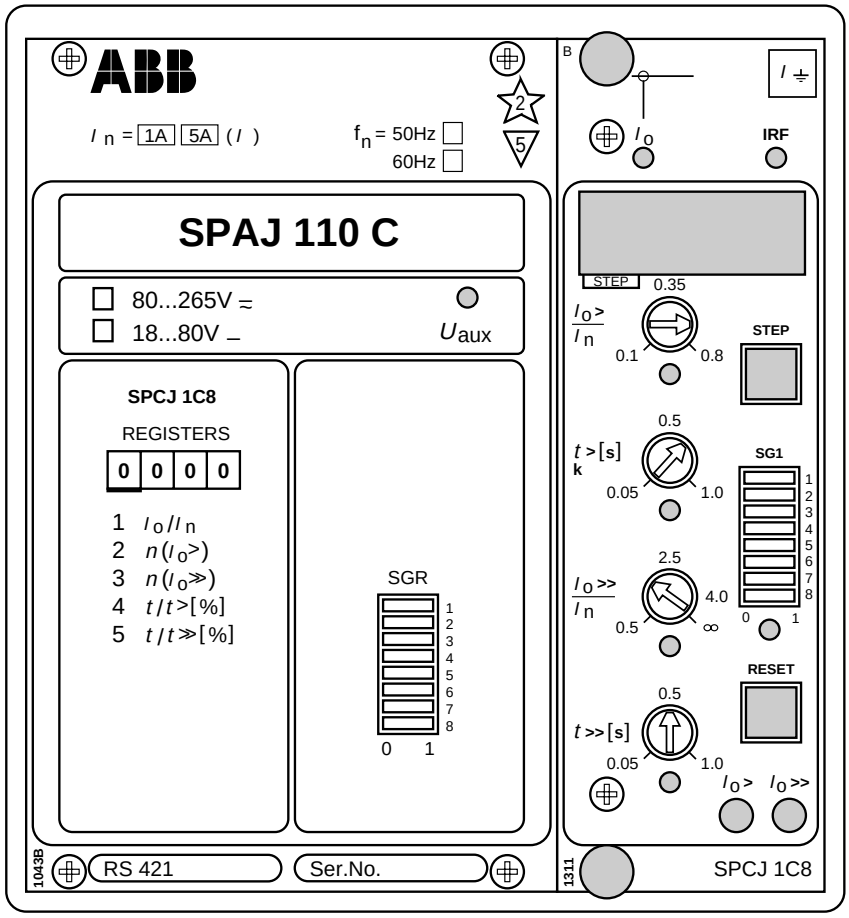
SPAJ 110 C
Earth-fault relay

User´s manual and Technical description



1MRS 750801-MUM EN

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SPAJ 110 C
Earth-fault relay

Contents

The complete manual for the earth-fault relay SPAJ 110 C includes the following partial manuals:

Earth-fault relay SPAJ 110 C, general part	1MRS 750801-MUM EN
Non-directional earth-fault relay module SPCJ 1C8	1MRS 750603-MUM EN
General characteristics of C-type relay modules	1MRS 750328-MUM EN

Features

Low-set neutral overcurrent stage with definite time or inverse time characteristic

High-set neutral overcurrent stage with definite time characteristic

Output relay functions to be freely configured

Flexible adaptation to different types of application

Serial interface for connecting the relay to a fibre optic object bus and substation and network control systems

Digital display of setting values, neutral current measured, memorized fault values, etc.

Continuous self-supervision with auto-diagnostics of hardware and software

Application

The earth-fault relay SPAJ 110 C is designed to be used for selective earth-fault protection, either primary or back-up protection, in solidly earthed or low-resistance earthed power systems.

The relay has two protection stages: a low-set overcurrent stage $I_0>$ and a high-set overcurrent stage $I_0>>$. The low-set stage operates with definite-time characteristic or with inverse-time characteristic, while the high-set stage operates with definite time characteristic only. The earth-fault relay is used both as primary and back-up earth-fault protection relay for feeders, transformers, generators and motors. The relay can be configured to cooperate with a residual voltage relay used for blocking/deblocking the operation of the earth-fault relay.

Description of operation

The earth-fault relay SPAJ 110 C is a secondary relay that is connected to the current transformers of the object to be protected. The earth-fault current can be measured either via a set of three phase current transformers in a residual current connection or a window-type core-balance current transformer. When a core-balance current transformer is used, it should be secured that the repeatability of the current transformer is sufficient also at high earth-fault currents. 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 current exceeds the set start value $I_0>$ of the low-set stage, the earth-fault relay starts. When, at definite time operation, the set operate time t> or, at IDMT operation, the calculated operate time t>, expires, the relay operates. In the same way the high-set stage starts once its set start value $I_0>>$ is exceeded and, when the set operate time t>> expires, the relay operates.

The low-set stage of the earth-fault relay can be given either definite-time or inverse-time characteristic. At inverse time characteristic four inverse time curve sets with different degrees of inversity are available: Normal inverse, Very inverse, Extremely inverse and Long-time inverse. These curve sets comply with the BS 142 and IEC 60255 standards.

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

The relay contains one optically isolated logic input for incoming external control signals, generally blocking signals.

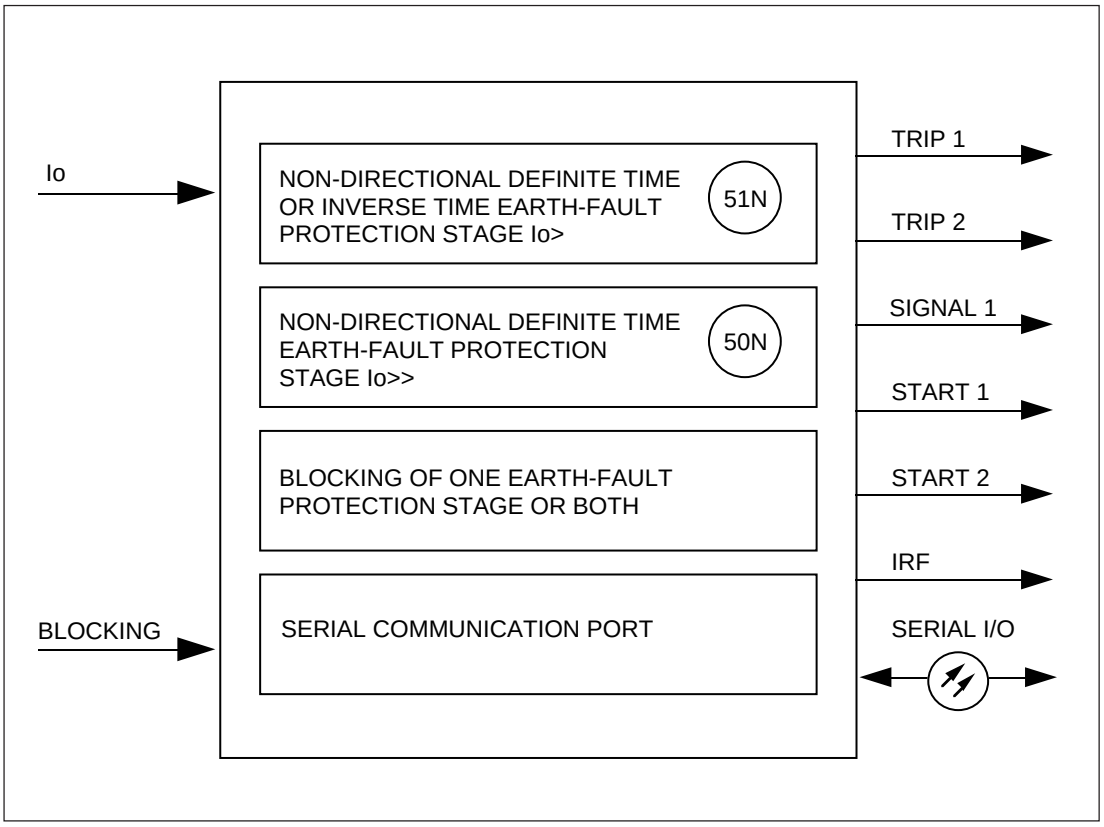


Fig. 1. Protection functions of the earth-fault relay SPAJ 110 C. The encircled numbers refer to the ANSI (=American National Standards Institute) number of the concerned protection function.

Connections

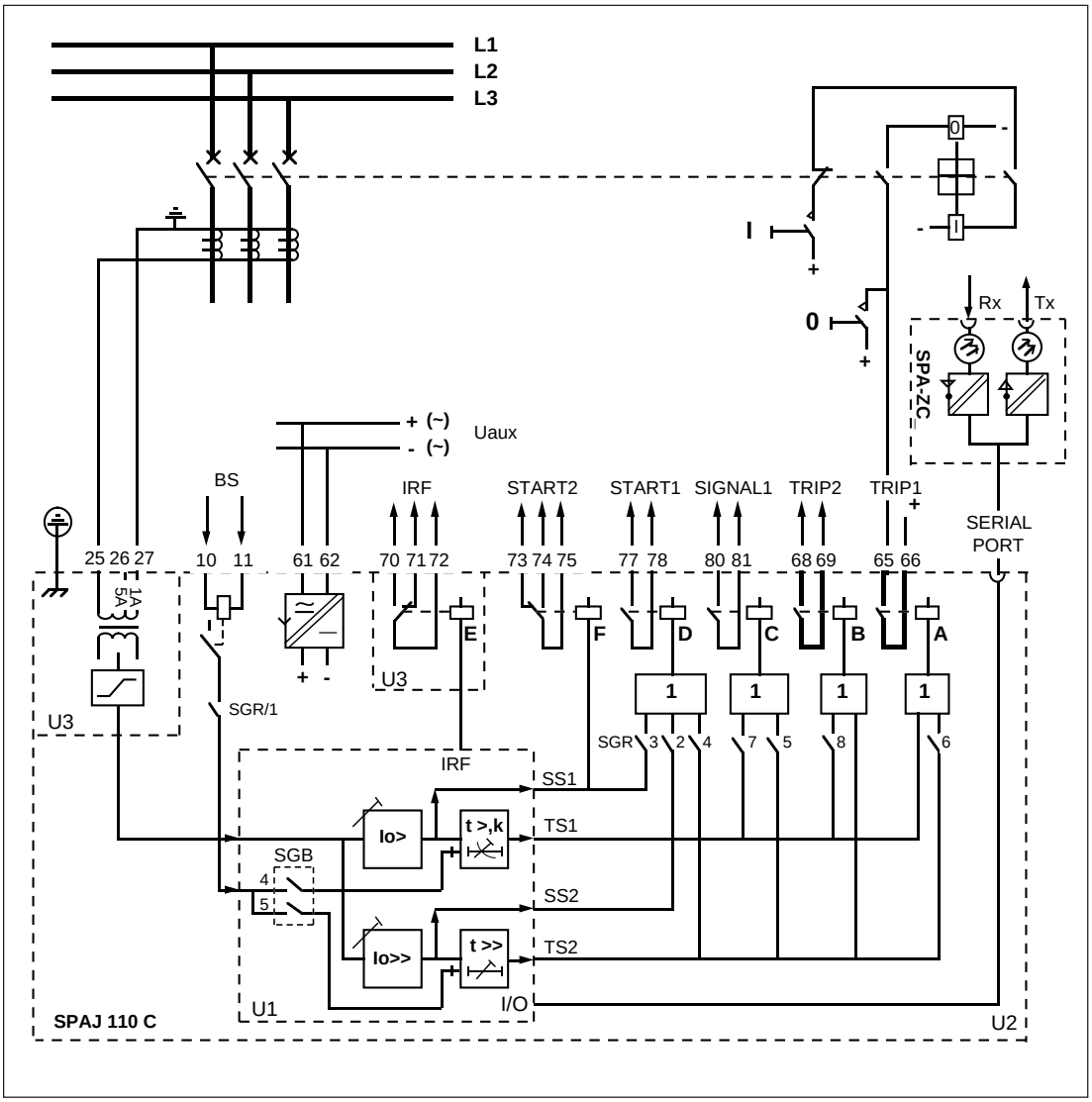


Fig. 2. Connection diagram for the earth-fault relay SPAJ 110 C.

U_{aux}	Auxiliary voltage
A, B, C, D, E, F	Output relays
IRF	Self-supervision function
BS	Blocking signal
SS	Start signal
TS	Trip signal
SGR	Switchgroup for configuring trip 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	Non-directional earth-fault relay module SPCJ 1C8
U2	Power supply and I/O module SPTU 240S1 or SPTU 48S1
U3	I/O module SPTE 1E12
SERIAL PORT	Serial communication port
SPA-ZC_	Bus connection module
Rx/Tx	Optical-fibre receiver (Rx) and transmitter (Tx) of the bus connection module

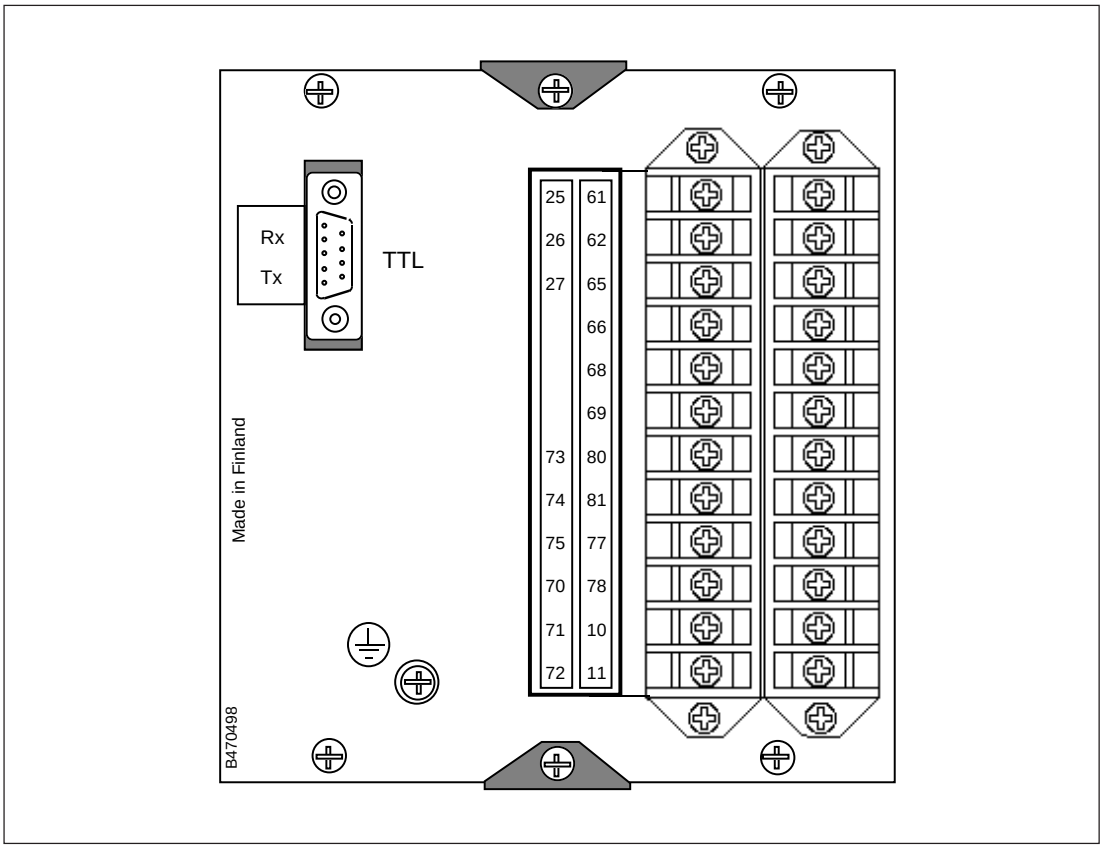


Fig.3. Rear view of earth-fault relay SPAJ 110 C.

