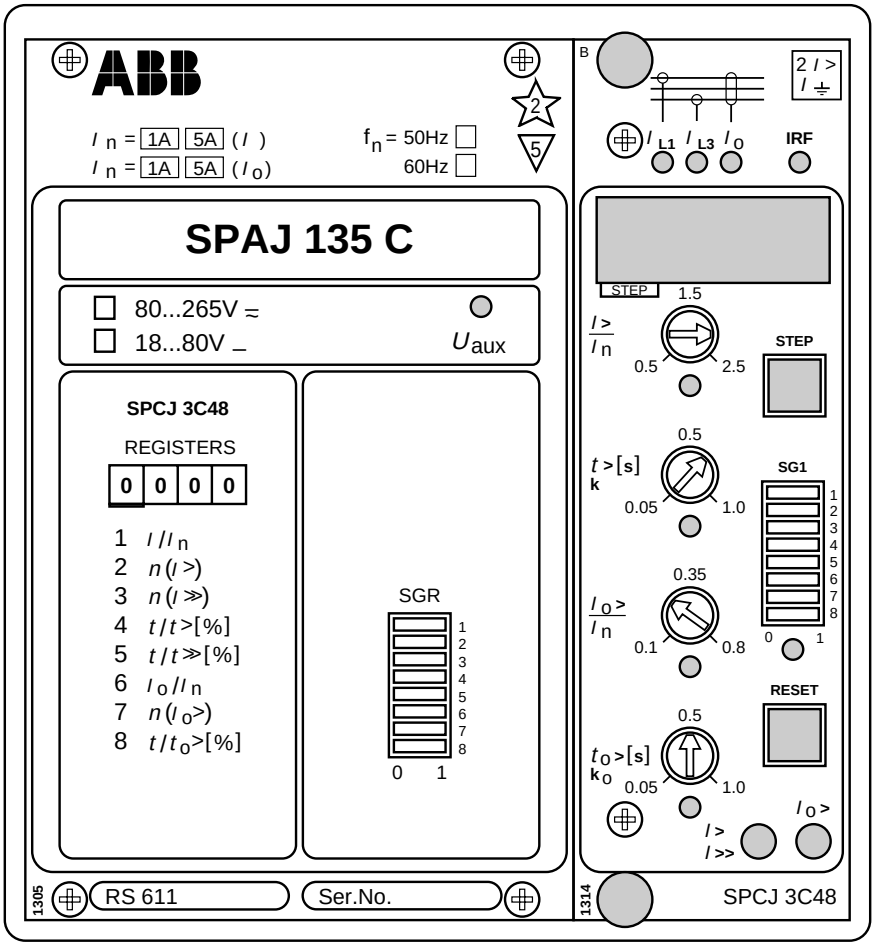
SPAJ 135 C
Combined overcurrent and earth-fault relay

User´s manual and Technical description



ABB

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Data subject to change without notice

Contents

The complete manual for the combined overcurrent and earth-fault relay SPAJ 135 C includes the following submanuals:

Combined overcurrent and earth-fault relay SPAJ 135 C	1MRS 750811-MUM EN
Combined overcurrent and earth-fault relay module SPCJ 3C48	1MRS 750812-MUM EN
General characteristics of C-type relay modules	1MRS 750328-MUM EN

Features

Two-stage phase overcurrent protection and single-stage earth-fault protection in one relay

Two-phase definite time or inverse time (IDMT) low-set overcurrent stage

Two-phase instantaneous or definite time high-set overcurrent stage

Non-directional definite time or inverse time (IDMT) earth-fault stage

Fully field-configurable output relay functions

Flexible matching of the relay to a variety of protection applications

Numerical display of setting values, measured values, recorded fault values, indications etc.

Built-in pulse-width-modulated galvanically isolating power unit for a wide range of auxiliary voltages

Serial interface for bus connection module and optical-fibre substation bus

Continuous self-supervision of relay hardware and software for enhanced system reliability and availability

Auto-diagnostic fault indication to facilitate repair after detection of permanent internal relay fault.

Application

The combined phase overcurrent and earth-fault relay SPAJ 135 C is intended to be used for time and current graded overcurrent and earth-fault protection in distribution networks. The relay is especially suited for use in solidly earthed and low-resistance earthed networks.

The relay contains a two-phase non-directional overcurrent protection and a non-directional earth-fault protection. The two-stage overcurrent unit includes a low-set stage I> and a high-set stage I>>. The low-set stage I> features field-selectable definite time characteristic or inverse definite minimum time (IDMT) characteristic as per IEC 60255. The high-set stage I>> operates instantaneously or with definite time characteristic. The earth-fault unit I_0> also features field-selectable definite time characteristic or inverse definite minimum time (IDMT) characteristic as per IEC 60255.

Description of function

The combined overcurrent and earth-fault relay SPAJ 135 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. The relay measures two phase currents and the residual current. When a phase overcurrent fault or an earth-fault occurs, the relay operates according to the functions and configurations it has been given.

When one of the phase currents or both exceed the set start value I> of the low-set stage, the overcurrent unit starts. When, at definite time mode of operation, the set operate time t> or, at IDMT mode of operation, the calculated operate time, has expired, the overcurrent unit operates delivering a trip signal TS1. In the same way the high-set stage starts when its start value I>> is exceeded and when the set operate time t>> has expired, the relay operates, delivering a trip signal TS1.

The earth-fault unit functions in the same way. When the start value I_0> is exceeded the earth-fault unit starts and when, at definite time mode of operation, the set operate time t_0> or, at IDMT mode of operation, the calculated operate time, has expired, the earth-fault unit operates, delivering a trip signal TS2.

The low-set stage of the overcurrent unit and the earth-fault unit can be given either definite-time or inverse-time characteristic. At inverse time characteristic four inverse time curve sets with different inclination as per IEC 60255 are available: Normal inverse, Very inverse, Extremely inverse and Long-time inverse.

The overcurrent and earth-fault relay is provided with two output relays for tripping and four for signalling purposes.

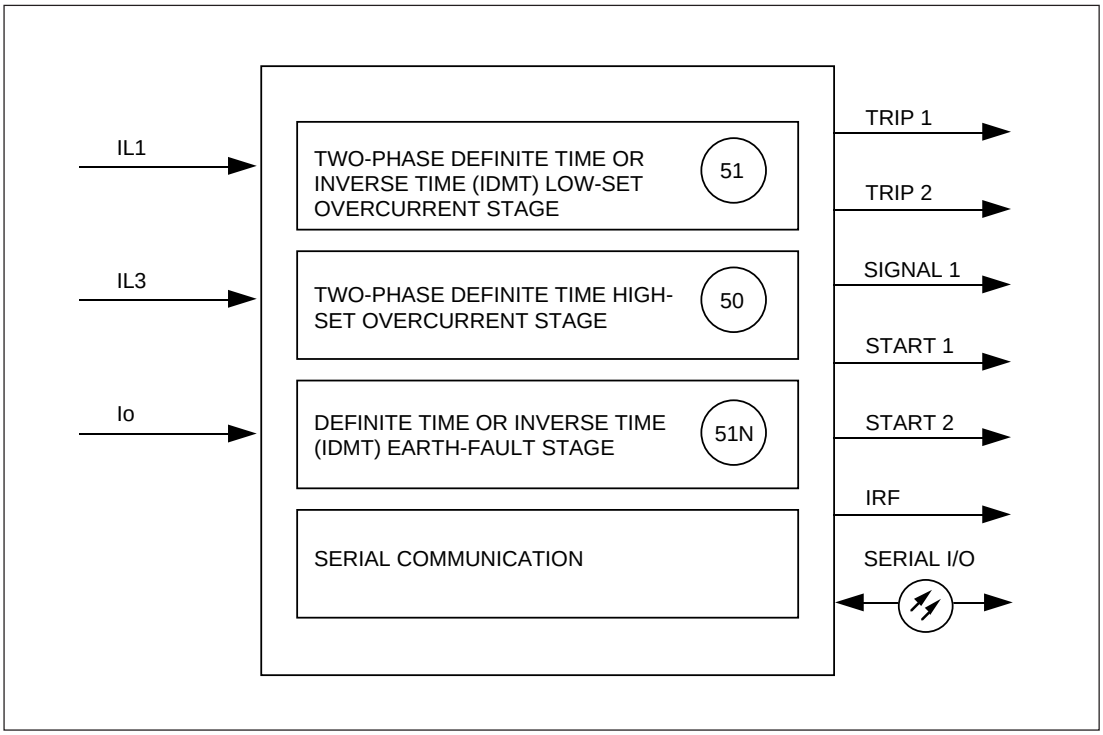


Fig. 1. Protection functions of the combined overcurrent and earth-fault relay SPAJ 135 C. The encircled numbers refer to the ANSI (=American National Standards Institute) number of the concerned protection function.

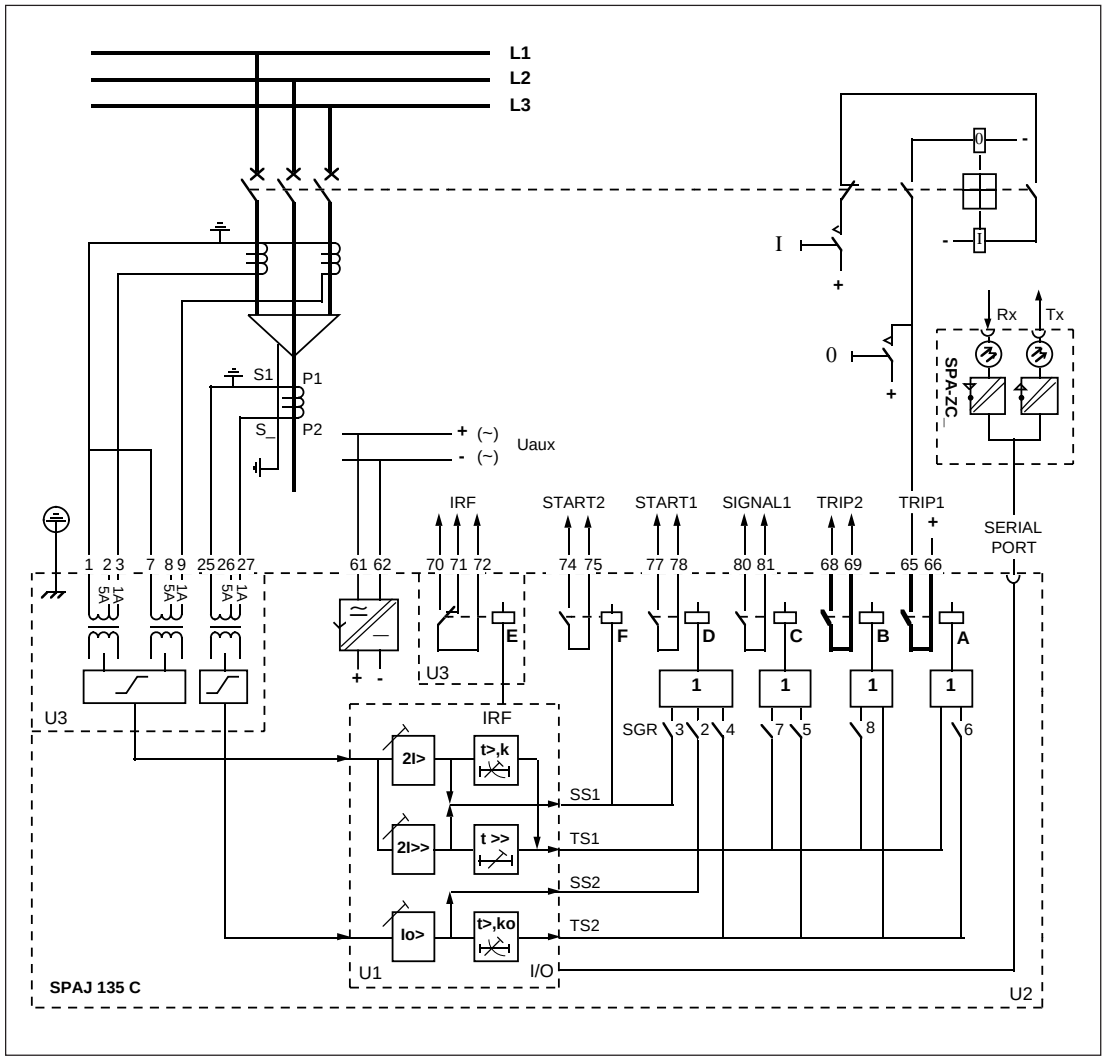


Fig. 2. Connection diagram for the combined overcurrent and earth-fault relay SPAJ 135 C.

