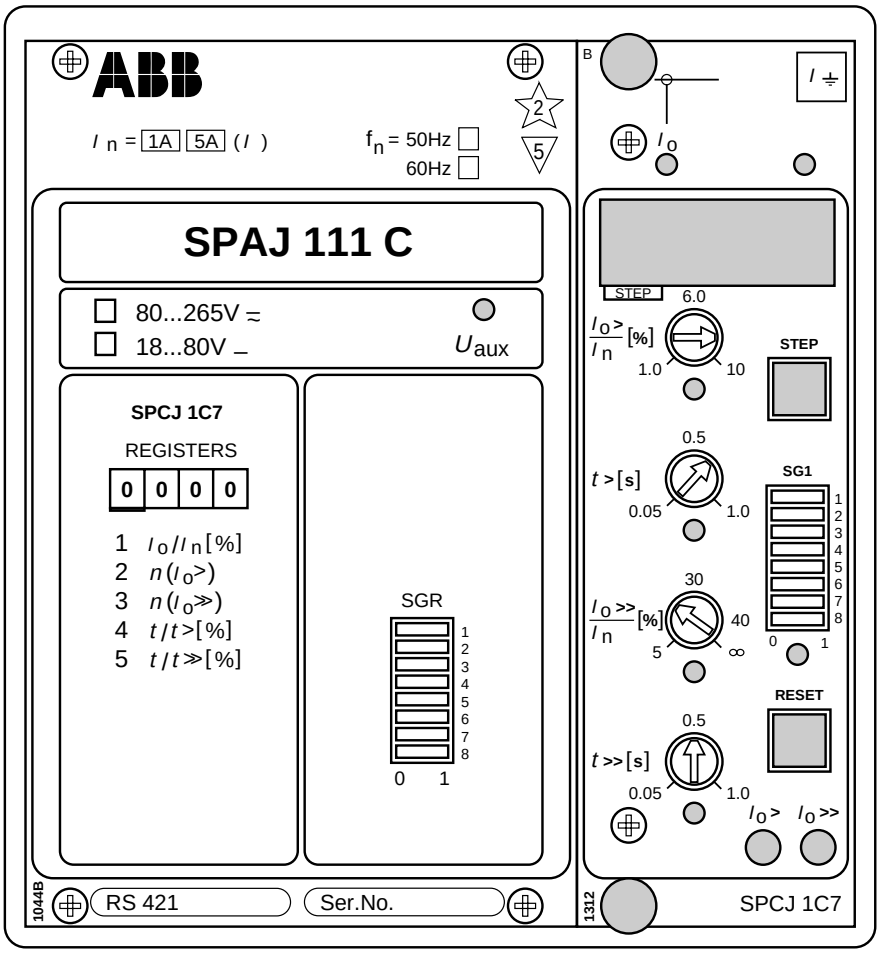
SPAJ 111 C
Sensitive earth-fault relay

User´s manual and Technical description



1MRS 750809-MUM EN

Issued 1997-08-05
Modified 2002-04-22
Version B (replaces 34 SPAJ 22 EN1)
Checked MK
Approved OL

SPAJ 111 C
Sensitive earth-fault relay

Contents

The complete manual for the sensitive earth-fault relay SPAJ 111 C includes the following submanuals:

Sensitive earth-fault relay SPAJ 111 C, general part	1MRS 750809-MUM EN
Sensitive neutral overcurrent relay module SPCJ 1C7	1MRS 750810-MUM EN
General characteristics of C type relay modules	1MRS 750328-MUM EN

Features

Sensitive low-set neutral overcurrent stage with definite time characteristic

High-set neutral overcurrent stage with definite time characteristic

Output relay functions to be freely configured by the user

Flexible adaptation to different types of application

1 A and 5 A energizing inputs and flexible selection of relay functions for various applications

Serial interface for connecting the relay to a fibre-optic serial bus and further to a substation or network control system

Digital display of setting values, measured neutral current, memorized values at relay operation, indications et cetera

Powerful software support for parametrization and supervision of the relay

Continuous hardware and software self-supervision including auto-diagnosis

Application

The sensitive earth fault relay SPAJ 111 C is designed to be used as neutral current measuring feeder earth fault relay, as generator interturn fault protection, as capacitor bank unbalance protection and rotor earth-fault protection.

The sensitive earth fault relay suits as both primary and back-up earth fault protection relay. The input impedance of the energizing circuit of the earth-fault relay is extremely low which means that the relay can also be energized from low output core-balance current transformers. Core-balance current transformers can be recommended when an extremely sensitive earth-fault protection is required. The earth-fault relay can also be energized from a set of three phase current transformers connected in parallel, the so called residual current connection.

Principle of function

The sensitive earth-fault relay SPAJ 111 C is a secondary relay which is connected to the current transformers of the object to be protected. 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 the set 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 start signal from the sensitive 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.

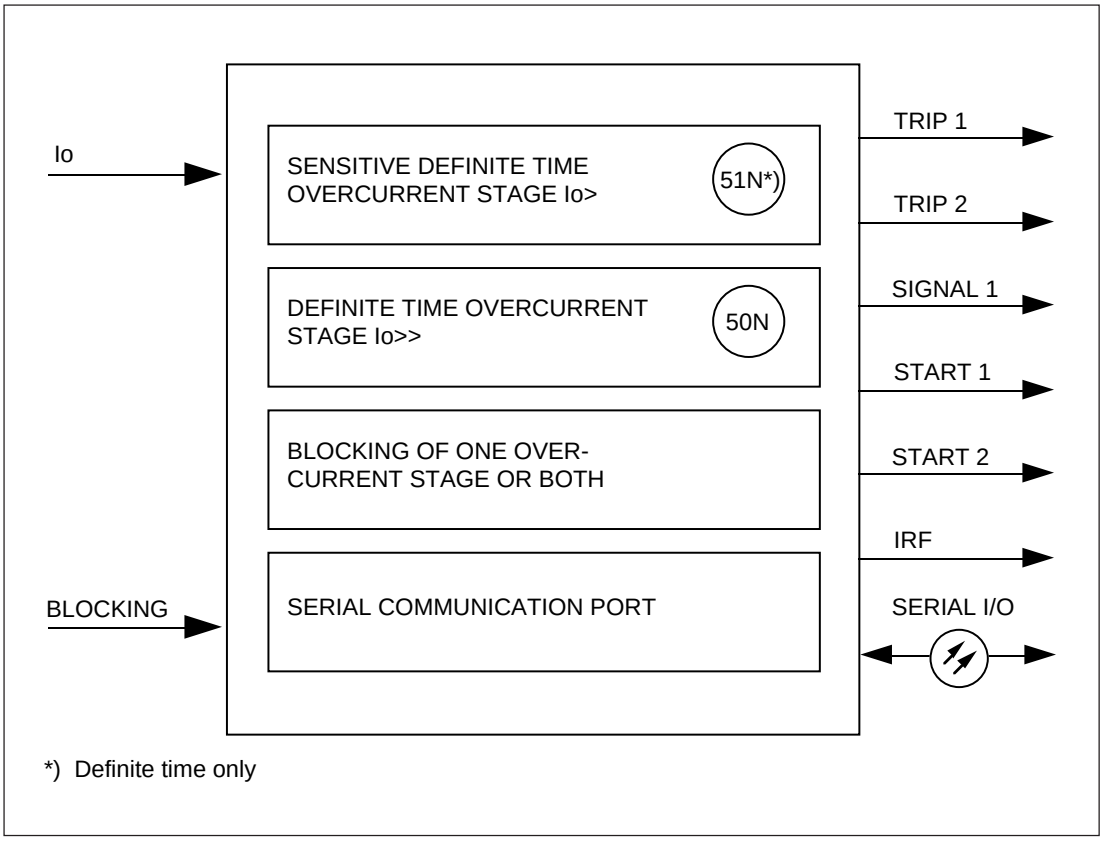


Fig. 1. Protection functions of the sensitive earth-fault relay SPAJ 111 C. The encircled numbers refer to the ANSI (=American National Standards Institute) number of the concerned protection function.

Connections

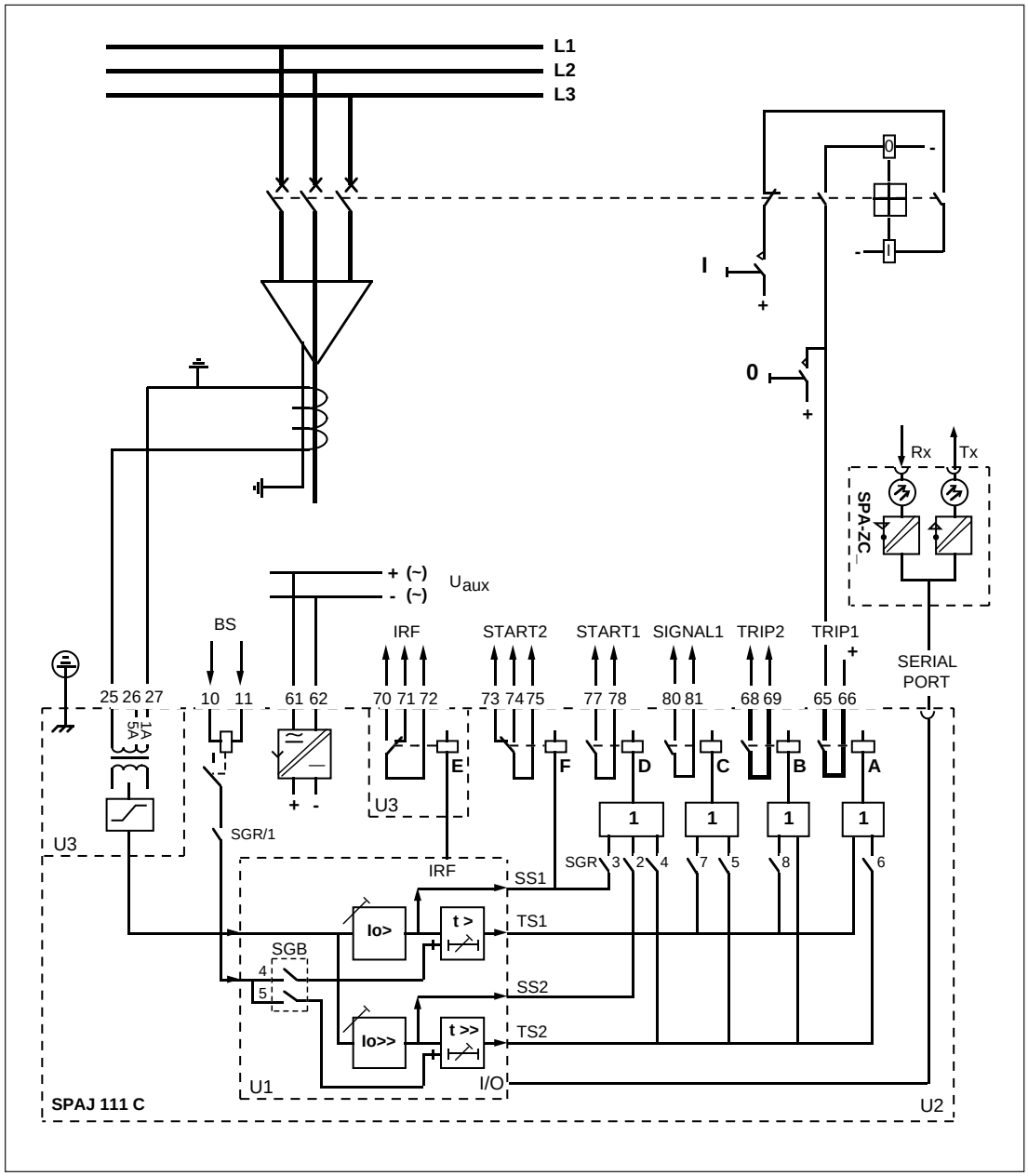


Fig. 2. Connection diagram for the sensitive earth-fault relay SPAJ 111 C.