Specification of input and output terminals

Contacts	Function
25-26	Neutral current I_0 (I_n = 5 A)
25-27	Neutral current I_0 (I_n = 1 A)
10-11	External blocking signal (BS)
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 I_0> and I_0>> (TRIP 1)
68-69	Trip output 2 for stages I_0> and I_0>> (TRIP 2)
80-81	Signal on tripping of stages I_0> and I_0>> (SIGNAL 1)
77-78	Signal on tripping of stage I_0>>, start of stages I_0> and I_0>> (START 1)
73-74-75	Start of stage I_0> (START 2). Under normal conditions the contact interval 73-75 is closed. When stage I_0> 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 earth-fault relay SPAJ 110 C is connected to the fibre optic data communication bus by means of the bus connection module SPA-ZC 17 or SPA-ZC 21.

The bus connection module is fitted to the D-type connector (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 on the bus connection module.

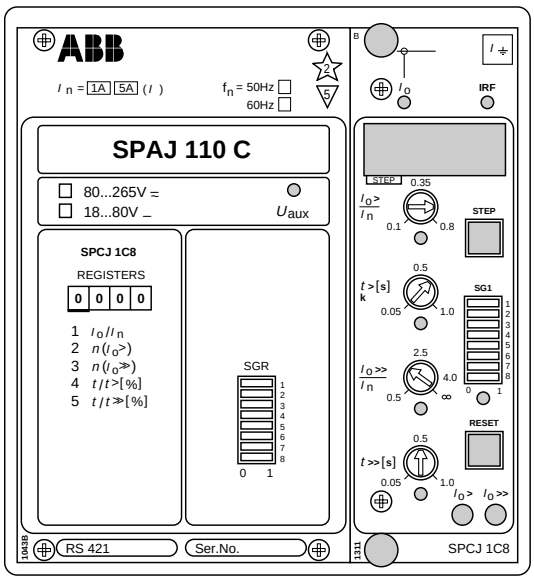
Configuration of output relays

The start signal of the I_0> stage is firmly/solidly wired to output relay F and the trip signal to output relay A. The trip signal of the I_0>> stage is wired to output relay A. In addition, the following functions can be selected with the switches of the SGR switchgroup on the front panel:

Switch	Function	Factory setting
SGR/1	Routes the external blocking signal to the neutral current module	1
SGR/2	Routes the start signal of stage I_0>> to output relay D	1
SGR/3	Routes the start signal of stage I_0> to output relay D	1
SGR/4	Routes the trip signal of stage I_0>> to output relay D	1
SGR/5	Routes the trip signal of stage I_0>> to output relay C	1
SGR/6	Routes the trip signal of stage I_0>> to output relay A	1
SGR/7	Routes the trip signal of stage I_0> to output relay C	1
SGR/8	Routes the trip signal of stage I_0> to output relay B	1

The circuit breakers can be operated directly both with output relay A or output relay B. Thus either operation stage may have its own output relay or two separate circuit breakers can be operated with the same protection relay.

Start and operation indicators



1. Either current stage has its own operation indicator (I_0> and I_0>>), 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 (I_0) on the upper black part of the front plate indicates, when lit, that the value of the neutral current I_0 is currently 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 appearing on the display once a fault has been detected should be recorded and notified when service is ordered.

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

5. The LED indicator below a setting knob indicates, when lit, that the 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 more detailed in manual for the non-directional earth-faut relay module SPCJ 1C8.

Combined 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, placed 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 which have 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 voltage range of the power supply and I/O module inserted in the relay is marked on the system front panel of the relay.

Technical data
(modified 2002-04)

Energizing inputs

	1 A	5 A
Terminals	25-27	25-26
Rated current I_n	1 A	5 A
Thermal withstand capability		
Carry continuously	4 A	20 A
Make and carry for 10 s	25 A	100 A
Make and carry for 1 s	100 A	500 A
Dynamic current withstand capability, half-wave value	250 A	1250 A
Input impedance	<100 mΩ	<20mΩ
Rated frequency f_n acc. to order	50 Hz or 60 Hz	

Output contact ratings

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

Terminals	10-11
Control voltage level	18...265 V dc or 80...265 V ac
Current consumption when input activated	2...20 mA

Auxiliary supply voltage

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

Non-directional earth-fault relay module SPCJ 1C8

Low-set stage I_0>	
Start current I_0>, setting range	0.1...0.8 x I_n
Selectable modes of operation	
- definite time characteristic	
- operate time t>	0.05...100 s
- inverse definite minimum time (IDMT) characteristic	
- curve sets acc. to IEC 60255-3 and BS 142	Normal inverse Very inverse Extremely inverse Long-time inverse
- time multiplier k	0.05...1.00
High-set stage I_0>>	
Start current I_0>>, setting range	0.1...4.0 x I_n and ∞, infinite
Operate time t>>	0.05...100 s

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

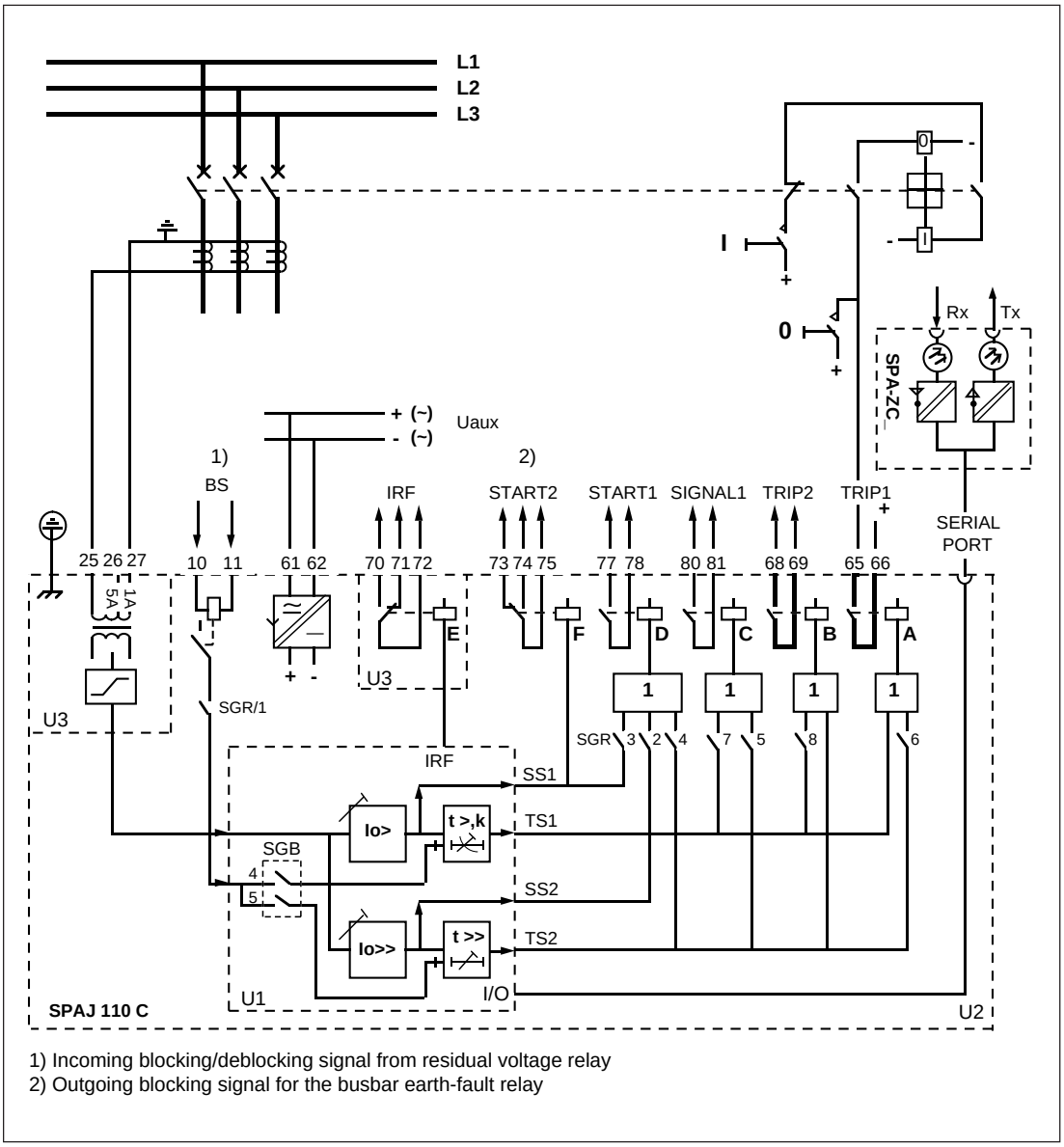


Fig. 4. Earth-fault relay SPAJ 110 C used for the earth fault protection of a feeder.

The earth-fault relay SPAJ 110 C is used for two-stage non-directional earth fault protection of a feeder. The neutral current can be measured either via a set of three phase current transformers in residual current connection or a core-balance current transformer.

The residual current connection is obtained by parallelling the secondary sides of the phase current transformers. The accuracy of the residual current connection depends on electrical similarity of the current transformers. To secure selectivity and stability at high fault current levels, current transformers with high accuracy limit factors are recommended especially if the high-set stage is to operate instantaneously.

The residual current connection can be used in cases with high earth-fault current magnitudes, moderate sensitivity requirements and low current transformer ratios. In solidly earthed networks or networks earthed over a low-resistance resistor or low-impedance coil, the earth-fault current is high enough to guarantee a sufficient accuracy of the residual current connection for measuring the earth-fault current.

Generally, the earth-fault relay SPAJ 110 C requires no blocking from a cooperating residual voltage relay. However, when required, the stability of the earth-fault relay can be secured with a blocking signal obtained from the residual voltage relay of the busbar system. Then, during a no-fault situation, the earth-fault relays of the feeders are blocked by the residual voltage relay. When an earth-fault arises on a feeder the feeder earth-fault relay starts but does not operate until deblocked by the residual voltage relay, when it starts. This blocking function is used to prevent spurious operation of the earth-fault relay, for instance, due to partial saturation of a phase current transformer.

The low-set stage of the earth-fault relay module can be given definite-time or inverse-time characteristic. The high-set stage can be used for instantaneous operation. In the above example the start signal of the low-set stage is used for blocking the earth-fault relay of the infeeder, also functioning as busbar earth-fault relay, see also example 2.

The function selector switches of the earth-fault relay SPAJ 110 C can be set as follows:

Switch	SG1/SPCJ 1C8	SGB/SPCJ 1C8	SGR
1	1 } Very inverse	0 Not in use	1 Block. signal from res. volt. relay
2	0 }	0 Not in use	1 I_0>> start signal to output relay D
3	1 Inverse time	0 Not in use	0 No I_0> start sign. to output relay D
4	0 No latching	1 Blocking to t>	0 No I_0>> trip sign. to output relay D
5	0 I_0>> no doubling	0 No blocking to t>>	0 No I_0>> trip sign. to output relay C
6	0 I_0>>=0.5...4 x I_n	0 Not in use	1 I_0>> trip signal to output relay A
7	0 } t>>=0.05...1 s	0 Not in use	1 I_0> trip signal to output relay C
8	0 }	0 Not in use	0 No I_0> trip signal to output relay B
Σ	5		

When the switches are set as above, the output contacts of SPAJ 110 C carry the following signals:

Contact	Function
65-66	Circuit breaker trip signal, stages I_0>, I_0>>
68-69	Signal on final trip, stage I_0>>
80-81	Signal on final trip of stage I_0>
77-78	Start signal of stage I_0>>
73-74-75	Start signal of stage I_0> , blocking signal to the earth-fault relay of the busbar system
70-71-72	Self-supervision signal

Example 2.
Earth-fault protection of infeeder and busbar system, back-up protection of feeders