U_{aux}	Auxiliary voltage
A,B,C,D,E,F	Output relays
IRF	Self-supervision signal
SS	Start signal
TS	Trip signal
SGR	Switchgroup for configuring trip and alarm signals
TRIP_	Trip output
SIGNAL1	Signal on relay operation
START_	Start signal or signal on relay operation
U1	Combined overcurrent and earth-fault relay module SPCJ 3C48
U2	Power supply and I/O module SPTU 240S1 or SPTU 48S1
U3	I/O module SPTE 3E14
SERIAL PORT	Serial communication port
SPA-ZC_	Bus connection module
Rx/Tx	Optical-fibre receiver (Rx) and transmitter (Tx) of the bus connection module

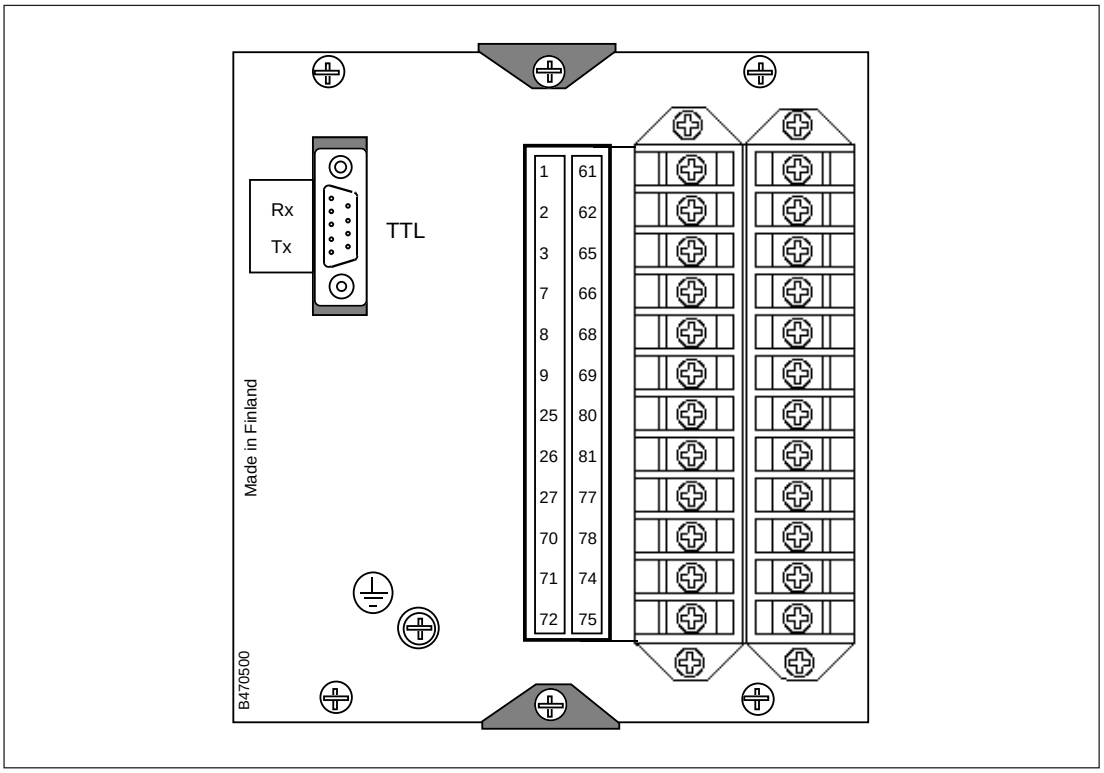


Fig.3. Rear view of the combined overcurrent and earth-fault relay SPAJ 135 C.

Specification of input and output terminals

Contacts	Function
1-2	Phase current I_{L1} (I_n = 5 A)
1-3	Phase current I_{L1} (I_n = 1 A)
7-8	Phase current I_{L3} (I_n = 5 A)
7-9	Phase current I_{L3} (I_n = 1 A)
25-26	Neutral current I_0 (I_n = 5 A)
25-27	Neutral current I_0 (I_n = 1 A)
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>, I>> and I_0> (TRIP 1)
68-69	Trip output 2 for stages I>, I>> and I_0> (TRIP 2)
80-81	Signal on tripping of stages I>, I>> and I_0> (SIGNAL 1)
77-78	Signal on tripping of stage I_0>, starting of stages I>, I>> and I_0> (START 1)
74-75	Starting of stage I> and I>> (START 2)
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

NOTE!
In single phase applications the energizing current can be connected through both serial connected phase current energizing inputs. This connection yields a faster relay operation on overcurrent, especially at instantaneous operation.

The combined overcurrent and earth-fault relay SPAJ 135 C is connected to the optical fibre 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 of the bus connection module. The selector switch for the mode of communication of the bus connection module is set in position "SPA".

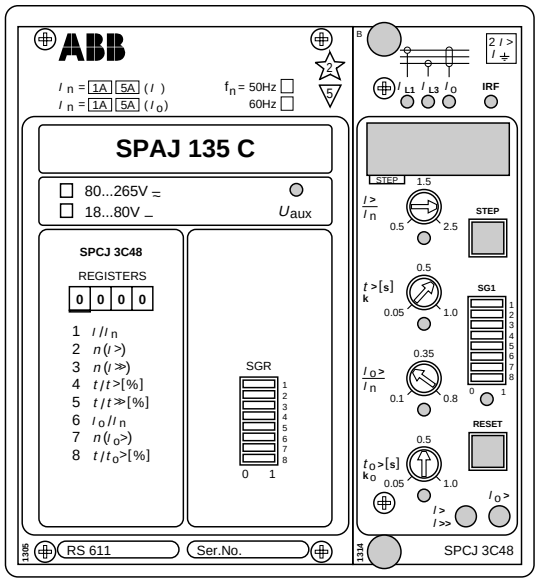
Configuration of output relays

The start signals of the I> and I>> stages are firmly wired to output relay F and the trip signals 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 of the relay:

Switch	Function	Factory default	User's settings
SGR/2	Routes the start signal of the I_0>>stage to output relay D	1	
SGR/3	Routes the start signals of the I> and I>> stages to output relay D	1	
SGR/4	Routes the trip signal of the I_0> stage to output relay D	1	
SGR/5	Routes the trip signal of the I_0> stage to output relay C	1	
SGR/6	Routes the trip signal of the I_0> stage to output relay A	1	
SGR/7	Routes the trip signals of the I> and I>> stages to output relay C	1	
SGR/8	Routes the trip signals of the I> and I>> stages to output relay B	1	

The circuit breakers can be controlled directly both with output relay A or output relay B. This enables two circuit breakers to be controlled at the same time or separate trip output relays can be configured for the overcurrent protection and the earth-fault protection.

Start and operation indicators



1. The relay module is provided with two operation indicator located in the right bottom corner of the front plate of the relay module. One indicates operation of the overcurrent unit and the other operation of the earth-fault unit. Yellow light indicates that the concerned unit has started and red light that the unit has operated (tripped).

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

2. The yellow LED indicators (I_{L1}, I_{L3} and I_0) on the upper black part of the front plate indicate, when lit, that the corresponding current value is currently being displayed.

   When the display is dark and the relay operates, the concerned LED indicator(s) is (are) lit showing which unit has operated. The LED indicators are reset by pushing the STEP or RESET push-button.

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 particular setting knob indicates, when lit, that the setting value of the knob is currently 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 the user's manual "Combined overcurrent and earth-fault relay module SPCJ 3C48".

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 and the control circuits of the output relays.

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 240S1 U_{aux} = 80...265 V ac/dc
- type SPTU 48S1 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	1-3, 7-9, 25-27	1-2, 7-8, 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

Trip contacts	
Terminals	65-66, 68-69
Rated voltage	250 V ac/dc
Carry continuously	5 A
Make and carry for 0.5 s	30 A
Make and carry for 3 s	15 A
Breaking capacity for dc, when the manoeuvre circuit time constant L/R ≤ 40 ms, at the control voltages	
- 220 V dc	1 A
- 110 V dc	3 A
- 48 V dc	5 A
Signalling contacts	
Terminals	70-71-72, 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

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

Combined overcurrent and earth-fault relay module SPCJ 3C48

Low-set overcurrent stage I>	
Start current I>	0.5...2.5 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	Normal inverse Very inverse Extremely inverse Long-time inverse
- time multiplier k	0.05...1.00
High-set stage I>>	
Start current I>>	0.5...17.5 x I_n or ∞, infinite
Operate time t>>	50 ms, 150 ms, 300 ms, 500 ms or ∞, infinite = out of operation
Earth-fault stage I_0>	
Start current I_0>	0.1...0.8 x I_n
Selectable modes of operation	
- definite time characteristic	
- operate time t_0>	0.05...100 s
- inverse definite minimum time (IDMT) characteristic	
- curve sets acc. to IEC 60255-3	Normal inverse Very inverse Extremely inverse Long-time inverse
- time multiplier k_0	0.05...1.00

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.

Application examples

Example 1.
Feeder overcurrent and earth-fault protection, residual current measurement with phase current transformers

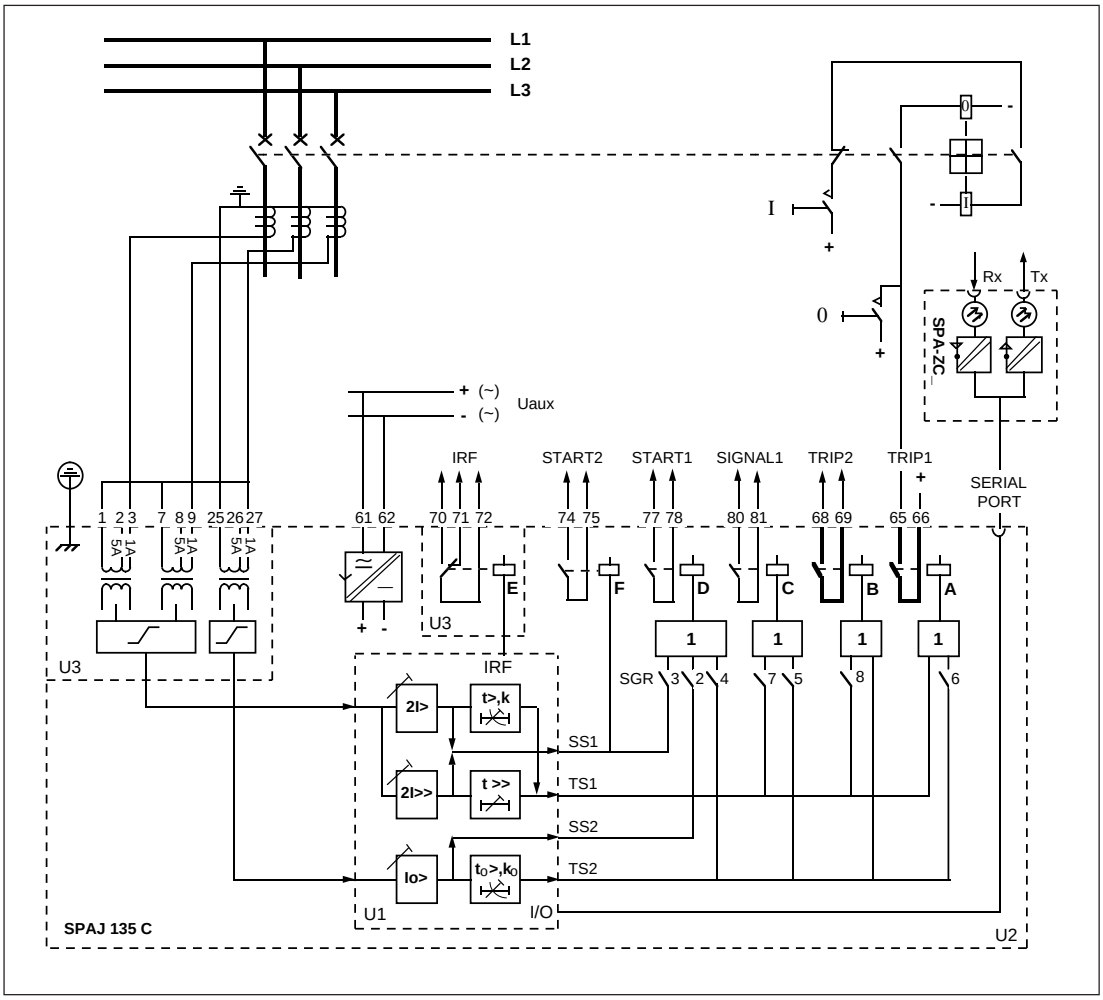


Fig. 4. Overcurrent and earth-fault relay SPAJ 135 C used for the protection of distribution feeders. The residual current is measured with three phase current transformers in residual current connection. The selector switch settings are shown overleaf.

