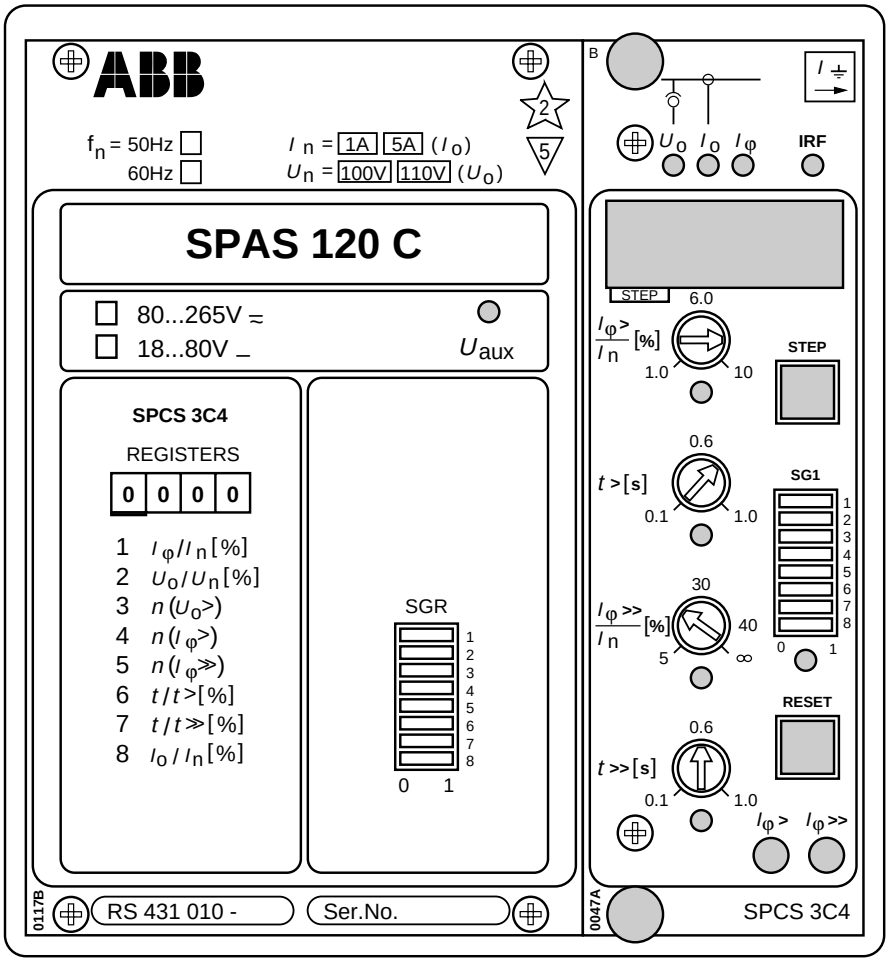
SPAS 120 C
Directional earth-fault relay

User´s manual and Technical description



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SPAS 120 C
Directional earth-fault relay

Data subject to change without notice

Contents

The complete manual for the directional earth-fault relay SPAS 120 C includes the following submanuals:

Directional earth-fault relay module SPCS 3C4	1MRS 750350-MUM EN
General characteristics of C type relay modules	1MRS 750328-MUM EN

Features

Two-stage directional earth-fault relay for distribution networks

Directional low-set earth-fault stage with definite time characteristic

Directional high-set earth-fault stage with instantaneous operation or definite time characteristic

The operation direction of the high-set earth-fault stage can be the same as that of the low-set stage or the opposite

Output relay functions can be freely configured by the user

Flexible adaptation of the relay to different applications

Manual selection or remote control of the operation characteristic $I_0\sin\varphi$ or $I_0\cos\varphi$

Digital display of settings, measured quantities, recorded fault values, etc

Extensive two-way data communication via fibre-optic serial bus

Continuous self-supervision of hardware and software including autodiagnosis

Powerful software support for parametrization and supervision of the relay

Member of the SPACOM product family and PYRAMID®, ABB's coordinated protection and control concept

Application

The directional earth-fault relay SPAS 120 C is designed to be used for selective feeder earth-fault protection in isolated neutral and impedance earthed networks. The relay is especially useful in networks, where the operation characteristic of the earth-fault relay must be remotely controllable.

The directional earth-fault relay can also be used for the earth-fault protection of power generators and large motors.

The relay is a member of the SPACOM product family, which is part of PYRAMID®, ABB's coordinated protection and control concept.

Description of function

The directional earth-fault relay SPAS 120 C is a secondary relay which is connected to the current and voltage transformers of the protected object. The earth-fault current can be measured either via a set of three phase current transformers in a residual current connection or via a window-type core-balance current transformer.

When an earth fault occurs, the relay delivers an alarm signal, trips the circuit breaker or starts an external auto-reclose relay, depending on the application and the configuration of the relay.

When the energizing voltage exceeds the set start value $U_0>$ and the energizing current and the phase angle between voltage and current is such that $I_0\sin\varphi$ or $I_0\cos\varphi$ exceeds the set start current $I\varphi>$, the earth-fault relay starts. After the set operate time t> the relay operates. In the same way the high-set stage starts when the energizing voltage exceeds the set start value $U_0>$ and the energizing current and the phase angle between voltage and current is such that $I_0\sin\varphi$ or $I_0\cos\varphi$ exceeds the set start current $I\varphi>>$. After the set operate time t>> the relay operates.

The direction of operation of the high-set stage can be the same as that of the low-set stage or the opposite.

The start signal from the earth-fault relay is obtained as a contact function. The start signal can be used, for instance, for blocking cooperating protection relays.

The earth-fault relay holds one optically isolated binary input for incoming external control signals, e.g. for blocking protection stages or for selecting operation characteristic.

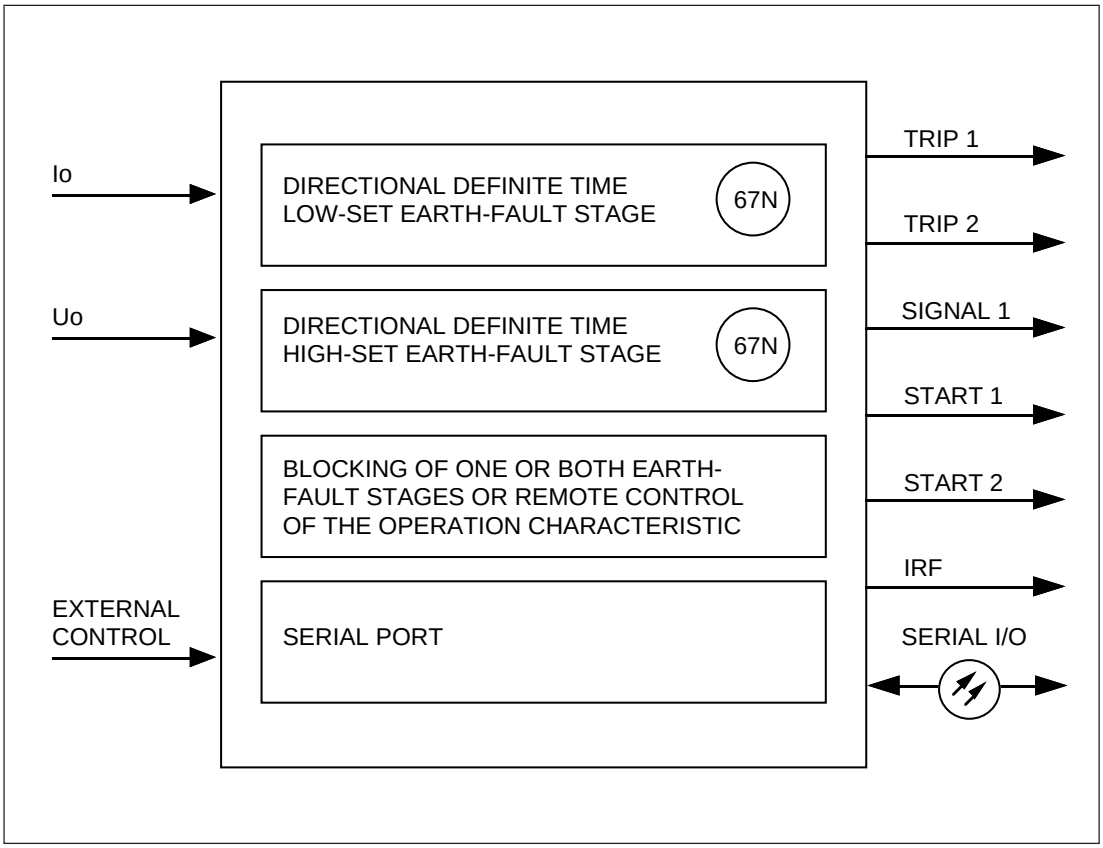


Fig. 1. Protection functions of the directional earth-fault relay SPAS 120 C. The encircled numbers refer to the ANSI (=American National Standards Institute) number of the concerned protection function.

Connections

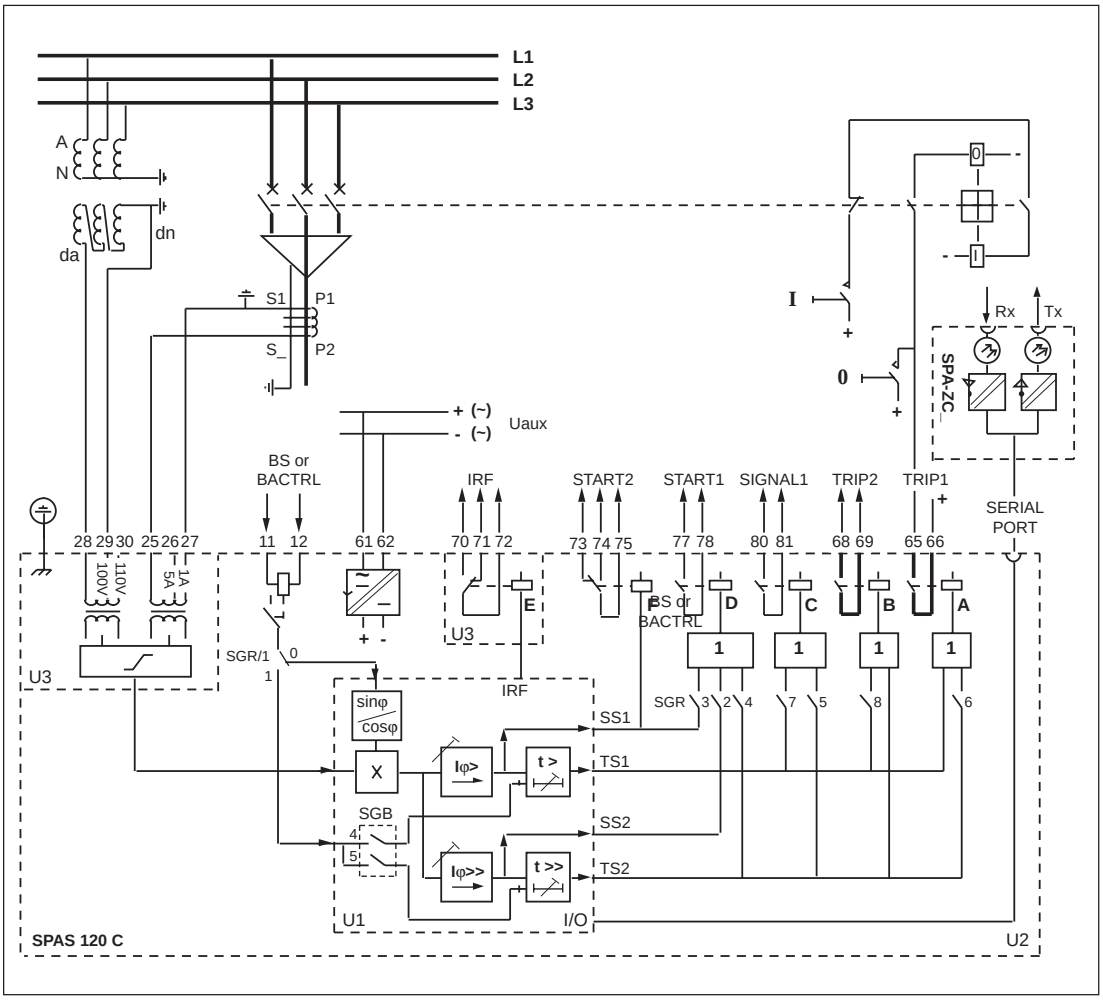


Fig. 2. Connection diagram for the directional earth-fault SPAS 120 C.

U_{aux}	Auxiliary voltage
A, B, C, D, E, F	Output relays
IRF	Self-supervision output
BS	Blocking signal for the protection stages
BACTRL	Control signal for selection of operation characteristic
SS	Start signal
TS	Trip signal
SGR	Switchgroup for configuring operate and alarm signals
SGB	Switchgroup for configuring blocking signals
TRIP_	Trip output
SIGNAL1	Signal on relay operation
START_	Start signal or signal on relay operation
U1	Directional earth-fault relay module SPCS 3C4
U2	Power supply and I/O module SPTU 240S1 or SPTU 48S1
U3	Connection module SPTE 2E13
SERIAL PORT	Serial communication port
SPA-ZC_	Bus connection module
Rx/Tx	Receiver (Rx) and transmitter (Tx) of the bus connection module

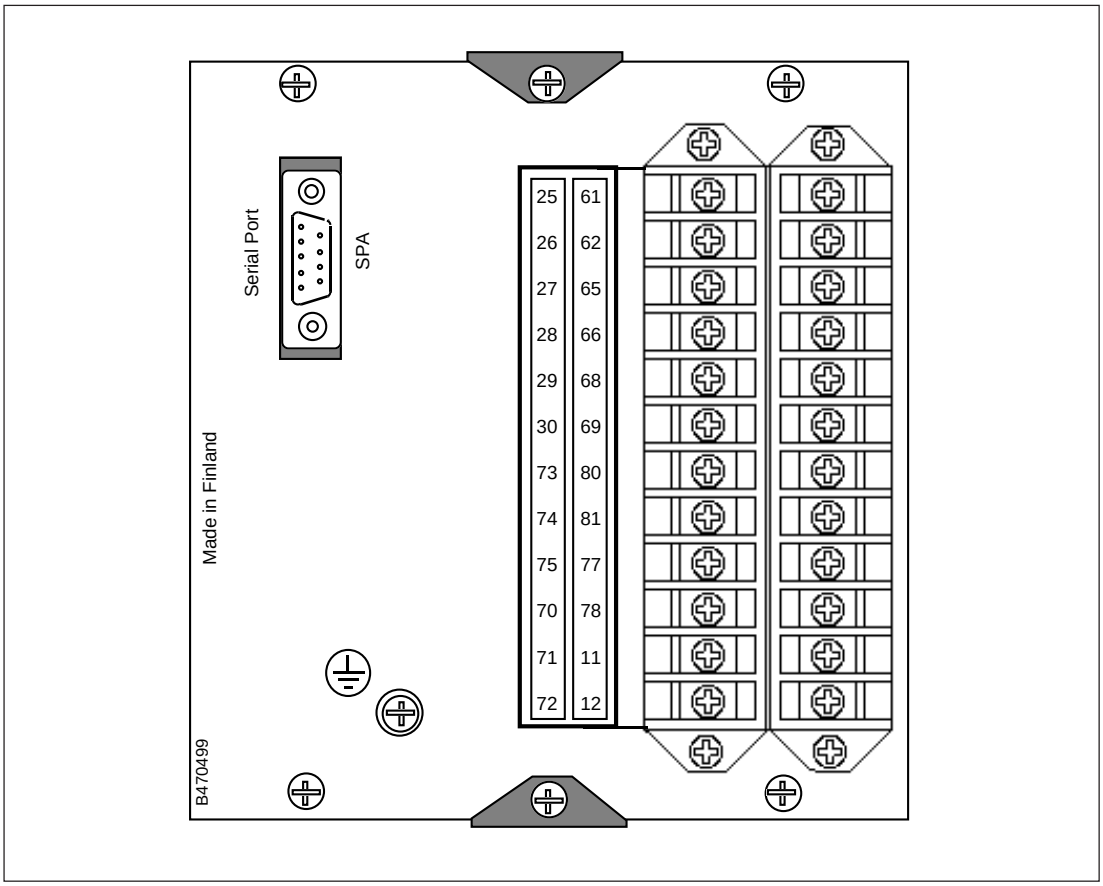


Fig. 3. Rear view of the directional earth-fault relay SPAS 120 C.