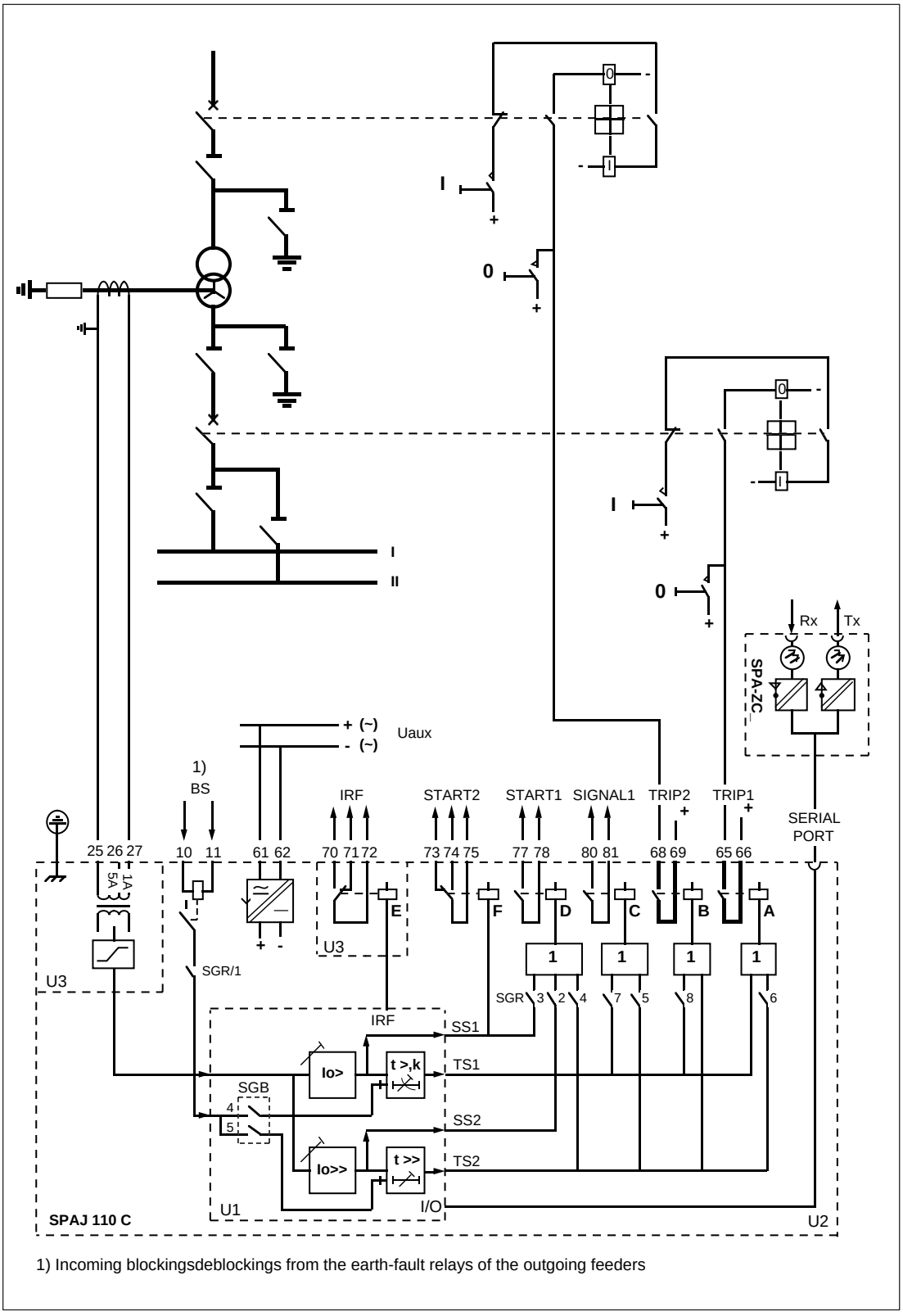


Fig. 5. Earth-fault relay SPAJ 110 C for the earth-fault protection of an infeeder and back-up protection of outgoing feeders.

The low-set stage of the earth-fault relay serves as back-up protection for the outgoing feeders and the high-set stage as primary earth-fault protection of the busbar system. If the earth-fault occurs on an outgoing feeder, the earth-fault relay of the outgoing feeder delivers a blocking signal to the earth-fault relay of the infeeder on starting. Should the earth-fault occur on the busbar system or in the infeeder cubicle, no blocking signal is obtained and the earth-fault relay of the infeeder operates. The incoming blocking signals are linked to the high-set stage of the earth fault relay of the infeeder with the SGB/5 switch on the PC board of the earth-fault relay module SPCJ 1C8 of the infeeder earth-fault relay.

The neutral current is measured via a current transformer located in the neutral earthing circuit on the LV side of the power transformer.

On operation the high-set stage of the earth-fault relay trips the circuit breaker on the HV side of the power transformer. Thus an earth-fault on the busbar system is rapidly disconnected. The low-set stage trips the circuit breaker on the LV side of the power transformer. This allows operate times of down to 100 ms at busbar earth-faults.

In the above example the trip relay has been given a latching function (SG1/4=1). The trip relay can be manually reset from the front panel of the relay, or via a command over the serial bus.

The function selector switches of the earth-fault relay SPAJ 110 C can be set as follows:

Switch	SG1/SPCJ 1C8	SGB/SPCJ 1C8	SGR
1	1 } Very inverse	0 Not in use	1 Blocking signal from feeders
2	0 }	0 Not in use	0 No I_0>> start sign. to output relay D
3	1 Inverse time	0 Not in use	0 No I_0> start signal to output relay D
4	1 Latching	0 No blocking to t>	1 I_0>> trip signal to output relay D
5	0 No I_0>> doubling	1 Blocking to t>>	0 No I_0>> trip signal to output relay C
6	1 I_0>>=0.1...0.8 x I_n	0 Not in use	0 No I_0>> trip signal to output relay A
7	0 } t>>=0.05...1 s	0 Not in use	1 I_0> trip signal to output relay C
8	0 }	0 Not in use	0 No I_0> trip signal to output relay B
Σ	45		

When the switches are set as above, the output contacts of SPAJ 110 C have the following functions:

Contact	Function
65-66	LV side circuit breaker trip signal, stage I_0>
68-69	HV side circuit breaker trip signal, stage I_0>>
80-81	Signal on final trip of stage I_0>
77-78	Signal on final trip of stage I_0>>
73-74-75	Start signal of stage I_0>
70-71-72	Self-supervision signal

Recorded data and fault analysis

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 stores the maximum measured neutral current of the relay as a multiple of the rated current of the energizing input used. If the relay operates, the current measured at the moment of operation is memorized. A new relay operation erases the previous value from the register and updates the register contents. The register is also erased and updated whenever the measured current exceeds the currently recorded value.

The level of the neutral current value recorded in a fault situation shows the degree of development of the earth fault. The data of register 1 also show how close the relay's start current is to the actual fault current value.

Correspondingly the ratio between the set start current and the current values during normal operation can be determined by reading the normal current values via the display of the relay.

The number of times the different stages have started, registers 2 and 3, provides information on the occurrence of earth-faults and information on the distribution of earth-faults in respect of the fault resistance. Frequent starts may be a sign of an imminent earth-fault or some kind of disturbance apt to cause an earth-fault.

Registers 4 and 5 show the duration of the latest start situation of the stages, expressed in per cent of the set operate time or, at inverse time operation the calculated operate time. Any new start resets the counter, which restarts from zero. If the stage operates, the register value will be 100.

The registers 4 and 5 give 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. If, for instance, the value of register 4 of the busbar earth-fault relay operating as feeder back-up protection is 75 when the earth-fault relay of the feeder has operated, the safety margin between the primary protection and the back-up protection is 25%.

The registers 1...5 are reset either by pressing the STEP and RESET push-buttons simultaneously or with a command, V102, over 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.

To enable secondary injection testing the relay has to be disconnected, either through disconnectable terminal blocks or a test plug 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 includes 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 voltage transformer 0...260 V, 1 A
- current transformer
- ammeter, accuracy ±0.5%
- 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".

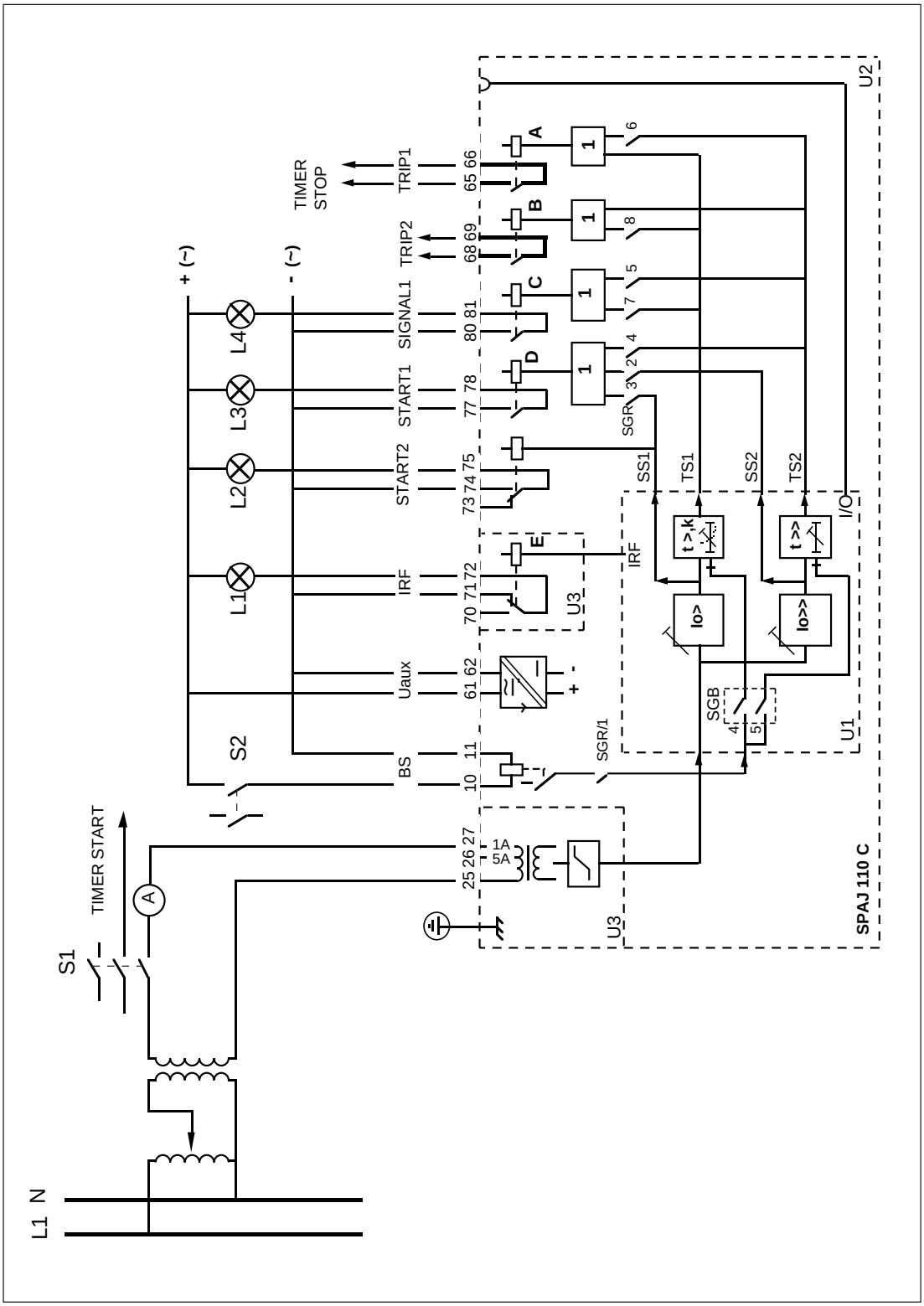


Fig. 6. Secondary injection test connection for earth-fault relay SPAJ 110 C.

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 using a multimeter.

Testing of internal matching transformers

Apply a pure sinusoidal voltage to the relay and compare the current value indicated on the display of the relay with that shown by the ammeter. The measurements can be made, for instance, at the rated current of the relay. Note that the relay shows the measured current as a multiple of the rated current I_n of the energizing input used.

Testing of the low-set stage I_0>

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

When the switches are set as above, the output relays have the following functions.

Output relays (terminals)	Function
A (65-66)	Trip signal of stage I_0>
B (68-69)	(Trip signal of stage I_0>>)
C (80-81)	Signal on trip of stage I_0>>
D (77-78)	Not in use
E (71-72)	Self-supervision signal (L1)
F (74-75)	Start signal of stage I_0> (L2)

Starting

Carry out the test according to Fig. 6. Close the S1 switch and increase the test current slowly until the relay starts (L2 is lit). Then read the start current value indicated by the ammeter.

Operate time

Definite-time characteristic

Set the test current at 2 x the set start value of stage I_0>. The clock is started by the closing of 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 I_0> LED in the right bottom corner of the front panel is lit with yellow light. When the relay operates, the indicator LED turns red.

Inverse time characteristic

At inverse-time characteristic, the operate time is measured with two different test current values (2 x I_0> and 10 x I_0>). The operate times thus obtained are compared with the operate times received from the current/time curves for the concerned inverse-time characteristic.

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 S2. Increase the test current until the low-set stage I_0> starts. After the set operate time the low-set stage is not allowed to operate as long as the blocking is active.

Testing of the high-set stage I_0>>

Set the switches of the SGR switchgroup on the front panel as follows before starting the test of the high-set stage:

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

When the switches are set as above, the output relays have the following functions

Output relays (terminals)	Function
A (65-66)	(Operation of stage I_0>)
B (68-69)	Operation of stage I_0>>
C (80-81)	Signal on trip of stage I_0>> (L4)
D (77-78)	Start signal of stage I_0>> (L3)
E (71-72)	Self-supervision signal (L1)
F (74-75)	(Start signal of stage I_0>)

The test procedure is the same as for the low-set stage, but with the exception that, when the operate times are measured, the clock is stopped via contact 68-69, output relay B.

Note!
The current carrying capacity of the wiring, terminals and matching transformers of the relay is limited, see chapter "Technical data". The test wires should have an cross-section of 4 mm^2. Then 100 A is allowed to be connected for max. 1 s to a 1 A energizing input and for max. 10 s to a 5 A energizing input.

Testing of 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 on 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 liable to serious 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.

