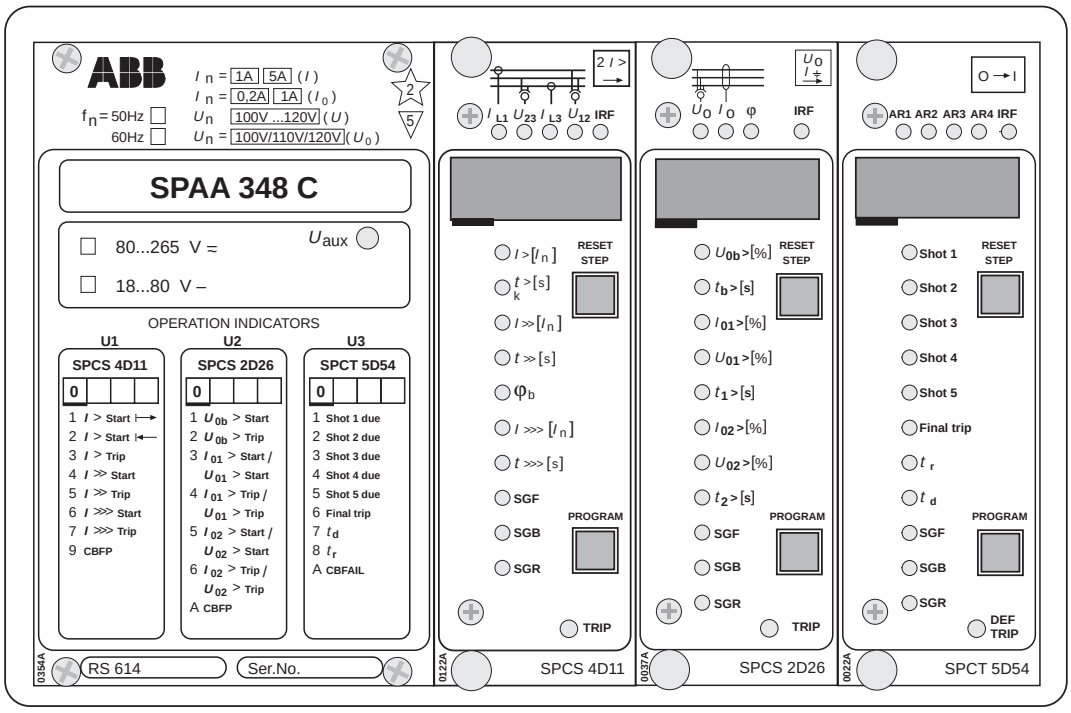
SPAA 348 C
Feeder Protection Relay

User´s manual and Technical description



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SPAA 348 C
Feeder Protection Relay

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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 348 C:

Combined overcurrent and earth-fault relay module SPCS 4D11	1MRS 750115-MUM EN
Directional or non-directional earth-fault relay module SPCS 2D26	1MRS 750100-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

Directional overcurrent protection with three stages

Special memory circuit for maintaining the stability and reliability of the directional measurement at close three-phase faults

Two-stage sensitive directional earth-fault protection

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 to 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 348 C is designed to be used in applications requiring directional phase overcurrent, directional short-circuit and directional earth-fault protection. Typically, the relay are used for the overcurrent and earth-fault protection of infeeders and busbars in distribution substations provided with multiple infeeders supplied from the same high-voltage busbar system via power transformers.

The relays are also applied for the selective short-circuit and earth-fault protection of parallel multiple feeders between substations and for feeder protection in ring-type and meshed distribution networks.

Further, directional relays are used for the protection of radial feeders supplied with a small back-feed of energy from a generator in the consumer-end of the feeder.

Description of operation

The feeder protection relay SPAA 348 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 two-phase directional overcurrent relay module type SPCS 4D11, a directional or non-directional earth-fault relay module type SPCS 2D26 and an auto-reclose relay module type SPCT 5D54.

Directional overcurrent relay module SPCS 4D11

The directional overcurrent module SPCS 4D11 is intended to be used for single-phase or two-phase overcurrent protection. It includes three overcurrent stages: two directional stages I>, I>> and one non-directional stage I>>>. An overcurrent stage starts, as soon as the current on one of the phases exceeds the setting value of the stage concerned and if directional operation is selected the directional criteria must be fulfilled. Should the stage still be started when the operate time selected for the stage elapses, it trips the circuit breaker by delivering the trip signal configured.

The low-set stages I> 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 high-set stages can be totally blocked by means of the configuration switches.

The directional control of the relay module SPCS 4D11 is based on measuring the phase angle between phase current and the opposite phase-to-phase voltage, say, L1 and U23.

To secure a reliable relay operation in close three-phase fault situations characterized by an exremely low phase-to-phase voltage, a memory function is implemented. At sudden loss of voltage in a fault situation this memory function gives the directional stages an additional 2.5 s time to operate after a total loss of voltage (=voltage level below 7%).

Further, if the circuit breaker is closed against a fault, which means that you can have a situation where the voltage does not rise to such a level that the direction of the current could be determined. In this case the high-set stage I>> will operate non-directionally.

Directional earth-fault relay module SPCS 2D26

The directional earth-fault relay module SPCS 2D26 includes two protection stages: a low-set stage I_{01}> and a high-set stage I_{02}>. The start value of the deblocking voltage U_{0b}> is the same for both I_{01}> and I_{02}>. The protection is based on measuring the neutral current I_0, the residual voltage U_0 and the phase angle between these. An earth-fault stage starts if the neutral current and the residual voltage exceed the set values and the phase angle is within the specified operating sector $\varphi_b \pm \Delta\varphi$. When these conditions remain fulfilled during the set operate time, the stage provides a trip signal.

The earth-fault relay module SPCS 2D26 can also be configured to operate as a three-stage residual voltage relay. Then the two neutral current stages are replaced by two voltage stages. The three residual voltage stages measure the same voltage, but they can be given separate start values and operate times.

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 short circuit.

An auto-reclose shot can be initiated by start or trip signals of the protection. When initiated by a start signal of one of the protection 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 tripping can be carried out either by a protection relay module 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 circuit-breaker operations. 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 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 integrated into the relay modules SPCS 4D11 and SPCS 2D26 enables a secured circuit breaker 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.

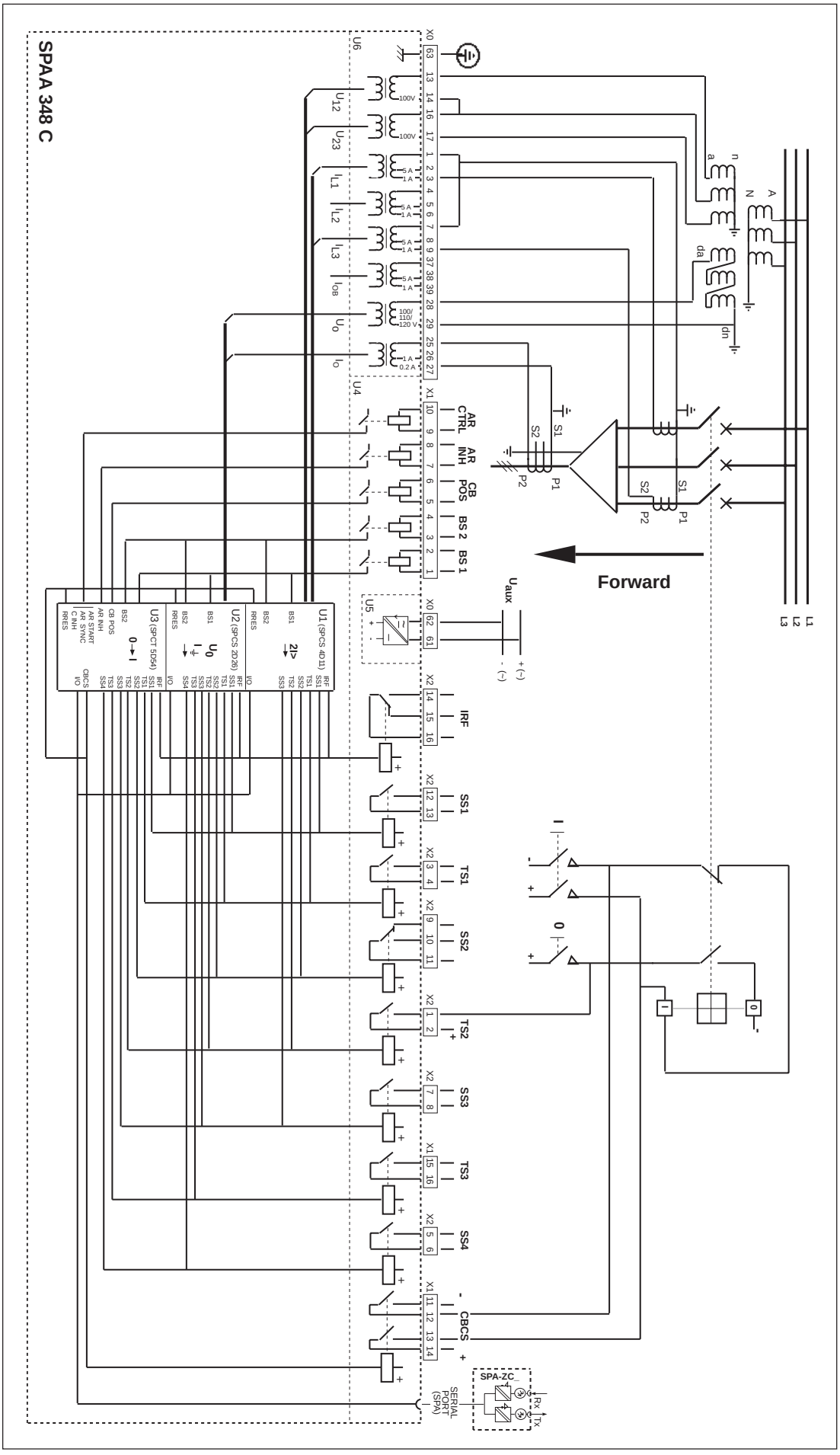


Fig. 1. Connection diagram for feeder protection relay SPAA 348 C

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	Directional overcurrent relay module SPCS 4D11
U2	Directional earth-fault relay module SPCS 2D26
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

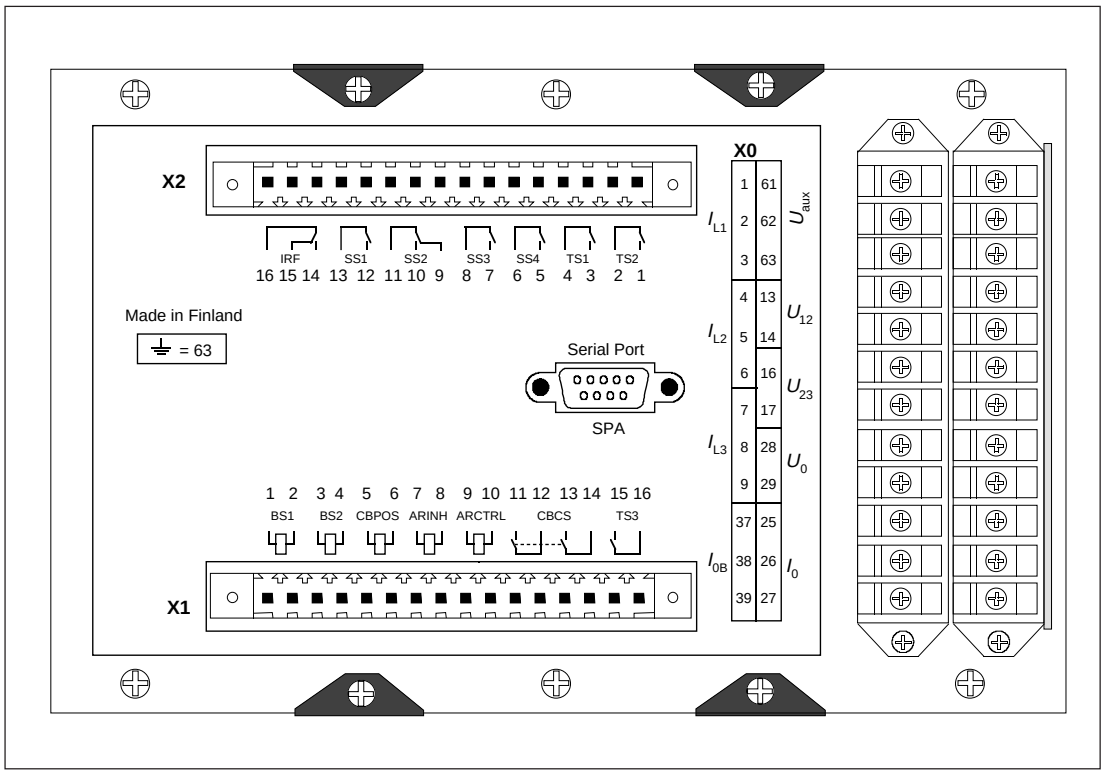


Fig. 2. Terminals of feeder protection relay SPAA 348 C.

Specification of input and output terminals

Terminal group	Terminal interval	Function
XO	1–2	Phase current I_{L1} (5 A). Directional overcurrent protection
	1–3	Phase current I_{L1} (1 A). Directional overcurrent protection
	4–5	Phase current I_{L2} (5 A). (Not used in SPAA 348 C)
	4–6	Phase current I_{L2} (1 A). (Not used in SPAA 348 C)
	7–8	Phase current I_{L3} (5 A). Directional overcurrent protection
	7–9	Phase current I_{L3} (1 A). Directional overcurrent protection
	13–14	Phase-to-phase voltage U_{12} (100 V) Directional overcurrent protection
	16–17	Phase-to-phase voltage U_{23} (100 V) Directional overcurrent protection
	37–38	Neutral current I_{0B} (5 A) (Not used in SPAA 348 C)
	37–39	Neutral current I_{0B} (1 A) (Not used in SPAA 348 C)
	25–26	Neutral current I_0 (1 A). Directional earth-fault protection (SPCS 2D26)
	25–27	Neutral current I_0 (0.2 A). Directional earth-fault protection (SPCS 2D26)
	28–29	Residual voltage U_0 (100 V). Dir. earth-fault protection (Selection of rated voltage 110 V- and 120 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 to be 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 into 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. TS1 and TS2).

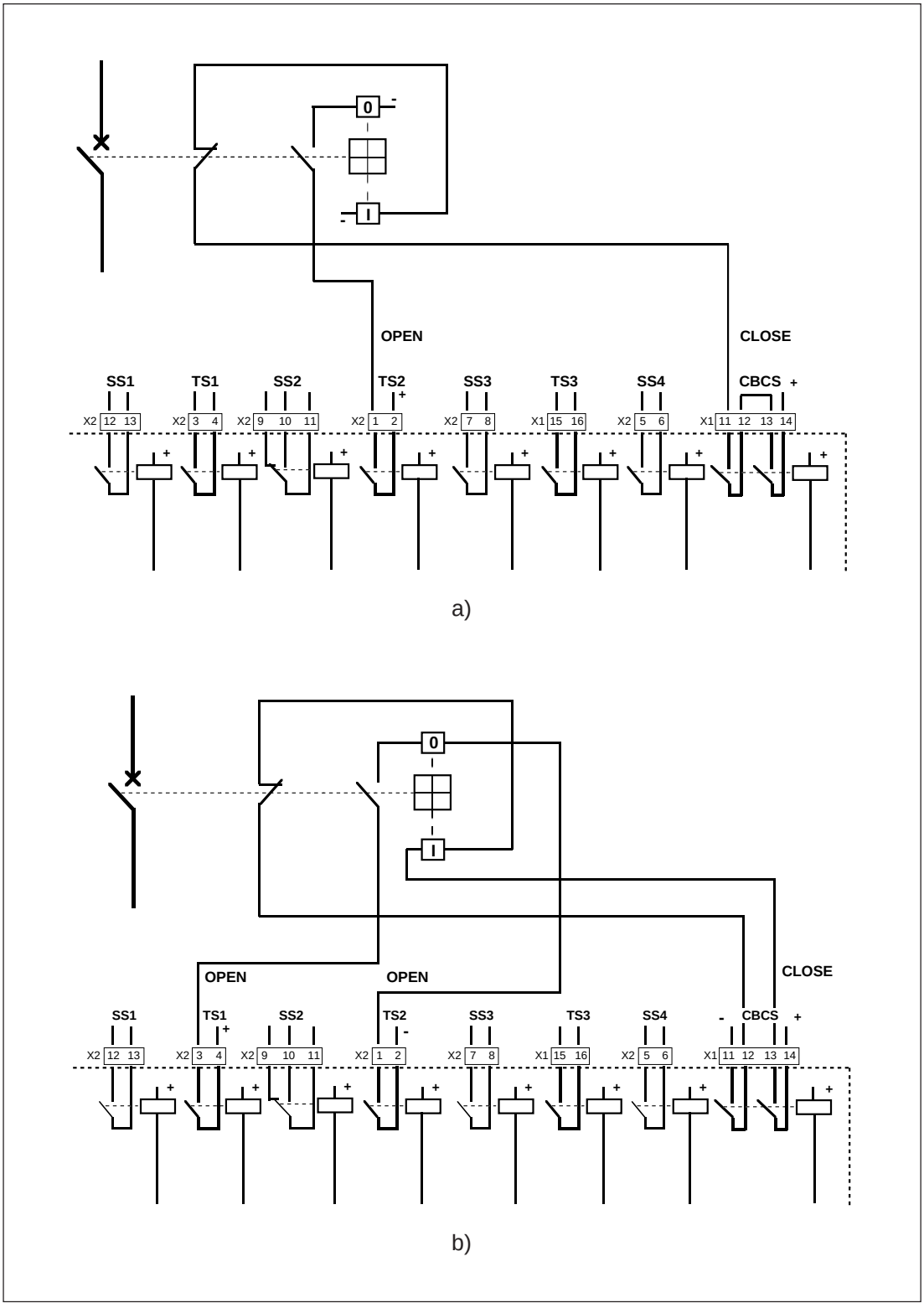


Fig. 3. Principle of one-pole (a) and double-pole (b) operation.

Signal flow diagram
(modified 97-01)

Fig. 4 illustrates the internal signals of the feeder protection relay and their configuration. 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 configure the start and trip signals to operate as desired output signals or AR initiation signals.

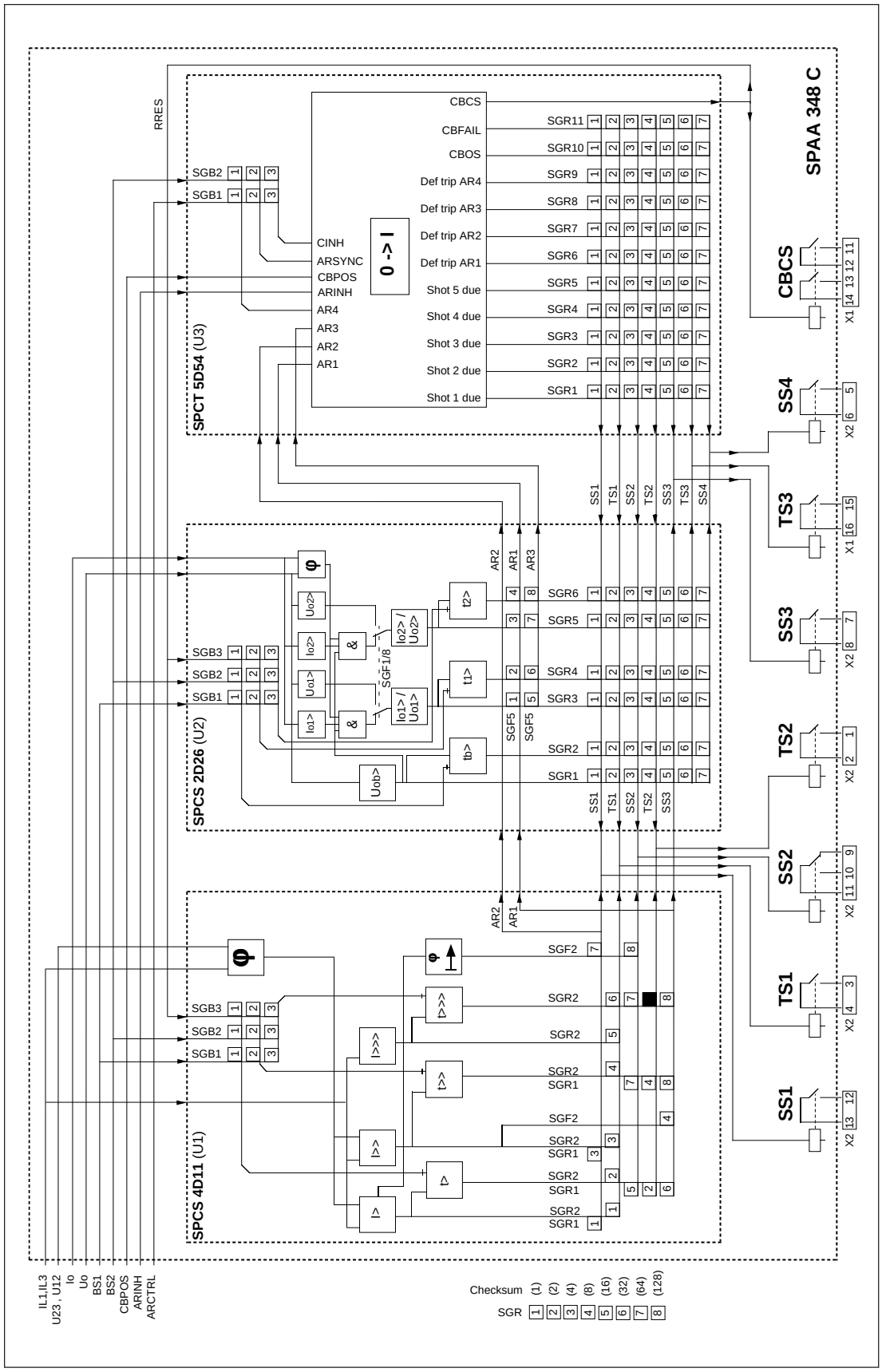


Fig. 4. Internal signals of feeder protection relay SPAA 348 C.

Operation indicators

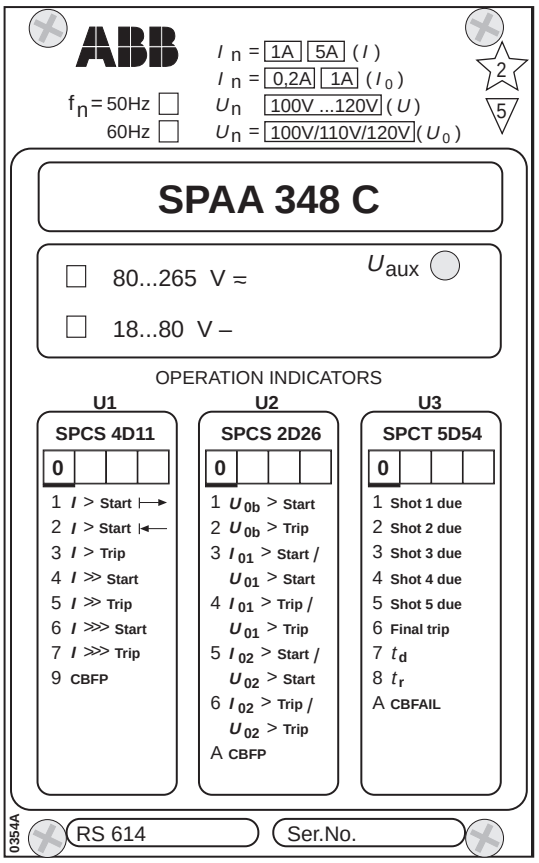


Fig. 5. Front panel of feeder protection relay SPAA 348 C.

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 starting and tripping. The BS1, BS2 and RRES signals can be configured to reset the trip indicators automatically. 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 348 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 are 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 relay module manuals.

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 into 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 2002-06)

Energizing inputs

Rated current I_n	0.2 A	1 A	5 A
Terminal numbers		X0/1-3,4-6	X0/1-2,4-5
		X0/7-9,37-39	X0/7-8, 37-38
	X0/25-27	X0/25-26	
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/120 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 SPCS 4D11

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

Directional earth-fault relay module SPCS 2D26

- 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 21BB
- for glass fibre cables	SPA-ZC 21 MM
Electrical/optical bus connection module powered from the host relay or from an external power source	
- for plastic core cables	SPA-ZC 17BB
- for glass fibre cables	SPA-ZC 17 MM

Insulation Tests *)

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

EMC tests

CE-approved and tested according to	EN 50081-2 EN 50082-2

Electromagnetic Compatibility Tests *)

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

Mechanical environmental test

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

Environmental conditions

Service temperature range	-10...+55°C
Transport and storage temperature range (IEC 60068-2-8)	-40...+70°C
Temperature influence	0.2%/°C
Damp heat test (IEC 60068-2-30)	93...95%, +55°C, 6 cycles
Degree of protection by enclosure of flush mounting relay case (IEC 60529)	IP 54
Weight of fully equipped relay	6 kg

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

Application examples

(modified 97-01)

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

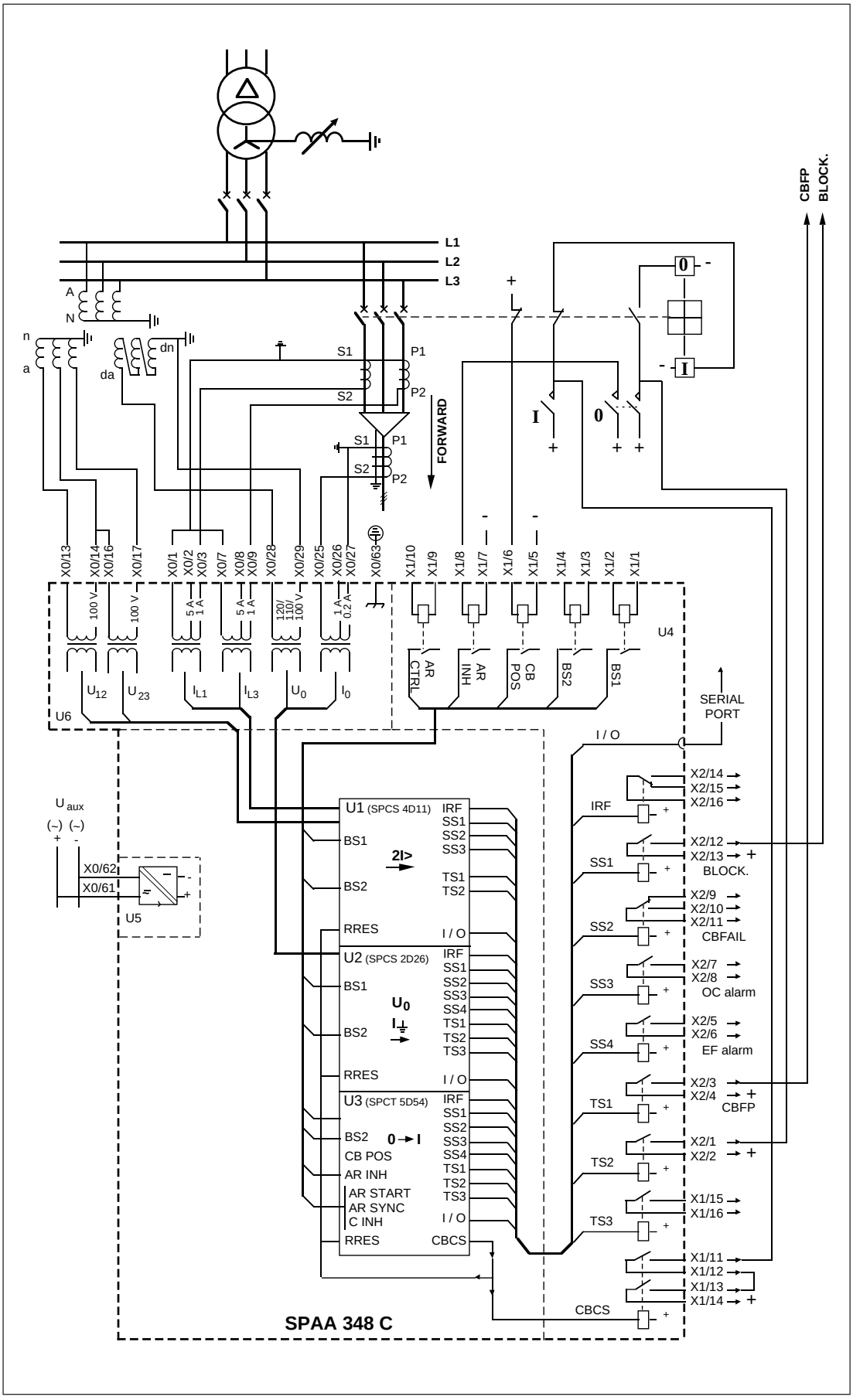


Fig. 6. Feeder protection relay SPAA 348 C used for protecting a feeder in a resonant earthed network.

Directional overcurrent relay module SPCS 4D11

The overcurrent relay module SPCJ 4D11 includes three overcurrent stages. By using all three stages and giving each overcurrent stage its own operate value and operate time good selectivity with short operate times can be obtained. The operation of the short-circuit protection in this example 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 zone and trips the circuit breaker. Thus it is possible to use a minimum operate time of 120 ms at busbar system faults.

The low-set stage I> is used as a directional stage operating in "forward" direction. Definite time operation has been used in this example, but inverse time characteristic can also be selected for the stage I>. The current setting of the stage I> must extend to the setting of the following protection stage.

The high-set stage I>> is also used as a directional stage operating in the same direction as the low-set stage. The current setting of the high-set stage I>> is set to operate at short-circuits occuring close to the substation. Further, the start of the stage I>> is used to block the infeeder protection if the fault is located on the outgoing feeder.

The non-directional high-set stage I>>> is not used in this example. When long operate times are used for the directional stages, the second high-set stage should however be used as back-up protection. The stages I> and I>> can determine the direction of the current for about 2.5 s after a total collapse of the voltage. If, in a fault situation, a trip signal is not delivered within 2.5 s after the voltage collapse, the trip must be performed non-directionally by the second high-set stage I>>>.

The directional element of each phase current, determines the direction of the current by measuring the phase differance between the current and the opposite phase-to-phase voltage. Since the relay in this case is used to protect a feeder with the zero sequence source behind the relaying point, the base angle selected should be -30°as shown in the figure 7.

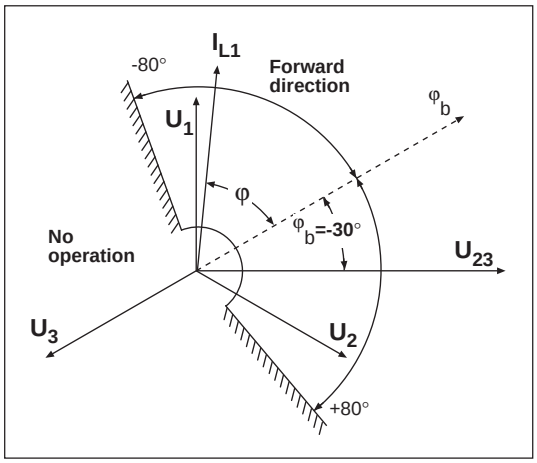


Fig. 7. Directional element of phase L_1

Directional or non-directional earth-fault relay module SPCS 2D26

In the resonant earthed network illustrated in this example the relay module SPCS 2D26 is 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. Changes in the extension of the network due to variations in the network configuration do not cause inselectivity, because the direction of the earth fault current of a faulty feeder is opposite to the earth fault current of a healthy feeder.

In the SPAA 348 type relay the directional earth fault protection uses the sensitive neutral current input; the rated values are 0.2 A / 1 A.

The basic angle of the relay module SPCS 2D26 can be set at 0°, -30°, -60° or -90°. When the network to be protected is resonant earthed or earthed via a resistor as in this example , the basic angle should be set at 0°. When an isolated neutral system is protected the basic angle is set at -90°. It is also possible to use an external control signal BS1 or BS2 for selecting the basic angle (0°/-90°) to be automatically determined by the earthing situation of the network. When the control voltage is connected, the basic angle φ_b = 0°.

The start value of the low-set stage 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 mainly fulfilled by the operation of the high-set stage I_{02}>.

Auto-reclose relay module SPCT 5D54

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

In this example two auto-reclosures initiated by the trip signal of the protection are carried out. Shot 1 is a high-speed auto-reclosure (short dead time) mainly used for extinguishing the arc at the fault place. When the set dead time elapses, the auto-reclose module closes the circuit breaker and, simultaneously, the reclaim time is started. Since the protection trips again before the reclaim time has elapsed the second shot is initiated. 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 completed, nofurther shot is initiated, the CB remains open and a DEF.TRIP alarm signal is received.

The discriminating time is only used with inverse time characteristic type of protection. When the auto-reclose module delivers the CB close signal, the discriminating time is started. If the fault still persists after the CB closing and the amplitude of the fault current trips the circuit-breaker before the end of the discriminating time, the auto-reclose sequence is inhibited. The circuit breaker remains open and a DEF.TRIP alarm will be received from the auto-reclose module.

The auto-reclosing module SPCT 5D54 offers a wide variety of different auto-reclosing schemes, For further information, see the submanual of the auto-reclose module SPCT 5D54.

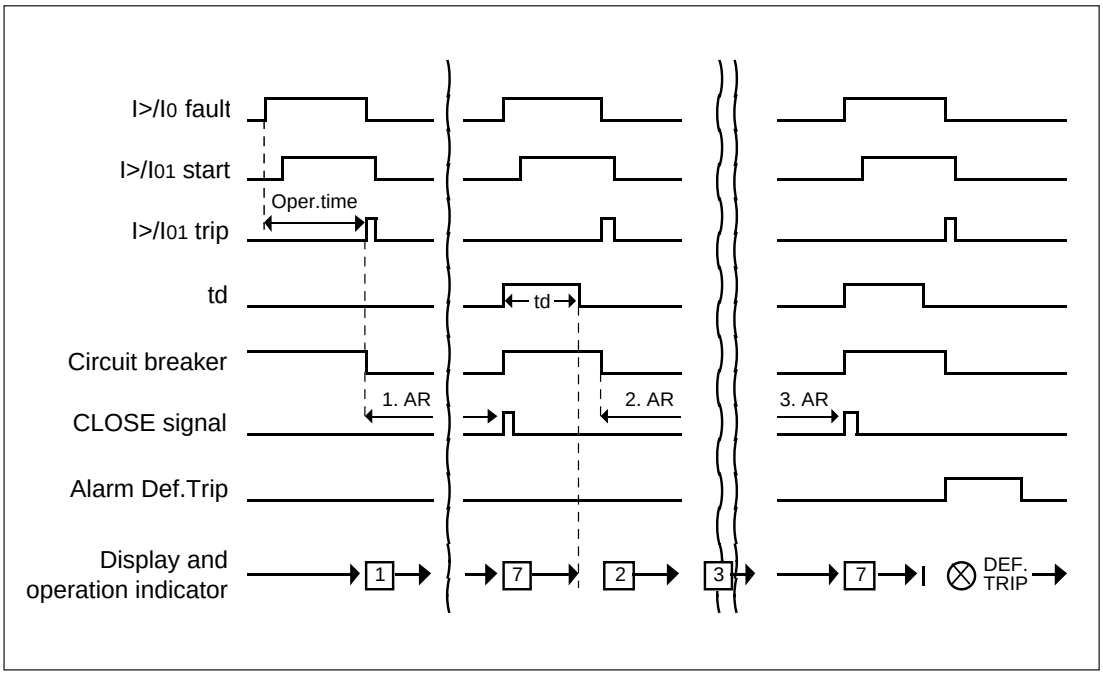


Fig. 8. Auto-reclose sequence when initiated by the start signal.

