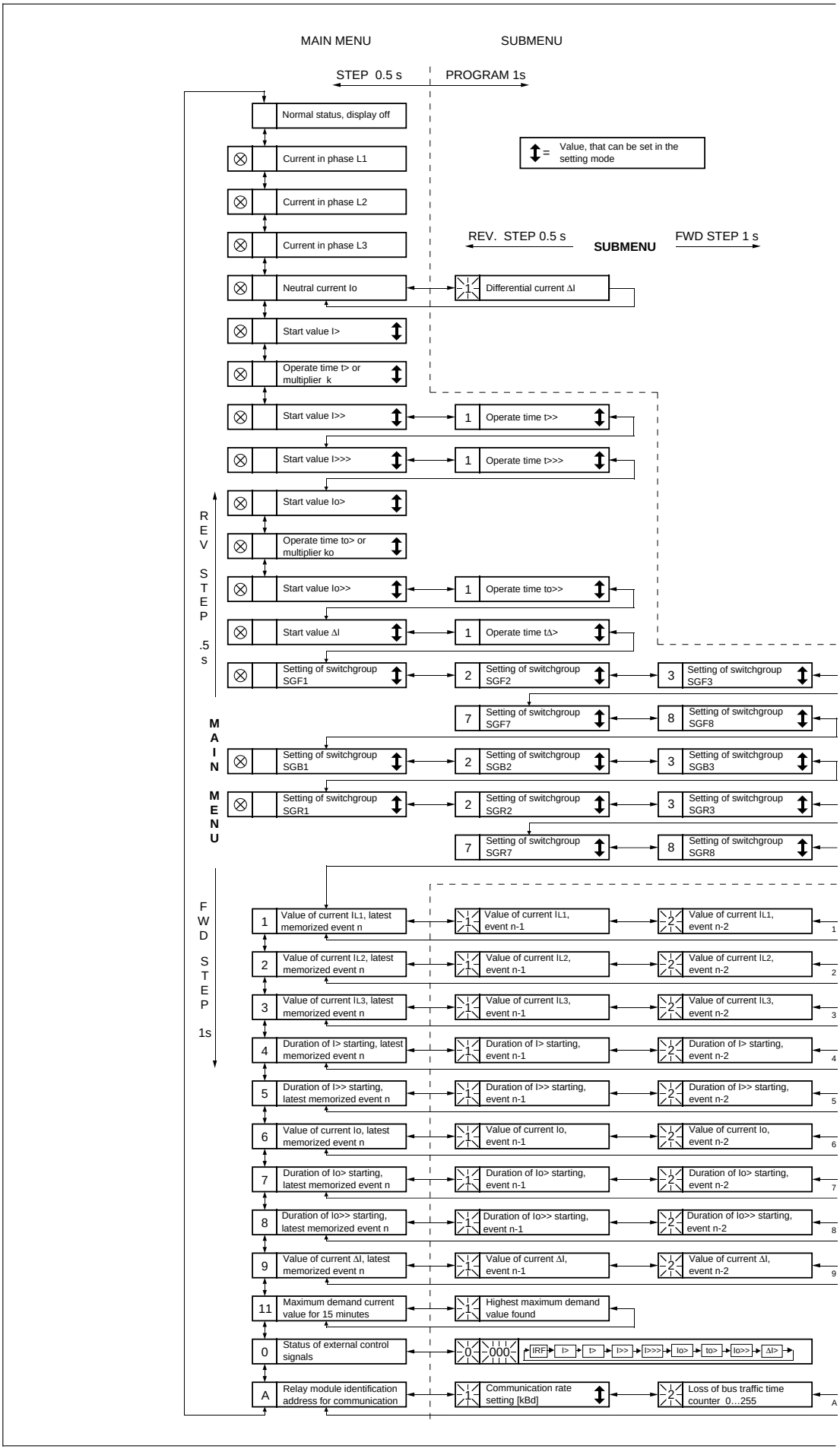
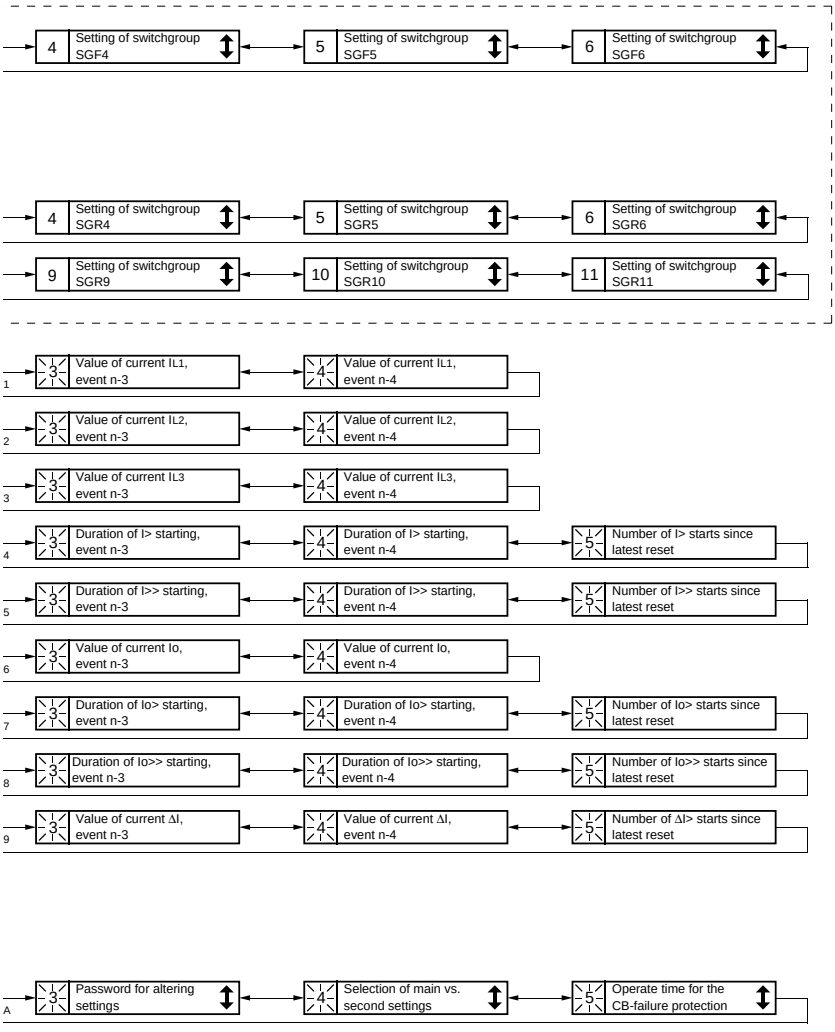


Fig. 7. Main and submenus of the combined overcurrent and earth-fault relay module SPCJ 4D28.

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.

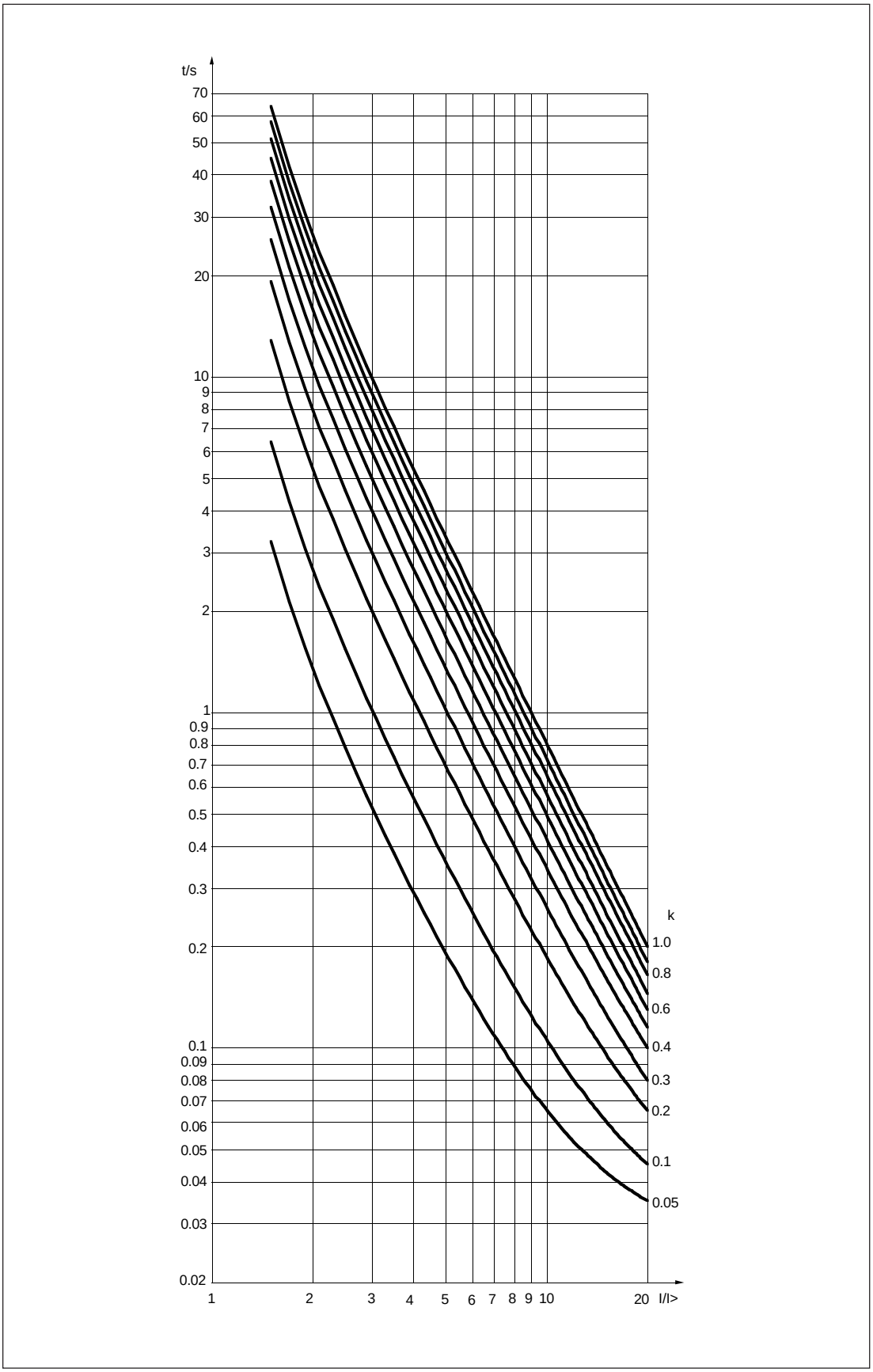


Fig. 8. Inverse-time characteristics of overcurrent and earth-fault relay module SPCJ 4D28

Extremely inverse

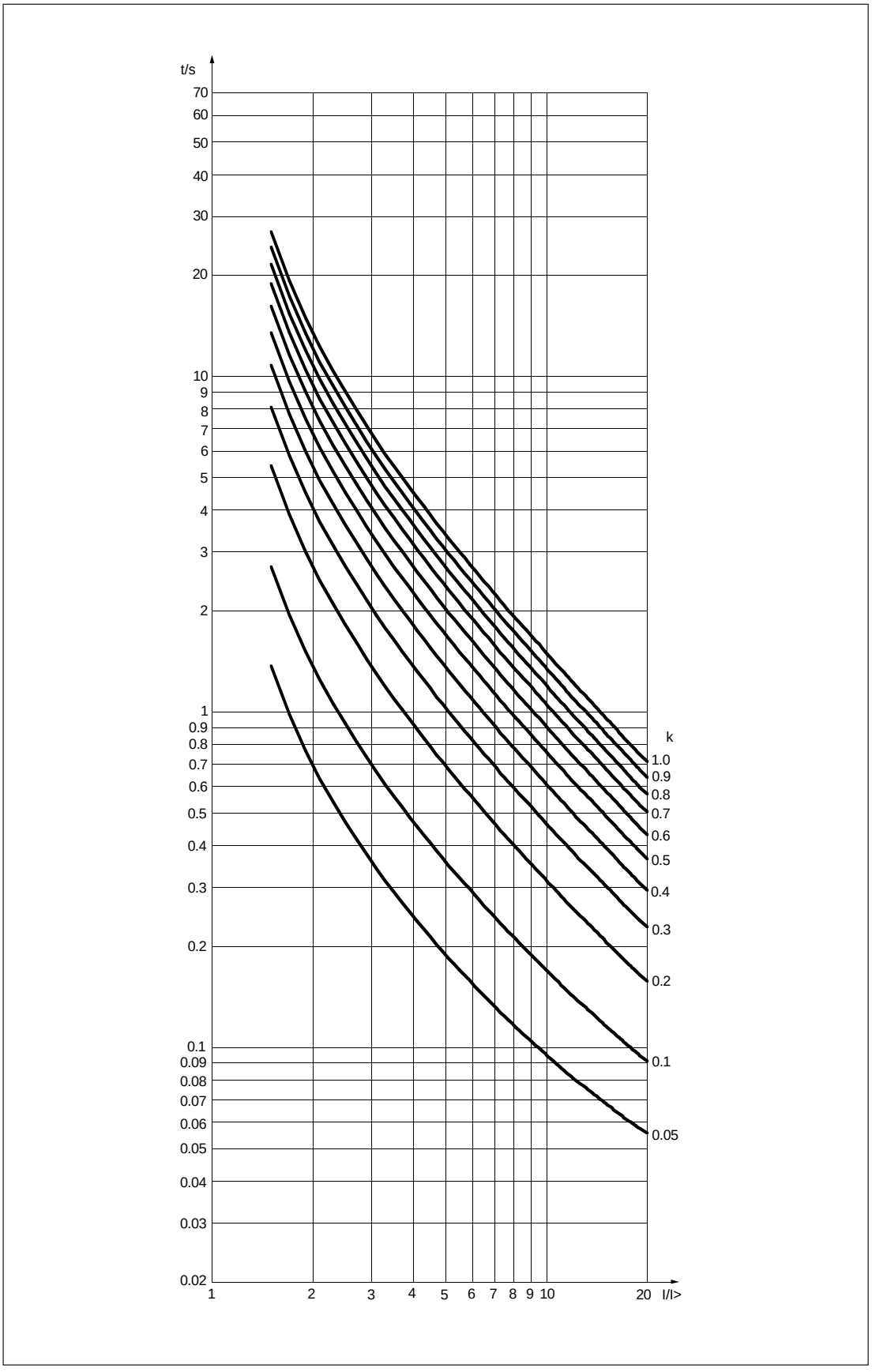


Fig. 9. Inverse-time characteristics of overcurrent and earth-fault relay module SPCJ 4D28

Very inverse

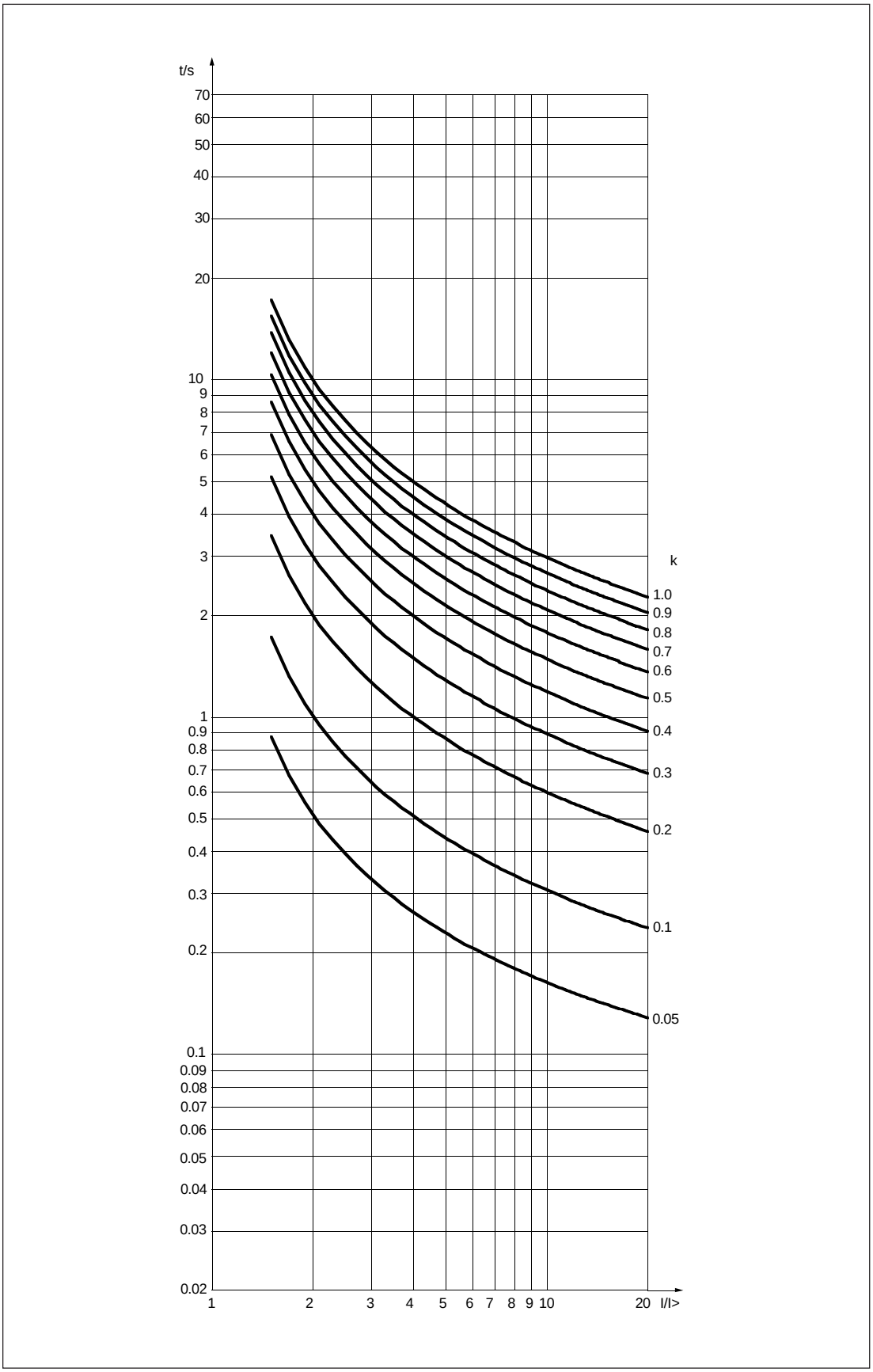


Fig. 10. Inverse-time characteristics of overcurrent and earth-fault relay module SPCJ 4D28

Normal inverse

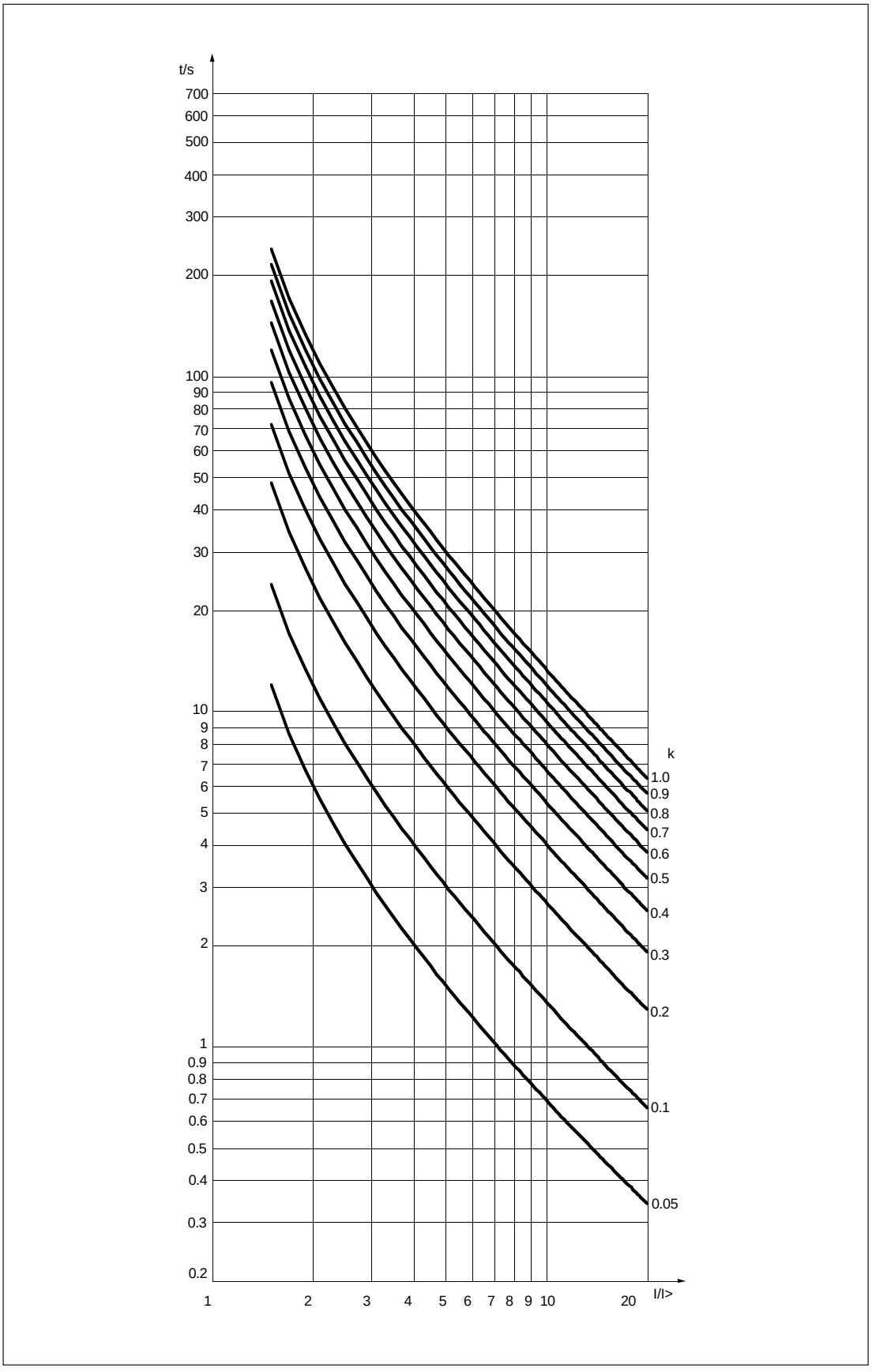


Fig. 11. Inverse-time characteristics of overcurrent and earth-fault relay module SPCJ 4D28

Long-time inverse

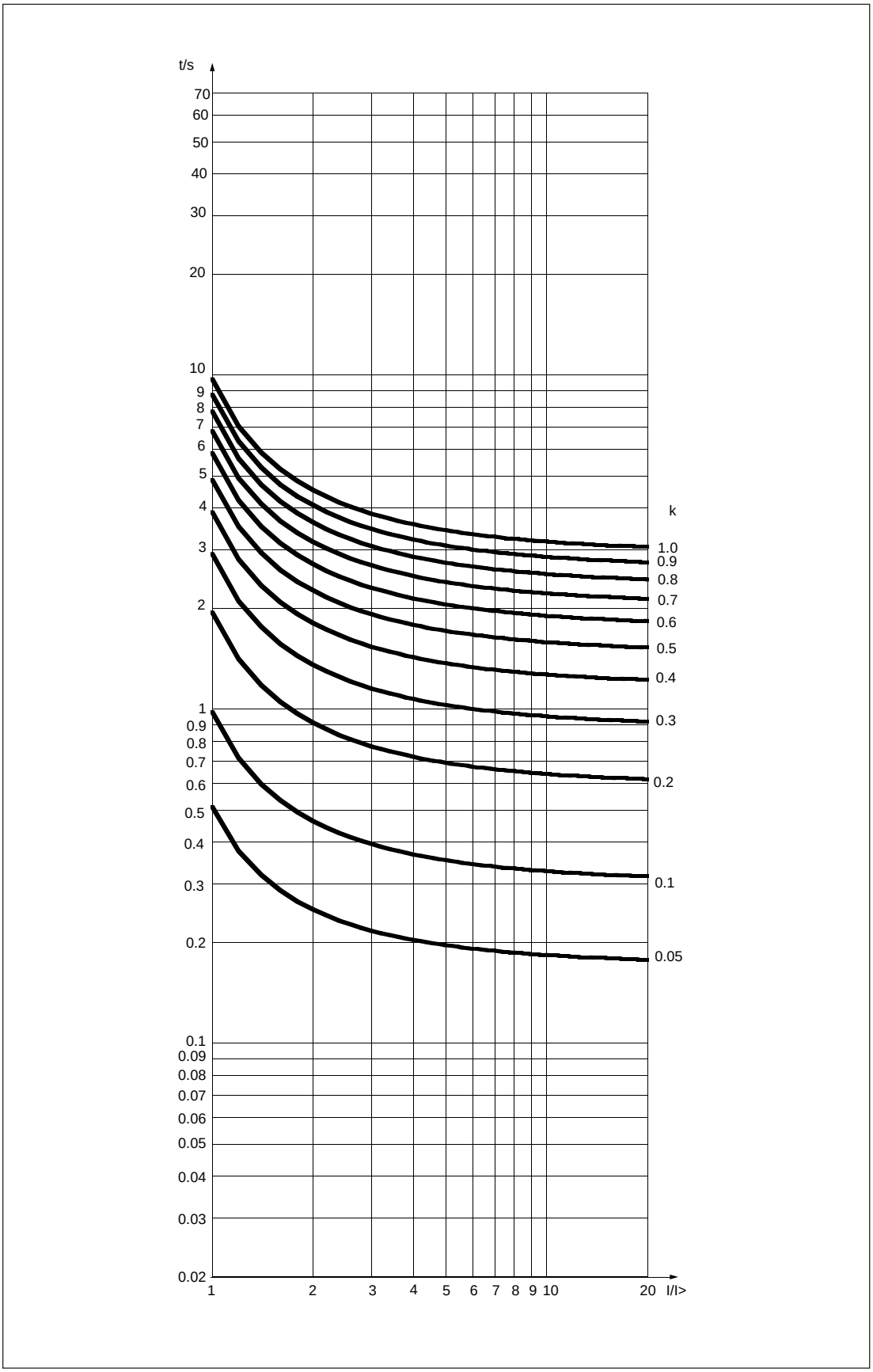


Fig. 12. Inverse-time characteristic of overcurrent and earth-fault relay module SPCJ 4D28

RI-type inverse

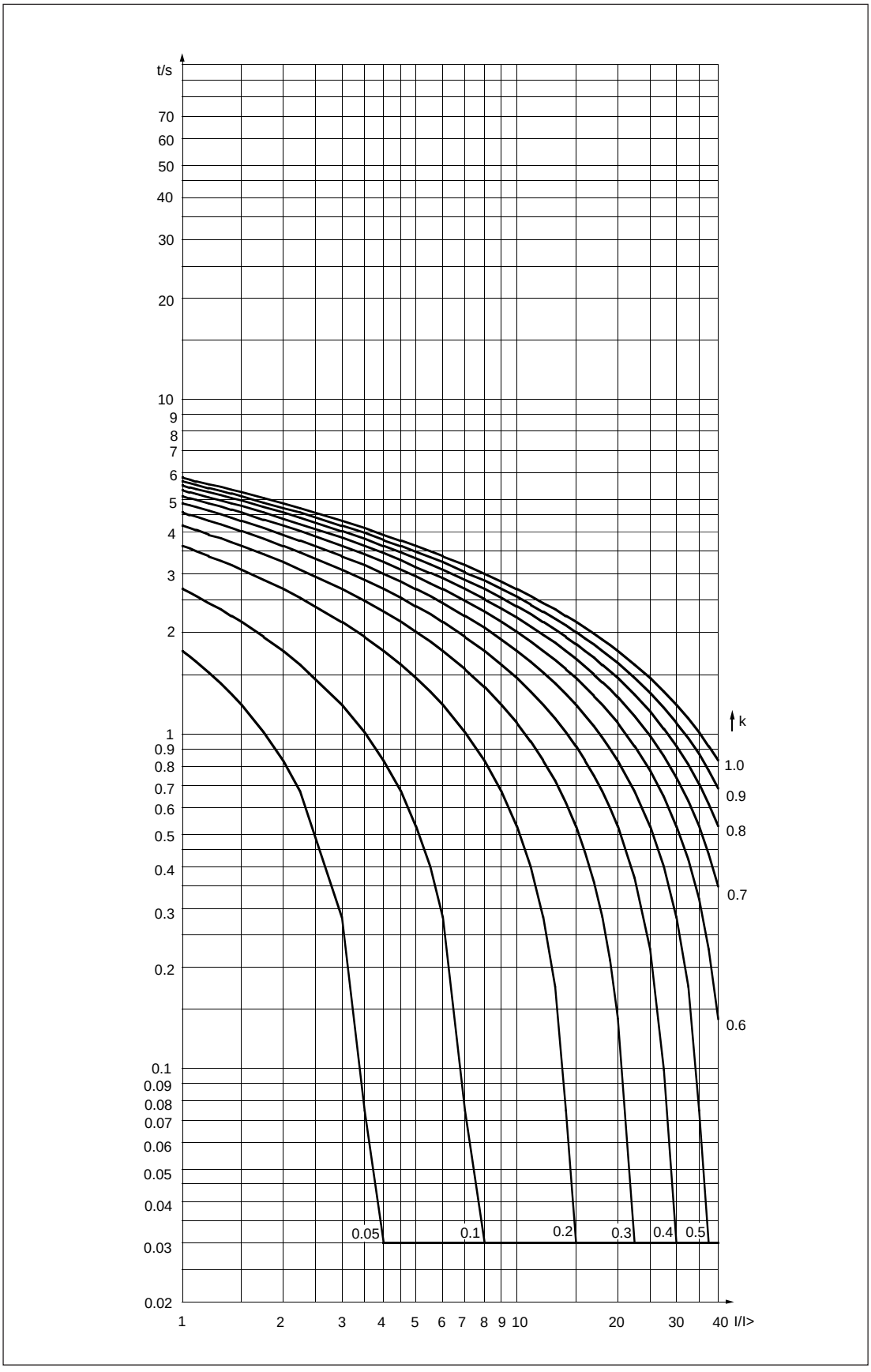


Fig. 13. Inverse-time characteristic of overcurrent and earth-fault relay module SPCJ 4D28

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

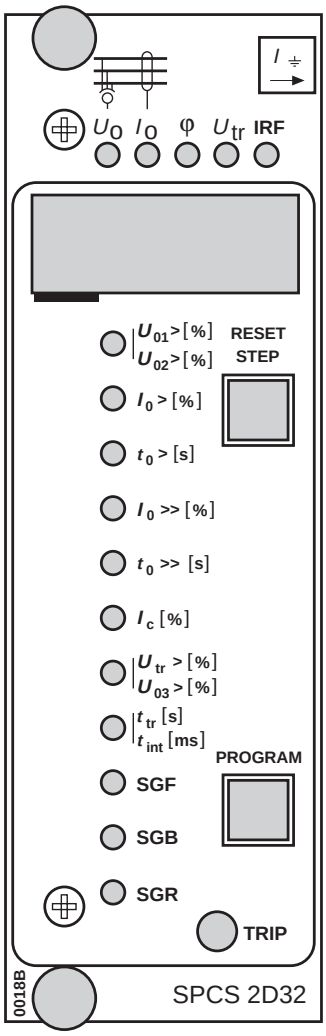
Once the self-supervision system has detected an internal relay fault, the IRF indicator on the front panel of the relay module is lit. At the same time the self-supervision alarm relay that is normally picked up, drops off. In most situations a fault code appears on the display of the relay module. 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

SPCS 2D32
Earth-fault relay module

User´s manual and Technical description



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SPCS 2D32
Earth-fault relay module

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Contents

Features

Transient measuring earth-fault protection.