The relay SPAJ 135 C is used for overcurrent and earth-fault protection of distribution feeders. The high-set stage is set in such a way that it reaches the following protection stage. The high-set stage operates on close-up faults. The earth-fault stage acts as a single-stage feeder earth-fault protection.

When the current settings are calculated no possible unsymmetry of the current needs to be considered. The relay uses a so called top-to-top measuring principle, which makes the relay insensitive to any unsymmetry of the current.

The low-set stage of the overcurrent unit and the earth-fault unit can be given definite time or inverse time characteristic. In the above example inverse time characteristic has been selected for both stages.

At inverse time characteristic the operate time is shorter the higher the energizing current is. Thus the operate time of the relay is short for close-up overcurrent faults and low-resistance earth-faults. Thanks to the inverse time characteristic short overload situations, connection inrush currents, intermittent earth-faults etc cause no false relay operation.

The desired inverse time curve is selected separately for the overcurrent and the earth-fault stage with switchgroup SG2.

When coordination is required between fuses and relays the extremely inverse curve is preferred. The extremely inverse curve is also used in applications where the fault current under any network connection situation is many times grater than the rated current. When the extremely inverse curve is used the relay permits temporary overloads e.g. during the run-up of a large motor.

In network, where the magnitude of the short-circuit current strongly varies with the network configuration the normal inverse characteristic is recommended. This allows relatively short operate times for the overcurrent stage, although the short-circuit current only slightly exceeds the rated current.

The very inverse curve is an intermediate form between the normal inverse and extremely inverse curves. At a short-circuit the operate time is rather short, although the short-circuit current should vary in accordance with the network configuration. On the other hand the very inverse characteristic allows the feeder to be temporarily overloaded.

Within the operate time t>> the selectivity between consecutive protection steps can be obtained. The operate time t>> is selected with switchgroup SG1 from a set of four selectable values.

In the above example the earth-fault current is measured with three phase current transformers in residual current connection, i.e the secondary sides of the current transformers are connected in parallel. The accuracy of the Holmgren connection depends on the equalness of the current transformer. When current transformers are chosen special attention must be paid to the overcurrent factor, because especially the operation of the high-set stage requires a good current reproduction capability at heavy fault currents.

The Holmgren connection suits applications characterized by heavy earth-fault currents, moderate sensitivity requirements or low CT turns ratios. In directly earthed networks or networks earthed through a low-impedance reactor or resistor the magnitude of the earth-fault current is so high, that the accuracy of the residual current connection is high enough for the fault current to be measured.

The selector switches of the overcurrent and earth-fault relay SPAJ 135 C can be set as follows:

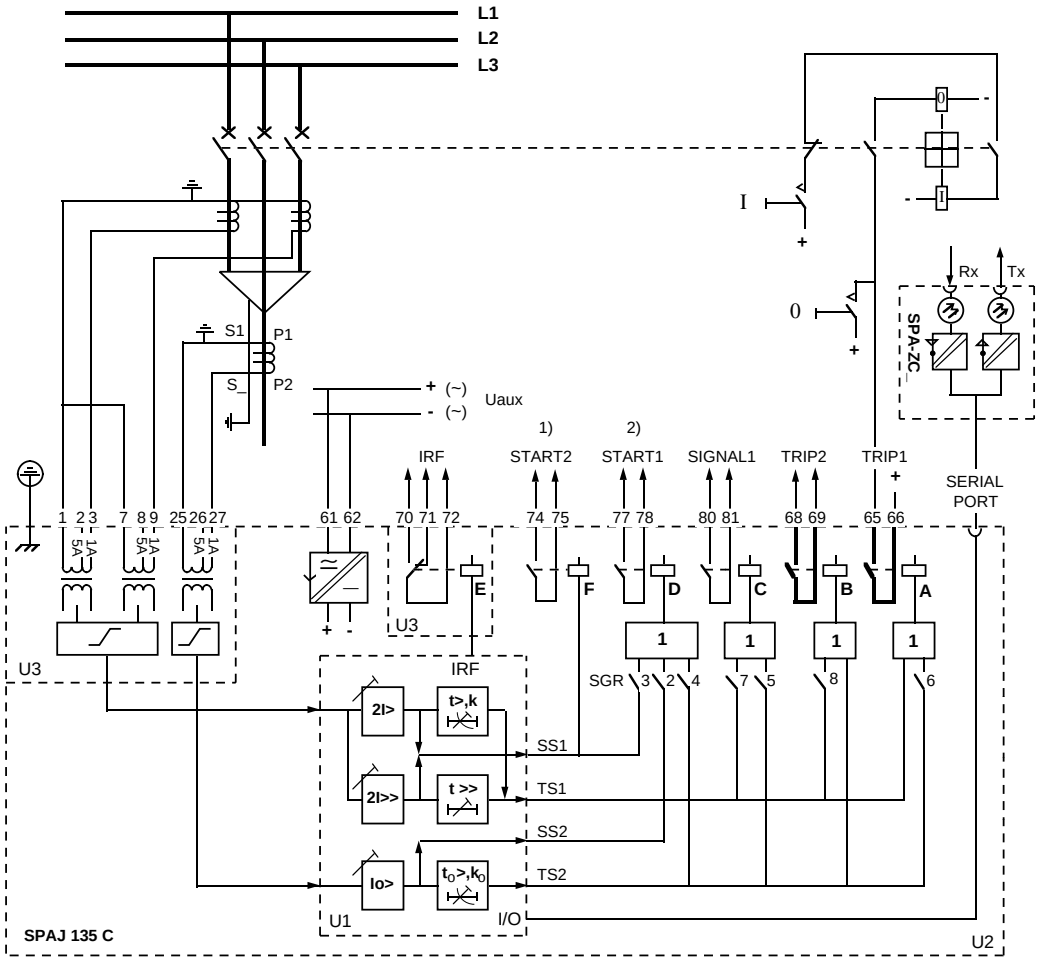
Switch	SG1/SPCJ 3C48	SG2/SPCJ 3C48
1	1 } I>> = 5.0 x I_n	1 } t>: very inverse
2	0 }	0 }
3	0	1 I>: inverse time characteristic
4	0 TS1 and TS2 latching	0 I>/I>>-LED: self-reset
5	0 I>> no doubling	0 I_0>-LED: self-reset
6	0 I>> = 2.5…17.5 x I_n	1 } t_0>: very inverse
7	0 } t>> = 50 ms	0 }
8	0 }	1 I_0>: inverse time characteristic
Σ	1	165

Switch	SGR/SPCJ 3C48
1	0 Not in use
2	1 Start signal of stage I_0> to output relay D
3	0 No start signal of stages I>/I>> to output relay D
4	0 No operate signal of stage I_0> to output relay D
5	0 No operate signal of stage I_0> to output relay C
6	1 Operate signal of stage I_0> to output relay A
7	1 Operate signal of stages I>/I>> to output relay C
8	0 No operate signal of stages I>/I>> to output relay B

When the selector switches are set as in the tables above the output relays of SPAJ 135 C have the following functions:

Output relay	Function
A (65-66)	CB trip signal, stages I>, I>>, I_0>
B (68-69)	Signal on operation, stage I_0>
C (80-81)	Signal on operation, stages I>, I>>
D (77-78)	Start signal, stage I_0>
E (70-71-72)	Self-supervision signal (IRF)
F (74-75)	Start signal, stages I>/I>>

Example 2.
Feeder overcurrent and earth-fault protection, residual current measurement with a core-balance current transformer



1) Blocking signal to the overcurrent relay of the incoming feeder
2) Blocking signal to the residual current relay of the incoming feeder

Fig. 5. Overcurrent and earth-fault relay SPAJ 135 C used for the protection of a distribution feeder. The residual current is measured with a core-balance current transformer. The selector switch settings are shown overleaf.

The above solution suits resistively earthed networks in the first place, where the current reproduction capacity of the core balance current transformers is high enough. Thanks to the core balance transformers the stability and the accuracy of the protection is high enough.

The relay SPAJ 135 C is used for overcurrent and earth-fault protection of distribution feeders. The high-set stage is set in such a way that it reaches the following protection stage. The high-set stage operates on close-up faults. The earth-fault stage acts as a single-stage feeder earth-fault protection.

The low-set stage of the overcurrent unit and the earth-fault stage can be given definite time or inverse time characteristic. In the above example definite time characteristic has been selected for both stages.

Definite time characteristic and core balance current transformers are used in applications requiring great accuracy. When core balance current transformers are used the disadvantages of the Holmgren connection can be avoided.

The operation of the protection relay of the incomming feeder can be speeded up with blocking signals from the protection relays of the outgoing feeders. If the fault is located on the outgoing feeder the relay of the concerned feeder, when it starts, puts forward a blocking signal to the relay of the incoming feeder. If, on the other hand, the fault is located on the busbars or on the incoming feeder, no blocking signal is forwarded and the relay of the incoming feeder operates.

The selector switches of the overcurrent and earth-fault relay SPAJ 135 C can be set as follows:

Switch	SG1/SPCJ 3C48	SG2/SPCJ 3C48
1	1 }	0 } t> = 0.05…1.00 s
2	1 } I>> = 2.0 x I_n	0 }
3	0 }	0 I>: definite time characteristic
4	0 TS1 , TS2: no latching	0 I>/I>> LED: self-reset
5	0 I>> no doubling	0 I_0> LED: self-reset
6	1 I>> =0,5…3,5 x I_n	0 } t_0 = 0.05…1.00 s
7	0 } t>> = 50 ms	0 }
8	0 }	0 I_0>: definite time characteristic
Σ	35	0

Switch	SGR/SPCJ 3C48
1	0 Not in use
2	1 Start signal of stage I_0> to output relay D
3	0 No start signal of stages I>/I>> to output relay D
4	0 No operate signal of stage I_0> to output relay D
5	0 No operate signal of stage I_0> to output relay C
6	1 Operate signal of stage I_0> to output relay A
7	1 Operate signal of stages I>/I>> to output relay C
8	0 No operate signal of stages I>/I>> to output relay B

When the selector switches are set as in the tables above the output relays of SPAJ 135 C have the following functions:

Output relay	Function
A (65-66)	CB trip signal, stages I>, I>>, I_0>
B (68-69)	Signal on operation, stage I_0>
C (80-81)	Signal on operation, stages I>, I>>
D (77-78)	Start signal, stage I_0>, blocking signal to the residual current relay of the incoming feeder
E (70-71-72)	Self-supervision signal (IRF)
F (74-75)	Start signal, stages I>/I>>, blocking signal to the overcurrent relay of the incoming feeder

Registered data and fault analysis

The data registered by the relay can be used to analyze network faults and the behaviour of the network under normal operation conditions.

Register 1 contains the maximum value of the phase currents I_{L1} and I_{L3} as multiple of the rated current of the used energizing input. The register is updated, if

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

The value in register 1 shows how close the set relay start current value is to the fault current value. Correspondingly, the set start current values can be compared with the phase current values measured by the relay under normal operation conditions.

When a fault arises on the feeder the fault current values at relay operation are recorded in register 1. By means of the fault current value the location of the fault can be estimated. Further, the indicators on the front panel show in which phases the fault current has exceeded the set start current.

The registered values directly show the magnitude of the fault current. For example, if the registered value after a fault is 05.0 the maximum phase current at relay operation has been five times the rated current of the CT primary side.

The number of starts of stage I> and I>>, registers 2 and 3, provides information about the occurrance of overcurrents.If the relay of a particular feeder starts too frequently, the reason may be too low a relay setting, switching inruch currents or hidden faults, for instance faulty insulators.

Registers 4 and 5 show the duration of the latest start situation of stages I> and I>, 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 values recorded in register 4 and 5 provide information about the duration of, for example, a switching inruch current or the safety margin between the protection relays of a selective protection.