Spare parts

Non-directional earth-fault relay module	SPCJ 1C8
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 1E12
I/O module	SPTE 1E12
Bus connection module	SPA-ZC 17_ or SPA-ZC 21_

Ordering numbers

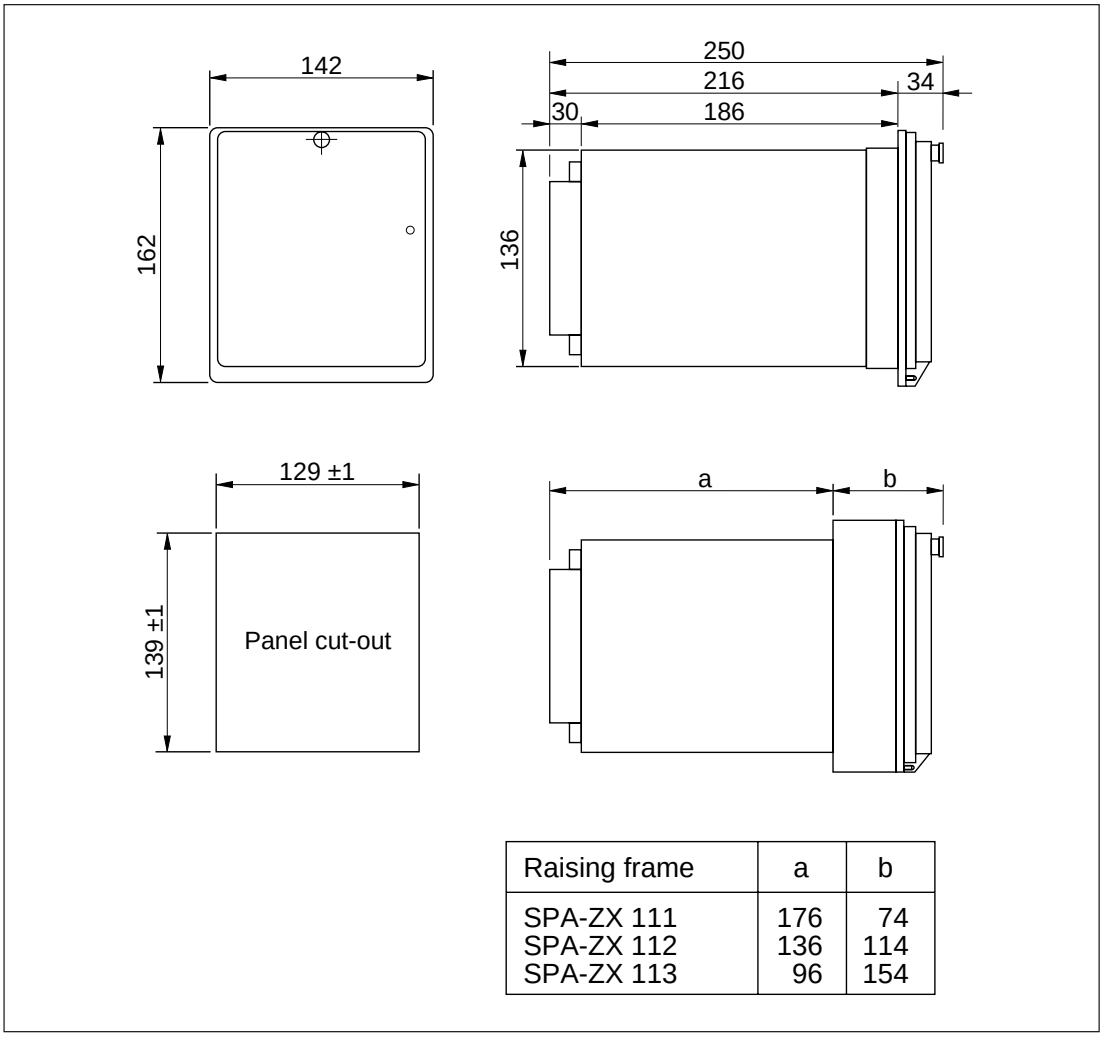
Earth-fault relay without test adapter SPAJ 110 C	RS 421 010 -AA, CA, DA, FA
Earth-fault relay with test adapter RTXP 18 SPAJ 110 C	RS 421 210 -AA, CA, DA, FA

The two last 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 instructions for mounting

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



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

Fig. 7. Dimensions of the earth-fault relay SPAJ 110 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 relay case and 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 along the edge of the cover provides an IP54 degree of protection between the case and the cover.

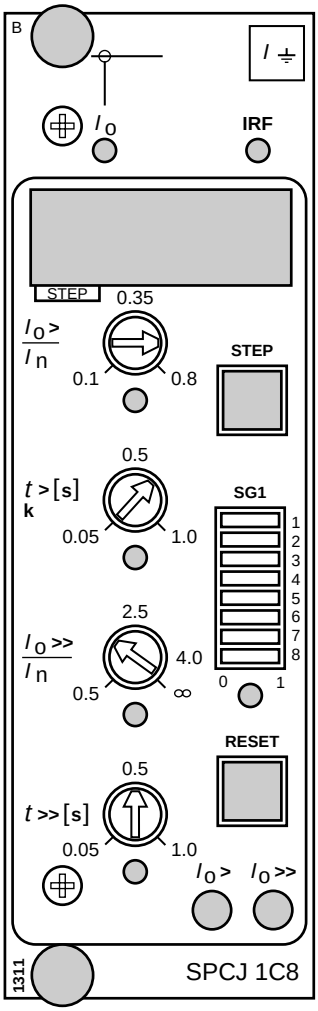
All input and output wires are connected to the screw terminal blocks on the rear panel. Each terminal is dimensioned for one max. 6 mm^2 wire or two max. 2.5 mm^2 wires. The D-type connector connects to the serial communication bus.

Information required with order

1. Quantity and type designation	15 pces relay SPAJ 110 C
2. Order number	RS 421 010-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	–

SPCJ 1C8
Non-directional earth-fault relay module

User´s manual and Technical description



1MRS 750603-MUM EN

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Version B (replaces 34 SPCJ 3 EN1)
Checked MK
Approved OL

SPCJ 1C8
Non-directional earth-fault relay module

Contents

Features

Low-set neutral overcurrent stage I_0> with selectable definite time or inverse definite minimum time (IDMT) operation characteristic

High-set neutral overcurrent stage I_0>> with definite time operation characteristic

Automatic doubling feature of the set start value of the high-set stage I_0>> on sudden rise of the energization current can be selected

The high-set stage I_0>> can be set out of operation if not needed

Both neutral overcurrent stages can sep-arately be blocked with an external control signal

Memory controlled function of start and operation indicators selectable

Digital display of measured and set values as well as data recorded at the moment a fault occurs

Constant self-supervision of hardware and software. At a permanent fault the alarm output relay picks up and the operation of tripping and signalling outputs is blocked

Description of function

The non-directional earth-fault relay module SPCJ 1C8 is a single-pole neutral overcurrent relay module. It contains two neutral overcurrent stages, i.e. a low-set overcurrent stage $I_0>$ and a high-set overcurrent stage $I_0>>$.

The low-set or high-set overcurrent stage starts if the input energizing current exceeds the set start value of the stage concerned. When starting, the stage provides a start signal SS1 or SS2 and simultaneously the operation indicator of the stage is lit with yellow colour. If the overcurrent situation lasts long enough to exceed the set operate time, the stage that started also operates and provides a tripping signal, TS1 or TS2. At the same time the operation indicator of the concerned stage turns red. The start and operation indicators can individually be given self-reset or manual reset mode of operation. If the self-reset mode of operation is selected, the indicator is automatically turned off when the stage resets. If the manual reset mode is selected the indicators are reset with the RESET push-button on the front panel of the relay module or via the serial port by means of the command V102 or V101.

The operation of the low-set overcurrent stage $I_0>$ can be blocked by routing a blocking signal BTS1 to the stage. Similarly, the starting of the high-set current stage $I_0>>$ can be blocked by a blocking signal BTS2. The blocking signals are routed by means of switchgroup SGB on the PC-board of the relay module.

If the protection relay incorporates an auto-reclose module, switchgroup SGB is additionally used for the purpose of selecting proper start signals for the auto-reclose module. The instructions for setting the switchgroup are given in the general description of the protection relay, in the diagram illustrating the signal interchange between the relay modules.

The operation of the low-set overcurrent stage $I_0>$ can be based on definite time or inverse time characteristic. The operation characteristic is selected with switch SG1/3. At definite time characteristic the operate time t> is chosen from one out of three operate time setting ranges. The setting range is selected with switches SG1/1 and SG1/2. When the inverse time characteristic (IDMT) is used four time/current curve groups, referred to as "Normal, very, extremely and long-time inverse" are available. The required operation characteristic is selected with switch SG1/1 and SG1/2.

The operate time t>> of the high-set overcurrent stage $I_0>>$ is set separately. The setting range, one of three available alternatives, is selected with switch SG1/7 and SG1/8.

The two overcurrent stages are provided with a so called latching facility, which means that the tripping output remains energized, although the signal which caused the operation disappears. The latching function is selected with switch SG1/4 and the stages are reset by pressing the push-buttons STEP and RESET simultaneously.

The set start value $I_0>>$ of the high-set overcurrent stage may be automatically doubled on starting. Thus the start value of the high-set overcurrent stage can be set lower than the connection inrush current. The doubling feature is selected with switch SG1/5. A start situation is defined as a situation where the energizing current rises from a value below $0.12 \times I_0>$ to a value exceeding $3.0 \times I_0>$ in less than 60 ms. The start situation ceases when the current falls below $2.0 \times I_0>$.

The start current setting range of the high-set overcurrent stage is selected with switch SG1/6. Two setting ranges are available, $0.5...4 \times I_n$ and $0.1...0.8 \times I_n$.

The operation of this stage may be totally blocked by selecting the setting value ∞, infinite.

Block diagram

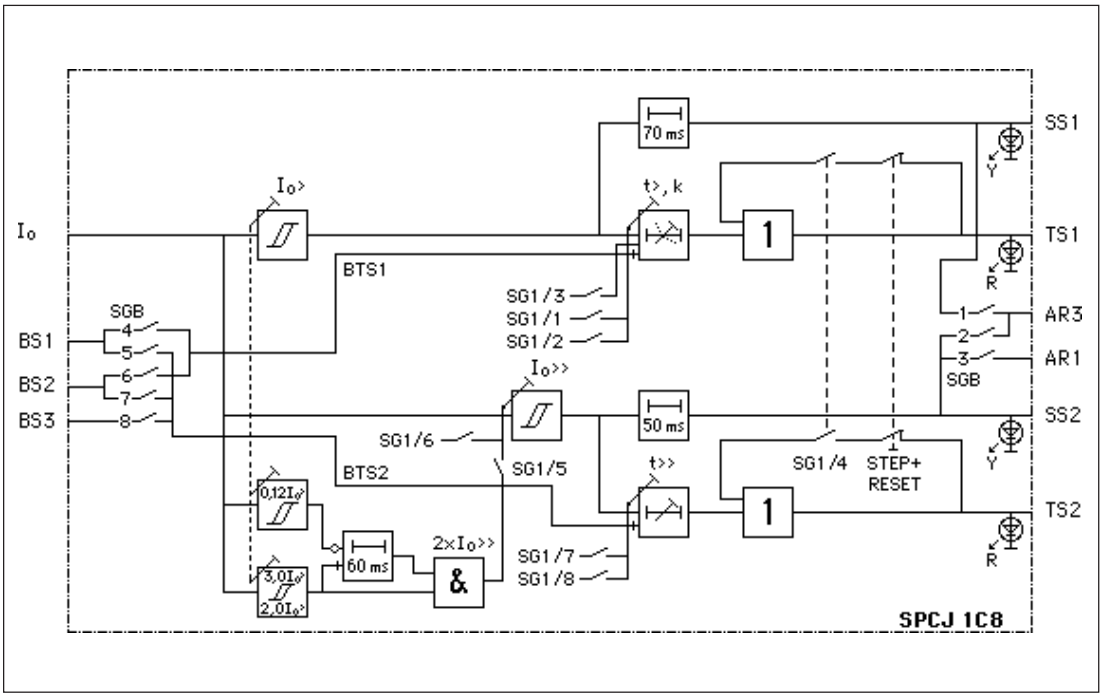


Fig. 1. Block diagram for earth-fault relay module SPCJ 1C8.

I_0	Energizing current (neutral current or residual current)
BS1, BS2, BS3	External blocking signals
BTS1	Blocking of the operation of stage I_0>
BTS2	Blocking of the operation of stage I_0>>
SG1	Selector switchgroup on the front panel
SGB	Selector switchgroup on the PC board for blocking signals and for the starting signals for auto-reclose functions, if applicable
SS1	Start signal of stage I_0>
TS1	Operate signal of stage I_0>
SS2	Start signal of stage I_0>>
TS2	Operate signal of stage I_0>>
AR1, AR3	Start initiation signals for auto-reclosure functions
Y	Yellow indicator, starting
R	Red indicator, operation

NOTE!
All input and output signals of the relay module are not necessarily wired to the terminals of every protection relay using this module. The signals wired to the terminals are shown in the diagram illustrating the signal interchange between the relay modules of the protection relay or feeder terminal in question.