Intermittent earth-fault protection.

$I_0\cos\varphi$ or $I_0\sin\varphi$ available for the directional earth-fault protection stages.

Directional low-set earth-fault protection stage with forward operation.

Directional or non-directional operation selectable for the high-set protection stage.

The high-set stage can be configured to operate as a residual voltage stage $U_{02}>$.

Forward or reverse operation selectable for the directional high-set earth-fault stage.

Output relay matrix allowing any start or operate signal to be linked with the desired output signal.

Programmable auto-reclose initiation signals.

Digital display of measured values, setting values and data recorded in a fault situation.

Setting values to be written and read using the local display and front panel push-buttons, via a PC with configuration software or from higher levels over the serial port and the fibre-optic serial bus.

Continuous self-supervision system including both hardware and software. When a permanent fault is detected, a control signal is delivered to the signal relay and the other outputs are blocked.

Description of operation

The transient measuring directional earth-fault relay module SPCS 2D32 continuously measures the residual voltage U_0 and neutral current I_0 of the feeder to be protected. In the event of a fault the relay module operates according to the protection scheme configured by the user.

An earth fault occurring in the network can be detected in three ways: by using the traditional method of determining the direction of the earth fault, by measuring the earth-fault transient or using a method for detecting an intermittent earth fault.

Directional earth-fault protection

The directional earth-fault protection includes two stages: a low-set stage $I_0>$ and a high-set stage $I_0>>$. The stages can be given different setting values.

The directional earth-fault protection measures neutral current I_0, residual voltage U_0 and the phase angle φ between these. The operation of the earth-fault protection can be based on two different fault criterions: the phase angle φ or the Iφ (= I_0sinφ or I_0cosφ):

- when the phase angle principle has been selected, the stage starts once the neutral current I_0 and residual voltage U_0 exceed their setting values and the phase angle φ is within the operation area.
- when the Iφ principle is employed, the fault criterions are based upon U_0 and Iφ.

The operation characteristics to be selected for the directional earth-fault protection are: cosφ, sinφ and the operation characteristics corresponding to the basic angles $\varphi_b = 0°$ or $\varphi_b = -90°$.

The direction of the $I_0>$ stage is always forward, whereas, the operation of the high-set stage $I_0>>$ is either forward or reverse. In addition, the $I_0>>$ stage can operate as a non-directional stage or it can be configured to operate as residual voltage protection, i.e. as a $U_{02}>$ stage (the I_0 criterion does not apply).

The low-set stage $I_0>$ can be set out of use (SGF3/4 = 1). In addition, the stages $I_0>$ and $I_0>>$ can be temporarily blocked (see the section describing the transient measuring earth-fault protection).

When starting, the protection stage issues a start signal and at the same time a start indicating code appears on the display. Should the stage still be started when the set operate time expires, then a trip signal is activated.

Operation characteristics

Compensated network

The basic angle $\varphi_b = 0°$ (or cosφ operation characteristic) is normally used in a compensated network.

Fig. 1a illustrates the operation characteristic corresponding to the basic angle $\varphi_b = 0°$ and Fig. 1 b illustrates the cosφ characteristic.

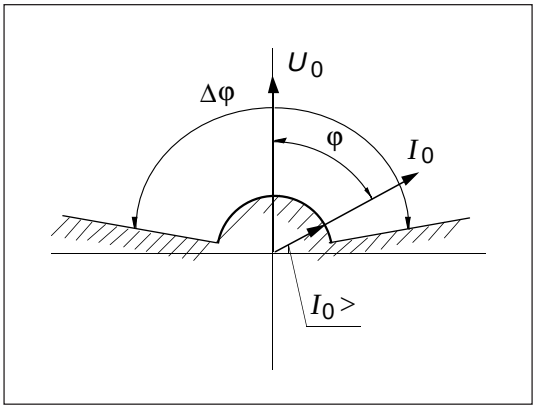


Fig. 1 a. Operation characteristic, when $\varphi_b = 0°$

Fig. 1b. Cosφ operation characteristic

Isolated neutral network

In general, the basic angle φ_b = -90° (or sinφ operation characteristic) is used in an isolated network.

Fig. 2a illustrates the operation characteristic when φ_b = -90° and Fig. 2b illustrates the sin φ characteristic.

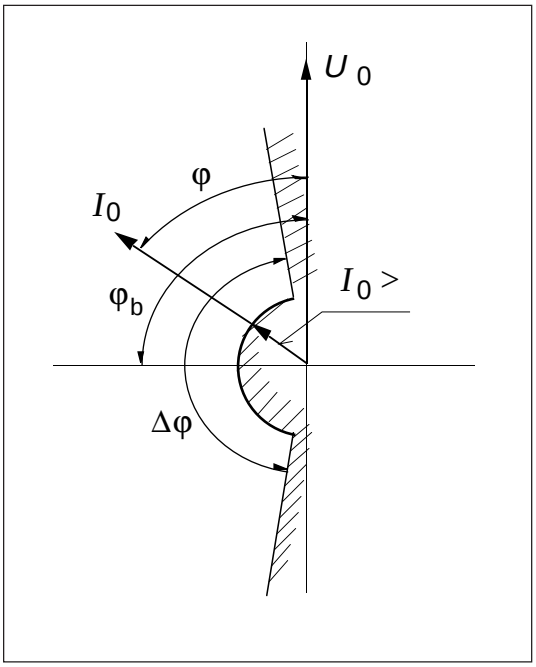


Fig. 2a. Operation characteristic when φ_b = -90°

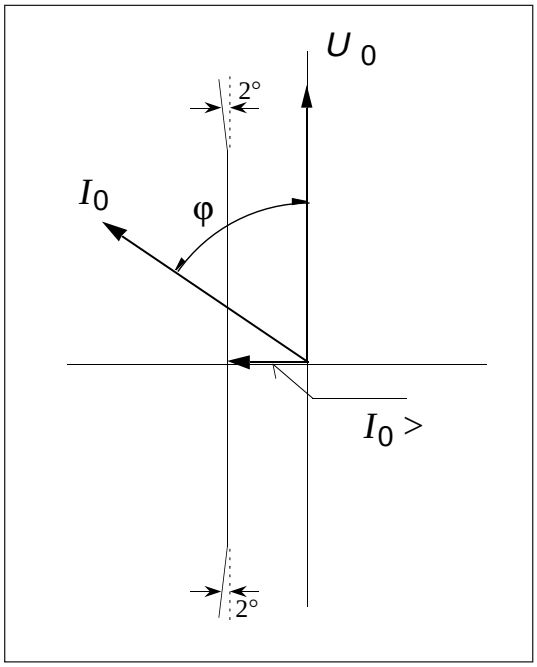


Fig. 2b. Sinφ operation characteristic

Operation characteristic corresponding to basic angle φ_b = 0°

When the angle criterion (U_0, I_0, φ) is used in an operation characteristic where the basic angle φ_b = -90°, the sensitivity remains constant at all values of the phase angle φ. When the basic angle φ_b = 0°, there will be some difficulty when the neutral current is small and the phase angle approaches the edge of the operation characteristic. This will cause the operation sector to be ±70° at setting values <3%. At values above this threshold value the operation sector will be ±80°.

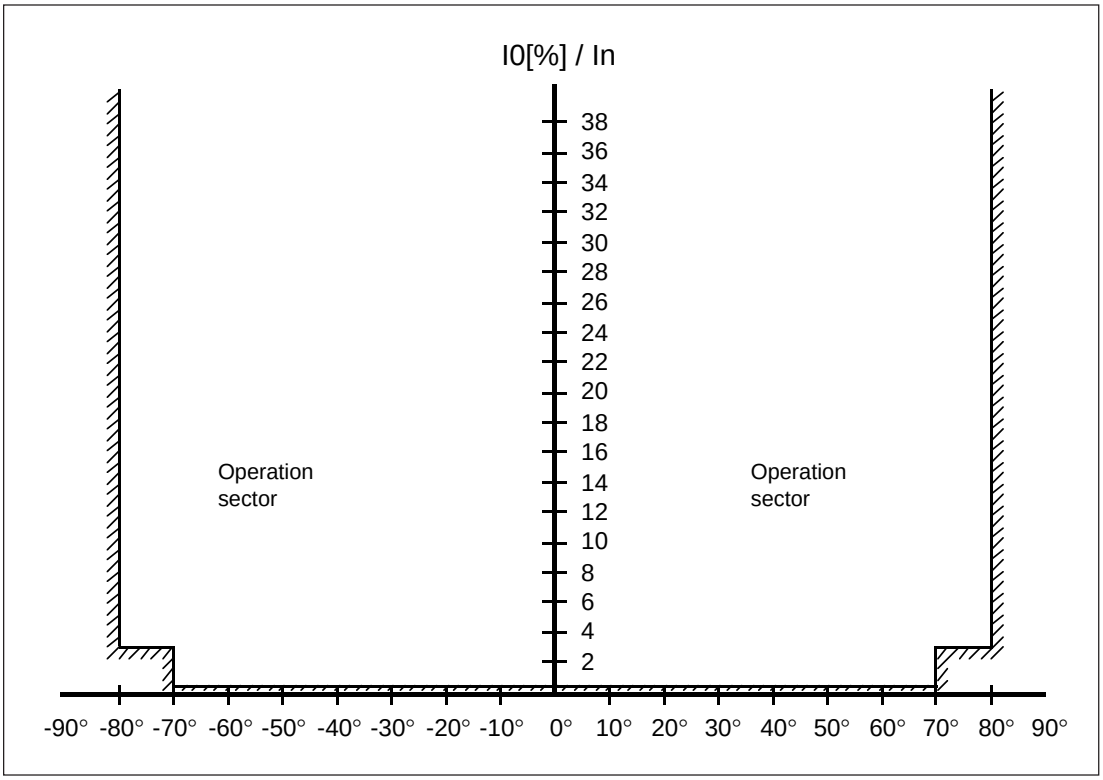


Fig. 3. Operation characteristic illustrated in an I_0 - φ diagram, when the basic angle φ_b = 0°

Transient measuring earth-fault protection

The operation of the transient measuring protection stage is based on measuring the neutral current and residual voltage transient at the moment an earth fault occurs and calculating the capacitive current of the background network.

The stage starts if the residual voltage suddenly exceeds the set triggering level $U_{tr}>$ of the stage. If a higher fault resistance is to be achieved it is important to select a $U_{tr}>$ setting that has the required sensitivity. Observing the normal values (no network or capacitor switching, no fault voltages of U_0) of parameter I4 (U_{tr}; a noise level of residual voltage) and increasing the value of $U_{tr}>$ give an indication of the appropriate parameter setting; typically 0.5...2.0% x U_n.

It is recommended to test the set value of $U_{tr}>$ in order to obtain the best sensitivity for the transient measuring earth-fault protection. The set value is correct if the normal state of the network does not trig the transient measuring protection. If the fault impedance remains below 5 kΩ, a suitable set value for $U_{tr}>$ is approx. 2%. The set values in the range of 0.4…0.8% can be used when the earth-fault impedance is 7…10 kΩ. However these are only basic rules, the setting depends always on the network.

The calculation of a possible fault starts at the same moment as the protection starts (the operation counter starts). Should the residual voltage still be above the set value of $U_{03}>$ when the set time elapses, the stage operates. A transient alone does not cause operation, but the residual voltage rise has to be permanent. Thus spurious operations are eliminated. In the same way, the setting of the residual voltage $U_{03}>$ can be used to limit the operation of the protection stage to the desired fault resistance.

When setting the transient measuring earth-fault protection, it should be noted that the I_c criterion used by the protection is the setting value of I_c divided by three. In spite of that, experiments have shown that the setting value can be the normal capacitive currents of the network or even 0.9...1.0 x I_c. If the protection is to cover solely low-impedance faults (underground networks) the sensitivity can be reduced by increasing the value of I_c. The integration time t_{int} should be in the order of the default value (1.8 ms). By varying the integration time the user is able to influence the selectivity of the protection. Depending on the type of fault the protection stage may use an integration time shorter than that selected.

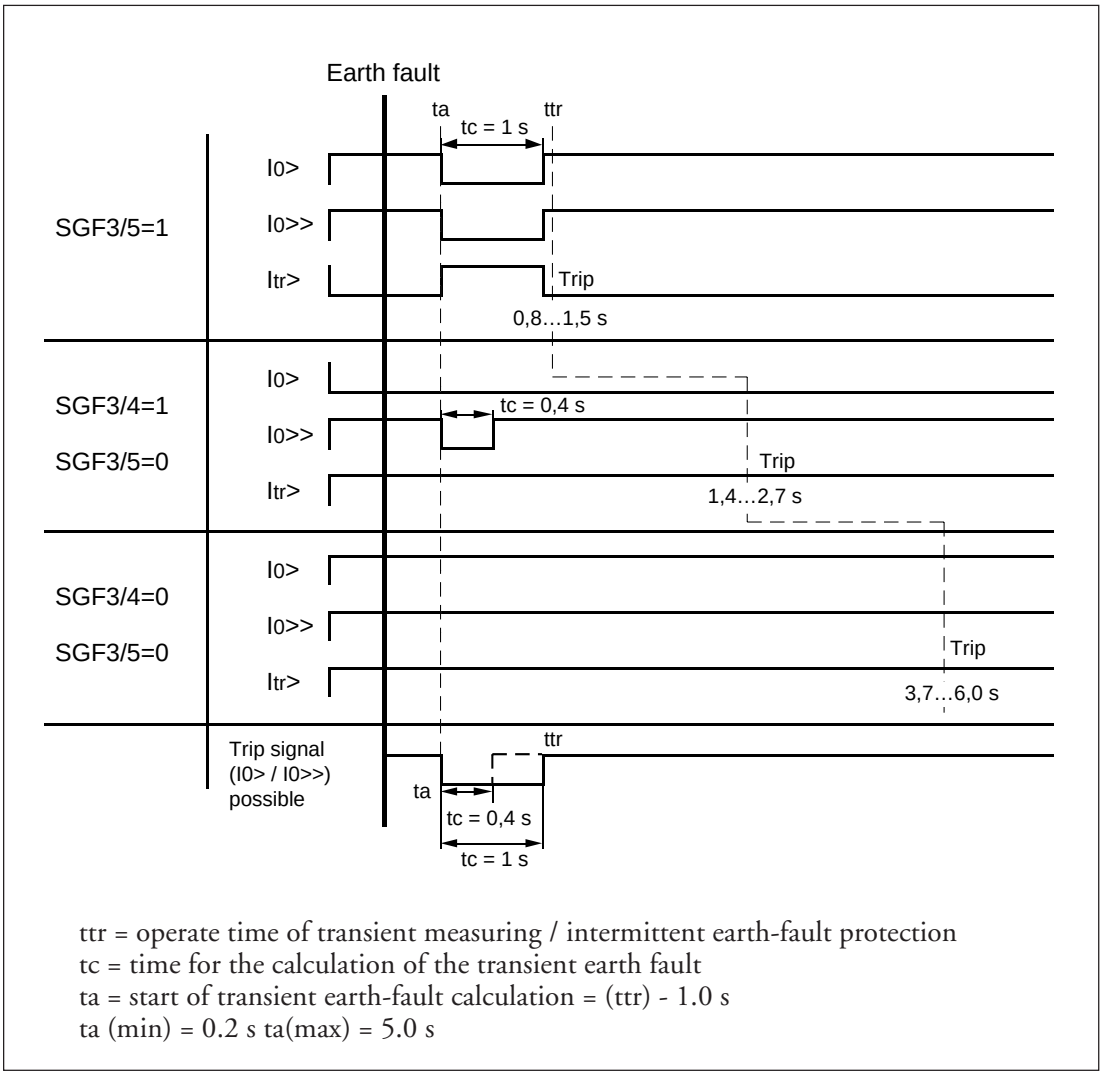
Various configurations are available for speeding up the operation of the transient measuring earth- fault protection. The switches SGF3/4 and SGF3/5 allow the following configurations to be selected:

- when SGF3/4 = 1, the $I_0>$ stage is non-operational and the $I_0>>$ stage is blocked for 0.4 s, i.e. the time required for identifying a transient fault, if any.
- when SGF3/5 = 1, the operation of the stages $I_0>$ and $I_0>>$ is blocked for the time required for identifying a possible transient fault (blocking time approx. 1 s).

Typical operate times of the transient measuring earth-fault protection at different configurations are as follows (see Fig. 4):

- the operate time of the transient measuring protection is about 1 s in a configuration, where the operation of the stages $I_0>$ and $I_0>>$ is blocked for the time required to determine a possible transient fault (calculation time 1 s, when SGF3/5 = 1).
- by disconnecting the $I_0>$ stage and giving the transient measuring protection a calculation time of 400 ms (SGF3/4 = 1, SGF3/5 = 0) an operate time of 2 - 3 seconds can be achieved.
- if all the stages operate normally (SGF3/4 = 0, SGF3/5 = 0), the operate time of the transient measuring protection will be 4 - 6 seconds.

The operate time t_{tr} of the transient measuring protection also determines the start time t_a for the calculation of the transient fault. The stages $I_0>$ and $I_0>>$ are not able to give a trip signal as long as the calculation of the transient fault is in progress. A trip signal is possible only when $t< (t_{tr} - 1.0 s)$ or when $t> (t_{tr})$ (see Fig. 4). The transient measuring protection should be given an operate time exceeding the operate times of the stages $I_0>$ and $I_0>>$.



ttr = operate time of transient measuring / intermittent earth-fault protection
tc = time for the calculation of the transient earth fault
ta = start of transient earth-fault calculation = (ttr) - 1.0 s
ta (min) = 0.2 s ta(max) = 5.0 s

Fig. 4. Effect of the configurations of the protection stages on the minimum operate times of the transient stage.

When SGF3/3 = 1, the transient measuring protection takes into account the ratio between the settings of the input signal to be measured and the directional earth-fault protection, and allows the normal I_0 stage to operate first, provided the I_0 current is high and stable/constant. The phase angle will not be taken into account. Then the start of stage I_0> or stage I_0>> blocks the operation of the transient measuring protection, i.e. stage I_0> or stage I_0>> operates before the transient measuring stage, irrespective of the operate times.

The intervals between the transient triggerings should be some 10 s to allow the relay to detect the transients. When required, the transient measuring protection can be deactivated (switch SGF1/1) without the operation of the intermittent earth-fault protection being affected.

Intermittent earth-fault protection

The intermittent earth-fault protection has been designed to detect low-impedance faults in underground cables. The intermittent earth-fault protection operates in parallel with the transient protection, with common settings and protection stages. The protection monitors the regularly occurring fundamental-frequency and high-frequency I_0 pulses. Should all the fault criterions (regular I_0 pulses, phase criterion and U_0 value) be fulfilled, the intermittent earth-fault stage starts. The stage operates, provided the cosφ operation characteristic is in use or the basic angle $\varphi_b = 0°$.

The intermittent earth-fault protection increases the V variables of the $I_{tr}>$ stage (event parameters).

The intermittent earth-fault protection has a threshold limit for I_0 that, irrespective of the setting value, requires a sufficiently high current (approx. 10% x I_n). The intermittent earth-fault protection blocks the transient measuring protection if the fault directions defined by these protections deviate from each other. Starting of the stages $I_0>$ and $I_0>>$ blocks the operation of the intermittent earth fault protection, if switch SGF3/3 = 1. The intermittent earth-fault protection can be set out of operation (switch SGF3/6).

The operate time of the intermittent earth-fault protection is not unambiguous. The main conditions are that six fault current pulses have been obtained and the operate time has expired. If the six fault current pulses have occurred before the operate time expires, the protection operates at the first fault current pulse following the operate time. If the intermittent earth-fault protection is to operate faster, the start signal of the protection should be used.

Residual voltage input

Two alternative rated voltages U_n are available: 100 V and 110 V. The switch SGF3/2 is used for selecting the desired rated voltage.

External control signals

Three external control signals BS1, BS2 and RRES are available to the earth-fault relay module SPCS 2D32. The control signals can be used for blocking the operation of the protection stages, for switching between main settings and second settings, for changing the basic angle and for resetting operation indicators, output relays and registers. The switches of the SGB switchgroups are used for configuring the external control signals.

In addition, the relay module SPCS 2D32 has been made compatible with the direction earth-fault relay module SPCS 3C4 by enabling the use of the BACTRL signal (SGF3/1 has to be in position 1).

Output signals

The earth-fault relay module SPCS 2D32 includes a freely configurable output relay matrix. The switchgroups SGR1...SGR6 can be used to link the start and operate signals of any protection stage to the desired SS or TS output signal (output contact).

A latching feature can be selected for the output signals TS1...TS4. When this feature has been selected, the output signal remains active, even though the signal that caused the operation resets. The means of resetting the output relays are demonstrated in the table in the section entitled "Resetting".

The TRIP operation indicator on the front panel are linked with the trip stages. The operation indicator remains lit when the stage resets. For resetting see the table in the section headed "Resetting".

Signals initiating auto-reclosing

The auto-reclose signal AR3 can be configured to be activated by any start or trip signal. The signal AR1 is permanently linked with the output signal SS3 and the signal AR2 is permanently linked with output signal SS1.

Second settings

Two different types of setting values are available for the relay: main setting values and second setting values. Switching between these settings can be done as follows:

1) Over the serial bus, using the command V150
2) By means of an external control signal: BS1, BS2 or RRES
3) Via the push-buttons on the front panel of the relay module and subregister 4 of register A (also affects the parameter V150)

Resetting

The operation indicators on the front panel of the relay module, the operation codes on the display, latched output relays and the registers of the relay module can be reset in three ways: with the push-buttons on the front panel, via an external control signal or a serial communication parameter, as shown in the table below.

Means of resetting	Operation indicators	Output relays	Registers
RESET	x		
PROGRAM	x	x	
RESET & PROGRAM	x	x	x
External control signal BS1, BS2 or RRES, when			
SGB_/6 = 1	x		
SGB_/7 = 1	x	x	
SGB_/8 = 1	x	x	x
Parameter V101	x	x	
Parameter V102	x	x	x

Block schematic diagram

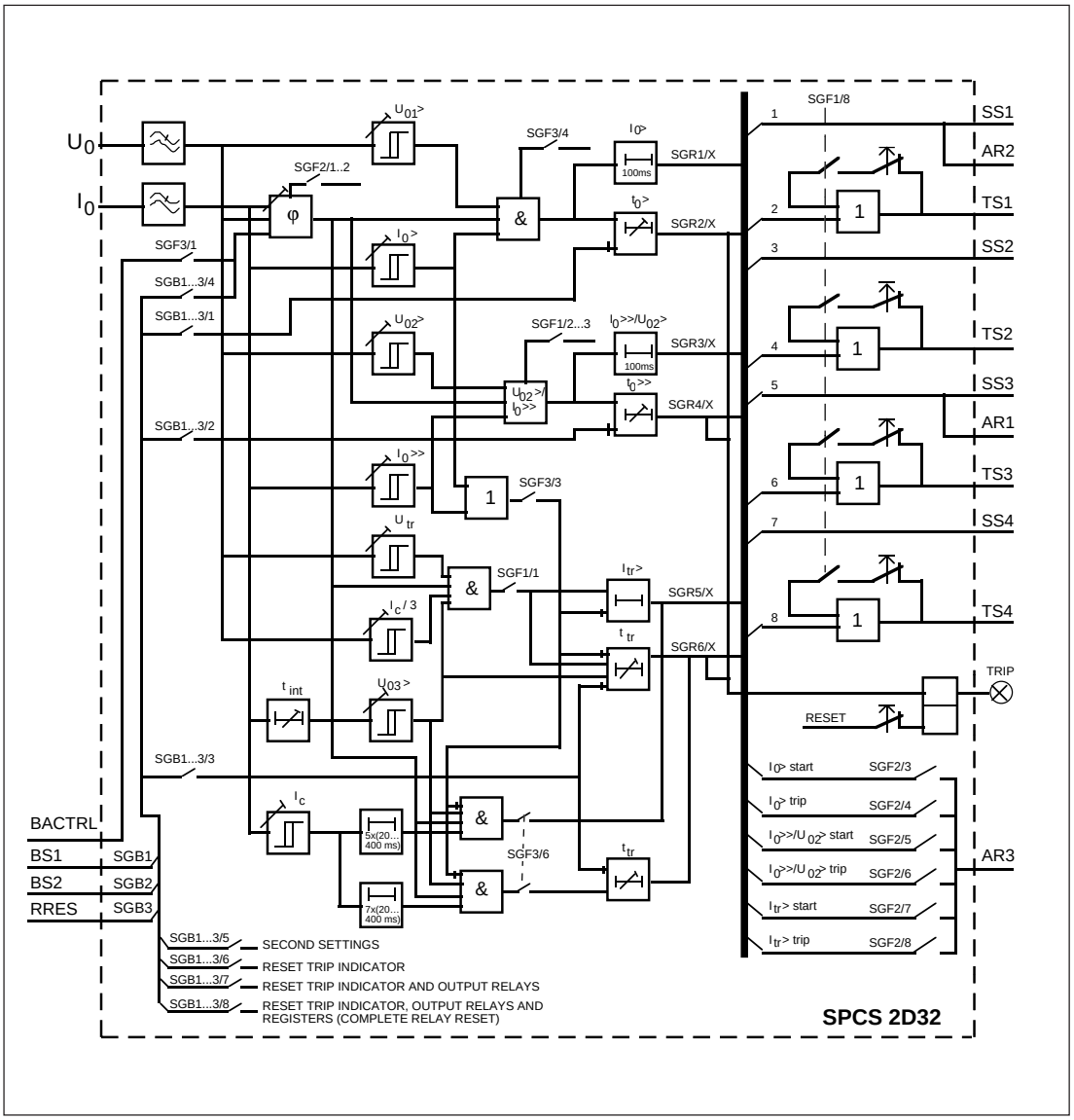


Fig. 5. Block schematic diagram for the transient measuring directional earth-fault relay module SPCS 2D32

U_0	Residual voltage to be measured
I_0	Neutral current to be measured
BS1, BS2 and RRES	External control signals
BACTRL	Signal for changing the basic angle (not in SPAA 345 C)
SGF1...3	Switchgroups for configuring the operation of the module
SGB1...3	Switchgroups for configuring the external control signals
SGR1...6	Switchgroups for configuring the output relay matrix
SS1...SS4	Output signals SS1...SS4
TS1...TS4	Output signals TS1...TS4
TRIP	Red trip indicator
AR1, AR2, AR3	Internal initiation signals for auto-reclosing

Note!
All input and output signals of the module are not necessarily wired to the terminals of every relay assembly using this module. The signals wired to the terminals are shown in the diagram illustrating the flow of signals between the relay modules of the relay assembly.