Register 6 contains the maximum value of the residual current I_0 as multiple of the rated current of the used energizing input. The register is updated, if

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

By means of the recorded earth-fault current value the degree of development of the earth-fault can be estimated. The value in register 6 also shows how close the set relay start current value is to the fault current value. Correspondingly, the set start current values can be compared with the residual current values measured by the relay under normal operation conditions.

The number of starts of stage I_0>, register 7, provides information about the occurrance and distribution of earth-faults as far as the fault resistance is conserned. If the relay of a particular feeder starts too frequently, it may indicate an earth-fault under development (faulty insulator) or any other disturbance, which easily may cause an earth-fault (a tree branch touching the line).

Register 8 shows the duration of the latest start situation of stage I_0>, 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 value of register 8 shows the duration of the earth-fault or the safety margin of the time-grading of the selective protection.

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. The testing 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 generated by an open CT secondary circuit could be lethal and may damage instruments and insulation.

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

Equipment required for testing:

- adjustable voltage transformer 0...260 V, 1 A
- current transformer
- ammeter, accuracy ±0.5%
- stop watch or counter for time measurement
- dc voltage source for the 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 under the heading "Technical data, Energizing inputs".

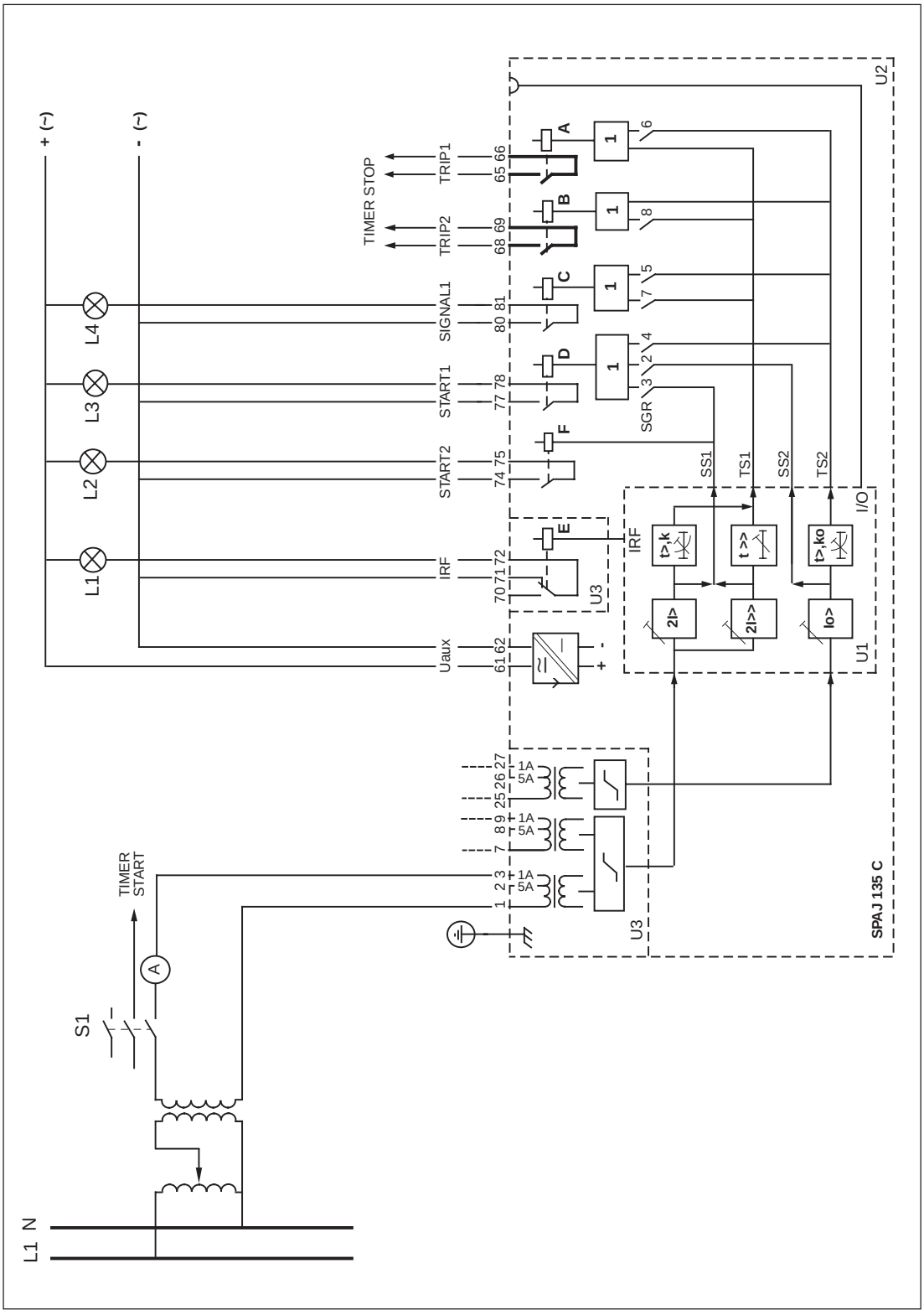


Fig. 6. Secondary injection test circuitry for the overcurrent and earth-fault relay SPAJ 135 C

When the test circuit has been completed and the selector switches properly set, the auxiliary voltage may be connected to the relay. The operation of the test circuit can be verified with the aid of a multimeter.

Testing of the internal matching transformers

The input transformers of the relay are tested aeparately for each enegizing input. 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 overcurrent stage I>

Set the switches of SGR switchgroup as follows before the test is started:

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 relay (terminals)	Function
A (65-66)	Trip signal of stage I> and I>>
B (68-69)	(Trip signal of stage I_0>)
C (80-81)	Signal on tripping of stage I> and I>>, indicator L4
D (77-78)	Not in use
E (71-72)	Self-supervision signal, indicator L1
F (74-75)	Starting of stage I> and I>>, indicator L2

If the start current settings of the high-set stage and the low-set stage are close to each other, switches SG1/1, SG1/2 and SG1/3 are preferably set at 1, which sets the high-set stage out of operation.

Starting

The test is carried out as a single-phase test according to Fig. 6. Close switch S1. Slowly increase the test current until the relay starts and the indicator L2 is lit. Then read the start current value from the ammeter.

Operate time

Definite-time characteristic

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

Operation of output relay C is verified with indicator L4.

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

Inverse time characteristic

At inverse time characteristic, the operate time is measured at 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 obtained from the current/time curves of the concerned inverse time curve.

Testing of the high-set overcurrent stage I>>

The operate time t> of the low-set stage is set at 100 s to avoid interference with the high-set stage. The operate time of stage t>> of the high-set stage is set at 50 ms, switches SG1/7=0 and SG1/8=0. If the high-set stage was set out of operation during testing of the low-set stage, it must be taken in use again.

Starting

Increase the test current until the relay starts and indicator L4 is lit. Then read the start current value from the ammeter. Note! When indicator L2 lits only the I> stage has started.

Operate time

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

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.

Set the switches of SGR switchgroup as follows before the test is started:

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 relay (terminals)	Function
A (65-66)	(Trip signal of stage I> and I>>)
B (68-69)	Trip signal of stage I_0>
C (80-81)	Signal on tripping of stage I_0>, indicator L4
D (77-78)	Start signal of stage I_0>,
indicator L3	
E (71-72)	Self-supervision signal, indicator L1
F (74-75)	(Starting of stage I> and I>>, indicator L2)

Starting

Close switch S1. Slowly increase the test curent until the relay starts and the indicator L3 is lit. Then read the start current value from the ammeter.

Operate time

Definite-time characteristic

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

When the relay starts, the I_0 indicator in the right bottom corner of the front panel is lit with yellow light. When the relay operates, the indicator turns red.

Inverse time characteristic

At inverse time characteristic, the operate time is measured at 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 obtained from the current/time curves of the concerned inverse time curve.

Testing of the self-supervision system (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.

Exchange and spare parts

Overcurrent and earth-fault relay module	SPCJ 3C48
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 3E14
I/O module	SPTE 3E14
Bus connection module	SPA-ZC 17_ or SPA-ZC 21_

Ordering numbers

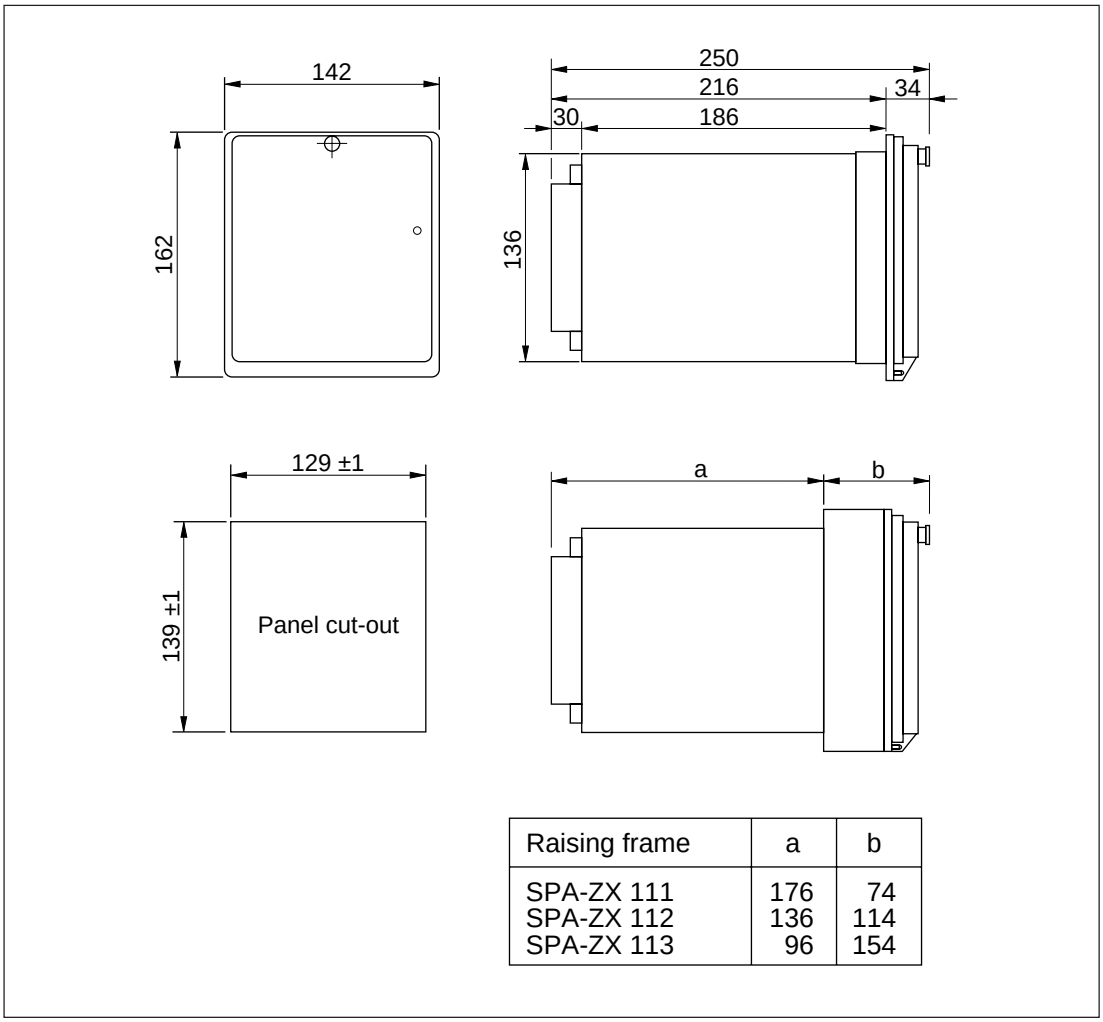
Combined overcurrent and earth-fault relay	
SPAJ 135 C	RS 611 030 -AA, CA, DA, FA
Combined overcurrent and earth-fault relay with test adapter RTXP 18	
SPAJ 135 C	RS 611 230 -AA, CA, DA, FA

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 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. 7. Dimensions of the combined overcurrent and earth-fault relay SPAJ 135 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.