Additional functions

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 348 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 TS1 and TS2 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 348 C can be configured as follows:

Configuration of SPCS 4D11

Switch-group	Serial comm. parameter	Checksum	Operation
SGF1	S28	040	Definite time operation, CBFP in use, I>> directional
SGF2	S29	032	Automatic resetting of start indicators, I>>> not used
SGB1	S30	000	No blocking/control by the BS1 signal
SGB2	S31	000	No blocking/control by the BS2 signal
SGB3	S32	032	Operation indicators reset by CB closing
SGR1	S33	174	I> trip linked to TS2 (trip) and AR1 (auto-reclose) I>> start linked to output contact SS1 I>> trip linked to TS2 (trip) and AR1 (auto-reclose)
SGR4	S34	000	Not used

Configuration of SPCS 2D26

Switch-group	Serial comm. parameter	Checksum	Operation
SGF1	S49	003	Earth-fault stages I_{01}> & I_{02}> operate in forward direction, basic angle $\varphi_b = 0°$
SGF2	S50	000	Resetting time of stages I_{01}/U_{01} = 80 ms, rated voltage of U_0 = 100 V, $\Delta\varphi = \pm 80°$
SGF3	S51	008	Signal TS2 controls TRIP LED
SGF4	S52	016	U_0 deblocking criterion in use, TS2 starts the circuit-breaker failure protection
SGF5	S53	160	Auto-reclose sequence (AR3) initiated by I_{01}> trip and I_{02}> trip
SGB1	S54	000	No blocking/control by the BS1 signal
SGB2	S55	000	No blocking/control by the BS2 signal
SGB3	S56	016	Operation indicators reset by CB closing
SGR1	S57	000	U_{0b}> start not linked to output contacts
SGR2	S58	000	U_{0b}> trip not linked to output contacts
SGR3	S59	000	I_{01}> start not linked to output contacts
SGR4	S60	008	I_{01}> trip linked to trip contact TS2
SGR5	S61	000	I_{02}> start not linked to output contacts
SGR6	S62	008	I_{02}> trip linked to trip contacts TS2

Configuration of SPCT 5D54

Setting	Serial comm. parameter	Value	Operation
Shot 1	1S2, 1S3, 1S4	1, 0, 1	AR1 and AR3 initiates shot 1
	1S1	0,3 s	Dead time shot 1
Shot 2	2S2, 2S3, 2S4	1, 0, 1	AR1 and AR3 initiates shot 2
	2S1	120 s	Dead time shot 2
Final trip	6S2, 6S3, 6S4	0, 0, 0	Final trip not used

Switch-group	Serial comm. parameter	Checksum	Operation
SGF1	S2	000	Shot 1 & 2 initiated by tripping of the protection
SGF2	S3	000	No synchrocheck function, maintenance monitor alarming
SGF3	S4	047	DEF.TRIP indicator is lit, when DEF.TRIP AR1, AR2, AR3,AR4 or CBFAIL is 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	032	Def trip AR1 linked to TS3
SGR7	S16	000	Def trip AR2 not linked to output contact
SGR8	S17	064	Def trip AR3 linked to SS4
SGR9	S18	000	Def trip AR4 not linked to output contact
SGR10	S19	000	CB opening not linked to output contact
SGR11	S20	004	CBFAIL linked to SS2

(modified 97-01)

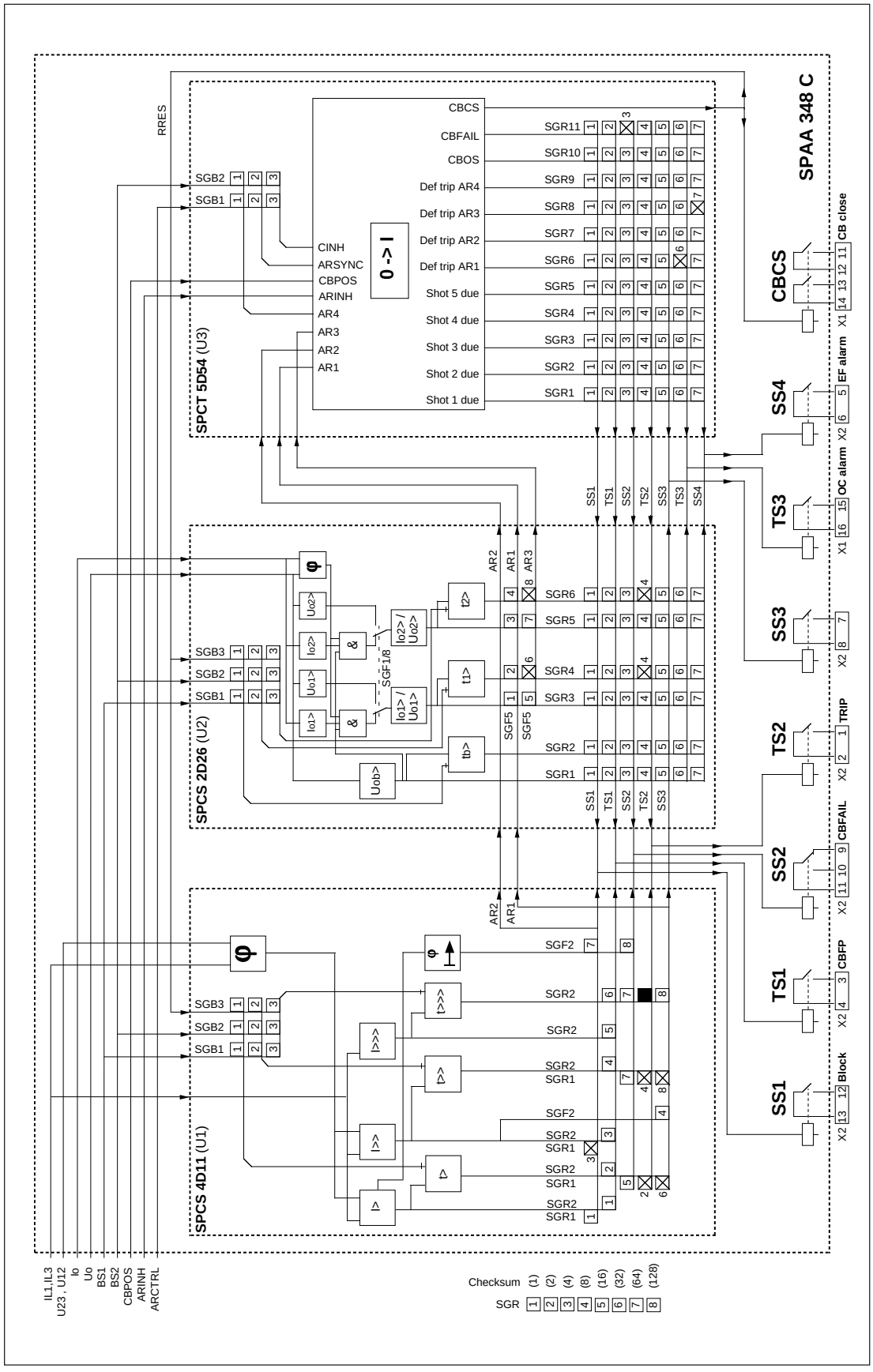


Fig. 9. Configuration of the internal signals in the application example 1 for the SPAA 348 C.

Note! The above configuration is not the factory setting.

Testing

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

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

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

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

The test is recommended to be carried out using the normal setting values of the relay and the energizing inputs used. When required, the test can be extended to include 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 are 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 directional overcurrent relay module SPCS 4D11

General

The protection stages used (I>, I>>, I>>>) 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

The directional stages has to be tested with voltage and current fed to the relay simultaneously. To enable relay operation, the phase angle between the current and voltage has to be within the operation sector selected for the relay. Start by applying voltage to the relay and then 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.

The directional operation can be tested by connecting current and voltage to the relay (the current should be above the setting value) and changing the phase angle until the relay starts and resets.

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

When multi-stage protection relays are tested it is recommended to start from the highest stage and then proceed to the lower stages. The advantage of this method is that the original settings of the stages really are restored.

Start and trip times

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

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

Testing of directional earth-fault relay module SPCS 2D26

General

Testing of the protection stages in use (U_{0b}>, U_{01}>/I_{01}> and U_{02}>/I_{02}>) includes:

- start value(s)
- start time
- trip time
- trip indication, output relay operation and signalling
- circuit breaker failure protection (CBFP)

Start value

Measure the start value of the U_{0b}> stage by gradually raising the voltage, starting from zero, until the relay starts. Record the voltage value required for starting. The value should be within the permitted tolerances.

Test the stages U_{01}>/I_{01}> and U_{02}>/I_{02}> in the same way as the U_{0b}> stage, if they are programmed to operate as U_0 stages. Otherwise current and voltage should be fed to the relay simultaneously. Start by setting the voltage above the setting value and raise the current until the relay starts. Record the value of the start current. Then set the current at a value above the setting value and raise the voltage until the relay starts. Record the value of the start voltage.

The operation of the U_{01}>/I_{01}> stage and U_{02}>/I_{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 to be applied to the relay 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, use a current and voltage above the setting values. Then reduse the current, 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

Testing of the auto-reclose relay module includes:

- initiation of auto-reclosure
- 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. once an overcurrent stage or an earth-fault stage has been tested, the operation of the same stage should be tested 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 the circuit breaker. Then the required configuration is selected 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 run the entire AR sequence. Depending on the configuration the sequence may include one or several AR shots and 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. Depending on the configurations definite tripping will provide an alarm signal (DEFTRIP).

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 damp and mechanical stress, especially during transport.

Spare parts

Directional overcurrent relay module	SPCS 4D11
Directional earth-fault relay module	SPCS 2D26
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	SPCS 4D11	SPCS 2D26	SPCT 5D54
SPAA 348 C	Basic version, including all relay modules	x	x	x
SPAA 348 C1	Basic version excluding AR relay module	x	x	
SPAA 348 C2	Basic version excluding earth-fault relay module	x		x
SPAA 348 C3	Basic version excluding earth-fault relay module and AR relay module	x		

Delivery alternatives of feeder protection relay SPAA 348 C

Order numbers

Feeder protection relay SPAA 348 C without test adapter:
SPAA 348 C: RS 614 103-AA, CA, DA, FA
SPAA 348 C1: RS 614 104-AA, CA, DA, FA
SPAA 348 C2: RS 614 105-AA, CA, DA, FA
SPAA 348 C3: RS 614 106-AA, CA, DA, FA

Feeder protection relay SPAA 348 C with test adapter RTXP 18:
SPAA 348 C: RS 614 303-AA, CA, DA, FA
SPAA 348 C1: RS 614 304-AA, CA, DA, FA
SPAA 348 C2: RS 614 305-AA, CA, DA, FA
SPAA 348 C3: RS 614 306-AA, CA, DA, FA

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

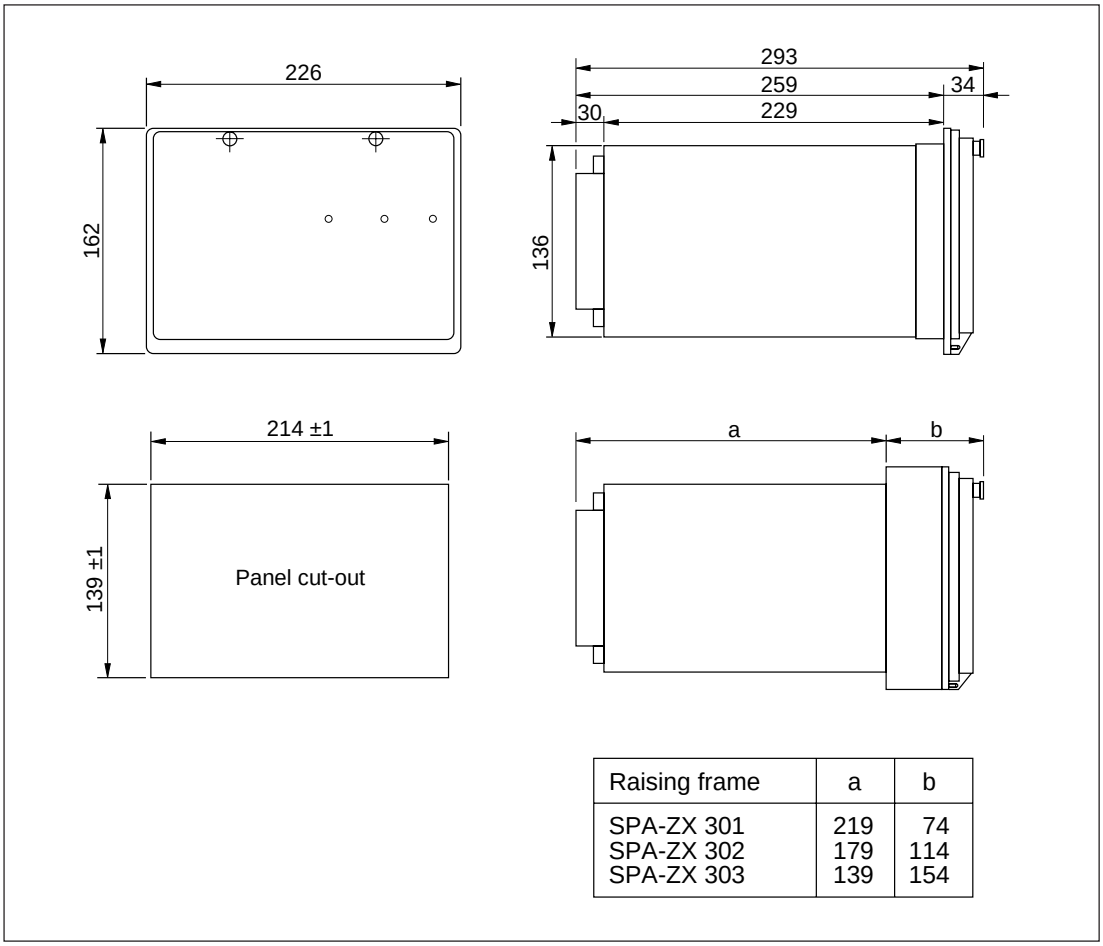
AA: f_n = 50 Hz and U_{aux} = 80...265 V ac/dc
CA: f_n = 50 Hz and U_{aux} = 18...80 V dc
DA: f_n = 60 Hz and U_{aux} = 80...265 V ac/dc
FA: f_n = 60 Hz and U_{aux} = 18...80 V dc

Order data

	Example
1. Number and type designation	10 SPAA 348 C units
2. Order number	RS 614 103 -AA
3. Rated frequency	f_n = 50 Hz
4. Auxiliary voltage	U_{aux} = 110 V dc
5. Accessories	10 bus connection modules SPA-ZC 17 MM2A
6. Special requirements	–

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. For projecting mounting 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. 16. Dimension and mounting drawings for feeder protection relay SPAA 348 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 signals are connected 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.

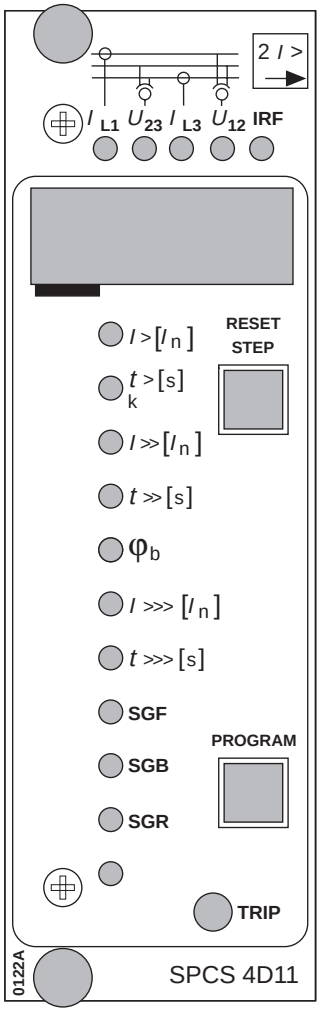
Binary input and output signals are connected to the multi-pole terminal blocks X1 and X2. Each screw terminal is dimensioned for one wire of maximum 1.5 mm^2 or two wires of maximum 0.75 mm^2.

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

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

SPCS 4D11 and SPCS 4D12
Two-phase directional overcurrent relay modules

User´s manual and Technical description



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SPCS 4D11 and SPCS 4D12 Two-phase directional overcurrent relay module

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Characteristics

Three overcurrent stages

A directional low-set stage I> with definite time and inverse time mode of operation.

A directional high-set stage I>> with a setting range of 0.5...40 x I_n.

A non-directional high-set stage I>>> with a setting range of 2...40 x I_n.

The high-set stages can be set out of operation.

Memory circuit for maintaining the stability and reliability of the directional operation at close three-phase faults.

Digital display of measured and set values and sets of data recorded at the moment when a fault occurs.

The settings may be keyed in via the push-buttons on the front panel or from higher level systems over the serial interface and the fibreoptic bus.

Continuous self-supervision including both hardware and software. At a permanent fault the alarm output relay operates and the other outputs are blocked.

Description of function

General

The directional overcurrent relay modules SPCS 4D11 and SPCS 4D12 are designed for two-phase directional operation. Each module contain two directional overcurrent stages and one non-directional high-set stage.

The directional overcurrent modules SPCS 4D11 and SPCS 4D12 are identical except for the phase currents and phase-to-phase voltages measured by the modules.

Module	current and voltage	current and voltage
SPCS 4D11	I_{L1} and U_{23}	I_{L3} and U_{12}
SPCS 4D12	I_{L1} and U_{23}	I_{L2} and U_{31}

When a stage exceeds the current setting and if directional operation has been selected the directional criteria should be fulfilled, a start signal is provided and, simultaneously, the digital display on the front panel indicates start. If the overcurrent situation lasts long enough to exceed the set operate time, the stage that started provides a trip signal. At the same time the red operation indicator is lit.

The operation of the overcurrent stages can be blocked by a blocking signal BS1, BS2 or RRES linked to the module. The blocking configuration is set by means of switchgroups SGB1, SGB2 and SGB3.

Directional low-set stage I>

The operation of the low-set stage I> is based on definite time or inverse time characteristic. The mode of operation is programmed with the SGF1 switch. At definite time mode of operation the operating time t> is set in seconds. At inverse time mode of operation (I.D.M.T.) four internationally standardized and two special type time/current characteristics are available. The programming switch SGF1 is also used for selecting the desired operation characteristic. An operation stage starts, if the current on one of the phases exceeds the setting value and the phase angle between the current and base angle falls within the operation sector ± 80°.

The inverse time function of stage I> is inhibited, when the second high-set stage I>>> starts. In this case the operate time is determined by the operate time t>>> of stage I>>>.

Directional high-set stage I>>

The operation of the high-set stage I>> is based on definite time characteristic and can be either directional or non-directional. When directional operation is selected, the start and operate times are slightly dependent on how the voltage is measured. For more information; see section "Technical data". The stage can also be set out of operation by means of switch SGF2/5. When the high-set stage is out of operation, the set value in the display shows three dashes "- - -" , indicating that the operating value is infinite.

If the circuit breaker is closed against a fault, for example, if the system earthing has not been removed after maintenance, the directional high-set stage I>> will operate non-directionally. For example, in a start situation, if both phase-to-phase voltages are below 7% and one of the phase currents exceeds the set value of the high-set stage I>>, the stage will trip non-directionally after the set operate time.

The setting value of the high-set stage I>> may be subject to automatic doubling when the protected object is connected to the network, i.e. in a start situation. Thus the setting value of the I>> stage may be below the connection inrush current. The automatic doubling function is selected with switch SGF1/5. The start situation is 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>.

Directional element

The directional control is based on measuring the phase current and the opposite phase-to-phase voltage, because then each phase of the relay is polarized with a voltage which, during a fault situation, will not be reduced excessively except, at close three-phase faults. The module is a two-phase module, which means that there are two independent directional elements, one for each phase current.

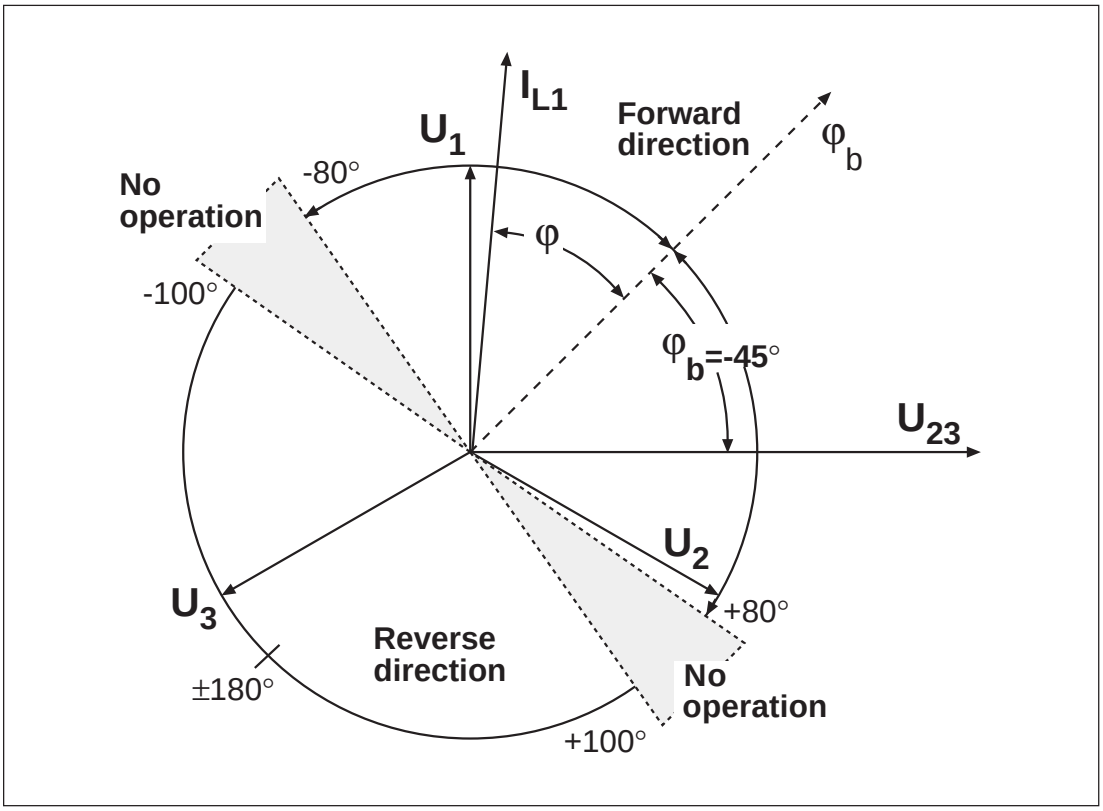


Fig. 1. Operation characteristic, when the base angle φ_b = -45°

Fig. 1. describes the operation of the directional element for phase L_1. The relay module measures the phase difference between current and voltage, but the phase angle φ shown in the display is the angle between current and the base angle setting φ_b. In this way it is easy to determine whether the actual angle shown in the display is within the operating sector or not. If the display shows a number between -80 and +80, the phase angle is within the operation sector and the current is flowing in "forward" direction. A phase angle reading between 80 and 100 means the directional element cannot determine the direction of the current and, when the reading is above 100, the current is flowing in "reverse" direction. In most applications the base angle setting is either -30° or -45°, depending on the neutral point arrangements of the network.

The operation direction of the directional stages can be selected to be “forward” or “reverse” using the switches SGF1/7 and SGF1/8. The switch SGF1/7 is used to change the operation direction of the high-set stage I>> and the switch SGF1/8 is used to change the operation direction of the complete module, see section programming switches.

Memory function

To secure reliable relay operation at a close three-phase fault characterized by an extremely low phase-to-phase voltage, a memory function for each directional element is implemented. At sudden loss of voltage at a close three-phase fault, the angle between voltage and current is calculated on the basis of a fictive voltage. This memory function gives the directional stages a possibility to operate up to 2.5 s after a total loss of voltage.

The criteria for starting a memory function is that the voltage has been above 8% and when the voltage of the concerned memory function drops below 7% for a time of 40ms the memory function is activated. As soon as the voltages again rise above 8% the directional element returns to its normal state and the measured voltage is used. Normally, the module can perform a trip if one directional element is within the operation sector. However, when the memory function of both directional elements is activated (both voltages suddenly drops below 7%), the current vector on both directional elements has to be within the operation sector before tripping is allowed.

The memory functions are activated for max. 2.5 s, which means that if the set operate times of the directional stages are longer than 2.5 s the second high-set stage I>>> must be used to ensure operation of the module in situations of a close three-phase fault.

In an isolated environment, at three-phase short circuit, the frequency of the voltage behaves abnormally. To secure the directional operation in these situations, the frequency is measured continuously.

Non-directional high-set stage I>>>

The non-directional high-set stage I>>> can be used as back-up protection for the directional stages. An important consideration is that if the set operate time of the directional stages exceeds 2.5 s and the voltage has collapsed, the directional stages will not perform a trip. Then the second high-set stage I>>> should be set to take care of the tripping.

When the non-directional high-set stage I>>> starts, it will block the operation of the low-set stage if inverse time characteristics operation has been selected. This feature prevents unselective trips at high fault currents when the inverse time characteristics would operate faster than the selectivity scheme allow. The trip time is thus equal to set t>>> for any current higher than I>>>.

The high-set stages I>>> can be set out of operation by means of switch SGF2/6. Then the display shows "- - -" indicating that the operating value is infinite.

Trip direction information

The trip direction information signal is activated when the current is flowing in the operation direction of the low-set stage I>. Apart from the operation of the low-set stage I>, a condition for the activation of the trip direction information is that both phase currents are within the operation sector. To get an output signal as contact information the trip direction information should be linked to an output relay by means of the SGF2 switch.

Circuit-breaker failure protection

The directional overcurrent module is provided with a circuit-breaker failure protection unit (CBFP) which provides a trip signal TS1 within 0.1...1 s after the normal trip signal TS2 has been delivered, provided the fault still persists when the time elapses. The CBFP normally controls an upstream circuit breaker. 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 and the other with TS1. The circuit-breaker failure protection is selected by means of switch SGF1/4. The operate time is set in submenu 5 of register A.

Latched output relays and resetting

The operation of the overcurrent stages is provided with a latching facility keeping the tripping output energized, although the signal which caused the operation disappears. The output relays can be reset in five different ways; a) by pressing the PROGRAM push-button, b) by pressing the RESET and PROGRAM push-buttons simultaneously, by remote control over the SPA bus using c) the command V101 or d) the command V102 and further e) by remote control over the external control input. Resetting according to a) or c) does not affect the stored data, whereas resetting according to b), d) or e) erases the recorded data.

Second settings

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

1) By using the command V150 over the serial communication bus
2) By using 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 or 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		
SGB2…3/7 = 1	x	x	
SGB1…3/8 = 1	x	x	x
Parameter V101	x	x	
Parameter V102	x	x	x

Block diagram

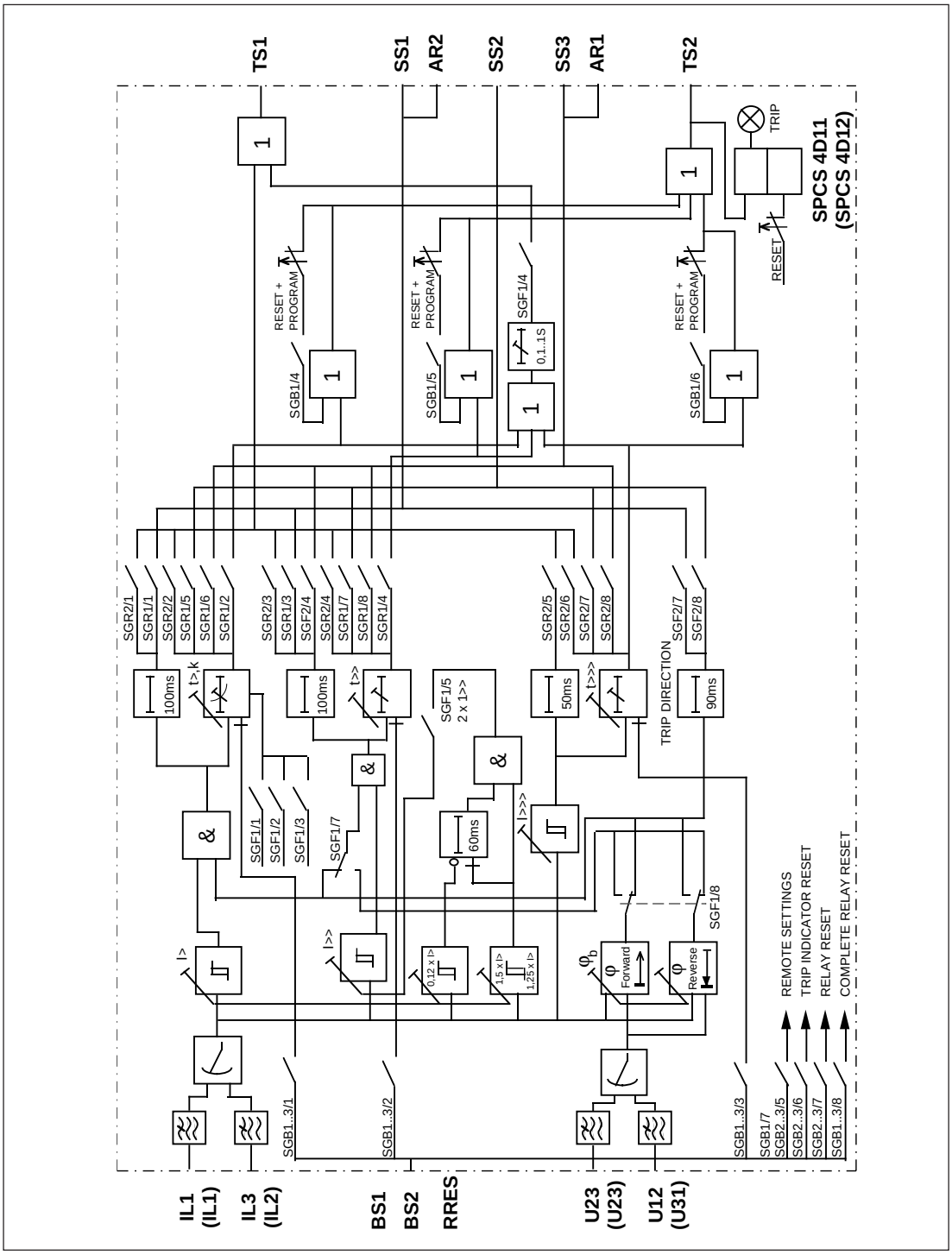


Fig. 2. Block diagram for two-phase directional o/v module type SPCS 4D11

I_{L1}, I_{L3}	Measured phase currents
U_{23}, U_{12}	Measured voltage
BS1, BS2 and RRES	External blocking or resetting signals
SGF1...2	Programming switchgroups SGF1...SGF2
SGB1...3	Programming switchgroups SGB1...SGB3
SGR1...2	Programming switchgroups SGR1...SGR2
SS1...SS3, TS1, TS2	Output signals
TRIP	Red trip indicator

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 plug-in modules of the relay assembly.

Front panel

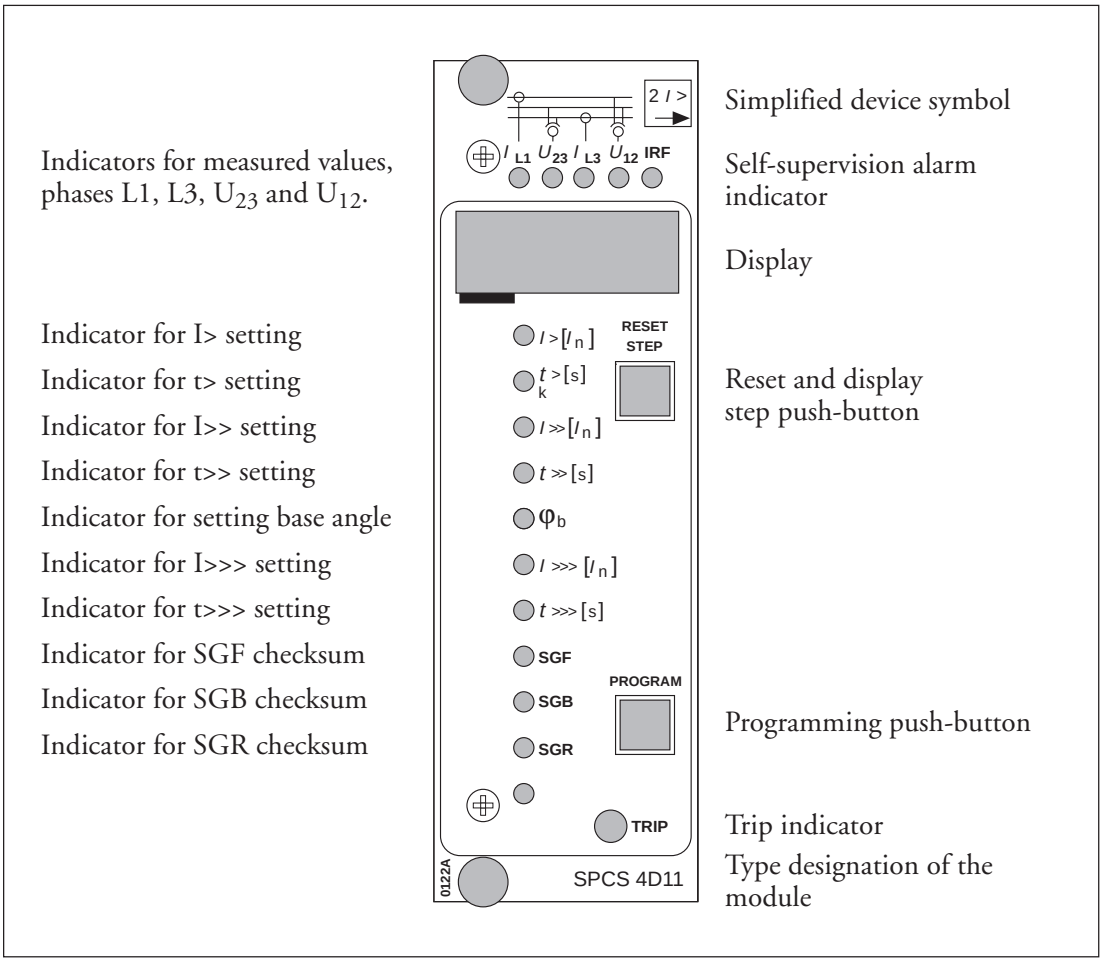


Fig. 3. Front panel of the two-phase directional o/v module type SPCS 4D11

Operation indicators

Each stage has its own start indicator and operation indicator shown as a figure on the digital display. Further all stages share an operation indicator named "TRIP", red light indicates that the module has delivered a trip signal.

The operation indicator on the display remains on when the stage resets, thus indicating which protection stage was operating.

If the start of a stage does not last long enough to cause tripping, the start indication normally resets, when the stage is reset. If required, the start indicators can be given a latching function by means of switches SGF2/1...3.

The following table shows the start and trip indicators and their messages.

Indication	Explanation	
1	I> start	The low-set stage of the overcurrent unit has started in reverse direction
2	I> start	The low-set stage of the overcurrent unit has started in forward direction
3	I> trip	The low-set stage of the overcurrent unit has tripped
4	I>> start	The high-set stage of the overcurrent unit has started
5	I>> trip	The high-set stage of the overcurrent unit has tripped
6	I>>> start	The high-set stage of the overcurrent unit has started
7	I>>> trip	The high-set stage of the overcurrent unit has tripped
9	CBFP	The circuit breaker failure protection has operated

The self-supervision alarm indicator IRF indicates that the self-supervision system has detected a permanent fault. The red indicator is lit about 1 minute after the fault has been detected. At the same time the relay module delivers a signal to the self-supervision system output relay of the protection assembly. Additionally, in most cases, a fault code showing the nature of the fault appears on the display of the module. The fault code consist of a red figure one and a green code number. When a fault occurs, the fault code should be recorded and stated when service, is ordered.

The setting values are shown by the right-most three digits of the display. A LED infront of the setting value symbol indicates the setting value presented on the display.