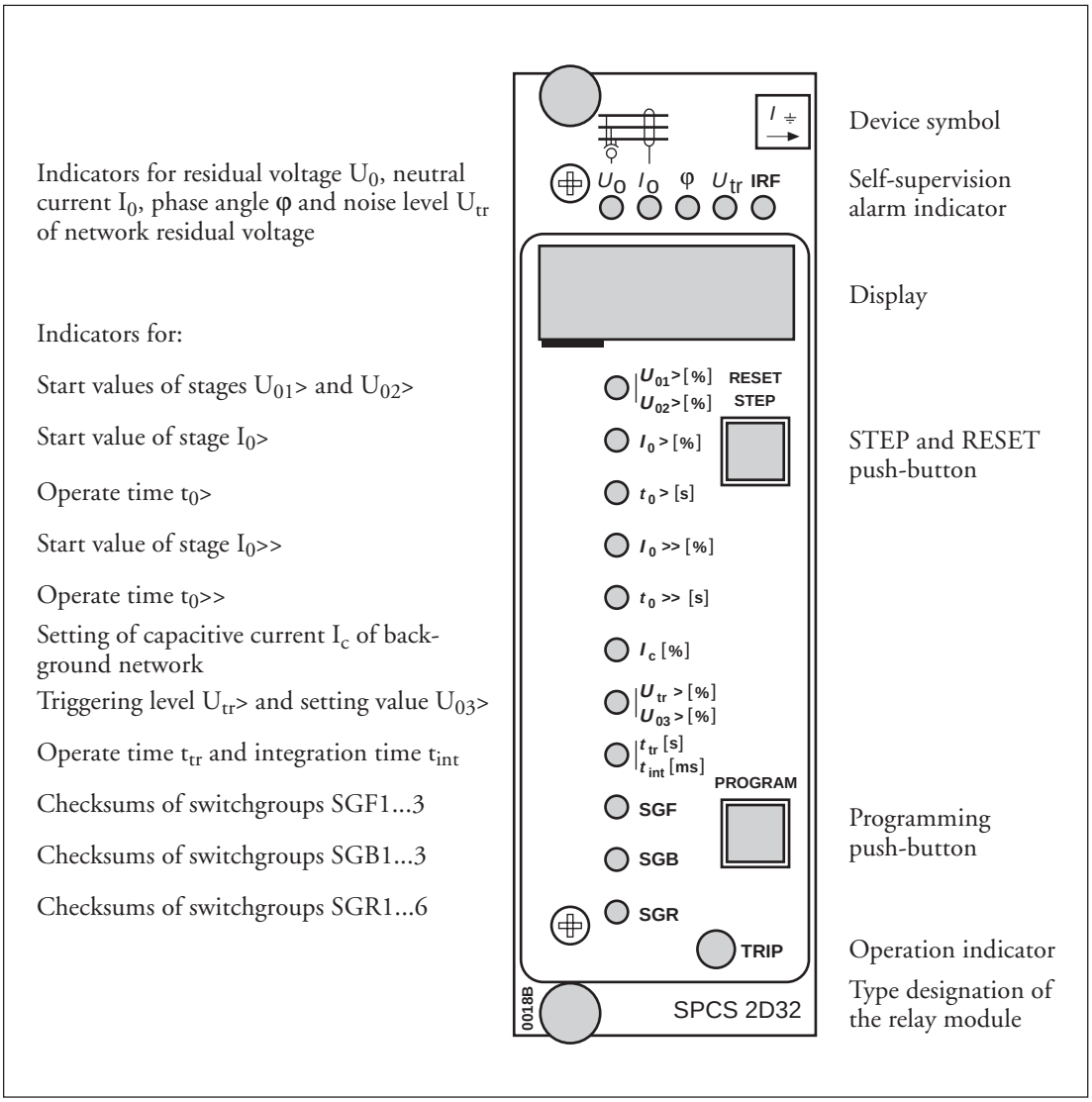


Fig. 6. Front panel of earth-fault relay module SPCS 2D32

Operation indicators

Each earth-fault stage has its own start indicator and trip indicator represented by a red number on the display. In addition, tripping is indicated by the TRIP indicator located at the right bottom corner of the relay module.

As the code number that indicates tripping and the red TRIP indicator remain lit after the relay has issued a trip signal, the operating stage is easily identified. The operation indicators remain on even though the stage resets, and have to be separately reset. The start indicators, on the other hand, go off when the protection stage resets. When required, manual resetting can be selected for the start indicators (switches SGF1/ 4...7).The numbers indicating start go out when the stage resets. Should the stage provide a trip signal before resetting, the start indicators go on indicating tripping.

Non-reset operation indicators are reset with the push-buttons on the front panel of the relay, via an external control signal or over the serial bus, see the table in the section "Description of operation". Non-reset operation indicators do not affect the operation of the relay module.

The symbols of the numbers indicating start and operation on the display and in the serial communication parameter V7 are explained in the following table:

Operation code	Parameter V7	Symbol	Explanation
1	1	U_{01}> START	Start of residual voltage stage U_{01}>
2	2	I_0> START	Start of low-set earth-fault stage I_0>
3	3	I_0>> START	Start of high-set earth-fault stage I_0>>
4	4	U_{02}>> START	Start of residual voltage stage U_{02}>
5	5	–	Not in use in SPCS 2D32
6	6	I_{tr}>START	Start of stage I_{tr}>
7	7	I_0> TRIP	Tripping of low-set earth-fault stage I_0>
8	8	I_0>> TRIP/ U_{02}> TRIP	Tripping of high-set earth-fault stage I_0>>/ Tripping of residual voltage stage U_{02}>
9	9	I_{tr}>TRIP	Tripping of stage I_{tr}>

The operation indicators of the transient measuring earth-fault protection and the intermittent earth-fault protection (I_{tr}> stage) are distinguished by the following LED on the display:

- operation indicator + LED φ = the intermittent earth-fault protection has operated.
- operation indicator = the transient measuring earth-fault protection has operated.

Once the self-supervision system of the relay module has detected a permanent fault, the red self-supervision alarm indicator IRF is lit. At the same time the self-supervision system delivers a control signal to the output relay which drops off. In a normal situation the IRF output relay is operated. Under normal conditions a fault code that shows the nature of the fault appears on the display of the relay module. This fault code that consists of a red digit 1 and a green code number cannot be reset from the display. The fault code should always be recorded and stated when service is ordered.

The setting values are indicated by the three right-most digits on the display. When a LED in front of a setting value symbol is lit, it indicates that the particular setting value is being displayed. The default setting is given in parentheses below the setting range.

Setting	Description	Setting range (Default setting)
U_{01}>, U_{02}> (% U_n)	Setting value of the residual voltage U_{01}> as a percentage of the rated voltage U_n. Setting value of the residual voltage U_{02}> as a percentage of the rated voltage U_n.	2.0...80.0% x U_n (8.0% x U_n)
I_0> (%I_n)	Setting value of stage I_0> as a percentage of the rated current I_n. Setting the switch SGF3/4 at 1 blocks the operation of stage I_0>	1.0...100% x I_n (5.0% x I_n)
t_0> (s)	Operate time of stage I_0> in seconds	0.1...300 s (1.5 s)
I_0>> (%I_n)	Setting value of stage I_0>> as a percentage of the rated current I_n. By setting the switch SGF1/3 at 1 (SGF1/2 = 0) the stage I_0>> can be connected to operate as a U_{02}> stage.	1.0...100% x I_n (5.0% x I_n)
t_0>> (s)	Operate time of stage I_0>>/ U_{02}> in seconds	0.1...300 s (0.2 s)
I_c (%I_n)	Capacitive current I_c of background network as a percentage of the rated current I_n. Note! The I_c setting of the transient measuring earth-fault protection is the actual I_c setting divided by three.	3.0...100% x I_n (5.0% x I_n)
U_{tr}>, U_{03}> (%U_n)	Triggering level U_{tr} of the transient measuring protection as a percentage of the rated voltage U_n.	0.2...6.0% x U_n (2.0% x U_n)
	Setting of the U_{03} condition for the transient measuring / intermittent earth- fault protection, as a percentage of the rated voltage U_n.	2.0...80,0% x U_n (8.0% x U_n)
t_{tr} (s), t_{int} (ms)	Operate time t_{tr} of transient measuring / intermittent earth-fault protection, in seconds	0.5...300 s *) (1.5 s)
	Integration time t_{int} of transient measuring protection in milliseconds	0.6...3.0 ms (1.8 ms)

*) The real operate time of the transient measuring earth-fault protection depends on the configuration of the switches SGF3/4 & SGF3/5. However, the setting range of the operate time t_{tr} is 0.5...300 s.

Note!
The settings cannot be changed from the front panel as long as a fault persists.

Note!
The settings are in effective once they have been selected, but the storing of them will take about 30 seconds.

Note!
The software switch SGF3/2 is used for selecting the rated voltage U_n of the residual voltage input, i.e. 100 V or 110 V.

The setting of the configuration switchgroups SGF1...3, SGB1...3 and SGR1...6 is described in the section "Configuration switches".

Configuration switches

The switchgroups SGF1...3, SGB1...3 and SGR1...6 are used for selecting additional functions required for individual applications. The switchgroups settings are implemented as checksums. The checksums corresponding to the default settings are also given in the tables. The calculation of the checksum is described in the end of this section.

Setting of switchgroup SGF1

Switch	Operation	Default
SGF1/1	Blocking of transient measuring earth-fault protection When SGF1/1 = 0, the transient measuring protection operates When SGF1/1 = 1, the protection is non-operational Note! The operation of the intermittent earth-fault protection is independent of the switch position.	0
SGF1/2 SGF1/3	Configuration of the operation of the high-set stage I_0>>.	1 0
	Operation mode of the codes indicating start of the protection stages. When the switch is in position 0, the operation code resets once the fault has been cleared.	
SGF1/4	Automatic resetting of the start of the residual voltage stages U_{01}> and U_{02}>, when SGF1/4 = 0. Manual resetting, when SGF1/4 = 1.	0
SGF1/5*)	Automatic resetting of the start of the low-set earth-fault stage I_0> , when SGF1/5 = 0. Manual resetting, when SGF1/5 = 1.	0
SGF1/6*)	Automatic resetting of the start of the high-set earth-fault stage I_0>> (or U_{02}>), when SGF1/6 = 0. Manual resetting, when SGF1/6 = 1.	0
SGF1/7*)	Automatic resetting of the start of the I_{tr}> stage, when SGF1/7 = 0. Manual resetting, when SGF1/7 = 1.	0
SGF1/8	This switch is used for selecting self-holding for the trip signals TS1... TS4. When SGF1/8 = 0, the trip signal returns to normal once the measured signal that caused the operation falls below the setting value. If SGF1/8 = 1, the trip signal remains active even though the measured signal falls below the setting value. Output signals with self-holding are reset with the push-buttons on the front panel, via an external control input or over the serial bus, see the section "Description of operation".	
	Default checksum of switchgroup SGF1	002

Operation	SGF1/2	SGF1/3
I_0>> non-directional	0	0
I_0>> directional, forward direction of operation	1	0
I_0>> replaced by U_{02}>	0	1
I_0>> directional, reverse direction of operation	1	1

Note!
The switches SGF1/4...8 are determined by the main settings even when the second settings are used.

*) If manual resetting has been selected the switch SGF3/7 has the following function:

When SGF3/7 = 0, just the operation code requires manual resetting.
When SGF3/7 = 1, both the operation code and the protection stage require manual resetting.

Setting of switch-group SGF2

<table>
<tr><th>Switch</th><th>Operation</th><th>Default</th></tr>
<tr><td>SGF2/1
SGF2/2</td><td>Selection of operation characteristic for stages $I_0>$ and $I_0>>$.
<table><tr><th></th><th>SGF2/1</th><th>SGF2/2</th></tr><tr><td>φ_b = 0°
φ_b = -90°
cosφ
sinφ</td><td>0
1
0
1</td><td>0
0
1
1</td></tr></table></td><td>0
0</td></tr>
<tr><td>SGF2/3</td><td>The $I_0>$ start signal is linked to the AR3 output, when SGF2/3 = 1</td><td>1</td></tr>
<tr><td>SGF2/4</td><td>The $I_0>$ trip signal is linked to the AR3 output, when SGF2/4 = 1</td><td>0</td></tr>
<tr><td>SGF2/5</td><td>The $I_0>>$ (or $U_{02}>$) start signal is linked to the AR3 output, when SGF2/5 = 1</td><td>1</td></tr>
<tr><td>SGF2/6</td><td>The $I_0>>$ (or $U_{02}>$) trip signal is linked to the AR3 output, when SGF2/6 = 1</td><td>0</td></tr>
<tr><td>SGF2/7</td><td>The $I_{tr}>$ start signal is linked to the AR3 output, when SGF2/7 = 1</td><td>0</td></tr>
<tr><td>SGF2/8</td><td>The $I_{tr}>$ trip signal is linked to the AR3 output, when SGF2/8 = 1</td><td>0</td></tr>
<tr><td></td><td>Default checksum of switchgroup SGF2</td><td>020</td></tr>
</table>

Setting of switch-group SGF3

The switchgroup SGF3 is determined by the the main settings even when the second settings are used.

Switch	Operation	Default
SGF3/1	Operation of BACTRL signal When SGF3/1 = 0, the signal cannot be used. (in SPAA 345 C packages) When SGF3/1 = 1, the signal can be used.	0
SGF3/2	Selection of rated voltage U_n for residual voltage energizing circuit When SGF3/2 = 0, the rated voltage is 100 V When SGF3/2 = 1, the rated voltage is 110 V	0
SGF3/3	Selection of the function of the transient measuring and intermittent earth-fault protection at the start of I_0> or I_0>> When SGF3/3 = 0, the start of I_0> or I_0>> does not affect the operation of the transient measuring and intermittent earth-fault protection. When SGF3/3 = 1, the start of I_0> or I_0>> inhibits the operation of the transient measuring and intermittent earth-fault protection.	0
SGF3/4	Blocking of the operation of the I_0> stage to speed up the operation of the transient measuring earth-fault protection. When SGF3/4 = 0, the I_0> stage is operational When SGF3/4 = 1, the I_0> stage is non-operational. In addition, the I_0>> stage is blocked for 0.4 s, the time required for calculating the transient fault.	0
SGF3/5	Speeding up the operation of the transient measuring protection When SGF3/5 = 0, the operation is not speeded up. When SGF3/5 = 1, the operation of the stages I_0> and I_0>> are blocked for the time required for calculating a possible transient fault (about 1 s). Note! Described more in detail in the section "Description of operation".	1
SGF3/6	Blocking of the operation of the intermittent earth-fault protection When SGF3/6 = 0, the intermittent earth-fault protection is operational. When SGF3/6 = 1, the intermittent earth-fault protection is non-operational.	0
SGF3/7	Selection of operations and start indicators to be manually reset (see switches SGF1/5...7) When SGF3/7 = 0, the protection stage is automatically reset, but the operation indicator requires manual resetting (if SGF1/5...7 = 1) When SGF3/7 = 1, the protection stage, too, has to be manually reset (see "Resetting"). **SGF3/7 should normally be in position 0.**	0
SGF3/8	Not in use	0
	Default checksum of switchgroup SGF3	016

Switchgroups SGB1...3 for the configuration of blocking and control inputs

The switchgroups SGB1...3 are used for configuring the use of the control signals BS1, BS2 and RRES. The matrix below can be used for the programming. The control signals are linked to each other, for example, by circling the intersection of the lines. Each intersection is marked with the number and the weighting value of the switch. By adding the weighting values of the switches selected the checksums of the switchgroups are obtained to the right of the matrix.

Note!
Before starting the configuration it should be checked whether all control signals of the relay module SPCS 2D32 are used in the concerned protection relay.

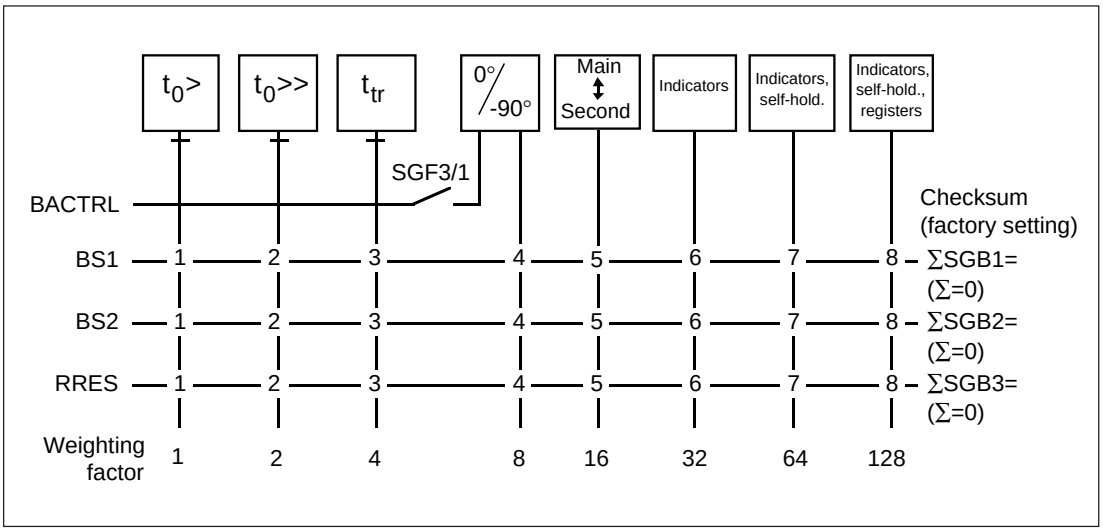


Fig. 7. Control signal matrix for earth-fault relay module SPCS 2D32

<table>
<tr><th>Switch</th><th>Function</th></tr>
<tr><td>SGB_/1</td><td>The low-set earth-fault stage I_0> can be blocked by the signals BS1, BS2 or RRES.

When the switch is in position 1, the concerned protection stage is blocked by the activation of the control signal.</td></tr>
<tr><td>SGB_/2</td><td>The high-set stage I_0>> / U_{02}> can be blocked by the signals BS1, BS2 or RRES.

When the switch is in position 1, the concerned protection stage is blocked by the activation of the control signal.</td></tr>
<tr><td>SGB_/3</td><td>The I_{tr}> stage can be blocked by the signals BS1, BS2 or RRES. When the switch is in position 1, the concerned protection stage is blocked by the activation of the control signal.

Note!
The control signal does not block (reset) the activated I_{tr}> stage.</td></tr>
<tr><td>SGB_/4</td><td>The signals BS1, BS2 or RRES can be used to change the operation characteristics of the directional earth-fault protection (selected with SGF2/1...2). When the switch SGB_/4 is in position 1 the operation characteristic can be changed:

<table>
<tr><th>SGF2/1</th><th>SGF2/2</th><th>Control signal not active</th><th>Control signal active</th></tr>
<tr><td>0
1
0
1</td><td>0
0
1
1</td><td>φ_b = 0°
φ_b = -90°
cosφ
sinφ</td><td>φ_b = -90°
φ_b = 0°
sinφ
cosφ</td></tr>
</table>
Note!
The old SPCS 3C4 module can be replaced by the SPCS 2D32 module. The BACTRL operation (shifting between I_0sinφ /I_0cosφ) of the SPCS 3C4 module can be implemented in the module SPCS 2D32 by setting switch SGF3/1 into position 1, provided the BACTRL signal is available in the relay package.</td></tr>
<tr><td>SGB_/5</td><td>Shifting between second settings and main settings

The main setting values are effective when the input is non-energized. When the control input is energized, the second setting values are in use.

When SGB_/5 = 0, the setting values cannot be changed via an external control signal.

When SGB_/5 = 1, the setting values can be changed using an external control signal

To be noted!
If the V150 parameter is 1, it is not possible to switch back to the main settings from the second settings, even though the control signal is not active. This is possible only when V150 is 0. To avoid this conflict situation the settings should be changed either over the serial bus or via external control signals.</td></tr>
<tr><td>SGB_/6</td><td>Resetting of front panel operation indicators, when SGB_/6 = 1.</td></tr>
<tr><td>SGB_/7</td><td>Resetting of operation indicators and latched output relays, when SGB_/7 = 1.</td></tr>
<tr><td>SGB_/8</td><td>Resetting of operation indicators, latched output relays and register values, when SGB_/8 = 1.</td></tr>
</table>

Switchgroups SGR1...SGR6

The switchgroups SGR1...6 are used to configure the start and trip signals of the protection stages to operate as desired output signals SS1...SS4 or TS1...TS4.

The matrix below can be used for the configuration. The start and trip signals of the protection stages are linked with the desired output signal SS1...SS4 or TS1...TS4, for example, by circling the intersections of the signal lines. The number of the switch to be used is marked at each intersection and the weighting factor of the switch is given under the matrix. By adding the weighting values of the switches selected from each switchgroup the checksums of the switchgroups are obtained to the right of the matrix. The checksums of the default settings are given in parenthesis.

Note!
Before starting the configuration check whether all output signals of the relay module SPCS 2D32 are in use in the concerned protection relay.

Fig. 8 shows the output relay matrix for configuring the switchgroups SGR 1...6/1...8. A signal is linked to a certain protection stage by setting the switch marked at the intersection in position "1".

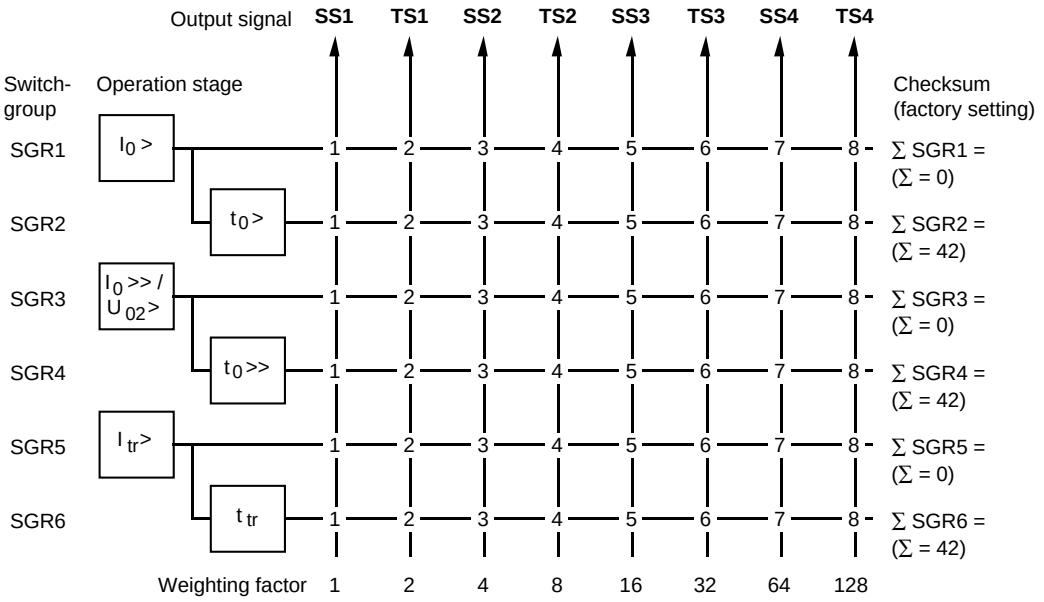


Fig. 8. Output relay matrix for the earth-fault relay module SPCS 2D32

Example of calculating the checksum of a switchgroup.

Switch	Weighting value		Position		Value
SGF1/1	1	x	0	=	0
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 Σ of switchgroup SGF1					68

Measured data

The values measured are indicated by the three digits to the right. The measured data displayed are identified by a yellow LED above the display.

LED	Measured data	Measuring range
U_0	Residual voltage measured by the relay module expressed as a percentage of the rated voltage U_n.	0...210% x U_n
I_0	The neutral current measured by the relay module expressed as a percentage of the rated current I_n.	0...140% x I_n
φ	Phase angle between the residual voltage U_0 and neutral current I_0	0...±180°
U_{tr}	Indicates, under normal conditions, the noise level of the residual voltage of the network as a percentage of the rated voltage U_n. The display shows "- - -", when the transient measuring earth-fault protection has triggered and is locating a possible fault.	0...6% x U_n

Recorded information

The left-most digit on the display shows the address of the register, the other three digits indicate the value recorded. The configuration of the registers is illustrated in "Main menus and submenus of settings and registers".

Registers 1...6 are updated once a protection stage of the module starts or starts and operates. Then the previous items are moved one step forward the oldest value being lost. The five latest values are stored in the memory; the most recent one in the main register and the other four in subregisters.

Register/ STEP	Data recorded
1	Residual voltage U_0 expressed as a percentage of the rated voltage U_n.
2	Neutral current I_0 expressed as a percentage of the rated current I_n.
3	Phase angle φ between residual voltage U_0 and neutral current I_0. Once a protection stage starts, but without operating, the value measured at the moment of start is recorded in the registers 1...3. Should one of the stages start and provide a trip signal, the value recorded at the moment of operation is stored in the registers. The registers are updated when the stage resets.
4	Duration of the start situation of stage I_0> in seconds.
5	Duration of the start situation of stage I_0>>/U_{02}> in seconds. A value corresponding to the set operate time is stored in the registers 4...5 , if the stage provides a trip signal.
6	The capacitive current I_c calculated on the basis of the earth-fault transient and expressed as a percentage of the rated current I_n. Register 6 is updated once the stage operates. When the transient measuring protection operates, the value of the first I_c pulse is stored, whereas, when the intermittent earth fault protection operates, the last I_c pulse is stored. Note! The value recorded, when the transient measuring earth-fault protection has operated, is the actual I_c value divided by three (see Settings).

<table>
<tr><th>Register/
STEP</th><th>Data recorded</th></tr>
<tr><td>7</td><td>Number of starts of stage U_{01}>. Register 7 has four subregisters with the following contents:
1. Number of starts of stage I_0>
2. Number of starts of stage U_{02}>>
3. Number of starts of stage I_0>>
4. Number of starts if stage I_{tr}> after the previous resetting of the event registers (0...255).</td></tr>
<tr><td>0</td><td>Display of external blocking and control data.

The right-most digits on the display show the status of the external control signals. Each control signal has its own weighting value. The sum of the weighting values of the active control signals is numerically indicated on the display as follows:

<table>
<tr><th rowspan="2">Number displayed</th><th colspan="4">Active signal (weighting value in paranthesis)</th></tr>
<tr><th>BS1 (16)</th><th>BS2 (32)</th><th>RRES (4)</th><th>BACTRL (1) (SGF3/1 = 1)</th></tr>
<tr><td>0</td><td></td><td></td><td></td><td></td></tr>
<tr><td>1</td><td></td><td></td><td></td><td>x</td></tr>
<tr><td>4</td><td></td><td></td><td>x</td><td></td></tr>
<tr><td>5</td><td></td><td></td><td>x</td><td>x</td></tr>
<tr><td>16</td><td>x</td><td></td><td></td><td></td></tr>
<tr><td>17</td><td>x</td><td></td><td></td><td>x</td></tr>
<tr><td>20</td><td>x</td><td></td><td>x</td><td></td></tr>
<tr><td>21</td><td>x</td><td></td><td>x</td><td>x</td></tr>
<tr><td>32</td><td></td><td>x</td><td></td><td></td></tr>
<tr><td>33</td><td></td><td>x</td><td></td><td>x</td></tr>
<tr><td>36</td><td></td><td>x</td><td>x</td><td></td></tr>
<tr><td>37</td><td></td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>48</td><td>x</td><td>x</td><td></td><td></td></tr>
<tr><td>49</td><td>x</td><td>x</td><td></td><td>x</td></tr>
<tr><td>52</td><td>x</td><td>x</td><td>x</td><td></td></tr>
<tr><td>53</td><td>x</td><td>x</td><td>x</td><td>x</td></tr>
</table>

The weighting value of BACTRL is taken into account, provided SGF3/1 = 1.

The switchgroups SGB1...3 are used for configuring the external control signals.

The TEST mode can be entered from this register. In this mode the relay outputs are tested by activating the start and trip signals one by one. The signals to be activated and the corresponding LEDs are presented in the table below.