Specification of input and output terminals

Contacts	Function
25-26	Neutral current I_0 (5 A)
25-27	Neutral current I_0 (1 A)
28-29	Residual voltage U_0 (100 V)
28-30	Residual voltage U_0 (110 V)
11-12	External blocking signal (BS) or external control signal for selection of operation characteristic $I_0\sin\varphi$ or $I_0\cos\varphi$ (BACTRL).
61-62	Auxiliary power supply When DC voltage is used the positive pole is connected to terminal 61
65-66	Trip output 1 for stages Iφ> and Iφ>> (TRIP 1)
68-69	Trip output 2 for stages Iφ> and Iφ>> (TRIP 2)
80-81	Signal on operation of stages Iφ> and Iφ>> (SIGNAL 1)
77-78	Signal on operation of stage Iφ>>, start signal of stages Iφ> and Iφ>> (START 1)
73-74-75	Start signal of stage Iφ> (START 2). Under normal conditions the contact interval
73-75	is closed. When stage Iφ> starts, the contact interval 74-75 closes.
70-71-72	Self-supervision (IRF) alarm output. Under normal conditions the contact interval
70-72	is closed. When the auxiliary voltage disappears or an internal fault is detected, the contact interval 71-72 closes.
⏚	Protective earth terminal

The directional earth-fault relay SPAS 120 C is connected to the fibre-optic communication bus via a bus connection module, type SPA-ZC 17 or SPA-ZC 21.

The bus connection module is fitted to the D-type connector marked SERIAL PORT on the rear panel of the relay. The opto-connectors of the optical fibres are plugged into the counter connectors Rx and Tx of the bus connection module.

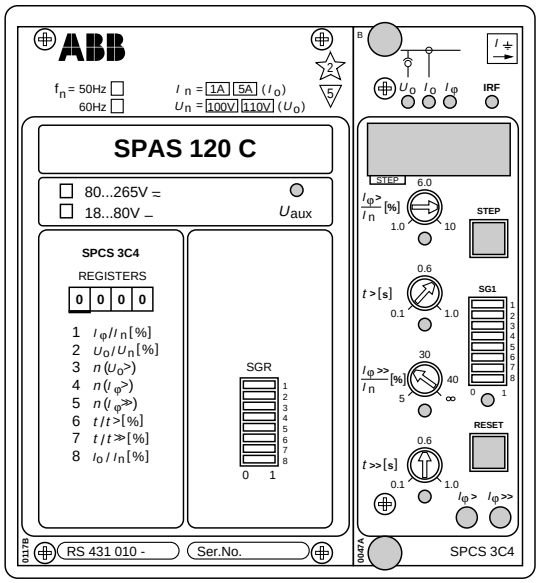
Configuration of output relays

The start signal of the Iφ> stage is firmly wired to output relay F and the trip signal to output relay A. The trip signal of the Iφ>> stage is firmly wired to output relay B. In addition, the start and operate signals can be routed in the following way with the switches of the SGR switchgroup on the front panel of the relay:

Switch	Function	Factory default	User's settings
SGR/1	Routes the external blocking signal (SGR/1 = 1) or the control signal for selecting the $I_0 \sin\varphi$ or $I_0 \cos\varphi$ characteristic (SGR/1 =0)	1	
SGR/2	Routes the start signal of the Iφ>> stage to output relay D	1	
SGR/3	Routes the start signal of the Iφ> stage to output relay D	1	
SGR/4	Routes the trip signal of the Iφ>> stage to output relay D	1	
SGR/5	Routes the trip signal of the Iφ>> stage to output relay C	1	
SGR/6	Routes the trip signal of the Iφ>> stage to output relay A	1	
SGR/7	Routes the trip signal of the Iφ> stage to output relay C	1	
SGR/8	Routes the trip signal of the Iφ> stage to output relay B	1	

Output relays A and B are capable of controlling the circuit breakers directly. Thus two circuit breakers can be controlled at the same time or separate trip output relays can be obtained from the high-set stage and the low-set stage of the earth-fault relay.

Start and operation indicators



1. Either earth-fault protection stage has its own operation indicator (Iφ> and Iφ>>), located in the right bottom corner of the front plate of the relay module. Yellow light indicates that the concerned stage has started and red light that the stage has operated (tripped).

   With the SG2 software switchgroup the start and trip indicators can be given a latching function, which means that the LEDs remain lit, although the signal that caused operation returns to normal. The indicators are reset with the RESET push-button. An unreset indicator does not affect the operation of the relay.

2. The yellow LED indicators (U_0, I_0 and Iφ) on the upper black part of the front plate indicate, when lit, that the value of the concerned voltage or current is being displayed.

3. The red IRF indicator of the self-supervision system indicates, when lit, that a permanent internal relay fault has been detected. The fault code which appears on the display once a fault has been detected should be recorded and notified when overhaul is ordered.

4. The green U_{aux} LED on the front panel is lit when the power supply module operates properly.

5. The LED indicators below the different setting knobs indicate, when lit, that the concerned setting value is being displayed.

6. The LED of the SG1 switchgroup indicates, when lit, that the checksum of the switchgroup is being displayed.

The start and operation indicators, the function of the SG2 software switchgroup and the functions of the LED indicators during setting are described in the user's manual for the directional earth-fault relay module SPCS 3C4.

Power supply and I/O module

The combined power supply and I/O module (U2) is located behind the system front panel of the protection relay and can be withdrawn after removal of the system front panel. The power supply and I/O module incorporates a power unit, five output relays, the control circuits of the output relays and the electronic circuitry of the external control input.

The power unit is transformer connected, that is, the primary side and the secondary circuits are galvanically isolated. The primary side is protected by a slow 1 A fuse F1, located on the PC board of the module. When the power source operates properly, the green U_{aux} LED on the front panel is lit.

The power supply and I/O module is available in two versions with different input voltage ranges:

- type SPTU 240 S1 U_{aux} = 80...265 V ac/dc
- type SPTU 48 S1 U_{aux} = 18...80 V dc

The auxiliary input voltage range of the power supply and I/O module inserted in the relay on delivery from the factory is marked on the system front panel.

Technical data
(modified 2002-04)

Energizing inputs	1 A	5 A
Terminals	25-27	25-26
Rated current I_n	1 A	5A
Thermal current carrying capacity		
- continuously	4 A	20 A
- for 10 s	25 A	100 A
- for 1 s	100 A	500 A
Dynamic current carrying capacity, half-wave value	250 A	1250 A
Input impedance	<100 mΩ	<20 mΩ

Energizing inputs	100 V	110 V
Terminals	28-29	28-30
Rated voltage U_n	100 V	110 V
Continuous withstand	2 x U_n	2 x U_n
Burden at rated voltage U_n	<0,5 VA	
Rated frequency f_n, on request	50 Hz or 60 Hz	

Output contacts

Trip contacts	
Terminals	65-66, 68-69
Rated voltage	250 V ac/dc
Carry continuously	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 manoeuvre circuit time constant L/R ≤ 40 ms, at the control voltages	
- 220 V dc	1 A
- 110 V dc	3 A
- 48 V dc	5 A
Signalling contacts	
Terminals	70-71-72, 73-74-75, 77-78, 80-81
Rated voltage	250 V ac/dc
Carry continuously	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 signalling circuit time constant L/R ≤ 40 ms, at the control voltages	
- 220 V dc	0.15 A
- 110 V dc	0.25 A
- 48 V dc	1 A

External control input

Blocking input or control input for operation characteristic	
Terminals	11-12
Control voltage range	18...265 V dc or 80...265 V ac
Current consumption at activated input	2...20 mA

Auxiliary supply voltage

Power supply and I/O modules and voltage ranges:	
- module type SPTU 240 S1	80...265 V ac/dc
- module type SPTU 48 S1	18...80 V dc
Power consumption under quiescent/operation conditions	~4 W/~6 W

Directional earth-fault relay module SPCS 3C4

Earth-fault protection stage Iφ>	
Start current Iφ>	1.0…10.0% x I_n
Operation characteristic	I_0 sinφ or I_0 cosφ
Operate time t>	0.1…10.0 s
Earth-fault protection stage Iφ>>	
Start current Iφ>>	1.0…40.0% x I_n and ∞
Operation characteristic	±I_0 sinφ or ±I_0 cosφ
Operate time t>>	0.1…1.0 s
Residual voltage U_0	
Start voltage U_0>, fixed values	2%, 5%, 10% or 20% x U_n

Data communication

Transmission mode	Fibre-optic serial bus
Data code	ASCII
Selectable data transfer rates	300, 1200, 2400, 4800 or 9600 Bd
Fibre-optic bus connection module, powered from the host relay	
- for plastic fibre cables	SPA-ZC 21 BB
- for glass fibre cables	SPA-ZC 21 MM
Fibre-optic bus connection module with a built-in power supply unit	
- for plastic fibre cables	SPA-ZC 17 BB
- for glass fibre cables	SPA-ZC 17 MM

Insulation Tests *)

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

Electromagnetic Compatibility Tests *)

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

Environmental conditions

Specified ambient service temperature range	-10...+55°C
Long term damp heat withstand acc. to IEC 60068-2-3	<95%, +40°C, 56 d/a
Relative humidity acc. to IEC 60068-2-30	93...95%, +55°C, 6 cycles
Transport and storage temperature range	-40...+70°C
Degree of protection by enclosure for panel mounted relay	IP 54
Weight of relay including flush mounting case	3.0 kg

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

Examples of application

Example 1.
Feeder earth-fault protection

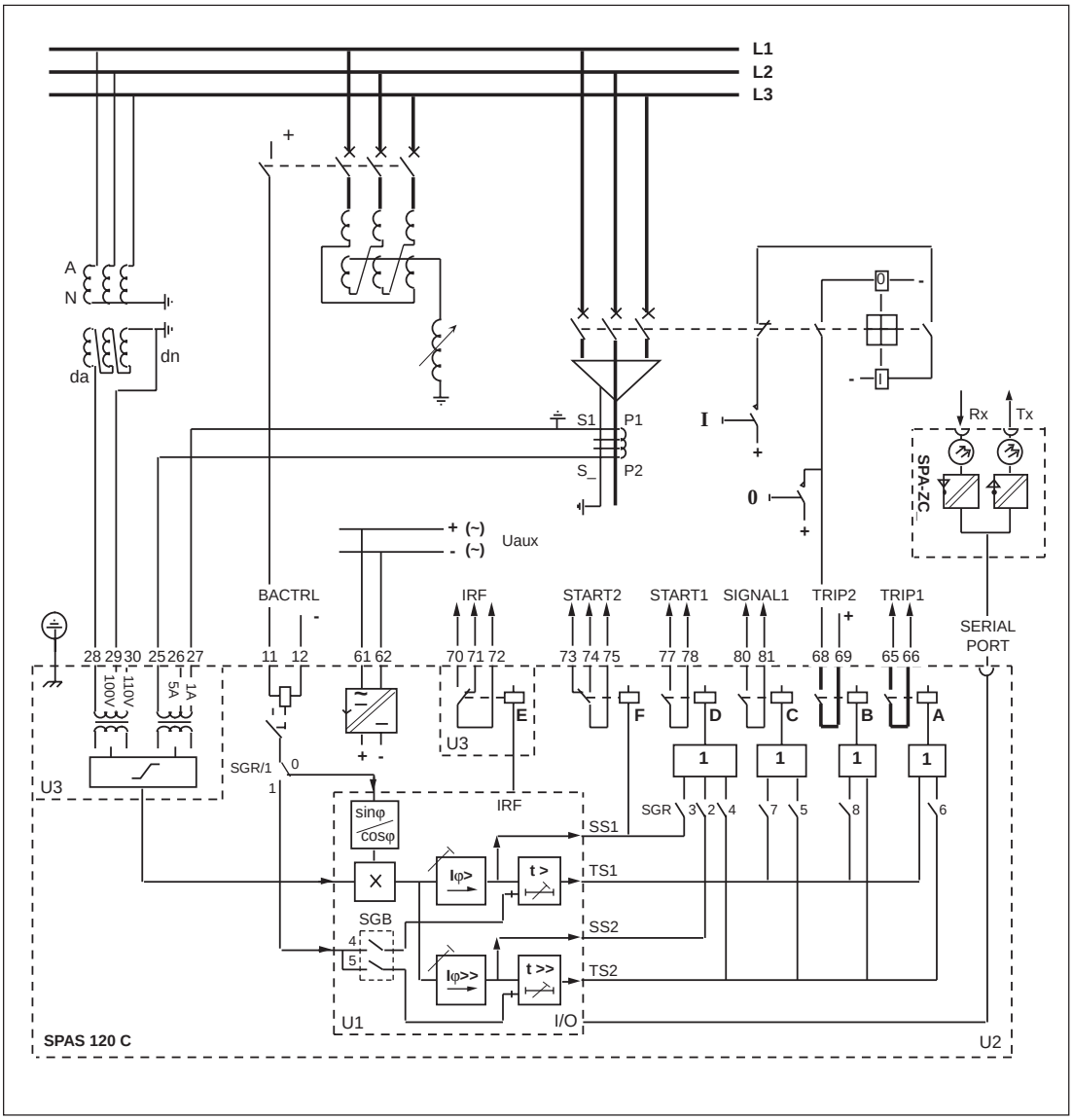


Fig. 4. Feeder earth-fault protection with directional earth-fault relay SPAS 120 C. The selector switch positions are shown in the table on the following page.

If selectivity cannot be obtained with non-directional earth-fault relays, directional relays have to be used. Then changes in the total extent of the network at any given time do not effect selectivity. In isolated neutral networks the direction of the fault current on the faulty feeder is opposite to that of the healthy feeders. In resonant earthed networks the selective earth-fault protection can be based on directional earth-fault relays measuring the resistive component of the residual voltage.

Directional earth-fault relays are recommended to be used in networks where sensitive earth-fault protection is required and, at the same time, the network configuration and the total length of the network often varies. In distribution networks directional earth-fault relays can detect earth-faults with a fault resistance of up to several thousand ohms.

In resitively or resonant earthed networks the $I_0\cos\varphi$ characteristic is selected and in isolated neutral networks the $I_0\sin\varphi$ characteristic. The operation characteristic of the earth-fault relay can be manually selected or automatically controlled from outside. When the operation characteristic is controlled from outside the relay the control signal is obtained from an auxiliary contact of the switching device of the arc suppression coil. Thus, at any time, the relay is automatically matched to the network earthing principle in use. When a control voltage is applied to the BACTRL control input the operation characteristic is $I_0\cos\varphi$ and when the control input is non-energized the operation characteristic is $I_0\sin\varphi$.

The low-set stage Iφ> of the earth-fault protection relay is set low enough to fulfil the sensitivity requirements of the national safety regulations. The operate time requirements of the national safety regulations are primarily fulfilled with the operate time setting of the high-set stage Iφ>>.

The best way to check the direction of operation of the relay is to test the relay. The primary test is preferrably carried out during commissioning.

In the following example the earth-fault protection is implemented as a two-stage protection. The low-set stage is signalling only whereas the high-set stage is used for both tripping and signalling.