Setting	Parameter	Setting range	Default values
$I>(I_n)$	The start current of the low-set stage as a multiple of the rated current of the protection. - at definite time operation - at inverse time operation	 0.3...5.0 x I_n 0.3...2.5 x I_n	 0.3 x I_n
t>(s), k	The operate time of the I> stage, expressed in seconds, at definite time mode of operation (SGF1/1, 2, 3 = 0). At inverse definite minimum time mode of operation the time multiplier k is used.	0.1...300 s 0.05...1.00	0.1 s 0.10
$I>>(I_n)$	The start current of the high-set stage as a multiple of the rated current of the protection. The setting "infinite" (displayed as - - -), to be selected with switch SGF2/5, makes the stage I>> non-operational.	0.5...40.0 x I_n	0.5 x I_n
t>>(s)	The operate time of the I>> stage, expressed in seconds.	0.04...300s	0.05 s
φ_b	Base angle setting	0° ... -90°	-30°
$I>>>(I_n)$	The start current of the high-set stage as a multiple of the rated current of the protection. The setting "infinite" (- - -) to be selected with switch SGF2/6, makes the stage I>>> non-operational.	2...40.0 x I_n	2 x I_n
t>>>(s)	The operating time of the I>>> stage, expressed in seconds.	0.04...30s	0.04 s

In addition, the checksums of the programming switchgroups SGF1, SGB1 and SGR1 are indicated on the display when the indicators in front of the switchgroup symbols on the front panel are lit. The checksums for SGF2, SGB2, SGB3 and SGR2 are found in the submenus of the switchgroups SGF1, SGB1 and SGR1. See section "Main menus and submenus of settings and registers". An example of calculating the checksum is given in the general description of the D-type SPC relay modules.

Programming switches

The switchgroups SGF, SGB and SGR are used for selecting additional functions required by individual applications. The numbering of the switches, 1...8, and the switch positions, 0 and 1, are indicated when the switchgroups are being set. In normal service only the checksums are shown. The switchgroups SGF2, SGB2, SGB3 and SGR2 are found in the submenus of the switchgroups SGB, SGF and SGR.

<table>
<tr><th>Switch</th><th>Function</th><th>Factory setting</th></tr>
<tr><td>SGF1/1
SGF1/2
SGF1/3</td><td>Selection of the operation characteristic for the low-set stage I>, i.e. definite time mode of operation or inverse definite minimum time (I.D.M.T.) mode of operation. At inverse definite minimum time mode of operation the switches are also used for selecting the current/time characteristic of the stage.
<table>
<tr><th>SGF1/1</th><th>SGF1/2</th><th>SGF1/3</th><th>Mode of operation</th><th>Characteristics</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>I.D.M.T.</td><td>Extremely inv.</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 inv.</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>"</td><td>RI-character.</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>"</td><td>RXIDG-character.</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>"</td><td>Not used (long-t. i.)</td></tr>
</table></td><td>0
0
0</td></tr>
<tr><td>SGF1/4</td><td>Selection of the circuit-breaker failure protection.

When SGF1/4=1 the trip signal TS2 will start a timer that produces a delayed trip signal via TS1, unless the fault has been cleared within the CBFP time.
When switch SGF1/4=0, the CBFP is not used</td><td>0</td></tr>
<tr><td>SGF1/5</td><td>Selection of automatic doubling of the setting value of the high-set stage I>>, when the protected object is energized.

When SGF1/5=0, the setting value I>> will not be doubled.
When SGF1/5=1, the setting value of the I>> stage doubles automatically. This makes it possible to give the high-set stage a setting value below the connection inrush current level.</td><td>0</td></tr>
<tr><td>SGF1/6</td><td>Selection of directional or non-directional operation for the stage I>>.

When SGF1/6=0, the stage I>> is non-directional
When SGF1/6=1, the stage I>> is directional</td><td>0</td></tr>
<tr><td>SGF1/7
SGF1/8</td><td>Selection of reverse biased direction for stage I>>
Change direction for both directional stages
<table>
<tr><th>SGF1/7</th><th>SGF1/8</th><th>Stage I ></th><th>Stage I>></th></tr>
<tr><td>0</td><td>0</td><td>forward</td><td>forward</td></tr>
<tr><td>1</td><td>0</td><td>forward</td><td>backward</td></tr>
<tr><td>0</td><td>1</td><td>backward</td><td>backward</td></tr>
<tr><td>1</td><td>1</td><td>backward</td><td>forward</td></tr>
</table></td><td>0
0</td></tr>
</table>

Switch	Function	Factory setting
SGF2/1 SGF2/2 SGF2/3	Switches SGF2/1...3 are used for selecting the operation mode for the start indicators of the different stages. When the switches are in position 0, the start indicators are automatically reset, when the fault is cleared. When the switches are in position 1 the start indicators require manual resetting: When SGF2/1=1 the start indicator of the I> stage is to be manually reset When SGF2/2=1 the start indicator of the I>> stage is to be manually reset When SGF2/3=1 the start indicator of the I>>> stage is to be manually reset	0 0 0
SGF2/4	The start signal of the high-set stage linked to the output AR1 When SGF2/4=0 the start signal of I>> stage does not affect the output signal AR1 When SGF2/4=1 the start signal of I>> stage controls the output signal AR1	0
SGF2/5	High-set stage I>> can be set out of operation by means of this switch When switch SGF2/5=0, the high-set stage I>> is operative When switch SGF2/5=1, the high-set stage I>> is non-operational	0
SGF2/6	High-set stage I>>> can be set out of operation by means of this switch When switch SGF2/6=0, the high-set stage I>>> is operative When switch SGF2/6=1, the high-set stage I>>> is non-operational	0
SGF2/7	Linking of trip direction info to SS1 When SGF2/7=0, the trip direction info is not linked to SS1 When SGF2/7=1, the output from SS1 is energized if the relay measures energy flowing in the operation direction of the low-set stage I>.	0
SGF2/8	Linking of trip direction info to SS2 When SGF2/8=0, the trip direction info is not linked to SS2 When SGF2/8=1, the output from SS2 is energized if the relay measures energy flowing in the operation direction of the low-set stage I>.	0

Blocking or control input switchgroups SGB1,SGB2 and SGB3

The switchgroup SGB1 is used for configuring the external control input BS1.

Switch	Function	Factory setting
SGB1/1 SGB1/2 SGB1/3	Switches SGB1/1...3 are used when the external control signal BS1 is to be used for blocking one or more of the current stages of the module. When all the switches are in position 0, no stage is blocked When SGB1/1=1, the tripping of stage I> is blocked, when the input signal BS1 is energized When SGB1/2=1, the tripping of stage I>> is blocked, when the input signal BS1 is energized When SGB1/3=1, the tripping of stage I>>> is blocked, when the input signal BS1 is energized	0 0 0
SGB1/4 SGB1/5 SGB1/6	Selection of latching function for the trip output signal TS2, from I> Selection of latching function for the trip output signal TS2, from I>> Selection of latching function for the trip output signal TS2, from I>>> When the switch is =0 the trip signal of the stage resets, when the stage resets When the switch =1, the trip signal of the stage must be manually reset by pressing the RESET and PROGRAM push-buttons simultaneously. (or by signal BS1 using switch SGB1/8). When the display is off the signals can also be reset by pressing PROGRAM push-button.	0 0 0
SGB1/7	This switch enables switching between main settings and second settings, using the external control input signal BS1. When SGB1/7=0, the setting banks are not controlled via the external control input BS1. When SGB1/7=1, the settings are remotely controlled via the external input BS1. The main setting values are in force when there is no control voltage on the input, and the second settings are valid when a control voltage is connected to the control input. Note! Whichever setting is used, it is important that the switch SGB1/7 is in the same position in the main and second setting bank. Otherwise there may be conflict situation when switching from one setting bank to another. SGB1/7 must be in position 0 if serial parameter V150 or the push-buttons are used to switch between the setting banks.	0
SGB1/8	Complete remote relay reset, including trip indicators, latched relays and memorized values The relay can be remotely reset via the control input signal BS1. When SGB1/8=1, The relay is remotely reset by the control input signal BS1.	0

The switchgroup SGB2 is used for controlling the external control input BS2. The switchgroup SGB3 has the same function as described in the table below, except for the external control signal that is RRES instead of BS2. Also see section "Block diagram".

Switch	Function	Factory setting
SGB2/1 SGB2/2 SGB2/3	Switches SGB2/1...3 are used when the external control signal BS2 is to be used for blocking one or more of the current stages of the module. When all the switches are in position 0, no stage is blocked When SGB2/1=1, the tripping of stage I> is blocked, when the input signal BS2 is energized When SGB2/2=1, the tripping of stage I>> is blocked, when the input signal BS2 is energized When SGB2/3=1, the tripping of stage I>>> is blocked, when the input signal BS2 is energized	0 0 0
SGB2/4	Not used	0
SGB2/5	This switch enables switching between main and second settings even without serial communication, using the external control input signal BS2. When SGB2/5=0, the setting banks are not controlled via the external control input. When SGB2/5=1, the settings are remotely controlled via the external input BS2. The main setting values are in force when there is no control voltage on the input, and the second settings are valid when a control voltage is connected to the control input. Note! Whichever setting is used, it is important that the switch SGB2/5 is in the same position in the main and second setting bank. Otherwise there may be conflict situation when switching from one setting bank to another. SGB2/5 must be in position 0 if serial parameter V150 or the push-buttons are used to switch between the setting banks.	0
SGB2/6	Remote reset of the trip indicators When SGB2/6=0, the trip indicators are not reset by signal BS2 When SGB2/6=1, the trip indicators are reset by signal BS2	0
SGB2/7	Remote reset of trip indicators and output relays When SGB2/7=0, the trip indicators and output relays are not reset by signal BS2 When SGB2/7=1, the trip indicators and output relays are reset by signal BS2	0
SGB2/8	Complete remote relay reset, including trip indicators, latched relay and memorized values The control input signal BS2 can be used to reset the relay remotely. When SGB2/8=1, the relay is remotely reset by the control input signal BS2	0

Output relay matrix switchgroups SGR1, SGR2

Switch	Function	Factory setting
SGR1/1	When SGR1/1=1, the start signal of stage I> is linked to SS1 + AR2	1
SGR1/2	When SGR1/2=1, the trip signal of stage I> is linked to TS2	1
SGR1/3	When SGR1/3=1, the start signal of stage I>> is linked to SS1 + AR2	0
SGR1/4	When SGR1/4=1, the trip signal of stage I>> is linked to TS2	1
SGR1/5	When SGR1/5=1, the tri signal of stage I> is linked to SS2	1
SGR1/6	When SGR1/6=1, the trip signal of stage I> is linked to SS3	0
SGR1/7	When SGR1/7=1, the trip signal of stage I>> is linked to SS2	0
SGR1/8	When SGR1/8=1, the trip signal of stage I>> is linked to SS3	1
	Default checksum	155

SGR2/1	When SGR2/1=1, the start signal of stage I> is linked to TS1	0
SGR2/2	When SGR2/2=1, the trip signal of stage I> is linked to TS1	0
SGR2/3	When SGR2/3=1, the start signal of stage I>> is linked to TS1	0
SGR2/4	When SGR2/4=1, the trip signal of stage I>> is linked to TS1	0
SGR2/5	When SGR2/5=1, the start signal of stage I>>> is linked to TS1	0
SGR2/6	When SGR2/6=1, the trip signal of stage I>>> is linked to TS1	0
SGR2/7	When SGR2/7=1, the trip signal of stage I>>> is linked to SS2	0
SGR2/8	When SGR2/8=1, the trip signal of stage I>>> is linked to SS3 + AR1	1
	Default checksum	128

Note ! The trip signal of stage I>>> is always linked to TS2

Measured data

The measured values are shown by the three right-most digits of the display. The currently measured data are indicated by a LED indicator on the front panel.

Indicators SPCS 4D11	Indicators SPCS 4D12	Measured data	Measuring range
I_{L1}, I_{L3}	I_{L1}, I_{L2}	Measured line current as a multiple of the rated current I_n of the energizing input used. Submenu 1: The phase angle φ between the current and base angle φ_b.	0…52 x I_n ±180°
U_{23}, U_{12}	U_{23}, U_{31}	Measured phase-to-phase voltage as a percentage the rated voltage U_n.	0…152% U_n

Recorded data

The left-most red digit displays the register address and the other three digits the recorded information. A symbol "//" in the text indicates that the following item is found in a submenu.

Register	Recorded information
1	Phase current I_{L1} measured as a multiple of the rated current of the protection. If the overcurrent protection trips the CB, the current value at the moment of tripping is stored in the memory stack. A new trip moves the old value up one place in the stack and adds the new value to the stack. A maximum of five values are memorized - if a sixth tripping occurs, the oldest value will be lost.
2	Register 2 records the events of phase L2. The operation principle is the same as that of register 1.
3	Highest measured line voltage U_{23} during the latest start situation as a percentage of the rated volttage. If the overcurrent protection trips the CB, the line voltage at the moment of tripping is stored in the memory stack. A new trip moves the old value up one place in the stack and adds the new value to the stack. A maximum of five values are memorized - if a sixth tripping occurs, the oldest value will be lost.
4	Register 4 records the events of the voltage U_{12}. The operation principle is the same as that of register 3.
5	Duration of the latest start situation of stage I> as a percentage of the set operate time t> or at I.D.M.T. mode of operation, the calculated operate time. A new start resets the counter,which then starts counting from zero, and moves the previous value up in the memory stack. A maximum of five values are memorized - if a sixth start occurs the oldest value will be lost. When the stage has tripped the counter reading is 100. The fifth sub-menu contains 'Number of startings' of the stage I> in the range 0...255.
6	Duration of the latest starting situation of stage I>> as a percentage of the set operate time t>> or, at I.D.M.T. mode of operation the calculated operation time. A new start resets the counter,which then starts counting from zero, and moves the old value up in the memory stack. A maximum of five values are memorized - if a sixth start occurs the oldest value will be lost. When the concerned stage has tripped the counter reading is 100. The fifth sub-menu contains 'Number of startings' of stage I>> in the range 0...255.

Register	Recorded information
7	Duration of the latest starting situation of stage I>>> as a percentage of the set operating time t>>> or, at I.D.M.T. mode of operation, the calculated operate time. A new start resets the counter,which then starts counting from zero, and moves the old value up in the memory stack. A maximum of five values are memorized - if a sixth start occurs the oldest value will be lost. When the concerned stage has tripped the counter reading is 100. The fifth sub-menu contains 'Number of startings' of stage I>>> in the range 0...255.
8	Maximum demand current value for a period of 15 minutes, expressed in multiples of the relay rated current I_n and based on the highest phase current. // Highest maximum demand value obtained since the latest complete relay reset.
9	Phase angle between phase current L1 and the base angle. The operation principle is the same as that of register 1.
11	Phase angle between phase current L3 and the base angle. The operation principle is the same as that of register 1.
0	Status of blocking signals and other external control signals. The right-most digit indicates the state of the blocking inputs of the module. Each of the three input signals is represented by a number and the displayed number is the sum of the numbers of the inputs actived. The following numbers are used to indicate the states of the inputs: 0 = no blocking 1 = blocking or control signal BS1 is active 2 = blocking or control signal BS2 is active 4 = blocking or control signal RRES is active From this register "0" it is possible to enter the TEST mode, where the start and trip signals of the module are activated one by one. For further details, see the section "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 rolling 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

The registers 1...11 are set to zero by pressing the push-buttons RESET and PROGRAM simultaneously. The registers are also cleared if the auxiliary power supply module is interrupted. The address code of the relay module, the data transfer rate of the serial communication and the password are not erased by a voltage failure. Instructions for setting the address and the data transfer rate are given in the section "General characteristics of D- type SPC relay modules".

Main menus and submenus of settings and registers

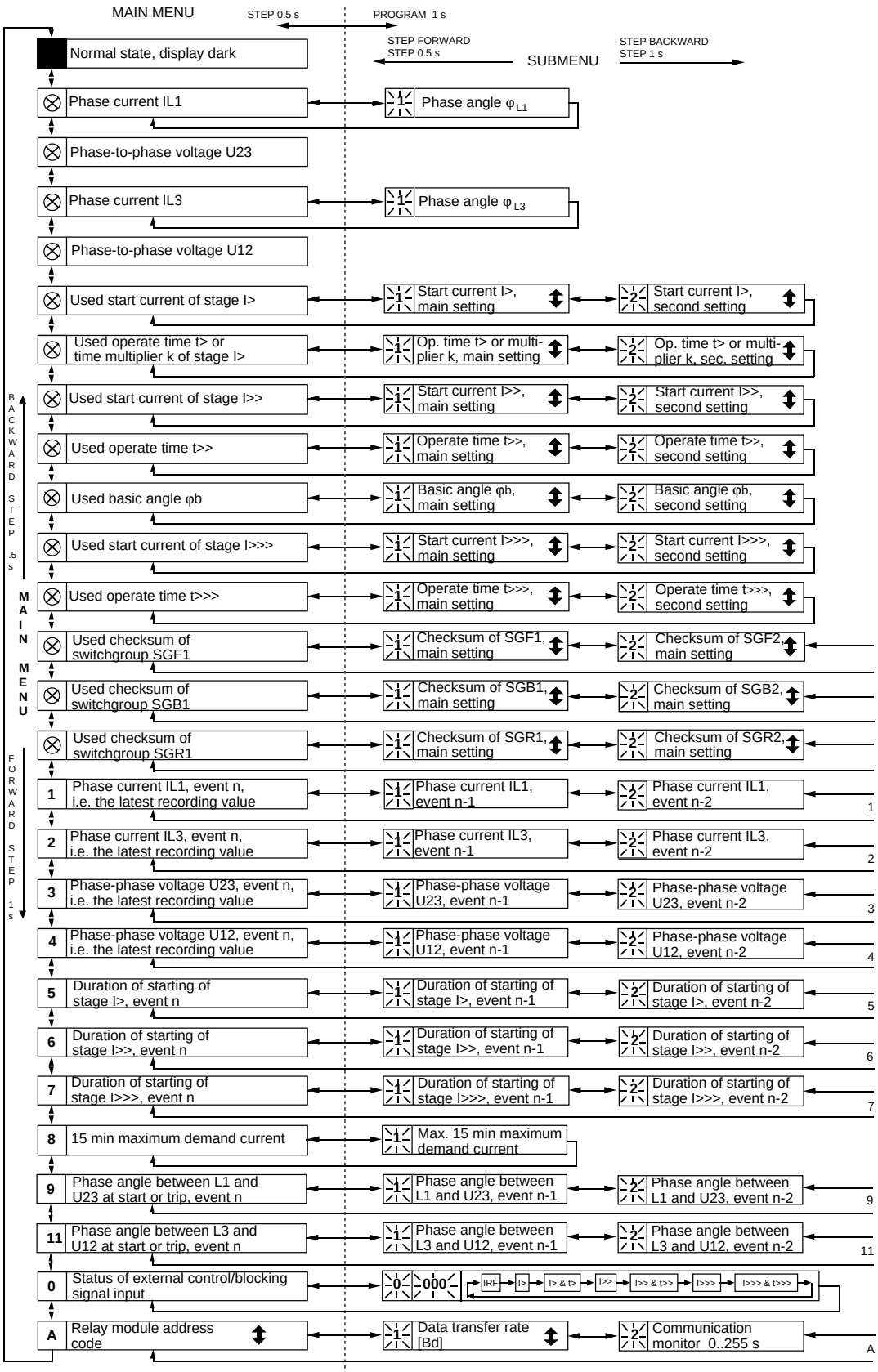


Fig. 4. Main menus and submenus of the module SPCS 4D11

How to perform the setting and use the TEST mode are described in detail in the section "General characteristics of the D-type relay modules". Below a short guide.

Desired step or operation	Push-button	Action
Forward step in main or submenu	STEP	Press > 0.5 s
Rapid scan forward in main menu	STEP	Keep depressed
Reverse step in main or submenu	STEP	Press < 0.5 s
Entering a submenu from the main menu	PROGRAM	Press 1 s
Entering or leaving setting mode	PROGRAM	Press for 5 s
Increasing a value in setting mode	STEP	
Moving the cursor in setting mode	PROGRAM	Press about 1 s
Storing a value in setting mode	STEP & PROGRAM	Press simultaneously
Resetting of memorized values + latched output relays	STEP & PROGRAM	
Resetting of latched output relays	PROGRAM	Note! Display must be dark

Time/current characteristics

The operation of the low-set stage I> is based on either definite time or inverse time characteristics. The switches SGF1/1...3 are used for selecting the desired mode of operation.

At I.D.M.T. mode of operation, the operate time of the stage is a function of the current; the higher the current, the shorter the operate time. The unit has six different time/current characteristics - four according to the BS 142 standard and two special type characteristics, called RI and RXIDG .

BS-type characteristics

There are four standard curves, extremely, very, normal and long time inverse. The relationship between current and time complies with the standards BS 142.1966 and IEC 255-4 and may generally be expressed as:

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

where
t = operating time in seconds
k = time multiplier
I = current value
I> = set current value

The module includes four BS 142 specified characteristics with different characteristic. The characteristics is determined by the values of the constants α and β

Degree of inversity of the characteristics	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

According to the standard BS 142.1966 the normal current range is defined as 2...20 times the setting current. Additionally the relay must start at the latest when the current exceeds a value of 1.3 times the setting, when the time/current characteristic is normal inverse, very inverse or extremely inverse. When the characteristic is long time inverse, the normal range in accordance with the standards is 2...7 times the setting and the relay is to start when the current exceeds 1.1 times the setting.

The following requirements with regard to operating time tolerances are specified in the standard (E denotes accuracy in per cent, -=not specified):

I / I>	Normal inverse	Very inverse	Extermely inv.	Long time inv.
2	2.22 E	2.34 E	2.44 E	2.34 E
5	1.13 E	1.26 E	1.48 E	1.26 E
7	-	-	-	1.00 E
10	1.01 E	1.01 E	1.02 E	-
20	1.00 E	1.00 E	1.00 E	-

In the normal current ranges defined, the inverse time stages of the two-phase o/c module SPCS 4D11 comply with the tolerances of class 5 at all degrees of inversity.

RI-type characteristic

The RI-type characteristic is a special characteristic used mainly for time grading with existing mechanical relays. The characteristic is based on the following mathematical expression:

$$t = \frac{k}{0.339 - 0.236 \times \frac{I>}{I}}$$

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

RXIDG-type characteristic

The RXIDG characteristic is a special characteristic where a high degree of selectivity is needed also for high resistance faults.

Time/current characteristic can be expressed as:

$$t = 5.8 - 1.35 \times \log_e \left(\frac{I}{k \times I>} \right)$$

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

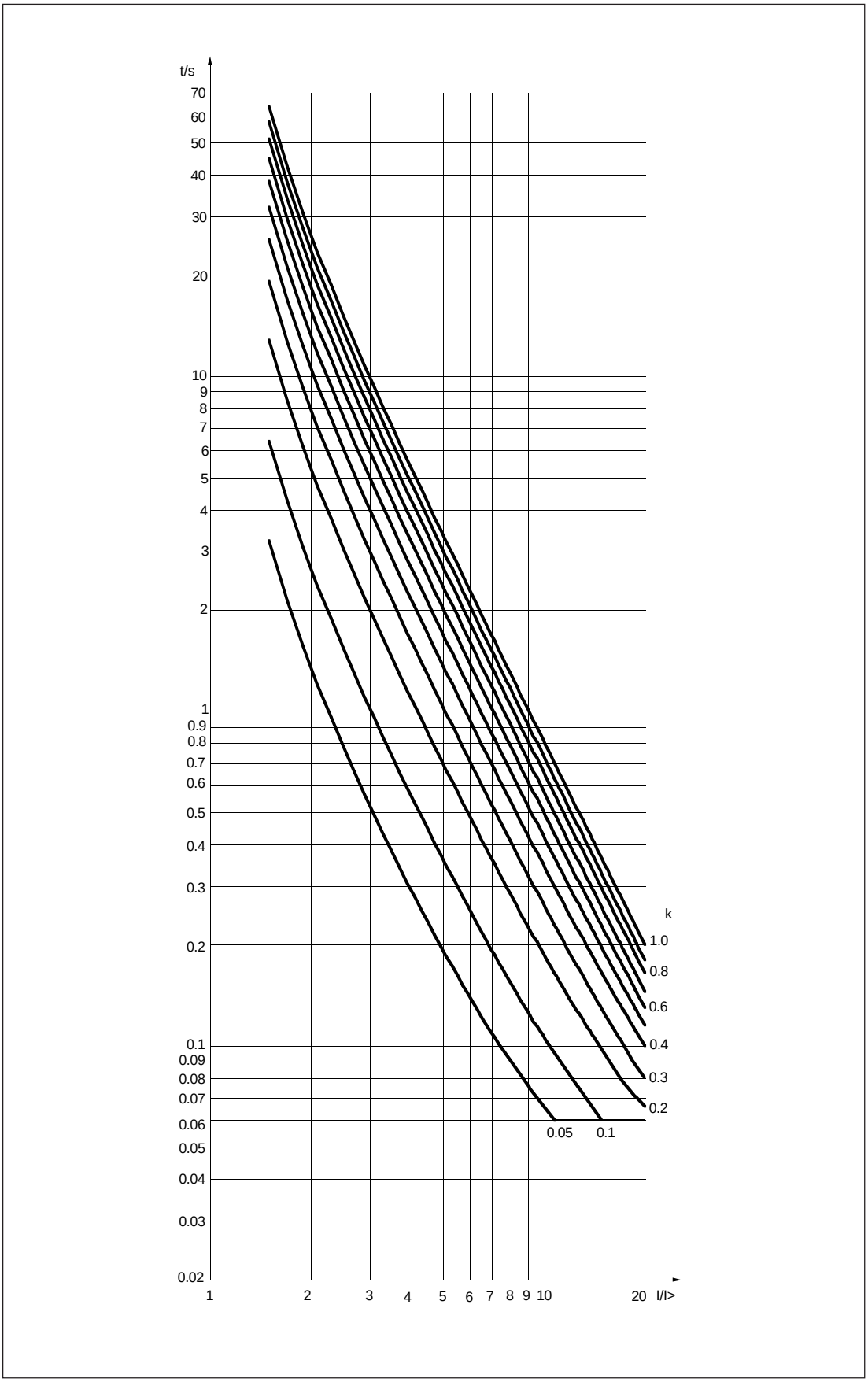


Fig. 5. Extremely inverse-time characteristics of the two-phase directional o/c module SPCS 4D11

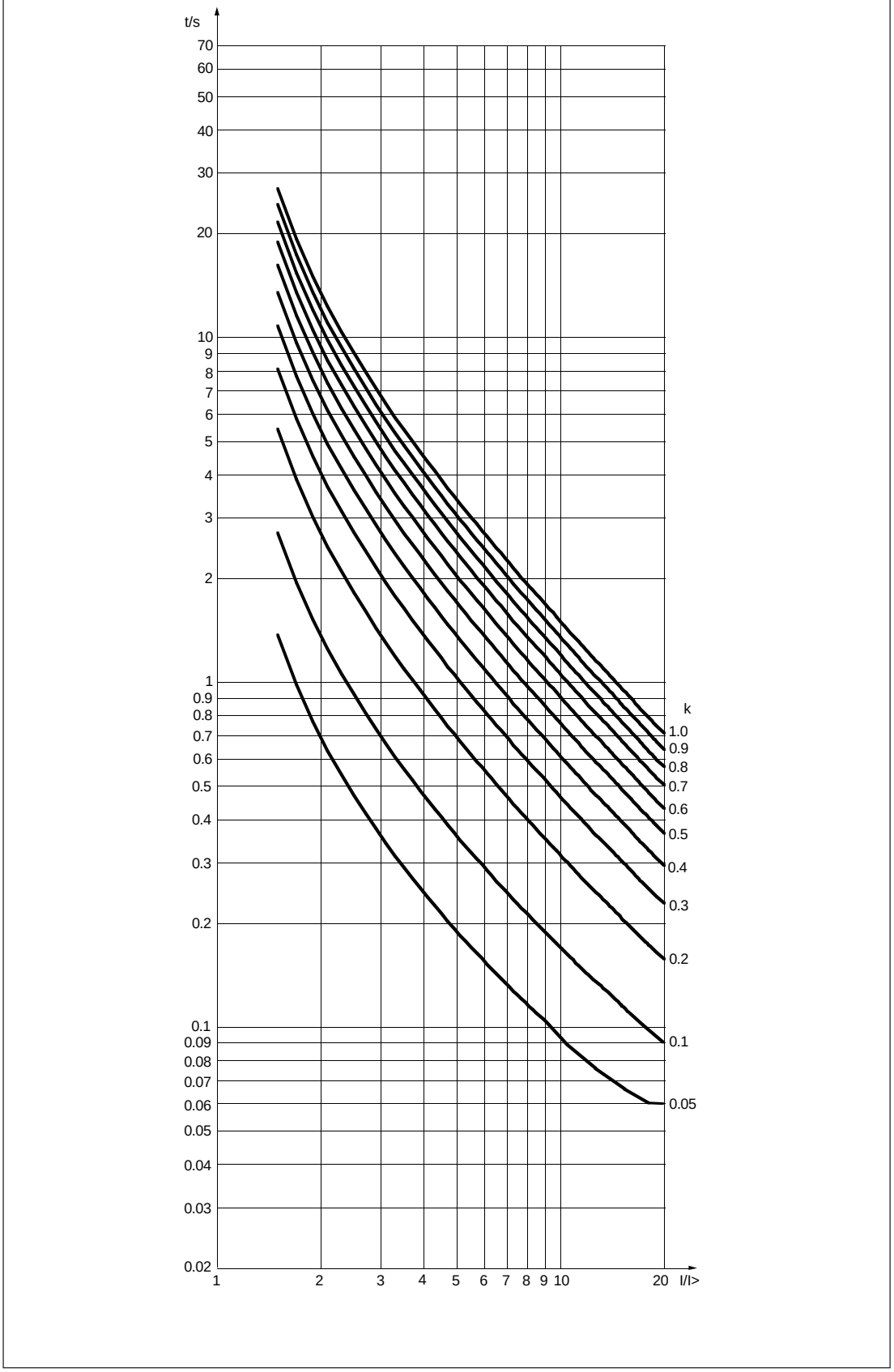


Fig. 6. Very inverse-time characteristics of the two-phase directional o/c module SPCS 4D11

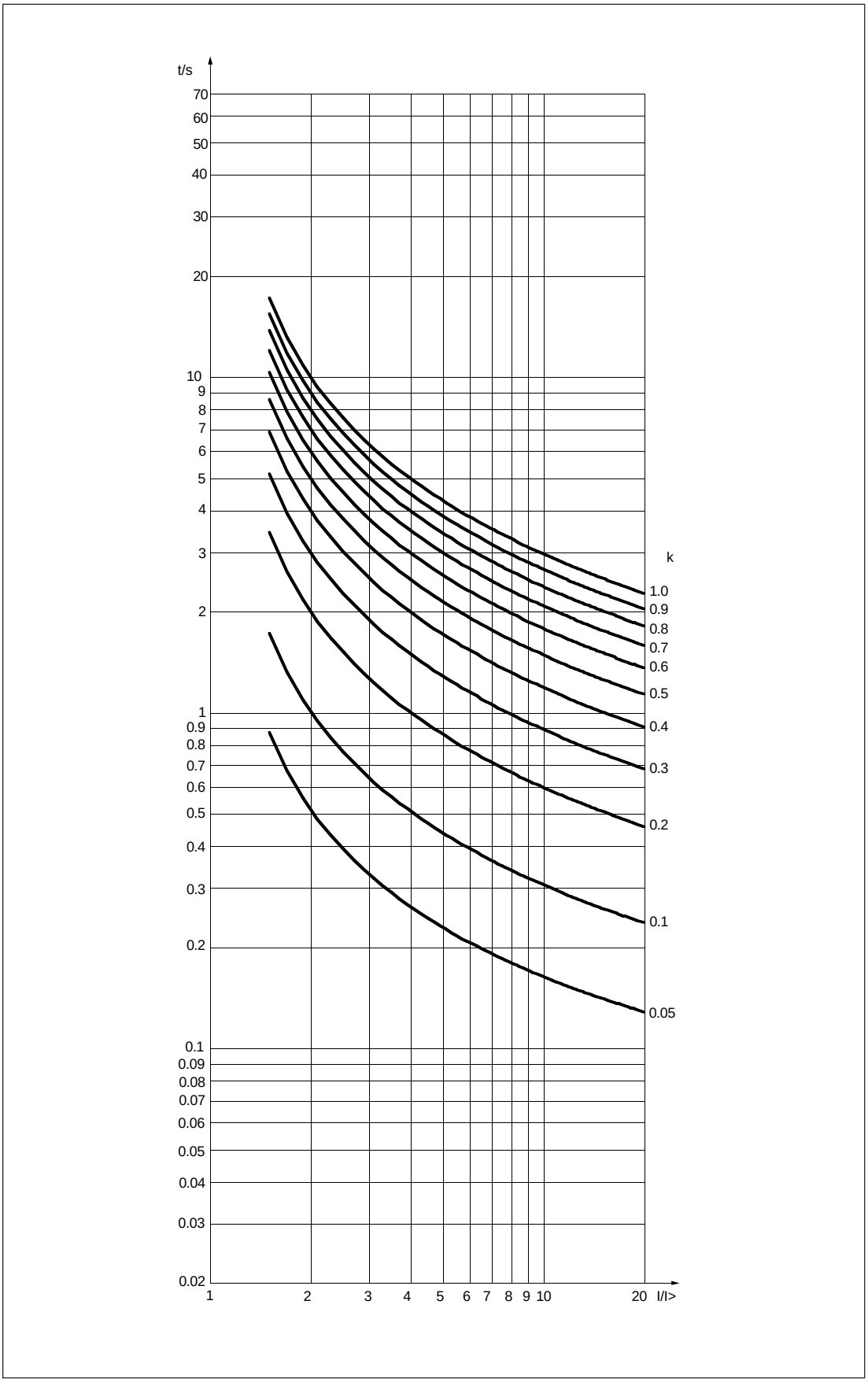


Fig. 7. Normal inverse-time characteristics of the two-phase directional o/c module SPCS 4D11

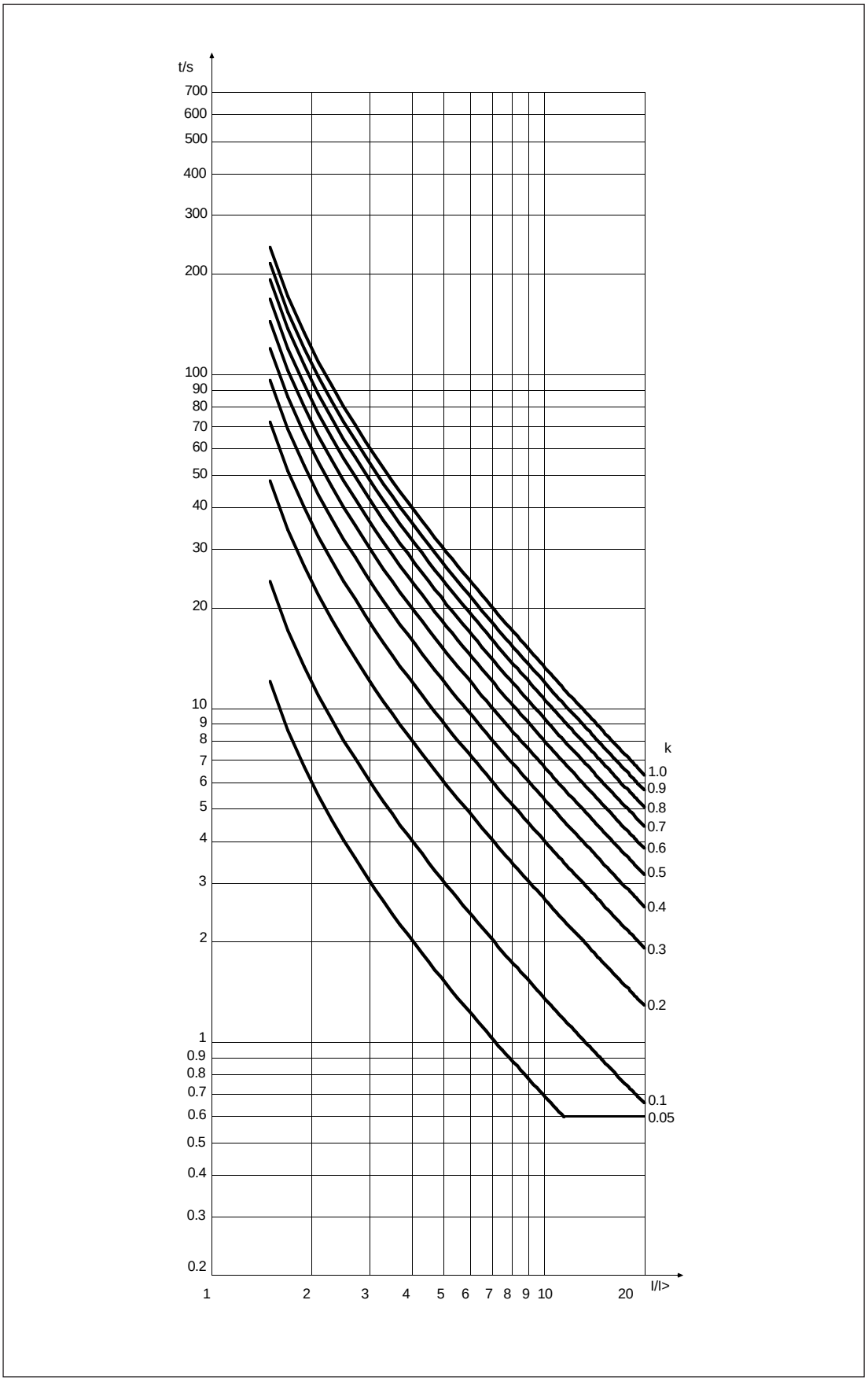


Fig. 8. Long-time inverse-time characteristics of the two-phase directional o/c module SPCS 4D11