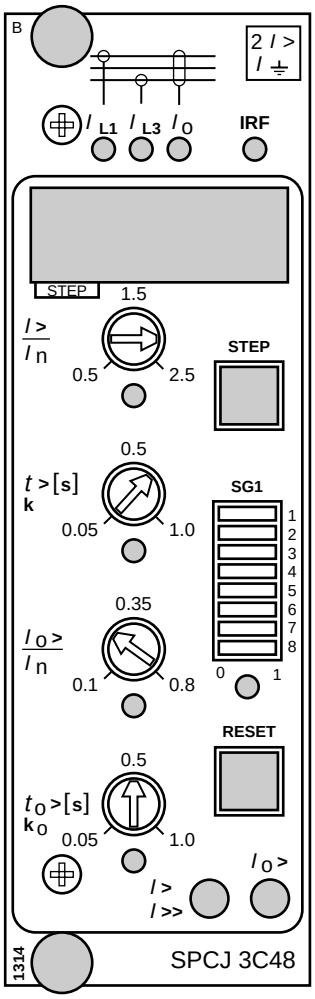
All input and output wires are connected to the screw terminal blocks on the rear panel. Each terminal is dimensioned for one max. 6 mm^2 wire or two max. 2.5 mm^2 wires. The D-type connector connects to the serial communication bus.

Information required with order

1. Quantity and type designation	15 pces relay SPAJ 135 C
2. Order number	RS 611 030-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 3C48
Combined overcurrent and earth-fault relay module

User´s manual and Technical description



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Approved OL

SPCJ 3C48
Combined overcurrent and earth-fault relay module

Contents

Features

Two-phase, two-stage overcurrent unit and single-stage earth-fault unit combined in one relay module

Low-set overcurrent stage with definite time or inverse time (IDMT) characteristic for phase overcurrent protection

High-set overcurrent stage with instantaneous operation or definite time characteristic for phase short-circuit protection

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

Local man-machine and remote serial communication capability

Flexible configuration of the relay module to obtain the desired protection functions

Enhanced reliability and availability of the relay module through extensive continuous self-supervision of hardware and software

Advanced software support for setting and monitoring of relay modules with portable computer

Function

Overcurrent unit

The combined overcurrent and earth-fault relay module SPCJ 3C48 can be used in single-phase and two-phase overcurrent protection applications. It features two protection stages: a low-set overcurrent stage I> and a high-set overcurrent stage I>>.

The low-set or high-set overcurrent stage starts, if the current on one of the protected phases exceeds the set start current of the concerned stage. When a protection stage starts, it generates a start signal SS1 and simultaneously the common LED indicator of the two overcurrent stages is lit with yellow colour. If the overcurrent situation persists long enough to exceed the set operate time at definite time characteristic or the calculated operate time at inverse time characteristic, the stage that started generates a trip signal TS1. At the same time the LED indicator of the concerned stage turns red. The red operation indication persists although the protection stage resets. The operation indication is reset with the RESET push-button on the front panel of the relay module or with the command V101 or V102 via the SPA serial bus. See also table (switchgroup SG3) on page 10 in chapter "Selector switches".

The operation of the low-set overcurrent stage I> can be based on definite time or inverse definite minimum time (IDMT) characteristic. The required operation characteristic is selected with switch SG2/3. At definite time characteristic three operate time t> setting ranges are available. The operate time setting range is selected with switches SG2/1 and SG2/2. At inverse time operation characteristic (IDMT) four different time/current curve sets are available. The required characteristic is selected with switches SG2/1 and SG2/2.

The start and trip signals of the high-set overcurrent stage have been linked to the same outputs SS1 and TS1 as the corresponding signals of the low-set overcurrent stage.

The start current I>> of the high-set overcurrent stage is selected from a set of fifteen preset current values using switches SG1/1…SG1/3 and SG1/6. The operate time t>> of the high-set overcurrent stage is selected from a set of four preset time values using switches SG1/7 and SG1/8. For further information, see section "Selector switches".

The set start current I>> of the high-set overcurrent stage can be automatically doubled when the protected object is energized, i.e. during a current inrush situation. Thus the set start current of the high-set overcurrent stage can be lower than the connection inrush current of the protected object. The automatic doubling feature is selected with switch SG1/5. A start situation is defined as a situation where the phase currents increase from a value below 0.12 x I> to a value exceeding 3.0 x I> within less than 60 ms. The start situation ends when the phase currents fall below 2.0 x I>.

The high-set overcurrent stage can be set out of operation by selecting the start current value ∞, infinite.

Earth-fault unit

The combined overcurrent and earth-fault relay module SPCJ 3C48 includes a non-directional earth-fault protection stage I_0>.

The earth-fault protection stage I_0> starts if the neutral current exceeds the set start current I_0> of the stage. On starting, the earth-fault stage generates a start signal SS2 and simultaneously the LED indicator of the earth-fault stage is lit with yellow colour. If the earth-fault situation persists long enough to exceed the set operate time at definite time characteristic or the calculated operate time at inverse time characteristic, the earth-fault stage generates a trip signal TS2. At the same time the LED indicator of the earth-fault stage is lit with red colour. The red operation indicator remains lit although the protection stage resets. The operation indication is reset with the RESET push-button on the front panel of the relay module or with the command V101 or V102 via the SPA bus.

The operation of the earth-fault stage I_0> can be based on definite time or inverse definite minimum time (IDMT) characteristic. The required operation characteristic is selected with switch SG2/8. At definite time characteristic three operate time t_0> setting ranges are available. The operate time setting range is selected with switches SG2/6 and SG2/7. At inverse time operation characteristic (IDMT) four time/current curve sets are available. The required characteristic is selected with switches SG2/6 and SG2/7.

If the protection relay incorporates an auto-reclose module, the SGB switches can be used for routing start initiation signals from the protection relay module to the auto-reclose module.The functions of the SGB switches are described in the general descriptions of the different protection relays, see section "Signal diagram".

Normally the protection stages of the relay module are self-reset, which means that the trip outputs TS1 and TS2 are automatically reset, when the protection stage resets. However, the trip outputs TS1 and TS2 can be given a so called latching function, which means that the trip outputs are kept activated after an operation, although the fault has disappeared and the protection stage has reset. The latched outputs are manually reset by pressing the push-buttons STEP and RESET simultaneously or by remote control with the commands V101 and V102. See also table (switchgroup SG3) on page 10 in chapter "Selector switches".

The start and operation indicators on the front panel of the relay module, the latched output signals TS1 and TS2 and the registers 1…8 can be reset locally or by remote control as presented in the following table:

	Resetting of start and operation indicators	Resetting of latched output relay	Erasing of recorded values
RESET	x		
STEP & RESET	x	x	x
Parameter V101	x	x	
Parameter V102	x	x	x

Block diagram

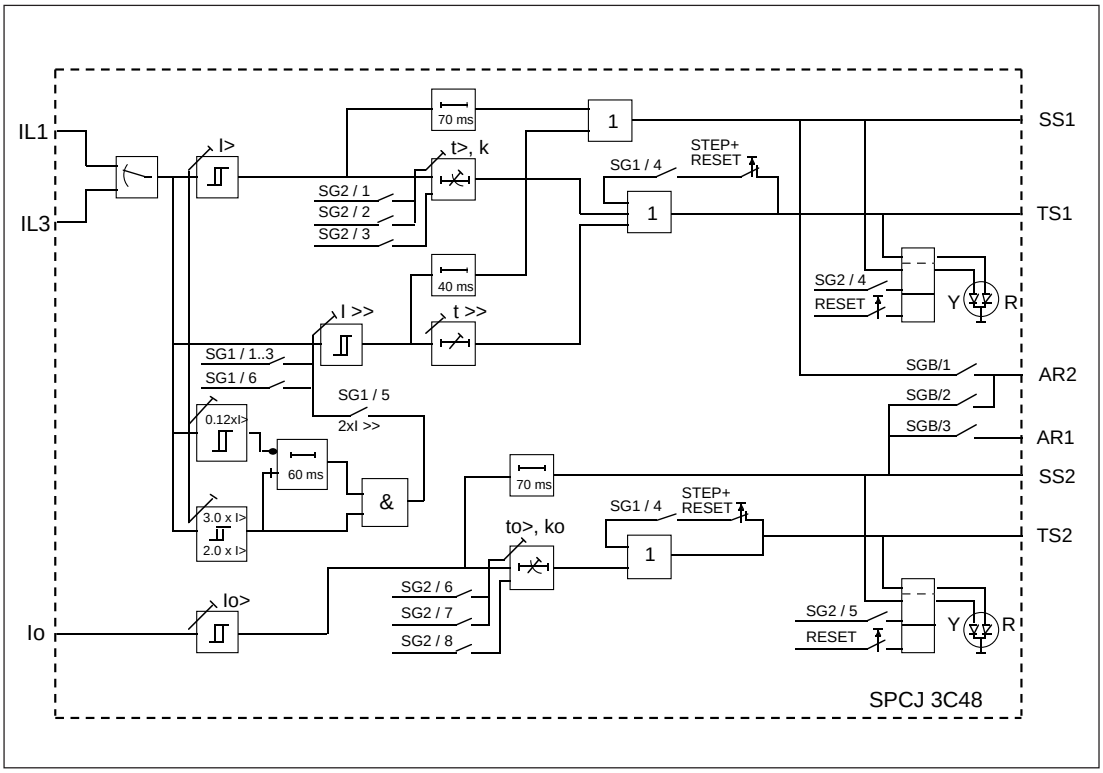


Fig.1. Block diagram of the combined overcurrent and earth-fault relay module SPCJ 3C48

I_{L1}, I_{L3}	Measured phase currents
I_0	Measured neutral current
SG1	Function selector switchgroup, hardware switchgroup
SG2	Function selector switchgroup, software switchgroup
SGB	AR start signal selector switchgroup, hardware switchgroup
SS1	Start signal of the I> and I>> stages
TS1	Operate (trip) signal of the I> and I>> stages
SS2	Start signal of the I_0> stage
TS2	Operate (trip) signal of the I_0> stage
AR1, AR2	Auto-reclose start initiation signals
Y	Yellow LED indication, starting
R	Red LED indication, operation

NB!
All input and output signals of the relay module are not necessarily wired to the terminals of any protection relay incorporating the above relay module. The signals wired to the terminals of a particular protection relay are shown in section "Signal diagram" in the general manual of the concerned protection relay.

Front panel

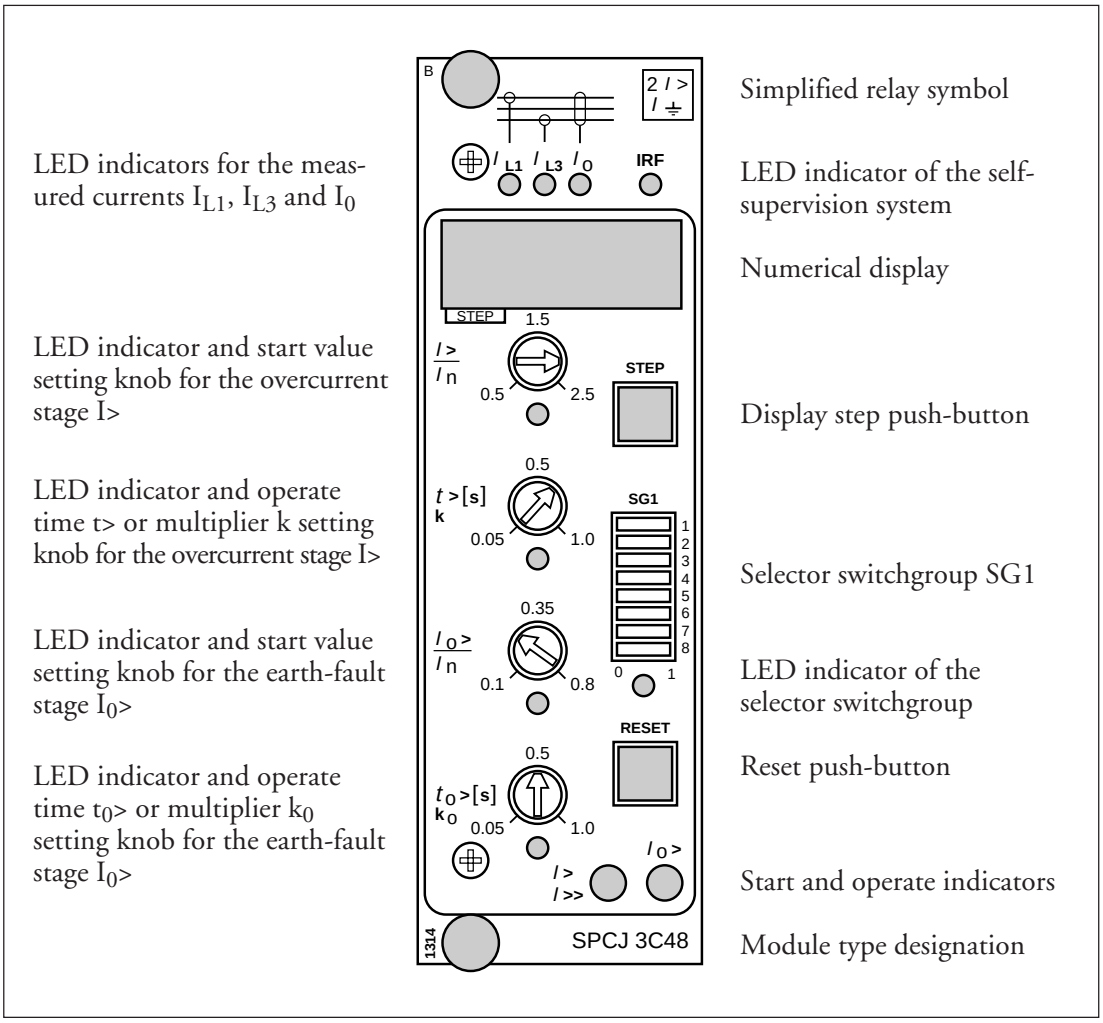


Fig. 2. Front panel of the combined overcurrent and earth-fault relay module SPCJ 3C48

Start and operation indicators

The overcurrent stages I> and I>> have a common yellow/red LED-indicator and the earth-fault stage I_0> a separate yellow/red LED indicator. Yellow light indicates starting of the concerned protection stage and red light indicates that the protection stage has operated.