The selector switches of the directional earth-fault relay SPAS 120 C can be given the following settings:

Switch	SG1/SPCS 3C4	SGB/SPCS 3C4	SGR
1	0 Iφ>> forward direction	0 not in use	0 external control of the characteristic (BACTRL)
2	1 external control of the Icosφ/Isinφ charact.	0 not in use	1 starting of stage Iφ>> to output relay D
3	1 external control of the Icosφ/Isinφ charact.	0 not in use	0 no starting of stage Iφ> to output relay D
4	0 no latching	0 no blocking of t>	0 no tripping of stage Iφ>> to output relay D
5	1 t> = 1…10 s	0 no blocking of t>>	1 tripping of stage Iφ>> to output relay C
6	0 Iφ>> = 5...40% x I_n	0 not in use	0 no tripping of stage Iφ>> to output relay A
7	0 U_0 = 10% x U_n	0 not in use	0 no tripping of stage Iφ> to output relay C
8	1 U_0 = 10% x U_n	0 not in use	0 no tripping of stage Iφ> to output relay B
Σ	150		

When the switches are set as above, the output contacts of the earth-fault relay SPAS 120 C carry the following signals:

Contact	Function
65-66	Signal on operation, stage Iφ>
68-69	Tripping of circuit breaker, stage Iφ>>
80-81	Signal on operation, stage Iφ>>
77-78	Start signal, stage Iφ>>
73-74-75	Start signal, stage Iφ>
70-71-72	Self-supervision signal

Example 2.
Generator
stator earth-fault
protection

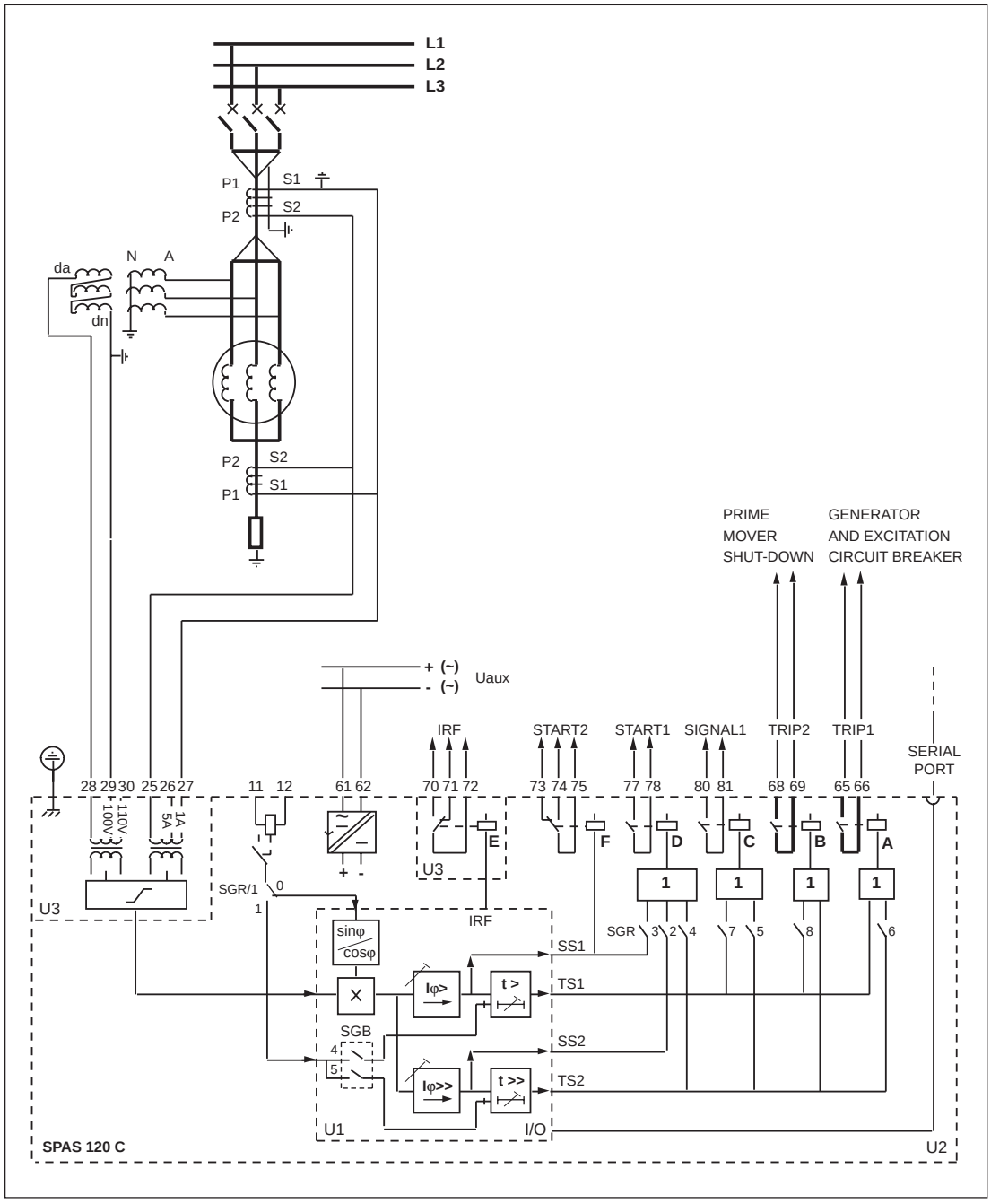


Fig. 5. Generator stator earth-fault protection with directional earth-fault relay SPAS 120 C. The selector switch positions are shown in the table on the following page.

The earth-fault protection of the stator of a generator should cover at least 90% of the winding. The closer the earth-fault spot is to the star point of the generator the smaller the earth-fault current. The earth-fault current has been increased by means of a resistor connected between the star point and earth. Selective earth-fault protection for several generators running in parallel can be arranged by providing each generator with a directional earth-fault relay. When several generators are directly connected to the busbar and running in parallel no discrimination between the faulty generators and the healthy ones can be obtained with a residual voltage relay alone.

When the generator is earthed through a resistor the earth-fault protection can be arranged with a directional earth-fault relay as in Fig. 5. The residual voltage is measured from an open delta connection of the voltage transformers. The residual current is measured on both sides of the generator using a differential current scheme. The residual current can be measured with core-balance current transformers as shown in Fig. 5. or, alternatively, by using a core-balance current transformer on the earth side of the generator and a set of three phase current transformers in parallel on the network side of the generator. The transforming ratio of the current transformers on both sides of the generator must be the same.

The differential current connection ensures selectivity. If the earth fault occurs somewhere else in the network, the differential current measured by the relay will be zero, while the direction of the fault current in either transformer is the same. When the earth fault arises in the generator stator the directions of the fault currents are opposite to each other.

In the present example a two-stage earth-fault protection has been implemented. The low-set stage of the earth-fault relay trips the generator circuit breaker and switches off the excitation. The high-set stage does the same and, moreover, initiates shut-down of the prime mover.

Switch	SG1/SPCS 3C4	SGB/SPCS 3C4	SGR
1	0 Iφ>> forward direction	0 not in use	0 no blocking signal nor BACTRL signal
2	0 Icosφ, manual selection	0 not in use	1 starting of stage Iφ>> to output relay D
3	0	0 not in use	0 no starting of stage Iφ> to output relay D
4	1 latching	0 no blocking to t>	0 no tripping of stage Iφ>> to output relay D
5	1 t> = 1…10 s	0 no blocking to t>>	1 tripping of stage Iφ>> to output relay C
6	0 Iφ>> = 5...40% x I_n	0 not in use	1 tripping of stage Iφ>> to output relay A
7	0 U_0 = 10% x U_n	0 not in use	1 tripping of stage Iφ> to output relay C
8	1	0 not in use	0 no tripping of stage Iφ> to output relay B
Σ	152		

When the switches are set as above, the output contacts of the earth-fault relay SPAS 120 C carry the following signals:

Contact	Function
65-66	Tripping of the generator and field circuit breakers, stages Iφ> and Iφ>>
68-69	Prime mover shut-down, stage Iφ>>
80-81	Signal on operation, stages Iφ> and Iφ>>
77-78	Start signal, stage Iφ>>
73-74-75	Start signal, stage Iφ>
70-71-72	Self-supervision signal

Example 3.
Double busbar system. Connection of the residual voltage to the relay. For the voltage selection auxiliary contacts of the disconnectors are used.

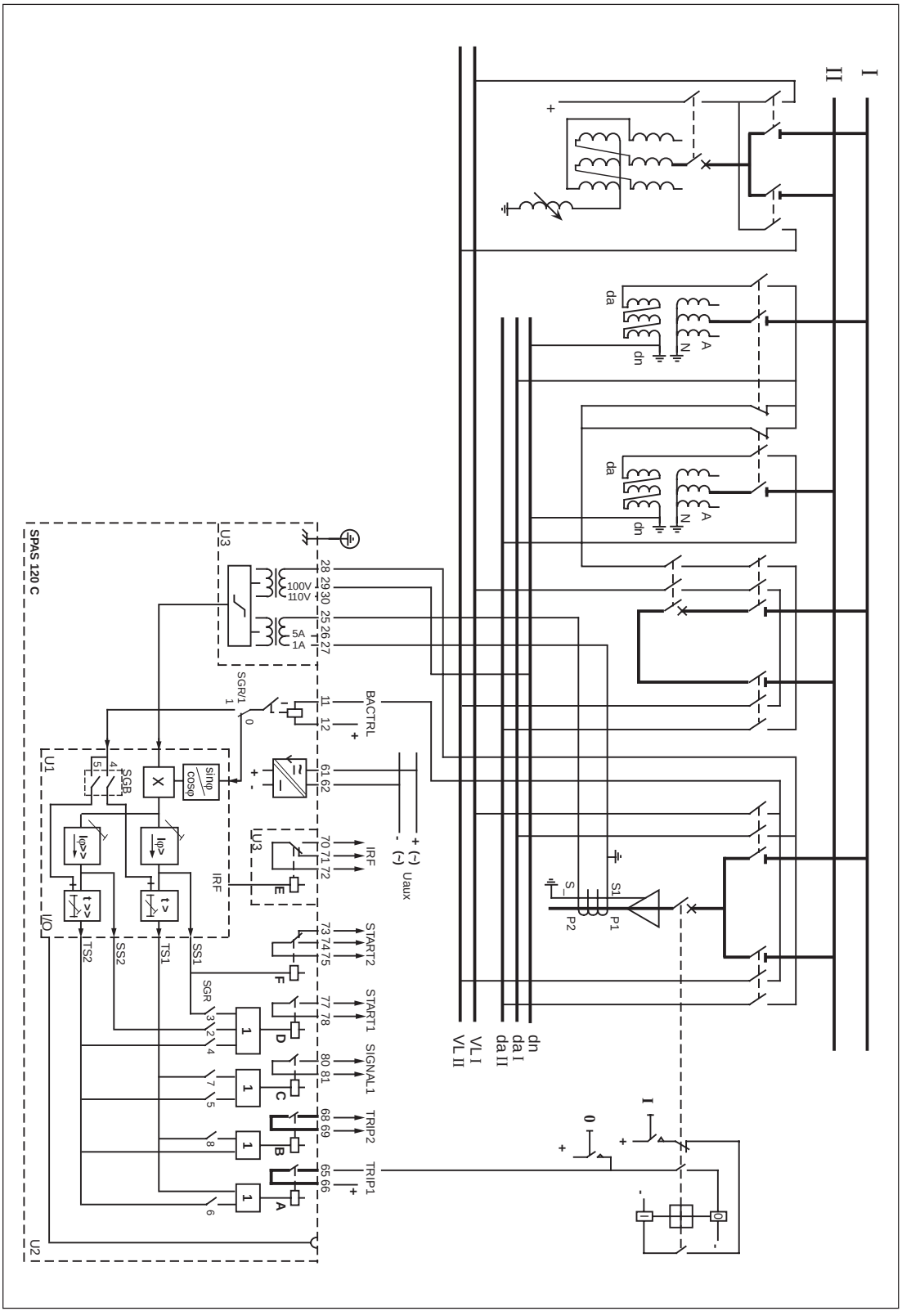


Fig. 6. Connection of the residual voltage to the directional earth-fault relays SPAS 120 C in a double busbar system.

In a double busbar system the busbars may be interconnected with a circuit breaker or they can be operated separately. The feeders are connected to the busbars by means of disconnectors. When the busbars are separated the residual voltage for the relays must be taken from the busbar to which the feeder is connected. In Fig. 6 the auxiliary contacts of the disconnectors are used for distributing residual voltage to the relays. The auxiliary contacts of the disconnectors of the measuring cubicle are used to keep the residual voltages apart. By means of the auxiliary contacts of the disconnectors of the bustie circuit breaker residual voltage will be routed to the relay even when one of the measuring cubicles is disconnected.

Example 4.
Double busbar system. Connection of the residual voltage to the relay. For the voltage selection residual voltage relays are used.

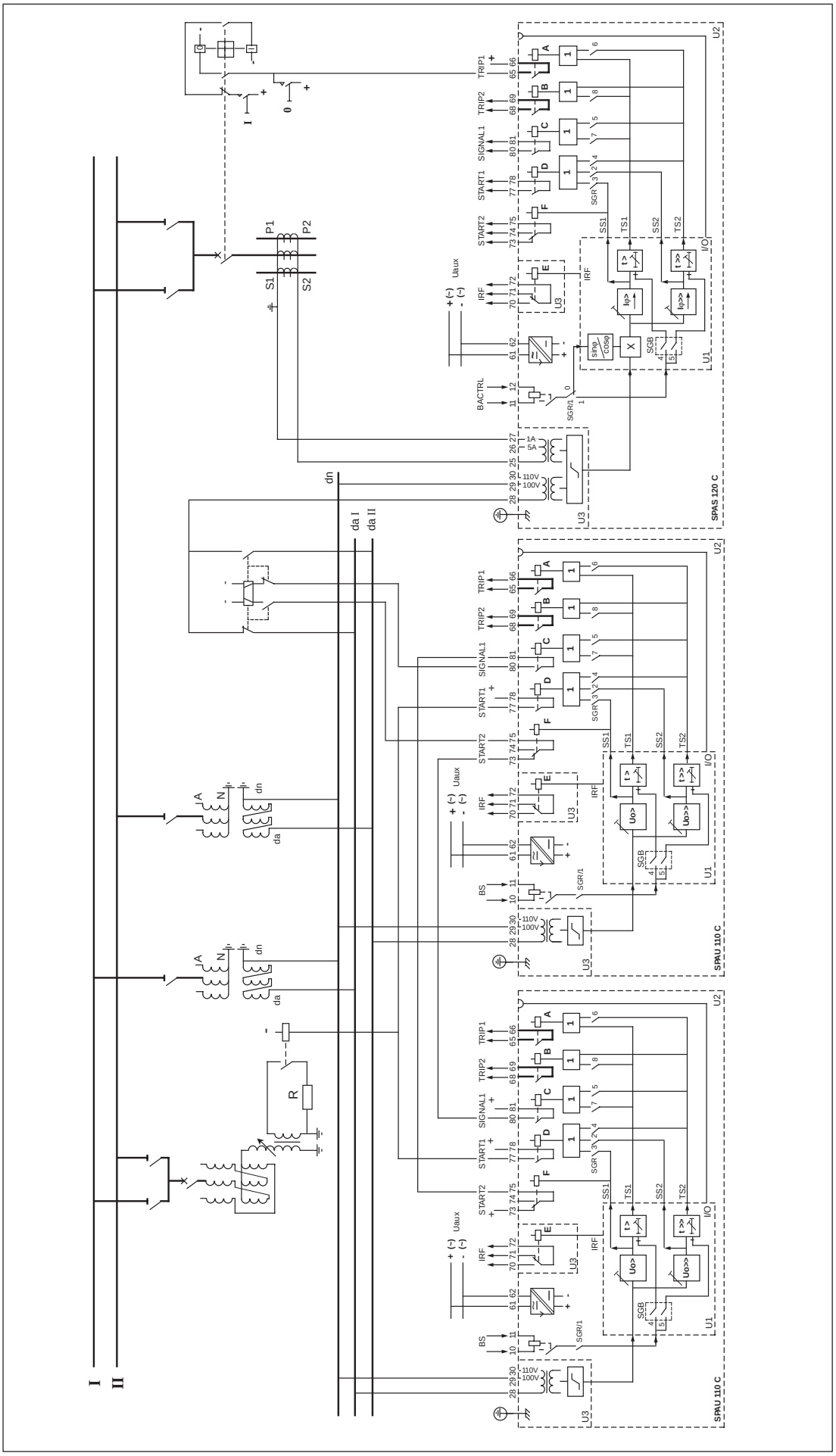


Fig. 7. Connection of residual voltage to the relay in a double busbar system.

In Ex. 4 a residual voltage relay SPAU 110 C and a bistable auxiliary relay are used for the distribution of residual voltage. The residual voltage of the busbar to which the faulty feeder is connected is automatically connected to the relay. When the busbars are interconnected the residual voltage is fed from one busbar only. When the busbars are separated it is assumed that there will not be two earth faults at the same time in two different network parts connected to different busbars.

The start contact of the residual voltage relay can be used for controlling the switching device of the parallel resistor of the arc suppression coil.

In Figs. 3 and 4, for control of the operation characteristic $I_0\sin\varphi$ or $I_0\cos\varphi$ auxiliary contacts of the disconnectors and the switching device of the arc suppression coil can be used.

Recorded data and fault analysis

(modified 2000-02)

The data recorded in the registers of the relay can be used both to analyze an earth-fault situation and to study the behaviour of the protection equipment.

Register 1 records measured $I_0\sin\varphi$ or $I_0\cos\varphi$ value as a percentage of the rated current. The register is updated when one of Iφ> or Iφ>> protection stages starts or operates. When the relay starts but does not operate, the relay module memorizes the maximum Iφ during the start situation. A second exceeding of Iφ> or Iφ>> protection stage will erase previously recorded value and starts to record a new maximum U_0 value. When a stage operates, the value of Iφ measured at the moment of operation is recorded.

Register 2 records measured residual voltage U_0 value as a percentage of the rated voltage U_n. The register is updated when one of Iφ> or Iφ>> protection stages starts or operates. When the relay starts but does not operate, the relay module memorizes the maximum U_0 during the start situation. A second exceeding of Iφ> or Iφ>> protection stage will erase previously recorded value and starts to record a new maximum U_0 value. When a stage operates, the value of U_0 measured at the moment of operation is recorded.

The data of register 1, 2 and 8 shows how close the relay settings are to the real fault current and voltage values. Correspondingly, the ratio between the set start values and the current and voltage values during normal operation can be determined by reading the normal current and voltage values via the display of the relay.

The recorded residual voltage and current values can be used for determining the fault resistance value. In this way the fault reason can be deduced and the fault location can be estimated.