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	Sensitive earth-fault relay module SPCJ 1C7
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	Receiver (Rx) and transmitter (Tx) of the bus connection module

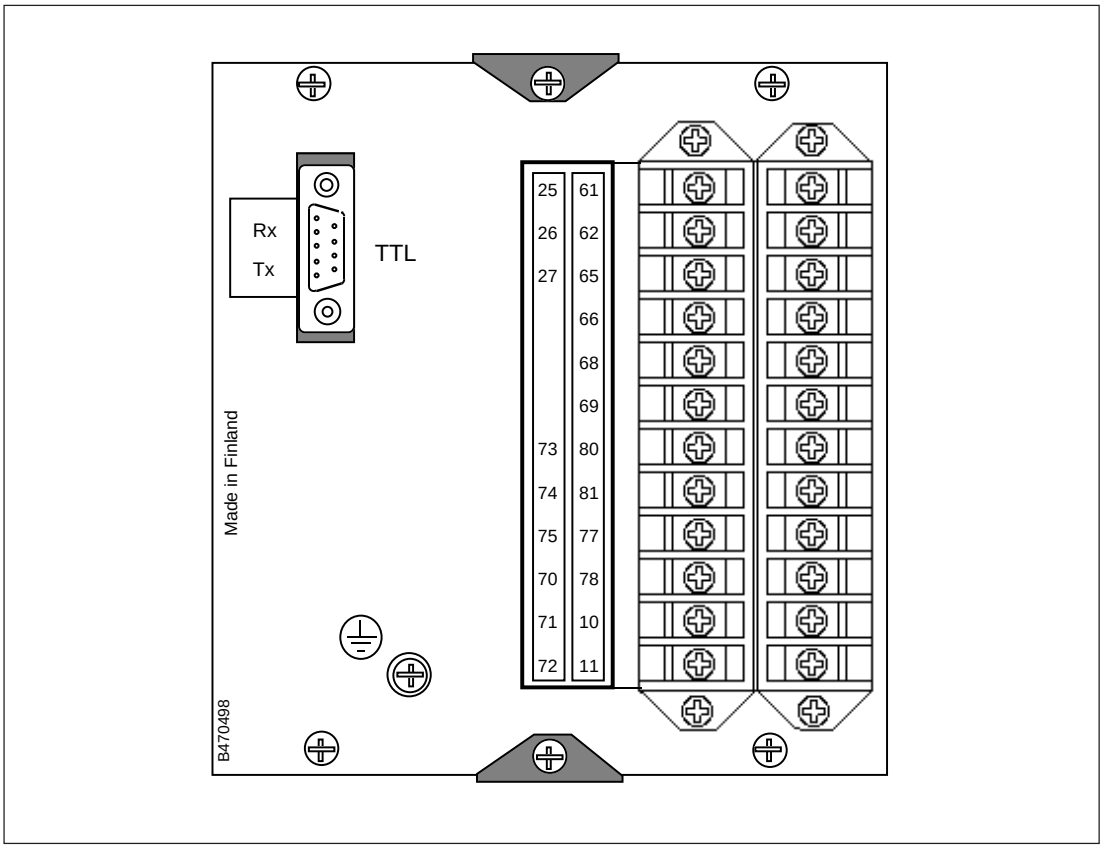


Fig. 3. Rear view of sensitive earth-fault relay SPAJ 111 C.

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 sensitive earth-fault relay SPAJ 111 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. In the bus connection module the switches for selection of the communication mode are to be set in position "SPA".

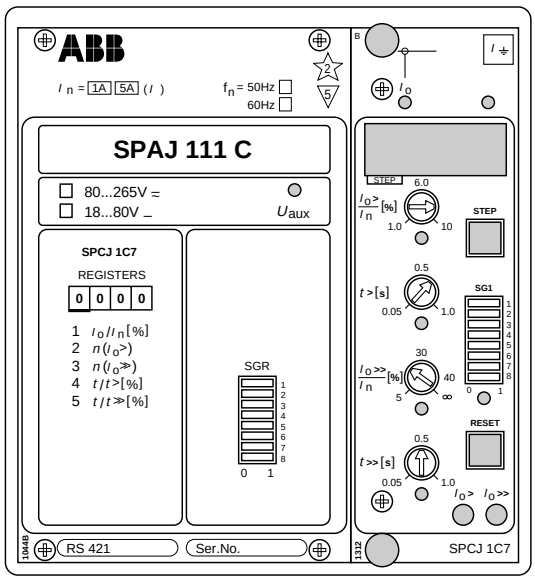
Configuration of output relays

The start signal of the I_0> stage is permanently 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 B. In addition, the following functions can be selected with the switches of the SGR switchgroup on the front panel:

Switch	Function	Factory setting	User´s 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 directly controlled with output relay A and output relay B. Thus either operation stage may have its own output relay or two separate circuit breakers can be controlled with the same protection relay.

Start and operation indicators



1. Either voltage 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 sensitive earth-fault relay module SPCJ 1C7.

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		
Continuous carry	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

Control contacts	
Terminals	65-66, 68-69
Rated voltage	250 V ac/dc
Continuous carry	5 A
Make and carry for 0.5 s	30 A
Make and carry for 3 s	15 A
Breaking capacity for dc, when the control circuit time constant L/R ≤ 40 ms, at the control 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
Continuous carry	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

Sensitive earth-fault relay module SPCJ 1C7

Low-set stage I_0>	
Start current I_0>, setting range	0.2...50% I_n
Operate time t>	0.05...10.0 s
High-set stage I_0>>	
Start current I_0>>, setting range	1...200% I_n and ∞, infinite
Operate time t>>	0.05...10.0 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

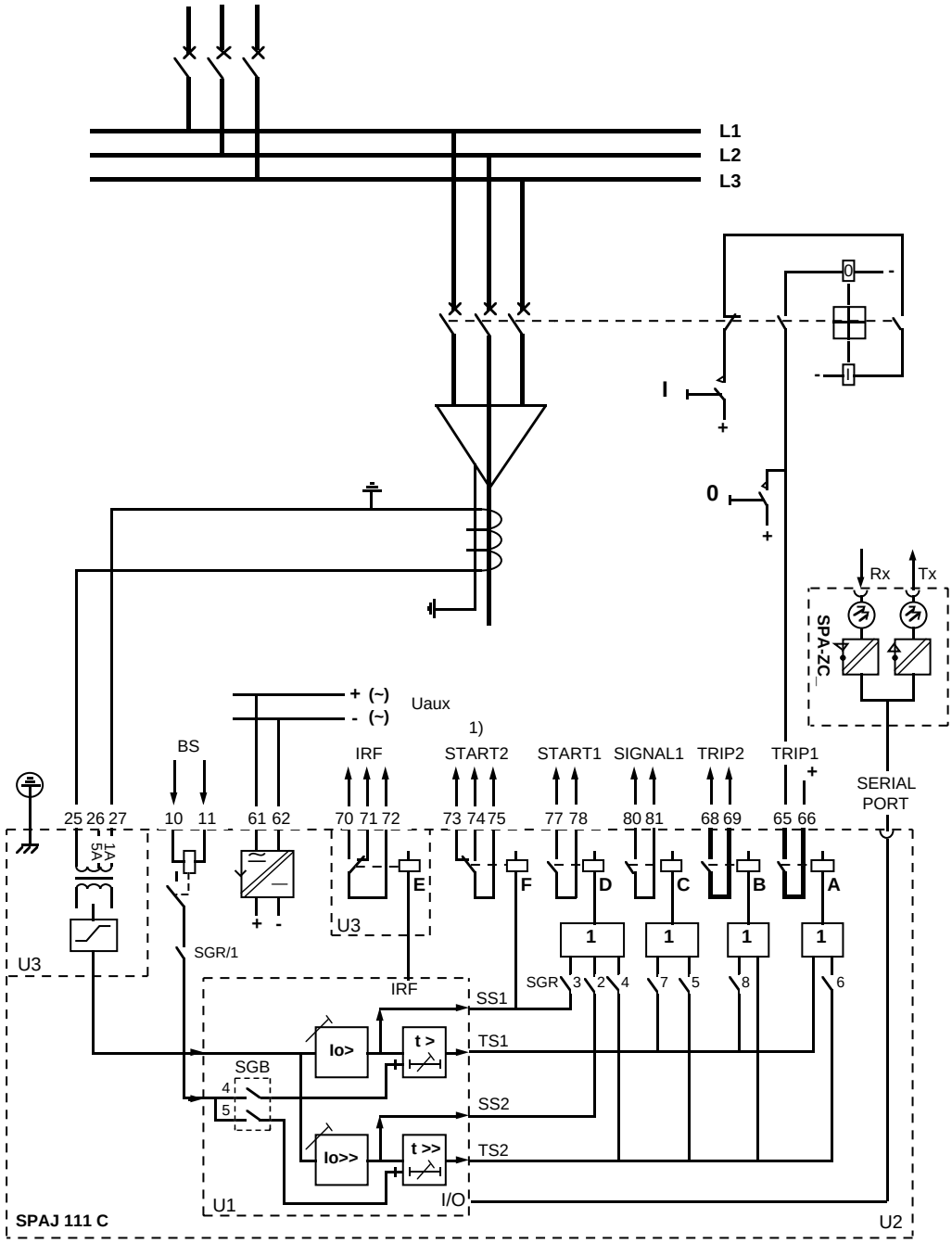
Environmental conditions

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



1) Blocking signal to be routed to the earth-fault relay of the incoming feeder

Fig. 4. Earth-fault relay SPAJ 111 C used for the protection of an outgoing feeder. The earth-fault current is measured with a core-balance current transformer. The selector switch positions are shown in the table on the following page.

The earth-fault relay provides two-stage earth-fault protection. The fault current can be measured with a core-balance transformer or three phase current transformers in parallel.

The earth-fault relay SPAJ 111 C is used in applications, where a high accuracy is required. By using core-balance current transformers the disadvantage with the three phase current transformers connected in parallel can be avoided. The core-balance transformer ensures a stable and sensitive earth-fault protection.

The above application can be used in isolated neutral networks and in networks earthed over a resistor, in which case the reproduction capability of the core-balance transformer is sufficient.

In isolated neutral networks and in networks which are earthed over a high-value resistor the magnitude of the earth-fault current is rather limited. At an earth-fault the healty network supplies fault current to the faulty feeder. Therefore non-directional earth-fault relays like SPAJ 111 C are best suited for the earth-fault protection of networks with rather short feeders, as for instance motor and transformer feeders of an industrial switchgear.

The earth-fault relay is provided with two stages, a high-set stage and a low-set stage. The low-set stage satisfies the sensitivity requirements of the protection and the high-set stage the operate time requirements. The two-stage relay also enables selective protection arrangements to be made in such cases, where the fault current generated by the feeder during a fault somewhere else in the network exceeds the set start current of the low-set stage but not the high-set stage.

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

Both earth-fault stages trip the CB. In the above example the start signal of the low-set stage blocks the earth-fault relay of the incoming feeder, also see Example 2.