The red operation indications always remain lit after the fault has disappeared and the protection stage has reset. The yellow indications can be given a self-reset or a manual reset mode of operation with switches SG2/4 and SG2/5. The manual reset mode means that the indicator remains lit after being switched on, although the protection stage resets. 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 protection functions of the relay module. The relay module is always operative, whether the indicators have been reset or not.

When one of the protection stages has operated the LED indicators on the upper part of the front panel indicates which current has exceeded its set start current value.

The self-supervision alarm indicator IRF indicates that the self-supervision system has detected a permanent internal relay module fault. The IRF indicator is lit with red light shortly after the fault has been detected. At the same time the relay module delivers 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 fault type appears on the display of the relay module. The fault code consists of a red figure one (1) and a green three-digit code number. When a fault message appears on the display, the code number should be noted to facilitate trouble-shooting and repair.

Settings

The setting values are shown by the three rightmost digits of the display. When lit, the LED indicator below a setting knob shows that the concerned setting value is being displayed.

$I>/I_n$	Start current of the overcurrent stage I> as a multiple of the rated current I_n of the occupied relay energizing input. Setting range 0.5...2.5 x I_n
t>	Operate time t> of stage I>, expressed in seconds,when the definite time characteristic (SG2/3 = 0) is used. Three setting ranges, that is 0.05…1.00 s, 0.5…10.0 s and 5…100 s, are available (SG2/1 and SG2/2). See section "Selector switchgroups".
k	Time multiplier k, when inverse definite minimum time (IDMT) has been selected (SG2/3 = 1). Setting range 0.05…1.00. See section "Selector switchgroups".
$I_0>/I_n$	Start current of the earth-fault stage $I_0>$ as a multiple of the rated current I_n of the occupied relay energizing input. Setting range 0.1...0.8 x I_n
$t_0>$	Operate time $t_0>$ of stage $I_0>$, expressed in seconds,when the definite time characteristic (SG2/8 = 0) is used. Three setting ranges, that is 0.05…1.00 s, 0.5…10.0 s and 5…100 s, are available (SG2/6 and SG2/7). See section "Selector switchgroups".
k_0	Time multiplier k_0, when inverse definite minimum time (IDMT) has been selected. (SG2/8 = 1). Setting range 0.05…1.00. See section "Selector switchgroups".
$I>>/I_n$	Start current of the overcurrent stage I>>. Setting range 2.5…17.5 x I_n and ∞, infinite (switch SG1/6 = 0) and 0.5…3.5 x I_n and ∞, infinite (SG1/6 = 1). Eight setting values selectable within the setting range (SG1/1, SG1/2 and SG1/3). The high-set overcurrent stage I>> is out of function, when switches SG1/1…3 all are in position 1.
t>>	Operate time t>> of stage I>>. Four preset values, 50 ms, 150 ms, 300 ms and 500 ms, are available (SG1/7 and SG1/8). See section "Selector switchgroups".

Further, the checksum of the selector switchgroup SG1 is indicated on the display when the LED indicator under the switchgroup is lit. In this way a check can be carried out to prove that the switchgroup has been set and that the individual switches work properly. An example of how the checksum is calculated is given in manual "General characteristics of C-type relay modules".

Selector switches

Application-related functions and settings are selected by means of the selector switches of switchgroups SG1 and SG2. Switchgroup SG1 is located on the front panel of the relay module. Switchgroup SG2 is a so called software switchgroup which is located in the second submenu of the checksum register of the switchgroup SG1. The settings of switchgroup SG2 are defined by means of a checksum corresponding to the settings of the switches.

<table>
<tr><th>Switch</th><th>Function to be selected</th></tr>
<tr><td>SG1/1
SG1/2
SG1/3</td><td>Start current of the overcurrent stage I>> (See also switch SG1/6).
Values within brackets are valid, when switch SG1/6 = 1.
<table>
<tr><th>SG1/1</th><th>SG1/2</th><th>SG1/3</th><th>Start current x I_n</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>2,5 (0,5)</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>5,0 (1,0)</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>7,5 (1,5)</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>10,0 (2,0)</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>12,5 (2,5)</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>15,0 (3,0)</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>17,5 (3,5)</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>∞, infinite</td></tr>
</table></td></tr>
<tr><td>SG1/4</td><td>Latching of the operate (trip) signals TS1 and TS2.
When SG1/4 = 0, the operate signals return to normal (= the output relay resets, when the energizing current causing the operation falls below the start level.
When SG1/4 = 1, the operate signals remain on (= output relay energized), although the energizing current falls below the starting level. The latched operate signals are reset by pressing the push-buttons STEP and RESET simultaneously or with the command V101. When the STEP and RESET push-buttons are pushed the recorded values are erased. *)</td></tr>
<tr><td>SG1/5</td><td>Automatic doubling of the set start current of the overcurrent stage I>> when the protected object is connected to the network.
When SG1/5 = 0, no doubling of the set start current of stage I>> is obtained.
When SG1/5 = 1, the set start current of stage I>> doubles automatically. The doubling feature makes it possible to give the overcurrent stage I>> a start current, which is below the connection inrush current of the protected object.</td></tr>
<tr><td>SG1/6</td><td>Start current setting range of the high-set overcurrent stage I>>.
When switch SG1/6=0, the setting range is 2.5...17.5 x I_n and ∞, infinite.
When switch SG1/6=1, the setting range is 0.5…3.5 x I_n and ∞, infinite.
When the setting range 0.5…3.5 x I_n has been selected the relay module contains two almost identical overcurrent stages, which, for instance, can be used for load shedding purposes. The high-set stage I>> can be set out of operation by selecting the setting ∞, infinite, indicated in the display by three short dashes, - - -.</td></tr>
<tr><td>SG1/7
SG1/8</td><td>Operate time t>> of the high-set overcurrent stage I>>
<table>
<tr><th>SG1/7</th><th>SG1/8</th><th>Operate time t>></th></tr>
<tr><td>0</td><td>0</td><td>50 ms</td></tr>
<tr><td>1</td><td>0</td><td>150 ms</td></tr>
<tr><td>0</td><td>1</td><td>300 ms</td></tr>
<tr><td>1</td><td>1</td><td>500 ms</td></tr>
</table></td></tr>
</table>

*) From the program version 087 B and later an additional switchgroup (SG3) has been incorporated into the relay module. When the latching function is used the latched output can be reset by pushing the RESET button alone, if SG3/3=1, or by pushing the STEP button alone, if SG3/2=1, in which case the stored information of the module is not erased.

<table>
<tr><th>Switch</th><th>Function</th></tr>
<tr><td>SG2/1
SG2/2
SG2/3</td><td>Selection of definite time / inverse definite minimum time characteristic for the overcurrent stage I> (SG2/3). At definite time characteristic the setting range of the operate time t> is selected with switches SG2/1 and SG2/2. At inverse time characteristic the time/current curves are chosen with switches SG2/1 and SG2/2.
<table>
<tr><th>SG2/1</th><th>SG2/2</th><th>SG2/3</th><th>Characteristic</th><th>Operate time t> or time/current curves</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>Definite time</td><td>0,5...10,0 s</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>Definite time</td><td>0,5...10,0 s</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>Definite time</td><td>5...100 s</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>Inverse time</td><td>Extremely inverse</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>Inverse time</td><td>Very inverse</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>Inverse time</td><td>Normal inverse</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>Inverse time</td><td>Long time inverse</td></tr>
</table></td></tr>
<tr><td>SG2/4
SG2/5</td><td>Selection of manual reset or self-reset mode of operation for the yellow start indicators.

When switch SG2/4 = 0, the combined start indicator of the I> and I>> stages is self-reset after the energizing current has fallen below the set start current level.
When switch SG2/4 = 1, the combined start indicator of the I> and I>> stages has to be manually reset, after the energizing current has fallen below the set start current level.
When switch SG2/5 = 0, the start indicator of the I_0> stage is self-reset after the energizing current has fallen below the set start current level.
When switch SG2/5 = 1, the start indicator of the I_0> stage has to be manually reset, after the energizing current has fallen below the set start current level.

The start and operation indicators are reset with the RESET push-button or via the SPA bus using the commands V101 tai V102.</td></tr>
<tr><td>SG2/6
SG2/7
SG2/8</td><td>Selection of definite time / inverse definite minimum time characteristic for the earth-fault stage I_0> (SG2/8). At definite time characteristic the setting range of the operate time t_0> is selected with switches SG2/6 ja SG2/7. At inverse time characteristic the time/current curves are chosen with switches SG2/6 and SG2/7.
<table>
<tr><th>SG2/6</th><th>SG2/7</th><th>SG2/8</th><th>Characteristic</th><th>Operate time t_0> or time/current curves</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>Definite time</td><td>0.5...10.0 s</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>Definite time</td><td>0.5...10. 0 s</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>Definite time</td><td>5...100 s</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>Inverse time</td><td>Extremely inverse</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>Inverse time</td><td>Very inverse</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>Inverse time</td><td>Normal inverse</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>Inverse time</td><td>Long-time inverse</td></tr>
</table></td></tr>
</table>

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

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

Further, a switchgroup SGB is located on the printed circuit board of the overcurrent and earth-fault module. The switches SGB1…3 are used to route auto-reclose start initiation signals from the overcurrent and earth-fault relay module to a possible cooperating auto-reclose module. For further information on the use of the SGB switchgroup for a particular protection relay, see section "Signal diagram" in the user's manual of the protection relay.

Measured data

The measured values are displayed by the rightmost three digits on the display. The relevant data measured are indicated by a lit yellow LED indicator on the front panel.

Indicator	Measured value
I_{L1}	Line current on phase L1 as a multiple of the rated current I_n of the occupied energizing input.
I_{L3}	Line current on phase L3 as a multiple of the rated current I_n of the occupied energizing input.
I_0	Neutral current (residual current) in the earth path as a multiple of the rated current I_n of the occupied energizing input.

Recorded information

The leftmost digit of the display shows the address of the register and the three rightmost digits show the recorded information. The address digit is recognized by its red colour.