The number of times the different stages have started, registers 3, 4 and 5, provides information on the fault frequency. Frequent starts may be a sign of an imminent earth fault, e.g. a faulty isolator or some kind of disturbance apt to cause an earth-fault, e.g. tree branch touching the line.

Registers 6 and 7 show the duration of the latest start situation of the stages, expressed in per cent of the set operate time. Any new start resets the counter, which restarts from zero. If the stage operates, the register value will be 100.

The registers 6 and 7 provide information on the duration of an earth fault, or, if a final trip has been performed, the safety margin of the grading times of the selective protection. This information is useful for checking the set values.

Register 8 records measured neutral current I_0 value as a percentage of the rated current I_n. The operation principle is the same as that of register 2. *)

*) *From the program version 068 D (012 F) and later version this register 8 has been incorporated into the relay module.*

Registers 1...8 are reset either by pressing the STEP and RESET push-buttons simultaneously or by giving a command V102 via the SPA bus.

Secondary injection testing

Testing, both primary and secondary, should always be performed in accordance with national regulations and instructions.

The protection relay incorporates an IRF function that continuously monitors the internal state of the relay and produces an alarm signal on the detection of a fault. According to the manufacturer's recommendations the relay should be submitted to secondary testing at five years' intervals. These tests should include the entire protection chain from the instrument transformers to the circuit breakers.

The secondary testing described in this manual is based on the relay's setting values during normal operation. If necessary, the secondary testing can be extended by testing the protection stages throughout their setting ranges.

As switch positions and setting values have to be altered during the test procedure the correct positions of switches and the setting values of the relay during normal operation conditions have to be recorded, for instance, on the reference card accompanying the relay.

For secondary testing the relay must be disconnected, either using disconnectable terminal blocks or a test adapter fitted on the relay.

DANGER!
Do not open the secondary circuit of a current transformer under any phases of the testing, if the primary circuit is live. The high voltage produced by an open CT secondary circuit could be lethal and may damage instruments and insulation.

When auxiliary voltage is connected to the protection relay, the relay performs a self-testing program, which does not include the matching transformers and the contacts of the output relays. The operational condition of the relay is tested by means of ordinary relay test equipment and such a test also includes the matching transformers, the output relays and the accuracy of the operate values.

Equipment required for testing:
- adjustable ac voltage source 0...40 V
- adjustable ac current source 4 mA…5 A
- ammeter, accuracy ±0.5%
- voltmeter
- stop watch or counter for time measurement
- dc voltage source
- switches and indicator lamps
- supply and pilot wires
- calibrated multimeter

The secondary current of the current transformer is to be selected on the basis of the rated current, 1 A or 5 A, of the relay energizing input to be tested. The energizing inputs are specified under the heading "Technical data, Energizing inputs".

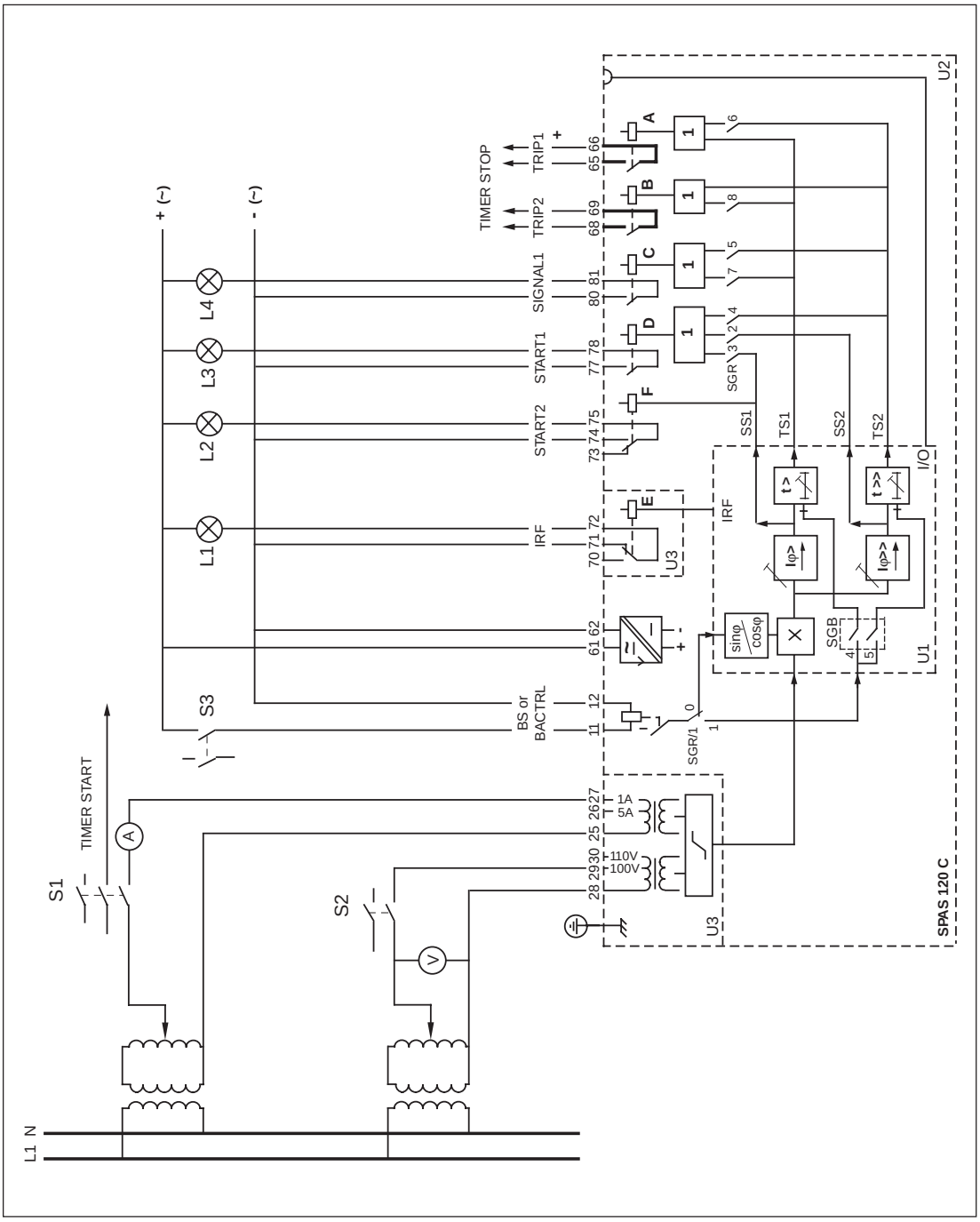


Fig. 8. Secondary injection test circuit for the directional earth-fault relay SPAS 120 C.

When the test connection has been completed and the selector switches properly set, the auxiliary voltage is connected to the relay. The operation of the test connection can be verified by means of a multimeter.

Testing of the matching transformers

Apply voltage and current to the relay and compare the current value indicated on the display of the relay with that shown by the meters. The measurements can be made for the energizing inputs used in the application.

Testing of the low-set stage Iφ>

Set the switches of the SGR switchgroup as follows before starting the test:

Switch	Position
1	1
2	0
3	0
4	0
5	0
6	0
7	1
8	0

The following relay functions are obtained:

Output relay (terminals)	Function
A (65-66)	Trip signal of stage Iφ>
B (68-69)	(Trip signal of stage Iφ>>)
C (80-81)	Signal on tripping of stage Iφ>
D (77-78)	Not in use
E (70-71-72)	Self-supervision signal
F (73-74-75)	Start signal of stage Iφ>

Checking the start current Iφ>

Apply a test voltage of approx. 2 x the set U_0 start value, check for switches SG1/7 and SG1/8. Close switch S1 and increase the test current slowly until the relay operates, indicator L2 is lit. Read the current value at the start moment from the ammeter.

Checking the start voltage U_0

Apply a test current approx. 2 x the set Iφ>start value. Close switch S2 and increase the test voltage slowly until the relay operates, indicator L2 is lit. Read the voltage value at the start moment from the voltmeter.

Checking the operate time

Set the test current at 2 x the set start value of stage Iφ> and the test voltage at 2 x the set start value of U_0. Connect the residual voltage to the relay by closing switch S2. The clock is started by closing switch S1 and stopped via contact 65-66, when output relay A picks up.

The operation of output relay C is indicated by L4.

When the relay starts, the Iφ> LED in the right bottom corner of the front panel is lit with yellow light. When the relay operates, the indicator LED turns red.

Checking the direction of operation

The direction function of the relay can be checked by changing the polarity of the test current wires at the relay test set. When the direction of operation of the relay is changed the relay is not allowed to work.

Blocking

Set switches 4 and 5 of switchgroup SGB and switch SGR/1 in position 1 (ON).

Apply a control voltage on the auxiliary voltage level to the external control input of the relay by closing switch S3. Set the residual voltage at 2 x the U_0 setting. Increase the test current until the low-set stage Iφ> starts. The relay is not allowed to operate.

Testing of the high-set stage Iφ>>

Set the switches of the SGR switchgroup as follows before starting the test:

Switch	Function
1	1
2	1
3	0
4	0
5	1
6	0
7	0
8	0

The following relay functions are obtained:

Output relay (terminals)	Function
A (65-66)	(Trip signal of stage Iφ>)
B (68-69)	Trip signal of stage Iφ>>
C (80-81)	Signal on tripping of stage Iφ>>
D (77-78)	Start signal of stage Iφ>
E (70-71-72)	Self-supervision signal
F (73-74-75)	(Start signal of stage Iφ>)

The testing is perfomed in the same way as for the low-set stage. When the operate time is measured the timer is stopped with contact 68-69, output relay B.

Testing of the self-supervision output relay (IRF)

The self-supervision system and the function of the IRF LED and the output relay E can be tested in the Trip test mode described in the document "General characteristics of C type relay modules". The operation of output relay E is indicated by L1.

Maintenance and repair

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

If the environmental conditions on site differ from those specified, as to temperature and humidity, or if the atmosphere around the relay contains chemically active gases or dust, the relay should be visually inspected during the relay secondary testing. The visual inspection should focus on:

- Signs of mechanical damage to relay case and terminals
- Dust accumulated inside the relay cover or case; remove carefully with compressed air or a soft brush
- Signs of corrosion on terminals, case or components inside the relay

If the relay fails in operation or if the operation values considerably differ from those stated in the relay specifications, the relay should be given a proper overhaul. Minor measures, such as exchange of a faulty module, can be taken by personnel from the customer's instrument workshop, but major measures involving the electronics are to be taken by the manufacturer. Please contact the manufacturer or his nearest representative for further information about checking, overhaul and calibration of the relay.

Note!
The protection relays contain electronic circuits which are sensitive to damage due to electrostatic discharge. Before removing a module, ensure that you are at the same electrostatic potential as the equipment by touching the case.

Note!
Static protection relays are measuring instruments and should be handled with care and protected against damp and mechanical stress, especially during transport and storage.

Exchange and spare parts

Directional earth-fault relay module	SPCS 3C4
Combined power supply and I/O module	
- U_{aux} = 80...265 V ac/dc	SPTU 240S1
- U_{aux} = 18...80 V dc	SPTU 48S1
Case (including I/O module)	SPTK 2E13
I/O module	SPTE 2E13
Bus connection module	SPA-ZC 17_ or SPA-ZC 21_

Ordering numbers

Directional earth-fault relay without test adapter
SPAS 120 C — RS 431 010 -AA, CA, DA, FA

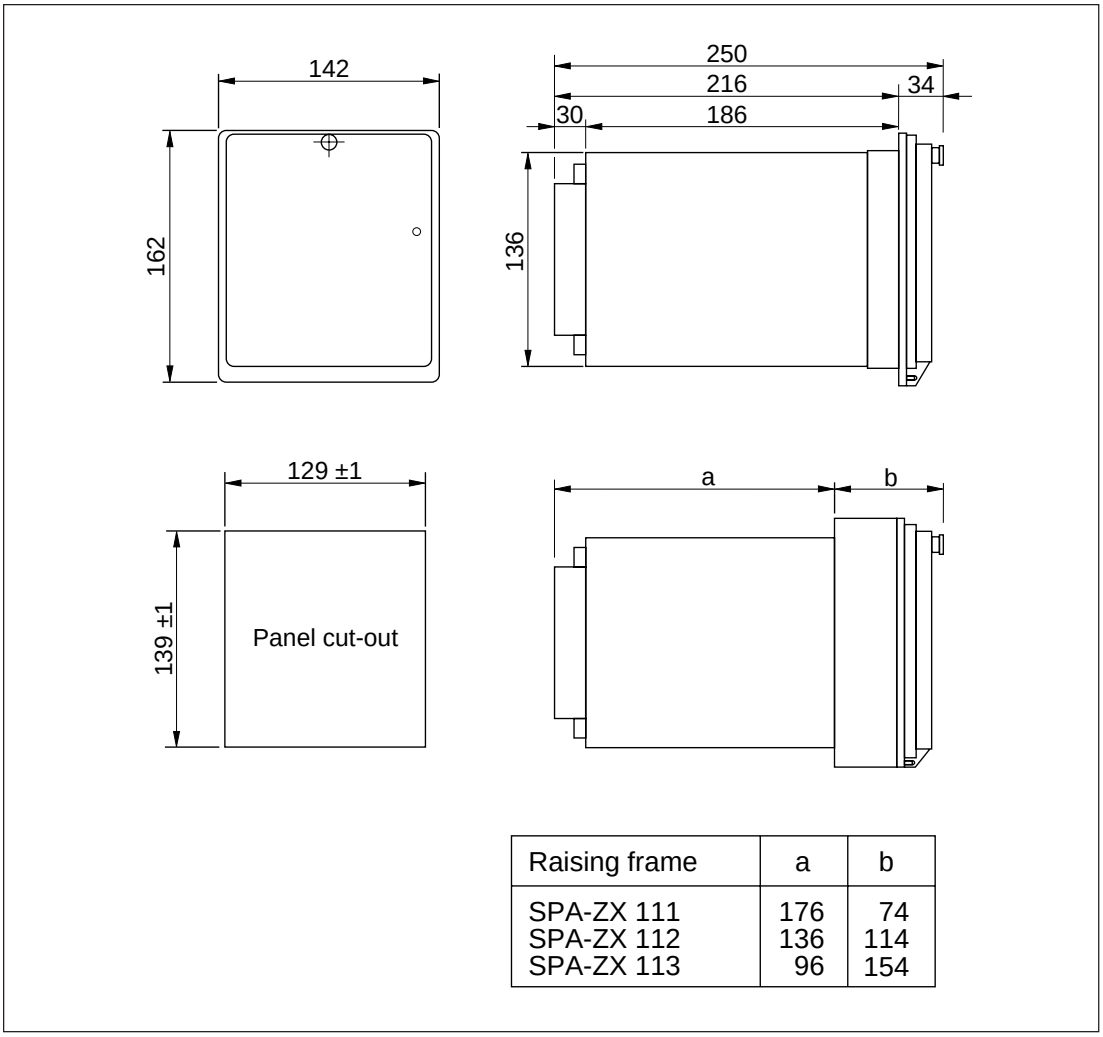
Directional earth-fault relay with test adapter RTXP 18
SPAS 120 C — RS 431 210 -AA, CA, DA, FA

The last two letters of the ordering number designate the rated frequency f_n and the U_{aux} voltage range of the relay as follows:

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

Dimensions and mounting

The relay case is basically designed for flush-mounting. The mounting depth can be reduced with a raising frame: type SPA-ZX 111 reduces the depth behind the panel by 40 mm, type SPA-ZX 112 by 80 mm and type SPA-ZX 113 by 120 mm. A surface mounting case type SPA-ZX 115 is also available.



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

Fig. 9. Dimension and mounting drawings of the directional earth-fault relay SPAS 120 C.

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

A rubber gasket fitted on the mounting collar provides an IP54 degree of protection between the relay case and the mounting panel, when the relay is flush mounted.

The hinged cover of the relay case is made of a clear, UV stabilized polycarbonate, and provided with a sealable fastening screw. A gasket at the edge of the cover provides an IP54 degree of protection between the case and the cover.

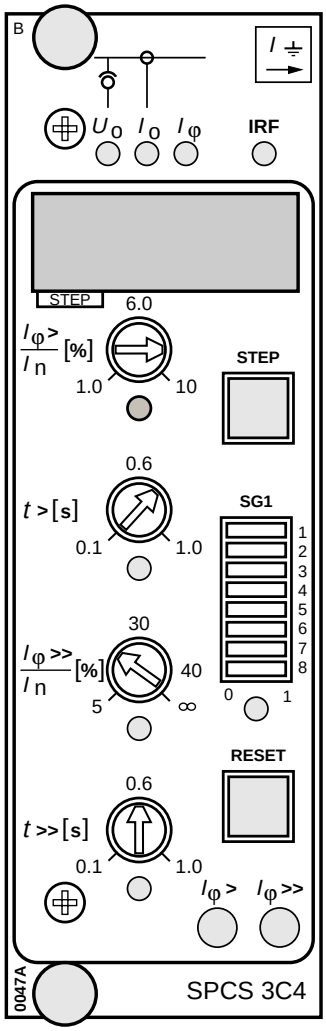
All input and output wires are connected to the screw terminal blocks on the rear panel. Each terminal is dimensioned for one max. 6 mm^2 wire or two max. 2.5 mm^2 wires. The D-type connector connects to the serial communication bus.