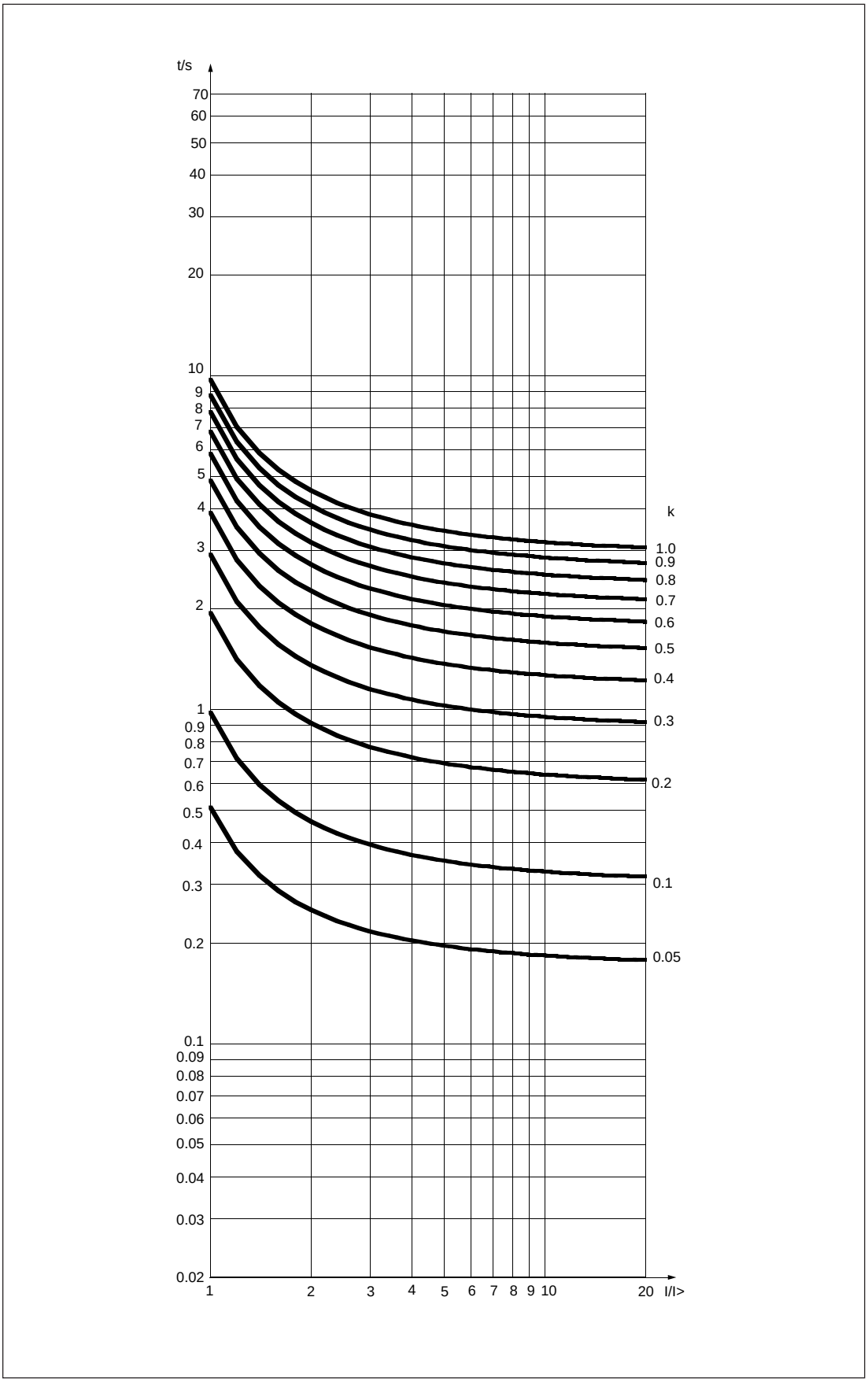


Fig. 9. RI-type inverse-time characteristics of the two-phase directional o/c module SPCS 4D11

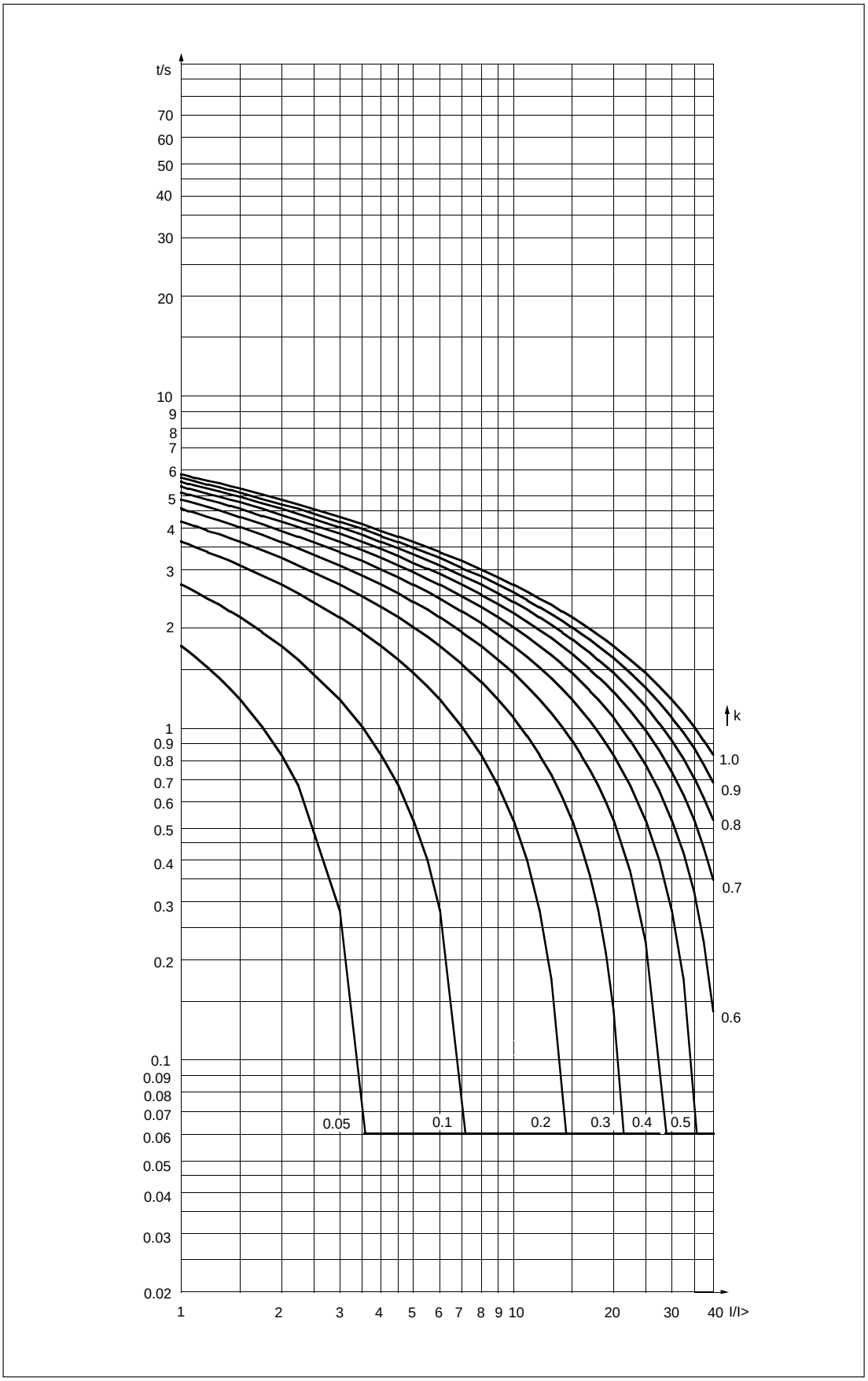


Fig. 10. RXIDG-type inverse-time characteristics of the two-phase o/c module SPCS 4D11

Low-set stage I>

Operating mode	directional
Start current I>	
– definite time characteristic	0.3...5.0 x I_n
– inverse time characteristic	0.3...2.5 x I_n
Start time, typ.	60 ms (100 ms)**
Operation characteristic	
– definite time characteristic	
– operate time	0.1...300 s
– inverse time characteristic	
acc. to BS 142 and IEC 255-4	Extremely inverse
	Very inverse
	Normal inverse
	Long time inverse
– special characteristic acc. to ABB practice	RI-type inverse
	RXIDG-type inverse
– time multiplier k	0.05...1.00
Reset time, typ.	60 ms
Drop-off/pick-up ratio, typ.	0.96
Operate time accuracy at definite time operation	±2% of set value or ±25 ms
Operate time accuracy class E at inverse time mode of operation	5
Operation accuracy	±3% of set value

High-set stage I>>

Operating mode	directional or non-directional
Start current	0.5...40.0 x I_n or infinite
Start time, typ.	60 ms (100 ms)**
Operate time	0.04...300 s *
Reset time, typ.	60 ms
Drop-off/pick-up ratio, typ.	0.96
Operate time accuracy	±2% of set value or ±25 ms
Operation accuracy	±3% of set value

Directional element

Setting range of basic angle φ_b	0°...-90°
Operation sector	$\varphi_b \pm 80°$
Operation sector accuracy	±5°
Strart delay of trip direction information, typ.	50 ms (90 ms)
Threshold current for angle measurement	
– pick-up / drop-off	13% I_n / 10% I_n
Threshold voltage for angle measurement	
– pick-up / drop-off	8% U_n / 7% U_n
Memory at sudden voltage drop	~2.5 s

High-set stage I>>>

Operating mode	non-directional
Start current	2...40.0 x I_n or infinite
Start time, typ.	50 ms
Operate time	0.04...30 s
Reset time	60 ms
Drop-off/pick-up ratio, typ.	0.96
Operate time accuracy	±2% of set value or ±25 ms
Operation accuracy	±3% of set value

* With a directional operation, the minimum operate time is not faster than the start time.

** The start time 100 ms is used when voltage and current are applied simultaneously. If the module has been measuring a voltage signal at least 40 ms before the current setting is exceeded the start time is typically 60 ms.

Event codes

When the two-phase directional o/c module SPCS 4D11 is linked to the control data communicator over the SPA bus, the module will, for instance, provide event markings to a printer. The events are printed out in the format: time, text which the user may have programmed, and event code.

The codes E1...E16 and the events representing these can be included in or excluded from the event reporting by writing an event mask V155 and V156 for the events.

The event masks V155 may have a value in the range 0...63 and V156 a value within the range 0...255. The default value of the directional two-phase o/c module SPCS 4D11 is 21 for V155 and 85 for V156, which means that all starts and trips of stage I> , I>> and I>>> are included in the reporting, but not the resetting.

The output signals are monitored by codes E17...E26 and the events represented by these can be included in or excluded from event reporting by writing an event mask V157 to the module. The event mask is a binary number coded to a decimal number. The event codes E17...E26 are represented by the numbers 1, 2, 4...512. An event mask is formed by multiplying the above numbers either by 0, event not reported or 1, event reported, and adding up the numbers received. Compare checksum calculation.

The event mask V157 may have a value in the range 0...1023. The default value is 768 which means that only the operations of the trip relay TS2 are included in the reporting.

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

Code	Event	Number representing the event	Default value of the factor
E1	Starting of stage I> in forward direction	1	1
E2	Starting of stage I> in forward direction reset	2	0
E3	Starting of stage I> in reverse direction	4	1
E4	Starting of stage I>in reverse direction reset	8	0
E5	Tripping of stage I>	16	1
E6	Tripping of stage I> reset	32	0
			21
E7	Starting of stage I>>	1	1
E8	Starting of stage I>> reset	2	0
E9	Tripping of stage I>>	4	1
E10	Tripping of stage I>> reset	8	0
E11	Starting of stage I>>>	16	1
E12	Starting of stage I>>> reset	32	0
E13	Tripping of stage I>>>	64	1
E14	Tripping of stage I>>> reset	128	0
			85

Code	Event	Number representing the event	Default value of the factor
E17	Output signal TS1 activated	1	0
E18	Output signal TS1 reset	2	0
E19	Output signal SS1 activated	4	0
E20	Output signal SS1 reset	8	0
E21	Output signal SS2 activated	16	0
E22	Output signal SS2 reset	32	0
E23	Output signal SS3 activated	64	0
E24	Output signal SS3 reset	128	0
E25	Output signal TS2 activated	256	1
E26	Output signal TS2 reset	512	1
			768
E50	Restarting	*	-
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	*	-

0 Not included in event reporting
1 included in event reporting
* No code number
- Cannot be programmed

Note!
The event codes E52... E54 are generated by the control data communicator unit. (SACO 100M, SRIO 1000M etc).

Data to be transferred over the bus

In addition to the event data transfer the SPA bus allows reading of all input data (I-data), setting values (S-data), information recorded in the memory (V-data), and some other data of the module. Further, part of the data can be altered by commands given over the SPA bus. All the data are available in channel 0.

Data	Code	Data direct.	Values
INPUTS			
Current measured on phase L1	I1	R	0...52 x I_n
Measured voltage U23	I2	R	0...152% U_n
Phase angle between IL1 and U23	I3	R	0...±180°
Current measured on phase L3	I4	R	0...52 x I_n
Measured voltage U12	I5	R	0...152% U_n
Phase angle between IL3 and U12	I6	R	0...±180°
Blocking or control signal BS1	I7	R	0 = no blocking 1 = BS1 signal active
Blocking or control signal BS2	I8	R	0 = no blocking 1 = BS2 signal active
Blocking or control signal RRES	I9	R	0 = no blocking 1 = RRES signal active

Data	Code	Data direct.	Values
OUTPUTS			
Starting of stage I> forward direction	O1	R	0 = I>-stage not started 1 = I>-stage started
Starting of stage I> backward direction	O2	R	0 = I>-stage not started 1 = I>-stage started
Tripping of stage I>	O3	R	0 = I>-stage not tripped 1 = I>-stage tripped
Starting of stage I>>	O4	R	0 = I>>-stage not started 1 = I>>-stage started
Tripping of stage I>>	O5	R	0 = I>>-stage not tripped 1 = I>>-stage tripped
Starting of stage I>>>	O6	R	0 = I>>>-stage not started 1 = I>>>-stage started
Tripping of stage I>>>	O7	R	0 = I>>>-stage not tripped 1 = I>>>-stage tripped
Signal TS1	O8	R,W(P)	0 = signal not active 1 = signal active
Signal SS1	O9	R,W(P)	0 = signal not active 1 = signal active
Signal SS2	O10	R,W(P)	0 = signal not active 1 = signal active
Signal SS3	O11	R,W(P)	0 = signal not active 1 = signal active
Signal TS2	O12	R,W(P)	0 = signal not active 1 = signal active
Output relays	O41	R,W(P)	0 = not operated 1 = operated
Memorized I> start, forward direction	O21	R	0 = signal not active 1 = signal active
Memorized I> start, backward direction	O22	R	0 = signal not active 1 = signal active
Memorized I> trip	O23	R	0 = signal not active 1 = signal active
Memorized I>> start	O24	R	0 = signal not active 1 = signal active
Memorized I>> trip	O25	R	0 = signal not active 1 = signal active
Memorized I>>> start	O26	R	0 = signal not active 1 = signal active
Memorized I>>> trip	O27	R	0 = signal not active 1 = signal active
Memorized output signal TS1	O28	R	0 = signal not active 1 = signal active
Memorized output signal SS1	O29	R	0 = signal not active 1 = signal active
Memorized output signal SS2	O30	R	0 = signal not active 1 = signal active
Memorized output signal SS3	O31	R	0 = signal not active 1 = signal active
Memorized output signal TS2	O32	R	0 = signal not active 1 = signal active

Data	Code	Data direct.	Values
PRESENT SETTING VALUES			
Present start value for stage I>	S1	R	0.3...5.0 x I_n
Present operate time for stage I>	S2	R	0.05...300 s
Present start value for stage I>>	S3	R	0.5...40 x I_n 999 = not in use
Present operate time for stage I>>	S4	R	0.04...300 s
Base angle setting	S5	R	0... - 90°
Present start value for stage I>>>	S6	R	2.0...40x I_n 999 = not in use
Present operate time for stage I>>>	S7	R	0.04...30 s
Present checksum of switchgroup SGF1	S8	R	0...255
Present checksum of switchgroup SGF2	S9	R	0...255
Present checksum of switchgroup SGB1	S10	R	0...255
Present checksum of switchgroup SGB2	S11	R	0...255
Present checksum of switchgroup SGB3	S12	R	0...255
Present checksum of switchgroup SGR1	S13	R	0...255
Present checksum of switchgroup SGR2	S14	R	0...255
MAIN SETTING VALUES			
Main start value for stage I>	S21	R,W(P)	0.3...5.0 x I_n
Main operate time for stage I>	S22	R,W(P)	0.05...300 s
Main start value for stage I>>	S23	R,W(P)	0.5...40 x I_n
Main operate time for stage I>>	S24	R,W(P)	0.04...300 s
Main base angle setting	S25	R,W(P)	0... - 90°
Main start value for stage I>>>	S26	R,W(P)	2.0...40 x I_n
Main operate time for stage I>>>	S27	R,W(P)	0.04...30 s
Main checksum of switchgroup SGF1	S28	R,W(P)	0...255
Main checksum of switchgroup SGF2	S29	R,W(P)	0...255
Main checksum of switchgroup SGB1	S30	R,W(P)	0...255
Main checksum of switchgroup SGB2	S31	R,W(P)	0...255
Main checksum of switchgroup SGB3	S32	R,W(P)	0...255
Main checksum of switchgroup SGR1	S33	R,W(P)	0...255
Main checksum of switchgroup SGR2	S34	R,W(P)	0...255
SECOND SETTING VALUES			
Second start value for stage I>	S41	R,W(P)	0.3...5.0 x I_n
Second operate time for stage I>	S42	R,W(P)	0.05...300 s
Second start value for stage I>>	S43	R,W(P)	0.5...40 x I_n
Second operate time for stage I>>	S44	R,W(P)	0.04...300 s
Second base angle setting	S45	R,W(P)	0... - 90°
Second start value for stage I>>>	S46	R,W(P)	2.0...40 x I_n
Second operate time for stage I>>>	S47	R,W(P)	0.04...30 s
Second checksum of switchgroup SGF1	S48	R,W(P)	0...255
Second checksum of switchgroup SGF2	S49	R,W(P)	0...255
Second checksum of switchgroup SGB1	S50	R,W(P)	0...255
Second checksum of switchgroup SGB2	S51	R,W(P)	0...255
Second checksum of switchgroup SGB3	S52	R,W(P)	0...255
Second checksum of switchgroup SGR1	S53	R,W(P)	0...255
Second checksum of switchgroup SGR2	S54	R,W(P)	0...255
Operate time for circuit-breaker failure protection	S61	R,W(P)	0.1...1.0 s

Data	Code	Data direct.	Values
RECORDED AND MEMORIZED PARAMETERS			
Current in phase L1 at start or trip	V11, V21..V51	R	0...52 x I_n
Current in phase L3 at start or trip	V12, V22..V52	R	0...52 x I_n
Line voltage U_{23} at start or trip	V13, V23..V53	R	0...152% U_n
Line voltage U_{12} at start or trip	V14, V24..V54	R	0...152% U_n
Phase angle between L1 and U_{23} at starting or tripping	V15, V25.. V55	R	0... ±180°
Phase angle between L3 and U_{12} at starting or tripping	V16, V26.. V56	R	0... ±180°
Duration of the latest start situation of stage I>	V17, V27.. V57	R	0...100 %
Duration of the latest start situation of stage I>>	V18, V28.. V58	R	0...100 %
Duration of the latest start situation of stage I>>>	V19, V29.. V59	R	0...100 %
Maximum demand current for 15 min.	V1	R	0...2.5 x I_n
Highest maximum demand current 15 min. value	V2	R	0...2.55 x I_n
Number of starts of stage I>	V3	R	0...255
Number of starts of stage I>>	V4	R	0...255
Number of starts of stage I>>>	V5	R	0...255
Phase condition during trip	V6	R	1 = I_{L3}>, 2 = I_{L1}> 4 = I_{L3}>>, 8 = I_{L1}>> 16 = I_{L3}>>>, 64 = I_{L1}>>>
Operation indicator	V7	R	0...9
CONTROL PARAMETERS			
Resetting of latched output relays	V101	W	1 = reset
Resetting of output relays and registers	V102	W	1 = reset
Remote control of settings	V150	R,W	0 = main settings activated 1 = second settings activated
Event mask word for low-set stage events	V155	R,W	0...63, see "Event codes"
Event mask word for high-set stage events	V156	R,W	0...255, see "Event codes"
Event mask word for output signal events	V157	R,W	0...1023, see "Event codes"
Opening of password for remote settings	V160	W	1...999
Changing or closing of password for remote settings	V161	W(P)	0...999
Activation of self-supervision output	V165	W	1 = self-supervision output is activated and IRF LED lit 0 = off

Data	Code	Data direct.	Values
Eeprom formatting	V167	W(P)	2 = format EEPROM
Internal error code	V169	R	0...255
Relay rated frequency	V180	R,W(P)	50 Hz or 60 Hz
Data communication address of the module	V200	R,W	1...254
Data transfer rate	V201	R,W	4.8 or 9.6 KBd (W) 4800 or 9600 (R)
Programme version number	V205	R	123_
Event register reading	L	R	time, channel number and event code
Re-reading of event register	B	R	time, channel and event code
Type designation of the module	F	R	SPCS 4D11
Reading of module status data	C	R	0 = normal state 1 = module been subject to automatic reset 2 = overflow of event register 3 = events 1 and 2 together
Resetting of module state data	C	W	0 = resetting
Time reading and setting	T	R,W	0.000...59.999 s

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

The event register can be read by the L command once only. Should a fault occur e.g. in the data transfer, the contents of the event register read by the L command may be re-read by means of the B command. When required, the B command can be repeated. Generally, the control data communicator reads the event data and forwards them to the output device continuously. Under normal conditions the event register of the module is empty. In the same way the data communicator resets abnormal status data, so this data is normally a zero.

The setting values S1...S14 are the setting values used by the protection programs. These values are set in the same way as main settings and switchgroup checksums S21...S34 or as the second settings S41...S54. All the settings can be read or written. A condition for writing is that the remote set password has been opened.

When settings are changed, manually or remotely, the relay module checks that the variable values are within the ranges specified in the technical data of the module. If not, the unit will not store the value but keeps the previous setting.

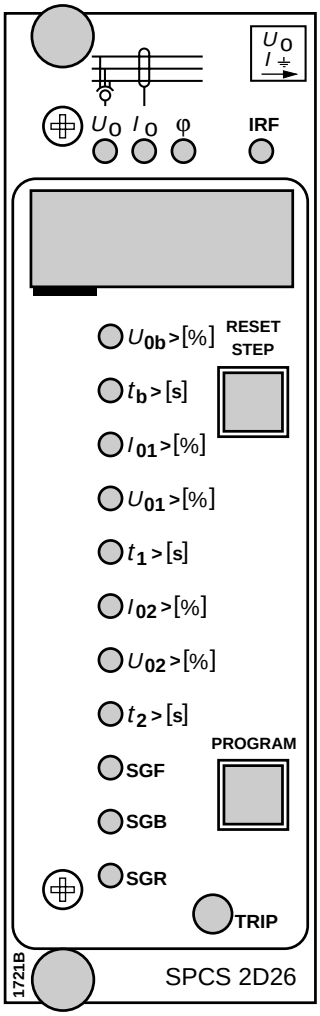
Fault codes

A short time after the internal self-supervision system has detected a permanent relay fault the red IRF indicator is lit and the output relay of the self-supervision system operates. Further, in most fault situations, an auto diagnostic fault code is shown on the display. This fault code consists of a red figure 1 and a green code number which indicates the fault type. When a fault code appears on the display, the code number should be recorded and stated to the authorized repair shop when repair is ordered. Below some fault codes that might appear with the module SPCS 4D11:

Fault code	Type of error in module
1	Power reset
4	Faulty trip relay path or missing output relay card
30	Faulty program memory (ROM)
50	Faulty work memory (RAM)
51	Parameter memory (EEPROM) faulty
52	Parameter memory (EEPROM) faulty
53	Parameter memory (EEPROM) faulty
54	Parameter memory (EEPROM) faulty
56	Parameter memory (EEPROM) key faulty. Format by writing a "2" to variable V167
195	Too low value in reference channel with multiplier 1
131	Too low value in reference channel with multiplier 5
67	Too low value in reference channel with multiplier 25
203	Too high value in reference channel with multiplier 1
139	Too high value in reference channel with multiplier 5
75	Too high value in reference channel with multiplier 25
253	No interruptions from the A/D-converter

SPCS 2D26
Directional or non-directional earth-fault relay module

User´s manual and Technical description



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SPCS 2D26
Directional or non-directional earth-fault relay module

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Features

Directional or non-directional low-set neutral overcurrent stage I_{01}> with definite time characteristic.

Directional or non-directional high-set neutral overcurrent stage I_{02}> with definite time characteristic.

When required, both directional neutral overcurrent stages of the directional earth-fault protection can be configured to operate as residual voltage stages. Then the relay module includes three separately adjustable residual voltage stages.

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

Directional earth-fault protection
(modified 2002-06)

The directional earth-fault unit of the phase overcurrent and earth-fault relay module SPCS 2D26 has two protection stages: a low-set current stage $I_{01}>$ and a high-set current stage $I_{02}>$.

The directional earth-fault unit measures the neutral current I_0, the residual voltage U_0 and the phase angle between residual voltage and neutral current. An earth-fault stage starts if all of the three criteria below are fulfilled at the same time:

- the residual voltage U_0 exceeds the start level set for the $U_0>$ stage. The setting is the same for stage $I_{01}>$ and stage $I_{02}>$.
- the neutral current I_0 exceeds the set start value of stage $I_{01}>$ or stage $I_{02}>$.
- if the phase angle between residual voltage and neutral current falls within the operation area $\varphi_b \pm \Delta\varphi$, where φ_b is the characteristic basic angle of the network and $\Delta\varphi$ is the operation sector.

The setting value of the characteristic basic angle φ_b of the network is selected according to the earthing principle of the network, that is, -90° in an isolated neutral network, and 0° in a resonant-earthed network, earthed through an arc suppression coil (Petersen coil), with or without a parallel resistor. The basic angle can be set at -90°, -60°, -30° or 0° via the SGF switches. In addition, the basic angle of the network can be changed via an external control signal, in which case the alternatives are -90° and 0°. The operation sector $\Delta\varphi$ can be set to ±80° or ±88° for both stages.

The operation direction can be measured either using the phase-angle measuring principle or the $I_0\cos\varphi/I_0\sin\varphi$ principle. Normally, the angle measuring principle is used, but, when required, the $I_0\cos\varphi$ principle can be used to obtain selectivity with other $I_0\cos\varphi/I_0\sin\varphi$ measuring relays and to improve the operation of healthy lines in an earth-fault situation.

The operation direction (forward or reverse) can be individually selected for the two earth-fault stages. When an reverse direction has been selected, the operation characteristic is the same as that illustrated in Fig. 1a) and 1b), but turned 180°.

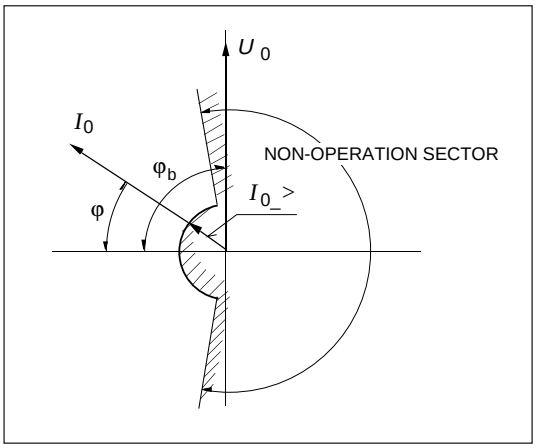


Fig. 1a. Operation characteristic when the basic angle φ_b = -90°.

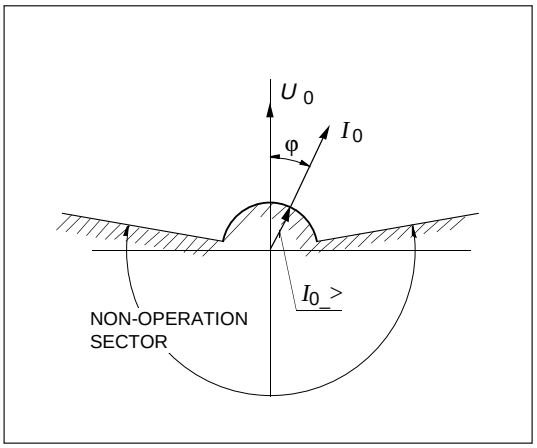


Fig. 1b. Operation characteristic when the basic angle φ_b = 0°.

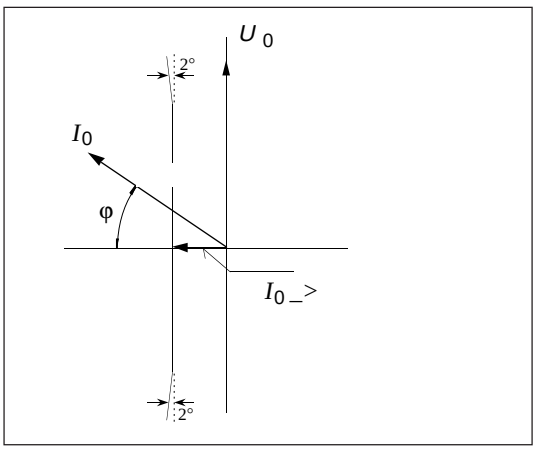


Fig. 1c. Operation characteristic sinφ.

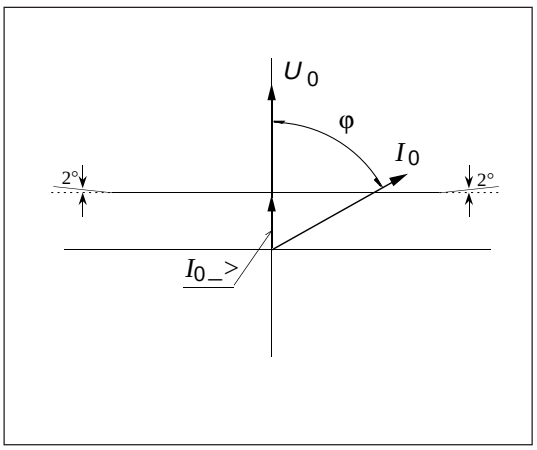


Fig. 1d. Operation characteristic cosφ.

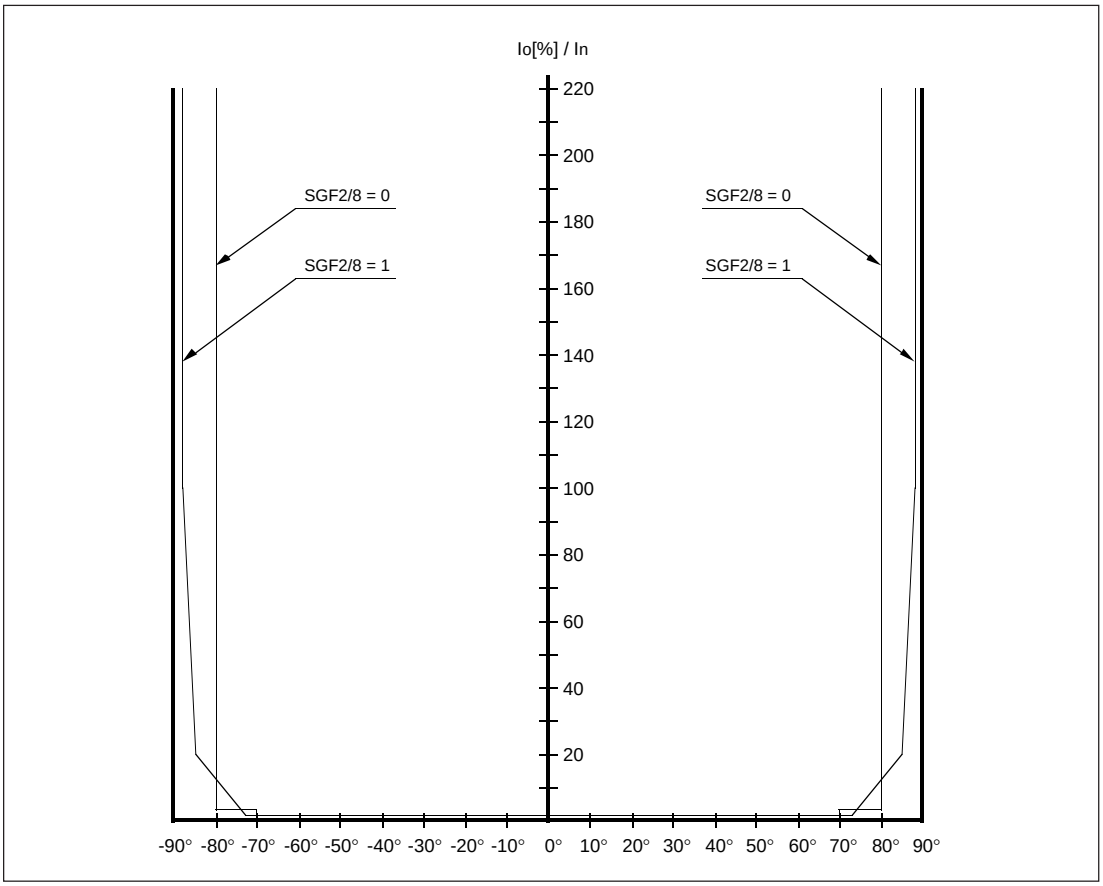


Fig. 1e. Operation characteristic of the directional earth-fault protection unit of the earth-fault relay module SPCS 2D26 illustrated in an I_0-φ diagram, when the basic angle $\varphi_b = 0°$.

Both earth-fault stages can be configured to provide non-directional earth-fault protection. Then the relay module measures neutral current only, or it measures both neutral current and residual voltage.