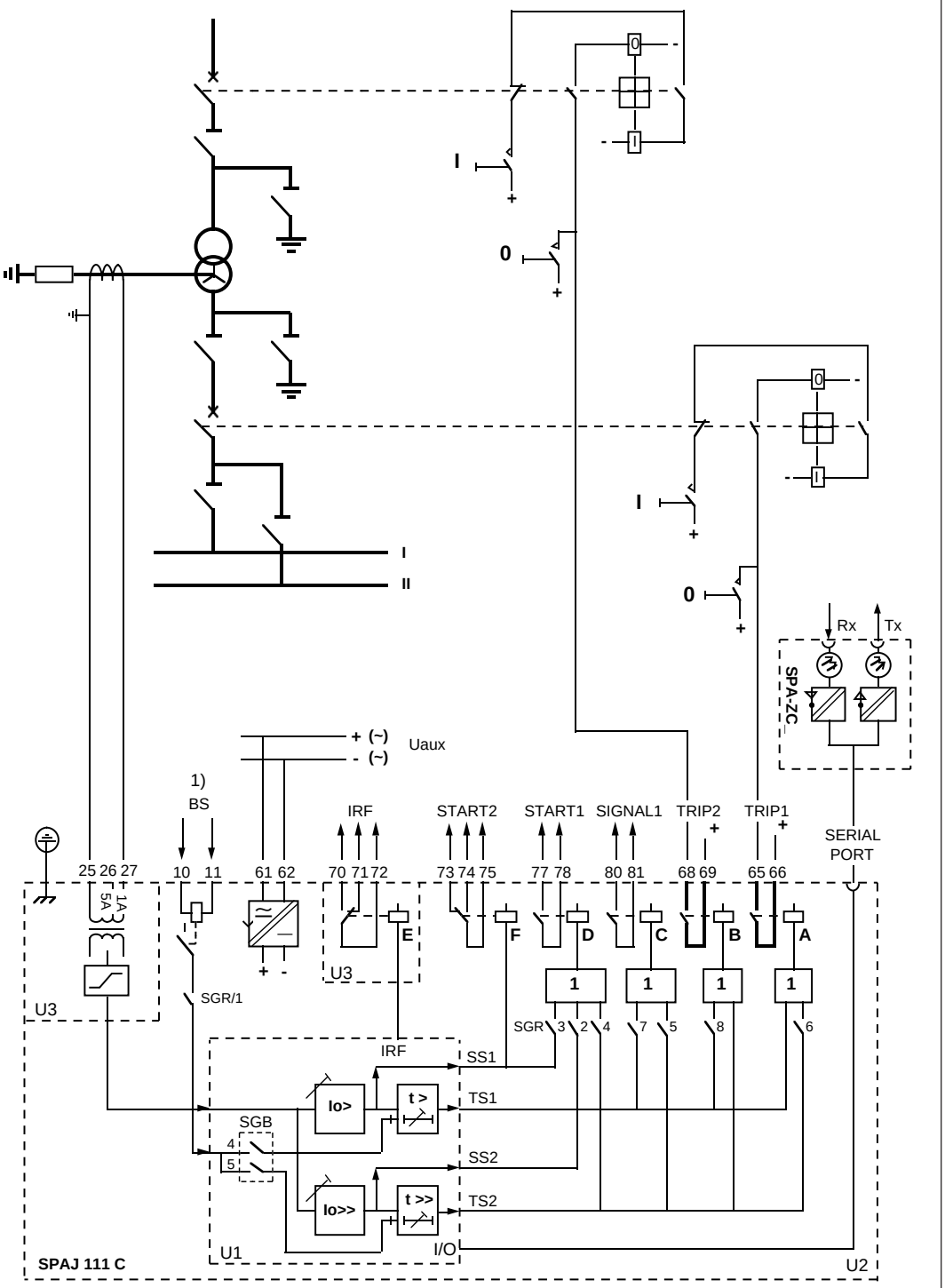
The selector switches of the earth-fault relay SPAJ 111 C can be set as follows:

Switch	SG1/SPCJ 1C7	SGB/SPCJ 1C7	SGR
1	1 t> = 0.5...10 s	0 not in use	0 no blocking signal
2	1 } I_0> = 0.2...2% x I_n	0 not in use	1 I_0>> start signal to relay D
3	0 }	0 not in use	0 no I_0> start signal to relay D
4	0 no latching	0 stage t> not blocked	0 no I_0>> trip signal to relay D
5	0 not in use	0 stage t>> not blocked	0 no I_0>> trip signal to relay C
6	1 } I_0>> = 1...8% x I_n	0 not in use	1 I_0>> trip signal to relay A
7	0 }	0 not in use	1 I_0> trip signal to relay C
8	0 t>> = 0.05...1.00 s	0 not in use	0 no I_0> trip signal to relay B
Σ	35		

When the switches are set as above, the output contacts of relay SPAJ 111 C provide the following signals:

Contact	Function
65-66	Circuit breaker trip signal, stage I_0> and stage I_0>>
68-69	Signal on tripping, stage I_0>>
80-81	Signal on tripping, stage I_0>
77-78	Start signal, stage I_0>>
73-74-75	Start signal, stage I_0>. Blocking signal for the e/f relay of the incoming feeder
70-71-72	Self-supervision signal

Example 2.
Earth-fault protection in resistively earthed network



1) Blocking signal from the earth-fault relay of an outgoing feeder

Fig. 5. The sensitive non-directional earth-fault relay SPAJ 111 C used as the earth-fault protection for the infeeder cubicle and the busbars. The selector switch settings are shown in the table on the following page.

The low-set stage of the earth-fault relay functions as back-up protection for the outgoing feeders and the high-set stage as the busbar earth-fault protection. If the earth- fault appears on an outgoing feeder the start signal of the feeder earth-fault relay blocks the earth-fault relay of the incoming feeder. If the earth-fault appears on the busbars no blocking signal is obtained and the earth-fault relay of the infeeder trips. The incoming blocking signal is routed to the high-set stage of the earth-fault relay module SPCJ 1C7 with switch SGB/5.

The fault current is measured with a current transformer between the neutral point of the low-voltage side of the power transformer and earth or between the neutral point of a generator and earth.

The high-set stage of the earth-fault relay trips the circuit breaker on the high-voltage side of the power transformer and the busbar earth-fault is rapidly isolated. The low-set stage trips the circuit breaker of the low-voltage side of the power transformer. Operate times down to 100 ms can be achieved at busbar earth-faults.

When an earth-fault appears somewhere in the earthed network a part of the fault current flows through the neutral earthing resistor. The busbar earth-fault relay starts on the same faults as the earth-fault relays of the feeders connected to the transformer. When the busbar earth-fault relay is used as a back-up relay for the earth-fault relays of the outgoing feeders the operate time of the busbar relay must be longer than the operate time of the feeder earth-fault relays. The busbar earth-fault relay in the above example can also be used for the detection of high-resistance earth-faults. When the busbar earth-fault relay is used for signalling only, the earth-fault relay can also be used for disconnection of the earthing resistor in order to lower the earth-fault current.

In the example the trip contact of the earth-fault relay is latching (SG1/4=1). The latched output relay can be reset with the push-button on the front panel or with a command via the serial bus.

The selector switches of the earth-fault relay SPAJ 111 C can be set as follows:

Switch	SG1/SPCJ 1C7	SGB/SPCJ 1C7	SGR
1	1 t> = 0.5...10 s	0 not in use	1 blocking signal from feeders
2	0 } I_0> = 1...10% x I_n	0 not in use	0 no I_0>> start signal to relay D
3	0 }	0 not in use	0 no I_0> start signal to relay D
4	0 no latching	0 stage t> not blocked	1 I_0>> trip signal to relay D
5	0 not in use	1 stage t>> blocked	0 no I_0>> trip signal to relay C
6	0 } I_0>> = 5...40% x I_n	0 not in use	0 no I_0>> trip signal to relay A
7	0 }	0 not in use	1 I_0> trip signal to relay C
8	0 t>> = 0.05...1.00 s	0 not in use	0 no I_0> trip signal to relay B
Σ	1		

When the switches are set as above, the output contacts of relay SPAJ 111 C provide the following signals:

Contact	Function
65-66	Circuit breaker trip signal, stage I_0>
68-69	Circuit breaker trip signal, stage I_0>>
80-81	Signal on tripping, stage I_0>
77-78	Signal on tripping, stage I_0>>
73-74-75	Start signal, stage I_0>
70-71-72	Self-supervision signal

Example 3.
Unbalance protection of capacitor battery

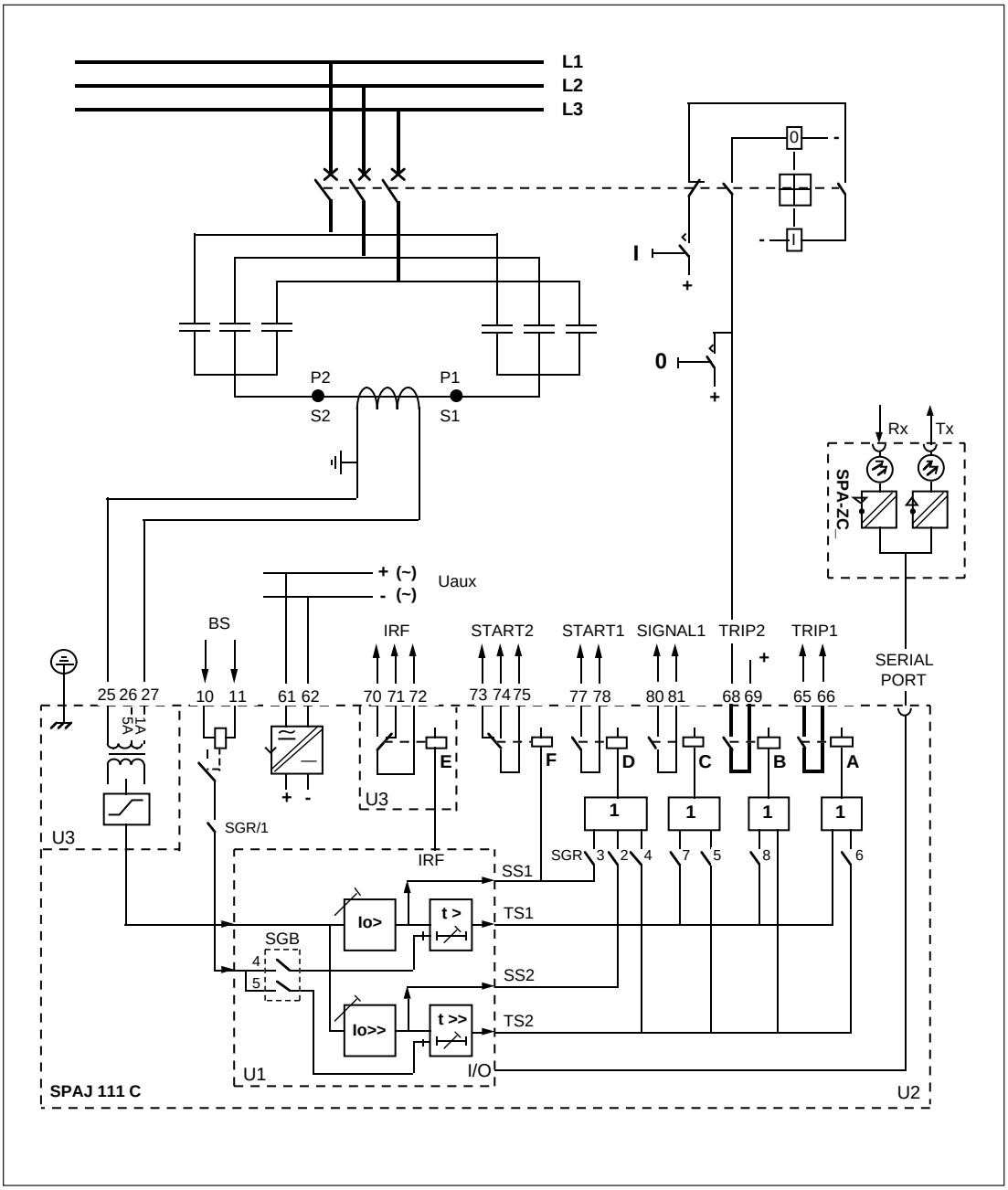


Fig. 6. The sensitive non-directional earth-fault relay SPAJ 111 C used as the unbalance protection for a capacitor battery. The selector switch settings are shown in the table on the following page.