Order information

	Example
1. Quantity and type designation	15 pcs relay SPAS 120 C
2. Order number	RS 431 010-AA
3. Rated frequency	f_n = 50 Hz
4. Auxiliary voltage	U_{aux} = 110 V dc
5. Accessories	15 bus connection modules SPA-ZC 21 MM 2 fibre-optic cables SPA-ZF MM 100 14 fibre-optic cables SPA-ZF MM 5
6. Special requirements	–

SPCS 3C4
Overcurrent relay module

User´s manual and Technical description



1MRS 750350-MUM EN

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Data subject to change without notice

SPCS 3C4
Overcurrent relay module

Contents

Features

Directional neutral overcurrent relay module with definite time characteristic for earth fault protection

Two neutral overcurrent stages, a low-set stage Iφ> and a high-set stage Iφ>>

The high-set stage can be given the same or the opposite direction of operation as compared with the low-set stage

$I_0 \sin\varphi$ or $I_0 \cos\varphi$ operation characteristic selected locally by switches or by remote control over the external control input

Four selectable start values for the residual voltage

Digital display of measured values, set values and recorded fault values

Continuous self-supervision with autodiagnostics including both hardware and software

Serial communication capability for extensive data exchange between the relay module and the substation level communication or control system

Description of operation

The directional neutral overcurrent relay module SPCS 3C4 measures the residual voltage U_0 and the active component $I_0\cos\varphi$ or the reactive component $I_0\sin\varphi$ of the neutral current I_0. The phase angle φ is the phase displacement between the measured voltage and current.

The module starts, generating a start signal SS1 or SS2, if $I_0\cos\varphi$ or $I_0\sin\varphi$ exceeds the set start value Iφ> or Iφ>>, and the neutral voltage simultaneously exceeds the selected start voltage value. The operation indicator of the stage which starts is lit with yellow light. If the situation persists long enough, the stage which started also operates generating a trip signal TS1 or TS2. Simultaneously, the yellow operation indicator of the concerned stage turns red. The operation indicators can be given self-reset or manual-reset mode of operation. If the manual reset mode of operation has been selected the operation indicator can be reset by pushing the RESET push button or by remote control via the SPA bus using the command V101 or V102.

The operation of the low-set stage Iφ> can be blocked by routing a blocking signal BTS1 to the stage. In the same way the operation of stage Iφ>> is blocked by means of the blocking signal BTS2. The external blocking signals are configured by means of switchgroup SGB located on the PC board of the relay module.

If the directional neutral overcurrent relay module is cooperating with auto-reclose relay module, switchgroup SGB is additionally used for the selection of start initiation signals for the auto-reclose module. See also paragraph "Signal diagram" in the general manual of the different protection relays.

The direction of operation of the stages is selected with switch SG1/1. The low-set stage Iφ> operates in the forward direction only, the high-set stage Iφ>> can be set to operate in either direction (see fig. 4).

The start value of the residual voltage is selected with switches SG1/7 and SG1/8. Four alternative start values are available.

The operation characteristics of the module are presented in Fig. 4. If the system to be protected is resonant earthed or solidly or nearly solidly earthed, the operation characteristic to be selected is $I_0\cos\varphi$, whereas $I_0\sin\varphi$ is selected for the protection of isolated neutral systems.

The operation characteristic, $I_0\sin\varphi$ or $I_0\cos\varphi$, can be selected manually by means of switch SG1/3 on the front panel of the relay module, when SG1/2 = 0. If SG1/2 = 1, the operation characteristic can be remotely controlled irrespective of the position of switch SG1/3. By bringing a control signal named BACTRL to the 0 state the operation characteristic will be $I_0\sin\varphi$. When the control signal BACTRL is in the 1 state, the operation characteristic is $I_0\cos\varphi$. If the operation characteristic is to be automatically controlled, the change from $I_0\sin\varphi$ to $I_0\cos\varphi$ or vice versa is initiated by an auxiliary contact of the disconnector of the earthing coil.

The setting range of the operation time t> of the low-set stage Iφ> is selected with switch SG1/5. Two setting ranges are available.

The setting range of the start current of the high-set stage Iφ>>, i.e. 5...40% x I_n or 1...8% x I_n, is selected with switch SG1/6. Additionally the operation of the high-set stage can be set out of function by selecting the setting ∞, infinite.

The operation outputs TS1 and TS2 of the two stages are provided with a so called latching function (switch SG1/4). If selected, the operation output and thus the output relay will remain energized, although the signal which caused operation disappears. The stages are reset by pushing the STEP and RESET push buttons simultaneously or by remote control via the SPA bus using the command V101 or V102. See also table (for switchgroup SG3) on page 9 in chapter "Selector switches".

The residual voltage and neutral current inputs are provided with effective filters by means of which harmonics of the energizing quantities are suppressed, see Fig. 1.

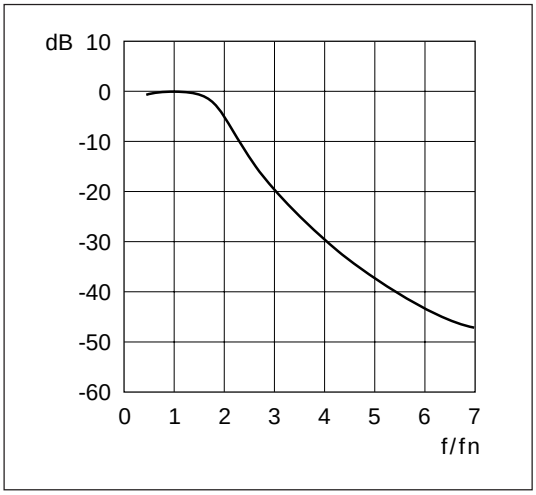


Fig. 1. Filter characteristics of the energizing inputs of the relay module SPCS 3C4.

Block schematic diagram

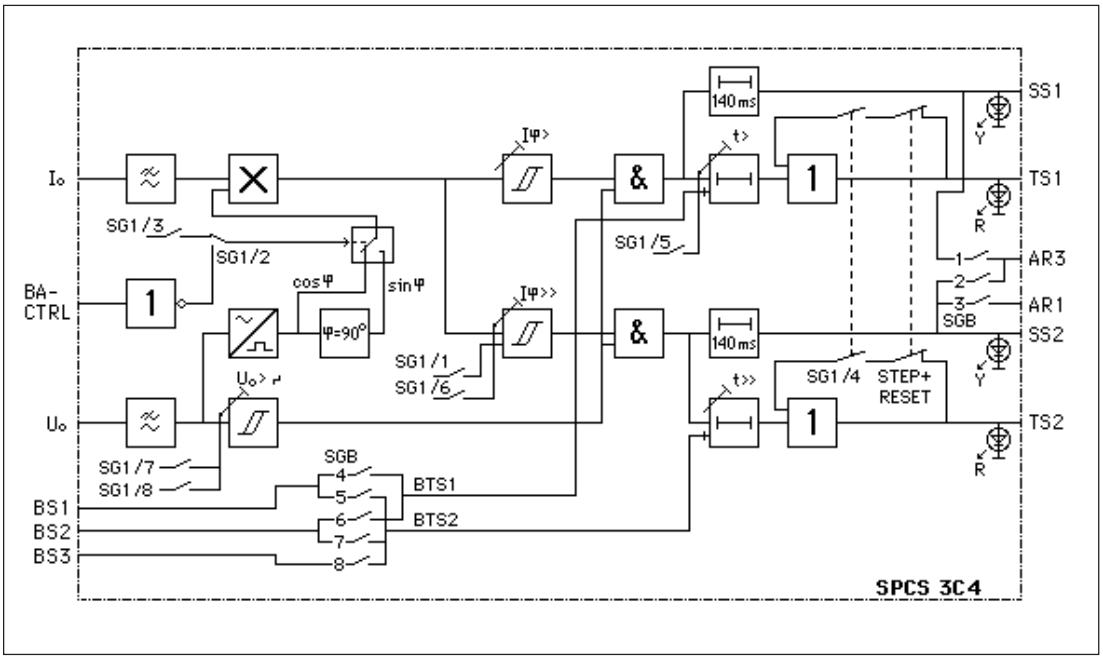


Fig. 2. Block diagram for the directional neutral current relay module SPCS 3C4.

U_0	Residual voltage
I_0	Neutral current
BS1, BS2, BS3	External blocking signals
BTS1	Blocking signal for the operation of stage Iφ>
BTS2	Blocking signal for the operation of stage Iφ>>
BACTRL	External control signal for selection of the operation characteristic $I_0\sin\varphi$ or $I_0\cos\varphi$
SG1	Front panel selector switchgroup
SG2	Function selector switchgroup for the operation indicators
SGB	Selector switches on the PC board for configuring incoming blocking signals and outgoing start signals
SS1	Start signal of the low-set stage Iφ>
TS1	Trip signal of the low-set stage Iφ>
SS2	Start signal of the high-set stage Iφ>>
TS2	Trip signal of the high-set stage Iφ>>
AR1, AR3	Start initiation signals for an optional auto-reclose relay module
Y	Yellow start indicator
R	Red operation indicator

NOTE!
All input and output signals of the directional neutral overcurrent relay module are not necessarily wired to the terminals of every protection relay unit incorporating the module. The signals wired to the terminals are shown in the paragraph "Signal diagram" in the general manual of the protection relay.

Front panel

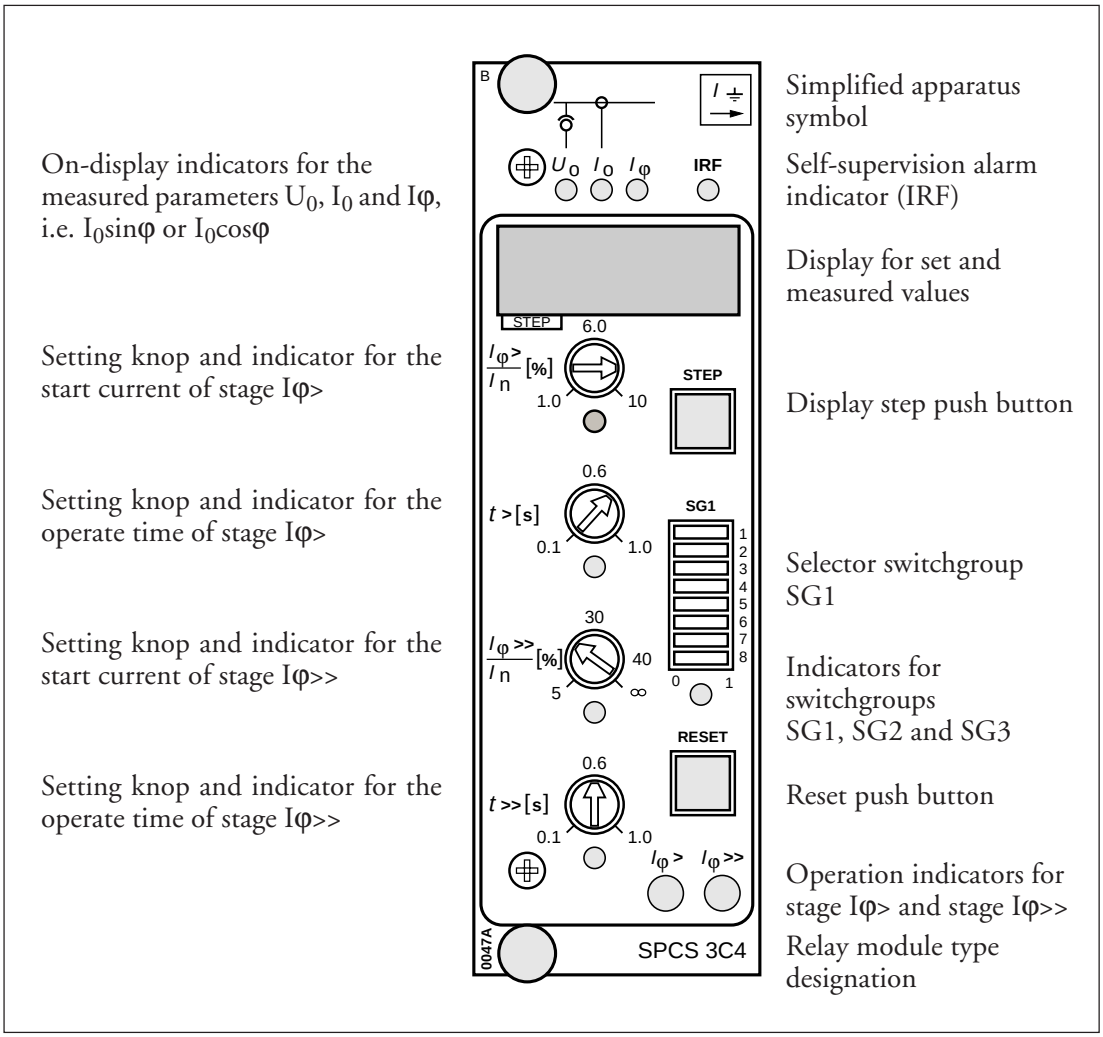


Fig. 3. Front panel of the directional neutral overcurrent relay module SPCS 3C4.

Operation indicators

Both neutral overcurrent stages are provided with a yellow/red indicator. Yellow light indicates starting of the concerned overcurrent stage and red light indicates that the overcurrent stage has operated (tripped).

The four indications, two starts and two trippings, can be given with switches in SG2 a self-reset mode of operation or a manual mode. If, for instance, the yellow start indication (but not the red operation indication) of a protection stage is given the manual mode, the yellow indication is lit when the protection stage starts and turned red when the stage operates. When the protection stage returns to normal the yellow indication remains lit. Manual reset indications are reset py pushing the RESET push button or by the command V101 or V102 via the serial interface. The function of the relay module is not affected by an unreset operation indicator. See also table (for switchgroup SG3) on page 9 in chapter "Selector switches".

The self-supervision alarm indicator IRF indicates that the self-supervision system has detected a permanent fault. The indicator is lit with red light shortly after a permanent internal fault has been detected. At the same time a control signal is put forward to the output relay of the self-supervision system. Additionally, in most fault cases, a fault code indicating type of fault appears on the display of the relay module. The fault code is to be recorded to serve the subsequent fault location and repair actions.

The setting values are shown by the three rightmost green digits of the display. The LED indicator below the setting knob shows, when lit, the setting value curently being shown on the display.

Iφ>/I_n	Start current of stage Iφ>, expressed as a percentage of the rated current of the energized relay input. Setting range 1...10% x I_n.
t> [s]	Operate time of stage Iφ>, expressed in seconds. The setting range is 0.1...1.0 seconds when SG1/5 = 0, and 1.0...10.0 seconds when SG1/5 = 1.
Iφ>>/I_n	Start current of stage Iφ>>, expressed as a percentage of the rated current of the energized relay input. The setting range is 5...40% x I_n when SG1/6 = 0, and 1...8% x I_n when SG1/6 = 1. Additionally, the setting ∞, infinite (displayed as- - -) can be selected, which means that stage Iφ>> has been set out of function. If the high-set stage Iφ>> operates in the reverse direction (SG1/1 = 1), the setting value is negative and the leftmost digit on the display shows a red minus sign.
t>> [s]	Operate time of stage Iφ>>, expressed in seconds. Setting range 0.1...1.0 seconds.

Further, the checksum of the selector switchgroup SG1 is presented on the display when the LED indicator under the switchgroup is lit. In this way the proper operation of the selector switches can be verified. An example illustrating the manual procedure for calculating the checksum is given in the manual "General characteristics of C type relay modules".

Selector switches

Additional relay functions required by specified applications are selected by means of the selector switches of switchgroup SG1 located on the front panel of the module. The numbering of the switches, 1...8, as well as the switch positions 0 and 1 are marked on the front panel.

<table>
<tr><th>Switch</th><th>Function</th></tr>
<tr><td>SG1/1</td><td>Selection of operation direction for the high-set stage Iφ>>.

Switch SG1/1 = 0 corresponds to the forward operation direction, i.e. the same direction as that of the low-set stage Iφ>.