Front panel

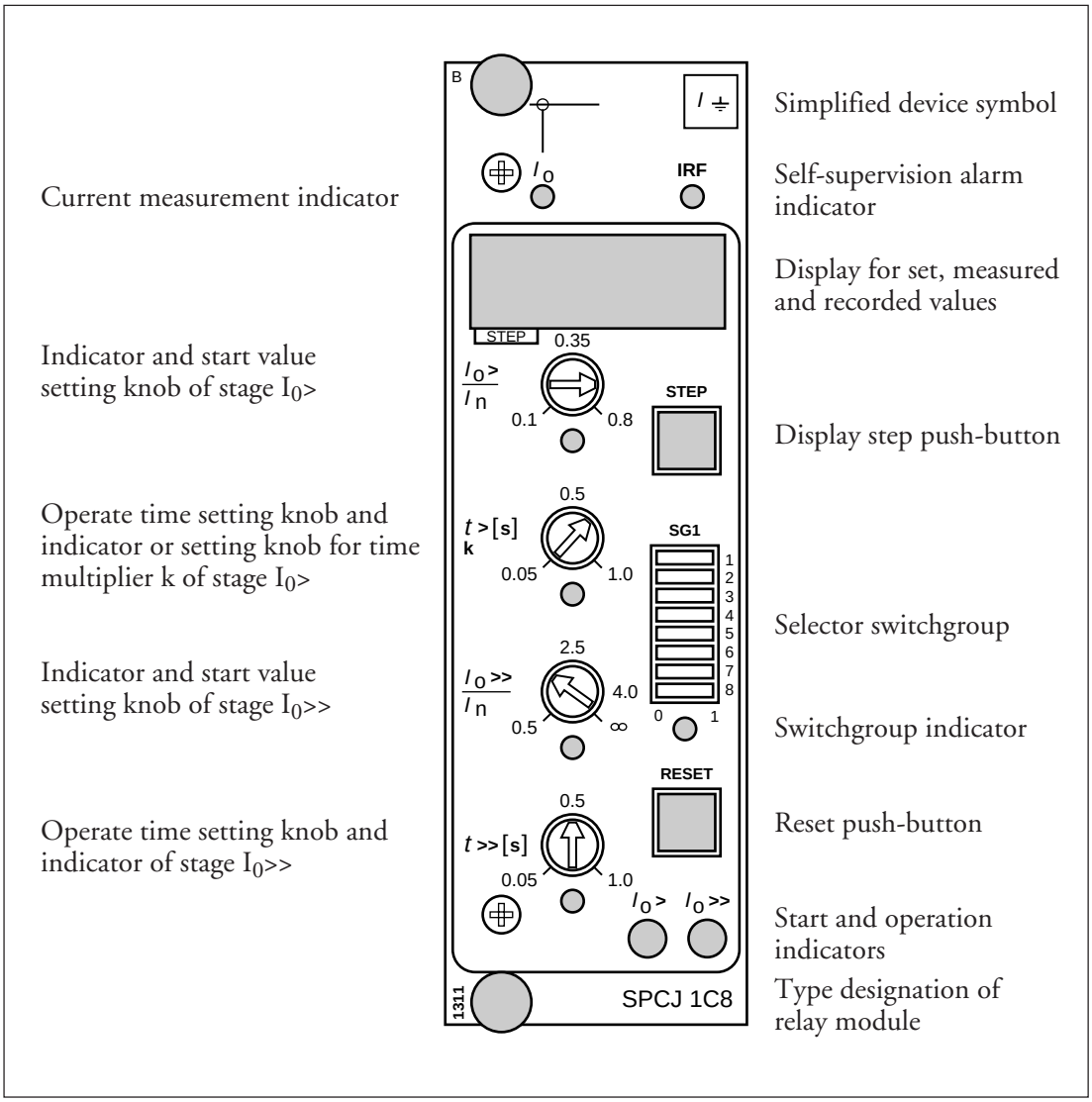


Fig. 2. Front panel of earth-fault relay module SPCJ 1C8.

Start and operation indicators

Both overcurrent stages have their own yellow/ red LED indicators. Yellow light indicates starting of the concerned overcurrent stage and red light indicates that the overcurrent stage has operated.

The four LED indicators can, independently of one another, be given self-reset or manual reset mode of operation. The manual reset mode means that the indicator remains lit after being switched on, although the earth-fault stage, which controls the indicator, resets. If, for instance, the yellow start indication is given the self-reset mode and the red indicator the manual reset mode, the yellow indicator is lit, when the stage starts, turning red if and when the stage operates. When the earth-fault stage resets only the red indication remains lit. The indicators, which have been given the manual reset mode, are reset locally by pushing the RESET push-button on the front panel or by remote control over the SPA bus using the command V101 or V102.

An unreset operation indicator does not affect the protective functions of the relay module. The relay module is constantly operative, regardless of the indicators have been reset or not.

The self-supervision alarm indicator IRF indicates that the self-supervision system has detected a permanent internal relay fault. The indicator is lit with red light shortly after the fault has been detected. At the same time the relay module puts forward a control signal to the self-supervision system output relay of the protection relay unit.

Additionally, in most fault cases, a fault code showing the type of the relay fault appears on the display of the module. The fault code consists of a red number one (1) and a green three-digit code number. When a fault message appears on the display, the code number should be noted down to facilitate the subsequent fault finding and repair work.

Relay settings

The setting values are shown by the three rightmost digits of the display. An LED indicator below each setting knob shows, when lit, which setting value is currently being shown on the display.

$I_0>/I_n$	Start current of stage $I_0>$ as a multiple of the rated current of the used relay energizing input. Setting range 0.10...0.80 x I_n.
t> [s]	Operate time of stage $I_0>$, expressed in seconds, when the definite time operation characteristic (SG1/3 = 0). The setting range, i.e. 0.05...1.00 s, 0.5...10.0 s or 5...100 s, is determined by the position of the switches SG1/1 and SG1/2. When the inverse definite minimum time (IDMT) operation characteristic is selected, switch SG1/3 = 1, the time multiplier k is set within the setting range 0.05...1.00.
$I_0>>/I_n$	Start current of stage $I_0>>$ as a multiple of the rated current of the used relay energizing input. The setting range, i.e. 0.5...4.0 x I_n or 0.1...0.8 x I_n, is selected with switch SG1/6. Addi- tionally, the setting infinite "∞" (dis- played as - - -) can be selected, which means that stage $I_0>>$ is ot of function.
t>> [s]	The operating time of the $I_0>>$ stage, expressed in seconds. The setting ranges, 0.05...1.00 s, 0.5...10.0 s or 5...100 s, are determined by the position of switches SG1/7 and SG1/8.

Further, the checksum of the function selector switchgroup SG1 is indicated on the display when the indicator under the switchgroup is lit. In this way a check can be carried out to prove that the switches have been set as planned and that the switches themselves work properly. An example of calculating the checksum is given in the description "General characteristics of C type relay modules".

Selector switches

Additional functions required by individual applications are selected by means of the program selector switches of switchgroup SG1 located on the front panel. 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
SG1/2
SG1/3</td><td>Switch SG1/3 is used for selecting the operation characteristic of the low-set current stage I_0>, i.e. definite time characteristic or inverse definite minimum time (IDMT) characteristic. At definite time characyeristic the setting range of the operate time t> is selected by means of switches SG1/1 and SG1/2 whereas, at inverse definite minimum time characteristic the switches are used for selecting the time/current characteristic of the low-set stage I_0>.
<table>
<tr><th>SG1/1</th><th>SG1/2</th><th>SG1/3</th><th>Characteristic</th><th>Operation time t> or type of characteristic</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>Definite time</td><td>0.05...1.00 s</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>"</td><td>0.5...10.0 s</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>"</td><td>0.5...10.0 s</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>"</td><td>5...100 s</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>IDMT</td><td>Extremely inverse</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>IDMT</td><td>Very inverse</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>IDMT</td><td>Normal inverse</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>IDMT</td><td>Long-time inverse</td></tr>
</table></td></tr>
<tr><td>SG1/4</td><td>Selection of mode of operation for the operate signals TS1 and TS2.

When SG1/4 = 0, the operate signals returns 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 operate signals remain on (= the output relay operated), although the energizing signal falls below the set start level. Resetting with command V101 via the serial interface or by pressing the push-buttons STEP and RESET simultaneously, which also erases the recorded information.</td></tr>
<tr><td>SG1/5</td><td>Selection of automatic doubling of the set start value of the high-set current stage I_0>> when the protected object is connected to the network.

When SG1/5 = 0, no doubling of the set start value of stage I_0>> is obtained.
When SG1/5 = 1, the set start value of the stage I_0>> doubles automatically.
This makes it possible to give the high-set current stage a setting value below the connection inrush current level of the protected object.</td></tr>
<tr><td>SG1/6</td><td>Selection of the setting range of the high-set overcurrent stage I_0>>.

When SG1/6 = 0, the setting range is 0.5...4.0 x I_n and ∞, infinite
When SG1/6 = 1, the setting range is 0.1...0.8 x I_n and ∞, infinite</td></tr>
</table>

<table>
<tr><th>Switch</th><th>Function</th></tr>
<tr><td>SG1/7
SG1/8</td><td>Selection of setting range of the operate time t>> of the high-set overcurrent stage I_0>>.
<table>
<tr><th>SG1/7</th><th>SG1/8</th><th>Operate time t>></th></tr>
<tr><td>0
1
0
1</td><td>0
0
1
1</td><td>0.05...1.00 s
0.5...10.0 s
0.5...10.0 s
5...100 s</td></tr>
</table></td></tr>
</table>

Switchgroup SG2 is a so called software switchgoup, which is located in the third submenu of switchgroup SG1. The mode of operation, i.e. self-reset or manually reset, of the LED indicators I_0> and I_0>> is determined by the switches of switchgoup SG2. The mode of operation can be separately set for each indicator. The mode of operation is set by means of the checksum, which can be calculated from the following table. Normally the start indications are self-reset and the operation indications manually reset.

Indicator	Manually reset	Factory default
Start indicator I_0>	1	0
Operation indicator I_0>	2	2
Start indicator I_0>>	4	0
Operation indicator I_0>>	8	8
Checksum	15	10

The PC board of the relay module contains a switchgroup SGB including switches 1...8. The switches 1...3 are used for selecting start initiation signals to a possible auto-reclose relay module, whereas switches 4...8 are used for routing external control signals to the neutral overcurrent stages of the relay module in various protection relays.

Measured information

The measured values are displayed by the three rightmost digits of the display. The measured neutral current is indicated with a LED indicator on the front panel.

Indicator	Measured current
I_0	Neutral current measured by the relay module as a multiple of the rated current I_n of the used energizing input of the protection relay.

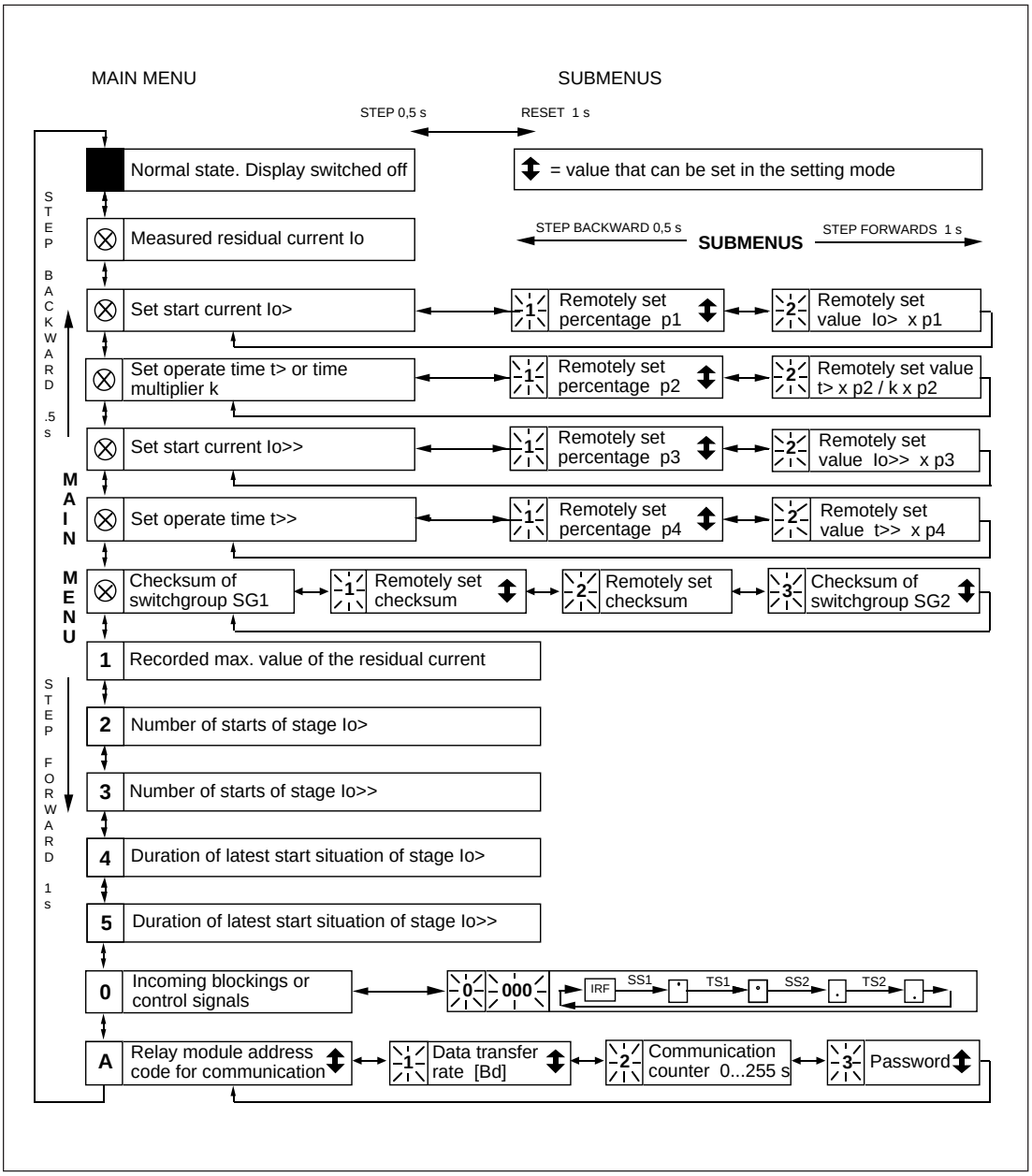
Recorded information

The leftmost digit of the display shows the address code of the register and the other three digits the value of the register.

Register/ STEP	Recorded information
1	Maximum current measured as a multiple of the rated current of the protection. The register is updated when one of the following criteria is fulfilled: I) The measured current exceeds the value currently recorded II) The relay module operates. On operation the current value at operation is recorded.
2	Number of starts of the low-set current stage I_0>, n (I_0>) = 0...255.
3	Number of starts of the high-set current stage I_0>>, n (I_0>>) = 0...255.
4	Duration of the latest start situation of stage I_0> as a percentage of the set operate time t> or at IDMT mode of operation the calculated operate time. A new start resets the counter which then starts counting from zero. When the concerned stage has tripped, the counter reading is 100.
5	Duration of the latest start situation of stage I_0>> as a percentage of the set operate time t>>. A new start resets the counter which then starts counting from zero. When the concerned stage has tripped, the counter reading is 100.
0	Display of blocking signals and other external control signals. The rightmost digit indicates the state of the blocking inputs of the module. The following states may be indicated: 0 = no blockings 1 = tripping of the low-set current stage I_0> blocked 2 = tripping of the high-set current stage I_0>> blocked 3 = tripping of both operation stages blocked On this module the middle digit of the register is always a zero. The third digit from the right indicates the state of the remote reset input, if the protection relay is provided with a control input. The following states may be indicated: 0 = remote reset control input not energized 1 = remote reset control input energized From this register it is possible to move on to the Trip test mode. 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. Register A has three subregisters with the following contents: 1) Selection of data transfer rate for the serial communication. Selectable values 300, 1200, 2400, 4800 or 9600 Bd. Default value 9600 Bd. 2) Communication interruption counter. If the relay module is connected to a communication system, which is in operation, the value of the communication interruption counter is 0 (zero). If the communication system is disturbed, the numbers 0…255 are scrolling in the communication interruption counter. 3) Password required for remote setting of relay module parameters.
–	Display dark. By pressing the STEP push-button the beginning of the display menu is re-entered.