The sensitive earth-fault relay can be used for the unbalance protection of a capacitor battery, provided that the capacitor battery is composed of two star-connected batteries. A capacitor battery is made up of a great number of fuse-protected capacitors connected in serias and parallel. When a fuse blows a small unbalance appears between the capacitor batteries and it can be measured with the sensitive earth-fault relay SPAJ 111 C. Two-stage protection is used, the first stage is signalling and the second stage trips the circuit breaker.

The settings of the relay are to be determined by the manufacturer of the capacitor battery, because the settings depend on the number of capacitor units and their ratings.

The selector switches of the earth-fault relay SPAJ 111 C can be set as follows:

Switch	SG1/SPCJ 1C7	SGB/SPCJ 1C7	SGR
1	1 t> = 0.5...10 s	0 not in use	0 no incoming blocking signal
2	1 } I_0> = 0.2...2% x I_n	0 not in use	1 I_0>> start signal to relay D
3	0 }	0 not in use	0 no I_0> start signal to relay D
4	0 no latching	0 stage t> not blocked	0 no I_0>> trip signal to relay D
5	0 not in use	0 stage t>> not blocked	1 I_0>> trip signal to relay C
6	1 } I_0>> = 1...8% x I_n	0 not in use	0 no I_0>> trip signal to relay A
7	0 }	0 not in use	0 no I_0> trip signal to relay C
8	0 t>> = 0.05...1s	0 not in use	0 no I_0> trip signal to relay B
Σ	37		

When the switches are set as above, the output contacts of relay SPAJ 111 C provide the following signals:

Contact	Function
65-66	Signal on tripping, stage I_0>
68-69	Circuit breaker trip signal, stage I_0>>
80-81	Signal on tripping, stage I_0>>
77-78	Start signal, stage I_0>>
73-74-75	Start signal, 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 records the maximum measured neutral current as a percentage of the rated current I_n of the energizing input in use. The register value is updated if:

- the measured neutral current exceeds the value already recorded in the register
- the relay operates. At relay operation the value at the moment of operation is recorded.

The value of the neutral current recorded in a fault situation shows the magnitude of the fault current. When the network's total earth-fault current is known, the degree of development (the fault resistance) of the earth-fault can be determined. By means of the recorded value in register 1 the relation between the set start current of the relay and the real fault current can be seen. Correspondingly the relation between the set start current of the relay and the current values under normal service conditions can be determined.

Registers 2 and 3 contain the number of starts of stage I_0> and I_0>> and provide information on the occurrence of earth-faults and on the distribution of earth-faults in respect of the fault resistance. Frequent starts may indicate the presence 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 starts of stage I_0> and I_0>>, expressed in per cent of the set operate time. Any new start resets the register, which then starts counting from zero. When the stage operates, the register shows the value 100 [%].

Registers 4 and 5 provide information on the duration of an earth-fault, or the safety margin of the grading times of the protection. If, for instance, the value of register 4 of the busbar earth-fault relay operating as feeder back-up protection relay is 75, when the feeder relay operates, the safety margin between the main protection and the back-up protection is 25%.

Registers 1…5 can be reset 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.

For secondary testing the relay must be disconnected from the voltage transformer circuits and other secondary circuits by means of disconnectable terminal blocks or a test adapter fitted on the relay.

WARNING!
The current transformer secondary circuits must not be opened when they are energized. The high voltage produced by an open CT secondary circuit could be lethal and may damage instruments and insulation.

When the auxiliary voltage is connected to the relay, a self-testing program is carried out automatically. The self-testing program includes the whole relay except for the matching transformers and the contacts of the output relays. The operational condition of the relay is tested using ordinary relay test equipment. The secondary injection test also includes the matching transformers, the output relays and the accuracy of the operate values.

When no relay test set is available the secondary injection test can be carried out with the following equipment:
- adjustable voltage transformer 0…260 V, 1 A
- current transformer
- ammeter, accuracy ±0.5% or better
- stop watch or counter for time measurement
- dc voltage source for auxiliary supply
- 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 in chapter "Technical data" under the heading "Energizing inputs".

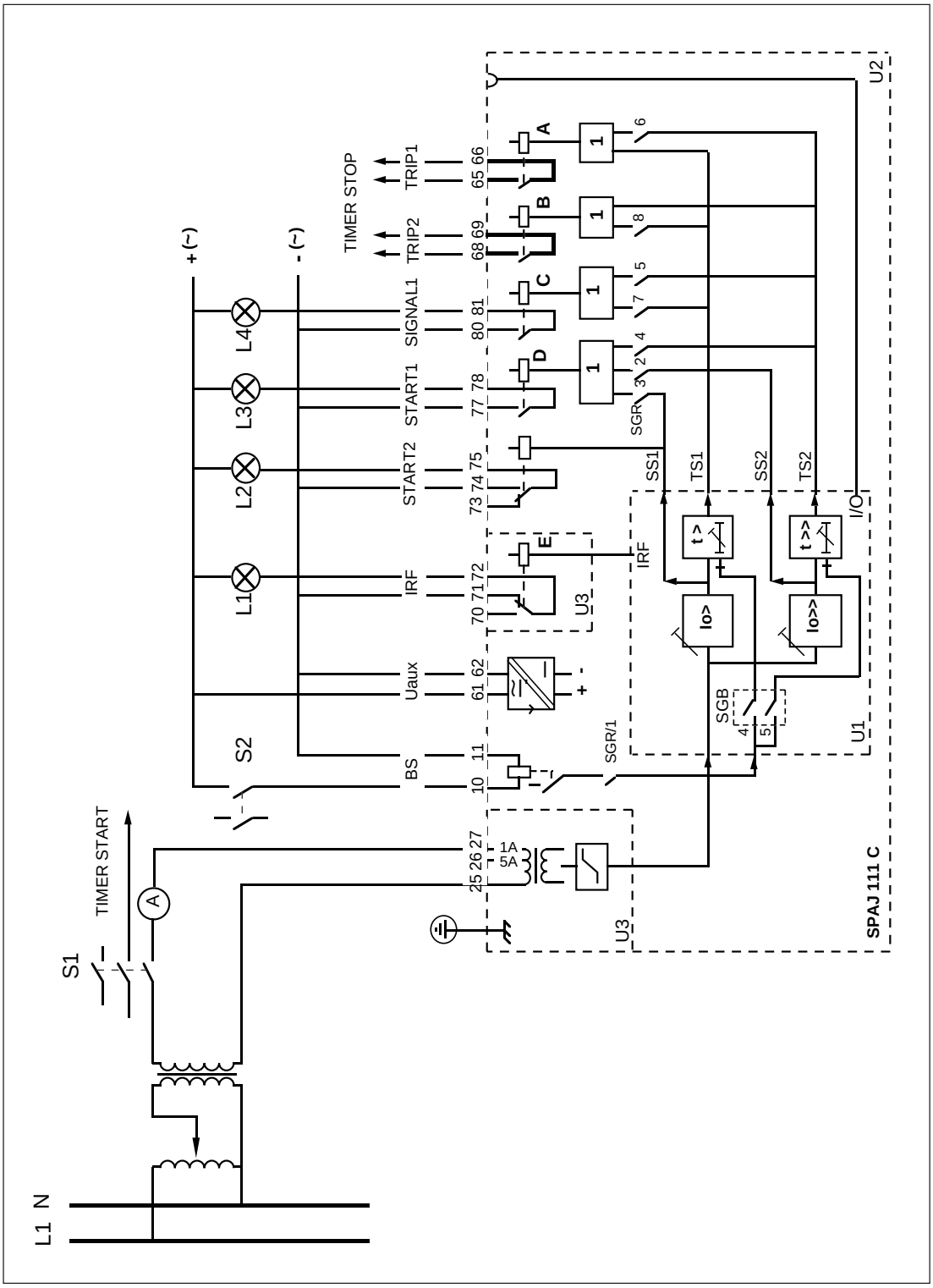


Fig. 7. Secondary injection test circuit for the earth-fault relay SPAJ 111 C.

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

Checking the matching transformers

Apply pure sine-formed test current to the relay and compare the current value read from the display of the relay with the current value shown by the ammeter. The measurements can, for instance, be performed at the rated current of the relay.

Checking 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

The following relay functions are obtained:

Output rel. (terminals)	Function
A (65-66)	Trip signal of the I_0> stage
B (68-69)	(Trip signal of the I_0>> stage)
C (80-81)	Signal on tripping of the I_0> stage (ind. L4)
D (77-78)	Not in use
E (71-72)	Self-supervision alarm (ind. L1)
F (74-75)	Start signal of the I_0> stage (ind. L2)

Checking the start function

Apply test voltage to terminals 25-26 or 25-27 depending on the used energizing input. Close switch S1 and increase the test current slowly until the low-set stage starts and indicator L2 is lit. Read the start current value from the ammeter.

Checking the operate time t>

Set the test current at 2 x the set start current of stage I_0>. The clock is started by closing the S1 switch and stopped via contact 65-66, when output relay A picks up.

The operation of output relay C is indicated with indicator L4.

When the relay starts the LED indicator I_0> in the right corner of the front panel is lit with yellow colour. When the low-set stage operates the LED indicator turns red.

Checking the blocking function

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

Apply control voltage to the external control input of the relay by closing switch S2. The control voltage should be of the same level as the auxiliary voltage of the relay. Increase the test current slowly until the low-set stage starts. After the set operate time the low-set stage is not allowed to operate as long as the blocking input is energized.

Checking the high-set stage I_0>>

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

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

Note!
Heavy test currents may be connected to the relay for a short time only. For technical specifications for the energizing inputs, see chapter "Technical data", section "Energizing inputs"

The following relay functions are obtained:

Output rel. (terminals)	Function
A (65-66)	(Trip signal of the I_0> stage)
B (68-69)	Trip signal of the I_0>> stage
C (80-81)	Signal on tripping of the I_0>> stage (ind. L4)
D (77-78)	Start signal of the I_0>> stage (ind. L3)
E (71-72)	Self-supervision alarm (ind. L1)
F (74-75)	(Start signal of the I_0> stage)

Set the test current at 2 x the set start current of stage I_0>>. The clock is started by closing the S1 switch and stopped via contact 68-69, when output relay B picks up.

Checking the self-supervision function (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 manual "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 static protection relays contain electronic circuits which may be damaged by static discharge electricity. Make sure that you are properly earthed when you are going to withdraw modules from the relay cases.