When starting, the earth-fault stage provides a start signal, and at the same time an operation code is lit on the display to indicate starting. Should the stage still be started, when the operate time set for the stage elapses, it provides an operate signal.

The angle between voltage and current allows the direction of the fault location to be determined.

The operation of stage I_{01}> and stage I_{02}> can be prevented by applying an external control signal BS1, BS2 or RRES to the relay module. The switchgroups SGB1...3 are used for configuring the blocking signals.

The operation of the high-set stage I_{02}> can be totally inhibited. In such a situation the setting value of the concerned stage is indicated as "- - -" on the display.

A band-pass filter suppresses the harmonics of the neutral current and the residual voltage measured by the earth-fault relay module. For example, the third harmonic is reduced by at least 17 dB. Harmonics of higher order are reduced even more.

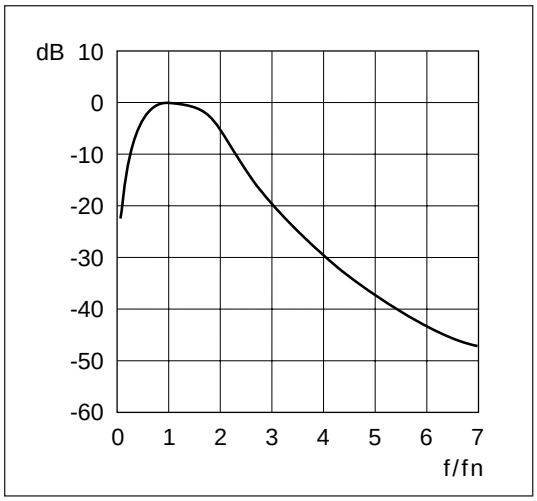


Fig. 2. Filtering of the input circuits of the neutral current I_0 and the residual voltage U_0 in the directional earth-fault relay module SPCS 2D26.

N.B.! Changes in the functions of the earth-fault stages I_{01}> and I_{02}> are presented in Appendix 1, page 29.

Residual voltage protection

The neutral current stages $I_{01}>$ and $I_{02}>$ can be configured to operate as residual voltage stages in which case the directional earth-fault relay module operates as a three-stage residual voltage module. The three stages measure the same voltage, but the sensitivity and the operate time can be separately set for the stages. The alarm and operate signals of the stages can be configured to operate as desired output signals.

Residual voltage input

Three alternative rated voltages U_n are available: 100 V, 110 V or 120 V. The switches SGF2/6 and SGF2/7 are used for selecting the desired rated voltage.

Circuit-breaker failure protection

The earth-fault relay module SPCS 2D26 is provided with circuit-breaker failure protection (CBFP), which provides an operate signal TS1 0.1...1 s after the operate signal TS2, TS3 or TS4, unless the fault has disappeared during this time. Generally, the control contacts of the circuit-breaker failure protection are used for operating the next circuit breaker towards the source. The circuit-breaker failure protection can also be used for establishing a redundant CB trip system by providing the circuit breaker with two tripping coils, one being controlled by the signal TS2, TS3 or TS4 and the other by the signal TS1. The switches SGF4/5...7 are used for alerting the circuit-breaker failure protection. The operate time is set in subregister 5 in register A.

External control signals

Three external control signals BS1, BS2 and RRES are available to the earth-fault relay module SPCS 2D26. The control signals can be used for blocking the operation of the protection stages, for switching between main and second settings and for resetting operation indicators, output relays and registers, and for selecting the basic angle. The switches of the SGB switchgroups are used for configuring the external control signals.

Output signals

The switchgroups SGR1...SGR6 can be used to link the start and operate signals of any protection stage to the desired output relays SS1...SS4 or TS1...TS4.

The switches SGF4/1...4 allow a latching feature to be selected for the output signals TS1...TS4. When this function 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 shown in the table in section "Resetting".

The operation of the TRIP indicator on the front panel can be configured to be lit by the activation of any output signal. The trip indicator remains lit when the output signal resets. The switchgroup SGF3 is used for configuring the trip indicator. The means of resetting are shown in the table in paragraph "Resetting".

Initiation signals for auto-reclosing

The signal AR1 or AR3 is used to initiate an auto-reclose sequence. The signals can be programmed to be activated by the start or operate signals of the earth-fault stages. Switchgroup SGF5 is used to select the initiation signals to be used.

Second settings

Two different setting values are available for the relay: main setting values and second setting values. Switching between these two types of setting value 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 5 of register A. Selecting the value 0 for the subregister activates the main settings, whereas the value 1 activates the second settings.

The S parameters allow the main setting values and second setting values to be read and set over the serial bus. The push-buttons on the front panel can be used for reading and setting the actual setting values only.

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.

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	Output	Registers
RESET	x		
PROGRAM	x		
PROGRAM, when display is dark	x	x	
RESET & PROGRAM	x	x	x
External control signal BS1, BS2 or RRES, when			
SGB_/5 = 1	x		
SGB_/6 = 1	x	x	
SGB_/7 = 1	x	x	x
Parameter V101	x	x	
Parameter V102	x	x	x

Block schematic diagram

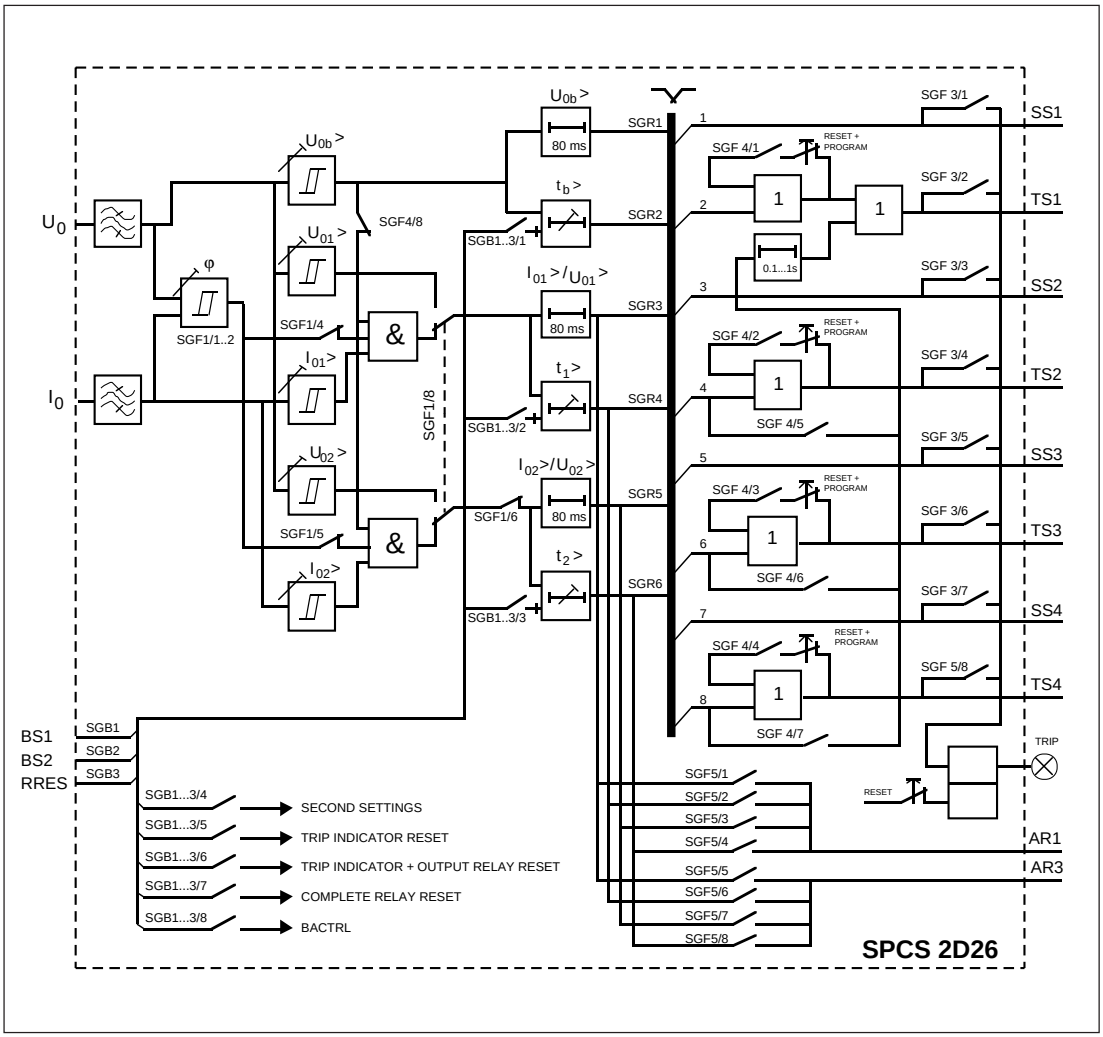


Fig. 3. Block schematic diagram for earth-fault relay module SPCS 2D26

U_0	Residual voltage to be measured
I_0	Neutral current to be measured
BS1, BS2 and RRES	External control signals
SGF1...5	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, TS1...TS4	Output signals
TRIP	Red trip indicator
AR1, 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.

Front panel

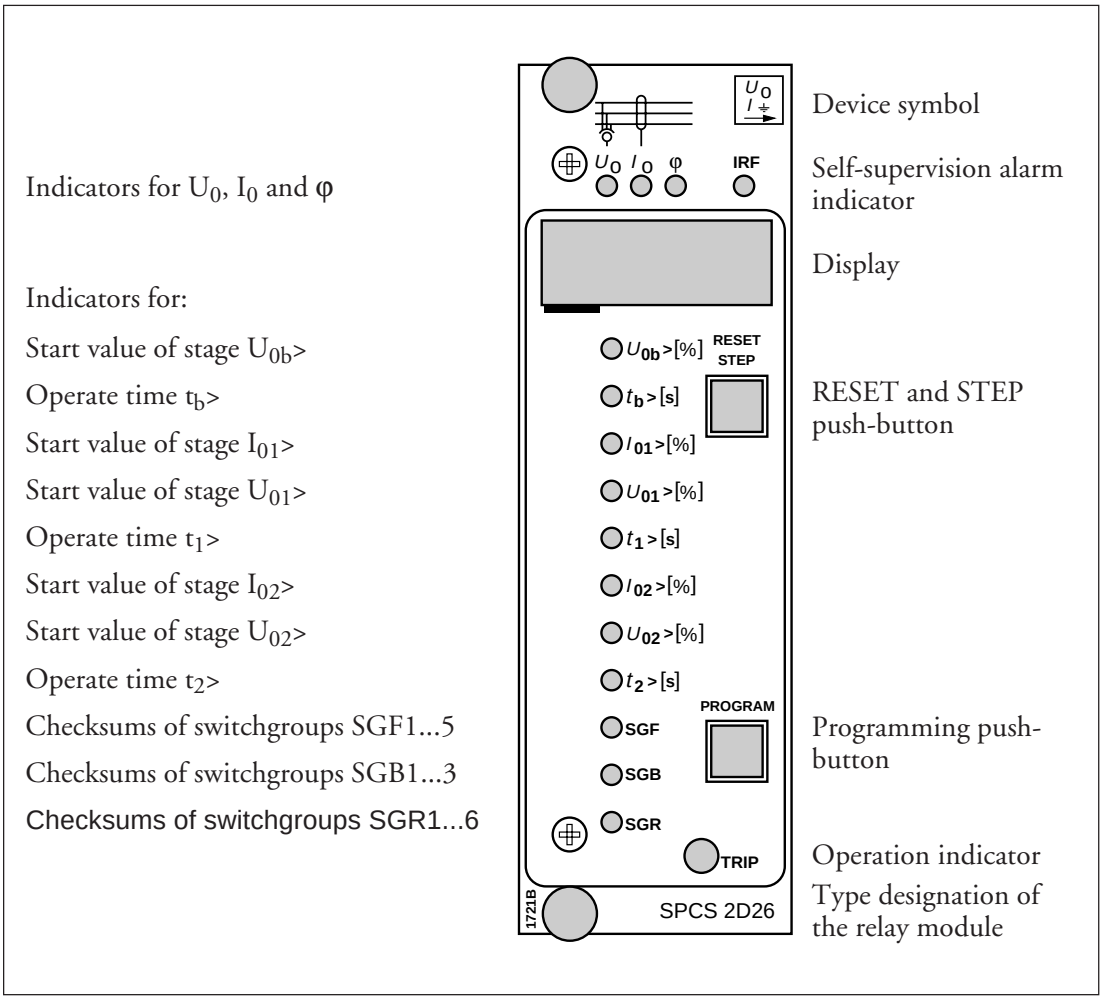


Fig. 4. Front panel of earth-fault relay module SPCS 2D26

Operation indicators

(modified 2002-06)

Each earth-fault stage has its own start indicator and operate indicator presented as a red number on the display. In addition, the earth-fault stages share a TRIP indicator located at the right bottom corner of the relay module. The switch-group SGF3 is used for configuring this TRIP indicator.

The code indicating operation and the red TRIP indicator remain lit after the relay has issued an operate signal, thus facilitating the identification of the stage that operated. The codes indicating operation and the red TRIP indicator remain lit, even though the stage resets, and have to be separately reset. The numbers indicating start go out when the stage resets. Should the stage provide an operate signal before resetting, the start indicating numbers start indicating operation. When required, the trip indicator for stage U_{0b}>can be set to automatically reset when the fault disappears. This function is selected with the switch SGF2/1. A latching function can be selected for the start indicators of the stages I_{0}_>and U_{0}_> (switches SGF2/2…3). This means that the indications have to be manually reset.

Unreset 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". Unreset 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 parameters are explained in the following table:

Operation code	Parameter V4	Symbol	Explanation
1	1	U_{0b}> START	Start of residual voltage stage U_{0b}>
2	2	U_{0b}> TRIP	Operation of residual voltage stage U_{0b}>
3	3	I_{01}>/U_{01}> START	Start of stage I_{01}>/U_{01}>
4	4	I_{01}>/U_{01}> TRIP	Operation of stage I_{01}>/U_{01}>
5	5	I_{02}>/U_{02}> START	Start of stage I_{02}>/U_{02}>
6	6	I_{02}>/U_{02}> TRIP	Operation of stage I_{02}>/U_{02}>
A	12	CBFP	Operation of circuit-breaker failure protection

Note! When U_{0b} is used as deblocking stage, set the time t_{b}> to 300 s in order avoid the operation indicator U_{0b}> TRIP.

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 relay module delivers a control signal to the output relays of the self-supervision system of the relay assembly. In most cases a fault code that shows the nature of the fault appears on the display of the relay module. This fault code consisting of a red digit 1 and a green code number cannot be reset from the display. The code should 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 that particular setting value is being displayed. The default setting is given in parentheses below the setting range.

Setting	Description	Setting range (Default setting)
U_{0b}> (%U_n)	Start voltage of stage U_{0b}> as a percentage of the rated voltage	2.0...80.0% U_n (2.0% U_n)
t_b> (s)	Operate time of stage U_{0b}> in seconds	0.1...300 s (0.1 s)
I_{01}> (%I_n)	Start current of stage I_{01}> as a percentage of the rated current	1.0...100% I_n *) (1.0% I_n)
U_{01}> (%U_n)	Start voltage of stage U_{01}> as a percentage of the rated voltage	2.0...80.0% U_n *) (2.0% U_n)
t_1> (s)	Operate time of stage I_{01}> or stage U_{01}> in seconds	0.1...300 s (0.1 s)
I_{02}> (%I_n)	Start current of stage I_{02}> as a percentage of the rated current	1.0...100% I_n *) (1.0% I_n)
U_{02}> (%U_n)	Start voltage of stage U_{02}> as a percentage of the rated voltage	2.0...80.0% U_n *) (2.0% U_n)
t_2> (s)	Operate time of stage I_{02}> or stage U_{02}> in seconds	0.1...300 s (0.1 s)
CBFP	Operate time of circuit-breaker failure protection in seconds	0.1...1.0 s (0.2 s)

*) A state when the stage has been set out of use (switch SGF1/_) is indicated as "- - -" on the display.

Note!
The rated voltage U_n of the residual current input, 100 V, 110 V or 120 V, is selected by means of the software switches SGF2/6...7. The configuration of the configuration switchgroups SGF1...5, SGB1...3 and SGR1...6 are described in the section "Configuration switches".

Note!
Changes in the functions of the earth-fault stages I_{01}> and I_{02}> are presented in Appendix 1, page 29.

Configuration switches

(modified 2002-06)

The switchgroups SGF1...5, SGB1...3 and SGR1...6 are used to select additional functions required for individual applications. In addition to these switchgroups, the module is provided with a switchgroup SGX, which can be programmed from the front panel via submenu 6 in register A or over the serial SPA communication using parameter V152. The number of the switches, 1...8, and the position of the switches, 0 and 1, are displayed during the setting procedure. Normally, the checksums of the switchgroups are indicated on the display. These are found in the main menu of the relay module, see section "Main menus and submenus of settings and registers". The default settings with checksums Σ are also given in the tables. The calculation of the checksum is described in the end of this section.

Switchgroup SGF1

<table>
<tr><th>Switch</th><th>Operation</th><th>Default</th></tr>
<tr><td>SGF1/1
SGF1/2</td><td>Selection of basic angle. The operation area of the protection = basic angle $\varphi_b \pm$ operation sector.
<table><tr><th>SGF1/1</th><th>SGF1/2</th><th>Basic angle</th></tr><tr><td>0
1
0
1</td><td>0
0
1
1</td><td>-90°
-60°
-30°
0°</td></tr></table></td><td>0
0</td></tr>
<tr><td>SGF1/3</td><td>Selection of operation direction for the low-set stage stage $I_{01}>$

When SGF1/3 = 0, the low-set stage $I_{01}>$ operates in forward direction.
When SGF1/3 = 1, the low-set stage $I_{01}>$ operates in reverse direction.</td><td>0</td></tr>
<tr><td>SGF1/4</td><td>Selection of directional or non-directional operation for the low-set stage $I_{01}>$

When SGF1/4 = 0, the operation of the low-set stage $I_{01}>$ is directional.
When SGF1/4 = 1, the operation of the low-set stage $I_{01}>$ is non-directional.</td><td>0</td></tr>
<tr><td>SGF1/5</td><td>Selection of directional or non-directional operation for the high-set stage $I_{02}>$

When SGF1/5 = 0, the operation of the high-set stage $I_{02}>$ is directional.
When SGF1/5 = 1, the operation of the high-set stage $I_{02}>$ is non-directional.</td><td>0</td></tr>
<tr><td>SGF1/6</td><td>Operation of stage $I_{02}>/U_{02}>$

When SGF1/6 = 0, the high-set stage $I_{02}>/U_{02}>$ is alert
When SGF1/6 = 1, the high-set stage $I_{02}>/U_{02}>$ is out of operation</td><td>0</td></tr>
<tr><td>SGF1/7</td><td>Selection of operation direction for the high-set stage stage $I_{02}>$

When SGF1/7 = 0, the high-set stage $I_{02}>$ operates in forward direction.
When SGF1/7 = 1, the high-set stage $I_{02}>$ operates in reverse direction.</td><td>0</td></tr>
<tr><td>SGF1/8</td><td>Selection of I_0/U_0 operation

When SGF1/8 = 0, the relay module provides two-stage neutral current protection. In addition the relay module includes a separate residual voltage stage.
When SGF1/8 = 1, the relay module provides three-stage residual voltage protection.</td><td>0</td></tr>
<tr><td>Σ SGF1</td><td></td><td>0</td></tr>
</table>

Switchgroup SGF2

<table>
<tr><th>Switch</th><th>Operation</th><th>Default</th></tr>
<tr><td>SGF2/1</td><td>Selection of mode of operation for the trip indicator of stage U_{0b}>.
When SGF2/1 = 0, the operation indicator remains lit until manually reset (latching function)
When SGF2/1 = 1, the operation indicator (2) resets once the fault disappears.</td><td>0</td></tr>
<tr><td>SGF2/2
SGF2/3</td><td>Selection of operation mode for the start indicators of the stages I_{0}_>
and U0_>. When the switches are in position 0, the start indicators reset once the fault disappears. To select a latching indication mode of operation, the SGF2 switch for the concerned stage has to be set in position 1:
When SGF2/2 = 1, the start indicator (3) for stage I_{01}> or stage U_{01}> has to be manually reset.
When SGF2/3 = 1, the start indicator (5) for stage I_{02}> or stage U_{02}> has to be manually reset.</td><td>0
0</td></tr>
<tr><td>SGF2/4
SGF2/5</td><td>Selection of resetting time of stage I_{01}>/U_{01}>
<table><tr><th>Switch</th><th colspan="4">Switch position</th></tr><tr><th></th><th>80 ms</th><th>100 ms</th><th>500 ms</th><th>1000 ms</th></tr><tr><td>SGF2/4</td><td>0</td><td>1</td><td>0</td><td>1</td></tr><tr><td>SGF2/5</td><td>0</td><td>0</td><td>1</td><td>1</td></tr></table></td><td>0
0</td></tr>
<tr><td>SGF2/6
SGF2/7</td><td>Selection of rated voltage U_n for the residual voltage energizing circuit
<table><tr><th>Switch</th><th colspan="4">Switch position</th></tr><tr><th></th><th>100 V</th><th>110 V</th><th>120 V</th><th>Not in use (100 V)</th></tr><tr><td>SGF2/6</td><td>0</td><td>0</td><td>1</td><td>1</td></tr><tr><td>SGF2/7</td><td>0</td><td>1</td><td>0</td><td>1</td></tr></table></td><td>0
0</td></tr>
<tr><td>SGF2/8</td><td>Selection of operation areas for the directional earth-fault protection

When SGF2/8 = 0, the operation sector is ±80°
When SGF2/8 = 1, the operation sector is ±88°</td><td>0</td></tr>
<tr><td>∑SGF2</td><td></td><td>0</td></tr>
</table>

Switchgroup SGF3

<table>
<tr><th>Switch</th><th>Operation</th><th>Default</th></tr>
<tr><td>SGF3/1
SGF3/2
SGF3/3
SGF3/4
SGF3/5
SGF3/6
SGF3/7
SGF3/8

∑ SGF3</td><td>Selection of the output signal to control the front panel TRIP indicator.
When the switch linked with the concerned output signal is in position 1, the TRIP indicator is lit by the activation of the signal.

<table>
<tr><th rowspan="2">Switch</th><th rowspan="2">Controlled by signal</th><th colspan="2">Switch position</th></tr>
<tr><th>TRIP is not lit</th><th>TRIP is lit</th></tr>
<tr><td>SGF3/1</td><td>SS1</td><td>0</td><td>1</td></tr>
<tr><td>SGF3/2</td><td>TS1</td><td>0</td><td>1</td></tr>
<tr><td>SGF3/3</td><td>SS2</td><td>0</td><td>1</td></tr>
<tr><td>SGF3/4</td><td>TS2</td><td>0</td><td>1</td></tr>
<tr><td>SGF3/5</td><td>SS3</td><td>0</td><td>1</td></tr>
<tr><td>SGF3/6</td><td>TS3</td><td>0</td><td>1</td></tr>
<tr><td>SGF3/7</td><td>SS4</td><td>0</td><td>1</td></tr>
<tr><td>SGF3/8</td><td>TS4</td><td>0</td><td>1</td></tr>
</table>
</td><td>0
1
0
1
0
1
0
1

170</td></tr>
</table>

Switchgroup SGF4

Switch	Operation	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	0
	When the switch = 0, the output signal resets, when the signal that caused the operation falls below the setting value. When the switch = 1, the output signal remains active, even though the signal that caused the operation falls below the setting value. A signal provided with self-holding is reset via the push-buttons on the front panel, an external control input or the serial bus, see "Description of operation".	
SGF4/5	Circuit-breaker failure protection (CBFP) started by signal TS2	0
SGF4/6	Circuit-breaker failure protection (CBFP) started by signal TS3	0
SGF4/7	Circuit-breaker failure protection (CBFP) started by signal TS4	0
	When the switch = 1, an output signal TS_ starts the time circuit of the circuitbreaker failure protection. If the set operate time elapses, the output signal still being active, the relay issues a trip signal TS1. When the switch = 0, the circuit-breaker failure protection is out of operation.	
SGF4/8	Selection of U_0 deblocking for the directional earth-fault stages $I_{01}>$ and $I_{02}>$. When SGF4/8 = 0, U_0 deblocking is in use When SGF4/8 = 1, U_0 deblocking is not in use	0
∑ SGF4		0

Switchgroup SGF5

The switches of switchgroup SGF5 are used to select those start and operate signals of the earth-fault protection which are to be used as auto-reclose initiation signal AR1 or AR3. The programming of the signals is shown in the figure below.

The start and operate signals are linked with the desired signal lines AR1 or AR3, for example, by circling the intersection of the signals. Each intersection is marked with the number and weighting value of the switch. The checksum of the switchgroup is obtained by adding the weighting values of the switches selected.

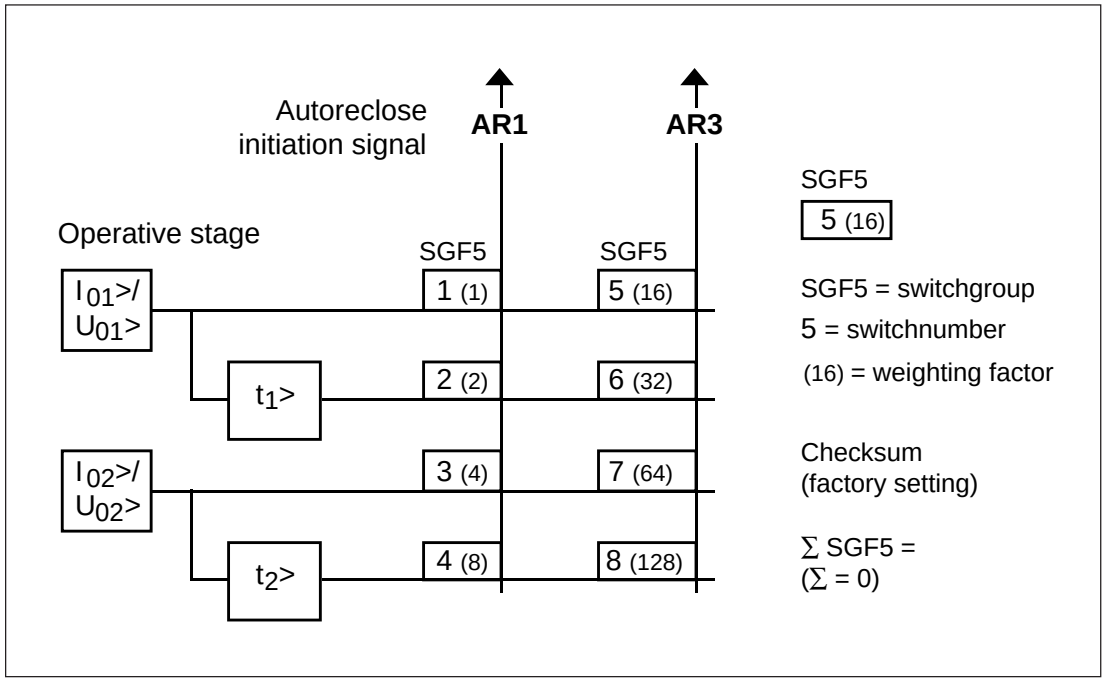


Fig. 5. Matrix for programming the AR initiation signals.

Switchgroup SGX

The SGX switchgroup is programmed either from the front panel via submenu 6 in register A or over the serial communication using parameter V152.

Switch	Operation	Default
SGX/1	Selection of operation principle for the directional earth-fault stages $I_{01}>$ and $I_{02}>$ When SGX/1= 0, phase-angle measuring function When SGX/1= 1, $I_0\cos\varphi$ function	0
SGX/2 SGX/3 SGX/4 SGX/5 SGX/6	Switches 2…6 are available in version SW 186 B presented in Appendix 1, page 29.	

Switchgroups SGB1...3

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.

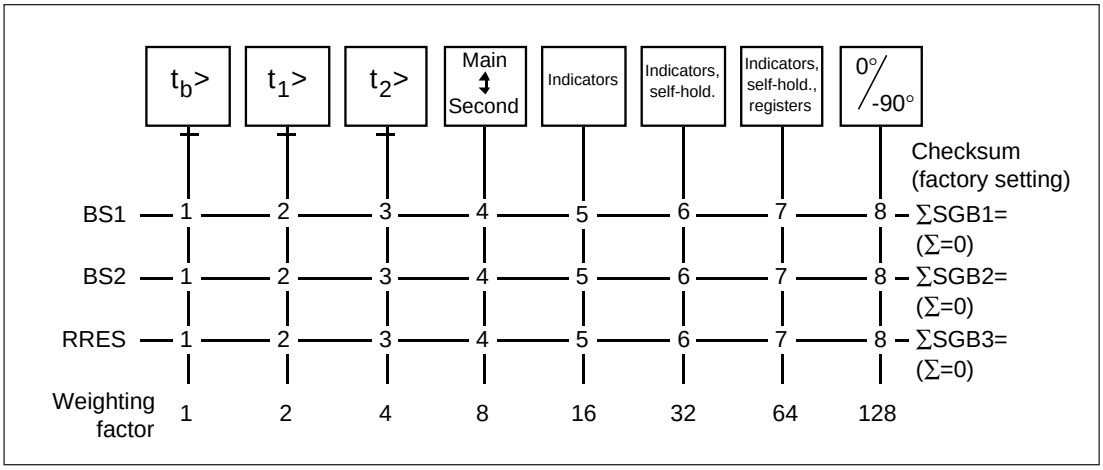


Fig. 6. Matrix for programming the earth-fault relay module SPCS 2D26.

Switch	Operation
SGB_/1...3	Selection of the external control signals BS1, BS2 or RRES to be used for blocking the earth-fault stages. When the switch is in position 1, the concerned stage is blocked by the activation of the control signal.
SGB_/4	Selection of main setting values or second setting values using an external control signal. When SGB_/4 = 0, the main or second setting values are determined according to the actual setting, that is, the setting selected via command V150 over the serial interface or manually with the pushbuttons. When SGB_/4 = 1, an external control signal is used for selecting main setting or second setting values. The main settings are active, when no control voltage is applied to the control input, whereas the second settings are active, when a control voltage is applied to the control input. N.B. When SGB_/4 is in position 1, the relay module does not accept main settings or second settings made over the serial interface or via the pushbuttons on the front panel. N.B. Only one of the switches SGB1…3/5 is allowed to be in position 1. N.B. Switch SGB_/4 must always be in the same position in the main settings and the second settings
SGB_/5	Resetting of front panel operation indicators
SGB_/6	Resetting of front panel operation indicators and latched output relays
SGB_/7	Resetting of front panel operation indicators, latched output relays and registers
SGB_/8	Selection of the basic angle φ_b using an external control signal. Available alternatives: 0° and -90°. When SGB_/8 = 0, the basic angle is determined according to the actual setting, that is, the setting selected with switches SGF1/1…2. When SGB_/8 = 1, the basic angle φ_b is determined using an external control signal. When no control voltage is applied to the input, the basic angle φ_b = -90° and when a control voltage is applied to the input the basic angle φ_b = 0°.

Switchgroups SGR1...6

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

The matrix below can be used for the programming. The start and operate signals are linked with the desired output signal SS1...SS4 or TS1...TS4, for example, by circling the intersection of the signals lines. The switch number is marked at each intersection and the weighting value of the switch is given under the matrix. By adding the weighting values of the switches selected the checksums of the switchgrops are obtained to the right of the matrix. The checksum of the factory setting is given in parenthesis.

Note!
Before starting the programming, check that all the output signals of the relay module SPCS 2D26 are in use in the relay concerned.

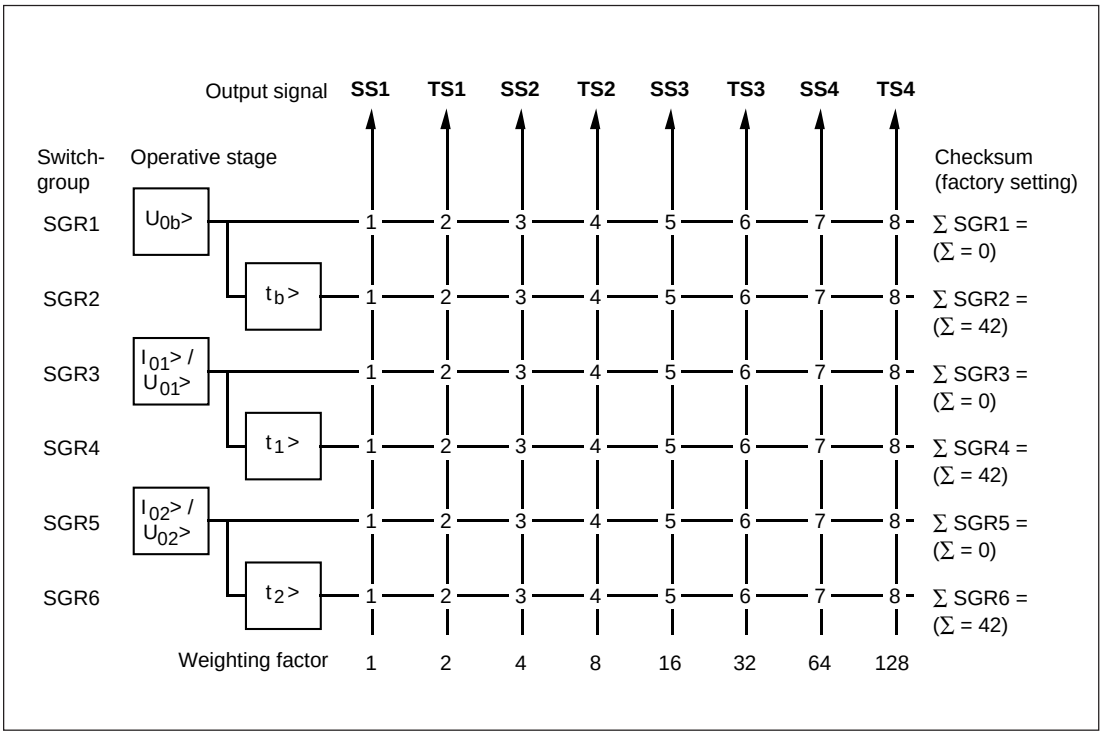


Fig. 7. Output relay matrix for earth-fault relay module SPCS 2D26

Example of checksum calculation

Switch	Weighting value		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 $\sum$ of switchgroup SGF1					69

Measured data

The values measured are indicated by the three green right-most digits on the display. The data being presented on the display is indicated by yellow LEDs above the display.

LED indicator	Measured data	Measuring range
U_0	Residual voltage measured by the relay module expressed as a percentage of the rated voltage U_n	0...106% x U_n
I_0	Neutral current measured by the relay module expressed as a percentage of the rated current I_n	0...210% x I_n
φ	The phase angle φ is the difference between the basic angle $φ_b$ selected and the earth-fault current I_0. N.B! The phase angle φ cannot be measured unless the input signals are at least 0.3%. Otherwise the display shows "- - -".	-180°…0...+180°

Recorded data

(modified 2002-06)

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

Registers 1...6 are updated once a protection stage starts or starts and operates. Then the previous items are moved one step forward the oldest item being lost. The five latest values are stored in the memory: the most recent value stored in the main register and the other four values in the 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	The phase angle φ between basic angle and current I_0 (see Figure 1a). Once a protection stage starts, but without operating, the value measured at the moment of start is recorded in registers 1...3. If one of the stages starts and provides an operate signal, the value recorded at the moment of operation is stored in the registers. The registers are updated when all the stages have reset.
4	Duration of the start situation of stage $U_{0b}>$ expressed as a percentage of $t_b>$
5	Duration of the start situation of stage $I_{01}>$ or stage $U_{01}>$ expressed as a percentage of $t_1>$
6	Duration of the start situation of stage $I_{02}>$ or stage $U_{02}>$ expressed as a percentage of $t_2>$ Registers 4...6 store the duration of the start situations of the protection stages. The values are expressed as a percentage of the set operate time. When the stage operates, the counter reading is 100. Registers 4...6 contain the subregister 5, which stores the number of times the concerned stages have started (0...255)

<table>
<tr><th>Register/
STEP</th><th>Data recorded</th></tr>
<tr><td>0</td><td>Display of external blocking and control data. The right-most digit on the display indicates the status of the external control signals. The following alternatives are available:
<table>
<tr><th rowspan="2">Digit displayed</th><th colspan="3">Active signal</th></tr>
<tr><th>BS1</th><th>BS2</th><th>RRES</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 switchgroups SGB1...3 are used to configure the external control signals.