<table>
<tr><td>LED</td><td>Signal to be activated</td></tr>
<tr><td>U_{01}>/U_{02}></td><td>I_0>start</td></tr>
<tr><td>I_0></td><td>I_0>trip</td></tr>
<tr><td>t_0></td><td>I_0>>start</td></tr>
<tr><td>I_0>></td><td>I_0>>trip</td></tr>
<tr><td>t_0>></td><td>I_{tr}>start</td></tr>
<tr><td>I_c</td><td>I_{tr}>trip</td></tr>
</table>

It should be noted that the switches SGF1/5...8 have to be in position 0, which means that self-holding is not allowed for the protection stages/trip signals to be tested in the TEST mode.</td></tr>
</table>

Register/ STEP	Data recorded
A	Address code of the relay module, required for serial communication. Register A has four subregisters with the following contents: 1. Setting of the data transfer rate of the relay module: 4.8 or 9.6 kBd. Default setting 9.6 kBd. 2. Bus traffic monitor. If the relay module is connected to a data communication system and the communication operates correctly, the value of the monitor is 0. Otherwise the counter indicates the number of seconds that has passed since the last activity. 3. Password required for remote setting. The password (parameter V160) must always be entered before a setting can be changed over the serial bus. 4. Selection of main and second settings (0 = main settings, 1 = second settings)

When the display is dark, access to the beginning of the main menu is gained by pressing the STEP push-button on the front panel for more than 1 s. Pressing the STEP push-button for less than 0.5 s provides direct access to the end of the main menu of the relay module.

The values recorded in registers 1...7 can be set to zero via the push-buttons on the front panel, an external control signal or a serial communication parameter, see "Resetting" in the section "Description of function". In addition, the registers are cleared by a failure in the auxiliary power supply. The setting values, the address code, the data transfer rate and the password of the relay module are not affected by voltage failures. Instructions for setting the address code and data transfer rate are given in the document "General characteristics of D-type relay modules".

Main menu and submenus of settings and registers

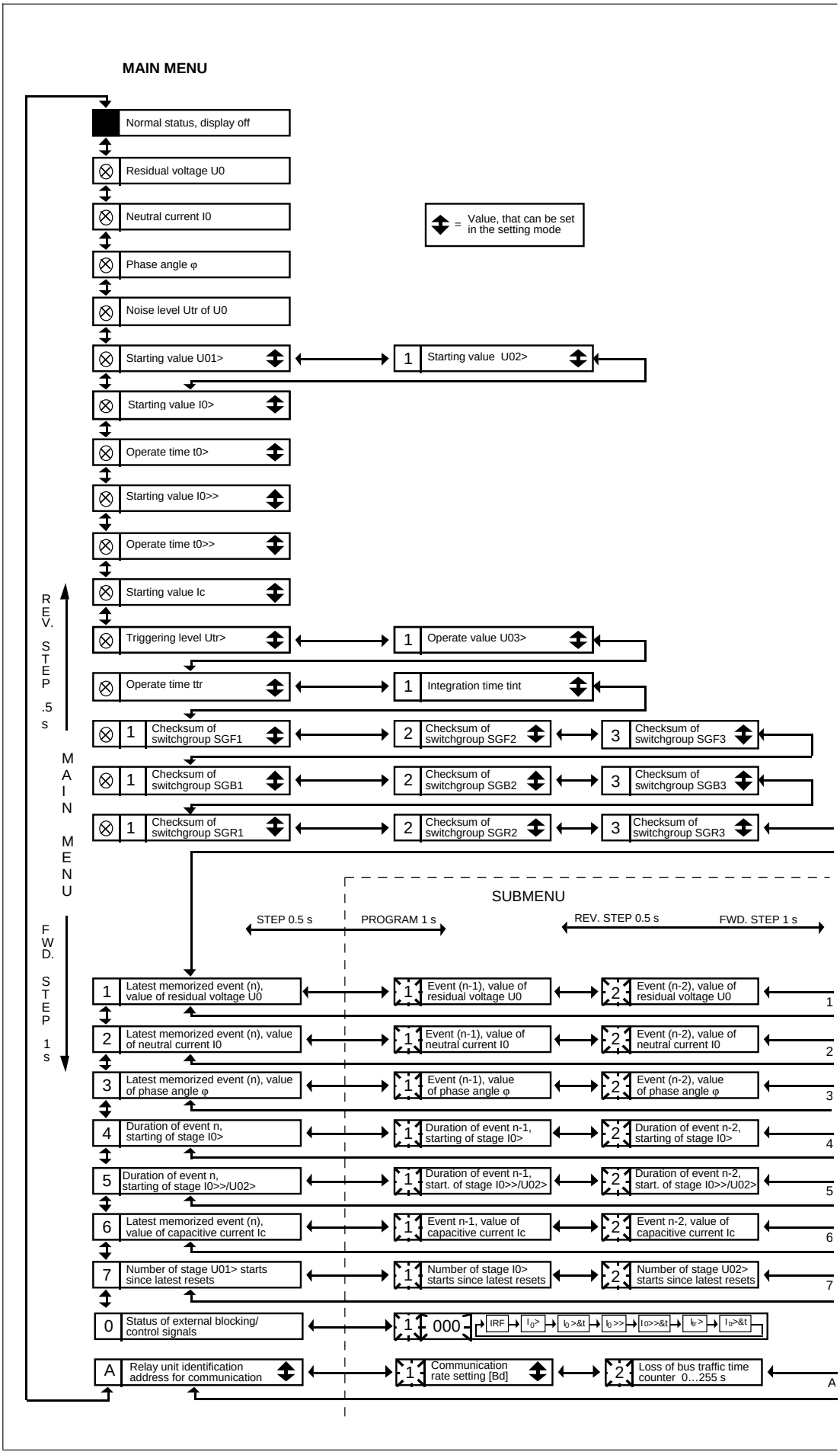
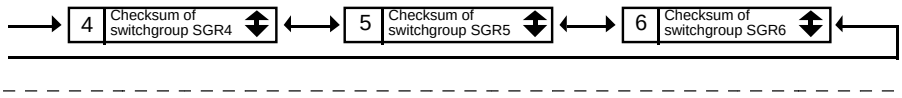
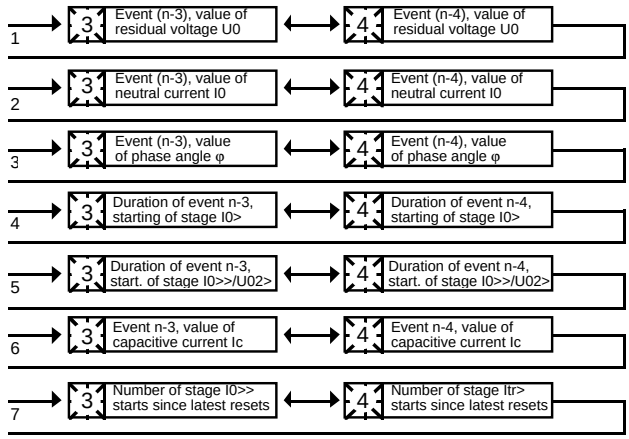


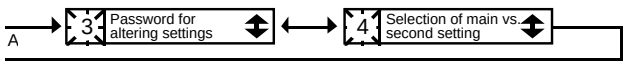
Fig. 9. Main menu and submenus for the earth-fault relay module SPCS 2D32.

The procedure for entering a submenu or a setting mode, the configuration of the module and the operation of the TEST mode are described in detail in the manual "General characteristics of D-type SPC relay modules". Below simplified instructions.

Desired step or function	Push-button	Action
One step forward in main menu or submenu	STEP	Press for more than 0.5 s
Rapid browse forwards in main menu	STEP	Keep depressed
One step reverses in main menu or submenu	STEP	Press for less than 0.5 s
Entering a submenu from the main menu	PROGRAM	Press for 1 s (activated when the push-button is released)
Entering or quitting a setting mode	PROGRAM	Press for 5 s
Increasing a value in the setting mode	STEP	
Moving the cursor in the setting mode	PROGRAM	Press for about 1 s
Storing a setting value in the setting mode	STEP & PROGRAM	Press simultaneously
Resetting of memorized values and latched output relays	STEP & PROGRAM	
Resetting of latched output relays	PROGRAM	Note! Display must be dark.







Low-set stage I_0>

Operation direction of stage I_0>	forward
Basic angle φ_b	-90° or 0°
Operation sector $\Delta\varphi$ (φ_b=-90° or 0°)	±80°
Operation mode of I_0> stage	directional
Setting range I_0>	1.0...100% x I_n
Setting range U_{01}>	2.0...80.0% x U_n
Start time, typical	100 ms
Operate time t_0>	0.1...300 s
Resetting time, typical	130 ms
Pick-up/drop-off ratio, typical	0.96
Operate time accuracy	±2% of set value or ±40 ms
Operation accuracy	±3% of set value +0.0005 x I_n

High-set stage I_0>> / U_{02}>

Operation direction of stage I_0>>	forward or reverse
Basic angle φ_b	-90° or 0°
Operation sector $\Delta\varphi$ (φ_b=-90° or 0°)	±80°
Operation mode of stage I_0>>	directional or non-directional
Setting range I_0>>	1.0...100% x I_n
Setting range U_{02}>>	2.0...80.0% x U_n
Start time, typical	100 ms
Operate time t_0>>	0.1...300 s
Resetting time, typical	130 ms
Pick-up/drop-off ratio, typical	0.96
Operate time accuracy	±2% of set value or ±40 ms
Operation accuracy	±3% of set value + 0.0005 x I_n

Transient measuring earth-fault protection and intermittent earth-fault protection

Note! The I_c setting of the transient measuring earth-fault protection is the actual I_c setting divided by three. The I_c setting of the intermittent earth-fault protection is equal to the actual setting value of I_c.

	Intermittent earth-fault protection	Transient measuring earth-fault protection
I_c setting range	3.0...100.0% x I_n	1.0...33.3% x I_n
U_{03}> setting range	2.0...80.0% x U_n	2.0...80.0% x U_n
U_{tr}> setting range	–	0.2...6.0% x U_n
t_{int} setting range	–	0.6...3 ms
Start time	0.1...2.0 s **	1.0 s/2.0 s/ 5 s *
Operate time t_{tr}	0.5...300 s	0.5...300 s *
Operate time accuracy	±2% of set value or ±50 ms	
Operation accuracy	±3% of set value +0.0005 x I_n	

* The minimum time depends on the configuration selected with switches SGF3/4 & SGF3/5.

** The start time depends on the interval between the fault current pulses of the intermittent earth fault.

Serial communication parameters

Special codes have been specified to represent certain events such as start, operation of the protection stages and different output signal status. The event codes can be transferred to higher-level systems over the serial bus.

Events to be included in event reporting are marked with a "1". An event mask is obtained by adding the weighting values of the events included, see the table below.

Event codes

Event mask	Codes	Setting range	Default setting
V154	E1...E6	0...255	21
V155	E7...E14	0...255	85
V156	E15...E18	0...255	5
V157	E19...E26	0...255	255
V158	E27...E34	0...255	0
V159	E35...E40	0...255	13

Event codes for the transient measuring directional earth-fault relay module SPCS 2D32:

Code	Event	Weighting value	Default
E1	Start of stage U_{01}>	1	1
E2	Start of stage U_{01}> reset	2	0
E3	Start of stage I_0>	4	1
E4	Start of stage I_0> reset	8	0
E5	Operation of stage I_0>	16	1
E6	Operation of stage I_0> reset	32	0
	Default value of event mask V154		21
E7	Start of stage U_{02}>	1	1
E8	Start of stage U_{02}> reset	2	0
E9	Operation of stage U_{02}>	4	1
E10	Operation of stage U_{02}> reset	8	0
E11	Start of stage I_0>>	16	1
E12	Start of stage I_0>> reset	32	0
E13	Operation of stage I_0>>	64	1
E14	Operation of stage I_0>> reset	128	0
	Default value of event mask V155		85
E15	Start of transient measuring protection	1	1
E16	Start of transient measuring protection reset	2	0
E17	Operation of transient measuring protection	4	1
E18	Operation of transient measuring protection reset	8	0
	Default value of event mask V156		5
E19	Output signal SS1 activated	1	1
E20	Output signal TS1 activated	2	1
E21	Output signal SS2 activated	4	1
E22	Output signal TS2 activated	8	1
E23	Output signal SS3 activated	16	1
E24	Output signal TS3 activated	32	1
E25	Output signal SS4 activated	64	1
E26	Output signal TS4 activated	128	1
	Default value of event mask V157		255

Code	Event	Weighting value	Default
E27	Output signal SS1 reset	1	0
E28	Output signal TS1 reset	2	0
E29	Output signal SS2 reset	4	0
E30	Output signal TS2 reset	8	0
E31	Output signal SS3 reset	16	0
E32	Output signal TS3 reset	32	0
E33	Output signal SS4 reset	64	0
E34	Output signal TS4 reset	128	0
	Default value of event mask V158		0
E35	Output signal AR3 activated	1	1
E36	Output signal AR3 reset	2	0
E37	Start of intermittent earth-fault protection	4	1
E38	Operation of intermittent earth-fault protection	8	1
E39	Start of intermittent earth-fault protection reset	16	0
E40	Operation of intermittent earth-fault protection reset	32	0
	Default value of event mask V159		13
E50	Restarting of microprocessor		
E51	Overflow of event register		
E52	Temporary disturbance in data communication		
E53	The relay module does not respond over the data bus.		
E54	The module responds again over the data bus		

The event codes E50...E54 and the events represented by these are always included in the event reporting. The event codes E52...E54 are generated by the control data communicator (e.g. SRIO 1000M).

Data to be transferred over the serial bus

In addition to the event codes input data (I data), output data (O data), setting values (S data) memorized data (V data), and some other data can be read from the module over the serial bus. The values of parameters marked with the letter W can be changed over the SPA bus.

When a setting value is to be changed, either via the push-buttons on the front panel or over the serial bus, the relay module checks whether the given parameter value is legal. A value outside the permitted setting range will not be memorized, in which case the previous setting will be retained.

To change a setting parameter over the serial bus a password in the range 1..999 will, generally, be needed. The default setting is 1.

The password is opened by giving the serial communication parameter V160 the desired numerical value. The parameter V161 is used for closing the password. The password is also closed when there is a failure in the voltage supply.

The push-buttons of the relay module or a command given over the serial bus can be used for changing the password. To be able to change the password over the serial bus, the password first has to be opened. The new password is entered using the parameter V161. When the push-buttons are used, the new password is written over the old one in subregister 3 of register A.

R = data to be read from the module
W = data to be written to the module
(P) = writing allowed through a password

Input data

The parameters I1...I5 can be used for reading measured values (R) and status data of external control signals. The value of parameter I5 is formed by the sum of the weighting values (in paranthesis) of the active signals.

Parameter	Data	Direction of data	Values
I1	Residual voltage U_0	R	0...210% x U_n
I2	Neutral current I_0	R	0...140% x I_n
I3	Phase angle between U_0 and I_0	R	0...180°
I4	Noise level U_{tr} of residual voltage	R	0...6% x U_n
I5	Control signal RRES	R	0 = no control signal 1 = signal active (4)
	Control signal BS1	R	0 = no control signal 1 = signal active (16)
	Control signal BS2	R	0 = no control signal 1 = signal active (32)
	Control signal BACTRL	R	0 = no control signal 1 = signal active (1)

The O parameters provide information about the status of the protection stages or the output signals. The value of an individual signal is 0, if the signal is inactive. When the signal has been activated, the value is 1. Each value of the parameters O1...3 is formed by the sum of the weighting values of the active signals.

Parameter	Protection stage/operation	Data direction	Values	Weight value
O1	I_0> start signal	R	0=signal not active 1=signal activated	1
	I_0> trip signal	R	0=signal not active 1=signal activated	2
	I_0>>/U_{02}> start signal	R	0=signal not active 1=signal activated	4
	I_0>>/U_{02}> trip signal	R	0=signal not active 1=signal activated	8
	I_{tr}> start signal	R	0=signal not active 1=signal activated	16
	I_{tr}> trip signal	R	0=signal not active 1=signal activated	32
O2	U_{01}> start signal	R	0=signal not active 1=signal activated	1
	U_{02}> start signal	R	0=signal not active 1=signal activated	2
O3*)	Output signal SS1	R,W(P)	0=signal not active 1=signal activated	1
	Output signal TS1	R,W(P)	0=signal not active 1=signal activated	2
	Output signal SS2	R,W(P)	0=signal not active 1=signal activated	4
	Output signal TS2	R,W(P)	0=signal not active 1=signal activated	8
	Output signal SS3	R,W(P)	0=signal not active 1=signal activated	16
	Output signal TS3	R,W(P)	0=signal not active 1=signal activated	32
	Output signal SS4	R,W(P)	0=signal not active 1=signal activated	64
	Output signal TS4	R,W(P)	0=signal not active 1=signal activated	128
O4	Start signal AR3	R,W(P)	0=signal not active 1=signal activated	1
O5	Permission for remote control of output signals	R,W(P)	0=not enabled 1=enabled	1

*) The trip signals TS1...4 must not be subject to self-holding, i.e. the switch SGF1/8 has to be 0. The switches SGF1/4...7 have to be in position 0, i.e. manual resetting has not been selected for the output signals SS1...4. Parameter O3 does not necessarily indicate the status of the output signal (if the output signal has been activated by a protection stage).

Setting values

Setting	Actual values (R)	Main setting values (R,W,P)	Second setting values (R,W,P)	Setting range
Start value of stage U_{01}>	S1	S36	S71	2.0...80% x U_n
Start value of stage U_{02}>	S2	S37	S72	2.0...80% x U_n
Start value of stage I_0>	S3	S38	S73	1.0...100% x I_n
Operate time t_0> of stage I_0>	S4	S39	S74	0.1...300 s
Start value of stage I_0>>	S5	S40	S75	1.0...100% x I_n
Operate time t_0>> of stage I_0>>/U_{02}>	S6	S41	S76	0.1...300 s
Capacitive current I_c of background network	S10	S45	S80	3.0...100% x I_n
Triggering level U_{tr}> of transient protection	S11	S46	S81	0.2...6.0% x U_n
U_{03}> criterion of transient protection/ intermittent earth-fault protection	S12	S47	S82	2.0...80% x U_n
Operate time t_{tr} of transient protection/ intermittent earth-fault protection	S13	S48	S83	0.5...300 s
Integration time t_{int} of transient protection	S14	S49	S84	0.6...3.0 ms
Checksum, SGF1	S15	S50	S85	0...255
Checksum, SGF2	S16	S51	S86	0...255
Checksum, SGF3	S17	S52	(S87)*)	0...255
Checksum, SGB1	S18	S53	S88	0...255
Checksum, SGB2	S19	S54	S89	0...255
Checksum, SGB3	S20	S55	S90	0...255
Checksum, SGR1	S21	S56	S91	0...255
Checksum, SGR2	S22	S57	S92	0...255
Checksum, SGR3	S23	S58	S93	0...255
Checksum, SGR4	S24	S59	S94	0...255
Checksum, SGR5	S25	S60	S95	0...255
Checksum, SGR6	S26	S61	S96	0...255

*) Only main settings effective

Note! Settings cannot be changed if the protection is active.

Measured and stored parameter values

Value measured	Code	Data direction	Values
Number of starts, U_{01}>	V1	R	0...255
Number of starts, stage I_0>	V2	R	0...255
Number of starts, stage I_0>> / U_{02}>	V3	R	0...255
Number of starts, U_{02}>	V4	R	0...255
Number of triggerings, transient measuring protection	V5	R	0...255
Number of starts, transient measuring protection/ intermittent earth-fault protection	V6	R	0...255
Operation indicator	V7	R	0...9

The parameters V11...V56 can be used to read (R) the five latest values stored in the registers. Event n = is the most recent value recorded, event n-1 = the value before that, and so on.

Value measured	Event					Measuring range
	n	n-1	n-2	n-3	n-4	
Residual voltage U_0 (register 1)	V11	V21	V31	V41	V51	0...210% x I_n
Neutral current I_0 (register 2)	V12	V22	V32	V42	V52	0...140% x I_n
Phase angle φ (register 3)	V13	V23	V33	V43	V53	0...±180°
Duration of start situation, stage I_0> (register 4)	V14	V24	V34	V44	V54	0.1...300 s
Duration of start situation, stage I_0>>/U_{02}> (register 5)	V15	V25	V35	V45	V55	0.1...300 s
Capacitive current I_c (register 6)	V16	V26	V36	V46	V56	0...140% x I_n

Control parameters

Data	Code	Data direction	Values
Resetting of front panel indicators and latched output relays	V101	W	1 = resetting
Resetting of front panel indicators, latched output relays and registers	V102	W	1 = resetting
Remote control of settings	V150	R,W	0 = main settings active 1 = second settings active
Recording of set values in EEPROM	V151	W	1 = recording speeded up
Write command required for speeding up operation		R	0 = settings not recorded 1 = settings recorded in block 1 (recording takes 30 seconds) 3 = settings recorded and EEPROM checked
Event mask for the operation of stages U_{01}> and I_0>	V154	R,W	0...255, see "Event codes"
Event mask for the operation of stages U_{02}> and I_0>>	V155	R,W	0...255, see "Event codes"
Event mask for the operation of the transient measuring earth-fault protection	V156	R,W	0...255, see "Event codes"
Event mask for the activation of output signals	V157	R,W	0...255, see "Event codes"
Event mask for resetting of output signals	V158	R,W	0...255, see "Event codes"
Event mask for the AR3 signal and the intermittent earth-fault protection	V159	R,W	0...255, see "Event codes"

Data	Code	Data direction	Values
Opening of password for remote setting	V160	W	1...999
Changing or closing the password for remote setting	V161	W(P)	0...999
Activation of self-supervision input	V165	W	1 = self-supervision input is activated and IRF LED is lit
Data communication address of relay module	V200	R,W	1...899
Data transfer rate	V201	R,W	4.8 or 9.6 kBd
Program version symbol	V205	R	102_
Reading of event register	L	R	Time, channel number and event code
Re-reading of event register	B	R	Time, channel number event code
Type designation of relay module	F	R	SPCS 2D32
Reading of module status data	C	R	0 = normal status 1 = module been subject to automatic reset 2 = overflow of event register 3 = events 1 and 2 together
Resetting of module status data	C	W	0 = resetting
Time reading or setting	T	R,W	00.000...59.999 s

The event register can be read only once using the L command. Four events at a time can be read. 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 transfers 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 a permanent fault, the IRF LED on the front panel of the module is lit, and at the same time the normally operated signal relay of the self-supervision system drops off.

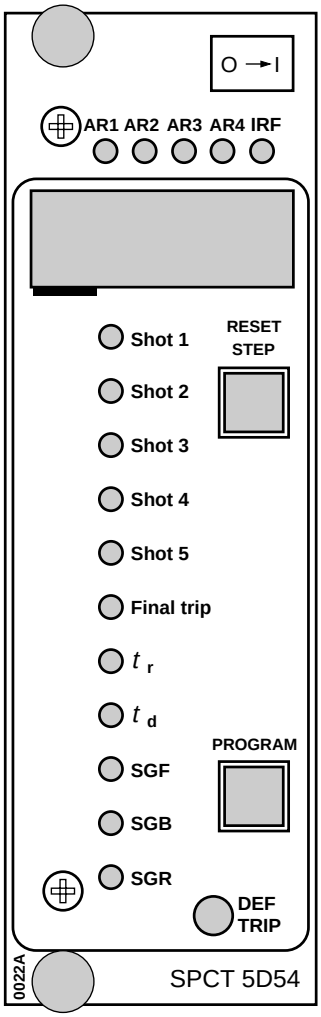
In most fault situations a fault code appears on the the display of the relay module. The fault code cannot be reset. It consists of a red digit one (1) to the left and a green code number that indicates the fault type. The fault code should be recorded and stated when service is ordered.

The fault codes of the earth-fault relay module are explained in the following table:

Fault code	Explanation
1...3	Faulty working memory (RAM)
4...6	Faulty program memory (ROM)
7...9	Faulty parameter memory (EEPROM)
10	Relay control circuit faulty or missing
12...20	A/D converter faulty

SPCT 5D54
Auto-reclose relay module

User´s manual and Technical description



1MRS 750095-MUM EN

Issued 95-05-05
Modified 96-12-16
Version C (replaces 34 SPCT 7 EN1)
Checked TK
Approved TK

Data subject to change without notice

SPCT 5D54
Auto-reclose relay module

Contents

Features

From one to five successive auto-reclose (AR) shots selectable

Three internal AR initiation lines from the overcurrent and earth-fault stages

One external AR initiation line

Auto-reclosing initiated by start and trip signals

Final tripping by the protection or by the auto-reclose module after a preset time delay

Circuit breaker control over serial port and optical bus

Digital display of setting values and recorded values

Setting values to be entered via front panel push-buttons or a PC

Continuous self-supervision including both software and hardware

At an internal fault the self-supervision system relay operates and the outputs of the module are blocked

Application

The majority (about 80-85%) of MV overhead line faults are transient and are automatically cleared by momentarily deenergizing the line. The rest of the faults (15-20%) can be cleared by longer interruptions. Deenergizing of the fault place for the desired period of time is implemented by auto-reclose relays. Auto-reclose relays are capable of clearing most of the faults. At a permanent fault auto-reclosing is followed by final tripping. A permanent fault has to be located and cleared before the fault location can be reenergized.

The auto-reclose module SPCT 5D54 can be used for auto-reclosing together with any circuit breaker suitable for auto-reclosing. The module provides five programmable auto-reclose shots which can perform from one to five successive auto-reclosures of desired type and duration, for instance, one high-speed and one delayed auto-reclosure. When reclosing is initiatiated by start of the protection, the auto-reclose module is capable of tripping the circuit breaker finally in a short operate time, if the fault still persists when the last reclosure selected has been carried out.

Fig. 1 illustrates a typical auto-reclose situation, where one auto-reclose shot has been performed after the fault was detected. In case a) the auto-reclose shot is initiated by a start signal of the protection, after the start delay time has elapsed. In case b) the auto-reclose shot is initiated by a trip signal of the protection. In both cases the auto-reclose sequence was successful.