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

Sensitive earth-fault relay module	SPCJ 1C7
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

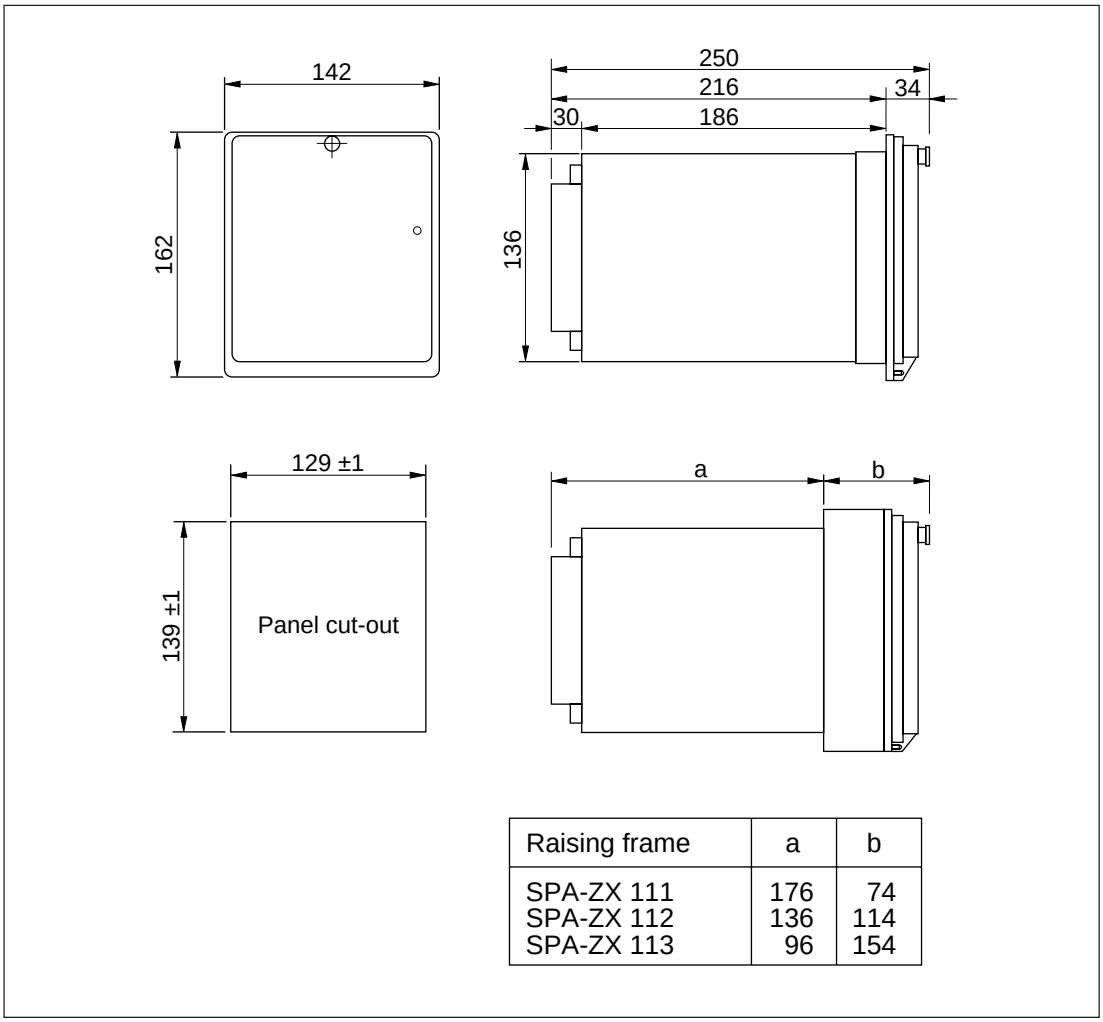
Earth-fault relay SPAJ 111 C	RS 421 011 -AA, CA, DA, FA
Earth-fault relay with test adapter RTXP 18 SPAJ 111 C	RS 421 211 -AA, CA, DA, FA

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 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 reduces the depth by 80 mm and type SPA-ZX 113 reduces the depth 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. 8. Dimensions of the earth-fault relay SPAJ 111 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.

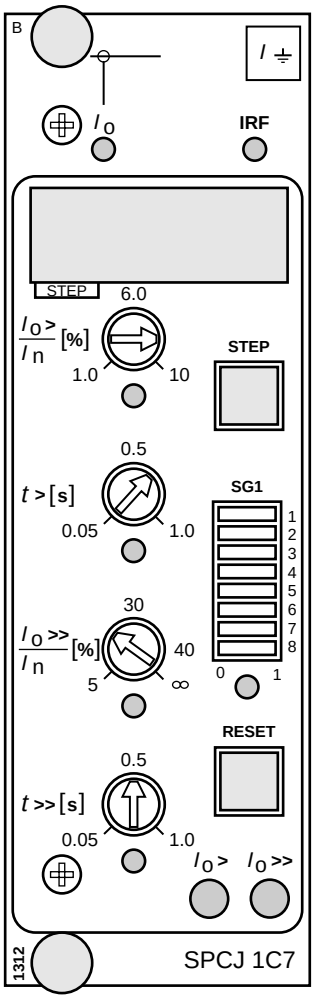
All input and output wires are connected to the screw terminal blocks on the rear panel. Each terminal is dimensioned for one 6 mm^2 wire or two 2.5 mm^2 wires. The D-type connector connects to the serial communication bus.

Order information

	Example
1. Quantity and type designation	15 pcs SPAJ 111 C
2. Ordering number	RS 421 011 -AA
3. Rated frequency	f_n = 50 Hz
4. Auxiliary voltage	U_{aux} = 110 V dc
5. Accessories	15 pcs bus connection module SPA-ZC 21 MM 2 pcs fibre-optic cables SPA-ZF MM100 14 pcs fibre-optic cables SPA-ZF MM5
6. Special requirements	-

SPCJ 1C7
Sensitive earth-fault relay module

User´s manual and Technical description



1MRS 750810-MUM EN

Issued 97-08-05
Version A (replaces 34 SPCJ 4 EN1)
Checked TK
Approved TK

SPCJ 1C7
Sensitive earth-fault relay module

Data subject to change without notice

Contents

Features

Definite time low-set residual current stage I_0>, setting range 0.2…50% x I_n

Definite time high-set residual current stage I_0>>, setting range 1…200% x I_n.

The operation of the high-set residual current stage can be set out of function

The operation of both residual current stages can be blocked by means of an external control signal

Local display of measured currents, set start currents, recorded fault data and other relay parameters

Remote serial communication capability

Enhanced reliability and system availability through extensive continuous self-supervision of hardware and software

Powerful software for setting and monitoring the relay module using a portable PC

Function

The sensitive residual current relay module SPCJ 1C7 is a single pole overcurrent module. It contains two residual overcurrent stages, a low-set stage I_0> and a high-set stage I_0>>.

The low-set or high-set residual current 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 trip signal, TS1 or TS2. At the same time the operation indicator of the concerned stage turns red. With switchgroup SG2 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 autoamtically 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 low-set stage I_0> includes three alternative setting ranges, i.e. 0,2…2% x I_n, 1…10% x I_n and 5…50% x I_n. The setting range to be used is selected with switches SG1/2 and SG1/3. Two operate time t> setting ranges are available, i.e. 0.05…1.00 s and 0.50…10.0 s. The setting range to be used is selected with switche SG1/1.

The high-set stage I_0>> also includes three alternative setting ranges, i.e. 1…8% x I_n, 5…40% x I_n and 25…200% x I_n. The setting range to be used is selected with switches SG1/6 and SG1/7. Two operate time t>> setting ranges are available, i.e. 0.05…1.00 s and 0.50…10.0 s. The setting range to be used is selected with switche SG1/8. The operation of the high-set stage can be set out of function by selecting the set value ∞, infinite.

The 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 or with a command V101 tai V102 vias the SPA-bus.

The energizing input is provided with a lowpass filter which suppresses harmonics of the energizing current, see Fig. 1.

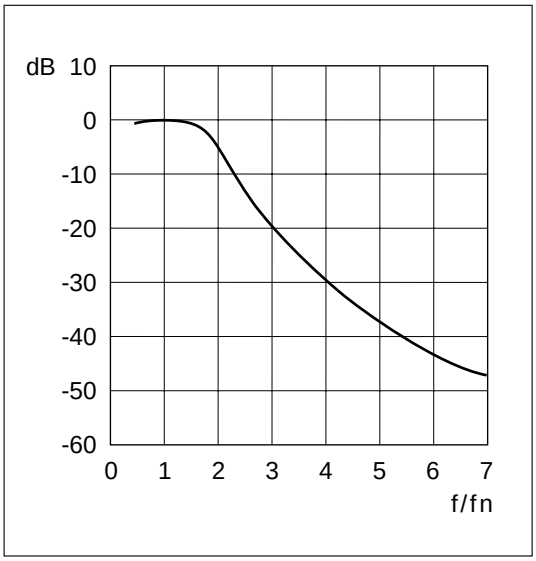


Fig. 1. Filter characteristics of the energizing input

Block diagram

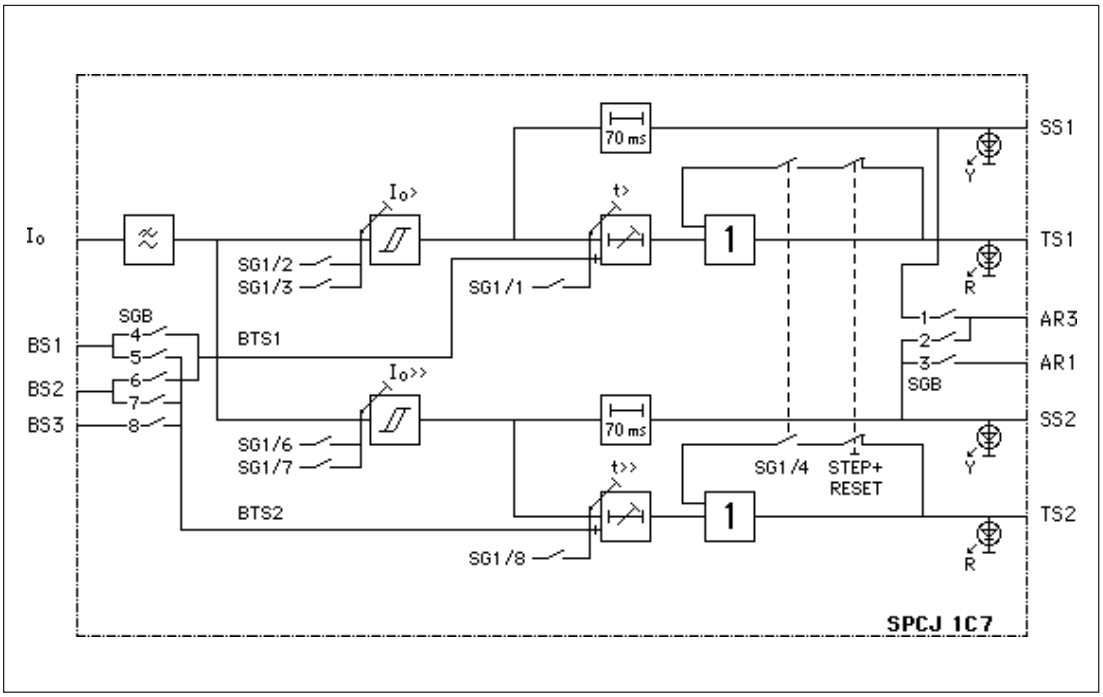


Fig. 2. Block diagram for the sensitive residual overcurrent relay module SPCJ 1C7

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
SG2	Indicator operation mode selector switchgroup (not shown in figure)
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
I_0>	Start current setting of the low-set stage I_0>
I_0>>	Start current setting of the high-set stage I_0>>
t>	Operate time setting of the low-set stage I_0>
t>>	Operate time setting of the high-set stage I_0>>
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