The registers 1...5 are set to zero by pressing the push-buttons STEP and RESET simultaneously or via the SPA bus with the command V102. The registers are also cleared if the auxiliary power supply to the module is interrupted. The address code of the relay module, the baud rate of the serial communication and the password are not erased by a voltage failure. The instructions for setting the address and the baud rate are described in the "General characteristics of C-type relay modules".

Main menu and submenus of settings and registers



The measures required for entering a submenu or a setting mode as well as how to perform the settings and use the TEST mode are described in Data Sheet "General characteristics of C-type relay modules".

Time/current characteristic

(modified 2002-05)

The operation of the low-set current stage $I_0>$ of the earth-fault relay module is based on either definite time or inverse time characteristics. The mode of operation is selected with switch 3 of switchgroup SG1 (see page 7).

When the IDMT mode of operation is selected, the operate time of the low-set current stage $I_0>$ will be a function of the current; the higher the current, the shorter the operate time. The relationship between current and time complies with the standards BS 142.1966 and IEC 60255-3 and may generally be expressed as:

$$t = \frac{k \times \beta}{\left(\frac{I}{I_{0>}}\right)^{\alpha} - 1} \quad [s]$$

where

t = operate time in seconds
k = time multiplier
I = current value
$I_0>$ = set current value

The module includes four characteristics with different degrees of inversity. The characteristic to be used is selected with switches 1 and 2 of switchgroup SG1 (see page 7).

The degree of inversity is determined by the values of the constants α and β:

Degree of inversity of the characteristic	α	β
Normal inverse	0.02	0.14
Very inverse	1.0	13.5
Extremely inverse	2.0	80.0
Long-time inverse	1.0	120.0

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

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

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

In the normal current ranges above, the inverse-time stage of the non-directional earth-fault relay module SPCJ 1C8 complies with the tolerances of class 5 at all degrees of inversity.

The time/current characteristics specified in the standards are illustrated in fig. 3 … 6.

Note.
The actual operate time of the relay, presented in the graphs in Fig. 3…6, includes an additional filter and detection time plus the operate time of the trip output relay. When the operate time of the relay is calculated using the mathematical expression above, these additional times of about 30 ms in total have to be added to the time received.

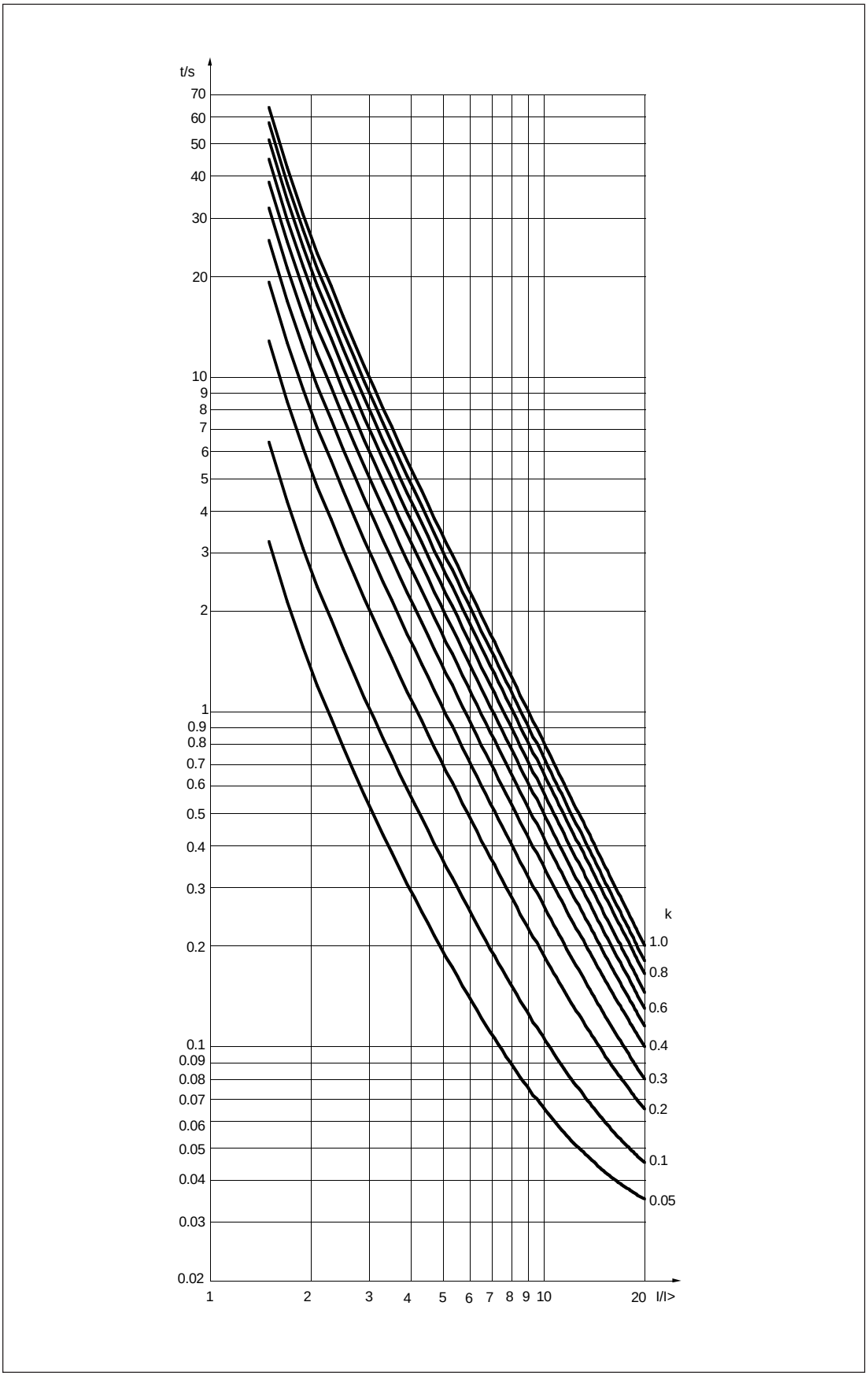


Fig. 3. Extremely inverse-time characteristic of earth-fault relay module SPCJ 1C8.

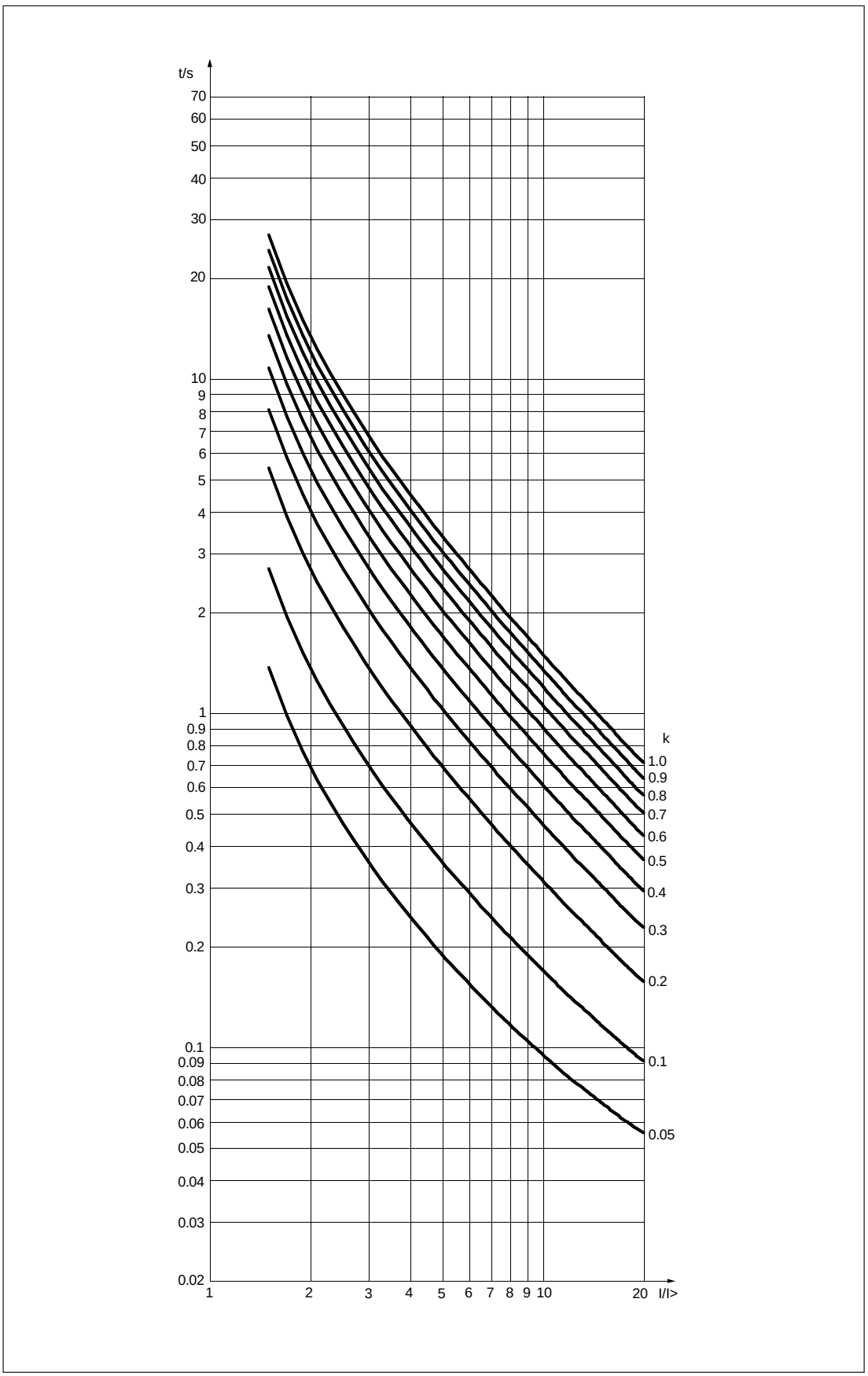


Fig. 4. Very inverse-time characteristic of earth-fault relay module SPCJ 1C8.

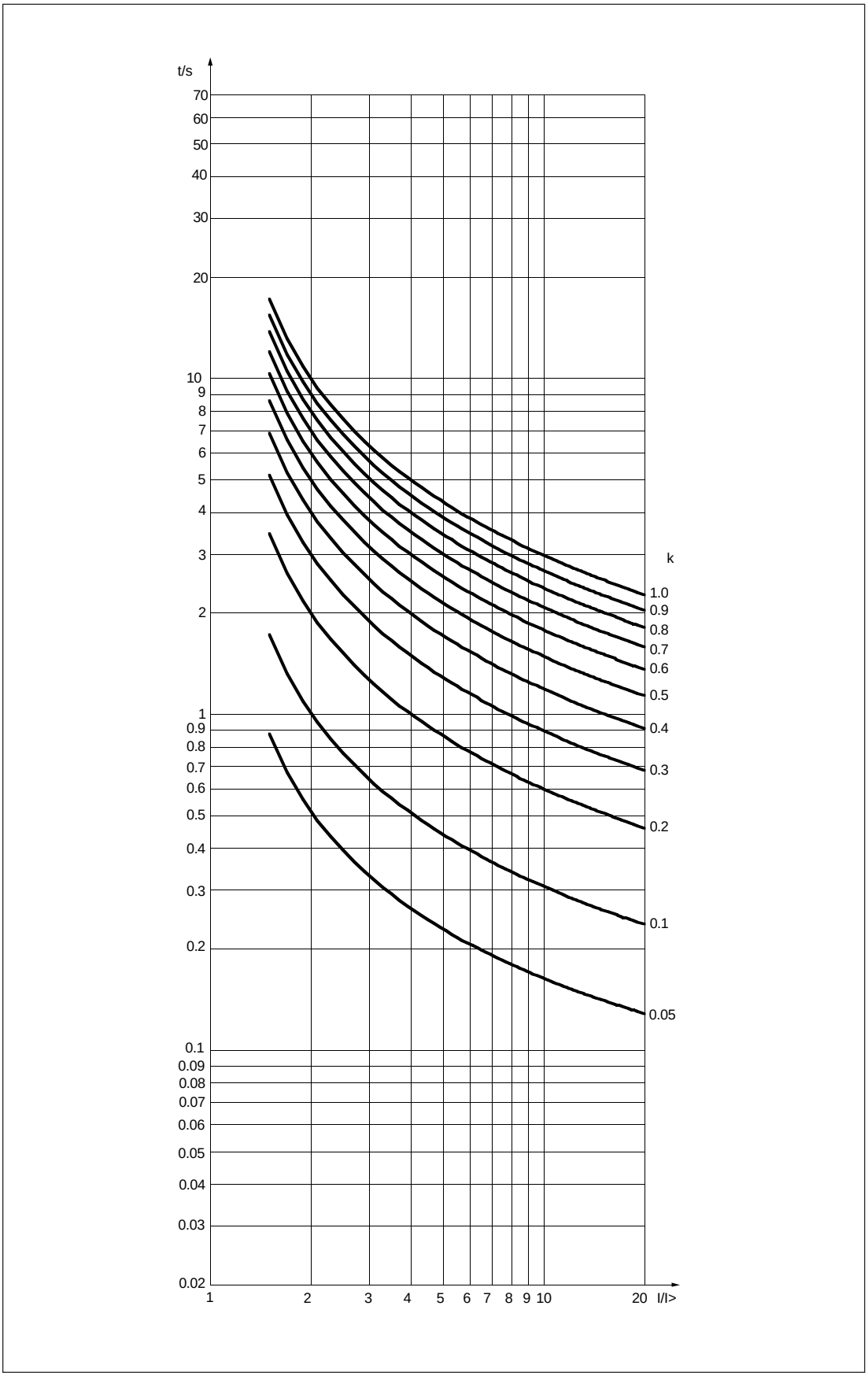


Fig. 5. Normal inverse-time characteristic of earth-faullt relay module SPCJ 1C8.