Switch SG1/1 = 1 corresponds to the reverse operation direction, also see Fig. 4 on page 8.</td></tr>
<tr><td>SG1/2</td><td>Selection of manual or external control of the operation characteristic, i.e. $I_0 \sin\varphi$ or $I_0 \cos\varphi$.
<table>
<tr><th>SG1/2</th><th>SG1/3</th><th>Method of controlling the operation characteristic</th><th>Obtained characteristic</th></tr>
<tr><td>0</td><td>0</td><td>Manual selection</td><td>$I_0 \cos\varphi$</td></tr>
<tr><td>0</td><td>1</td><td>Manual selection</td><td>$I_0 \sin\varphi$</td></tr>
<tr><td>1</td><td>0</td><td>By external control</td><td>Controlled by BACTRL</td></tr>
<tr><td>1</td><td>1</td><td>By external control</td><td>Controlled by BACTRL</td></tr>
</table></td></tr>
<tr><td>SG1/4</td><td>Selection of the latching function for the trip signals TS1 and TS2.

When SG1/4 = 0, the trip signals reset to the initial state (= the output relay drops off), when the energizing signal causing the operation falls below the set start level. When SG1/4 = 1, the trip signals remain in the activated (= the output relay operated), although the energizing signal falls below the set start level. The trip signals can be reset by pressing the push buttons STEP and RESET simultaneously or with the command V101. When the STEP and RESET push buttons are pushed the recorded values are erased as well. *)</td></tr>
<tr><td>SG1/5</td><td>Selection of setting range for the operate time t> of the low-set stage Iφ>.

When SG1/5 = 0, the setting range of the operate time t> is 0.1...1.0 s.
When SG1/5 = 1, the setting range of the operate time t> is 1...10 s.</td></tr>
<tr><td>SG1/6</td><td>Selection of setting range of the start value of the high-set stage Iφ>>.

When SG1/6 = 0, the setting range of stage Iφ>> is 5...40% x I_n or ∞, infinite.
When SG1/6 = 1, the setting range of stage Iφ>> is 1...8% x I_n or ∞, infinite.</td></tr>
<tr><td>SG1/7
SG1/8</td><td>Setting of the start value for the residual voltage as a percentage of the rated voltage of the energizing voltage input.
<table>
<tr><th>SG1/7</th><th>SG1/8</th><th>Set start value for U_0</th></tr>
<tr><td>0</td><td>0</td><td>2%</td></tr>
<tr><td>1</td><td>0</td><td>5%</td></tr>
<tr><td>0</td><td>1</td><td>10%</td></tr>
<tr><td>1</td><td>1</td><td>20%</td></tr>
</table></td></tr>
</table>

*) From the program version 068 C and later an additional switchgroup (SG3) has been incorporated into the relay module. When the latching function is used the latched output can be reset by pushing the RESET button alone, if SG3/3=1, or by pushing the STEP button alone, if SG3/2=1, in which case the stored information of the module is not erased.

Fig. 4 illustrates how the operation characteristic of the module are affected by the selector switches SG1 on the front panel and the external control signal BACTRL.

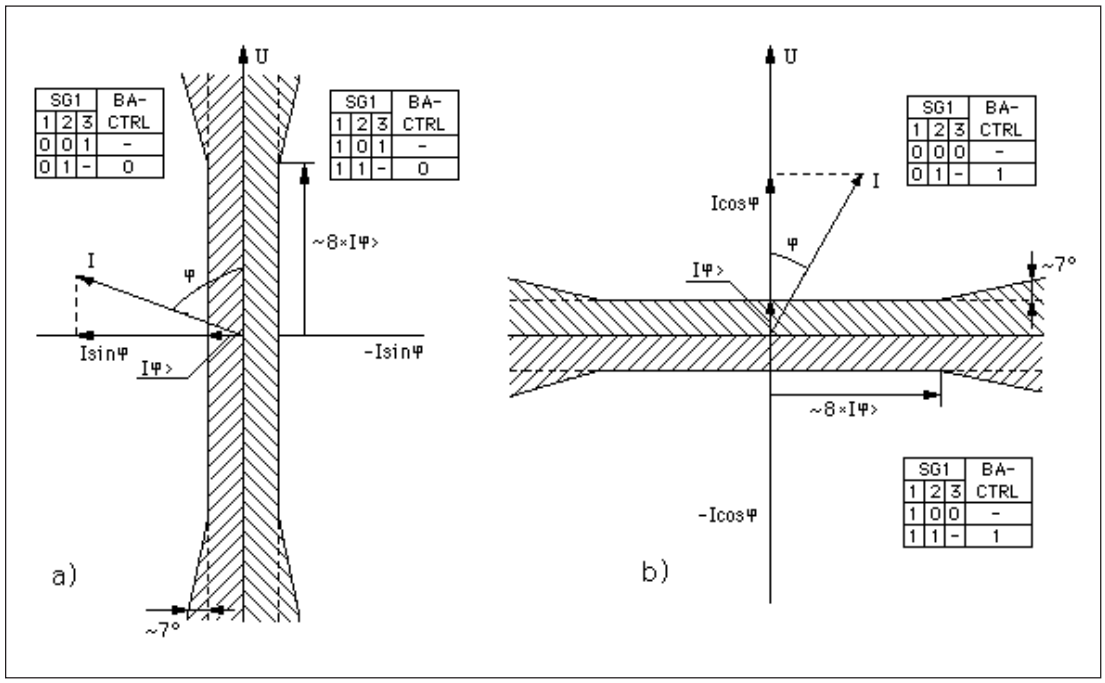


Fig. 4. Operation characteristic of the directional neutral overcurrent relay module SPCS 3C4. Fig. 4a shows the $I_0 \sin\varphi$ characteristic, Fig. 4b the $I_0 \cos\varphi$ characteristic.

Switchgroup SG2 is a so called software switchgroup, which is located in the third submenu of switchgroup SG1. In switchgroup SG2 the mode of operation of the LED indicators is selected. The start and operation indicators of the low-set stage and the high-set stage can be given self reset mode of operation or manual mode of operation.

The selection is made by means of a checksum which is calculated from the table below. Normally the start indications are self reset and the operation indications are manualy reset.

Indication	Manual	Default
Starting, stage Iφ>, yellow	1	0
Tripping, stage Iφ>, red	2	2
Starting, stage Iφ>>, yellow	4	0
Tripping, stage Iφ>>, red	8	8
Checksum Σ	15	10

Switchgroup SG3 is a so called software switchgroup, which is located in the fourth submenu of switchgroup SG1. The front panel push-buttons STEP and RESET can be programmed with switches SG3/1…3. Switches SG3/4…8 are not in use. The default value for SG3 is 0.

SG3/1	SG3/2	SG3/3	Push-button	Clear start/trip LED's	Reset latched relays	Erase memorized values
0	0	0	STEP			
			RESET	x		
			STEP & RESET	x	x	x
1	0	0	STEP	x		
			RESET	x		
			STEP & RESET	x	x	x
0	1	0	STEP	x	x	
			RESET	x		
			STEP & RESET	x	x	x
0	0	1	STEP			
			RESET	x	x	
			STEP & RESET	x	x	x
1	0	1	STEP	x		
			RESET	x	x	
			STEP & RESET	x	x	x

The PC board of the relay module contains a switchgroup named SGB with eight switches numbered 1...8. Switches 1...3 are used for configuring the start initiation signals to the auto-reclose module, whereas switches 4...8 are used for configuring blocking signals to the overcurrent stages of the module. For more detailed information, see the general descriptions of the different protection relay units.

Measured data

The measured values are presented with the rightmost three green digits on the display. The data being presented are indicated by LED indicators on the front panel.

Indicator	Measured data
U_0	Residual voltage measured by the module, expressed as a percentage of the rated voltage U_n of the energized relay input. If the measured value exceeds 25% of the rated voltage of the energized relay input the display shows - - -.
I_0	Neutral current measured by the module, expressed as a percentage of the rated current I_n of the energized relay input.
Iφ	$I_0 \sin\varphi$ value or $I_0 \cos\varphi$ value measured by the module, expressed as a percentage of the rated current of the relay assembly. If Iφ is negative, the digit at the extreme left on the display shows a red minus sign. If the measured value exceeds 100% of the rated current of the relay assembly, the display shows either - - - or - - - - depending on the sign of the Iφ value.

NOTE!
The rated current I_n of the protection relay unit is the rated current of the energizing inputs of the relay currently being energized in a particular application.

Recorded information
(modified 2000-02)

The leftmost red digit displays the register address and the other three digits the recorded information.

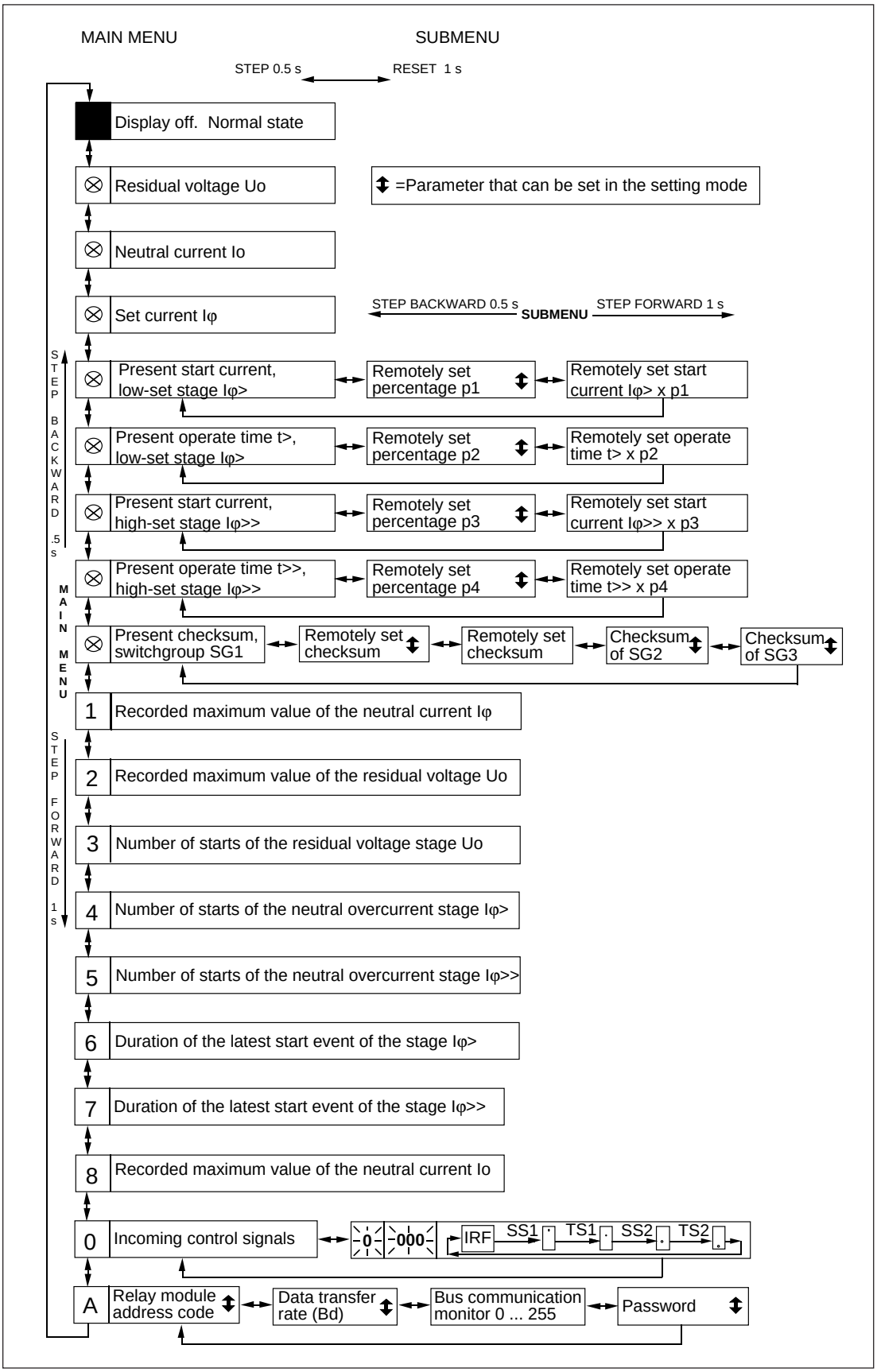
Register/ STEP	Recorded information
1	Measured $I_0 \sin\varphi$ or $I_0 \cos\varphi$ value as a percentage of the rated current. If Iφ has a negative sign, a red minus sign appears in the leftmost position in the display. If the measured value exceed 100% x I_n, the recorded value is expressed as 1- - - or - - - -. The register is updated when one of Iφ> or Iφ>> protection stages starts or operates. When the relay starts but does not operate, the relay module memorizes the maximum Iφ during the start situation. A second exceeding of Iφ> or Iφ>> protection stage will erase previously recorded value and starts to record a new maximum U_0 value. When a stage operates, the value of Iφ measured at the moment of operation is recorded.
2	Measured residual voltage U_0 value as a percentage of the rated voltage U_n. If the measured value exceed 25% of the rated voltage, the recorded value is expressed as 2 - - -. The register is updated when one of Iφ> or Iφ>> protection stages starts or operates. When the relay starts but does not operate, the relay module memorizes the maximum U_0 during the start situation. A second exceeding of Iφ> or Iφ>> protection stage will erase previously recorded value and starts to record a new maximum U_0 value. When a stage operates, the value of U_0 measured at the moment of operation is recorded.
3	Number of times the set start value of the residual voltage has been exceeded, n (U_0) = 0...255.
4	Number of starts of the low-set stage Iφ>, n (Iφ>) = 0...255.
5	Number of starts of the high-set stage Iφ>>, n (Iφ>>) = 0...255.
6	Duration of the latest start event of stage Iφ>, expressed as a percentage of the set operate time t>. Any new start resets the counter which starts counting from zero. If the stage operates, the register value 100.
7	Duration of the latest start event of stage Iφ>>, expressed as a percentage of the set operate time t>>. Any new start resets the counter which starts counting from zero. If the stage operates, the register value 100.
8	Measured neutral current I_0 value as a percentage of the rated current I_n. If the measured value exceed 100% of the rated current of the relay input, the recorded value is expressed as 8 - - -. The operation principle is the same as that of register 2. *) **) From the program version 068 D (012 F) and later version this register 8 has been incorporated into the relay module.*

Register/ STEP	Recorded information
0	Display of the state of the basic angle control signal BACTRL and other external control signals. The rightmost digit in the display shows the state of the blocking signals BTS1 and BTS2. The following states are indicated: 0 = no active incoming blocking signal 1 = operation of stage Iφ> blocked 2 = operation of stage Iφ>> blocked 3 = operation of both stages blocked The state of the basic angle control signal BACTRL is displayed by the mid digit of the green part of the display. The alternative states are: 0 =BACTRL in the 0 state, i.e. the operation characteristic is $I_0 \sin\varphi$, if the external control of the operation characteristic has been selected 1 =BACTRL in the 1 state, i.e. the operation characteristic is $I_0 \cos\varphi$, if the external control of the operation characteristic has been selected The leftmost green digit indicates the state of the remote reset control input, if any. The following states are indicated: 0 = remote reset control input not energized 1 = remote reset control input energized From this register one can move on to the TEST mode, where the start and operation signals of the module can be activated one by one in order to test the output relays. For further details see the description "General characteristics of C type relay modules".
A	Address code of the protection relay module, required by the serial communication system. The address code is set to zero when no serial communication is to be used. The subroutines of this register are: 1) Selection of data transfer rate for the serial communication. Selectable values: 300, 1200, 2400, 4800 and 9600 Bd. Default value 9600 Bd. 2) Bus communicaton counter. If the module is connected to a data communication device and the communication system is working the communication counter shows 0 (zero). If the communication is interrupted the numbers 0…255 is scrolling in the counter. 3) Password required for the remote control of the relay settings

The registers 1...8 are reset by pressing the push buttons STEP and RESET simultaneously or over the SPA bus by means of the command V102. The registers are also reset if the auxiliary power supply of the relay module is interrupted. The address code of the relay module, the data transfer rate of the serial communication system and the password are not erased by a supply interruption. The instructions for setting the address and the data transfer rate are given in the manual "General characteristics of C type relay modules".

Main menus and submenus for settings and registers

The figure below shows the menus and submenus of the directional neutral overcurrent relay module.



The manual "General characteristics of C type relay modules", describes how submenus and setting modes are entered and escaped from and how setting is carried out. Further the manual describes how the TRIP-TEST mode of the relay module works.