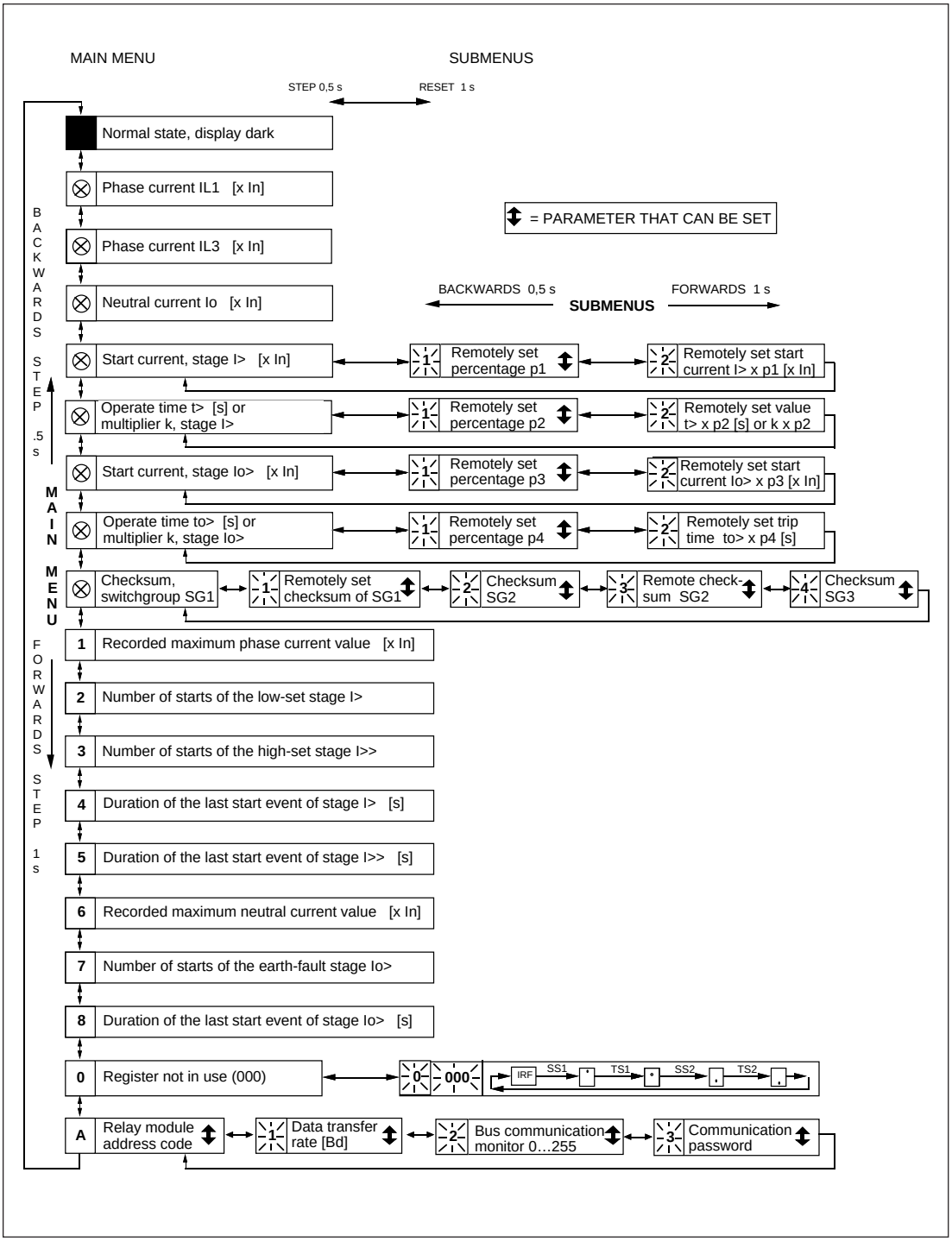
Register/ STEP	Recorded information
1	Maximum phase current I_{L1} or I_{L3} displayed as a multiple of the rated current I_n of the occupied energizing input. The registered value is updated, if one of the following conditions are fulfilled. 1) The measured current exceeds the value already in the register 2) The I> or I>> stage operates. At relay operation the current value at tripping is recorded
2	Number of starts of the low-set overcurrent stage I>, n (I>) = 0...255.
3	Number of starts of the high-set overcurrent stage I>>, n (I>>) = 0...255.
4	Duration of the latest start situation of stage I> as a percentage of the set operate time t> or at IDMT operation characteristic the calculated operate time. A new start resets the counter which thus always contains the value from the latest start. After the stage has operated, the counter reading is 100.
5	Duration of the latest start situation of stage I>> as a percentage of the set operate time t>>. A new start resets the counter which thus always contains the value from the latest start. After the stage has operated, the counter reading is 100.
6	Maximum neutral current I_0> displayed as a multiple of the rated current I_n of the occupied energizing input. The registered value is updated, if one of the following conditions are fulfilled. 1) The measured current exceeds the value already in the register 2) The I_0> stage operates. At relay operation the current value at tripping is recorded
7	Number of starts of the earth-fault stage I_0>, n (I_0>) = 0...255.
8	Duration of the latest start situation of stage I_0> as a percentage of the set operate time t_0> or at IDMT operation characteristic the calculated operate time. A new start resets the counter which thus always contains the value from the latest start. After the stage has operated, the counter reading is 100.
0	From this register it is possible to move to the TRIP TEST mode, where the start and operate functions of the overcurrent and earth-fault module can be tested one by one. For further information see manual "General characteristics of C-type relay modules".
A	Address code of the protection relay module, required by the serial communication system. If the address code is set at zero the serial communication is out of function. 1) Selection of data transfer rate for the serial communication. Selectable values: 300, 1200, 2400, 4800 or 9600 Bd. Default value 9600 Bd. 2) Bus communication counter. If the module is connected to a data communication device and the communication system is working, the communication counter is 0. If the communication is interrupted, the numbers 0…255 are rolling in the display. 3) Password required for remote setting of relay parameters

When the display is dark you can proceed to the beginning of the display menu by pressing the STEP push-button once.

The content of the registers 1...8 are erased by pressing push-buttons STEP and RESET simultaneously or with the remote control command V102. The register values are also erased, if the auxiliary power supply to the module is interrupted. The address code of the relay module, the value of the data transfer rate of the serial communication and the password are not erased by an auxiliary voltage interruption. Instructions for setting the address and the data transfer rate are given in the user's manual "General characteristics of C-type relay modules".

Register menu chart

The diagram below shows the main menu and the submenus of the overcurrent and earth-fault relay module SPCJ 3C48. The general principles for using the menues are described in detail in the user's manual "General characteristics of C type relay modules".



Inverse time characteristic curves

(modified 2002-05)

The operation of the low-set overcurrent stage I> and the earth-fault stage I_0> is based on definite time characteristic or inverse time characteristic, as selected by the user. The operation characteristic of the overcurrent stage is selected with switches SG2/1…3 and that of the earth-fault stage with switches SG2/6…8, see also section "Selection switches".

When the inverse time characteristic is chosen the operate time is a function of the magnitude of the current: the higher the current the shorter the operate time.The relationship between current and time complies with the standards IEC 60255-3 and is generally expressed as:

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

t = operate time in seconds
k = time multiplier
I = measured current
$I_{(0)}$> = set current

The overcurrent stage and the earth-fault stage both have four selectable operation characteristics; normal inverse, very inverse, extremely inverse and long-time inverse.

The characteristics are defined by the values of the constants α and β as follows:

Characteristic curve set	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 of 1966 the normal current range is defined as 2...20 times the setting. Additionally the relay must start at the latest when the measured current exceeds 1.3 times the set start current, when the time/current characteristic is normal inverse, very inverse or extremely inverse. At long-time inverse characteristic, the normal range according to the standard is 2...7 times the set start current and the relay is to start when the current exceeds 1.1 times the set start current.

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

I/I> I_0/I_0>	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 range defined above the overcurrent and earth-fault relay module SPCJ 3C48 complies with the tolerances of class 5 for all four characteristics. The characteristic curves specified in the standards are illustrated in Figs. 3, 4, 5 and 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.

Time-current curves of the combined over-current and earth-fault relay module SPCJ 3C48

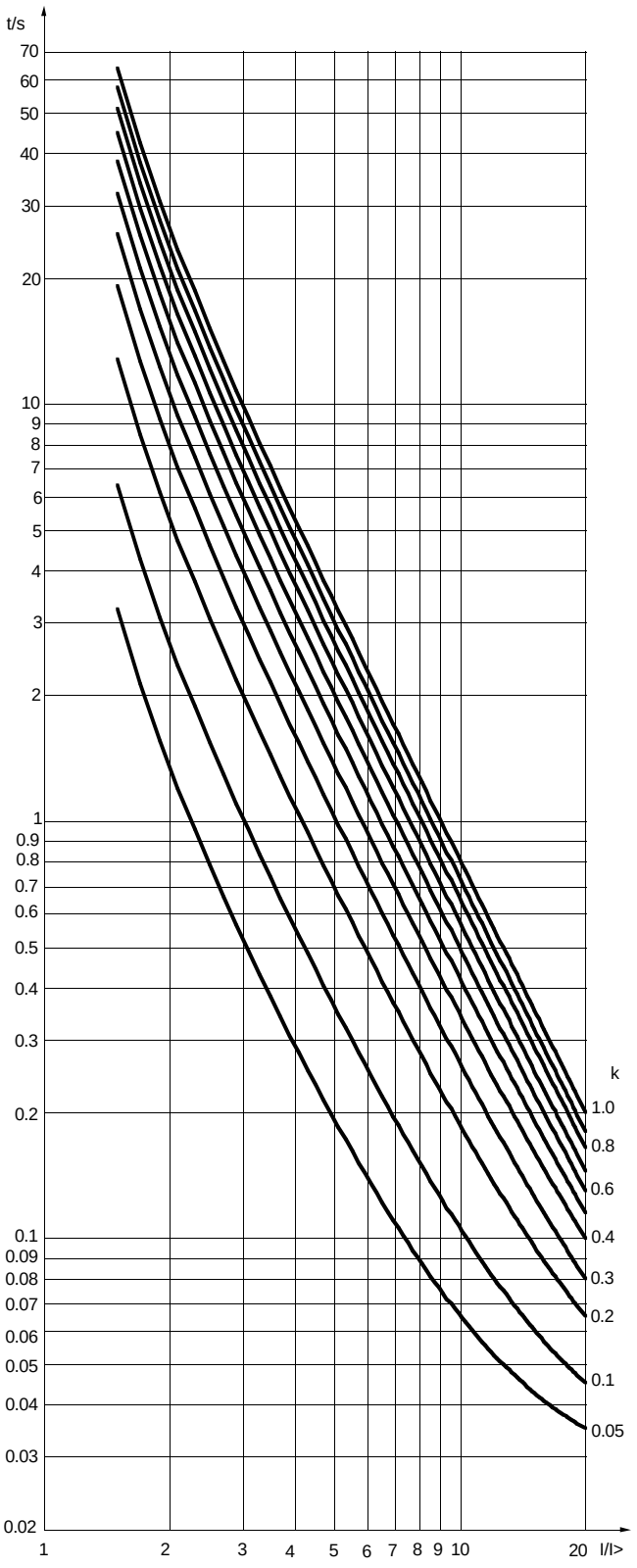


Fig. 3. Extremely inverse characteristic

I = measured current
$I_{(0)>}$ = set start current
t = operate time
k = time multiplier