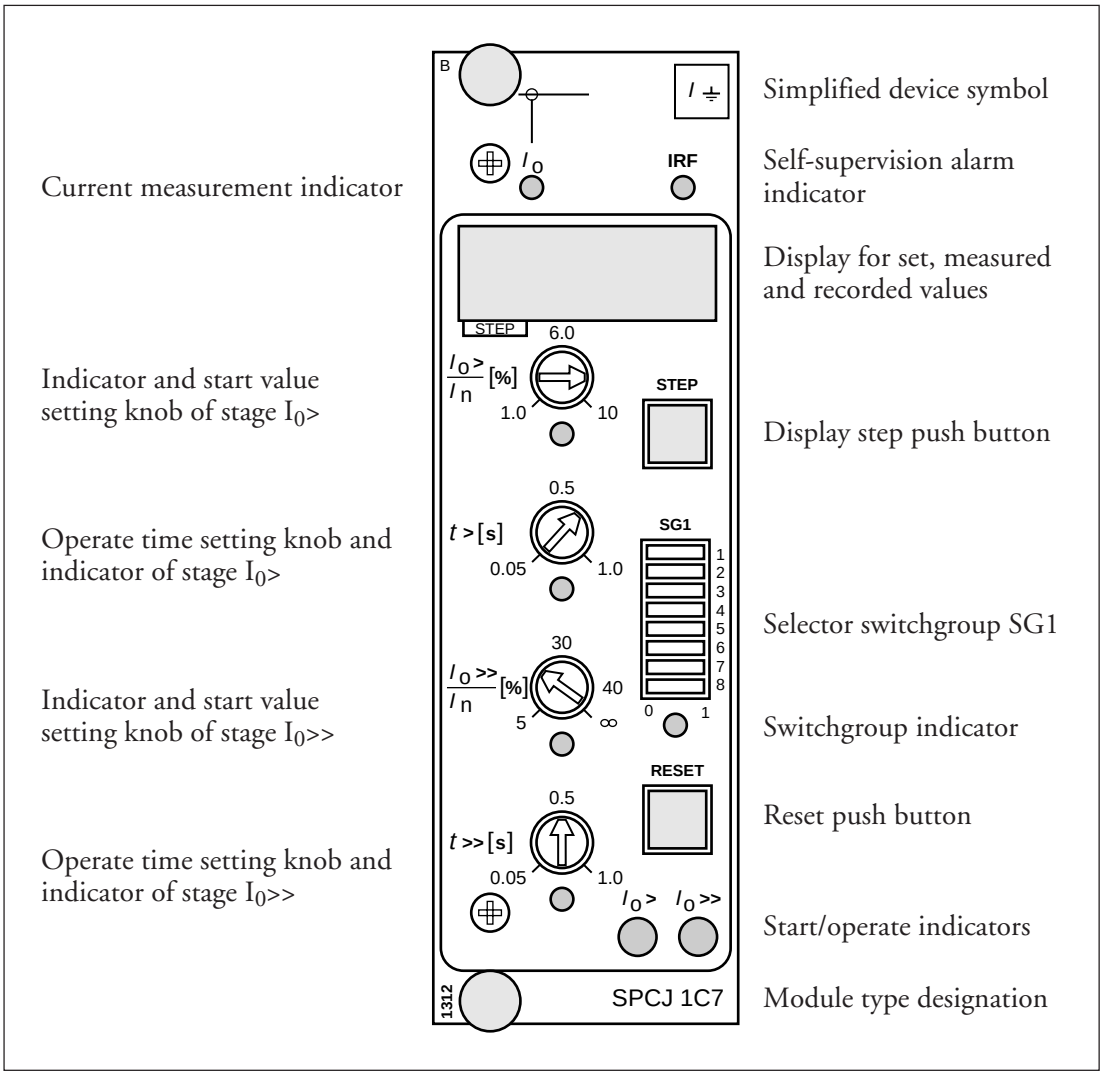


Fig. 3. Front panel of the sensitive residual current relay module SPCJ 1C7

Start and operation indicators

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

The four LED indications can, independently of one another, be given a self-reset or or a manual reset mode of operation. The manual reset mode means that the indicator remains lit after being switched on, although the overcurrent stage, which controls the indicator, resets. If, for instance, the yellow start indicator is given the manual reset mode and the red indicator the self-reset mode, the yellow indicator is lit, when the stage starts, which then turns red if and when the stage operates. When the overcurrent stage resets only the yellow 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.

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. The setting range, i.e. 0,2…2 % x I_n, 1…10 % x I_n or 5…50 % x I_n, to be selected with switch SG1/2 and SG1/3.
t>	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, to be selected with switch SG1/1 and SG1/2.
$I_0>>/I_n$	Start current of stage $I_0>>$ as a multiple of the rated current of the used relay energizing input. The setting range, i.e. 1…8 % x I_n, 5…40 % x I_n or 25…200 % x I_n, to be selected with switch SG1/6 and SG1/7. Additionally, the setting infinite "∞" (displayed as - - -) can be selected, rendering the stage I0>> inoperative.
t>>	The operate time of the $I_0>>$ stage, expressed in seconds. The setting range, 0.05…1.00 s or 0.5…10.0 s, is determined by the position of switch SG1/8.

Further, the checksum of 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 required and 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</td><td>Selection of the setting range of the operate time t> of stage $I_0>$

When SG1/1 = 0, the setting range of t> is 0.05…1.00 s
When SG1/1 = 1, the setting range of t> is 0.5…10.0 s.</td></tr>
<tr><td>SG1/2
SG1/3</td><td>Selection of the setting range of the low-set current stage $I_0>$
<table>
<tr><th>SG1/2</th><th>SG1/3</th><th>Setting range $I_0>$</th></tr>
<tr><td>0</td><td>0</td><td>1…10 % x I_n</td></tr>
<tr><td>1</td><td>0</td><td>0,2…2 % x I_n</td></tr>
<tr><td>0</td><td>1</td><td>5…50 % x I_n</td></tr>
<tr><td>1</td><td>1</td><td>1…10 % x I_n</td></tr>
</table>
</td></tr>
<tr><td>SG1/4</td><td>Selection of the mode of operation of the operate signals TS1 and TS2.

When SG1/4 = 0, the operate signals return to the initial state (= the output relay drops off), when the measuring 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 measuring 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>Not in use.</td></tr>
</table>

<table>
<tr><th>Switch</th><th>Function</th></tr>
<tr><td>SG1/6
SG1/7</td><td>Selection of the start current setting range of the high-set stage I_0>>.
<table>
<tr><th>SG1/6</th><th>SG1/7</th><th>Setting range I_0>></th></tr>
<tr><td>0</td><td>0</td><td>5…40% x I_n</td></tr>
<tr><td>1</td><td>0</td><td>1…8% x I_n</td></tr>
<tr><td>0</td><td>1</td><td>25…200% x I_n</td></tr>
<tr><td>1</td><td>1</td><td>5…40% x I_n</td></tr>
</table></td></tr>
<tr><td>SG1/8</td><td>Selection of the setting range of the operate time t>> of stage I_0>>

When SG1/8 = 0, the setting range of t>> is 0.05…1.00 s.
When SG1/8 = 1, the setting range of t>> is 0.5…10.0 s.</td></tr>
</table>

Switchgroup SG2 is a so called software switchgroup, 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 I0> and I0>> is determined by the switches of switchgroup 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	Manual reset	Factory default
Yellow indicator, I_0> starting	1	0
Red indicator, I_0> tripping	2	2
Yellow indicator, I_0>> starting	4	0
Red indicator, I_0>> tripping	8	8
Checksum Σ	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 data

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

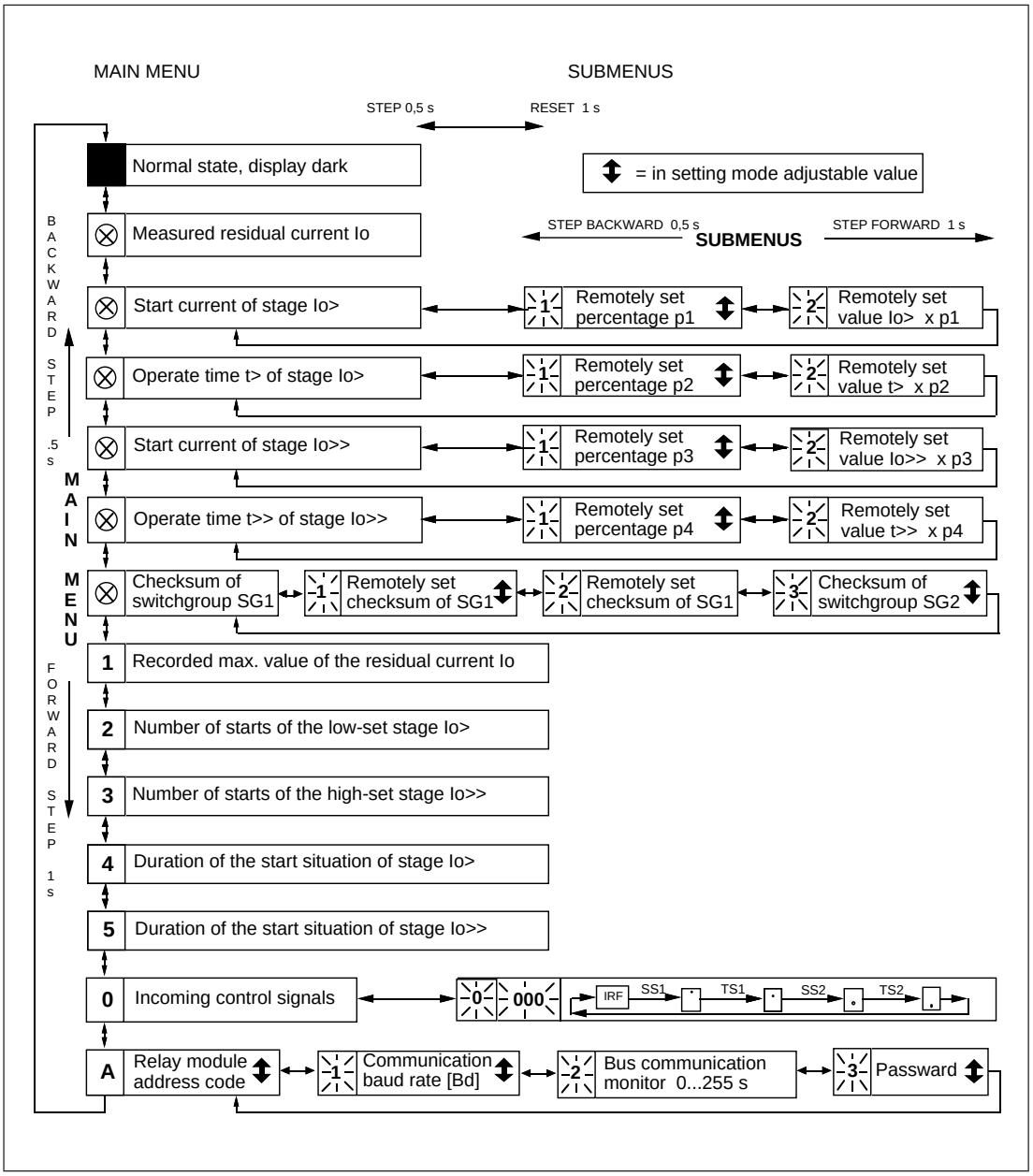
The leftmost digit of the display shows the address code of the register and the other three digits the value of the register.

Register/ STEP	Recorded information
1	Maximum current measured as a multiple of the rated current of the protection. The value of the register is updated, if one of the following conditions are fulfilled. 1) The measured current value exceeds the value already in the register. 2) The I_0> stage or the I_0>> operates. On operation the current value at the moment of operation is recorded in the register.
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>. 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 stage I_0> blocked 2 = tripping of the high-set stage I_0>> blocked 3 = tripping of both protection stages blocked The mid digit is permanently zero. The leftmost digit indicates the state of the remote reset input, if the protection relay is provided with one. 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, where the start and operate signals of the module can de activated by force one by one. For further details, see manual "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.

When the display is dark, the beginning of the display menu can be reached by pushing the STEP push-button once.

The registers 1...5 are reset by pressing the push-buttons STEP and RESET simultaneously or via the SPA bus using the V102 command. The registers are also reset if the auxiliary power supply of 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 outage. The instructions for setting the address number and the baud rate are described in the manual "General characteristics of C type relay modules".