Technical data
(modified 2000-02)

Low-set neutral overcurrent stage Iφ>

Start current	1...10% x I_n
Start time, typically	150 ms
Operate time, two ranges	0.1...1.0 s and 1.0...10.0 s
Reseting time, typically	100 ms
Drop-off/pick-up ratio, typically	0.95
Operate time accuracy	±2% of setting or ±50 ms
Operation accuracy	±3% of the maximum setting value of stage Iφ> + inaccuracy caused by ±1° phase displacement

High-set neutral overcurrent stage Iφ>>

Start current	5...40% x I_n and ∞, infinite, or 1...8% x I_n and ∞, infinite
Start time, typically	150 ms
Operate time	0.1...1.0 s
Reseting time, typically	100 ms
Drop-off/pick-up ratio, typically	0.95
Operate time accuracy	±2% of setting or ±50 ms
Operation accuracy	±3% of the maximum setting value of stage Iφ>> + inaccuracy caused by ±1° phase displacement

Event codes

Over the SPA serial bus the data communication equipment reads event data, for instance, start and trip information, produced by the relay module SPCS 3C4. On request the relay module transmits its event data in the format: time (ss.sss) and event code. The event codes of the module are E1...E8, E50 and E51. In addition the data communication equipment can form event codes related to the data communication.

The codes E1...E8 and the events represented by these can be included in or excluded from the event reporting by writing, over the SPA bus, a so called event mask (V155) to the module. The event mask is a binary number coded to a decimal number. The event codes E1...E8 are represented by the numbers 1, 2, 4...128. The event mask is formed by multiplying above numbers by 0, event not included in reporting, or 1, event included in reporting, and by adding the products thus received, compare switchgroup checksum calculation.

The event mask may take any value from 0 to 255. The default value of the directional neutral overcurrent module is 85, which means that the starts and trips, but no resettings, are included in the reporting. The codes E50...E54 and the events represented by these cannot be excluded from the reporting.

The event codes of the directional neutral overcurrent module SPCS 3C4:

Code	Event	Number representing the event	Definite value of the factor
E1	Start of stage Iφ>	1	1
E2	Reset of start of stage Iφ>	2	0
E3	Tripping of stage Iφ>	4	1
E4	Reset of tripping of stage Iφ>	8	0
E5	Start of stage Iφ>>	16	1
E6	Reset of start of stage Iφ>>	32	0
E7	Tripping of Iφ>>-stage	64	1
E8	Reset of tripping of stage Iφ>>	128	0
E50	Restart	*	-
E51	Overflow of event register	*	-
E52	Temporary disturbance 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!
In the SPACOM system the event codes E52...E54 are formed by the data communication equipment.

Remote transfer data

(modified 2000-02)

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

Data	Code	Data direct.	Values
Measured residual voltage value	I1	R	0...25% x U_n 999, if U_0 > 25% x U_n
Measured neutral current value	I2	R	0...100% x I_n 999, if I_0 > 100% x I_n
Measured value $I_0\cos\varphi$ or $I_0\sin\varphi$ (sign +/-)	I3	R	±0...100% x I_n ±999, if Iφ > 100% x I_n
Blocking of low-set stage Iφ>	I4	R	0 = no blocking 1 = tripping Iφ>-stage blocked
Blocking of high-set stage Iφ>>	I5	R	0 = no blocking 1 = tripping Iφ>>-stage blocked
Remote control of the operation characteristic sinφ/cosφ	I6	R	0 = $I_0\sin\varphi$ 1 = $I_0\cos\varphi$
Start of low-set stage Iφ>	O1	R	0 = stage Iφ> not started 1 = stage Iφ> started
Tripping of low-set stage Iφ>	O2	R	0 = stage Iφ> not tripped 1 = stage Iφ> tripped
Start of high-set stage Iφ>>	O3	R	0 = stage Iφ>> not started 1 = stage Iφ>> started
Tripping of high-set stage Iφ>>	O4	R	0 = stage Iφ>> not tripped 1 = stage Iφ>> tripped
Active start current Iφ of the low-set stage Iφ>	S1	R	1...10% x I_n
Active operate time t> of the low-set stage Iφ>	S2	R	0.1...10 s
Active start current Iφ>> of the high-set stage (sign ±)	S3	R	±1...40% x I_n ±999 = ∞
Active operate time t>> of the high-set stage Iφ>>	S4	R	0.1...1 s
Active checksum of selector switch-group SG1	S5	R	0...255
Start current Iφ of stage Iφ>, set with the setting knob	S11	R	1...10% x I_n
Operate time t> of stage Iφ>, set with the setting knob	S12	R	0.1...10 s
Start current of stage Iφ>>, set with the setting knob (sign ±)	S13	R	±1...40% x I_n ±999 = ∞
Operate time of stage Iφ>>, set with the setting knob	S14	R	0.1...1 s
Checksum of switchgroup SG1, set with the selector switches	S15	R	0...255

Data	Code	Data direct.	Values
Remotely set percentage for the set start current of stage Iφ>	S21	R, W	0...999%
Remotely set percentage of the set operate time of stage Iφ>	S22	R, W	0...999%
Remotely set percentage of the set start current of stage Iφ>>	S23	R, W	0...999%
Remotely set percentage of the set operate time of stage Iφ>>	S24	R, W	0...999%
Remotely set checksum of switchgroup SG1	S25	R, W	0...255
Remotely set start current of stage Iφ>	S31	R	1...10% x I_n
Remotely set operate time of stage Iφ>	S32	R	0.1...10 s
Remotely set start current of stage Iφ>>	S33	R	±1...40% x I_n ±999 = ∞
Remotely set operate time of stage Iφ>>	S34	R	0.1...1 s
Remotely set checksum of switchgroup SG1	S35	R	0...255
Maximum recorded value of the neutral current Iφ (sign ±)	V1	R	±0...100% x I_n ±999, if Iφ > 100% x I_n
Maximum recorded value of the residual voltage U_0	V2	R	0...25% x U_n 999, if U_0 > 25% x U_n
Number of starts of stage U_0	V3	R	0...255
Number of starts of stage Iφ>	V4	R	0...255
Number of starts of stage Iφ>>	V5	R	0...255
Duration of the latest start event of stage Iφ>	V6	R	0...100%
Duration of the latest start event of stage Iφ>>	V7	R	0...100%
Max. recorded value I_0	V8	R	0…100% x I_n, 999, if I_0> 100% x I_n
Resetting of output relays and operation indicators	V101	W	1 = output relays and operation indicators are reset
Resetting of output relays and operation indicators and erasing of recorded data	V102	W	1 = output relays and operation indicators are reset and registers (codes V1…V8) are erased
Remote control of setting values	V150	R, W	0 = setting knobs settings S11...S15 activated 1 = remote settings S31...S35 activated
Event mask word	V155	R, W	0...255, see chapter "Event codes"
Self-reset or manual reset mode of operation of the LED indicators (SG2)	V156	R,W	0…15, see chapter "Selector switches"
Programming push-buttons (SG3)	V157	R, W	0…7, see chapter "Selector switches"
Opening of password for the remote setting procedure	V160	W	1...999
Changing or closing of password for the remote setting procedure	V161	W	0...999

Data	Code	Data direct.	Values
Activation of the self-supervision output	V165	W	1 = self-supervision output activated and IRF indicator lit in about 5 s, whereafter the self-supervision system resets and the IRF indicator is switched off
Fault code generated by the self-supervision system	V169	R	0…255
Module data communication address	V200	W	1...254
Program version of the relay module	V205	R	e.g. 068 B
Relay module type designation	F	R	SPCS 3C4
Reading of event register	L	R	Time, channel number and event code
Re-reading of event register	B	R	Time, channel number and event code
Reading of relay module status data	C	R	0 = normal state 1 = module been subject to automatic reset 2 = overflow of event regist. 3 = events 1 and 2 together
Resetting of module status data	C	W	0 = resetting
Reading and setting of the time	T	R, W	00.000...59.999 s

R = data that can be read from the relay module
W = data that can be written to the relay module

The data transfer codes L, B, C and T are used for the communication between the relay module and the data communication equipment. The event register can be read only once by the L command. Should a fault occur, for instance, during the data transfer, the B command allows re-reading of the contents of the event register previously read by means of the L command. If required, the B command can be repeated.

The setting values S1...S5 are currently activated by the protection relay. They are set either remotely over the SPA bus and the serial port of the relay or locally by means of the setting knobs on the relay module front panel. The setting values S11...S15 are set with the setting knobs and the switches. The values S21...S25 are percentage factors to be multiplied by the values set with the knobs in order to obtain the remote set values of parameters S31…S35. The values of variables S21...S25 can be read and written. A condition for the writing is that the password, V160, for remote setting has been opened and the potentiometer settings must be valid, V150=0. The variables S31...S35 contain the actual remote setting values.

The remote setting percentages of variables S21…S24 can be given a value within the range 0…999. Thus it is also possible to alter a setting value beyond the specified setting range of the parameter. However, the accuracy of the setting values are guaranteed only within the setting ranges specified in the technical data.

Activation of the self-supervision input (V165) prevents the protection relay from operating as long as the self-supervision input is activated and the IRF indicator is illuminated.

Fault codes

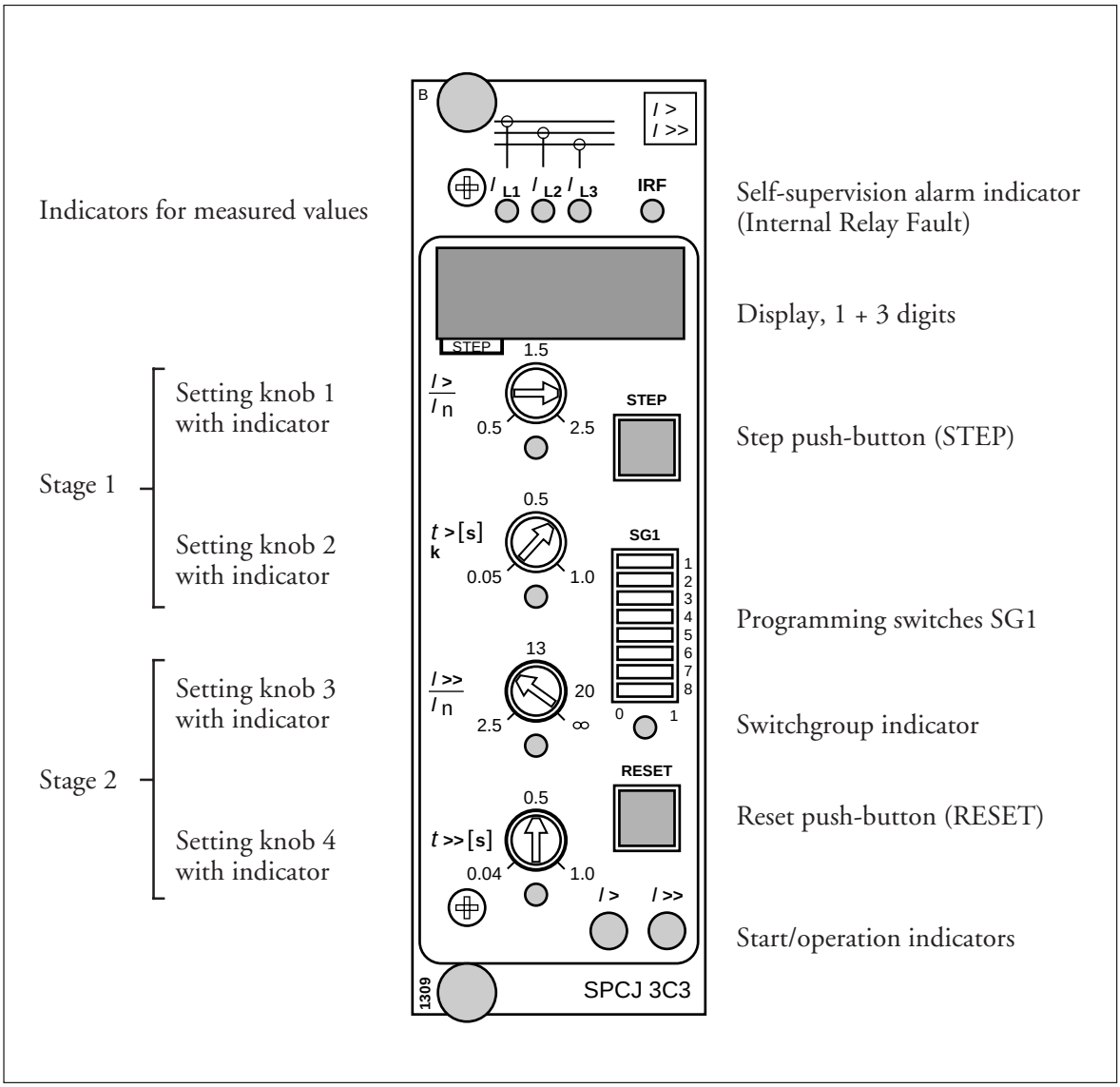
Shortly after that the self-supervision system has detected a permanent internal fault the red IRF indicator is lit. Simultaneously the relay module puts forward a control signal to the output relay of the self-supervision system. In most fault situations an autodiagnostic fault code appears on the display of the module. The fault code consists of a red number 1 (one), and a green, three digit code number. When a fault is detected the fault code should be recorded for further use when the relay module is to be repaired.

Some of the fault codes that may appear on the display of the directional neutral overcurrent relay module SPCS 3C4 are shown in the following list:

Fault code	Type of fault
4	Output relay control circuit interrupted or output relay module missing
30	Red Only Memory (ROM) damaged
50	Random Access Memory (RAM) damaged
195	Too low a value on reference channel with multiplier 1
131	Too low a value on reference channel with multiplier 5
67	Too low a value on reference channel with multiplier 25
203	Too high a value on reference channel with multiplier 1
139	Too high a value on reference channel with multiplier 5
75	Too high a value on reference channel with multiplier 25
253	No interruptions from the A/D converter

General characteristics of C-type relay modules

User´s manual and Technical description



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General characteristics of C-type relay modules

Contents

Push-buttons

The front panel of the relay module contains two push-buttons. The STEP button is used for stepping forward in the display and the RESET button for resetting the red indicators. Additionally, the push-buttons are used for certain settings, e.g. for setting the address of the relay module and the data transfer rate for the serial communication when the modules are used in relay packages provided with this quality. (See section Display).

Programming switches SG1

Part of the settings and the selections of the operating characteristics for the relay modules in various applications are made with the programming switches SG1 on the front panel. The indicator of the switchgroup glows when the checksum of the switchgroup is shown on the display. The checksum can be used for checking that the switches are properly set. Fig. 2 gives an example of calculating the checksum.

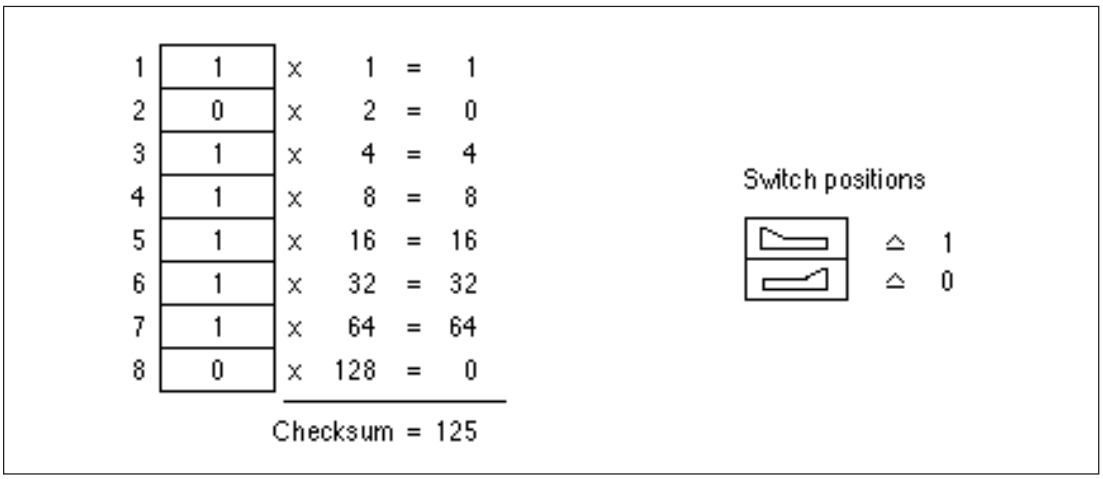


Fig. 2. Example of calculating the checksum of programming switchgroup SG1.

When the checksum calculated according to the example is equal to the checksum indicated on the display of the relay module, the switches are properly set.

The function of the programming switches of the individual measuring relay modules is specified in the description of the module concerned.

Setting knobs

Most of the operating values and operating times are set by means of the setting knobs on the front panel of the relay module. Each setting knob has its own (LED) indicator which glows when the concerned setting value is shown on the display.

If a setting knob is turned while the display is showing another measured or set value, the value being set automatically appears on the display. Simultaneously, the indicator for the concerned setting starts glowing.

In addition to the settings made with the setting knobs, most modules allow so called remote setting. This means that the settings made by means of the setting knobs of the module and the checksum of the programming switchgroup may be altered through an instruction over the serial communication bus. Remote setting is possible if the password in the register A is known, and the remote settings are not activated, i.e. parameter V150=0. The circumstance that the remote settings are activated is shown with a flashing light of the indicator of the setting knob, the value of which currently is being displayed.