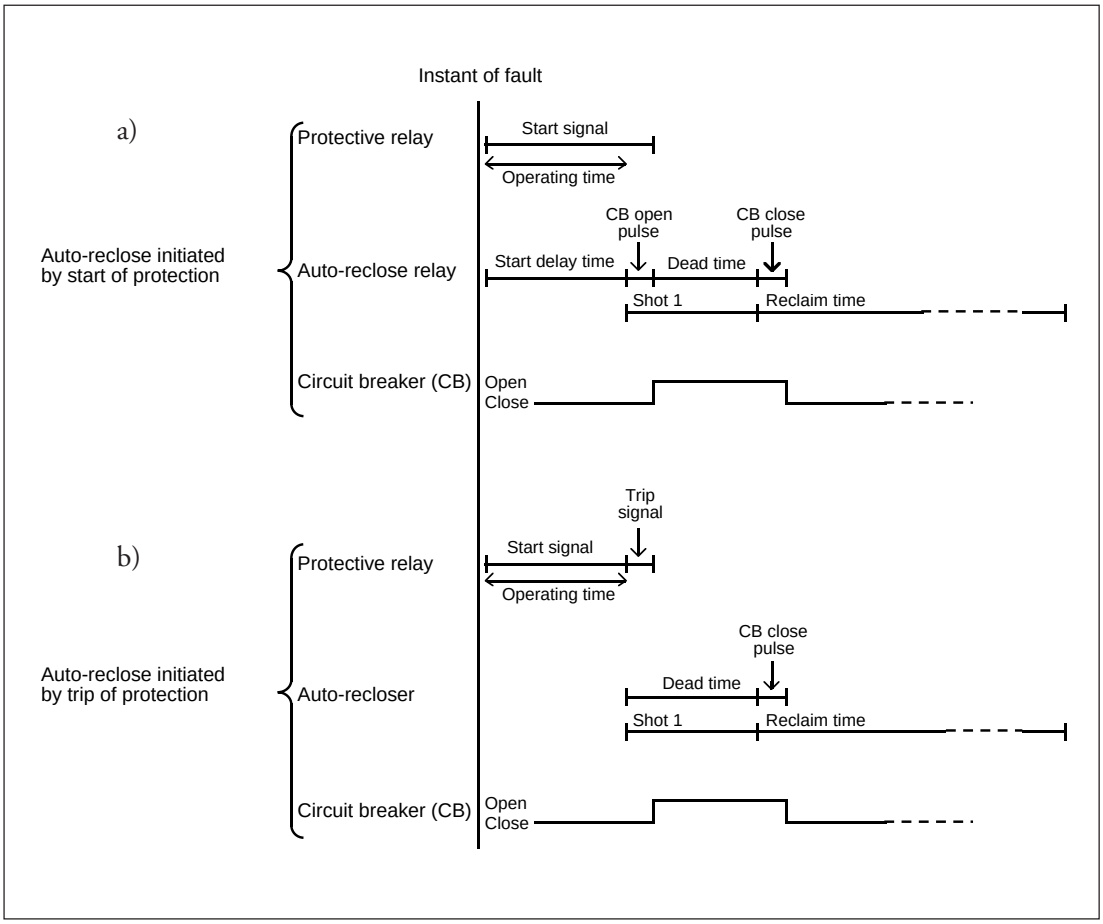


Fig. 1. Signal scheme illustrating the auto-reclose operation

Block schematic diagram

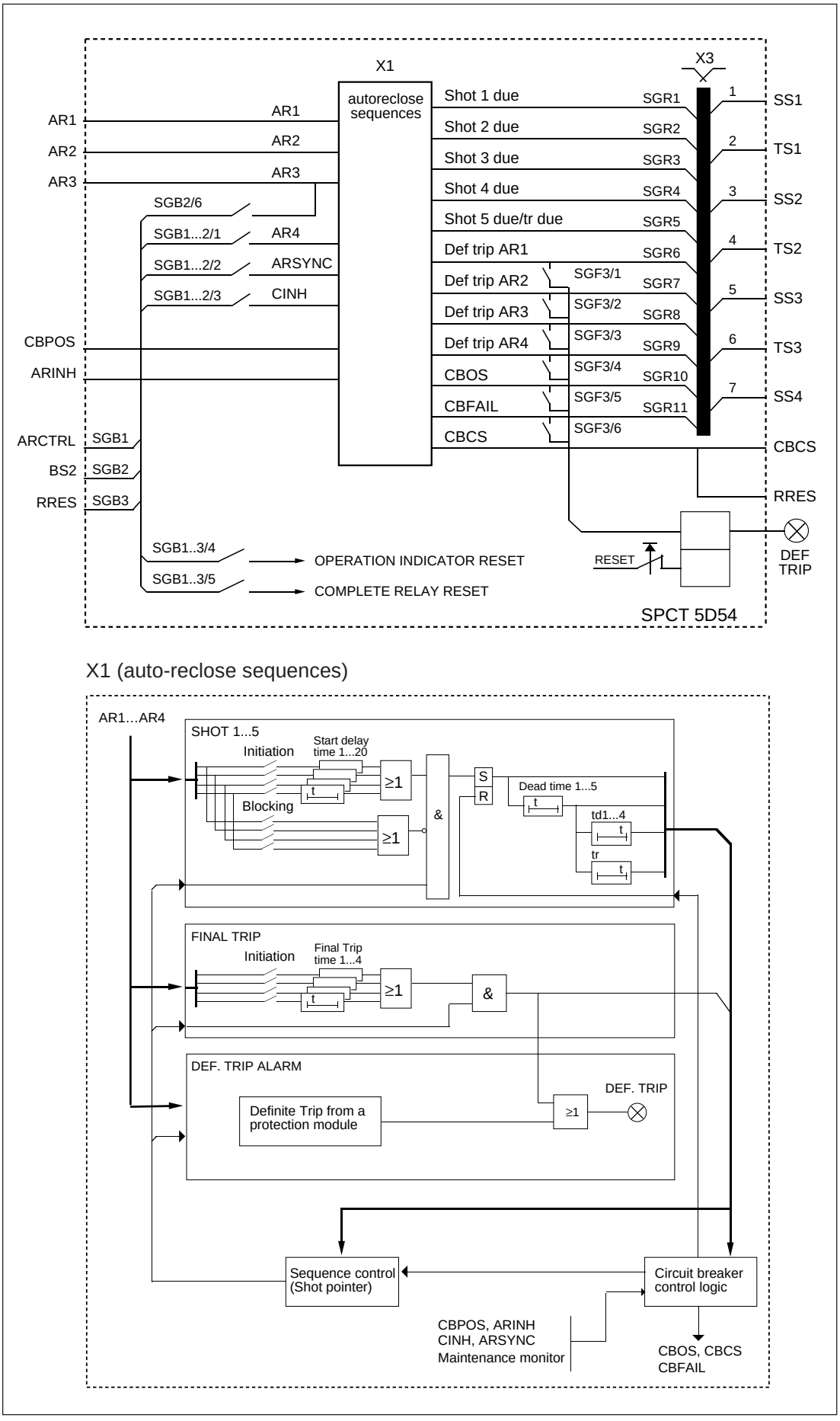


Fig. 2. Simplified block diagram for auto-reclose relay module SPCT 5D54

AR initiation signals

AR1	Internal AR initiation line from protection relay modules
AR2	Internal AR initiation line from protection relay modules
AR3	Internal AR initiation line from protection relay modules
AR4	AR initiation line via an external control input

AR control signals

CBPOS	Circuit breaker position signal (energized = open)
ARINH	Signal for AR interruption and inhibition
ARCTRL	External AR control signal, to be configured with the SGB1 switches
BS2	External AR control signal, to be configured with the SGB2 switches
RRES	Internal AR reset signal, to be configured with the SGB3 switches
ARSYNC	External signal for AR synchrocheck (energized = enabled)
CINH	External signal for blocking of CB closing (energized = blocked)

Output signals to be configured

SHOT1DUE	Signal "AR shot 1 due"
SHOT2DUE	Signal "AR shot 2 due"
SHOT3DUE	Signal "AR shot 3 due"
SHOT4DUE	Signal "AR shot 4 due"
SHOT5DUE	Signal "AR shot 5 due"
DEFTRIP AR1	Signal "AR failed or final trip by AR1"
DEFTRIP AR2	Signal "AR failed or final trip by AR2"
DEFTRIP AR3	Signal "AR failed or final trip by AR3"
DEFTRIP AR4	Signal "AR failed or final trip by AR4"
CBOS	Signal for CB opening (tripping)
CBFAIL	Signal "CB opening or closing failed"

Output relays

SS1...SS4	Signal relays
TS1...TS3	Heavy-duty relays, one-pole CB control
CBCS	Heavy-duty relay, two-pole CB closing

Configuration switches

SGF	Switchgroup for configuring the functions
SGB	Switchgroup for configuring the control inputs
SGR	Switchgroup for configuring the output signals

Explanation of abbreviations used

AR	Auto-reclosing
CB	Circuit breaker
AR_	Auto-reclose initiation lines AR1...AR4
CBOS	Signal for circuit breaker opening (tripping)
CBCS	Signal for circuit breaker closing (CB close signal)
CBFAIL	Signal for circuit breaker failure
Def trip	Alarm for definite tripping
t_r	Reclaim time
t_d	Discriminating time

Description of operation

AR shots and final trip function

The operation of the auto-recloser is illustrated in Figure 3. The shot pointer indicates the shot to start when the auto-reclose module receives its AR initiation signal through one of the initiation lines AR1...AR4. The boxes beneath the initiation lines AR1...AR4 determine the action to be taken when an auto-reclose initiation signal is received. Start means that an auto-reclose shot is initiated, block means that the autoreclose shot is prevented when the initiation signal is active. Dash means that no action will be taken.

The programmable start delay associated with the boxes in the gray area is activated, if the auto-reclose shot is initiated by the start signal of a protection stage (selected with SGF1). After the start delay the circuit breaker is opened by the auto-reclose module. When the auto-reclose shot is initiated from the trip signal of the protection, a protective relay module trips the circuit breaker and initiate the AR shot simultaneously.

The AR shots start from tripping of the circuit breaker and the dead time of the shot is started. When the dead time has elapsed, the circuit breaker is closed and simultaneously reclaim and discrimination time starts running. A new initiation signal received during the discrimination time will inhibit further AR shots and the shot pointer moves to stage (6). An auto-reclose request during the reclaim time will increase the shot pointer and performs the function selected. If not, the shot pointer moves down to the stage (7). At this point the AR module is locked-out during the reclaim time, after which the shot pointer is reset and the module is prepared for a new AR sequence.

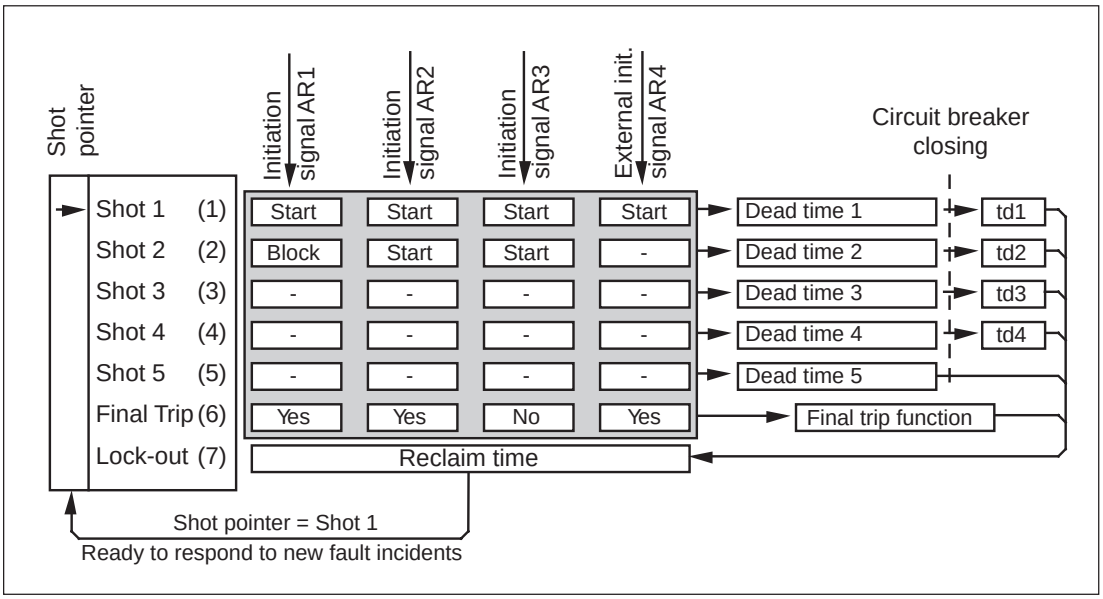


Fig. 3. Functional diagram for the auto-reclose relay module SPCT 5D54

Setting instructions

All settings are made using the front mounted push buttons or via the serial interface with the SPA parameters. The relay operating sequence can be determined by using the gray area in the figure above. The text in the boxes are then converted to numbers as follows: Dash (-)=0, Start=1, Block=2, Yes=1 and No=0.

Example, make the settings for shot 2 with push buttons:

1) the text in the boxes of shot 2 converted to numbers is 2,1,1,0
2) press the push button STEP until the indicator "shot 2" is lit.
3) set the value 211 in the main menu
4) set the value 0 in the first submenu of shot2

The dead time of the shot is set in the second submenu and the submenus 3...6 contains the start delay settings. Detailed examples of push-button operations is contained in section Settings and Examples of push-button operations in General characteristics of D-type SPC relay modules.

When making the same setting via the serial communication each box is represented by a SPA parameter (2S2=2, 2S3=1, 2S4=1 and 2S5=0).

Initiation of auto-reclosing

The protective stages to initiate or block the AR functions are selected with SGF switches of the protective relay modules. See sections "auto-reclose initiation signals" in the userguides of the protective relay modules.

The start of the AR shots are subject to the following conditions:

1) An AR shot of a value smaller than that indicated by the shot pointer cannot be started
2) An initiation signal (AR1...4) has to be active and the corresponding setting has to be Start.
3) No initiation signal that inhibits (Block) the shot must be active
4) Should a start delay have been set for the AR shot (rf. Auto-reclose shot initiated by a start signal of a protection relay module), the initiation signal still has to be active when the start delay elapses, to enable initiation of the AR shot.

Example (see Figure 3):
The initiation signals AR1 and AR2 are assumed to be activated when the value of the shot pointer is 2 (AR shot 1 has just been made). AR shot 2 would be the next one to start, but it is blocked by AR1. The AR shots 3...5 have not been configured to be initiated by either signal, but the final trip function (6) has. So the next operation will be final tripping.

Auto-reclose shot initiated by a trip signal

An AR shot initiated by a trip signal of the protection (SGF1/1...5 = 0) starts immediately. The circuit breaker is then opened by a protection relay module.

Auto-reclose shot initiated by a start signal

A start delay can be set to delay the start of an AR shot. Separate start delays can be set for each box in the gray area in Figure 3.

When the AR shot is to be initiated by the start signal of the protection (SGF1/1...5=1), the circuit breaker is opened by the auto-reclose module as soon as the start delay time of the concerned AR shot has elapsed. The value zero can also be selected for the start delay.

What is important for the start delay is that the corresponding initiation signal remains active throughout the time. Should the initiation signal reset the time delay starts from zero again. The use of another initiation signal for blocking the start of an AR shot does not influence the time delay.

In the example in Fig. 4 input AR2 has a starting function and AR1 an blocking function. In case a) momentary activation of input AR1 does not influence the start of the AR shot, nor the start delay. The input AR1 used for blocking in case b) remains active for a longer time than the start delay of AR2. The AR shot is started 50 ms after the blocking via AR1 is reset.

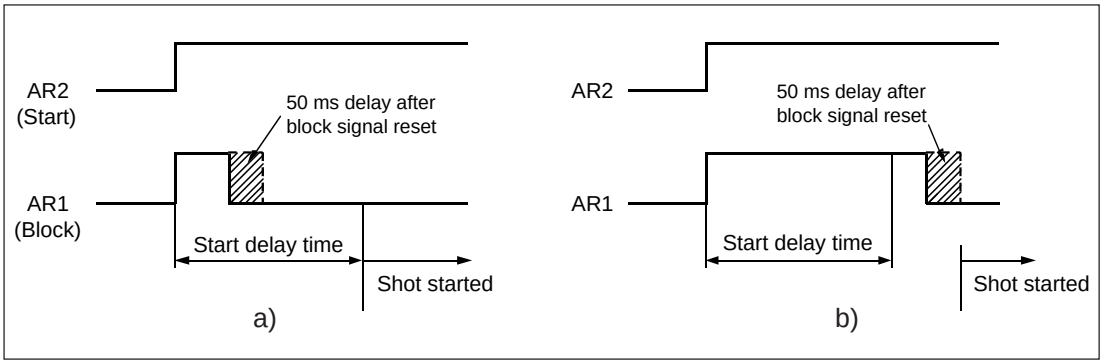


Fig. 4. Examples of AR initiation

Auto-reclose shot blocked by an initiation signal

An auto-reclose shot can be blocked by e.g. a high-set overcurrent stage. If an activation of initiation line AR1 is selected to block shot 1 it means that shot 1 is blocked as long as the initiation line AR1 is activated. However shot 2, 3, 4, 5 or the final trip function can be initiated. The block function does not increase the value of the shot pointer so if no shot or final trip can be initiated the AR module will wait until the block signal is reset or that the protection performs definite tripping.

Discriminating time and reclaim time

When the circuit breaker is closed by the AR shots 1...4, a discriminating time t_d will be started. Should one of the initiation signals AR1...AR4 be activated during the discriminating time, the AR shot pointer moves to the value (6). Then further AR shots are prevented and definite tripping will follow. This function is generally used at inverse time operation in order to limit the number of auto-reclosures when reclosing aggravates a fault situation further (the operate time of the relay module shortens). The discriminating time t_d can be set out of use by selecting the value 0.

The reclaim time is always started or restarted at the circuit breaker close operation. A new initiation signal during the reclaim time will perform the next shot if selected. When all shots are executed the auto-recloser is locked-out. When the reclaim time has elapsed the lock-out situation is ended and the shot pointer return to its original value (1).

Final trip function (6)

Definete tripping of the circuit breaker can be carried out by a trip signal of the protection or by the final trip function (6) of the auto-reclose module. The final trip function (6) has to be initiated by the start of the protection and allows final CB tripping to be carried out in a shorter time than the operate time of the protective relay module. In this case the fault is most probably of a permanent nature, and waiting for the protection relay to trip might aggravate the damage further. For the final trip function (6) the desired trip time can be selected separately for the initiation signals.

DEF.TRIP alarm

The purpose of the DEF.TRIP alarm is to give an alarm when, after tripping of the CB, further auto-reclosures are prevented.

A DEF TRIP alarm signals is given:
- when the final trip function (6) has operated
- when a protection relay module has tripped (the circuit breaker was opened, an initiation signal was active and no auto-reclosing was started)
- if one of the initiation signals AR1...4 remains active for more than two minutes

The alarm signal remains active until the fault disappears. However, the duration of the alarm signal is always at least 0.2 s. Four different output signals are available: one for each initiation signal. Thus it is possible to distinguish between the alarms, for instance, those caused by earth fault and those caused by short circuit. Should several initiation signals be active at the same time, only one alarm signal will be given (the smallest in number). If, for example, AR2 and AR4 are active at the moment of tripping the alarm signal is provided by "DEF.TRIP AR2".

Should the circuit breaker position status input CBPOS not be in use and final tripping is to be carried out by the protection, special arrangements are required. In this case the CBPOS input is connected in parallel with the opening coil of the circuit breaker (SGF2/7=1 and SGF2/8=1). Then the auto-reclose module gets information about the CB opening via the CBPOS input and uses this information to generate a DEF.TRIP alarm signal.

Lock-out

When the last shot or the final trip function (6), has been carried out, the shot pointer indicates the value LOCK-OUT (7), which means that the auto-reclose module does not respond to any initiation signal during the reclaim time. In addition, the shot pointer indicates the value (7) in the following situations:
- the circuit breaker operation failed
- the circuit breaker maintenance monitor is zero (determined by the setting of SGF2/7)
- the circuit breaker is manually closed during an auto-reclose sequence
- the circuit breaker is manually closed under normal conditions (determined by the setting of SGF1/6...7)
- the external input for inhibiting and interrupting auto-reclosing (ARINH) is active
- the auto-reclose programme has been set out of operation

When the signal or situation that resulted in lock-out resets the reclaim time t_r starts. When the set reclaim time t_r has elapsed the shot pointer returns to the value (1).

Interruption of auto-reclosing

An auto-reclose sequence (AR shots 1...5) can be interrupted or is interrupted in the following cases:
- the opening or closing of the circuit breaker fails (CBPOS input does not change status)
- the CB status data changes from "open" to "closed" during the dead time of the auto-reclosure, for example, due to manual closing of the circuit breaker
- the ARINH input is activated
- the circuit breaker is opened by remote control (parameter V1)
- the auto-reclose program is set out of use
- the auxiliary voltage supply to the relay is interrupted or the internal self-supervision system of the AR module detects a fault.

In all the cases mentioned above specified information about the cause of the interruption can be obtained over the serial communication system.

Circuit breaker supervision logic

When the auto-reclose module operates the circuit breaker, it also checks that the state of the CB position input changes properly during the set pulse lenght. To be able to check the position data the auto-reclose module needs information about the position of the circuit breaker (CBPOS). When required, the auto-reclose module is able to operate without this information. In such a case the control operations are not supervised, i.e. whether they are successful or not.

For the operation of the circuit breaker the length of the open pulse and the close pulse of the module is adjustable. These times are maximum times. If no CB position information is available the control impulses are in accordance with the setting. Open and close signals cannot be active at the same time. If so, the open signal interrupts the close signal. When CB position information is available, the impulse is interrupted, once the CB position has changed. Should the circuit-breaker position remain unchanged during the control operation a circuit breaker fail alarm will be issued (CBFAIL).

In addition, the following conditions are checked before the circuit breaker is closed:
- the circuit breaker is open
- the AR initiation signals AR1...4 are not active
- the close inhibit input CINH is not energized
- the value of the circuit breaker maintenance monitor must be greater than zero, if SGF2/6=1.
- if the synchrocheck function is in use, the input ARSYNC has to be energized

Once the conditions mentioned above are fulfilled the circuit breaker is closed. The maximum waiting time for the conditions to be fulfilled is 2 seconds. Should one or several conditions prevent closing, an alarm signal CBFAIL will be given in 2 seconds.

Aids to circuit breaker maintenance

The purpose of the maintenance monitor is to provide an alarm signal or, possibly, prevent closing of the circuit breaker after a certain number of CB operations. The operation of the maintenance monitor is based on counting the number of times the circuit breaker has opened. As soon as the auto-reclose module notices a circuit breaker trip the value of the maintenance monitor decreases.

Different load on the circuit breaker influences the maintenance monitor in a different way, for instance, overcurrent may have a weighting factor of 20 and manual CB opening a weighting factor of 1, which means that the monitor value is decreased by 20 or 1, respectively. The auto-reclose module has five weighting factors: opening initiated by AR1, by AR2, by AR3, by AR4, and manual control. The weighting factors can be set in the range 0...50.

When the maintenance monitor reaches the value zero, a permanent CBFAIL alarm signal is issued. The maintenance monitor can be so configured (SGF2/6) that the value zero prevents CB closing and auto-reclose operations. The alarm is reset by giving the maintenance monitor a new value.

In addition, a pre-alarm level can be set for the maintenance monitor. When the monitor reaches this level or falls below it, a pulse-shaped CBFAIL alarm signal is given when the CB is opened. The pre-alarm function can be set out of use by choosing the setting value zero (0) for it.

The maintenance monitor can be set out of use by setting all weighting factors at zero.

CBFAIL alarm

The CBFAIL alarm is a 0.2 s pulse that is obtained when a CB operation fails or the maintenance monitor reaches or falls below the set pre-alarm level. A possible auto-reclose sequence in progress is interrupted by unsuccessful circuit breaker operation.

Synchrocheck input ARSYNC

The ARSYNC input is used, for example, to delay or to avoid the connection of transmission lines fed from different directions, when the phase angle difference of the network sections is too large. Should there be no information about synchronism within 2 seconds after the dead time has elapsed, the auto-reclose sequence will be locked out and a CBFAIL alarm will be issued.

When the ARSYNC input is activated (energized) the synchronism condition is fulfilled.

The switches SGF2/1...5 can be used to specify whether information about synchronism is required for the individual AR shots. If the dead time is short, the circuit breaker can be closed without synchronism being lost.

Inhibition of circuit breaker closing CINH

Activation of the CINH input prevents CB closing in situations where the CB spring is not charged or the gas pressure is below the permitted level. When the CINH input is activated (energized), CB closing is inhibited. If the CINH input is not reset within two seconds after the dead time has elapsed, the auto-reclose sequence will be locked out and a CBFAIL alarm will be issued.

AR inhibition and interruption input ARINH

When the ARINH input is activated any auto-reclose operation in progress will be locked out. When the ARINH signal disappears a reclaim time t_r starts, and not until this time has elapsed an auto-reclose sequence can be carried out.

Recording of auto-reclose operations

The auto-reclose module records all shots made and also successful auto-reclosures. Registers containing information about the number of successful auto-reclosures can be accessed over the serial communication and over the event reporting system. The auto-reclose module decide if the auto-reclosure (the last AR shot) was successful or not when the reclaim time t_r has elapsed.

Registers containing information about the number of all shots made can be accessed via the push-buttons or over the serial communication.

Resetting

The operation indicators on the front panel of the relay module, the operation codes on the display and the registers can be reset via the front panel push-buttons, an external control signal or over the serial bus, as shown in the table below.

Means of resetting	Resetting of operation indicators	Resetting of registers
RESET	x	
PROGRAM	x	
RESET & PROGRAM	x	x
External control signal ARCTRL, BS2 and RRES, when		
SGB_/4=1	x	
SGB_/5=1	x	x
Parameter V101	x	
Parameter V102	x	x

Front panel

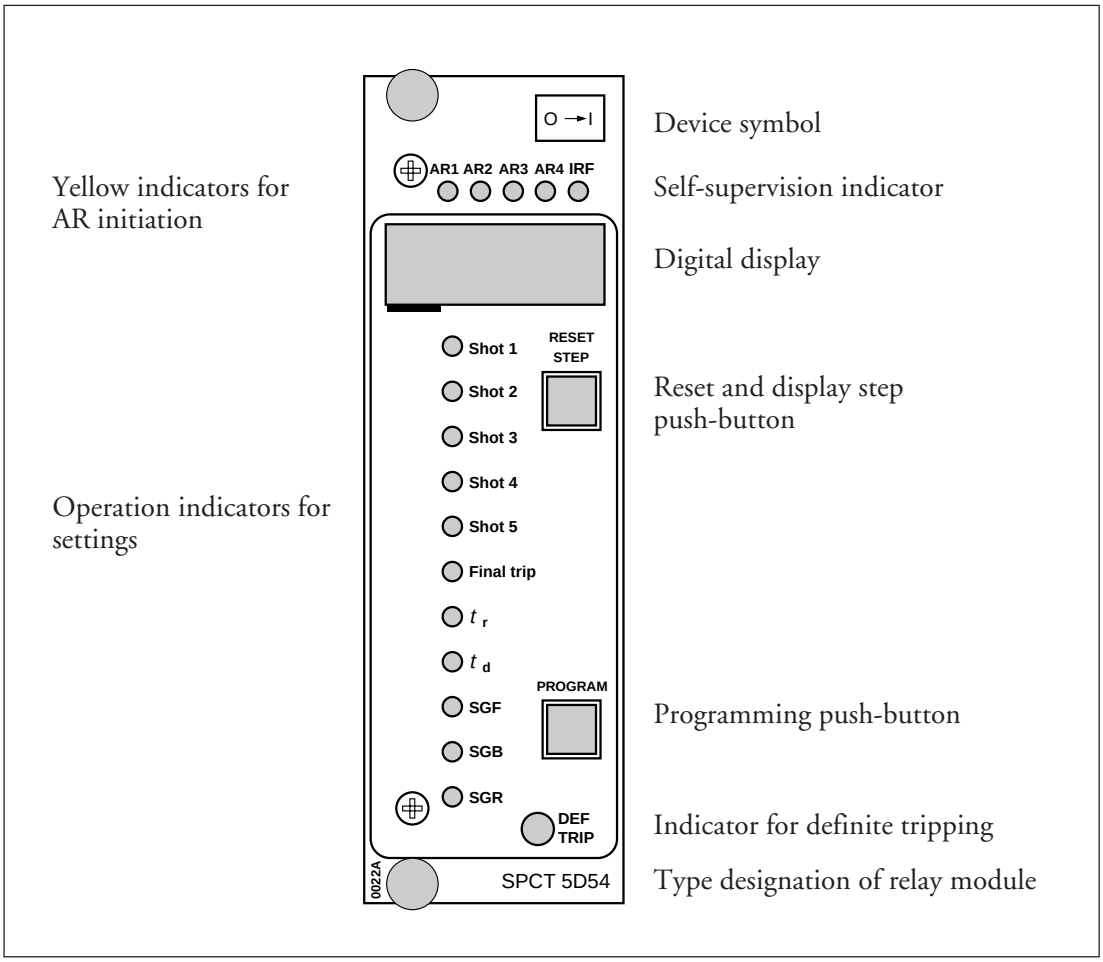


Fig.5. Front panel of auto-reclose module SPCT 5D54

Operation indicators

The auto-reclose module is provided with a programmable DEF.TRIP operation indicator. Normally, the operation indicator is lit, if the last AR shot selected is unsuccessful. The operation indicator remains lit until reset, either via the push-buttons on the front panel, an external control command or over the serial bus.

The yellow LEDs above the digital display show the AR line that caused the operation. The LEDs are reset by the initiation of a new shot or when the reclaim time elapses.

The left-most red figure on the display is also used for operation indication. The indications A1...A6 can be manually reset. Unless reset they disappear as soon as the next AR shot starts. The other indications are always automatically reset.

Indication	Explanation	Resetting
1	AR shot 1 in progress	automatic resetting
2	AR shot 2 in progress	automatic resetting
3	AR shot 3 in progress	automatic resetting
4	AR shot 4 in progress	automatic resetting
5	AR shot 5 in progress	automatic resetting
6	Final trip activated	automatic resetting
7	Discriminating time running	automatic resetting
8	Reclaim time running	automatic resetting
A1	CB opening failed	automatic or manual reset
A2	CB closing failed	automatic or manual reset
A3	Closing inhibited after AR (ASYNC, CINH)	automatic or manual reset
A4	Pre-alarm signal from maintenance monitor	automatic or manual reset
A5	Alarm signal from maintenance monitor	automatic or manual reset
A6	AR initiating signal active > 2 minutes	automatic or manual reset

Once the self-supervision system has detected a permanent fault the red self-supervision alarm indicator is lit. At the same time the relay module delivers a control signal to the self-supervision output relay of the protection assembly. In addition, in most cases a fault code is lit on the display of the module. This fault code that consists of a red "1" and a green code number indicates the nature of the fault and cannot be reset. It should be recorded and stated when service is ordered.

Settings

The settings of the module can be entered either via the push-buttons and the display on the front panel or over the serial communication system. The setting values are indicated by the three digits to the right on the display. The LED indicators in front of the setting value symbols on the front panel indicate the group of settings or the setting value displayed at a given moment. Manual setting of the module is described in "Main menu and submenus of settings and registers".