From this register the TEST mode of the output relays can be entered. In this test mode the start and operate signals can be activated one by one. The test mode is described in detail in the document"General characteristics of D- type SPC relay modules".</td></tr>
<tr><td>A</td><td>Address code of the earth-fault relay module, required for serial communication. Register A contains the following additional subregisters:

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 properly, the value of the monitor is 0. Otherwise the numbers 0...255 are rolling.
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)
5. Setting of operate time for circuit-breaker failure protection, setting range 0.1...1.0 s. Default setting 0.2 s.
6. Switchgroup SGX. Detailed information on page 14 and in Appendix 1, page29. Default setting 0.</td></tr>
</table>

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 gives direct access to the end of the main menu of the relay module.

The values recorded in registers 1…6 can be reset by pressing the front panel pushbuttons STEP and RESET simultaneously, with an external control signal, or via a serial communication parameter. In addition, an interruption in the supply voltage will clear the registers, except when SGX/2 = 1, in which case the data is stored in a non-volatile memory. The setting values of the module, the address code and the data communication rate of the serial communication are stored in a non-volatile memory, which retains the information at a power failure. Instructions for setting the address and data transfer rate of the module are given in the document "General characteristics of D-type SPC relay modules".

*) See Appendix 1

Main menus and submenus of settings and registers
(modified 2002-06)

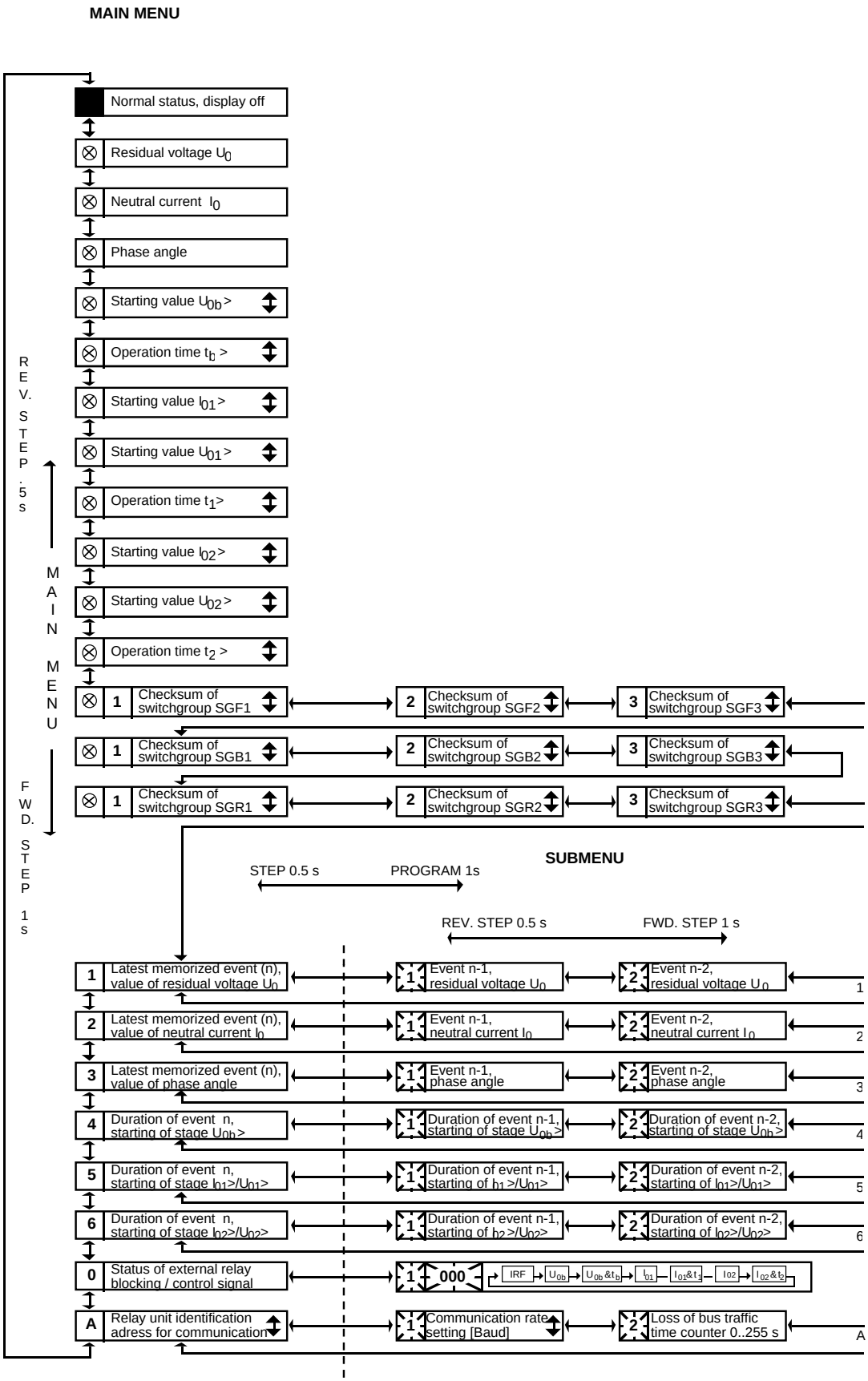
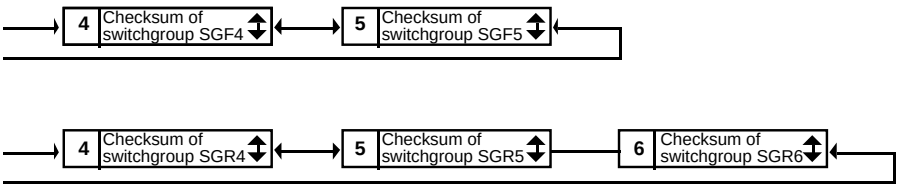
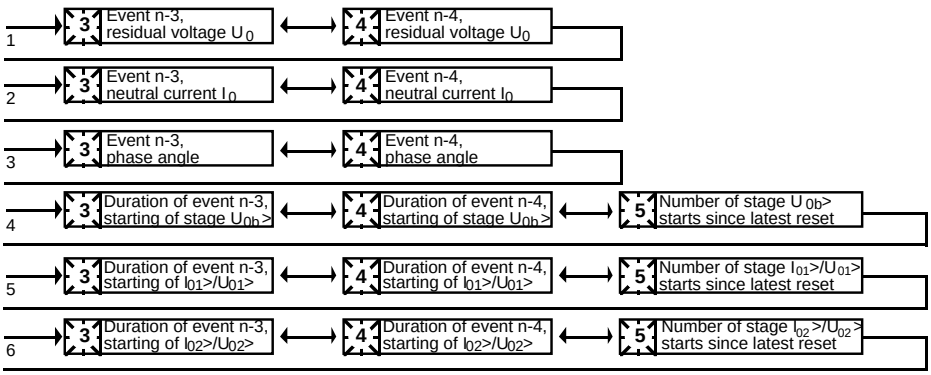


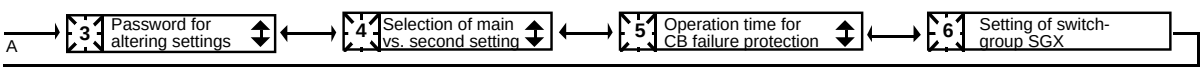
Fig. 8. Main menu and submenus for earth-fault relay module SPCS 2D26.

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 a simplified instruction.

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 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 (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.







Residual voltage stage U_{0b}>

Setting range U_{0b}>	2.0...80.0% U_n
Start time, typical	100 ms
Operate time t_b>	0.1...300 s
Resetting time, typical	60 ms
Pick-up/drop-off ratio, typical	0.96
Operate time accuracy	±2% of set value of ±25 ms
Operation accuracy	±3% of set value

Low-set stage I_{01}> or U_{01}>

Operation direction of stage I_{01}>	forward or reverse
Basic angle φ_b	-90°, -60°, -30° or 0°
Operation sector $\Delta\varphi$	±80°, ±88°. Extended and reduced operation sector *)
Operation principle	Phase-angle measuring function or $I_0\cos\varphi$ function
Operation characteristic of stage I_{01}>	directional or non-directional
Setting range I_{01}>	1.0...100% I_n
Setting range U_{01}>	2.0...80.0% U_n
Start time, typical	80 ms
Operate time t_1>	0.1...300 s
Resetting time, typical	80, 100, 500 or 1000 ms
Pick-up/drop-off ratio, typical	0.96
Operate time accuracy	±2% of set value or ±25 ms **)
Operation accuracy	±3% of set value + 0.0005 x I_n
Start value of phase angle measurement	
- neutral current	0.33% I_n
- residual voltage	0.2% U_n

High-set stage I_{02}> or U_{02}>

Operation direction of stage I_{02}>	forward or reverse
Basic angle φ_b	-90°, -60°, -30° or 0°
Operation sector $\Delta\varphi$	±80°, ±88°. Extended and reduced operation sector *)
Operation principle	Phase-angle measuring function or $I_0\cos\varphi$ function
Operation characteristic of stage I_{02}>	directional or non-directional
Setting range I_{02}>	1.0...100% I_n
Setting range U_{02}>	2.0...80.0% U_n
Start time, typical	80 ms
Operate time t_2>	0.1...300 s
Resetting time, typical	100 ms
Pick-up/drop-off ratio, typical	0.96
Operate time accuracy	±2% of set value or ±25 ms
Operation accuracy	±3% of set value + 0.0005 x I_n

*) See "Technical data affected by version SW 186 B", page 35

**) When the I_{01}> stage is set to detect disruptive discharge pulses exceeding 100 ms (SGF2/4,5), the operate time can be extended correspondingly (max. 1 s).

Serial communication parameters

(modified 2002-06)

Event codes

Special codes have been specified to represent certain events such as start and operation of the protection stages and different states of the output signals. 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 mask	Codes	Setting range	Default setting
V155	E1...E12	0...4095	1365
V156	E13...E20	0...255	192
V157	E21...E28	0...255	12

Event codes for earth-fault relay module SPCS 2D26:

Code	Event	Weighting value	Default
E1	Start of stage U_{0b}>	1	1
E2	Start of stage U_{0b}> reset	2	0
E3	Operation of stage U_{0b}>	4	1
E4	Operation of stage U_{0b}> reset	8	0
E5	Start of stage I_{01}>/U_{01}>	16	1
E6	Start of stage I_{01}>/U_{01}> reset	32	0
E7	Operation of stage I_{01}>/U_{01}>	64	1
E8	Operation of stage I_{01}>/U_{01}> reset	128	0
E9	Start of stage I_{02}>/U_{02}>	256	1
E10	Start of stage I_{02}>/U_{02}> reset	512	0
E11	Operation of stage I_{02}>/U_{02}>	1024	1
E12	Operation of stage I_{02}>/U_{02}> reset	2048	0
	Default of event mask V155		1365
E13	Output signal SS1 activated	1	0
E14	Output signal SS1 reset	2	0
E15	Output signal TS1 activated	4	0
E16	Output signal TS1 reset	8	0
E17	Output signal SS2 activated	16	0
E18	Output signal SS2 reset	32	0
E19	Output signal TS2 activated	64	1
E20	Output signal TS2 reset	128	1
	Default of event mask V156		192
E21	Output signal SS3 activated	1	0
E22	Output signal SS3 reset	2	0
E23	Output signal TS3 activated	4	1
E24	Output signal TS3 reset	8	1
E25	Output signal SS4 activated	16	0
E26	Output signal SS4 reset	32	0
E27	Output signal TS4 activated	64	0
E28	Output signal TS4 reset	128	0
	Default of event mask V157		12
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 event reporting and cannot be excluded. 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, but the previous setting will be retained.

Changing a setting parameter over the serial bus requires a password in the range 1..999. 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 given 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 using 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 seven 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

Input data

The parameters I1...I6 can be used to read measured values (R) and status data of external control signals. Value 1 for a parameter I4...I6 means that the signal is active.

Data	Parameter	Values
Residual voltage U_0 measured	I1	0...106% x U_n
Neutral current I_0 measured	I2	0...210% x I_n
Phase angle φ between basic angle φ_b and I_0	I3	-180°…0°...+180°, 999 = signal too low to be measured
Control signal BS1	I4	0 and 1
Control signal BS2	I5	0 and 1
Control signal RRES	I6	0 and 1

The actual status data provide information about the present status of the signals. The events stored in the memory indicate those signal activations which have taken place after the resetting of the relay module. When the value is 0, the signal is not activated and when the value is 1, the signal has been activated.

Status data of protection stages

Protection stage/signal	Actual status data (R)	Memorized events (R)	Values
Stage U_{0b}>, start signal	O1	O21	0 or 1
Stage U_{0b}>, operate signal	O2	O22	0 or 1
Stage I_{01}>/U_{01}>, start signal	O3	O23	0 or 1
Stage I_{01}>/U_{01}>, operate signal	O4	O24	0 or 1
Stage I_{02}>/U_{02}>, start signal	O5	O25	0 or 1
Stage I_{02}>/U_{02}>, operate signal	O6	O26	0 or 1

Signal activations

Output signal	Actual status data (R,W,P)	Memorized events (R)	Values
Output signal SS1	O7	O27	0 or 1
Output signal TS1	O8	O28	0 or 1
Output signal SS2	O9	O29	0 or 1
Output signal TS2	O10	O30	0 or 1
Output signal SS3	O11	O31	0 or 1
Output signal TS3	O12	O32	0 or 1
Output signal SS4	O13	O33	0 or 1
Output signal TS4	O14	O34	0 or 1
Permission for remote control of output signals	O41		0 or 1

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_{0b}>	S1	S41	S81	2.0...80% U_n
Operate time of stage U_{0b}>	S2	S42	S82	0.1...300 s
Start value of stage I_{01}>	S3 *)	S43	S83	1.0...100% I_n
Start value of stage U_{01}>	S4 *)	S44	S84	2.0...80% U_n
Operate time of stage I_{01}>/U_{01}>	S5	S45	S85	0.1...300 s
Start value of stage I_{02}>	S6 *)	S46	S86	1.0...100% I_n
Start value of stage U_{02}>	S7 *)	S47	S87	2.0...80% U_n
Operate time of stage I_{02}>/U_{02}>	S8	S48	S88	0.1...300 s
Checksum, SGF1	S9	S49	S89	0...255
Checksum, SGF2	S10	S50	S90	0...255
Checksum, SGF3	S11	S51	S91	0...255
Checksum, SGF4	S12	S52	S92	0...255
Checksum, SGF5	S13	S53	S93	0...255
Checksum, SGB1	S14	S54	S94	0...255
Checksum, SGB2	S15	S55	S95	0...255
Checksum, SGB3	S16	S56	S96	0...255
Checksum, SGR1	S17	S57	S97	0...255
Checksum, SGR2	S18	S58	S98	0...255
Checksum, SGR3	S19	S59	S99	0...255
Checksum, SGR4	S20	S60	S100	0...255
Checksum, SGR5	S21	S61	S101	0...255
Checksum, SGR6	S22	S62	S102	0...255
Circuit-breaker failure operate time	-	S121	S121	0.1...1.0 s

*) If the stage is out of use, the actual value of this stage is indicated as 999.

Measured and stored parameter values

Value measured	Code	Data direction	Values
Number of starts, stage U_{0b}>	V1	R	0...255
Number of starts, stage I_{01}> or U_{01}>	V2	R	0...255
Number of starts, stage I_{02}> or U_{02}>	V3	R	0...255
Operation indicator	V4	R	0...6, 12 *)

*) See "Operation indicators"

The parameters V11...V56 can be used to read the five latest values stored in the registers to be read. 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 (register1)	V11	V21	V31	V41	V51	0...106% I_n
Neutral current (register 2)	V12	V22	V32	V42	V52	0...210% I_n
Phase angle φ (register 3)	V13	V23	V33	V43	V53	-180°…0°...+180°, 999 = signal too low to be measured
Duration of start sitaution, stage U_{0b}> (register 4)	V14	V24	V34	V44	V54	0...100%
Duration of start situation, stage I_{01}> or U_{01}> (register 5)	V15	V25	V35	V45	V55	0...100%
Duration of start situation, stage I_{02}> or U_{02}> (register 6)	V16	V26	V36	V46	V56	0...100%

Data	Code	Data direction	Values
Resetting of front panel operation indicators and latched output relay	V101	W	1 = resetting
Resetting of operation indicators, output relays and registers	V102	W	1 = resetting
Remote control of settings	V150	R,W	0 = main settings active 1 = second settings active
Switchgroup SGX	V152	R, W(P)	0...63
Event mask for stages U_{0b}>, I_{01}/U_{01}> and I_{02}/U_{02}>	V155	R,W	0...4095, see "Event codes"
Event mask for output signals	V156	R,W	0...255, see "Event codes"
Event mask for output signals	V157	R,W	0...255, see "Event codes"
Opening of password for remote setting	V160	W	1...999
Changing or closing password for remote setting	V161	W(P)	0...999
Activation of self-supervision	V165	W	1 = self-supervision output is activated and IRF LED is lit
EEPROM formatting	V167	W(P)	2 = formatting
Internal fault code	V169	R	0...255
Data communication address of relay module	V200	R,W	1...254
Data transfer rate	V201	R,W	4.8 or 9.6 kBd
Program version symbol	V205	R	117_
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	SPCD 2D26
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 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

4	Faulty trip relay path or missing output relay card
30	Faulty program memory (ROM)
50	Internal RAM faulty
51	Parameter memory (EEPROM) block 1 faulty
52	Parameter memory (EEPROM) block 2 faulty
53	Parameter memory (EEPROM) block 1 and block 2 faulty
54	Parameter memory (EEPROM) block 1 and block 2 faulty, different checksums
55	Faulty parameter area in RAM
56	Parameter memory (EEPROM) key fault. To be formatted by giving parameter V167 the value 2.
195	Too low a value in reference channel with multiple 1
131	Too low a value in reference channel with multiple 5
67	Too low a value in reference channel with multiple 25
203	Too high a value in reference channel with multiple 1
139	Too high a value in reference channel with multiple 5
75	Too high a value in reference channel with multiple 25
252	I_0 channel faulty
253	No interruption from A/D converter

Appendix 1

General

Appendix 1 describes the improvements made in the operation of the directional earth-fault stages I_{01}> and I_{02}> of the relay module SPCS 2D26 at normal and intermittent earth faults on the faulted line or on healthy lines. The changes are valid in program version SW 186 B and later.

Description of functions added to version SW 186 B or later

Storing of recorded data in non-volatile memory

An optional function to be selected with switch SGX/2 has been added to the module SPCS 2D26. This function enables the recorded data to be stored in a non-volatile memory. The recorded data, i.e. residual voltage U_0, neutral current I_0, phase angle φ, duration of the start situation of U_{0b}, duration of the start situation of I_{01}> or U_{01}>, are retained also during a power supply failure, provided the recorded data include one or more trip functions.

Extending the negative part of the operation sector of the earth-fault stages

An optional function, selectable with switches SGX3 and SGX4, extending the negative part of the operation sector to -120° or -170° have been added to the directional earth-fault stages I_{01}> and I_{02}>. As the operation sector of the earth-fault stages can be set to -120° or -170°, the operation of the earth-fault relay of the faulted line can be considerably improved at an intermittent earth fault.

Reducing the positive part of the operation sector of the earth-fault stages

An optional function, selectable with switches SGX/5 and SGX/6, reducing the positive part of the operation sector to +60°, +70° or +80°, when SGF2/8 = 0 (+68°, +78° or +88°, when SGF2/8 = 1) have been added to the directional earth-fault stages I_{01}> and I_{02}>. This function can be selected in special situations, where the phase angle measured for the healthy line may turn towards the operation area.

Intermittent earth faults

A typical intermittent earth fault consists of one or several earth fault current peaks during one disruptive discharge. The peak current is very high and the time between the disruptive discharges may exceed 200 ms. For intermittent earth fault settings, see "Recommendations for setting the relay module SPCS 2D26", page 35.

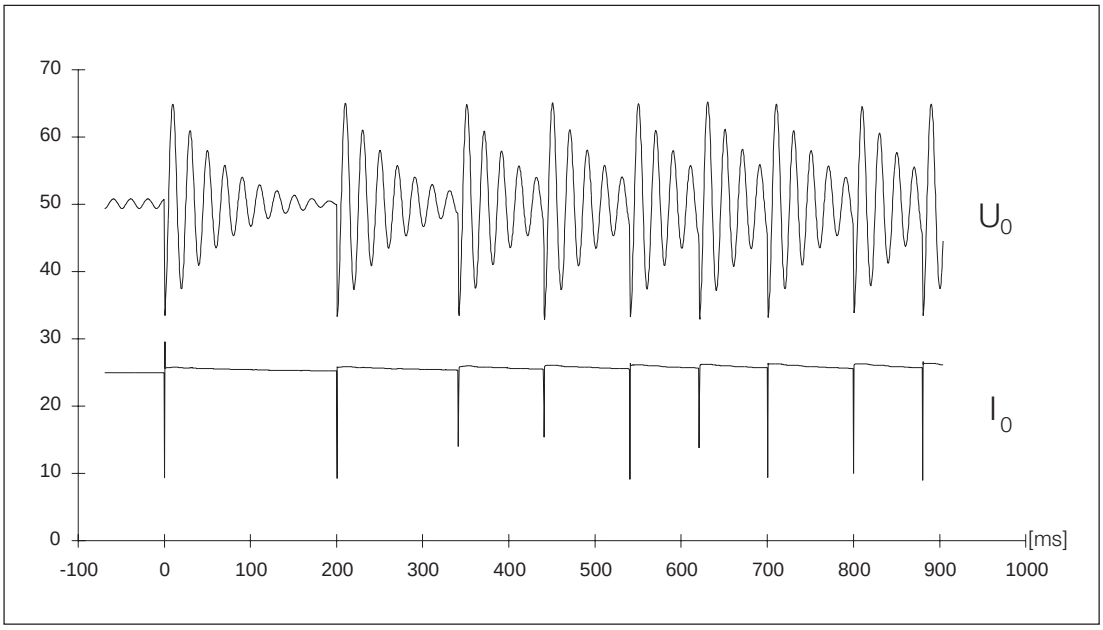


Figure 1. An intermittent earth fault measured in an underground cable.

Programming switches SGX/2...6

The programming switches SGX/2...6 have been put into use. The switches can be programmed either from the front panel of the module, via submenu 6 in register A, or over the serial SPA communication, parameter V152.

Functions to be selected with the programming switchgroup SGX:

<table>
<tr><th>Switch</th><th>Function</th><th>Default setting</th></tr>
<tr><td>SGX/1</td><td>Selection of operation principle for the directional earth-fault stages I_{01}> and I_{02}>

When SGX/1 = 0, phase-angle measuring function
When SGX/1 = 1, $I_0\cos\varphi$ function [1)]

1) When the operation sector -120° or -170° has been selected with the switches SGX/3 and SGX/4, the phase-angle measuring function will be automatically selected for the negative side and a $I_0\cos\varphi$ function for the positive side, see figure 2, page 32.</td><td>0</td></tr>
<tr><td>SGX/2</td><td>Selection of principle of storing recorded data

When SGX/2 = 0, recorded data are stored in a volatile memory,
i.e. the data will be lost at a supply voltage failure
When SGX/2 = 1, recorded data are stored in a non-volatile memory</td><td>0</td></tr>
<tr><td>SGX/3...4</td><td>Selection of negative operation sector for the directional earth-fault stages I_{01}> and I_{02}>
<table>
<tr><th>SGX/3</th><th>SGX/4</th><th>Operation sector when SGF2/8 = 0</th><th>Operation sector when SGF2/8 = 1</th></tr>
<tr><td>0
1
0
1</td><td>0
0
1
1</td><td>- 80°
-120°
-170°
-120°</td><td>- 88°
-120°
-170°
-120°</td></tr>
</table></td><td>0</td></tr>
<tr><td>SGX/5...6</td><td>Selection of positive operation sector for the directional earth-fault stages I_{01}> and I_{02}>
<table>
<tr><th>SGX/5</th><th>SGX/6</th><th>Operation sector when SGF2/8 = 0</th><th>Operation sector when SGF2/8 = 1</th></tr>
<tr><td>0
1
0
1</td><td>0
0
1
1</td><td>+80°
+70°
+60°
+60°</td><td>+88°
+78°
+68°
+68°</td></tr>
</table></td><td>0</td></tr>
<tr><td>SGX/7...8</td><td>Not in use</td><td>0</td></tr>
</table>

Configuration alternatives for the directional earth-fault stages

1. Earth-fault stages with phase-angle measuring function

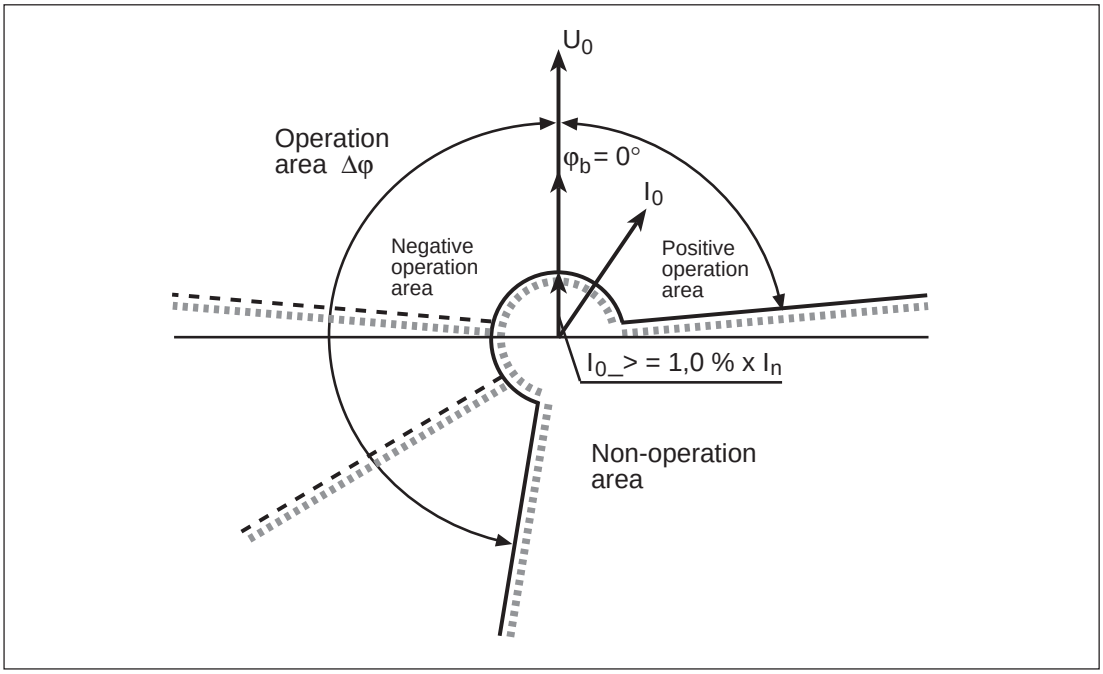


Fig.1. Example of three operation areas: Δφ, -80°...0°...+80°, -120°...0°...+80° and -170°...0°...+80°, when the basic angle is φ_b = 0°.

Table 1: Operation areas to be selected with the SGX switches at phase-angle measuring function

Switch			Earth-fault stages with phase-angle measuring function, SGX/1 = 0		
			Stage I_{01}> and I_{02}>		
SGF2/8	SGX/5	SGX/6	SGX/3=0 & SGX/4=0	SGX/3=1 & SGX/4=0	SGX/3=0 & SGX/4=1
0	0	0	-80°...0°...+80°	-120°...0°...+80°	-170°...0°...+80°
0	1	0	-80°...0°...+70°	-120°...0°...+70°	-170°...0°...+70°
0	0	1	-80°...0°...+60°	-120°...0°...+60°	-170°...0°...+60°
1	0	0	-88°...0°...+88°	-120°...0°...+88°	-170°...0°...+88°
1	1	0	-88°...0°...+78°	-120°...0°...+78°	-170°...0°...+78°
1	0	1	-88°...0°...+68°	-120°...0°...+68°	-170°...0°...+68°

2. Earth-fault stages with $I_0\cos\varphi$ function on the positive sector and phase-angle measuring function on the negative sector

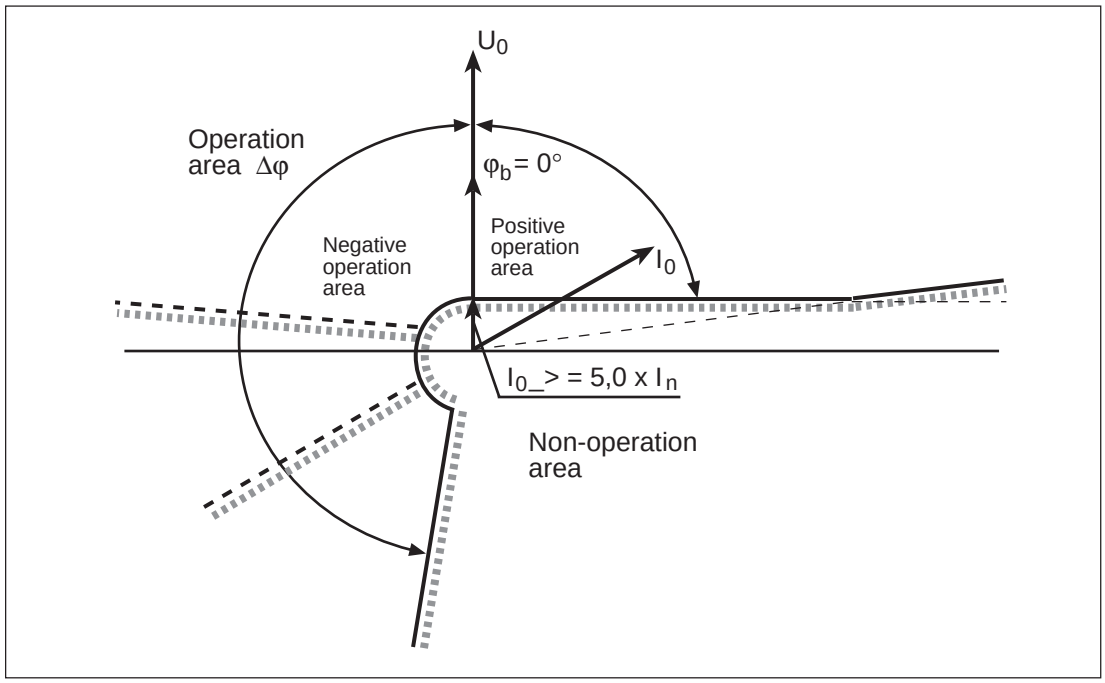


Fig.2. Example of two operation areas: Δφ, -120°...0°...+80° & $I_0\cos\varphi$ and -170°...0°...+80° & $I_0\cos\varphi$, when the basic angle φ_b = 0°.

Table 2: Operation areas to be selected with the SGX switches at $I_0\cos\varphi$ function on the positive sector and phase-angle measuring function on the negative sector

Switch			Earth-fault stages with $I_0\cos\varphi$ function on the positive sector and phase-angle measuring function on the negative sector. SGX/1 = 1 & SGX/3 = 1 or SGX/4 = 1	
Stage $I_{01}>$ and $I_{02}>$				
SGF2/8	SGX/5	SGX/6	SGX/3=1 & SGX/4=0	SGX/3=0 and SGX/4=1
0	0	0	-120°...0°...+80° & $I_0\cos\varphi$	-170°...0°...+80° & $I_0\cos\varphi$
0	1	0	-120°...0°...+70° & $I_0\cos\varphi$	-170°...0°...+70° & $I_0\cos\varphi$
0	0	1	-120°...0°...+60° & $I_0\cos\varphi$	-170°...0°...+60° & $I_0\cos\varphi$
1	0	0	-120°...0°...+88° & $I_0\cos\varphi$	-170°...0°...+88° & $I_0\cos\varphi$
1	1	0	-120°...0°...+78° & $I_0\cos\varphi$	-170°...0°...+78° & $I_0\cos\varphi$
1	0	1	-120°...0°...+68° & $I_0\cos\varphi$	-170°...0°...+68° & $I_0\cos\varphi$

3. Earth-fault stages with $I_0\cos\varphi$ function on the positive and the negative sector

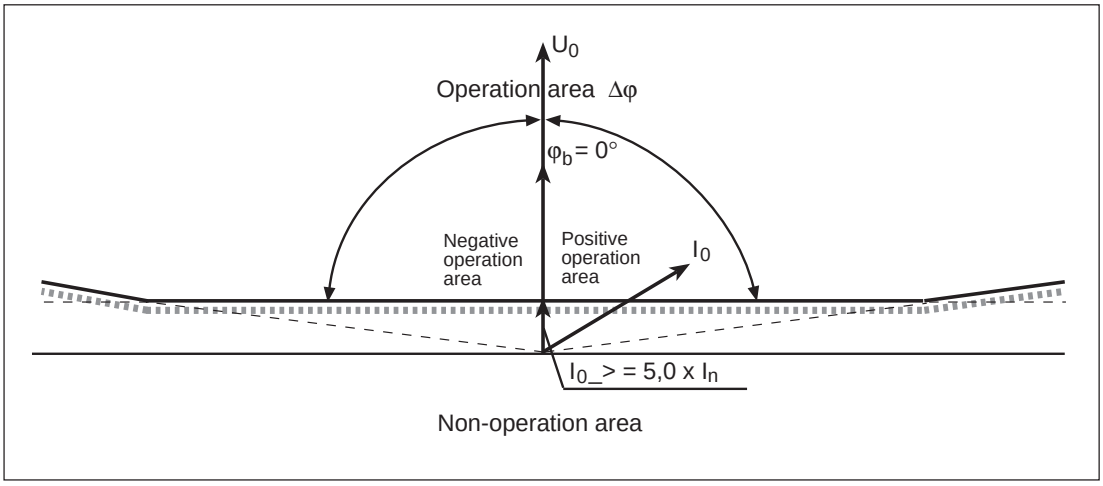


Fig.3. Example of operation area -80° & $I_0\cos\varphi$...0°...+80° & $I_0\cos\varphi$, when the basic angle is $\varphi_b = 0°$.

Table 3: Operation areas to be selected with SGX switches at $I_0\cos\varphi$ function on the negative and the positive sector.