Menu chart



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 manual "General characteristics of C type relay modules".

Low-set stage I_0>

Start current	0.2…2% x I_n, 1…10% x I_n or 5…50% x I_n
Start time, typically	75 ms
Operate time t>, definite time	0.05...1.00 s or 0.5...10.0 s
Reset time, typically	70 ms
Reset ratio, typically	0.96
Operate time accuracy	±2% of set value or ±40 ms
Operation accuracy	
- within the setting range 0.2…2% x I_n	±5% of set value
- within the setting range 2…50% x I_n	±3% of set value

High-set stage I_0>>

Start current	1…8% x I_n & ∞ ,infinite or 5…40% x I_n & ∞, infinite or 25…200% x I_n & ∞, infinite
Start time, typically	60 ms
Operate time t>>	0.05...1.00 s or 0.5...10.0 s
Reset time, typically	70 ms
Reset ratio, typically	0.96
Operate time accuracy	±2% of set value or ±40 ms
Operation accuracy	±3% of set value

Event codes

Over the SPA bus the substation communication system can read event data of the relay module SPCJ 1C7, e.g. start and trip events. Event information read 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. Further, the communication system forms event codes related to the data communication.

The event represented by the event codes E1…E8 can be included in or excluded from the event reporting by writing, via the SPA bus, an event mask (V155) to the relay module. The event mask is a binary number coded to a decimal number. The event codes E1…E8 are represented by the weight factors 1, 2, 4…128. The event mask is formed by multiplying the weight factors by 0 (event not included in the reporting) or 1 (event included in the reporting) and adding the weight factors so received, compare calculation of switchgroup checksum.

The event mask can take a value within the range 0…255. The default value of the sensitive earth-fault relay module SPCJ 1C7 is 85, which means that all startings and trip events are included in the reporting, but not the reset events. The events represented by the event codes E50…E54 cannot be excluded from the reporting.

Event codes of sensitive earth-fault relay module SPCJ 1C7:

Code	Event	Weight factor of event	Multiplyer default value
E1	Starting of stage I_0>	1	1
E2	Reset of starting of stage I_0>	2	0
E3	Tripping of stage I_0>	4	1
E4	Reset of tripping of stage I_0>	8	0
E5	Starting of stage I_0>>	16	1
E6	Reset of starting of stage I_0>>	32	0
E7	Tripping of stage I_0>>	64	1
E8	Reset of tripping of stage I_0>>	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 communication system.

Remote transfer data

Apart from the event codes the substation communication system can read, via the SPA bus, all input data (I data), output data (O data), setting values (S data), 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 availabe on channel 0

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

Data	Code	Data direction	Value
Measured residual current I_0	I1	R	0…250% x I_n
Blocking of tripping of stage I_0>	I2	R	0 = no blocking 1 = tripping blocked
Blocking of tripping of stage I_0>>	I3	R	0 = no blocking 1 = tripping blocked
Starting of stage I_0>	O1	R	0 = not started 1 = started
Tripping of stage I_0>	O2	R	0 = not tripped 1 = tripped
Starting of stage I_0>>	O3	R	0 = not started 1 = started
Tripping of stage I_0>>	O4	R	0 = not tripped 1 = tripped
Alerted start current of stage I_0>	S1	R	0.2…50% x I_n
Alerted operate time of stage I_0>	S2	R	0.05…10 s
Alerted start current of stage I_0>>	S3	R	1…200% x I_n 999 = ∞
Alerted operate time of stage I_0>>	S4	R	0.05…10 s
Alerted checksum of switchgroup SG1	S5	R	0…255
Start current of stage I_0>, set with the setting knob	S11	R	0.2…50% x I_n
Operate time of stage I_0>, set with the setting knob	S12	R	0.05…10 s
Start current of stage I_0>>, set with the setting knob	S13	R	1…200% x I_n 999 = ∞
Operate time of stage I0>>, set with the setting knob	S14	R	0.05…10 s
Checksum of switchgroup SG1 (set with the switches)	S15	R	0…255
Remotely set percentage of the start current of stage I_0>	S21	R, W	0…999%
Remotely set percentage of the operate time of stage I_0>	S22	R, W	0…999%
Remotely set percentage of the start current of stage I_0>>	S23	R, W	0…999%
Remotely set percentage of the operate time of stage I_0>>	S24	R, W	0…999%
Remotely set checksum of switch-group SG1	S25	R, W	0…255
Remotely set start current of stage I_0>	S31	R	0.2…50% x I_n
Remotely set operate time of stage I_0>	S32	R	0.05…10 s
Remotely set start current of stage I_0>>	S33	R	1…200% x I_n 999 = ∞
Remotely set operate time of stage I_0>>	S34	R	0,05…10 s
Remotely set checksum of switchgroup SG1	S35	R	0…255

Data	Code	Data direction	Value
Max. measured current or current measured at relay operation	V1	R	0…250% 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%
Remote resetting of output relays and operation indicators	V101	W	1 = output relays and operation indicators are reset
Remote resetting of output relays, operation indicators and recorded data	V102	W	1 = output relays, operation indicators and registers (codes V1…V5) are reset
Remote adjustment of settings	V150	R, W	0 = setting with setting knobs S11…S15 alerted 1 = remote settings S31…S35 alerted
Event mask	V155	R, W	0…255, see chapter "Event codes"
Manual/self reset of start and operation indicators (switchgroup SG2)	V156	R, W	0…15, see chapter "Selector switches"
Opening of password for remote setting of parameters	V160	W	1…999
Changing or closing of password for remote setting of parameters	V161	W	0…999
Activation of self-supervision system	V165	W	1 = self-supervision system output is activated and IRF indicator turns on 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 relay module	V200	W	1…254
Sofware version of module	V205	R	e.g. 069 B

Data	Code	Data direction	Value
Relay module type designation	F	R	SPCJ 1C7
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 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
Reading and setting of clock time	T	R, W	00.000…59.999 s

The data transfer codes L, B, C and T have been reserved for the event data transfer between the relay module and the communication system.

The event register can be read once by the L command. Should a fault occur, for instance in the data transfer, the event register can be re-read by means of the B-command. When required, the B-command can be repeated.

The parameters S1…S5 contain the alerted setting values. These values are defined either via the communication system or with the setting knobs. The values of S11…S15 are set with setting knobs and switchgroup SG1. Parameters S21…S25 contain the percentages set via the communication system. The parameters S21…S25 can be read and written. Writing requires that the password (V160) for has been opened and the potentiometer settings are alerted (V150 = 0). The parameters S31…S35 contain the remote setting values.

The parameters S21…S24 can be given a percentage value within the range 0…999.

Note!
The parameters S21…S24 can be given such values that the setting range limits of the different parameters are exceeded. However, the validity of the setting values are guaranteed only within the setting range limits specified in the technical data of the relay module.

Activation of the self-supervision output (V165) prevents the relay from operating as long as the self-supervision output is active and the IRF indicator is lit.

Fault codes

Shortly after the self-supervision system has detected a permanent internal fault in the relay module the red IRF (Internal Relay Fault) indicator is lit. Simultaneously the relay module generates a control signal to the IRF output relay.

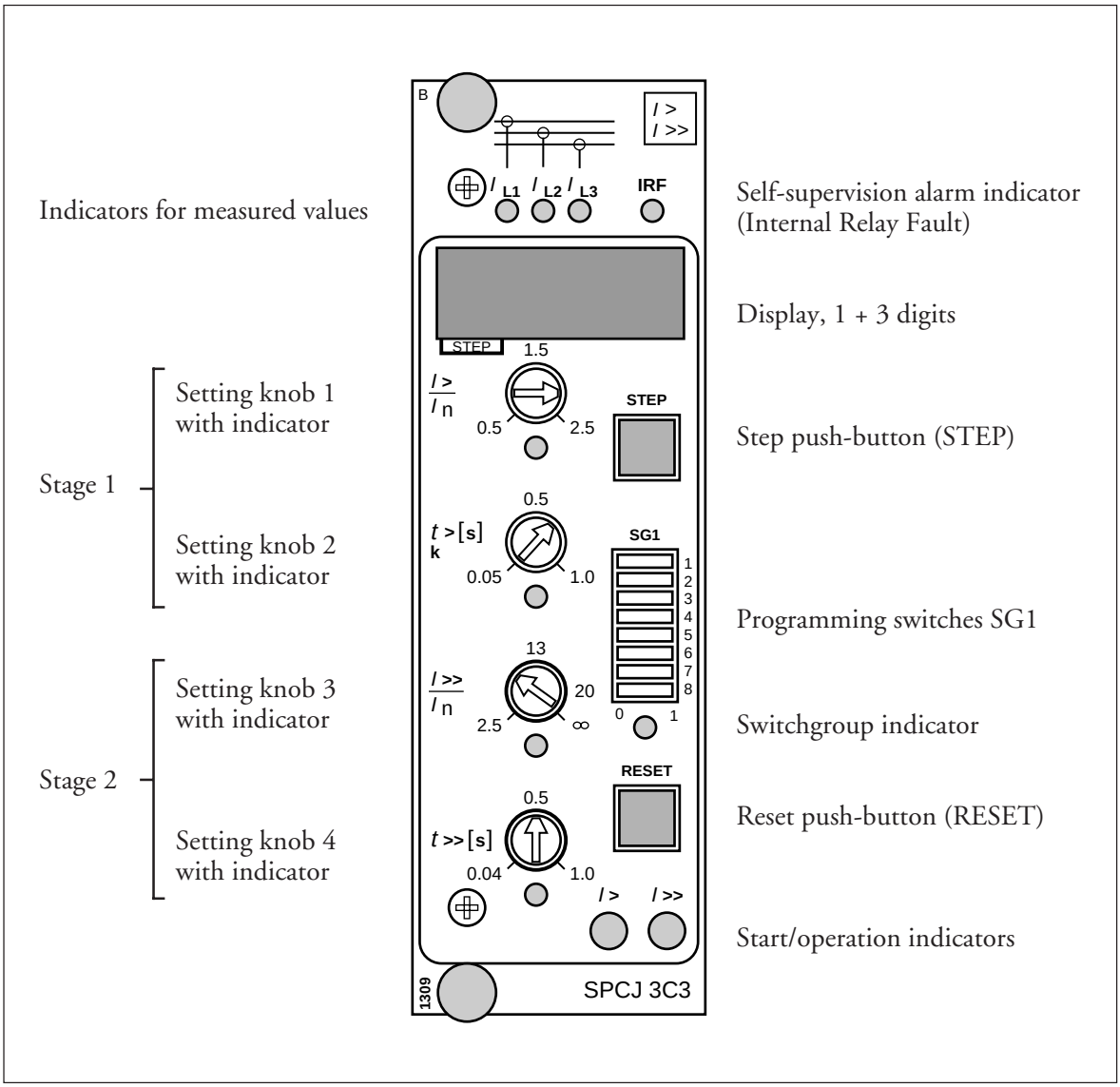
In most fault situations an autodiagnostic fault code appears on the display of the module. The fault code consists of a red number 1 (one), and a green, one to three digit code number. When a fault is detected the fault code should be recorded for further use when the relay module is to be repaired.

Some of the fault codes that may appear on the display of the sensitive earth-fault relay module SPCJ 1C7 are shown in the following list:

Fault code	Fault type
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



1MRS 750328-MUM EN

Issued 96-02-19
Version A (replaces 34 SPC 2 EN1)
Checked L-W U
Approved TK

Data subject to change without notice

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.