Setting	Description	Setting range (Default value)
Shot 1	Selection of operation mode for signals AR1...3: AR1 (the third digit from the right) AR2(the second digit from the right) AR3 (the right-most digit) 0 = no operation 1 = Initiation of AR shot 1 (Start) 2 = Initiation of AR shot 1 inhibited (Block) 1st submenu: Selection of the operation mode for signal AR4 (the right-most digit): 0 = no operation 1 = Initiation of AR shot 1 (Start) 2 = Blocking of AR shot 1 (Block) 2nd submenu: Dead time of AR shot 1 Start delay time 3rd submenu: - for initiation signal AR1 4th submenu: - for initiation signal AR2 5th submenu: - for initiation signal AR3 6th submenu: - for initiation signal AR4	0...2 0...2 0...2 (000) 0...2 (--0) 0.2...300 s (5 s) 0...10 s (0 s) 0...10 s (0 s) 0...10 s (0 s) 0...10 s (0 s)
Shot 2	See shot 1	
Shot 3	See shot 1	
Shot 4	See shot 1	
Shot 5	See shot 1	

Setting	Description	Setting range (Default value)
Final trip	Selection of operation mode for signals AR1...3: AR1 (the third digit from the right AR2(the second digit from the right) AR3 (the right-most digit) 0 = no final trip signal from the AR module (No) 1 = final trip signal from the AR module (Yes)	0...1 0...1 0...1 (000)
	Submenu 1: Selection of operation mode for signal AR4 (the right-most digit): 0 = no final trip signal from the AR module (No) 1 = final trip signal from the AR module (Yes)	0...1 (--0)
	Operate time of final tripping when 2nd submenu: - initiated by signal AR1 3rd submenu: - initiated by signal AR2 4th submenu: - initiated by signal AR3 5th submenu: - initiated by signal AR4	 0...5.0 s (0 s) 0...5.0 s (0 s) 0...5.0 s (0 s) 0...5.0 s (0 s)
t_r	Reclaim time	0.2...300 s (10 s)
	1st submenu: Lenght of CB closing signal 2nd submenu: Lenght of CB opening signal Note! The control signals are interrupted once information about change in CB position is received	 0.1...2.0 s (0.2 s) 0.1...2.0 s (0.2 s)
t_d	Discriminating time of AR shot 1 1st submenu: Discriminating time of AR shot 2 2nd submenu: Discriminating time of AR shot 3 3rd submenu: Discriminating time of AR shot 4	0...30 s (0 s) 0...30 s (0 s) 0...30 s (0 s) 0...30 s (0 s)
	Switchgroups See "Configuration switchgroups" for more details	
SGF	Switchgroups for the configuration of functions	0...255
SGB	Switchgroups for the configuration of blocking and control signals	0...255
SGR	Switchgroups for the configuration of the output relays	0...255
	Maintenance monitor	
1	Stress factor for CB opening - manual operation 1st submenu: - initiated by signal AR1 2nd submenu: - initiated by signal AR2 3rd submenu: - initiated by signal AR3 4th submenu: - initiated by signal AR4	 0...50 (0) 0...50 (0) 0...50 (0) 0...50 (0) 0...50 (0)
2	Value of CB maintenance monitor	0...999 (999)
	1st submenu: Pre-alarm level	 0...50 (0)

Configuration switchgroups

The switchgroups SGF1...4, SGB1...3 and SGR1...11 are used for selecting functions required for different applications. The switch number, 1...8, and position, 0 or 1, are displayed during the setting procedure. In normal service only the checksums of the switchgroups are indicated on the display. These checksums are found in the main menu of the relay module, see "Main menu and submenu of settings and registers". The tables show the default settings of the switches and the checksum ∑ of the default setting.

Swtichgroup SGF1

<table>
<tr><th>Switch</th><th>Function</th><th>Default</th></tr>
<tr><td>SGF1/1
SGF1/2
SGF1/3
SGF1/4
SGF1/5</td><td>Initiation of AR shot 1
Initiation of AR shot 2
Initiation of AR shot 3
Initiation of AR shot 4
Initiation of AR shot 5

When the switch = 0, the AR shot is initiated by a trip signal of the protection.
When the switch = 1, the AR shot is initiated by a start signal of the protection, after the set start delay.</td><td>0
0
0
0
0</td></tr>
<tr><td>SGF1/6
SGF1/7</td><td>Function at manual CB closing
<table><tr><th>SGF1/6</th><th>SGF1/7</th><th>Explanation</th></tr><tr><td>0</td><td>0</td><td>Auto-reclosing and final trip by the AR module is inhibited during the reclaim time</td></tr><tr><td>1</td><td>0</td><td>Auto-reclosing is inhibited during the reclaim time. Final trip by AR module possible.</td></tr><tr><td>0</td><td>1</td><td>Closing does not affect the operation</td></tr><tr><td>1</td><td>1</td><td>Not in use (same as 0 - 0)</td></tr></table>Note! Should the circuit breaker be manually closed during the dead time, the AR sequence will always be interrupted</td><td>0
0</td></tr>
<tr><td>SGF1/8</td><td>Not in use</td><td>0</td></tr>
<tr><td>∑SGF1</td><td></td><td>0</td></tr>
</table>

Switchgroup SGF2

Switch	Function	Default
SGF2/1	Synchrocheck for AR shot 1	0
SGF2/2	Synchrocheck for AR shot 2	0
SGF2/3	Synchrocheck for AR shot 3	0
SGF2/4	Synchrocheck for AR shot 4	0
SGF2/5	Synchrocheck for AR shot 5	0
	When the switch = 0, no synchrocheck function is available When the switch = 1, the ARSYNC signal has to be active before the circuit breaker is closed (waiting time max. 2 s)	
SGF2/6	Operation of CB maintenance monitor when it is zero When SGF2/6 = 0, the monitor has only an alarming function When SGF2/6 = 1, the monitor inhibits CB closing and auto-reclosing	0
SGF2/7	Use of CB position data input CBPOS When SGF2/7 = 0, CB position data is available and wired to the CBPOS input. When SGF2/7 = 1, CB position data is not available, see SGF2/8 if definite trip alarm is required.	0
SGF2/8	Use of CB trip data (voltage over opening coil) instead of CBPOS position data. To be able to use this switch, SGF2/7 has to be in position 1. When SGF2/8 = 0, the CBPOS input is not in use. When SGF2/8 = 1, the voltage of the CB opening coil is connected to the CBPOS input. If CB position data is not available and final tripping is initiated by a trip signal of the protection, the AR module is not capable of providing a DEF.TRIP signal unless the voltage of the CB opening coil, instead of CB position data, is connected to the CBPOS input and SGF2/8 = 1.	0
∑SGF2		0

Switchgroup SGF3

Switch	Function	Default
	The DEF.TRIP operation indicator is lit	
SGF3/1	- when the signal Def.trip AR1 is activated	1
SGF3/2	- when the signal Def.trip AR2 is activated	1
SGF3/3	- when the signal Def.trip AR3 is activated	1
SGF3/4	- when the signal Def.trip AR4 is activated	1
SGF3/5	- when the signal CBOS is activated	0
SGF3/6	- when the signal CBFAIL is activated	1
SGF3/7	Select operation of output signal "Shot 5 due/tr due" (see figure 2). When SGF3/7 = 0, the output signal is active when shot 5 is in progress When SGF3/7 = 1, the output signal is active when reclaim time is running	0
SGF3/8	Not in use	0
∑SGF3		47

Switchgroups SGB1...3

The switchgroups SGB1...3 are used to configure the control signals ARCTRL, BS2 and RRES. The matrix below can be used for the configuration. The control signals are linked with the desired functions by circling the intersections of the lines. The switch number is marked at each intersection point and the corresponding weighting factor below the matrix. Adding the weighting factors of the selected switches of each switchgroup gives the switchgroup checksums to the right of the matrix. Switches not mentioned are not used and should be in the position 0.

Note!
Before starting the programming, check whether all control signals of the relay module SPCT 5D54 are used in the relay assembly.

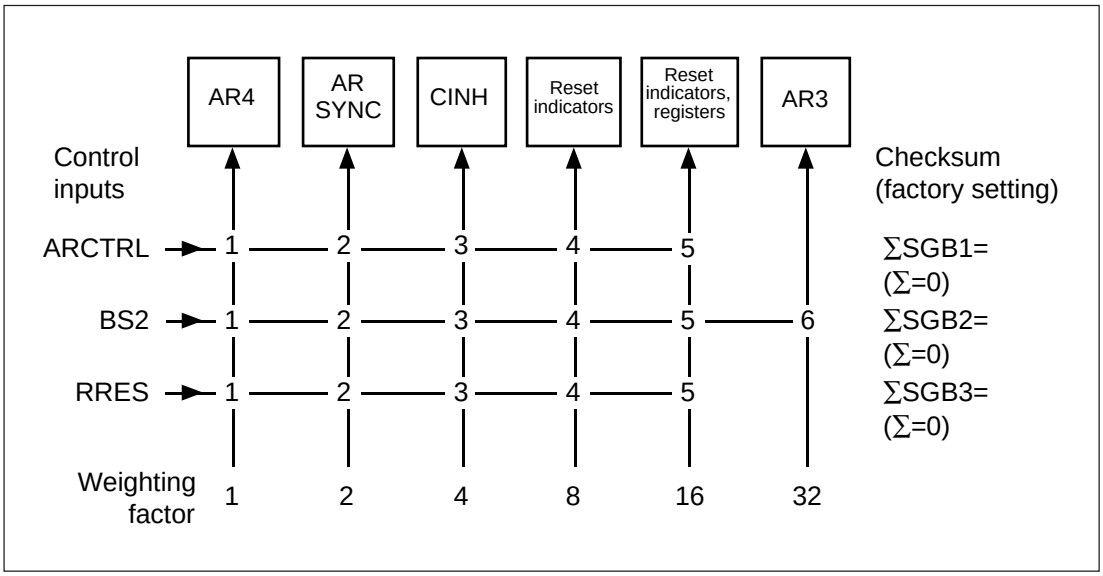


Fig. 6. Control signal matrix for auto-reclose module SPCT 5D54

Switch	Function
SGB_/1	AR initiation AR4
SGB_/2	Synchrocheck ARSYNC
SGB_/3	Inhibition of CB closing CINH
SGB_/4	Resetting of front panel operation indicators
SGB_/5	Resetting of operation indicators and registers
SGB2/6	BS2 linked to AR3
SGB1,3/6	Not in use
SGB_/7	Not in use
SGB_/8	Not in use

Switchgroups SGR1...SGR11

The switchgroups SGR1...11 are used to configure the output signals of the module to operate as desired output signals SS1...SS4 or TS1...TS3.

The matrix below can be used for the configuration. The signals are linked with the desired output signal SS1...SS4 or TS1...TS3, for example, by circling the intersections of the signal lines. The switch number is marked at each intersection and the weighting factor of the switch is given below the matrix. By adding the weighting values of the switches selected from each switchgroup the checksums of the switchgroups are obtained to the right of the matrix. (The checksums of the default setting are given in parenthesis).

Note!
Before starting the programming check whether all output signals of the relay module SPCT 5D54 are in use in the concerned protection relay.

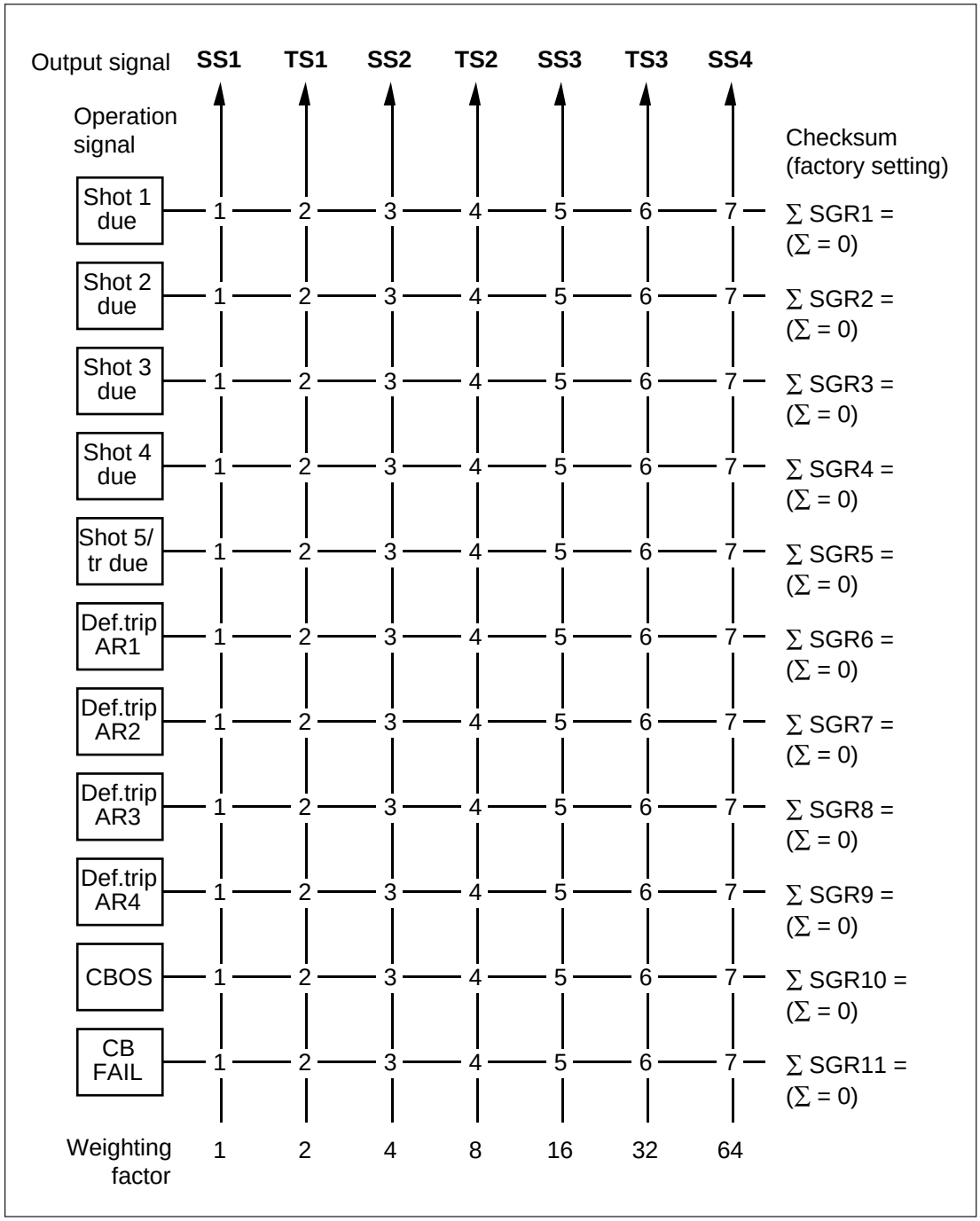


Fig. 7. Output relay matrix for the auto-reclose relay module SPCT 5D54

Recorded data

The red digit on the display indicates the address code of the register and the other three digits the value of the register.

Register/ STEP	Recorded information
3	Total number of AR shots 1 (0...999). Register 3 includes four subregisters with the following contents: Total number of AR shots 1 (0...255), initiated by 1) signal AR1 2) signal AR2 3) signal AR3 4) signal AR4
4	Total number of AR shots 2 (0...999). Register 4 includes four subregisters with the following contents: Total number of AR shots 2 (0...255), initiated by 1) signal AR1 2) signal AR2 3) signal AR3 4) signal AR4
5	Total number of AR shots 3 (0...999). Register 5 includes four subregisters with the following contents: Total number of AR shots 3 (0...255), initiated by 1) signal AR1 2) signal AR2 3) signal AR3 4) signal AR4
6	Total number of AR shots 4 (0...999). Register 6 includes four subregisters with the following contents: Total number of AR shots 4 (0...255), initiated by 1) signal AR1 2) signal AR2 3) signal AR3 4) signal AR4
7	Total number of AR shots 5 (0...999). Register 7 includes four subregisters with the following contents: Total number of AR shots 5 (0...255), initiated by 1) signal AR1 2) signal AR2 3) signal AR3 4) signal AR4

Register/ STEP	Recorded information
8	Total number of DEF.TRIP alarm signals (0...999). Register 8 includes four subregisters with the following contents: Total number of DEF.TRIP alarm signals (0...255), initiated by 1) signal AR1 2) signal AR2 3) signal AR3 4) signal AR4
9	The main register contains information about the number of AR shots (0...5) carried out during the latest AR sequence. If the final trip function (6) has operated, the value of the register is added by 10. The main register and the four subregisters form a memory stack. A new value stored in the main register moves the previous value of the main register to subregister 1, the value of subregister 1 is moved to subregister 2, and so on. The old value of subregister 4 will be lost. The following information is stored in the subregisters: Number of AR shots carried out 1) during the second last AR sequence 2) during the third last AR sequence 3) during the fourth last AR sequence 4) during the fifth last AR sequence
0	Display of external control signals The right-most digit indicates the state of the signals ARINH, ARCTRL and BS2. The states are indicated by the numbers 0...7. Each signal has its own weighting value. The value shown on the display is the sum of the weighting values of the activated signals. The weighting values of the signals are as follows: 1 = ARINH activated 2 = ARCTRL activated 4 = BS2 activated The middle green number shows the position of the circuit breaker: 0 = circuit breaker open (input energized) 1 = circuit breaker closed (input not energized) The green number to the left indicates the states of the signals AR1, AR2 and AR3. The states are indicated by the numbers 0...7. Each input signal has its own weighting value. The value shown on the display is the sum of the weighting values of the activated signals. The weighting values of the signals are as follows: 1 = AR1 activated 2 = AR2 activated 4 = AR3 activated

Register/ STEP	Recorded information
	From this register it is possible to enter the TEST mode, in which the output signals of the relay module can be activated one by one. The setting operation indicators and their corresponding output signals are presented below. Note! The CB closing signal can also be activated in the TEST mode.When all setting indicators are flashing, the CBCS signal can be activated by pressing the push-buttons STEP and PROGRAM simultaneously. BEFORE STARTING THE TEST PROCEDURE, MAKE SURE THAT IT IS SAFE TO CLOSE THE CIRCUIT BREAKER! Setting indicator — Output signal No indication — Self-supervision IRF SHOT 1 — AR shot 1 in progress SHOT 2 — AR shot 2 in progress SHOT 3 — AR shot 3 in progress SHOT 4 — AR shot 4 in progress SHOT 5 — AR shot 5 in progress Final trip — DEF.TRIP alarm signal by AR1 t_r — DEF.TRIP alarm signal by AR2 t_d — DEF.TRIP alarm signal by AR3 SGF — DEF.TRIP alarm signal by AR4 SGB — CBOS signal SGR — CBFAIL signal All flashing — CBCS signal
A	Address code of the AR relay module, required for serial communications. Register A has four subregisters with the following contents: 1. Selection of the data transfer rate: 4800 or 9600 Bd (4.8 or 9.6 kBd). 2. Bus traffic monitor. If the relay module is connected to a data communication system and the communication is in operation, the value of the monitor is 0. Otherwise the numbers 0...255 are rolling. 3. Password required for remote setting. 4. Selection of the operation mode for the AR module. When the register value is one (1) the AR program is out of use and when it is zero (0) the AR program is in use.

The registers are reset by pressing the RESET and PROGRAM push-buttons simultaneously. The registers, the address of the relay module, the data transfer rate and the password are not affected by voltage failures. Instructions for setting the address and the data transfer rate are given in the document "General characteristics of D-type relay modules".

Main menu and submenus for settings and registers

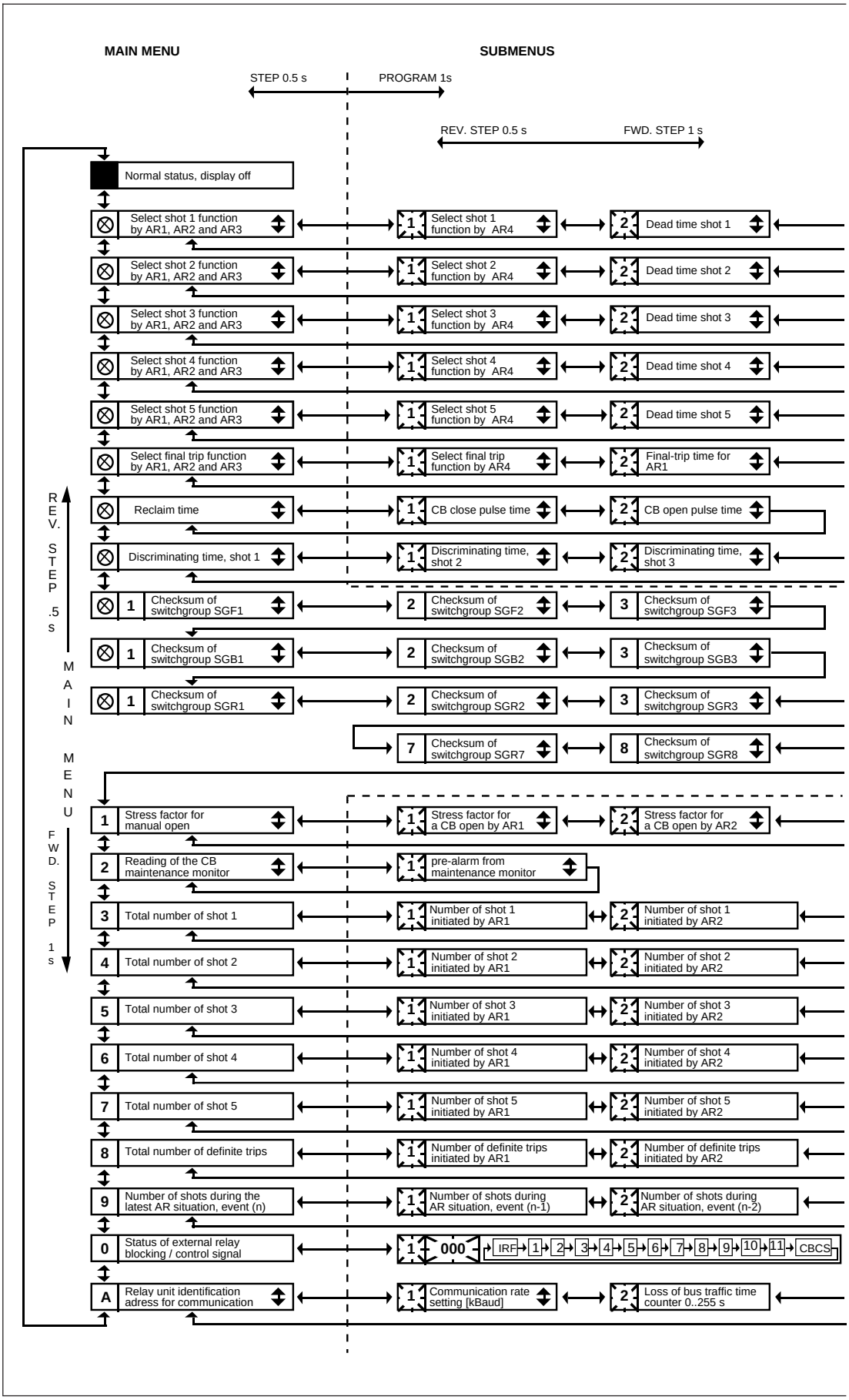
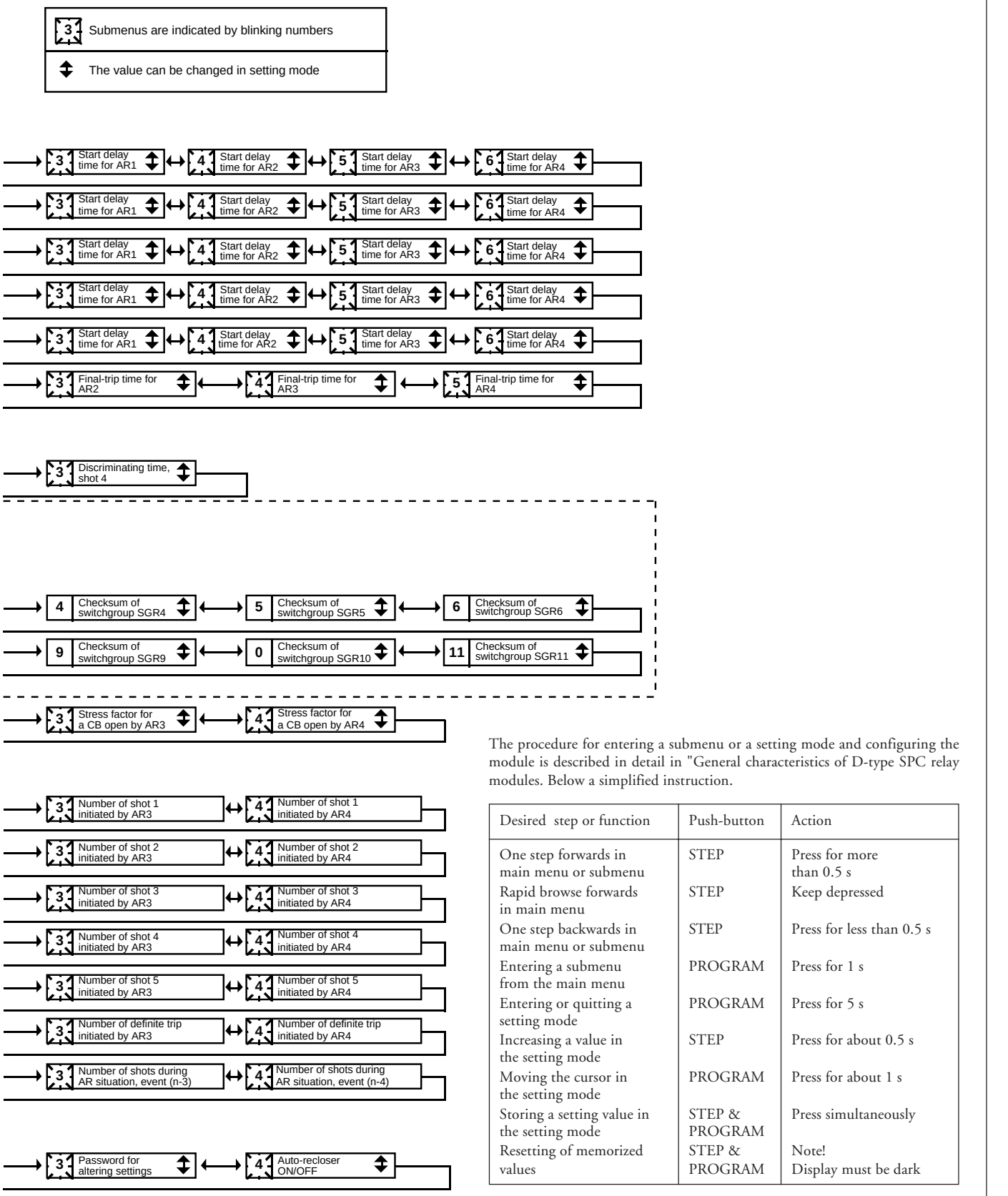


Fig. 8. Main menu and submenu for the auto-reclose relay module SPCT 5D54



The procedure for entering a submenu or a setting mode and configuring the module is described in detail in "General characteristics of D-type SPC relay modules. Below a simplified instruction.

Desired step or function	Push-button	Action
One step forwards in main menu or submenu	STEP	Press for more than 0.5 s
Rapid browse forwards in main menu	STEP	Keep depressed
One step backwards in main menu or submenu	STEP	Press for less than 0.5 s
Entering a submenu from the main menu	PROGRAM	Press for 1 s
Entering or quitting a setting mode	PROGRAM	Press for 5 s
Increasing a value in the setting mode	STEP	Press for about 0.5 s
Moving the cursor in the setting mode	PROGRAM	Press for about 1 s
Storing a setting value in the setting mode	STEP & PROGRAM	Press simultaneously
Resetting of memorized values	STEP & PROGRAM	Note! Display must be dark

Technical data

Maximum number of successive AR shots during a sequence	5
Start delay	0.00...10.0 s
Dead time	0.20...300 s
Discriminating time	0.00...30.0 s
Reclaim time	0.20...300 s
Final trip time	0.00...5.00 s
CB closing impulse	0.10...2.00 s
CB opening impulse	0.10...2.00 s
Operate time accuracy	±1% of setting value or ±30 ms

Event codes

Connected to a data communicator over the SPA bus, the auto-reclose module generates events which can be printed out, for instance, on a printer. The events are printed in the format: time, text, event code. The event text is written by the user.

Most of the events can be included in or excluded from reporting by writing an event mask (V155...V158) to the module. The parameters of the event mask are presented in the tables below.

The event codes E50...E54 and the events represented by these cannot be excluded from event reporting.