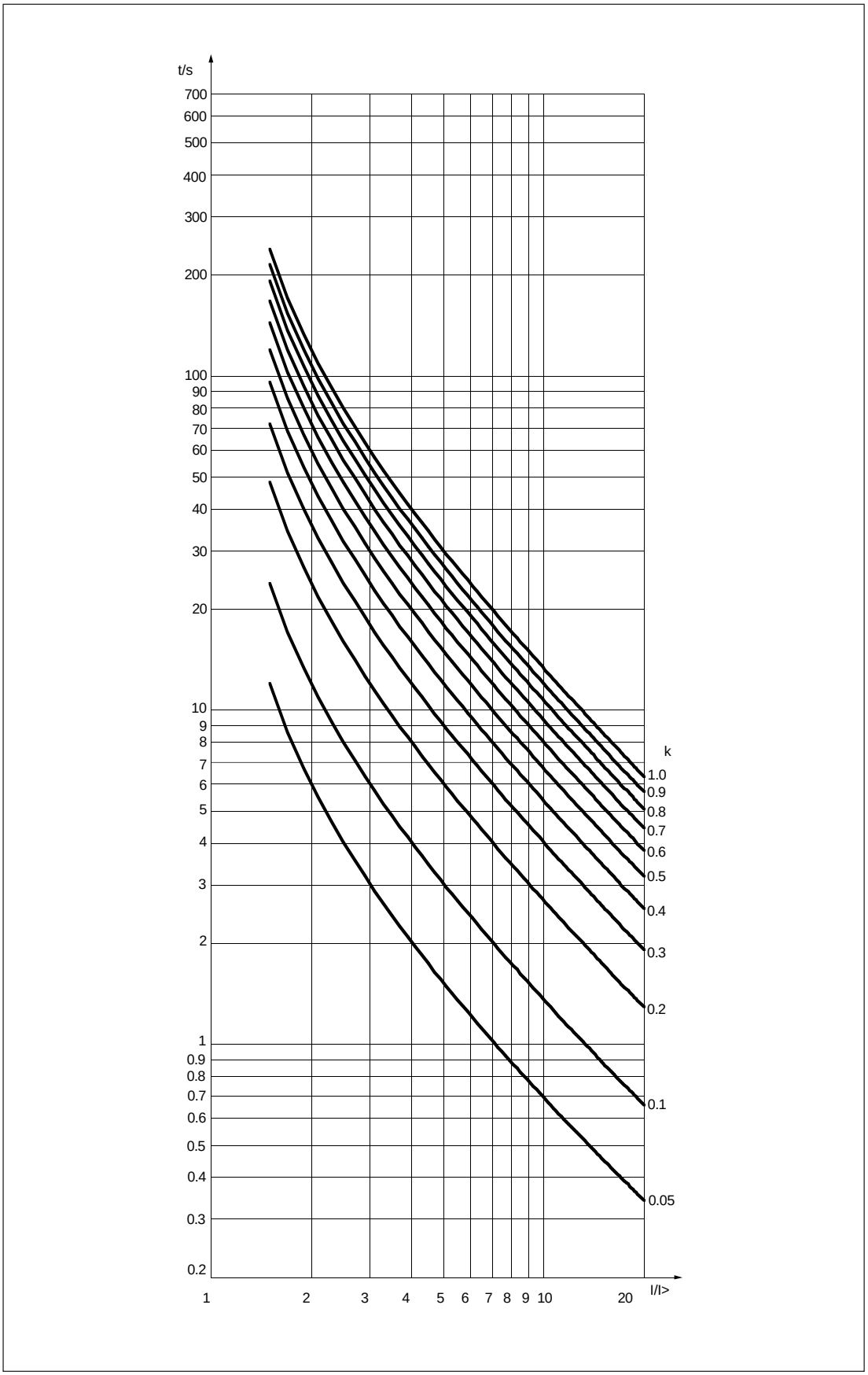


Fig. 6. Long-time inverse-time characteristic of earth-fault relay module SPCJ 1C8.

Low-set current stage I_0>

Start current I_0>	0.1...0.8 x I_n
Start time, typically	60 ms
Operate time t> at definite time operation	0.05...1.00 s, 0.5...10.0 s or 5...100 s
Operation characteristic at IDMT mode of operation	Extremely inverse Very inverse Normal inverse Long-time inverse
Time multiplier k	0.05...1.00
Reset time, typically	60 ms
Drop-off/pick-up ratio, typically	0.96
Operate time accuracy at definite time mode of operation	±2% of set value or ±25 ms
Operation time accuracy class E at inverse time mode of operation	5
Operation accuracy	±3% of set value

High-set current stage I_0>>

Start current I_0>>	0.5...4.0 x I_n & ∞, infinite or 0.1...0.8 x I_n & ∞, infinite
Start time, typically	50 ms
Operate time t>>	0.05...1.00 s, 0.5...10.0 s or 5...100 s
Reset time, typically	60 ms
Drop-off/pick-up ratio, typically	0.96
Operation time accuracy	±2% of set value or ±25 ms
Operation accuracy	±3% of set value

Event codes

The substation level control data communicator is able to read, over the SPA serial bus, the event data of the module, e.g. starts and trippings, from the non-directional earth-fault relay module SPCJ 1C8. Event information called for are printed out in the format: time (ss.sss) and event code. The event codes of the module are E1...E8 and E50 and E51. Furthermore, the substation level control data communicator is able to form event codes relating to e.g. 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 an event mask (V155) to the module over the SPA bus. 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 either with 0 (event not included in reporting) or 1 (event included in reporting) and adding up the numbers received (compare calculation of checksum).

The event mask may have a value in the range 0...255. The default value of the non-directional earth-fault module SPCJ 1C8 is 85, which means that all startings and trippings are included in the reporting, but not the resetting. The codes E50...E54 and the events represented by these cannot be excluded from the reporting.

Event codes of non-directional earth-fault module SPCJ 1C8:

Code	Event	Number representing the event	Factory set default value
E1	Starting of stage I_0>	1	1
E2	Starting of stage I_0> reset	2	0
E3	Tripping of stage I_0>	4	1
E4	Tripping of stage I_0> reset	8	0
E5	Starting of stage I_0>>	16	1
E6	Starting of stage I_0>> reset	32	0
E7	Tripping of stage I_0>>	64	1
E8	Tripping of stage I_0>> reset	128	0
E50	Restarting	*	-
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 the event reporting
1 included in the event reporting
* no code number
- cannot be programmed

Note!
The codes E52…E54 are formed by the substation level data communication equipment.

Data to be transferred remotely

Apart from the event codes the substation level control data communicator is able to read, over the SPA bus, all input data (I data), output data (O data) , setting values (S values), information recorded in the memory (V data), and some other data. Further, part of the data can be altered by commands given over the SPA bus. All the data are in channel 0.

Data	Code	Data direct.	Values
Measured neutral current	I1	R	0...21 x I_n
Blocking of tripping of stage I_0>	I2	R	0 = no blocking 1 = tripping of stage I_0> blocked
Blocking of tripping of stage I_0>>	I3	R	0 = no blocking 1 = tripping of stage I_0>> blocked
Starting of stage I_0>	O1	R	0 = stage I_0> not started 1 = stage I_0> started
Tripping of stage I_0>	O2	R	0 = stage I_0> not tripped 1 = stage I_0> tripped
Starting of stage I_0>>	O3	R	0 = stage I_0>> not started 1 = stage I_0>> started
Tripping of stage I_0>>	O4	R	0 = stage I_0>> not tripped 1 = stage I_0>> tripped
Activated start value for stage I_0>	S1	R	0.1...0.8 x I_n
Activated operate time for stage I_0> or time multiplier k	S2	R	0.05...100 s 0.05...1.00
Activated starte value for stage I_0>>	S3	R	0.1...4 x I_n 999 = ∞, out of operation
Activated operate time for stage I_0>>	S4	R	0.05...100 s
Activated checksum of switchgroup SG1	S5	R	0...255
Start value for stage I_0>, set with the setting knob	S11	R	0.1...0.8 x I_n
Operate time for stage I_0>, or time multiplier, set with the setting knob	S12	R	0.05...100 s 0.05...1.00
Start value for stage I_0>>, set with the setting knob	S13	R	0.1...4 x I_n 999 = ∞, out of operation
Operate time for stage I_0>>, set with the setting knob	S14	R	0.05...100 s
Checksum of switchgroup SG1 (set with the switches)	S15	R	0...255
Remote setting percentage of the start value for stage I_0>	S21	R, W	0...999 %
Remote setting percentage of the operate time for stage I_0>, or time multiplier k	S22	R, W	0...999 %
Remote setting percentage of the start value for stage I_0>>	S23	R, W	0...999 %
Remote setting percentage of operate time for stage I_0>>	S24	R, W	0...999 %
Remotely set checksum of switchgroup SG1	S25	R, W	0...255

Data	Code	Data direct.	Values
Remotely set start current for stage I_0>	S31	R	0.1...0.8 x I_n
Remote setting value for the operate time of stage I_0>, or time multiplier k	S32	R	0.05...100 s 0.05...1.00
Remotely set start current for stage I_0>>	S33	R	0.1...4 x I_n 999 = ∞
Remote setting value for the operat time of stage I_0>>	S34	R	0.05...100 s
Remotely set checksum for switchgroup SG1	S35	R	0...255
Max. measured current or current at tripping	V1	R	0...21 x I_n
Number of starts of stage I_0>	V2	R	0...255
Number of starts of stage I_0>>	V3	R	0...255
Duration of the latest start situation of stage I_0>	V4	R	0...100 %
Duration of the latest start situation of stage I_0>>	V5	R	0...100 %
Resetting of output relays and operation indicators	V101	W	1 = output relays and operation indicators reset
Resetting of output relays, operation indicators and recorded data simultaneously	V102	W	1 = output relays, operation indicators and registers (codes V1…V5) reset
Remote control of settings	V150	R, W	0 = setting with knobs S11...S15 activated 1 = remote settings S31...S35 activated
Event mask word	V155	R, W	0...255, see section "Event codes"
Manual reset or self-reset mode of operation for the indicators (SG2)	V156	R, W	0…15, see paragraph "Selector switches"
Opening of password for remote settings	V160	W	1...999
Changing or closing of password for remote settings	V161	W	0...999
Activation of self-supervision system	V165	W	1 = self-supervision system output is activated and IRF indicator lit in about 5 seconds, whereafter the self-supervision system resets and the IRF indicator is switched off
Internal fault code	V169	R	0…255
Data communication address of the module	V200	R	1...254
Program version symbol	V205	R	e.g. 065 A

Data	Code	Data direct.	Values
Type designation of the module	F	R	SPCJ 1C8
Event register reading	L	R	Time, channel number and event code
Re-reading of event register	B	R	Time, channel number and event code
Reading of module state data	C	R	0 = normal state 1 = module been subject to automatic reset 2 = overflow of event register 3 = events 1 and 2 together
Resetting of module state data	C	W	0 = resetting
Time reading and setting	T	R, W	00.000...59.999 s

R = data to be read from the unit
W = data to be written to the unit

The data transfer codes L, B, C and T have been reserved for the event data transfer between the module and the station level control data communicator.

The event register can be read by the L-command only once. Should a fault occur e.g. in the data transfer, it is possible, by using the B-command, to re-read the contents of the event register read by means of the L-command. When required, the B-command can be repeated.

The setting values S1...S5 are the setting values used by the protection programs. These values are set either remotely or by means of the setting knobs. The values S11...S15 are settings set with setting knobs or switches. S21...S25 are knob setting percentage factors to be set remotely. The settings S21...S25 allow reading or writing.

To be able to write the password (V160) for the remote setting must be opened and the potentionmeter settings must be activated (V150=0). The variables S31...S35 contain the remote setting values.

When changing the remote setting percentages S21...S24, these variables can be given a percentage factor within the range 0...999. Then it is also possible to alter the setting value beyond the limits specified in the technical data of the module. However, the validity of the setting values are guaranteed only within the limits specified in the technical data.