Display

The measured and set values as well as the data recorded are shown on the display of the measuring relay module. The display consists of four digits. The three digits (green) to the right indicate the measured, set or stored value and the digit at the extreme left (red) the number of the register. The measured or set value displayed is indicated by a yellow LED indicator. The number of the register glows only when a stored value is displayed.

When the auxiliary voltage is connected to a measuring relay module, the module initially tests the display by stepping through the digits 1...9 for about 15 seconds. When the test is finished the display turns dark. The testing can be interrupted by pressing the STEP button. The protective functions of the module are operative throughout the testing.

Display main menu

All the data required during normal operating conditions are accessible from the main menu which presents the measured values in real-time, the normal setting knob settings as well as the most important memorized data.

The data to be shown in the main menu are selected to the display in a certain sequence by means of the STEP button. When pressing the STEP button for about one second, the display moves forward in the display sequence. When pressing it for about 0.5 seconds, the display moves backwards in the display sequence.

From a dark display only forward movement is possible. When keeping the STEP button depressed, the display is continuously moving in forward direction stopping for a while at the dark point.

Unless the display is switched off by stepping to the dark point, it remains activated for about 5 minutes from the last pressing of the STEP button and then goes out.

Display submenu

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 module.

A submenu is entered from the main menu by pressing the RESET button for about one second. When the button thereafter is released, the red digit (STEP) of the display starts flashing, indicating that one is in a submenu. 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 pressing the STEP button for one second and backward when pressing it for 0.5 seconds. The return to the main menu has taken place when the red STEP display turns dark.

When entering a submenu from a measured or set value indicated by a LED indicator, the indicator remains glowing and the address window (STEP) of the display starts flashing. A flashing address window when no LED indicator is lit indicates that the submenu of a register has been entered.

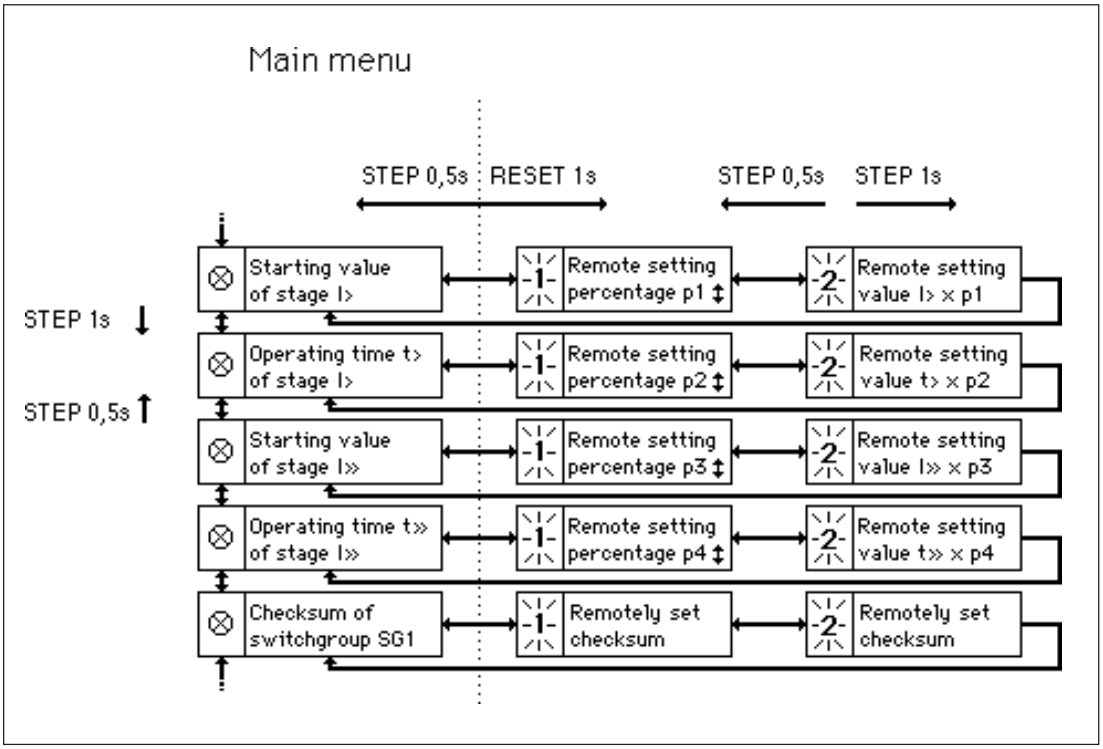


Fig. 3. Example of the main and submenus for the settings of the overcurrent relay module SPCJ 3C3. The settings made with the setting knobs are in the main menu and they are displayed by pressing the STEP button. In addition to the setting knob settings the main menu contains the measured current values as well as the registers 1…5, as well as 0 and A. The remote setting percentage and remote setting value are located in the submenus for the settings and are activated on the display by pressing the RESET button.

Setting mode

The registers of the main menu and the submenus also contain parameters to 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 RESET button, until the digit at the extreme right starts flashing (about 10 s). The flashing digit is set by means of the STEP button. The flashing is moved on from digit to digit by pressing the RESET button.

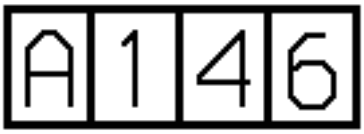
A set value is stored in the memory by pressing the push-buttons STEP and RESET simultaneously. In practice the RESET button must be pressed slightly in excess of the STEP button. Return from the setting mode to the main menu or submenu is possible by pressing (for about 10 s) the RESET button until the green digits on the display stop flashing. If the module is left in the setting mode, it will return automatically to the start condition after about 5 minutes.

The values to be set in the setting mode are for instance the address code of the relay module and the data transfer rate for the serial communication. Further the percentage values for the remote settings can be changed.

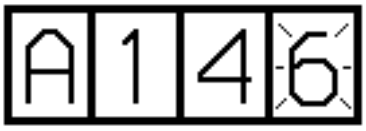
Example 1:

Function in the setting mode. Manual setting of the address code of a relay module and the data transfer rate for the serial communication. The initial value for the address code is 146.

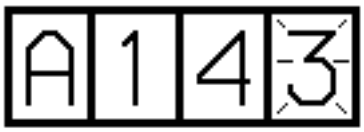
a)
Press push-button STEP until register address A appears on the display.



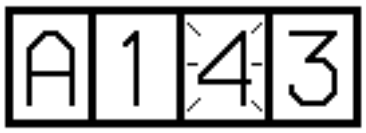
b)
Press the RESET button for about 10 s until the right most digit starts flashing.



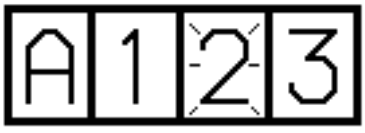
c)
Press the STEP button repeatedly to set the digit to the value desired.



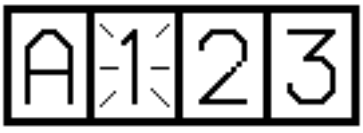
d)
Press the RESET button to make the middle of the green digits flash.



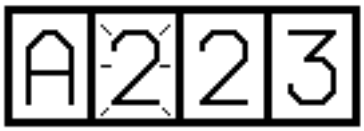
e)
Set the middle address digit by means of the STEP button.



f)
Press the RESET button to make the left most green digit flash.

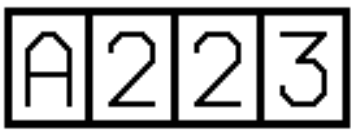


g)
Set the digit by means of the STEP button.



h)
Store the set address number in the memory of the relay module by pressing the RESET and STEP button simultaneously. At the moment the information enters the memory, the three green dashes flash in the display, i.e. A—.

i)
Leave the setting mode by pressing the RESET button for about 10 s, until the display stops flashing.



j)
Then enter submenu 1 of register A by pressing the RESET button for approx. one second. The register address A is then replaced by a flashing 1. This submenu is used for setting the data transfer rate of the serial communication.

k)
The data transfer rate for the serial communication is set and stored in the same way as the address, see sections b...i, except that the continuously glowing register address has been replaced by a flashing 1.

l)
After storing the data transfer rate for the serial communication you may return to the main menu of register A by pressing the STEP button for about 0.5 second.

Stored information

The parameter values measured at the moment when a fault occurs are recorded in the registers, in some modules also the setting values. The recorded data, except for some setting parameters, are set to zero by pressing the push-buttons STEP and RESET simul-taneously. The data in normal registers are erased if the auxiliary voltage supply to the relay is disrupted, only the set values and the number of autoreclosings are maintained in the registers at a voltage failure.

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

All C-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 and status information for the circuit breaker. The codes are explained in the descriptions of the relay modules.

Register A contains the address code of the relay module as required by the serial communication system. Example 1 on page 4 shows how the address code is altered. Submenu 1 of register A contains the data transfer rate value expressed in kilobaud for the serial communication.

Submenu 2 of register A contains a bus traffic monitor for the SPACOM system. If the protective relay, which contains the relay module, is linked to a system including the control data communicator and the data communication system is operating, the counter reading of the monitor will be zero. Otherwise the digits 1...255 are continuously rolling in the monitor.

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

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

Trip-test mode

Register 0 also allows access to the so called 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 will be included in the testing.

When pressing the RESET button for about 10 seconds, the three green digits to the right start flashing to indicate that the relay module is in test position. The indicators of the setting knobs indicate by flashing which output signal can be activated. The required output function is selected by pressing the RESET button for about 1 second, until the following LED indicator starts flashing.

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

Setting knob 1	SS1	Starting of stage 1
Setting knob 2	TS1	Tripping of stage 1
Setting knob 3	SS2	Starting of stage 2
Setting knob 4	TS2	Tripping of stage 2
No indication	IRF	Self-supervision

The selected starting or tripping is activated by simultaneous pressing of the push-buttons STEP and RESET. The signal remains activated as long as the two push-buttons are being pressed.

The self-supervision output is activated by pressing the STEP button once when no setting knob indicator is flashing. The IRF output is activated in about 5 seconds after pressing of the STEP button, and resets after that. Simultaneously, the display returns to the main menu and performs the initial testing indicated by rolling digits 0...9 in the display several times.

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

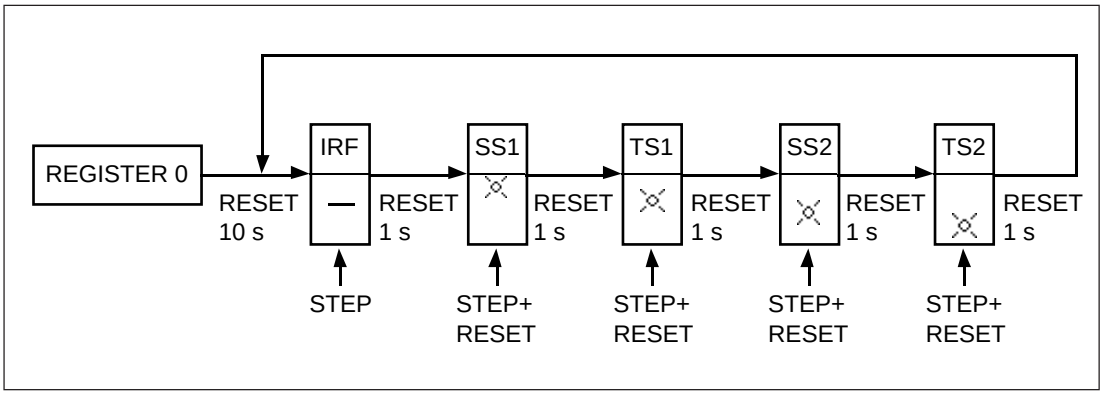


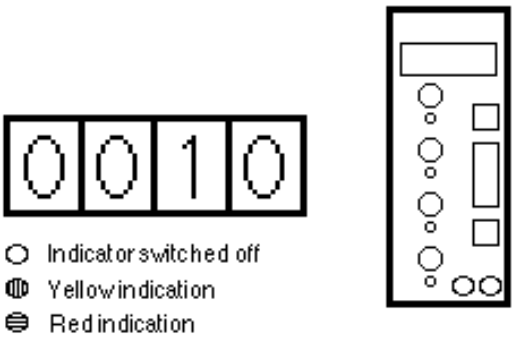
Fig. 4. Sequence order for selecting the output signals in the Trip-test mode.

If e.g. the indicator of the setting knob 2 (second from the top) is flashing, and the push-buttons STEP and RESET are being pressed, the signal TS1 (tripping of stage 1) is activated. Return to the main menu is possible at any stage of the Trip-test sequence scheme, by pressing the RESET button for about 10 seconds. If the module is left in the Trip-test mode, it will return automatically after approx. 5 minutes.

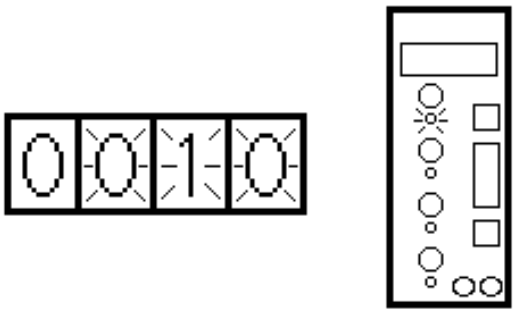
Example 2:

Trip-test function. Forced activation of the outputs is made as follows:

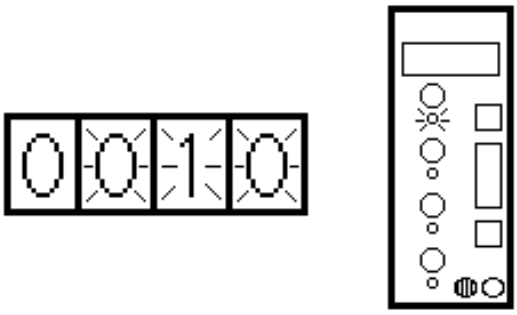
a)
Step forward on the display to register 0.



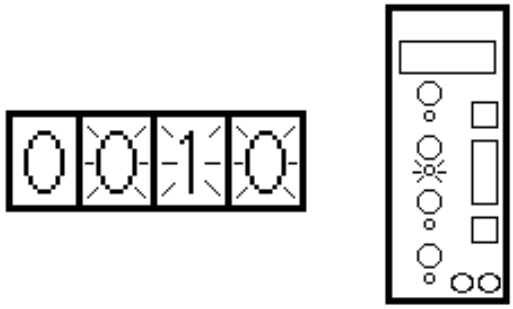
b)
Press the RESET button for about 10 seconds until the three green digits to the right and the LED indicator of the uppermost setting knob start flashing.



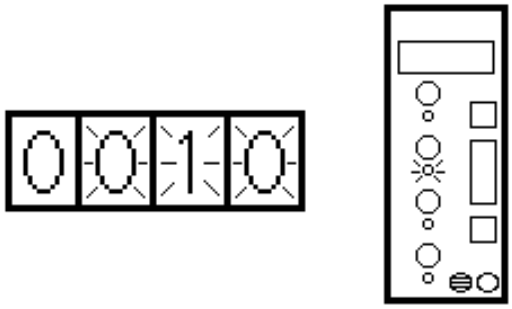
c)
Press the push-buttons RESET and STEP simultaneously. Then the starting of stage 1 (e.g. the I>-stage of the overcurrent module SPCJ 3C3) is activated and, simultaneously, the indicator of the stage starts glowing yellow.



d)
Press the RESET button for about 1 second until the indicator of the second setting knob starts flashing.



e)
Press the push-buttons RESET and STEP simultaneously to activate tripping of stage 1 (e.g. the I>-stage of the overcurrent module SPCJ 3C3). The indicator of the concerned stage starts glowing red.



f)
Starting and tripping of the second stage is activated in the same way as stage 1. The indicator of the third or fourth setting starts flashing to indicate that the concerned stage has been activated.

g)
To activate the self-supervision output step towards the test position, where no indicator is flashing. Press the STEP button once. In about 5 seconds the red IRF indicator starts glowing and the IRF output is activated. Shortly thereafter the indicator goes out and the output automatically resets. At the same time the module leaves the test position.

h)
It is possible to leave the trip test mode at any step of the sequence scheme by pressing the RESET button for about 10 seconds until the three digits to the right stop flashing.

Operation indicators

A measuring relay module is provided with two separate operating stages, each of which with its own yellow/red operation indicator on the lower part of the front plate of the relay module.

The operation indicator starts glowing yellow when the operating stage starts and red when a delayed tripping operates. The functions of the start and operation indicators are described in detail in the different protection relay module manuals.

Fault codes

In addition to the protective 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.

When the self-supervision system has detected a permanent fault in the relay module, the red IRF indicator on the panel starts glowing soon after the fault was discovered. At the same time the module puts forward a signal to the self-supervision contact of the relay assembly.

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 digit (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.

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