Maximum 60 events can be stored in the event buffer. When the 61st event message is received the code E51 will be stored in the buffer. The buffer and the code E51 are reset by giving the parameter WC the value 0.

The event codes E52...E54 are generated by a higher-level data communicator unit (e.g. SACO 100M, SRIO 1000M, etc.)

Detailed information about the serial communication over the SPA bus is given in the document "SPA Bus Communication Protocol" 34 SPACOM 2EN1.

Channel	Code	Event	Weighting coefficient	Default
General events				
0	E1	AR (shots 1...5) started	1	1
0	E2	AR (shots 1...5) initiated by AR1	2	0
0	E3	AR (shots 1...5) initiated by AR2	4	0
0	E4	AR (shots 1...5) initiated by AR3	8	0
0	E5	AR (shots 1...5) initiated by AR4	16	0
0	E6	AR (shots 1...5) ended	32	1
0	E7	AR sequence successful	64	0
0	E8	AR sequence initiated by AR1 successful	128	0
0	E9	AR sequence initiated by AR2 successful	256	0
0	E10	AR sequence initiated by AR1 successful	512	0
0	E11	AR sequence initiated by AR1 successful	1024	0
0	E50	Restart of module	*	-
0	E51	Overflow of event register	*	-
0	E52	Temporary disturbance in data communication	*	-
0	E53	No response from the module over the data comm.	*	-
0	E54	The module responds again over the data comm.	*	-
		Event mask	V155 = 33	

Channel	Code	Event	Weighting coefficient	Default
Circuit breaker events				
0	E12	Change in CB position: 1 -> 0 (open)	1	1
0	E13	Change in CB position: 0 -> 1 (closed)	2	1
0	E14	Manual CB opening	4	1
0	E15	Manual CB closing	8	1
0	E16	OPEN output activated	16	0
0	E17	OPEN output reset	32	0
0	E18	CLOSE output activated	64	0
0	E19	CLOSE output reset	128	0
		Event mask	V156 = 15	
Alarm events				
0	E20	CB opening failed	1	1
0	E21	CB closing failed	2	1
0	E22	CB closing inhibited	4	1
0	E23	Alarm from maintenance monitor	8	1
0	E24	Maintenance monitor alarm reset	16	1
0	E25	Initiation signal AR1...4 activated >2 min	32	1
0	E26	Alarm E25 reset	64	1
0	E27	Attempt to activate an output without open/close selection	128	1
		Event mask	V157 = 255	
Auto-reclose events				
0	E28	AR in use	1	1
0	E29	AR not in use	2	1
0	E30	AR interrupted by the signal ARINH	4	1
0	E31	AR interrupted by CB closing during the AR sequence	8	1
0	E32	AR interrupted by CB opening during the AR sequence	16	1
0	E33	t_d started	32	0
0	E34	t_d elapsed	64	0
0	E35	t_r started or restarted	128	0
0	E36	t_r elapsed	256	0
		Event mask	V158 = 31	
Events for AR shot 1				
1	E1	AR shot 1 started	1	1
1	E2	AR shot 1 initiated via AR1	2	0
1	E3	AR shot 1 initiated via AR2	4	0
1	E4	AR shot 1 initiated via AR3	8	0
1	E5	AR shot 1 initiated via AR4	16	0
1	E6	AR shot 1 concluded	32	0
1	E7	AR shot 1 successful	64	0
		Event mask	1V155 = 1	

Channel	Code	Event	Weighting coefficient	Default
Events for AR shot 2				
2	E1	AR shot 2 started	1	1
2	E2	AR shot 2 initiated via AR1	2	0
2	E3	AR shot 2 initiated via AR2	4	0
2	E4	AR shot 2 initiated via AR3	8	0
2	E5	AR shot 2 initiated via AR4	16	0
2	E6	AR shot 2 concluded	32	0
2	E7	AR shot 2 successful	64	0
		Event mask	2V155 = 1	
Events for AR shot 3				
3	E1	AR shot 3 started	1	1
3	E2	AR shot 3 initiated via AR1	2	0
3	E3	AR shot 3 initiated via AR2	4	0
3	E4	AR shot 3 initiated via AR3	8	0
3	E5	AR shot 3 initiated via AR4	16	0
3	E6	AR shot 3 concluded	32	0
3	E7	AR shot 3 successful	64	0
		Event mask	3V155 = 1	
Events for AR shot 4				
4	E1	AR shot 4 started	1	1
4	E2	AR shot 4 initiated via AR1	2	0
4	E3	AR shot 4 initiated via AR2	4	0
4	E4	AR shot 4 initiated via AR3	8	0
4	E5	AR shot 4 initiated via AR4	16	0
4	E6	AR shot 4 concluded	32	0
4	E7	AR shot 4 successful	64	0
		Event mask	4V155 = 1	
Events for AR shot 5				
5	E1	AR shot 5 started	1	1
5	E2	AR shot 5 initiated via AR1	2	0
5	E3	AR shot 5 initiated via AR2	4	0
5	E4	AR shot 5 initiated via AR3	8	0
5	E5	AR shot 5 initiated via AR4	16	0
5	E6	AR shot 5 concluded	32	0
5	E7	AR shot 5 successful	64	0
		Event mask	5V155 = 1	
Final trip events				
6	E1	Final trip	1	1
6	E2	Final trip via AR1	2	0
6	E3	Final trip via AR2	4	0
6	E4	Final trip via AR3	8	0
6	E5	Final trip via AR4	16	0
		Event mask	6V155 = 1	

Channel	Code	Event	Weighting coefficient	Default
Events for DEF.TRIP alarm				
7	E1	DEF.TRIP alarm activated	1	1
7	E2	DEF.TRIP alarm activated by AR1	2	0
7	E3	DEF.TRIP alarm activated by AR2	4	0
7	E4	DEF.TRIP alarm activated by AR3	8	0
7	E5	DEF.TRIP alarm activated by AR4	16	0
7	E6	DEF.TRIP alarm reset	32	1
		Event mask	7V155 = 33	

Data to be transferred over the serial bus

In addition to the event codes input data (I data), output data (O data), setting values (S data) memorized data (V data), and some other data can be read from the module over the serial bus. The values of parameters marked with the letter W can be changed over the SPA bus.

When a setting value is changed, either via the push-buttons on the front panel or over the serial bus, the relay module checks whether the given parameter value is legal. A value outside the permitted setting range will not be memorized, but the previous setting will be retained.

To be able to change a setting parameter over the serial bus a password in the range 1..999 is required. The default setting is 1.

The password is opened by giving the serial communication parameter V160 the desired numerical value. Parameter V161 is used for closing the password. The password is also closed by failures in the voltage supply.

The push-buttons of the relay module or a command over the serial bus can be used to change the password. To be able to change the password over the serial bus, the password first has to be opened. The new password is entered via parameter V161. When using the push-buttons, the new password is written in the place of the old one in subregister 3 of register A.

Should the wrong password be given 7 successive times, it turns into a zero and can no longer be opened over the serial bus. Then the password can be given a new numerical value via the push-buttons only.

R = data to be read from the module
W = data to be written to the module
(P) = writing allowed through a password

Data	Channel	Code	Data direction	Value
Status of input signals				
Signal ARINH	0	I1	R	0 = not active 1 = active
CBPOS circuit breaker position	0	I2	R	0 = open 1 = closed
Signal ARCTRL	0	I3	R	0 = not active 1 = active
Signal BS2	0	I4	R	0 = not active 1 = active
Signal RRES	0	I5	R	0 = not active 1 = active
Input signal AR1	0	I6	R	0 = not active 1 = active
Input signal AR2	0	I7	R	0 = not active 1 = active
Input signal AR3	0	I8	R	0 = not active 1 = active
Input signal AR4	0	I9	R	0 = not active 1 = active

Data	Channel	Code	Data direction	Value
Status data of output signals				
Signal AR shot 1 due	0	O1	R	0 = not active 1 = active
Signal AR shot 2 due	0	O2	R	0 = not active 1 = active
Signal AR shot 3 due	0	O3	R	0 = not active 1 = active
Signal AR shot 4 due	0	O4	R	0 = not active 1 = active
Signal AR shot 5 due	0	O5	R	0 = not active 1 = active
DEF.TRIP alarm via AR1	0	O6	R	0 = not active 1 = active
DEF.TRIP alarm via AR2	0	O7	R	0 = not active 1 = active
DEF.TRIP alarm via AR3	0	O8	R	0 = not active 1 = active
DEF.TRIP alarm via AR4	0	O9	R	0 = not active 1 = active
Signal CBOS	0	O10	R	0 = not active 1 = active
Signal CBFAIL	0	O11	R	0 = not active 1 = active
AR in progress	0	O12	R	0 = AR not in progress 1 = AR shot 1 in progress 2 = AR shot 2 in progress 3 = AR shot 3 in progress 4 = AR shot 4 in progress 5 = AR shot 5 in progress
Output relay test				
Enable output relay test	0	O20	R,W(P)	0 = not active 1 = active
Signal SS1 (enabled with (O20)	0	O21	R,W(P)	0 = not active 1 = active
Signal TS1 (enabled with (O20)	0	O22	R,W(P)	0 = not active 1 = active
Signal SS2 (enabled with (O20)	0	O23	R,W(P)	0 = not active 1 = active
Signal TS2 (enabled with (O20)	0	O24	R,W(P)	0 = not active 1 = active
Signal SS3 (enabled with (O20)	0	O25	R,W(P)	0 = not active 1 = active
Signal TS3 (enabled with (O20)	0	O26	R,W(P)	0 = not active 1 = active
Signal SS4 (enabled with (O20)	0	O27	R,W(P)	0 = not active 1 = active
Signal CBCS (CB closing, enabled with (O20)	0	O28	R,W(P)	0 = not active 1 = active

Data	Channel	Code	Data direction	Value
Setting parameters				
Setting values for AR shot 1 on channel 1, for AR shot 2 on channel 2, etc.				
Dead time, AR shots 1...5	1...5	S1	R,W,(P)	0.2...300 s
Initiated by signal AR1	1...5	S2	R,W,(P)	0 = no operation 1 = AR shot initiated 2 = initiation of AR shot blocked
Initiated by signal AR2	1...5	S3	R,W,(P)	0 = no operation 1 = AR shot initiated 2 = initiation of AR shot blocked
Initiated by signal AR3	1...5	S4	R,W,(P)	0 = no operation 1 = AR shot initiated 2 = initiation of AR shot blocked.
Initiated by signal AR4	1...5	S5	R,W,(P)	0 = no operation 1 = AR shot initiated 2 = initiation of AR shot blocked.
Start delay when AR shot initiated by				
- signal AR1	1...5	S6	R,W,(P)	0...10 s
- signal AR2	1...5	S7	R,W,(P)	0...10 s
- signal AR3	1...5	S8	R,W,(P)	0...10 s
- signal AR4	1...5	S9	R,W,(P)	0...10 s
Discriminating time t_d	1...4	S10	R,W,(P)	0...30 s
Final trip on channel 6				
Final trip initiated by				
- signal AR1	6	S2	R,W,(P)	1 = final trip by signal AR1
- signal AR2	6	S3	R,W,(P)	1 = final trip by signal AR2
- signal AR3	6	S4	R,W,(P)	1 = final trip by signal AR3
- signal AR4	6	S5	R,W,(P)	1 = final trip by signal AR4
Final trip time, when initiated by				
- signal AR1	6	S6	R,W,(P)	0...5.0 s
- signal AR2	6	S7	R,W,(P)	0...5.0 s
- signal AR3	6	S8	R,W,(P)	0...5.0 s
- signal AR4	6	S9	R,W,(P)	0...5.0 s

Data	Channel	Code	Data direction	Value
General setting values on channel 0				
Reclaim time t_r	0	S1	R,W,(P)	0.2...300 s
Checksum Σ				
- switchgroup SGF1	0	S2	R,W,(P)	0...255
- switchgroup SGF2	0	S3	R,W,(P)	0...255
- switchgroup SGF3	0	S4	R,W,(P)	0...255
- switchgroup SGB1	0	S7	R,W,(P)	0...255
- switchgroup SGB2	0	S8	R,W,(P)	0...255
- switchgroup SGB3	0	S9	R,W,(P)	0...255
- switchgroup SGR1	0	S10	R,W,(P)	0...255
- switchgroup SGR2	0	S11	R,W,(P)	0...255
- switchgroup SGR3	0	S12	R,W,(P)	0...255
- switchgroup SGR4	0	S13	R,W,(P)	0...255
- switchgroup SGR5	0	S14	R,W,(P)	0...255
- switchgroup SGR6	0	S15	R,W,(P)	0...255
- switchgroup SGR7	0	S16	R,W,(P)	0...255
- switchgroup SGR8	0	S17	R,W,(P)	0...255
- switchgroup SGR9	0	S18	R,W,(P)	0...255
- switchgroup SGR10	0	S19	R,W,(P)	0...255
- switchgroup SGR11	0	S20	R,W,(P)	0...255
Circuit breaker maintenance monitor				
Stress factor, when CB opened				
- manually	0	S21	R,W,(P)	0...50
- via signal AR1	0	S22	R,W,(P)	0...50
- via signal AR2	0	S23	R,W,(P)	0...50
- via signal AR3	0	S24	R,W,(P)	0...50
- via signal AR4	0	S25	R,W,(P)	0...50
Pre-alarm level of CB maintenance monitor	0	S26	R,W,(P)	0...50
Value of maintenance monitor	0	S27	R,W,(P)	0...999
Length of closing pulse	0	S28	R,W,(P)	0.1...2.0 s
Length of opening pulse	0	S29	R,W,(P)	0.1...2.0 s
Secured remote control of circuit breaker				
Opening selected (signal CBOS)	0	V1	R,W	0 = not selected 1 = selected
Closing selected (signal CBCS)	0	V2	R,W	0 = not selected 1 = selected
Carry out selected open/close control operation	0	V251	W	1 = carry out (V1, V2)
Cancel selected open/close control operation	0	V252	W	1 = cancel (V1,V2)

Data	Channel	Code	Data direction	Value
Recorded values				
Values recorded for AR shot 1 on channel 1, values recorded for AR shot 2 on channel 2, etc.				
Total number of AR shots	1...5	V1	R	0...999
Number of AR shots initiated by				
- signal AR1	1...5	V2	R,W,(P)	0...255
- signal AR2	1...5	V3	R,W,(P)	0...255
- signal AR3	1...5	V4	R,W,(P)	0...255
- signal AR4	1...5	V5	R,W,(P)	0...255
Number of successful AR shots initiated by				
- signal AR1	1...5	V6	R,W,(P)	0...255
- signal AR2	1...5	V7	R,W,(P)	0...255
- signal AR3	1...5	V8	R,W,(P)	0...255
- signal AR4	1...5	V9	R,W,(P)	0...255
Total number of DEF.TRIP alarms	0	V5	R	0...999
Number of DEF.TRIP alarms initiated by				
- signal AR1	0	V6	R,W,(P)	0...255
- signal AR2	0	V7	R,W,(P)	0...255
- signal AR3	0	V8	R,W,(P)	0...255
- signal AR4	0	V9	R,W,(P)	0...255
Number of reclosures carried out during the last AR sequence (0...5). Should the final trip function have operated (6), the value of the register has been added by 10.				
AR sequence n	0	V10	R,W,(P)	0...5, 11....15
AR sequence n-1	0	V11	R,W,(P)	0...5, 11....15
AR sequence n-2	0	V12	R,W,(P)	0...5, 11....15
AR sequence n-3	0	V13	R,W,(P)	0...5, 11....15
AR sequence n-4	0	V14	R,W,(P)	0...5, 11....15
Operation indicator	0	V15	R	0...9 (A = 9)
Control parameters for the module				
Resetting of operation indicators	0	V101	W	1 = resetting
Resetting of operation indicators and registers	0	V102	W	1 = resetting
Operation mode of AR module, ON/OFF	0	V153	R,W	0 = AR shots in use 1 = AR shots not in use
Resetting of AR module (resetting of timers and shot pointer)	0	V154	R,W	1 = resetting
Event masks, see also "Event codes"				
Event mask for events				
- E1...E11	0	V155	R,W	0...2047
- E12...E19	0	V156	R,W	0...255
- E20...E27	0	V157	R,W	0...255
- E28...E36	0	V156	R,W	0...511

Data	Channel	Code	Data direction	Value
Event mask				
- for AR shot 1	1	V155	R,W	0...127
- for AR shot 2	2	V155	R,W	0...127
- for AR shot 3	3	V155	R,W	0...127
- for AR shot 4	4	V155	R,W	0...127
- for AR shot 5	5	V155	R,W	0..127
- for final trip	6	V155	R,W	0..31
- for DEF.TRIP alarm	7	V155	R,W	0...63
Opening of password for remote setting	0	V160	W	1...999
Changing or closing the password	0	V161	W(P)	0...999
Activation of self-supervision output	0	V165	W	1 = self-supervision output is activated and IRF LED is lit 0 = IRF reset
Testing of LED indicators	0	V166	W,(P)	0...28
EEPROM formatting	0	V167	W(P)	2=formatted
Internal fault code	0	V169	R	1...255
Data communication address of the module	0	V200	R,W	1...254
Data transfer rate	0	V201	R,W	4800 or 9600 Bd (R) 4.8 or 9.6 kBd (W)
Program version	0	V205	R	122 _
Reading of event register	0	L	R	Time, channel number and event code
Re-reading of event register	0	B	R	Time, channel number and event code
				Type designation
of relay module	0	F	R	SPCT 5D54
Reading of module status data	0	C	R	0 = normal status 1 = module been subject to automatic reset 2 = overflow of event register 3 = events 1 and 2 together
Resetting of module status data	0	C	W	0 = resetting
Time reading or setting	0	T	R,W	00.000...59.999 s

The maximum capacity of the event register is 60 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.

When a setting value is changed, either via the push-buttons on the front panel or over the serial bus, the relay module checks whether the given parameter value is legal, i.e. within the permitted ranges. A value outside the permitted setting range will not be memorized, but the previous value will be retained.

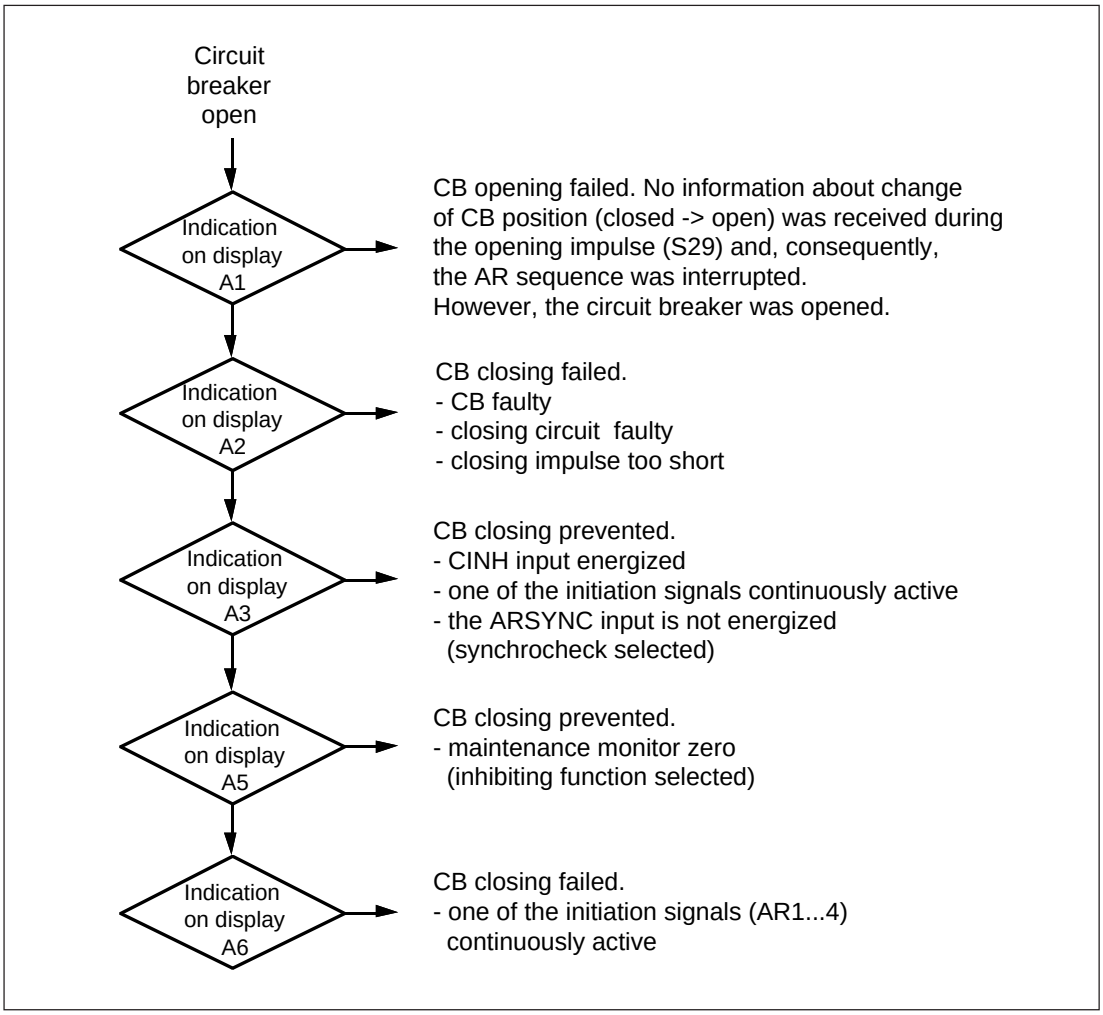


Fig. 9. Possible error indications when the circuit breaker remains open

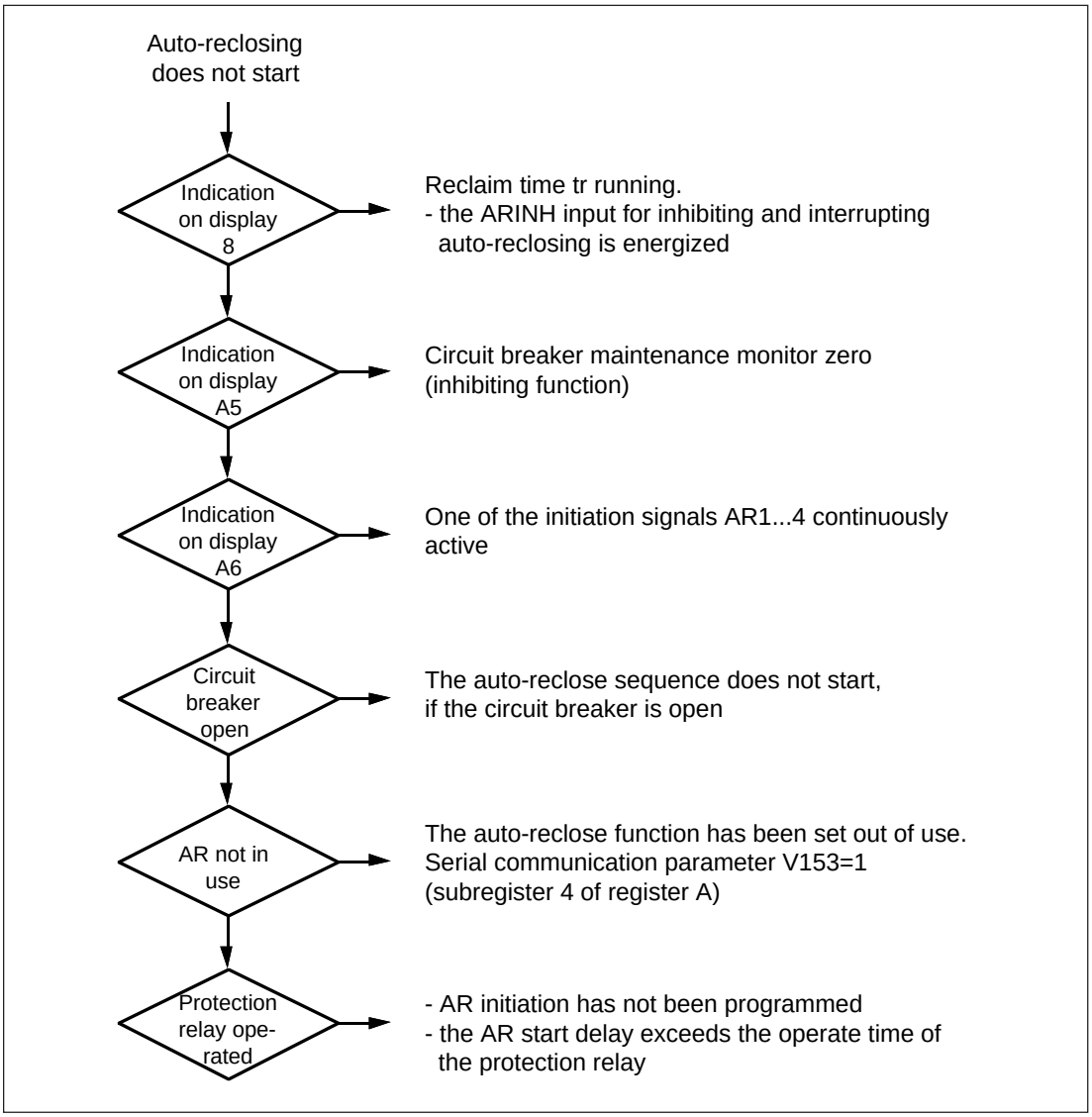


Fig. 10. Possible error indications when auto-reclosing does not start

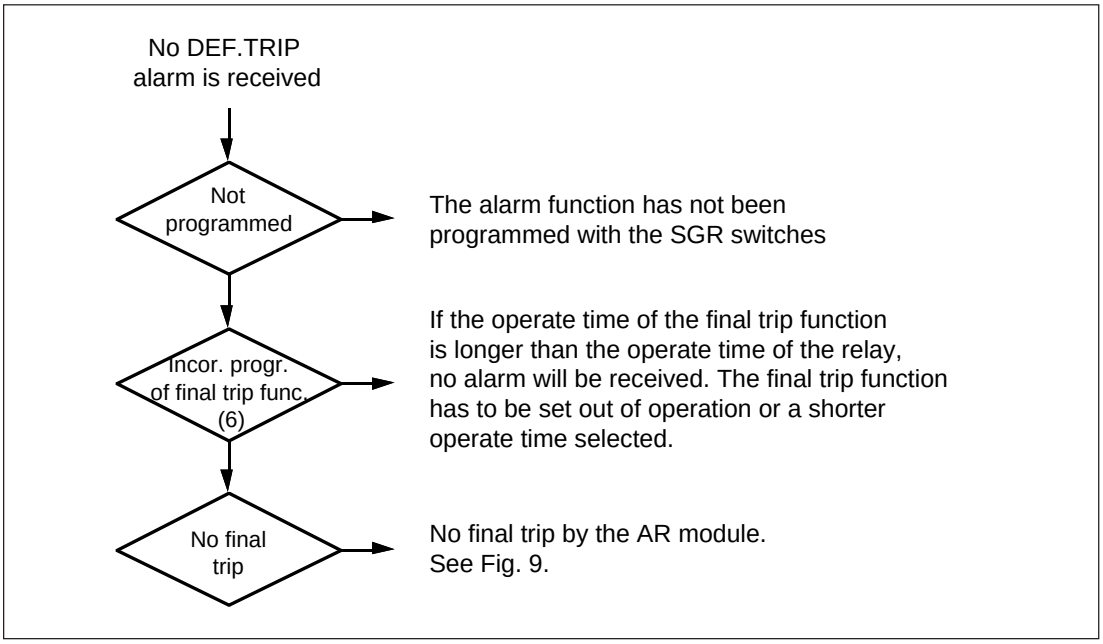


Fig. 11. Possible error indications, when no DEF.TRIP alarm is received.

Definitions

Reclosure
Operation, whereby the circuit breaker is automatically closed after a preset time delay from circuit breaker opening initiated by the protection relay.

Auto-reclose sequence
An auto-reclose sequence is a sequence of operations on one network fault. An auto-reclose sequence may include (SPCT 5D54) from one to five reclosures, final trip and definite trip alarm.

Shot pointer
The purpose of the shot pointer is to control the order of the operations (AR shots and final trip) during an auto-reclose sequence. After the lapse of the reclaim time t_r the shot pointer returns to the initial value one (1), whereupon the module is ready for a new auto-reclose sequence.

Lock-out
Automatic reclosing is prevented until the reclaim time has elapsed.

Start delays (used when reclosing is initiated by the start of the proteciton)
Start delays are used to delay the initiation of an auto-reclose operation. The initiation signal must still be active when the start delay expires, to enable initiation of the AR shot or final trip function.

Dead time
The time between the CB open signal and the CB close signal

Reclaim time (t_r)
The time following a closing operation, which must elapse before the auto-reclose relay will initiate a new reclosing sequence in the event of further fault incidents.