Switch			Earth-fault stages with I_o cosj function on both sectors, SGX/1 = 1 & SGX/3 = 0 & SGX/4 = 0
Stage $I_{01}>$ and $I_{02}>$			
SGF2/8	SGX/5	SGX/6	
0	0	0	-80° & $I_0\cos\varphi$...0°...+80° & $I_0\cos\varphi$
0	1	0	-80° & $I_0\cos\varphi$...0°...+70° & $I_0\cos\varphi$
0	0	1	-80° & $I_0\cos\varphi$...0°...+60° & $I_0\cos\varphi$
1	0	0	-88° & $I_0\cos\varphi$...0°...+88° & $I_0\cos\varphi$
1	1	0	-88° & $I_0\cos\varphi$...0°...+78° & $I_0\cos\varphi$
1	0	1	-88° & $I_0\cos\varphi$...0°...+68° & $I_0\cos\varphi$

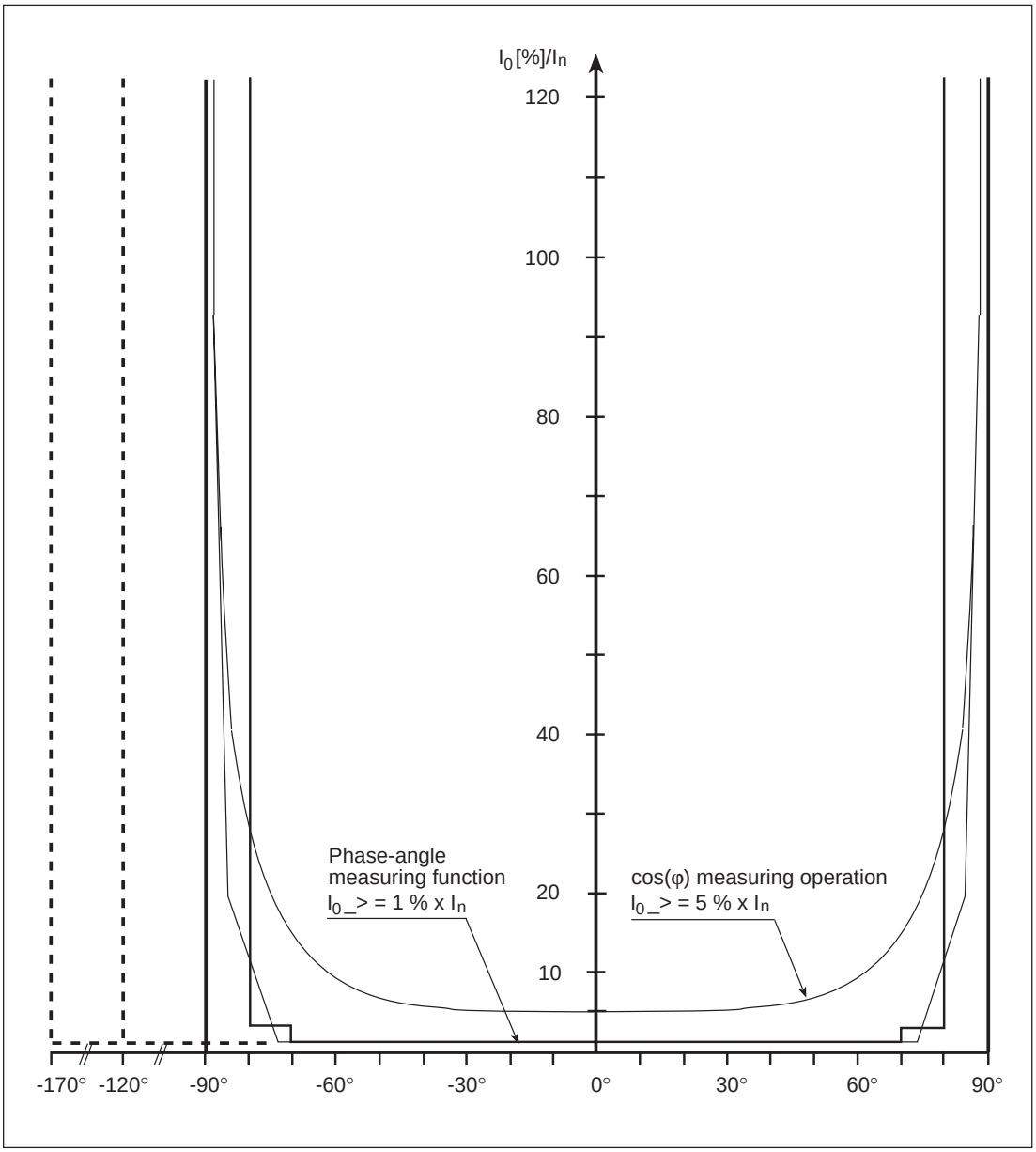


Fig.4 Overview of operation areas of the directional earth-fault stages, when the basic angle $\varphi_b = 0°$ and the start current $I_{0\_>} = 1.0\% \times I_n$ at phase-angle measuring function and 5.0% x In at $I_0\cos\varphi$ measuring function.

Technical data affected by versions SW 186 B

Earth-fault stages I_{01}> and I_{02}>

Operation sector Δφ	SW: -117 _, 186 A	-80°, -88°
	-186 B	-80°, -88°, -120°, -170° (+60°, +68°, +70°, +78°)

Recommendations for setting the module SPCS 2D26, SW 186 B

To maximize the functionality of the module at earth faults apt to develop into intermittent faults, the following module settings are recommended

Definition of setting values
- The residual voltage U_{0b}> is calculated as normal.
- The start current for the earth-fault stages I_{01}> and I_{02}> are calculated as normal.
- The operate times t_{01}> and t_{02}> are calculated as normal.

Programming of switches

SGF1/1	= 1	basic angle 0° for resonant-earthed networks
SGF2/2	= 1	- " -
SGF2/4	= 0	I_{01}> reset time 500 ms
SGF2/5	= 1	- " -
SGF2/8	= 0	operation area, Δφ = ±80°
SGX/3	= 0	negative operation area of stages I_{01}> and I_{02}>, -170°
SGX/4	= 1	- " -
SGX/1	= 1	I_0cosφ function on the positive side
SGX/5	= 0	positive operation area +80°
SGX/6	= 0	- " -

Other settings
Other module settings have to be adapted to the calculations made for the line and the network.

Other issues to consider

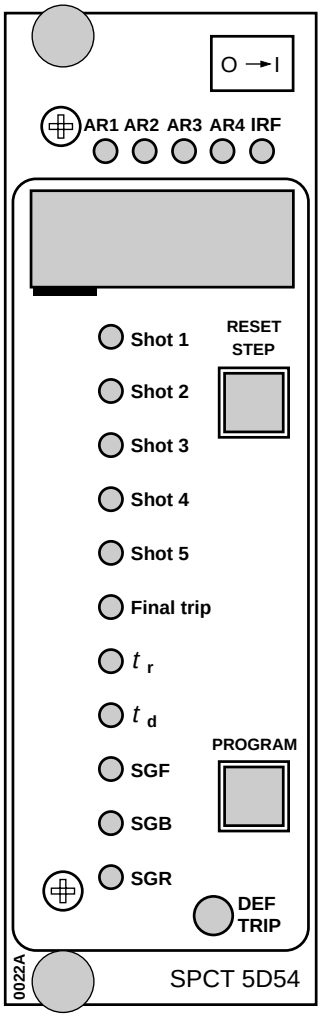
Reactor compensation
To obtain maximum protection for both the faulted line and the healthy lines, a compensation degree of 5…10% (overcompensated) is recommended.

Residual voltage relay
To avoid unselective tripping by the residual voltage relay, the operate time of the relay must be long enough compared to the operate times of the directional earth-fault relays of the feeders. At an intermittent earth fault, the earth-fault stages of the faulted line may be delayed. For this reason, the operate time of the residual voltage relay is at least 5 s (or at least twice the operate time of the directional earth-fault stages).

Local recommendations and regulations
In this document we have paid no attention to local recommendations and regulations, which have to be considered by the user.

SPCT 5D54
Auto-reclose relay module

User´s manual and Technical description



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SPCT 5D54
Auto-reclose relay module

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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.

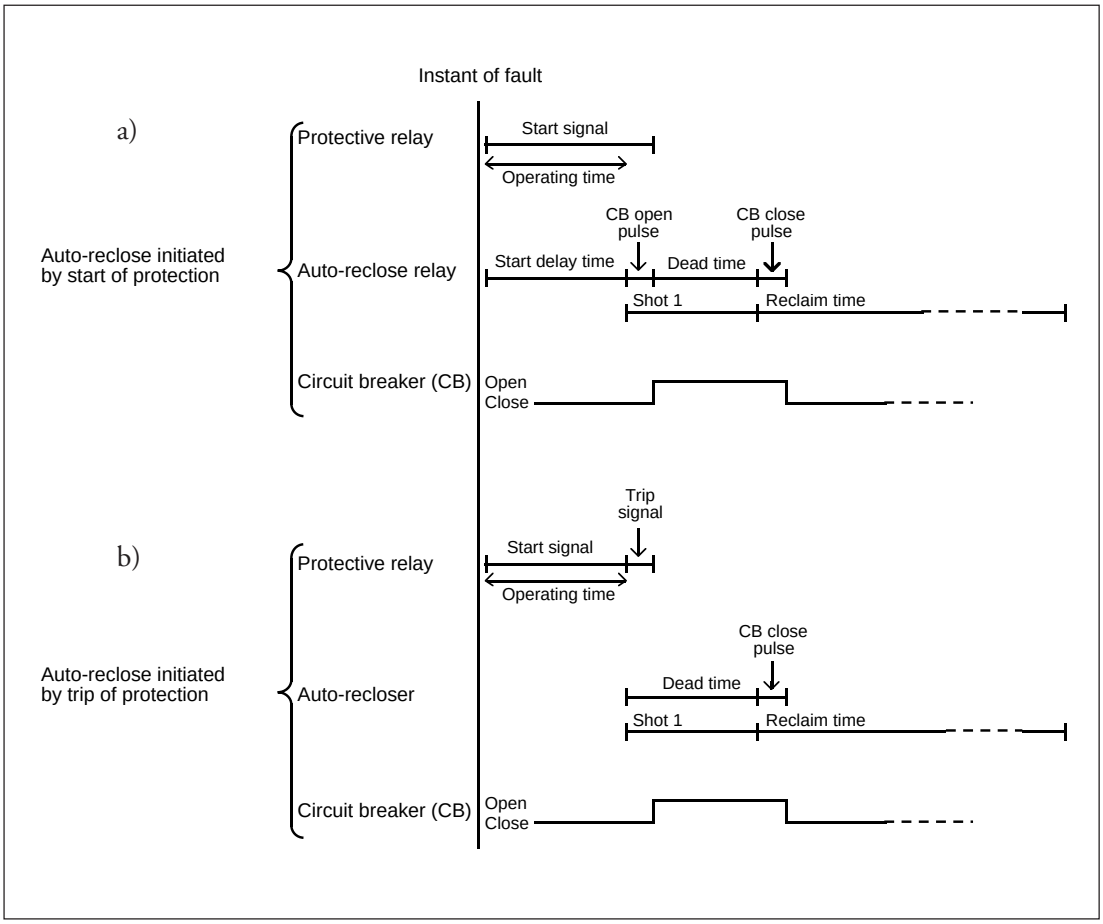


Fig. 1. Signal scheme illustrating the auto-reclose operation

Block schematic diagram

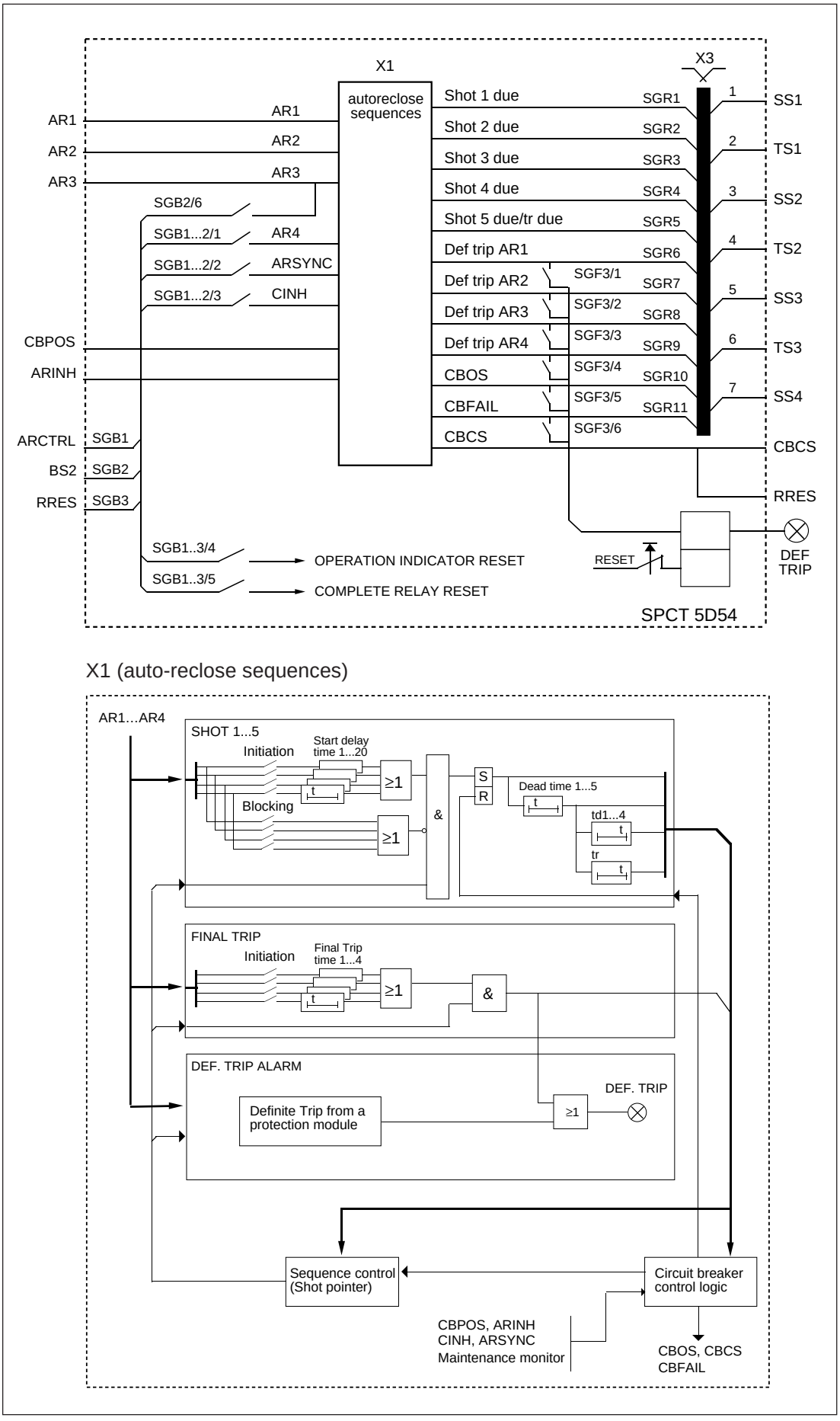


Fig. 2. Simplified block diagram for auto-reclose relay module SPCT 5D54

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.

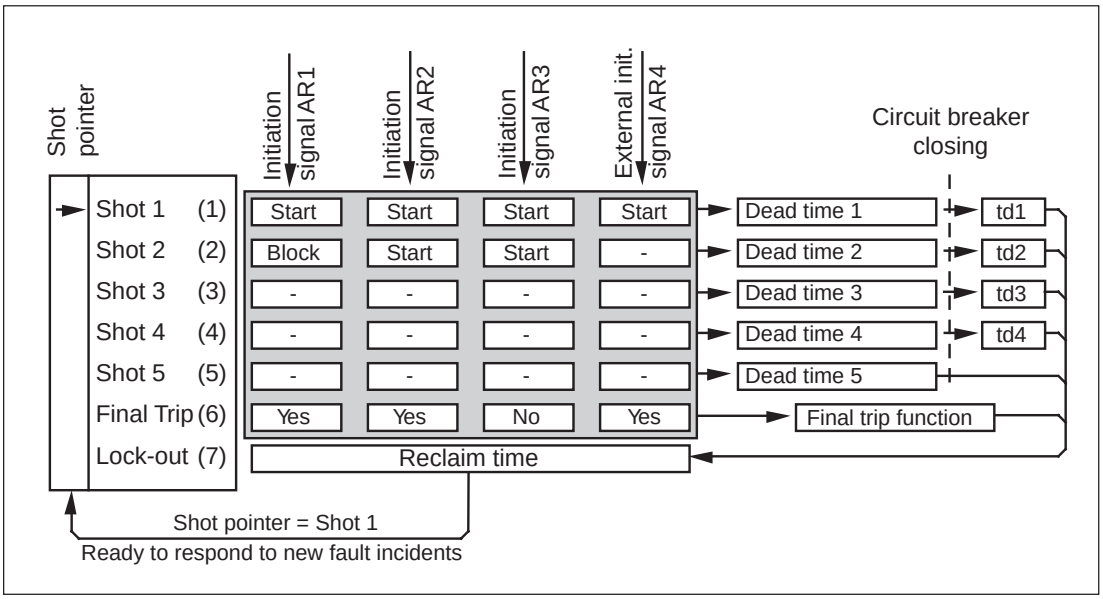


Fig. 3. Functional diagram for the auto-reclose relay module SPCT 5D54

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.

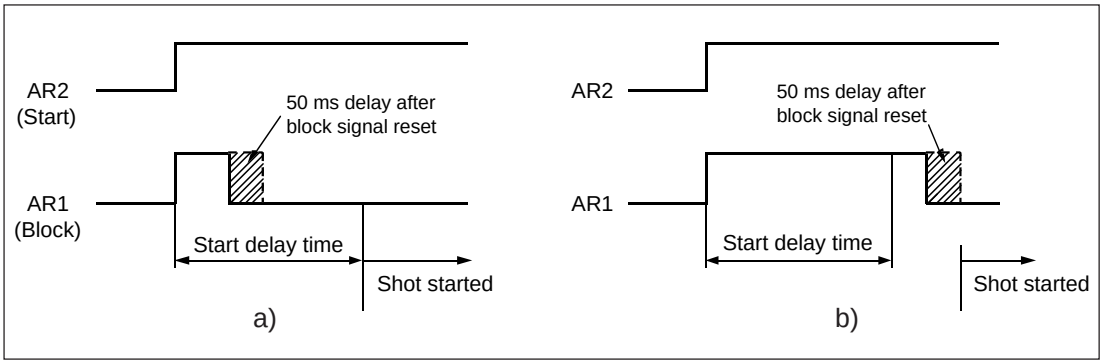


Fig. 4. Examples of AR initiation

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

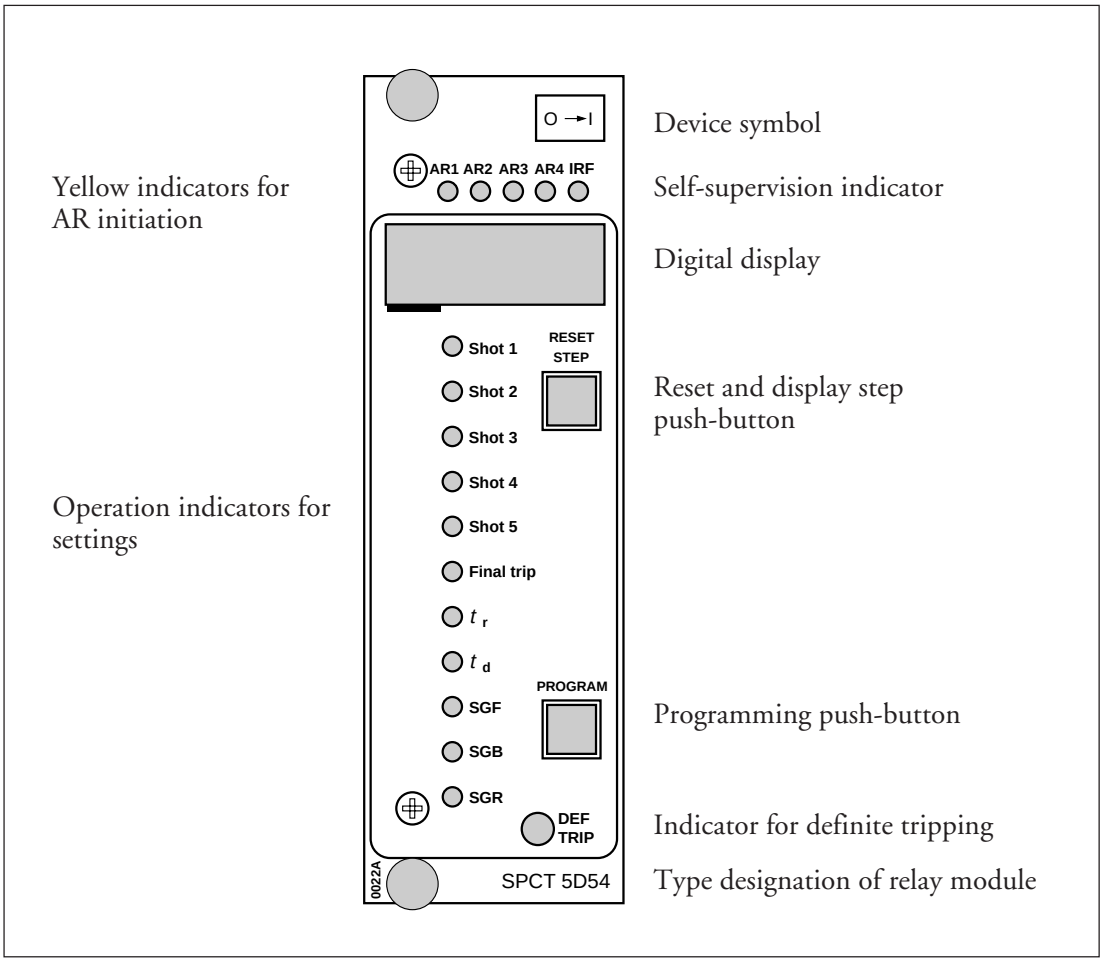


Fig.5. Front panel of auto-reclose module SPCT 5D54

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.

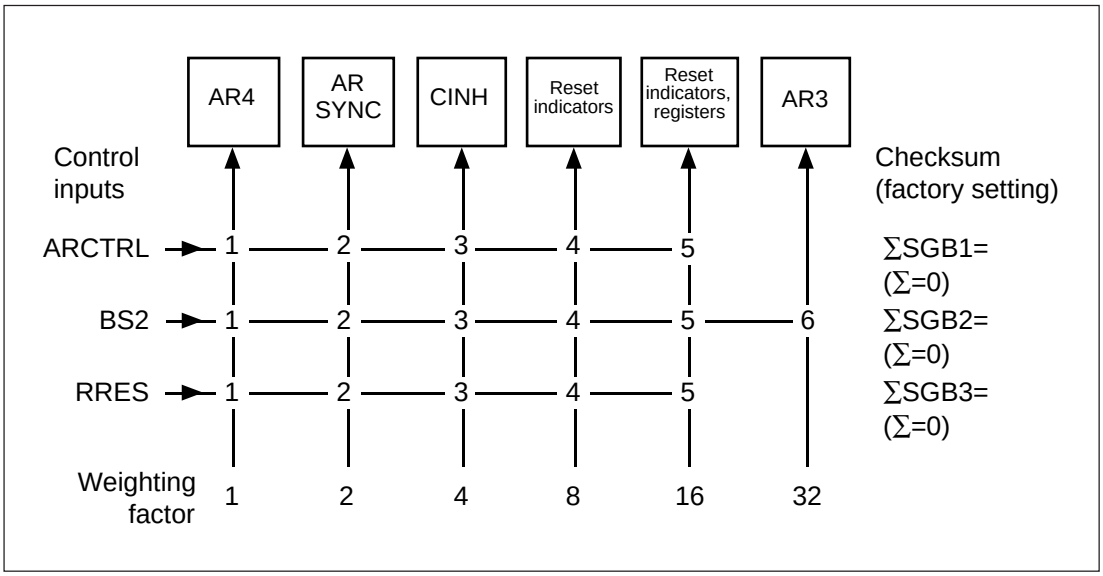


Fig. 6. Control signal matrix for auto-reclose module SPCT 5D54

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.

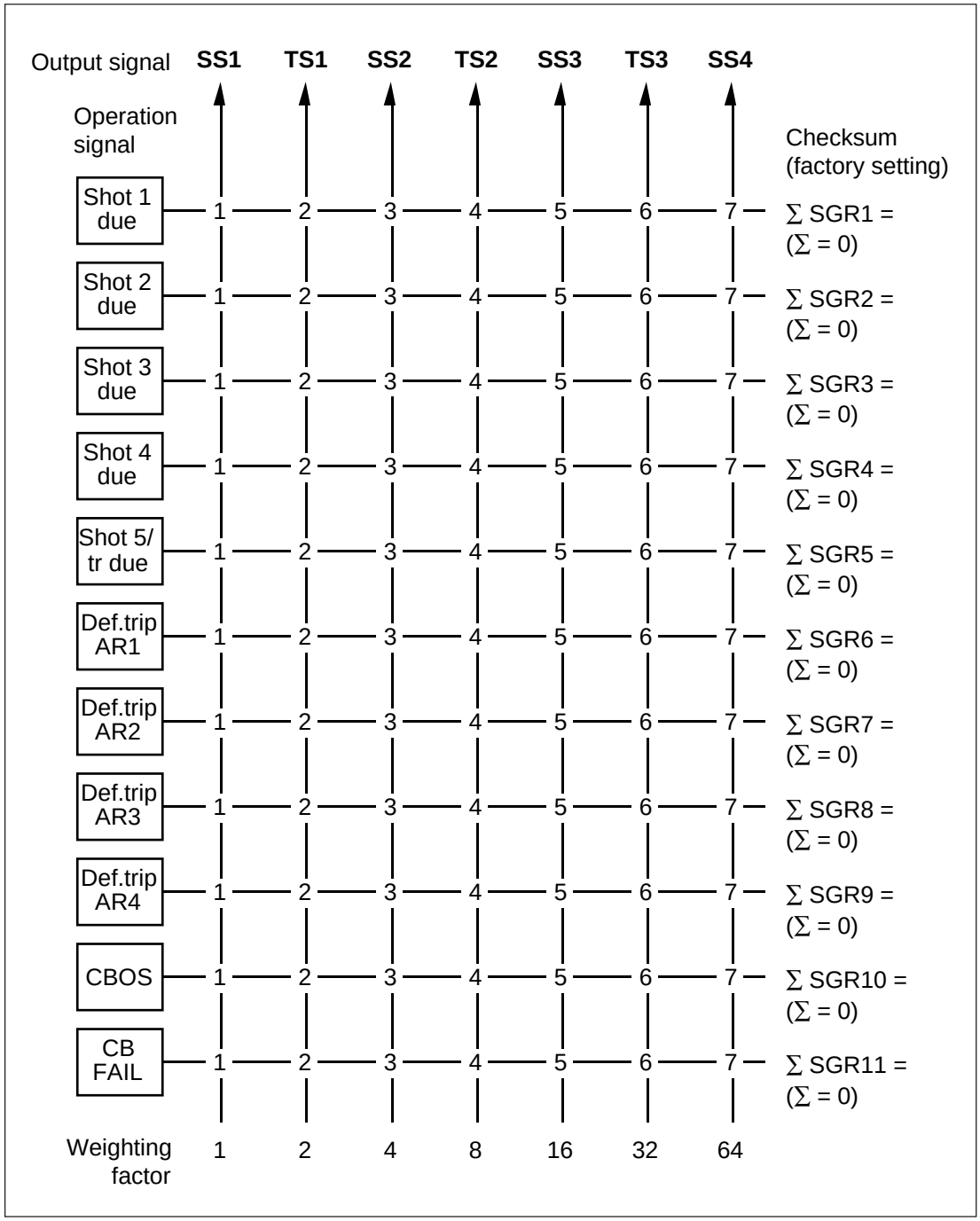


Fig. 7. Output relay matrix for the auto-reclose relay module SPCT 5D54

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

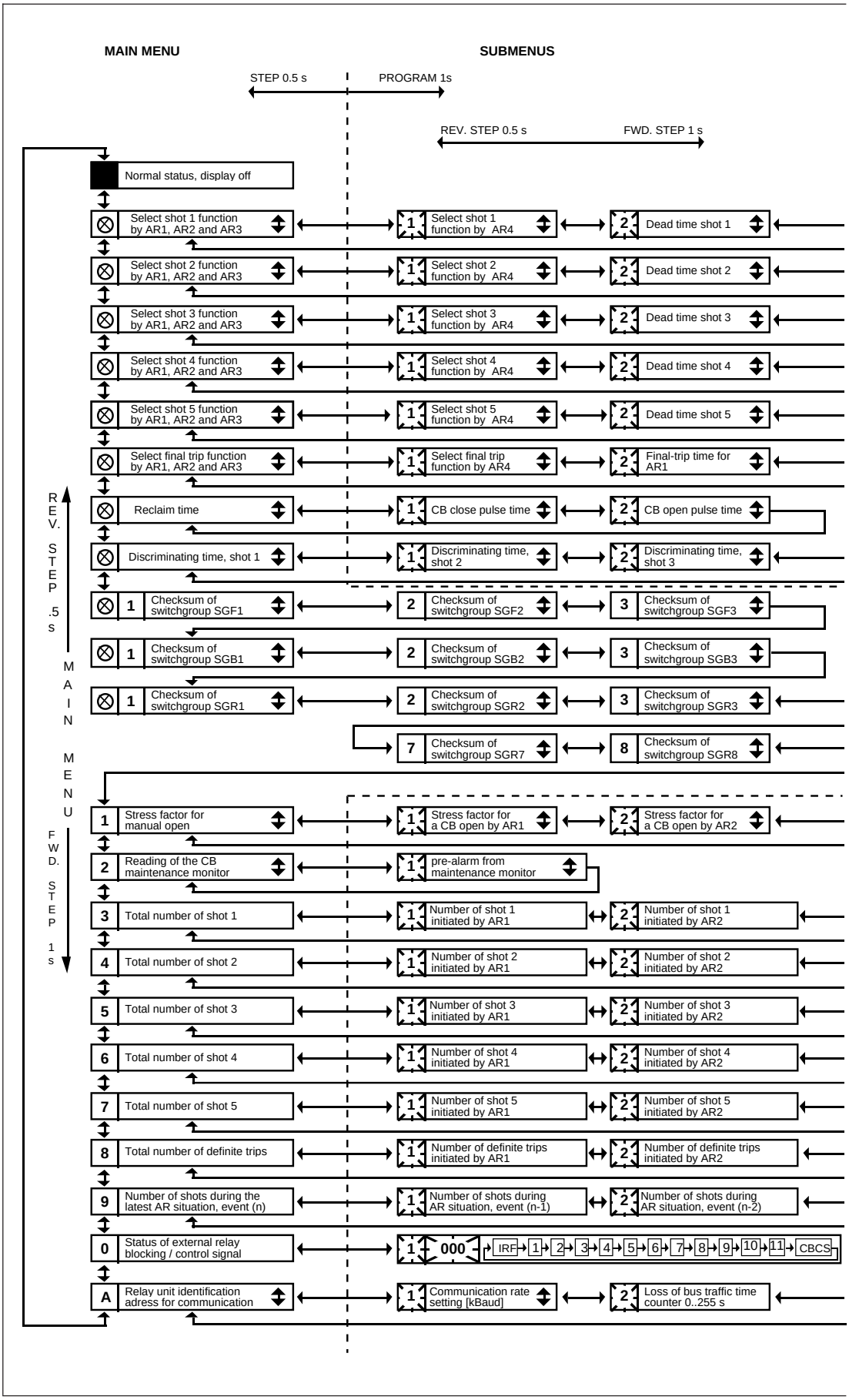
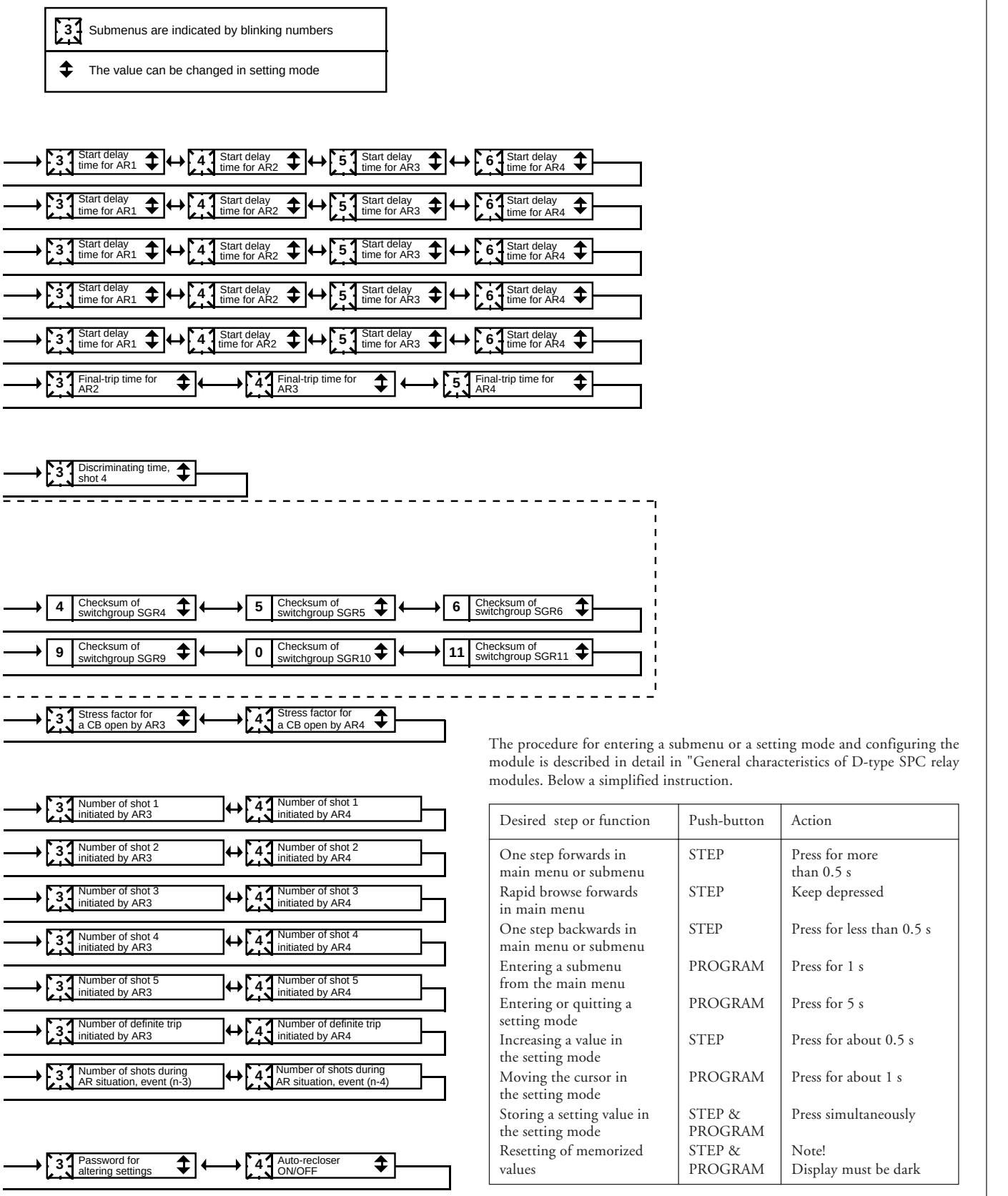


Fig. 8. Main menu and submenu for the auto-reclose relay module SPCT 5D54



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.