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

Fault codes

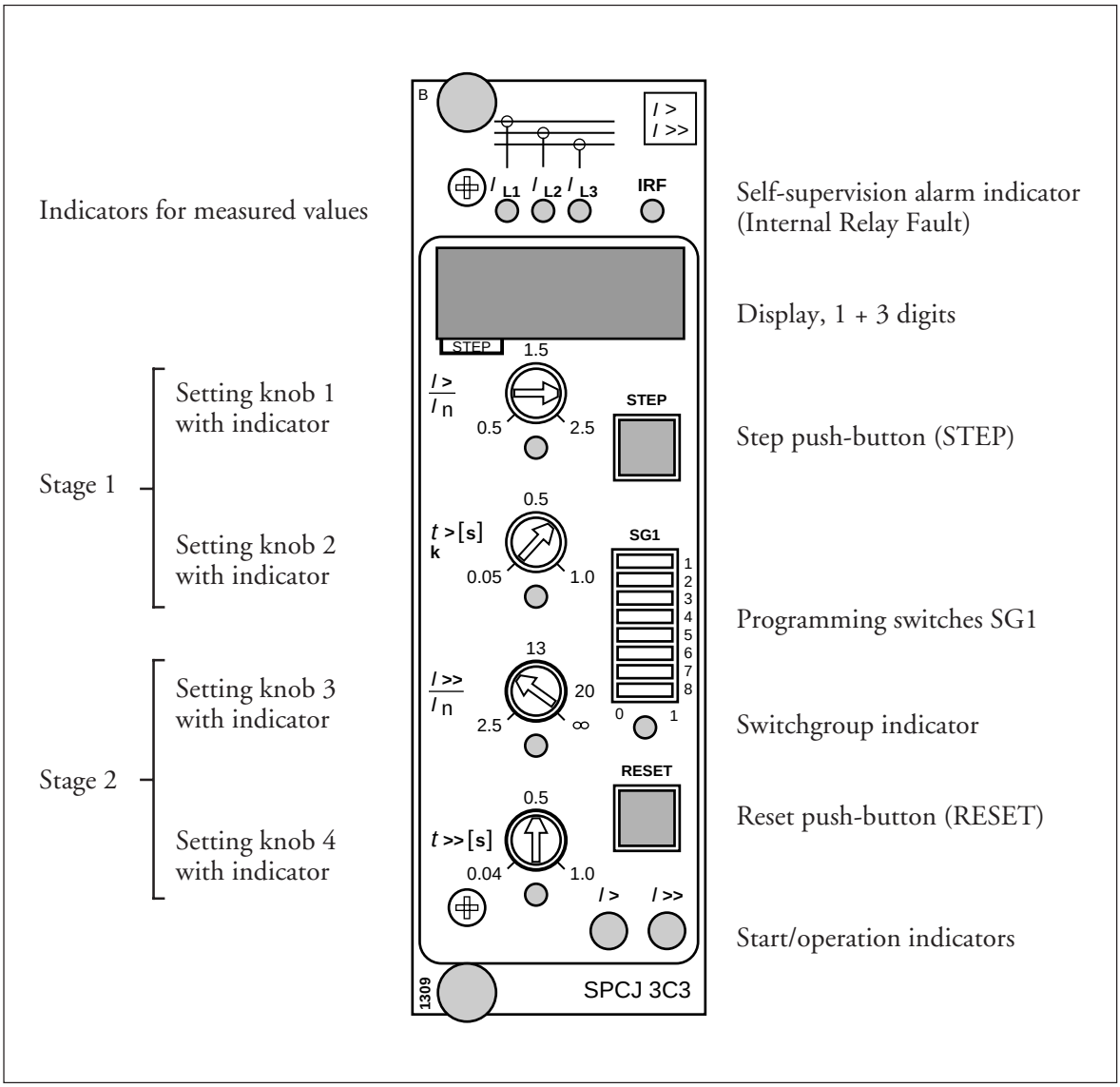
Shortly after the self-supervision system has detected a permanent internal fault the red IRF indicator is lit. Simultaneously the relay module puts forward a control signal to the output relay of the self-supervision system. In most fault situations an autodiagnostic fault code appears on the display of the module. The fault code consists of a red number 1 (one), and a green, one to 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 non-directional earth-fault relay module SPCJ 1C8 are shown in the following list:

Fault code	Type of fault
4	Output relay control circuit interrupted or output relay module missing
30	Faulty Read Only Memory (ROM)
50	Faulty Random Access Memory (RAM)
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.

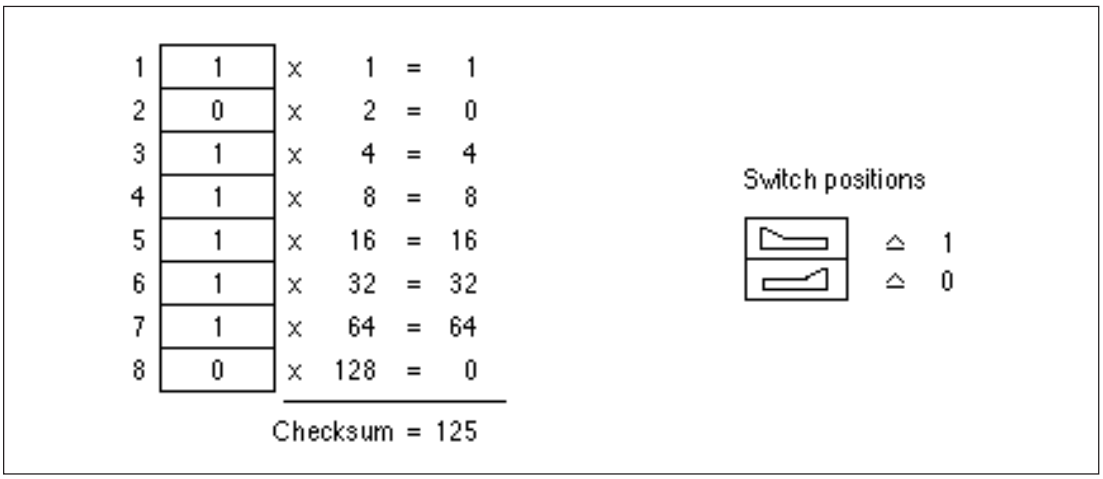


Fig. 2. Example of calculating the checksum of programming switchgroup SG1.

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.

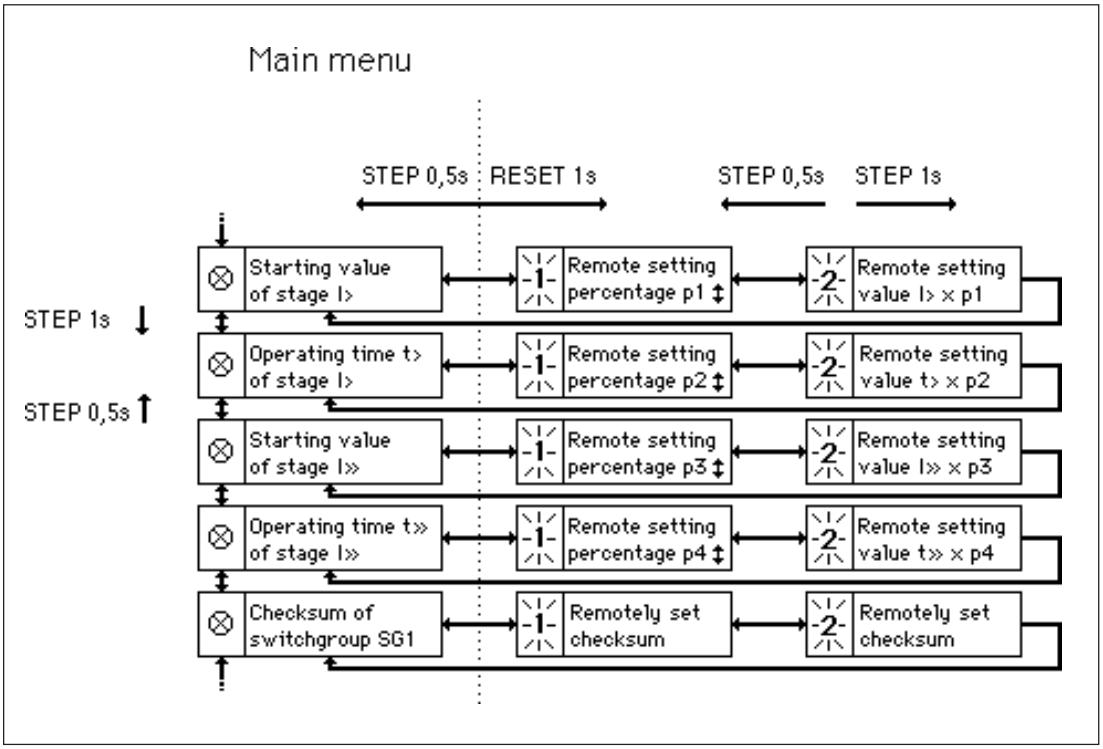


Fig. 3. Example of the main and submenus for the settings of the overcurrent relay module SPCJ 3C3. The settings made with the setting knobs are in the main menu and they are displayed by pressing the STEP button. In addition to the setting knob settings the main menu contains the measured current values 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.

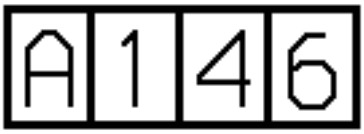
A set value is stored in the memory by pressing the push-buttons STEP and RESET simultaneously. In practice the RESET button must be pressed slightly in excess of the STEP button. Return from the setting mode to the main menu or submenu is possible by pressing (for about 10 s) the RESET button until 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.

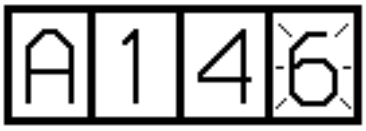
Example 1:

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.

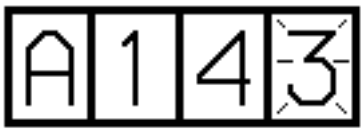
a)
Press push-button STEP until register address A appears on the display.



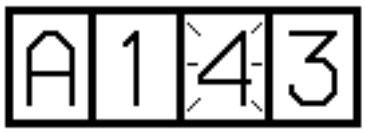
b)
Press the RESET button for about 10 s until the right most digit starts flashing.



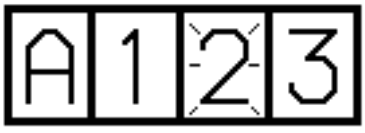
c)
Press the STEP button repeatedly to set the digit to the value desired.



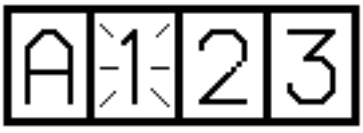
d)
Press the RESET button to make the middle of the green digits flash.



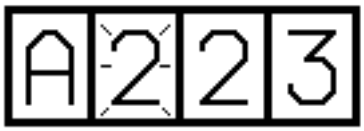
e)
Set the middle address digit by means of the STEP button.



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

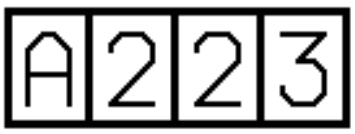


g)
Set the digit by means of the STEP button.



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.

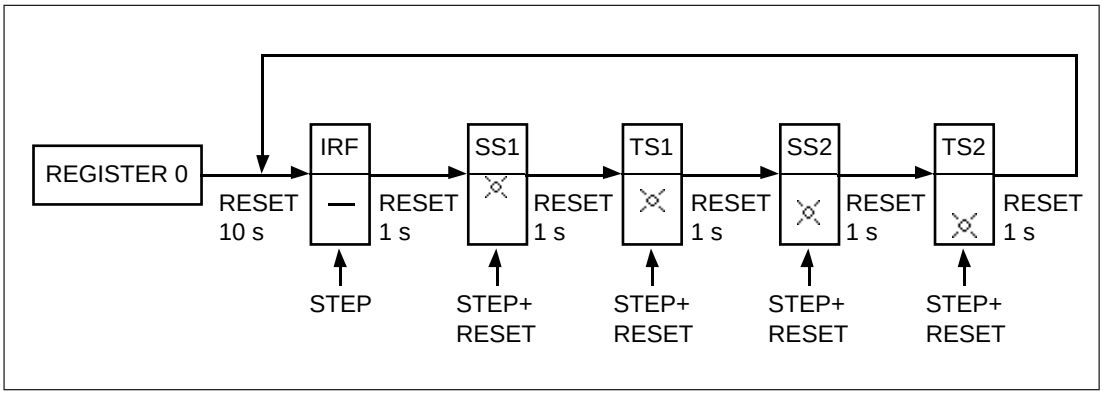


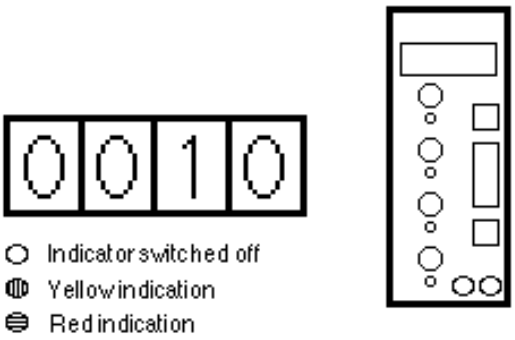
Fig. 4. Sequence order for selecting the output signals in the Trip-test mode.

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.

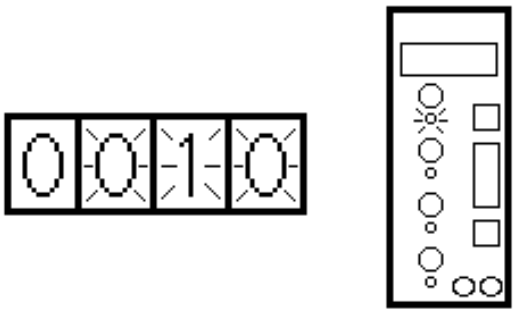
Example 2:

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

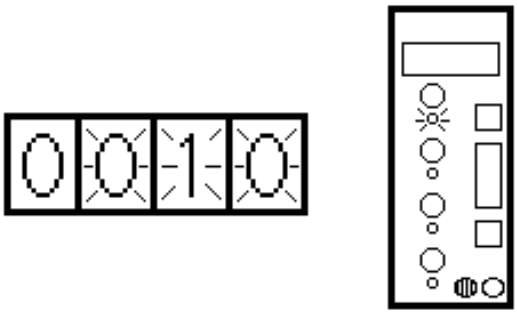
a)
Step forward on the display to register 0.



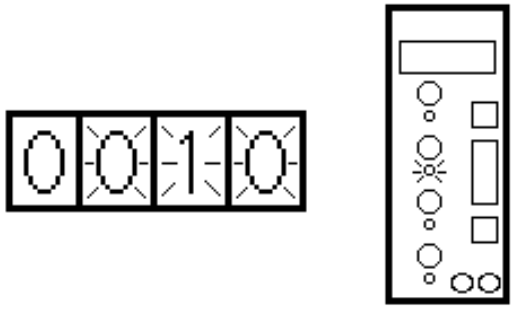
b)
Press the RESET button for about 10 seconds until the three green digits to the right and the LED indicator of the uppermost setting knob start flashing.



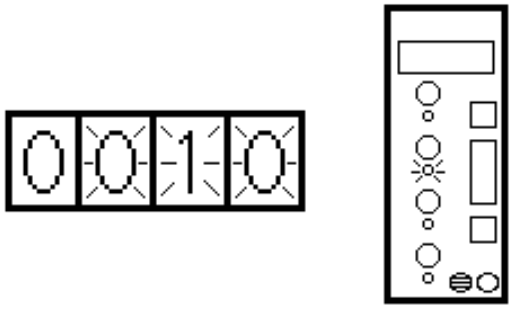
c)
Press the push-buttons RESET and STEP simultaneously. Then the starting of stage 1 (e.g. the I>-stage of the overcurrent module SPCJ 3C3) is activated and, simultaneously, the indicator of the stage starts glowing yellow.



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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