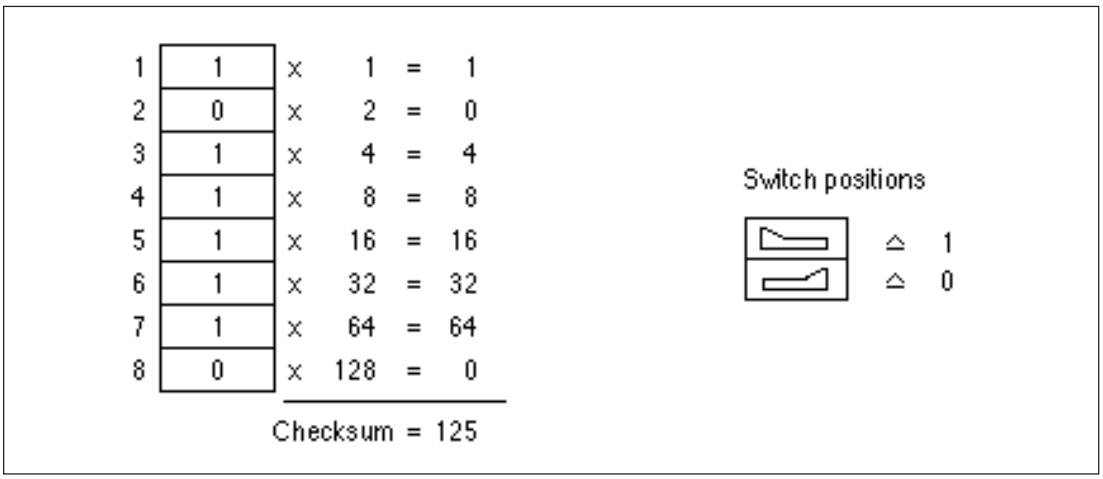


Fig. 2. Example of calculating the checksum of programming switchgroup SG1.

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.

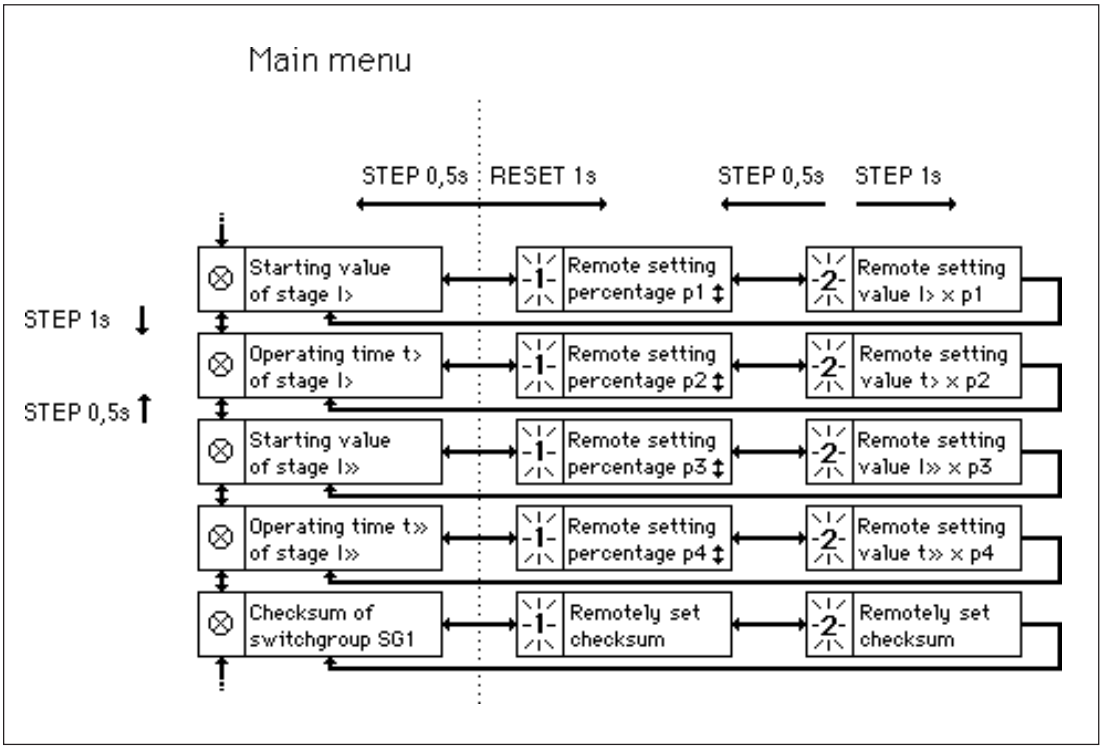


Fig. 3. Example of the main and submenus for the settings of the overcurrent relay module SPCJ 3C3. The settings made with the setting knobs are in the main menu and they are displayed by pressing the STEP button. In addition to the setting knob settings the main menu contains the measured current values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

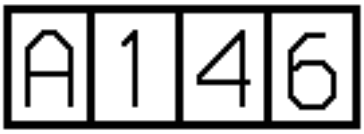
A set value is stored in the memory by pressing the push-buttons STEP and RESET simultaneously. In practice the RESET button must be pressed slightly in excess of the STEP button. Return from the setting mode to the main menu or submenu is possible by pressing (for about 10 s) the RESET button until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

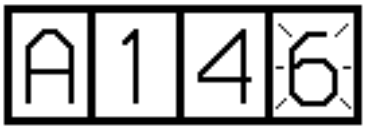
Example 1:

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.

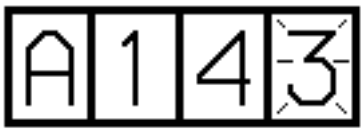
a)
Press push-button STEP until register address A appears on the display.



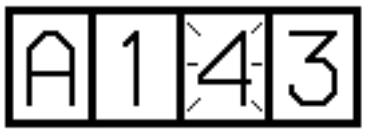
b)
Press the RESET button for about 10 s until the right most digit starts flashing.



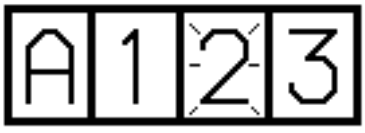
c)
Press the STEP button repeatedly to set the digit to the value desired.



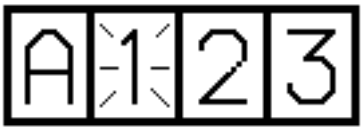
d)
Press the RESET button to make the middle of the green digits flash.



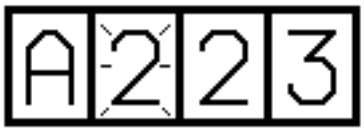
e)
Set the middle address digit by means of the STEP button.



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

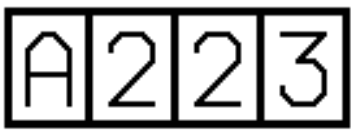


g)
Set the digit by means of the STEP button.



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.

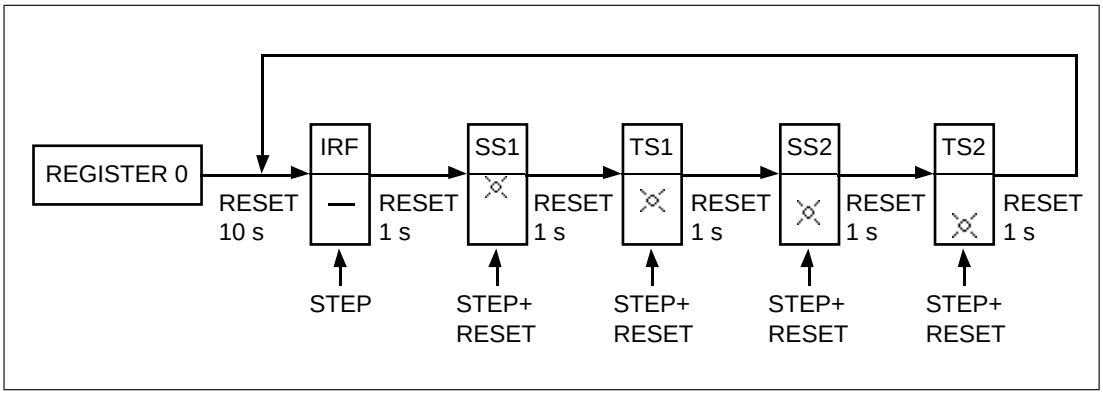


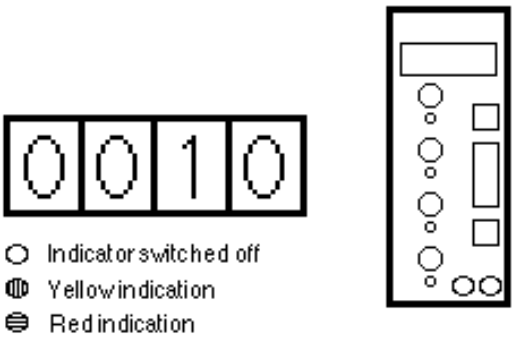
Fig. 4. Sequence order for selecting the output signals in the Trip-test mode.

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.

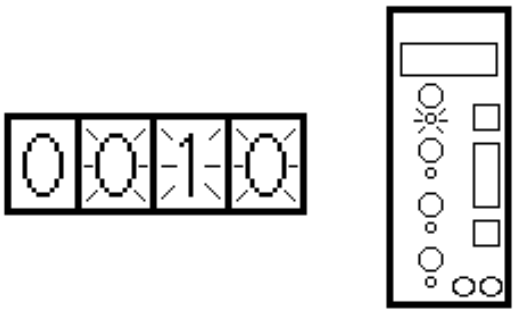
Example 2:

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

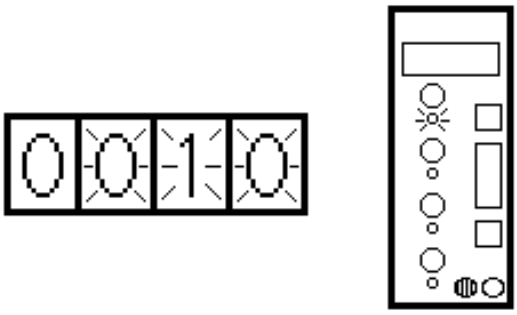
a)
Step forward on the display to register 0.



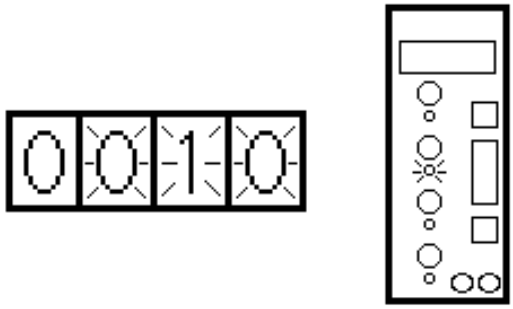
b)
Press the RESET button for about 10 seconds until the three green digits to the right and the LED indicator of the uppermost setting knob start flashing.



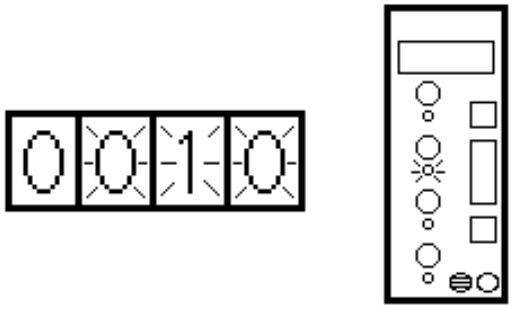
c)
Press the push-buttons RESET and STEP simultaneously. Then the starting of stage 1 (e.g. the I>-stage of the overcurrent module SPCJ 3C3) is activated and, simultaneously, the indicator of the stage starts glowing yellow.



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.

ABB Oy
Substation Automation
P.O.Box 699
FIN-65101 VAASA
Finland
Tel. +358 (0)10 22 11
Fax.+358 (0)10 22 41094
www.abb.com/substationautomation

1MRS 750809-MUM EN