Discriminating time (td)
The discriminating time starts, when the circuit breaker is closed by one of the AR shots 1...4. An auto-reclose attempt during the discriminating time prevents further auto-reclosures and leads to lock-out.

Final trip (used when reclosing is initiated by the start of the proteciton)
This facility provides a faster trip from the AR module when the last shot in the sequence proves unsuccessful. If one of the protection relay modules starts and delivers a new initiation signal to the AR module after the last shot, the AR module delivers a trip signal after a short operate time.

DEF. TRIP (definite trip alarm)
Alarm on unsuccessful auto-reclosing.

Circuit breaker maintenance monitor
The maintenance monitor counts the circuit breaker operations. The monitor gives an alarm and can be configured to block auto-reclose operations.

CBFAIL
Alarm on failed circuit breaker operation or maintenance monitor alarm.

CBPOS
Circuit breaker position input. The circuit breaker is assumed to be open when the input is energized.

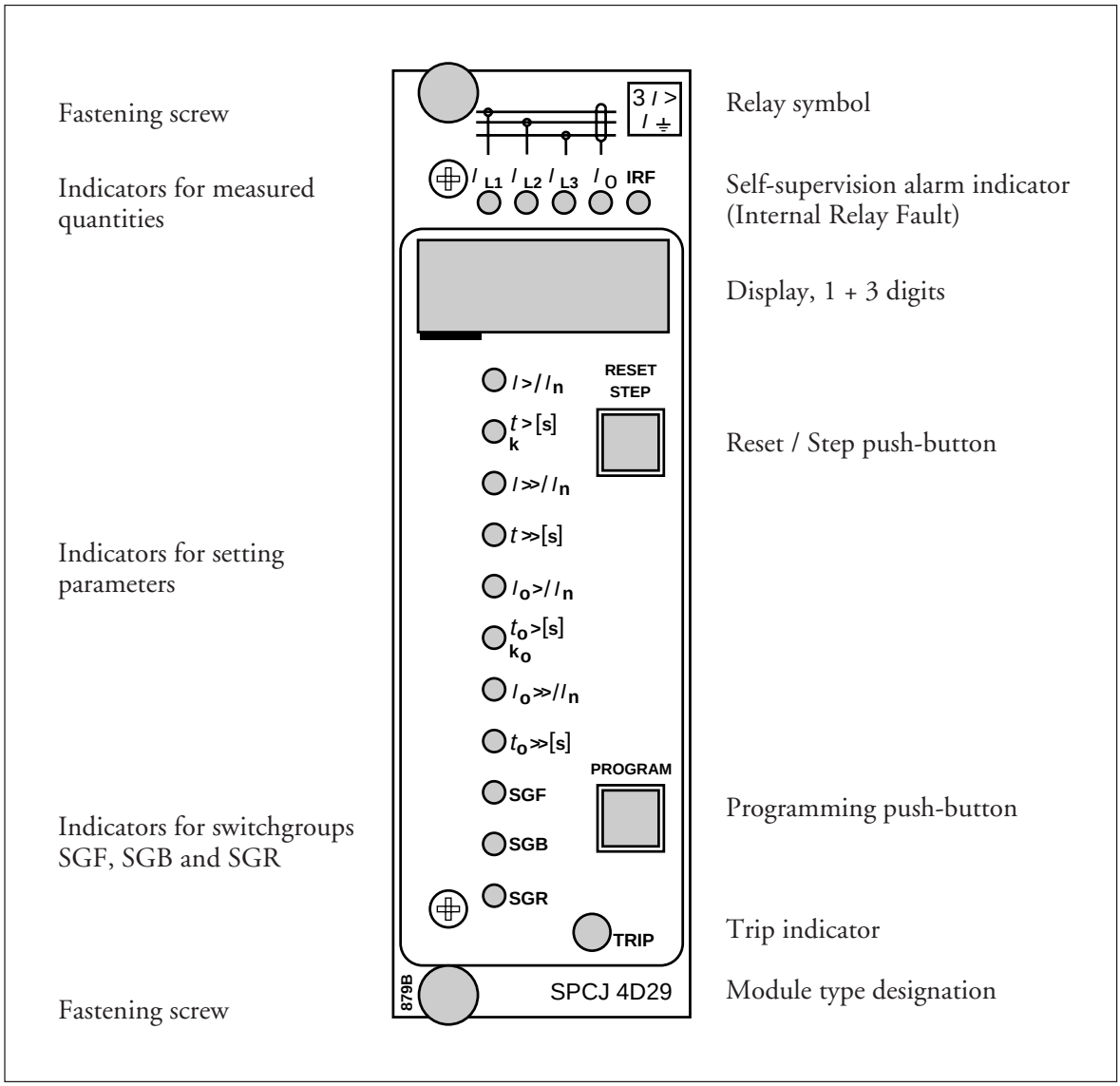
ARSYNC
If the synchronism check function has been selected, a close operation will not be made unless the ARSYNC signal (synchrocheck function) is active.

CINH
The CINH signal prevents circuit breaker closing.

ARINH
The ARINH signal inhibits and interrupts auto-reclosing.

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.*

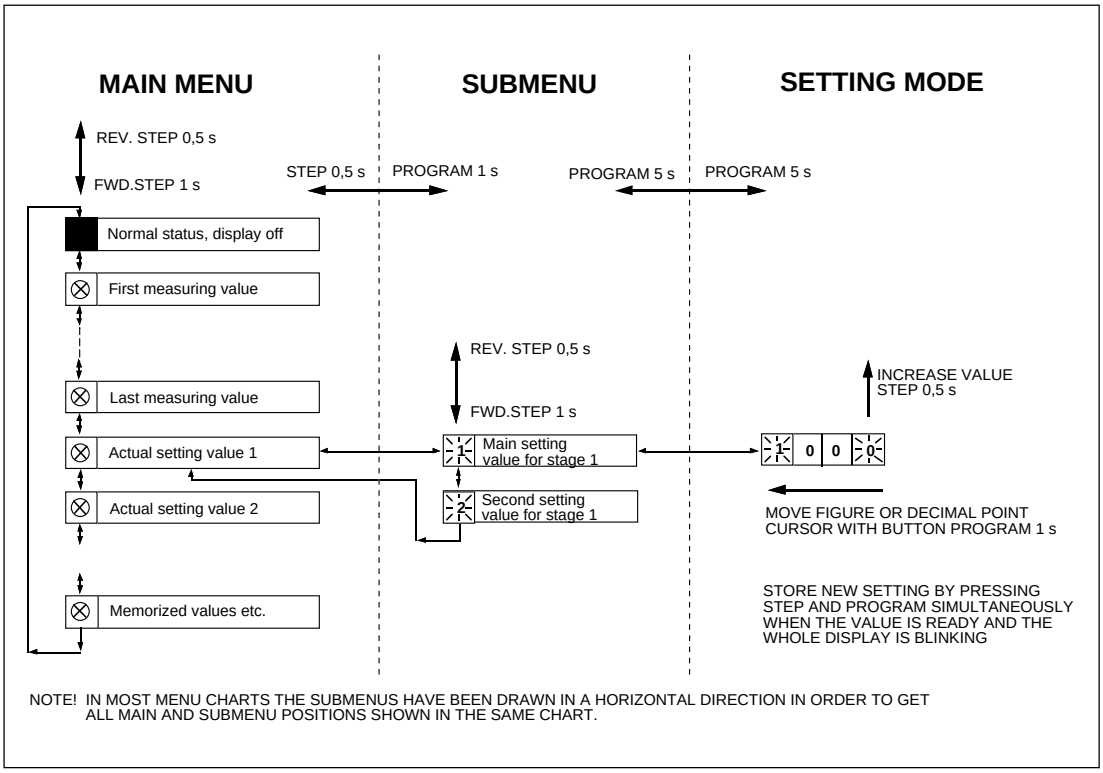


Fig.3. Basic principles of entering the main menus and submenus of a relay module.

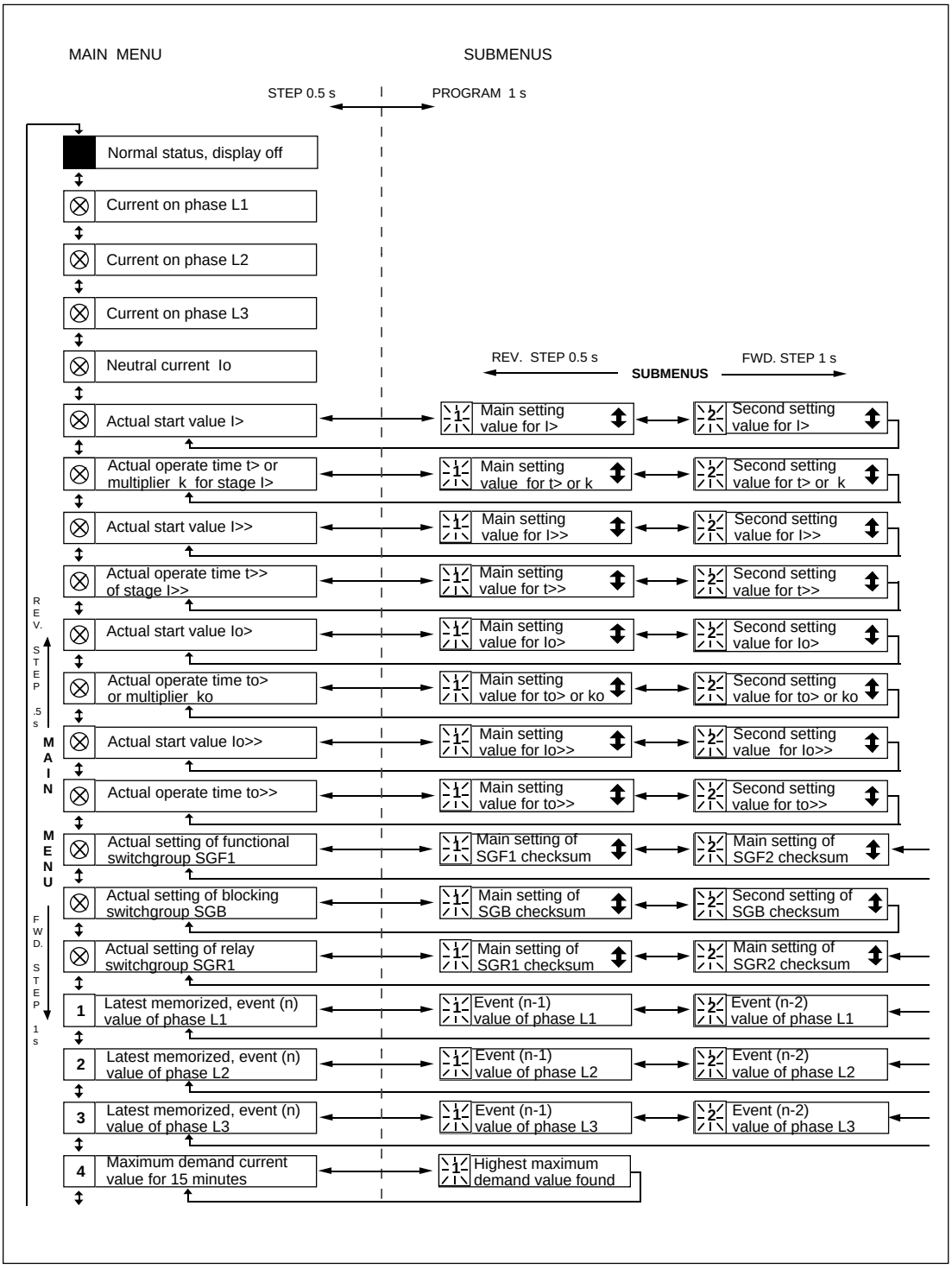
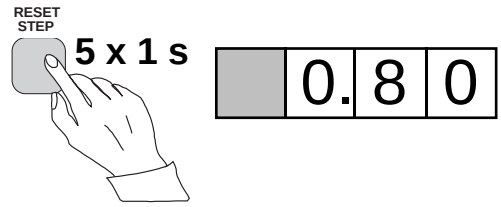


Fig. 4. Example of part of the main and submenus for the settings of the overcurrent and earth-fault relay module SPCJ 4D29. The settings currently in use are in the main manu and they are displayed by pressing the STEP push button. The main menu also includes the measured current values, the registers 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.

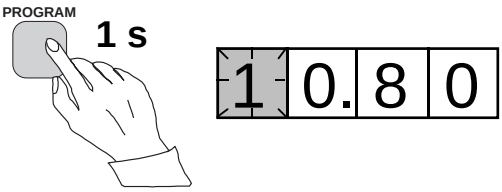
Example 1

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.

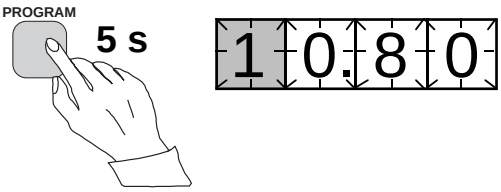
a)
Press push button STEP repeatedly until the LED close to the I> symbol is lit and the current start value appears on the display.



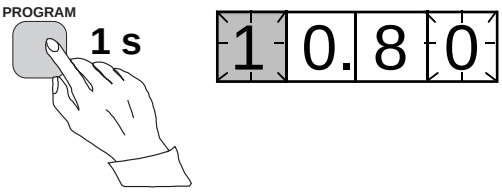
b)
Enter the submenu to get the main setting value by pressing the PROGRAM push button more than one second and then releasing it. The red display digit now shows a flashing number 1, indicating the first submenu position and the green digits show the set value.



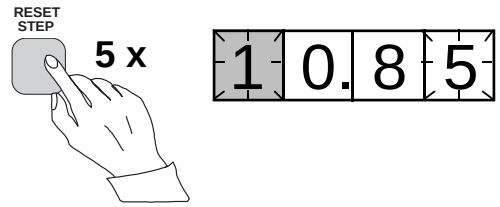
c)
Enter the setting mode by pressing the PROGRAM push button for five seconds until the display starts flashing.



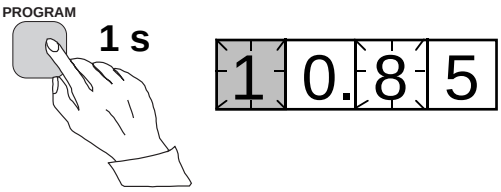
d)
Press the PROGRAM push button once again for one second to get the rightmost digit flashing.



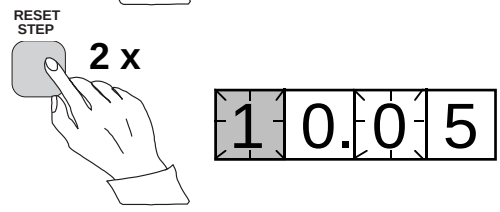
e)
Now the flashing digit can be altered. Use the STEP push button to set the digit to the desired value.



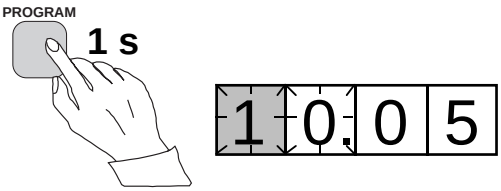
f)
Press the PROGRAM push button to make the middle one of the green digits flash.



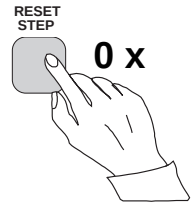
g)
Set the middle digit with of the STEP push button.

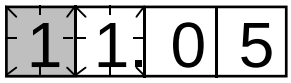


h)
Press the PROGRAM push button to make the leftmost green digit flash.

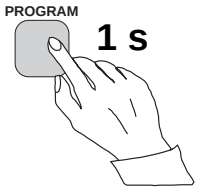


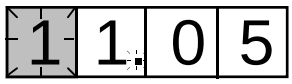
i)
Set the digit with the STEP push button.



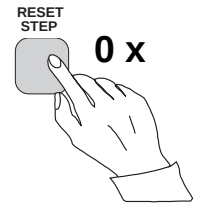


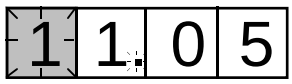
j)
Press the PROGRAM push button to make the decimal point flash.



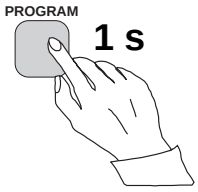


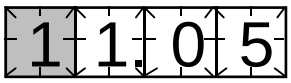
k)
If needed, move the decimal point with the STEP push button.



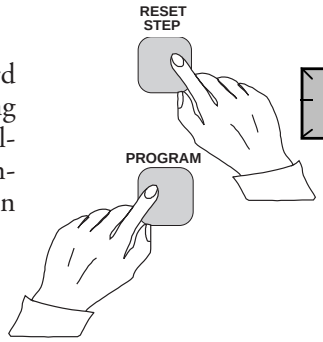


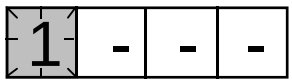
l)
Press the PROGRAM push button to make the whole display flash. In this position, corresponding to position c) above, one can see the new value before it is recorded. If the value needs changing, use the PROGRAM push button to alter the value.



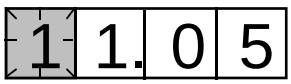


m)
When the new value has been corrected, record it in the memory of the relay module by pressing the PROGRAM and STEP push buttons simultaneously. At the moment the information enters the memory, the green dashes flash once in the display, i.e. 1 - - -.

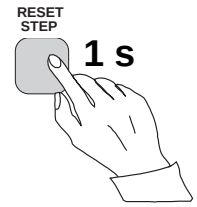


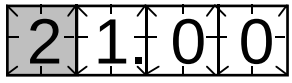


n)
Recording of the new value automatically initiates a return from the setting mode to the normal submenu. Without recording one can leave the setting mode any time by pressing the PROGRAM push button for about five seconds, until the green display digits stop flashing.



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>.



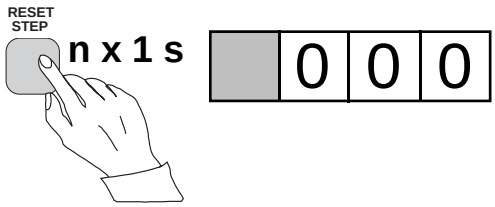


Enter the setting mode as in step c) and proceed in the same way. After recording of the requested values return to the main menu is obtained by pressing the STEP push button until the first digit is switched off. The LED still shows that one is in the I> position and the display shows the new setting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

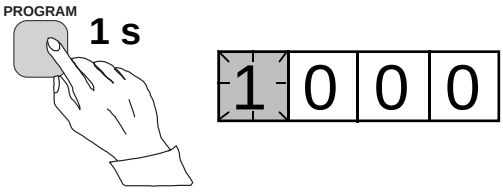
Example 2

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.

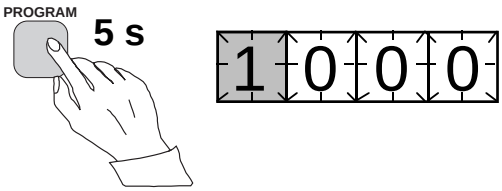
a)
Press push button STEP until the LED close to the SGF symbol is lit and the checksum appears on the display.



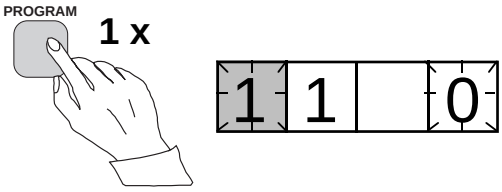
b)
Enter the submenu to get the main checksum of SGF1 by pressing the PROGRAM push button for more than one second and then releasing it. The red display now shows a flashing number 1 indicating the first submenu position and the green digits show the checksum.



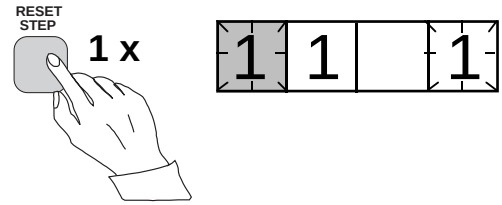
c)
Enter the setting mode by pressing the PROGRAM push button for five seconds until the display starts flashing.



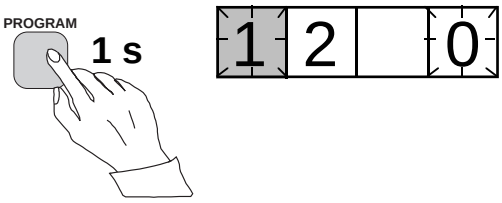
d)
Press the PROGRAM push button once again to get the first switch position. The first digit of the display now shows the switch number. The position of the switch is shown by the rightmost digit.



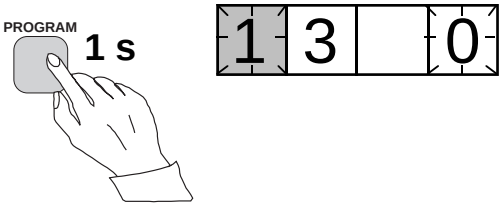
e)
The switch position can now be toggled between 1 and 0 by means of the STEP push button and it is left in the requested position 1.



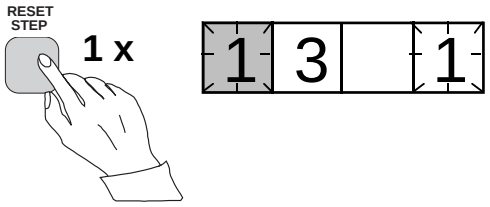
f)
When switch number 1 is in the requested position, switch number 2 is called up by pressing the PROGRAM push button for one second. As in step e), the switch position can be altered by using the STEP push button. As the desired setting for SGF1/2 is 0 the switch is left in the 0 position.



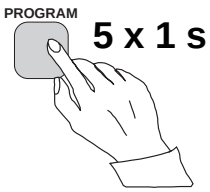
g)
Switch SGF1/3 is called up as in step f) by pressing the PROGRAM push button for about one second.



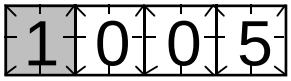
h)
The switch position is altered to the desired position 1 by pressing the STEP push button once.



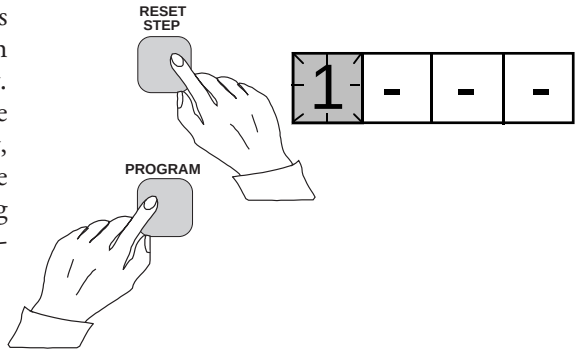
i)
Using the same procedure the switches SGF 1/ 4...8 are called up and, according to the example, left in position 0.



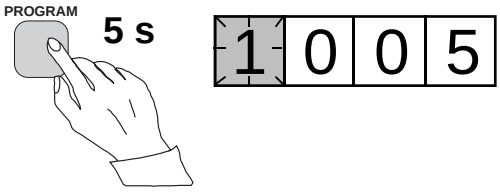
j)
In the final setting mode position, corresponding to step c), the checksum based on the set switch positions is shown.



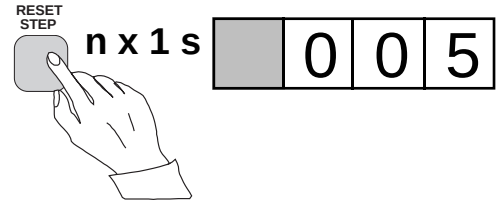
k)
If the correct checksum has been obtained, it is recorded in the memory by pressing the push buttons PROGRAM and STEP simultaneously. At the moment the information enters the memory, the green dashes flash in the display, i.e.1 - - -. If the checksum is incorrect, the setting of the separate switches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

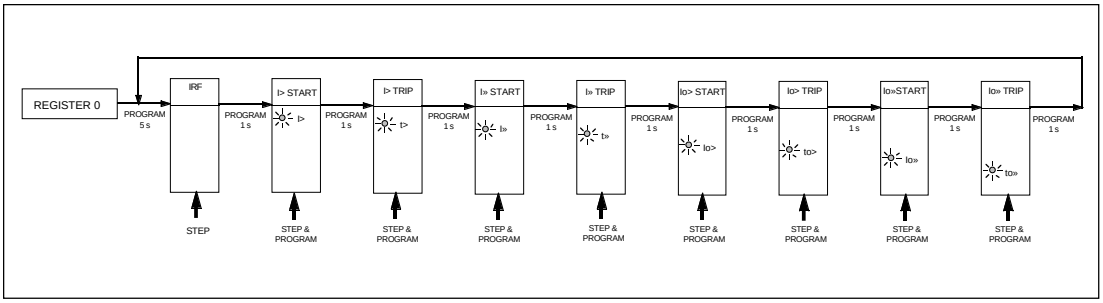


Fig. 5. Sequence order for the selection of output signals in the Trip test mode

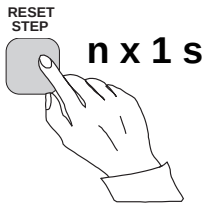
If, for instance, the indicator of the setting t> is flashing, and the push buttons STEP and PROGRAM are being pressed, the trip signal from the low-set overcurrent stage is activated. Return to the main menu is possible at any stage of the trip test sequence scheme, by pressing the PROGRAM push button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

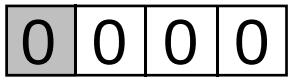
Note!
The effect on the output relays then depends on the configuration of the output relay matrix switchgroups SGR 1...3.

Example 3

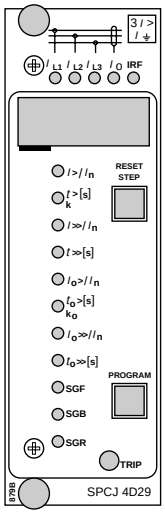
Trip test function. Forced activation of the outputs.

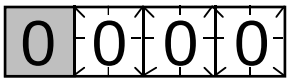
a)
Step forward on the display to register 0.





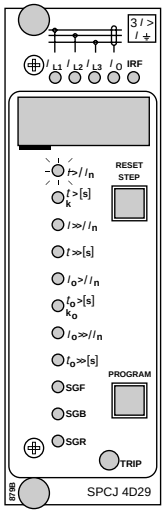
b)
Press the PROGRAM push button for about five seconds until the three green digits to the right.

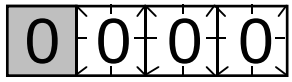




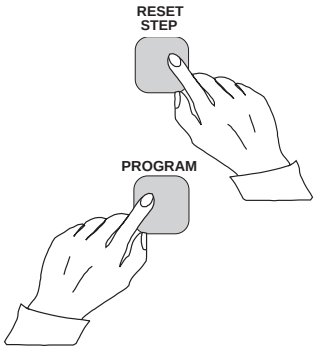
c)
Hold down the STEP push button. After one second the red IRF indicator is lit and the IRF output is activated. When the step push button is released the IRF indicator is switched off and the IRF output resets.

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

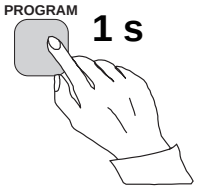


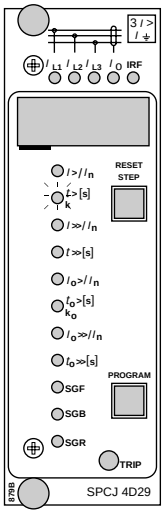


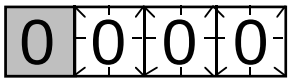
e)
If a start of the first stage is required, now press the push-buttons PROGRAM and STEP simultaneously. The stage output will be activated and the output relays will operate according to the actual programming of the relay output switchgroups SGR.



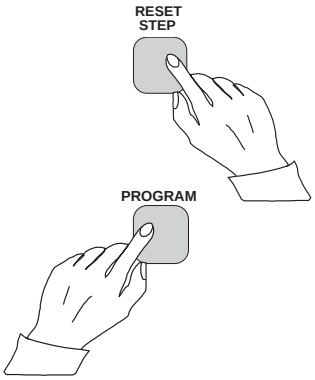
f)
To proceed to the next position press the PROGRAM push button for about 1 second until the indicator of the second setting starts flashing.

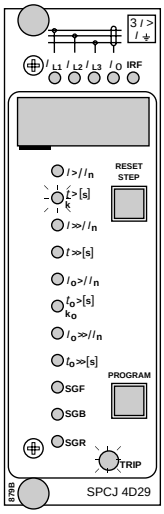


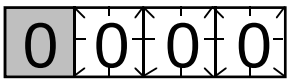




g)
Press the push buttons PROGRAM and STEP simultaneously to activate tripping of stage 1 (e.g. the I> stage of the overcurrent module SPCJ 4D29). The output relays will operate according to the actual programming of the relay switchgroups SGR. If the main trip relay is operated the trip indicator of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