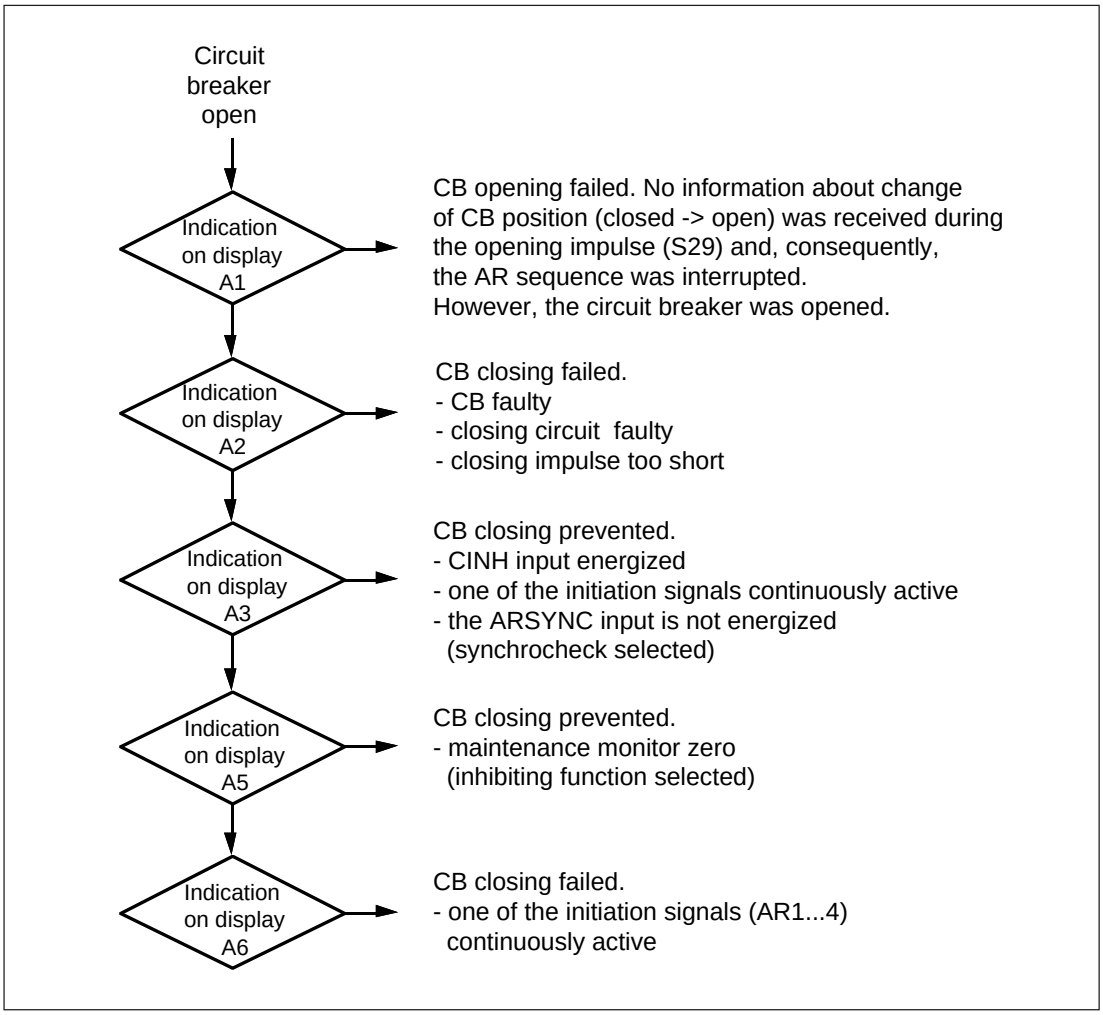


Fig. 9. Possible error indications when the circuit breaker remains open

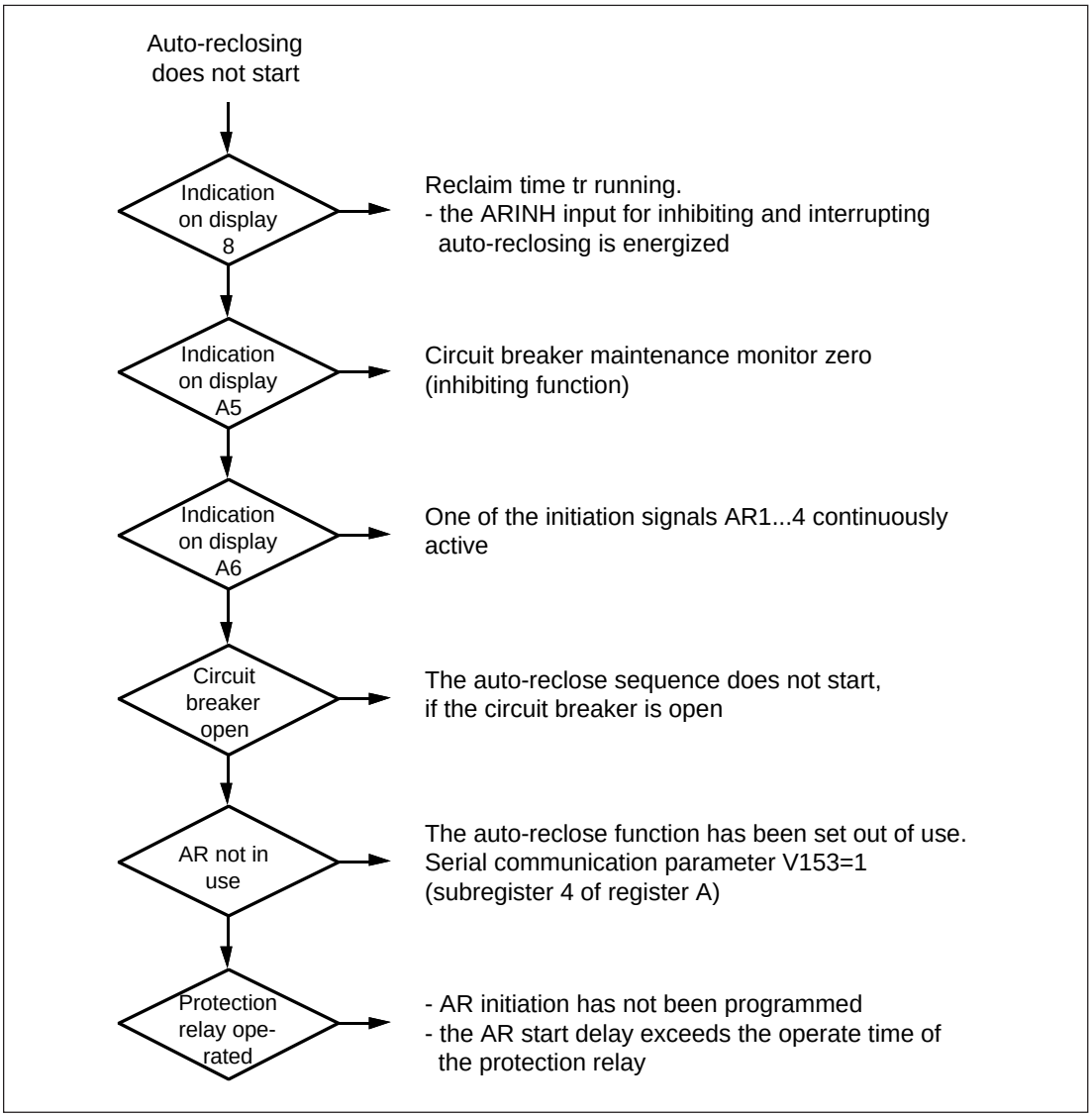


Fig. 10. Possible error indications when auto-reclosing does not start

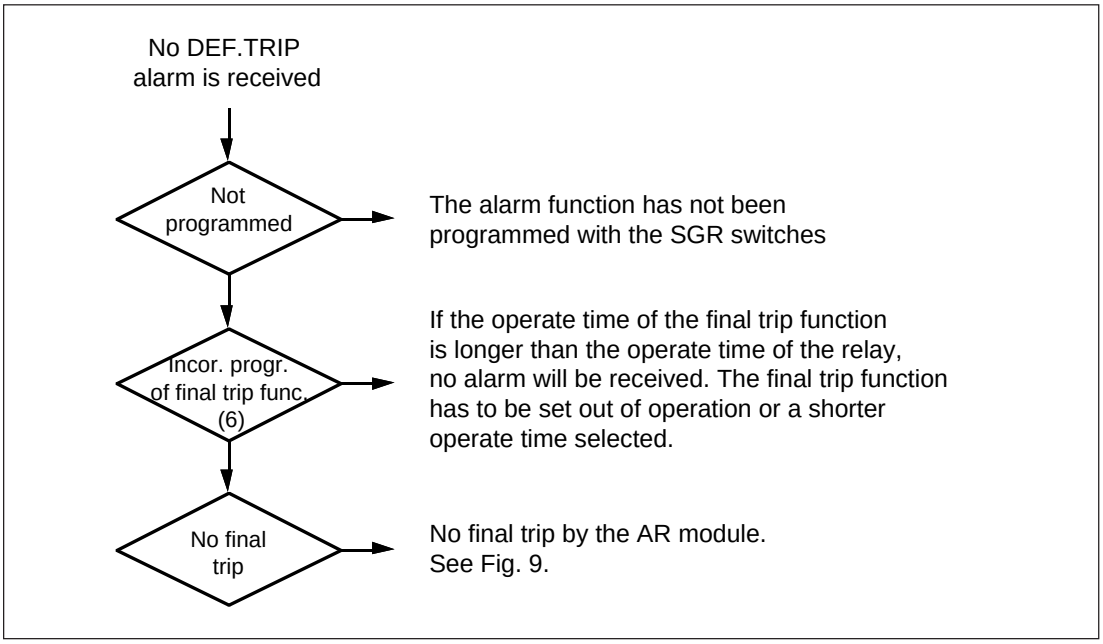


Fig. 11. Possible error indications, when no DEF.TRIP alarm is received.

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.

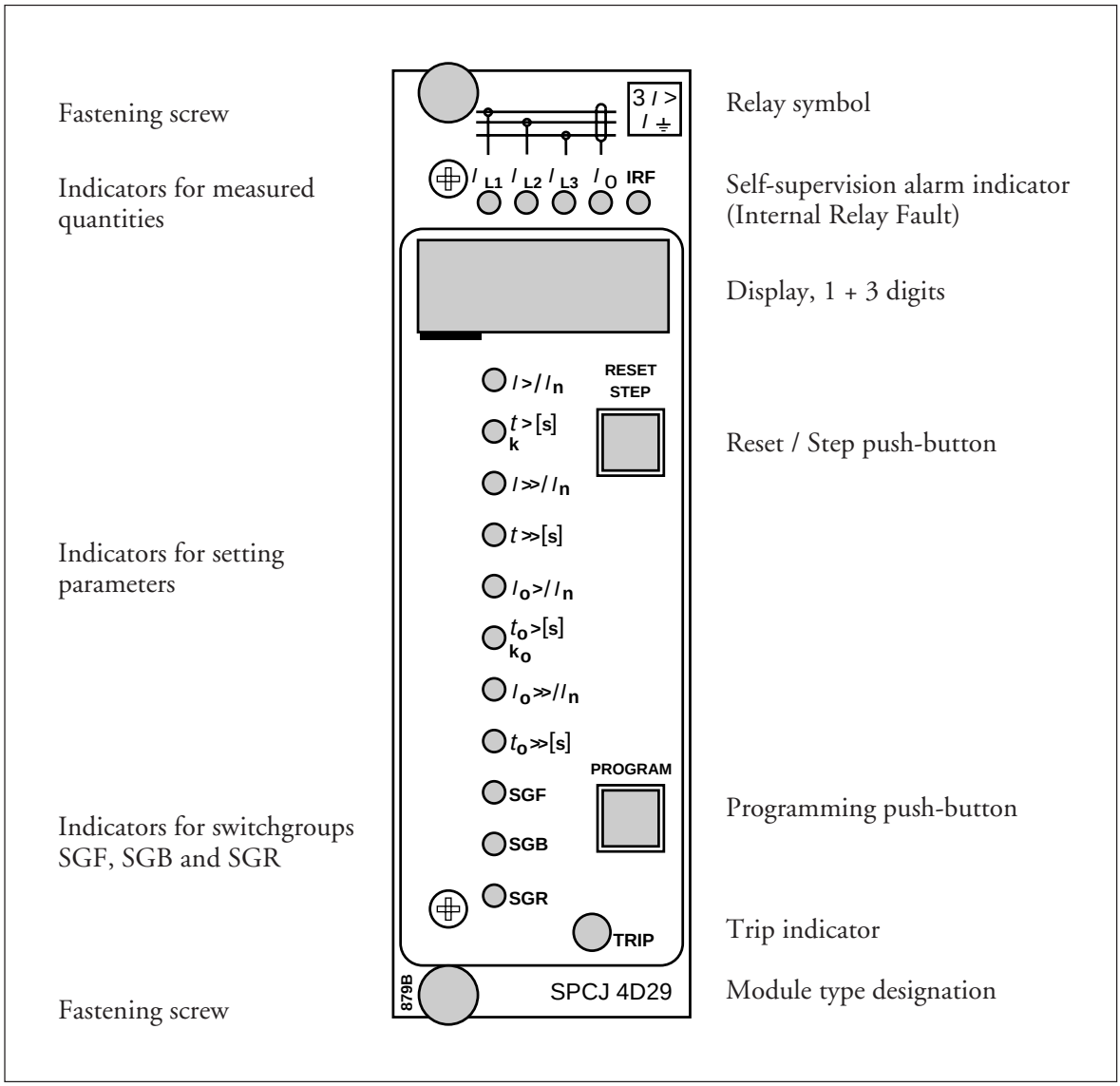
ARSYNC
If the synchronism check function has been selected, a close operation will not be made unless the ARSYNC signal (synchrocheck function) is active.

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

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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.*

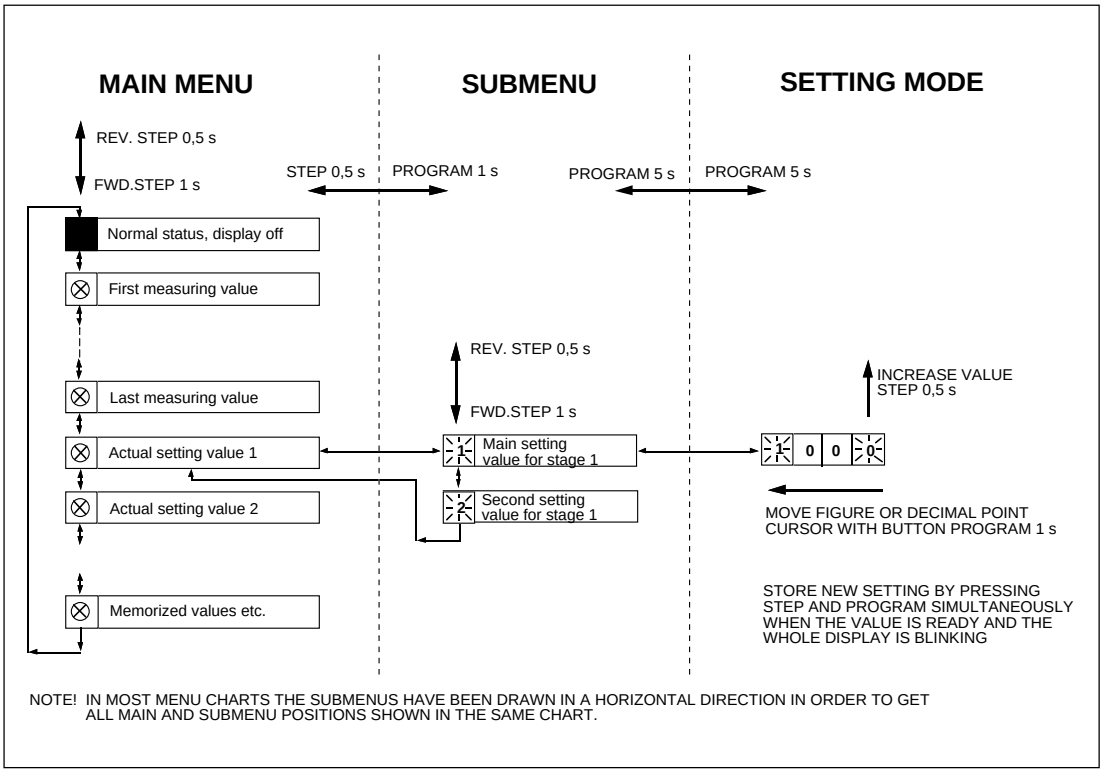


Fig.3. Basic principles of entering the main menus and submenus of a relay module.

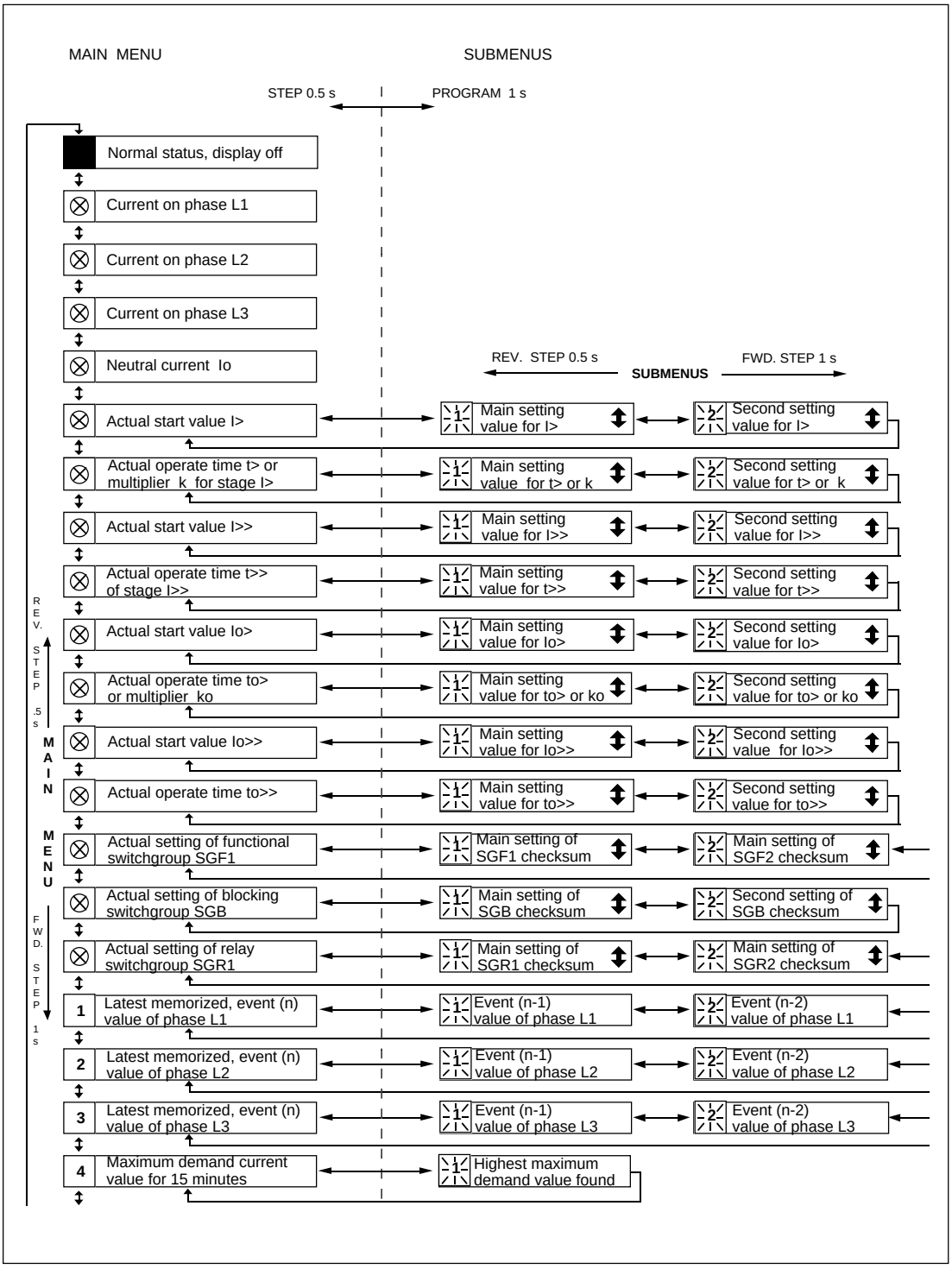
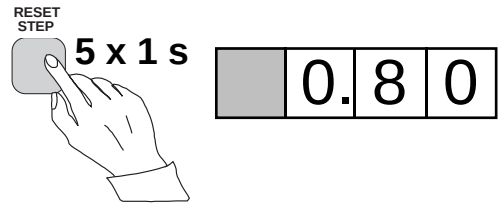


Fig. 4. Example of part of the main and submenus for the settings of the overcurrent and earth-fault relay module SPCJ 4D29. The settings currently in use are in the main manu and they are displayed by pressing the STEP push button. The main menu also includes the measured current values, the registers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

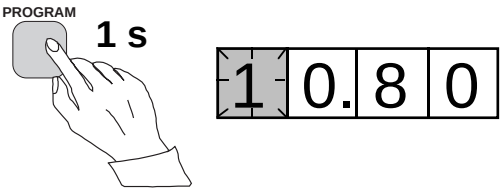
Example 1

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.

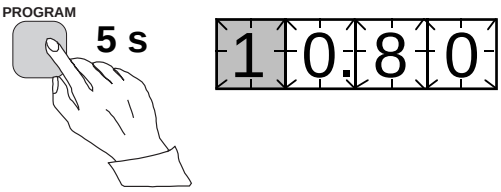
a)
Press push button STEP repeatedly until the LED close to the I> symbol is lit and the current start value appears on the display.



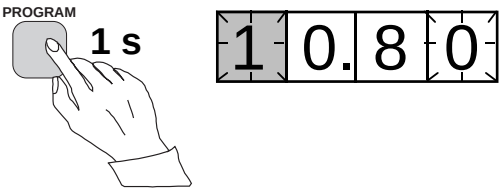
b)
Enter the submenu to get the main setting value by pressing the PROGRAM push button more than one second and then releasing it. The red display digit now shows a flashing number 1, indicating the first submenu position and the green digits show the set value.



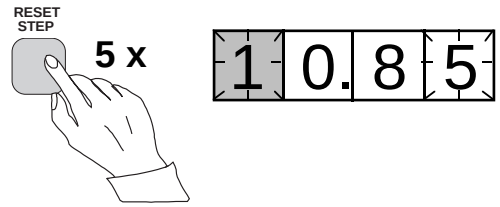
c)
Enter the setting mode by pressing the PROGRAM push button for five seconds until the display starts flashing.



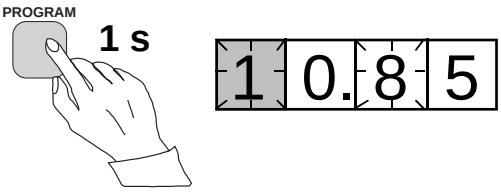
d)
Press the PROGRAM push button once again for one second to get the rightmost digit flashing.



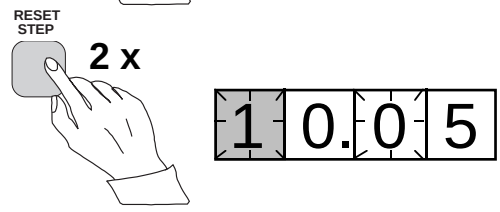
e)
Now the flashing digit can be altered. Use the STEP push button to set the digit to the desired value.



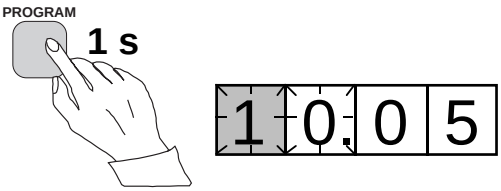
f)
Press the PROGRAM push button to make the middle one of the green digits flash.



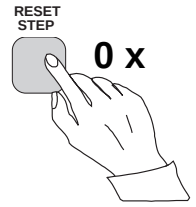
g)
Set the middle digit with of the STEP push button.

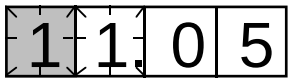


h)
Press the PROGRAM push button to make the leftmost green digit flash.

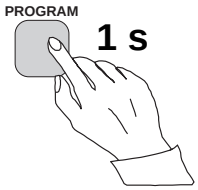


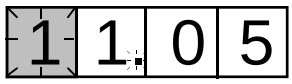
i)
Set the digit with the STEP push button.



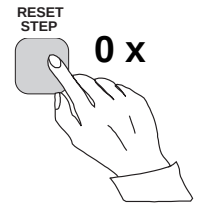


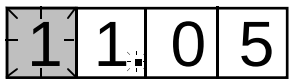
j)
Press the PROGRAM push button to make the decimal point flash.



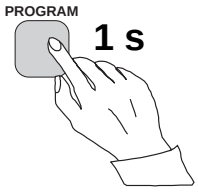


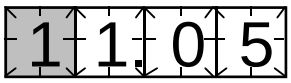
k)
If needed, move the decimal point with the STEP push button.



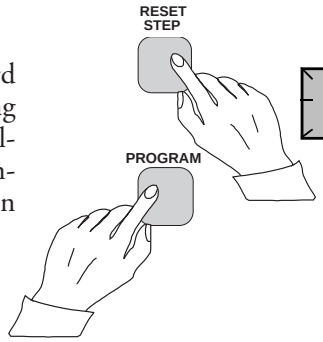


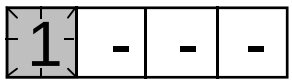
l)
Press the PROGRAM push button to make the whole display flash. In this position, corresponding to position c) above, one can see the new value before it is recorded. If the value needs changing, use the PROGRAM push button to alter the value.



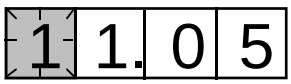


m)
When the new value has been corrected, record it in the memory of the relay module by pressing the PROGRAM and STEP push buttons simultaneously. At the moment the information enters the memory, the green dashes flash once in the display, i.e. 1 - - -.

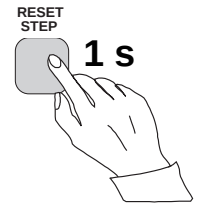


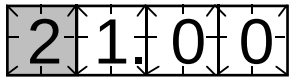


n)
Recording of the new value automatically initiates a return from the setting mode to the normal submenu. Without recording one can leave the setting mode any time by pressing the PROGRAM push button for about five seconds, until the green display digits stop flashing.



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>.



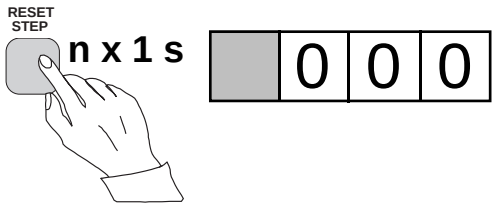


Enter the setting mode as in step c) and proceed in the same way. After recording of the requested values return to the main menu is obtained by pressing the STEP push button until the first digit is switched off. The LED still shows that one is in the I> position and the display shows the new setting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

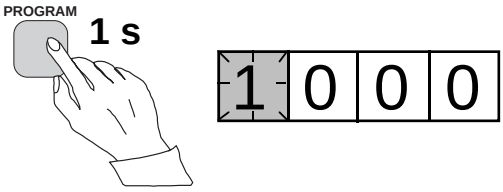
Example 2

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.

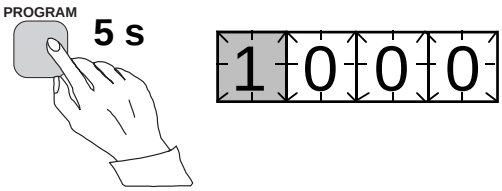
a)
Press push button STEP until the LED close to the SGF symbol is lit and the checksum appears on the display.



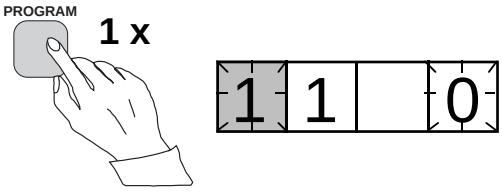
b)
Enter the submenu to get the main checksum of SGF1 by pressing the PROGRAM push button for more than one second and then releasing it. The red display now shows a flashing number 1 indicating the first submenu position and the green digits show the checksum.



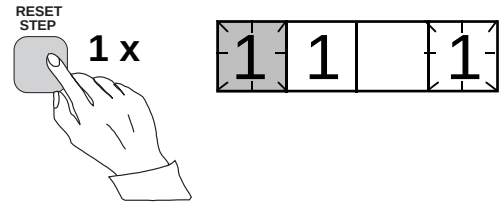
c)
Enter the setting mode by pressing the PROGRAM push button for five seconds until the display starts flashing.



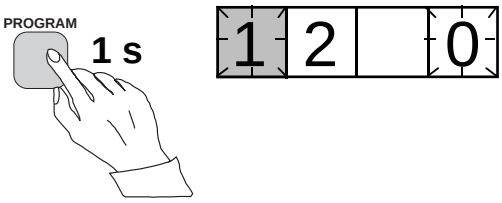
d)
Press the PROGRAM push button once again to get the first switch position. The first digit of the display now shows the switch number. The position of the switch is shown by the rightmost digit.



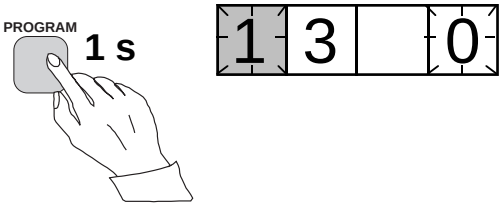
e)
The switch position can now be toggled between 1 and 0 by means of the STEP push button and it is left in the requested position 1.



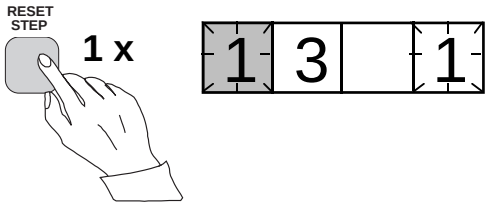
f)
When switch number 1 is in the requested position, switch number 2 is called up by pressing the PROGRAM push button for one second. As in step e), the switch position can be altered by using the STEP push button. As the desired setting for SGF1/2 is 0 the switch is left in the 0 position.



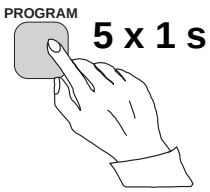
g)
Switch SGF1/3 is called up as in step f) by pressing the PROGRAM push button for about one second.



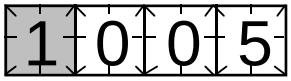
h)
The switch position is altered to the desired position 1 by pressing the STEP push button once.



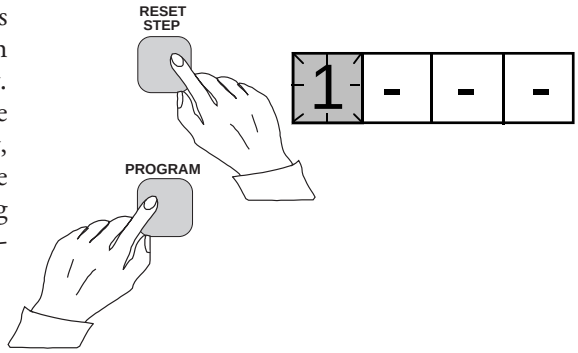
i)
Using the same procedure the switches SGF 1/ 4...8 are called up and, according to the example, left in position 0.



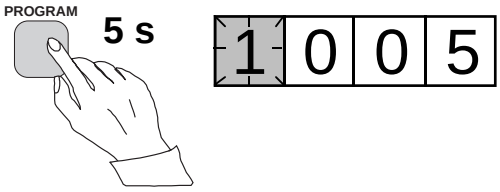
j)
In the final setting mode position, corresponding to step c), the checksum based on the set switch positions is shown.



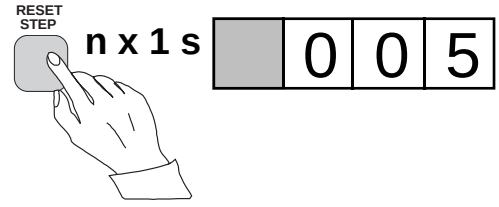
k)
If the correct checksum has been obtained, it is recorded in the memory by pressing the push buttons PROGRAM and STEP simultaneously. At the moment the information enters the memory, the green dashes flash in the display, i.e.1 - - -. If the checksum is incorrect, the setting of the separate switches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

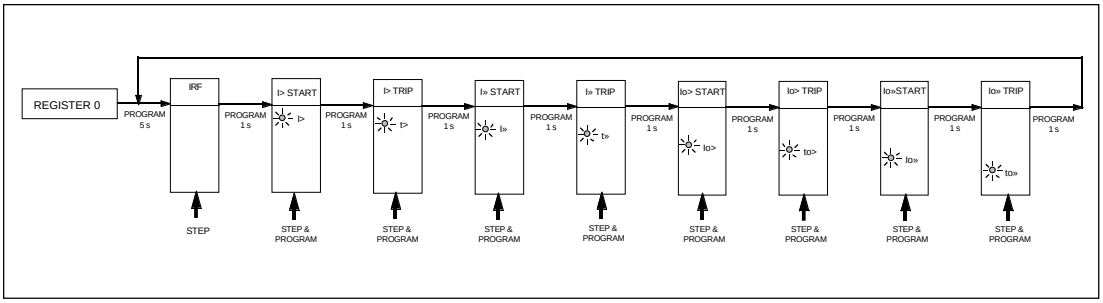


Fig. 5. Sequence order for the selection of output signals in the Trip test mode

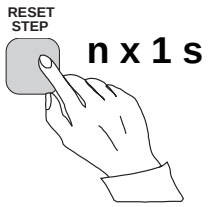
If, for instance, the indicator of the setting t> is flashing, and the push buttons STEP and PROGRAM are being pressed, the trip signal from the low-set overcurrent stage is activated. Return to the main menu is possible at any stage of the trip test sequence scheme, by pressing the PROGRAM push button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

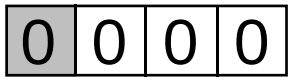
Note!
The effect on the output relays then depends on the configuration of the output relay matrix switchgroups SGR 1...3.

Example 3

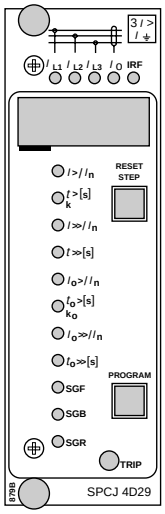
Trip test function. Forced activation of the outputs.

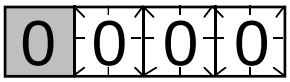
a)
Step forward on the display to register 0.





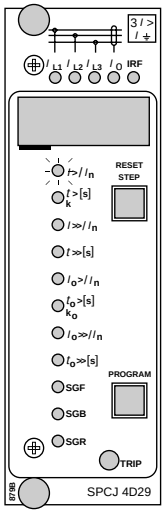
b)
Press the PROGRAM push button for about five seconds until the three green digits to the right.

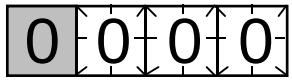




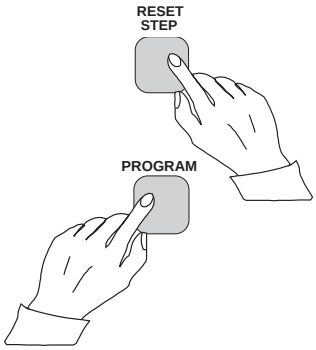
c)
Hold down the STEP push button. After one second the red IRF indicator is lit and the IRF output is activated. When the step push button is released the IRF indicator is switched off and the IRF output resets.

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

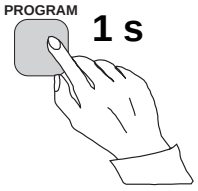


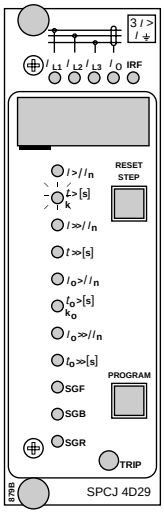


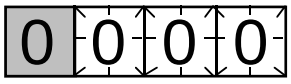
e)
If a start of the first stage is required, now press the push-buttons PROGRAM and STEP simultaneously. The stage output will be activated and the output relays will operate according to the actual programming of the relay output switchgroups SGR.



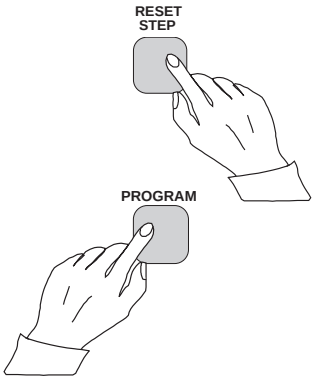
f)
To proceed to the next position press the PROGRAM push button for about 1 second until the indicator of the second setting starts flashing.

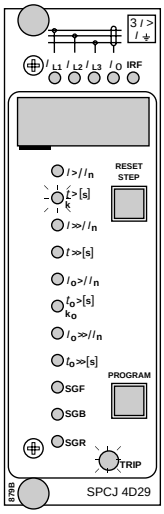


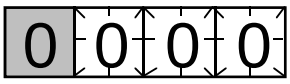




g)
Press the push buttons PROGRAM and STEP simultaneously to activate tripping of stage 1 (e.g. the I> stage of the overcurrent module SPCJ 4D29). The output relays will operate according to the actual programming of the relay switchgroups SGR. If the main trip relay is operated the trip indicator of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