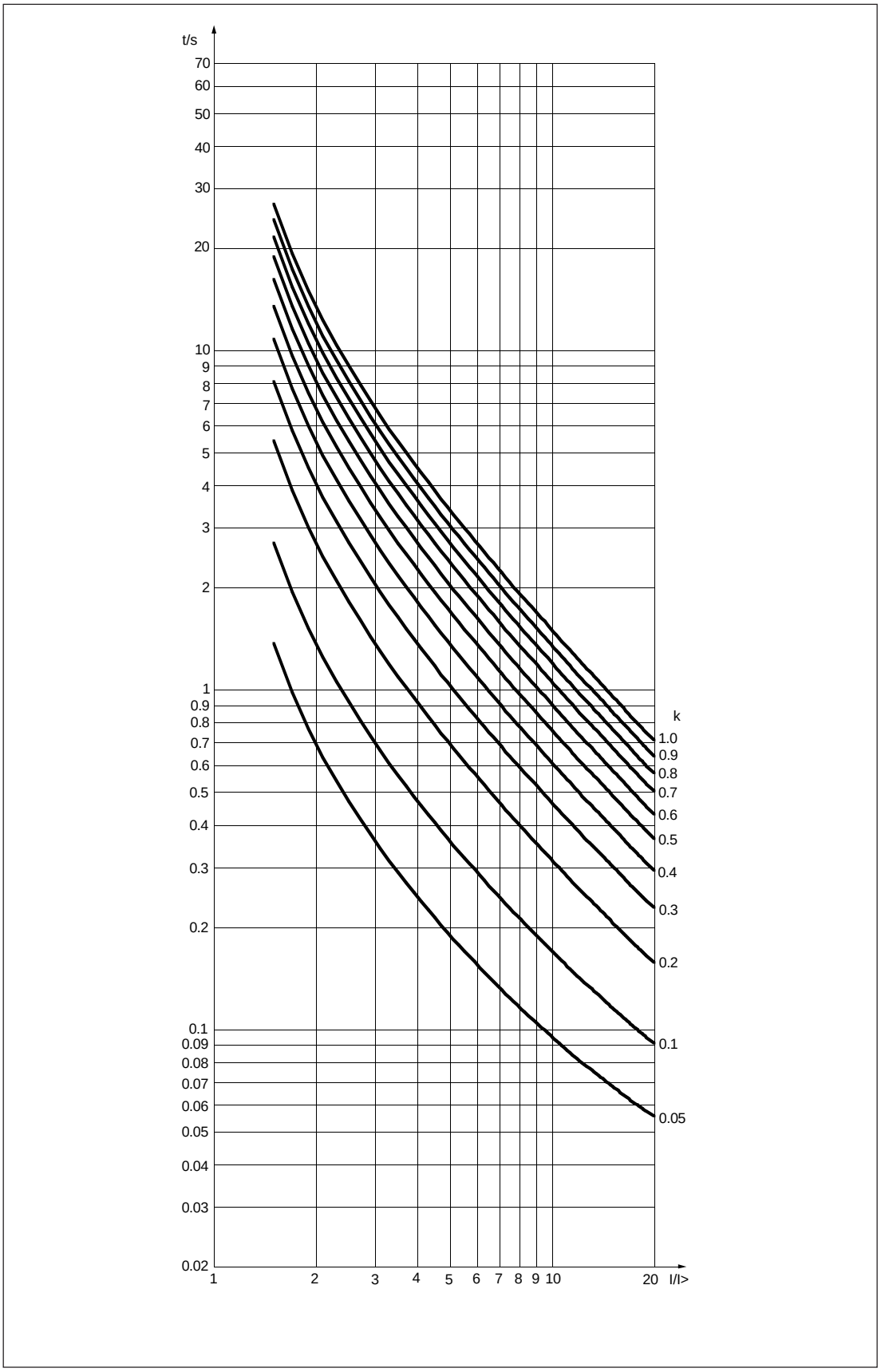


Fig. 4. Very inverse characteristic

I = measured current
$I_{(0)>}$ = set start current
t = operate time
k = time multiplier

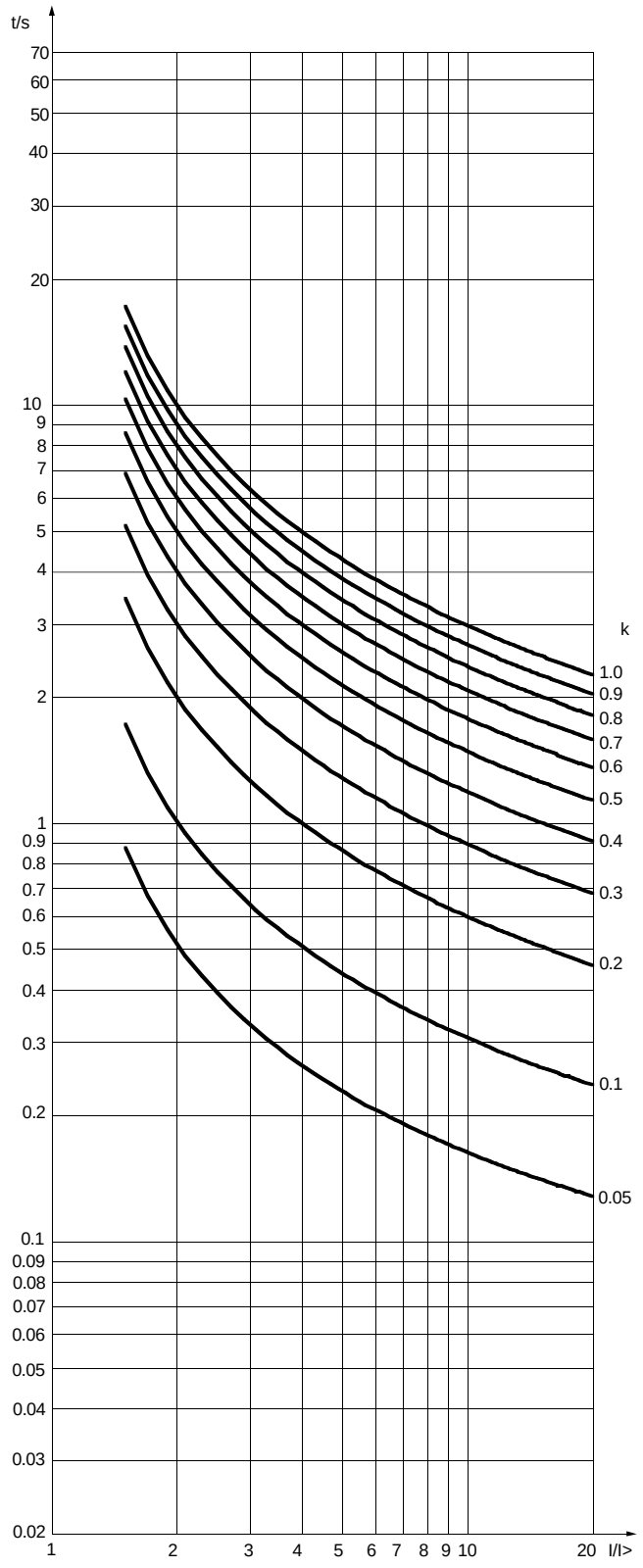


Fig. 5. Normal inverse characteristic

I = measured current
$I_{(0)}>$ = set start current
t = operate time
k = time multiplier

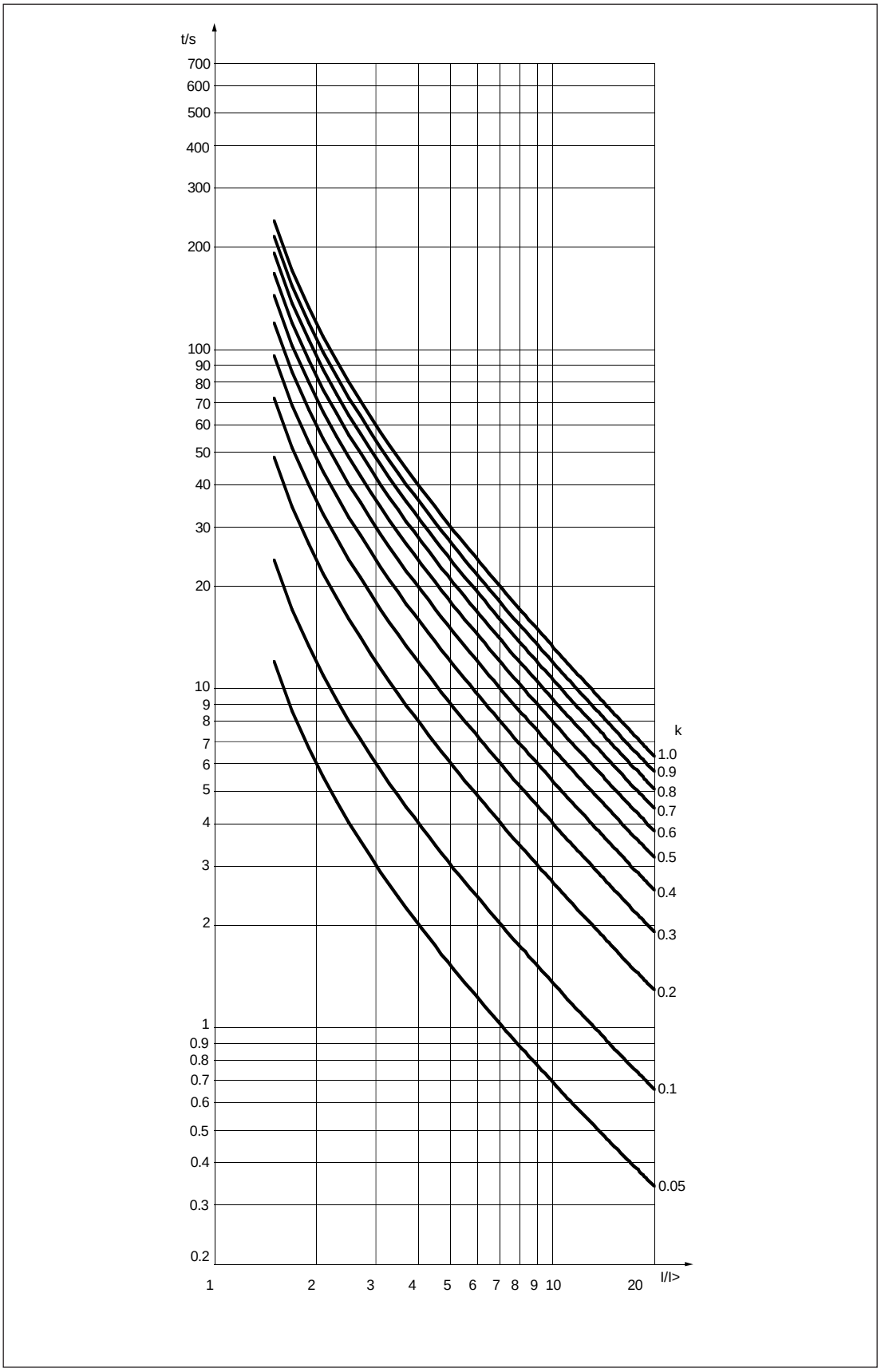


Fig. 6. Long-time inverse characteristic

I = measured current
$I_{(0)>}$ = set start current
t = operate time
k = time multiplier

Low-set overcurrent stage I>

Start current range	0.5…2.5 x I_n
Start time, typically	55 ms
Operate time at definite time characteristic	0.05…1.00 s, 0.5…10.0 s or 5…100 s
Time-current curves at inverse time characteristic	Extremely inverse Very inverse Normal inverse Long-time inverse
Time multiplier k	0.05…1.00
Reset time, typically	65 ms
Retardation time	<30 ms
Drop-off/pick-up ratio, typically	0.97
Operate time accuracy at definite time characteristic	±2% of set value or ±25 ms
Operate time accuracy class E at inverse time characteristic	5
Operation accuracy	±3% of set value

High-set overcurrent stage I>>

Start current range	2.5…17.5 x I_n and ∞, infinite or 0.5…3.5 x I_n and ∞, infinite
Start time, typically	40 ms
Operate time	50, 150, 300 or 500 ms
Reset time, typically	50 ms
Retardation time	<30 ms
Drop-off/pick-up ratio, typically	0.97
Operate time accuracy	±2% of set value or ±25 ms
Operation accuracy	±3% of set value

Earth-fault stage I_0>

Start current range	0.1…0.8 x I_n
Start time, typically	45 ms
Operate time at definite time characteristic	0.05…1.00 s, 0.5…10.0 s or 5…100 s
Time-current curves at inverse time characteristic	Extremely inverse Very inverse Normal inverse Long-time inverse
Time multiplier k	0.05…1.00
Reset time, typically	55 ms
Retardation time	<30 ms
Drop-off/pick-up ratio, typically	0,98
Operate time accuracy at definite time characteristic	±2% of set value or ±25 ms
Operate time accuracy class E at inverse time characteristic	5
Operation accuracy	±5% of set value

Event codes

The events of the overcurrent and earth-fault relay module SPCJ 3C48, that is, start and operation information, can be read via the SPA bus by a substation level data communication device, for instance, type SRIO 1000M. On request the relay module transmits its event information in the form: time (ss.sss) and event code. The event codes in conjunction with the overcurrent and earth-fault module SPCJ 3C48 are E1…E12, E50 and E51. Additional event codes, i.e. E52…E54, are generated by the data communication device. These event codes mainly relate to the performance of the data communication system.

The events representing the event codes E1…E12 can be included in or excluded from the event reporting by writing, via the SPA bus, an event mask number to parameter V155 of the relay module. Each event E1…E12 is represented by a weighting factor from the series 1, 2, 4, 8, …, 2048. The event mask is formed by multiplying the above weighting factors by either 0 = event excluded from the event reporting or by 1 = event included in the event reporting, and by adding the products. If, for example, the events E1, E3, E5, E7, E9, E11, that is all start and operation events but no reset events of the protection stages are to be included in the reporting, the event mask would be 1 x 1 + 1 x 4 + 1 x 16 + 1 x 64 + 1 x 256 + 1 x 1024 = 1365.

The event mask takes a value within the range 0…4095. The default value of the event mask for the overcurrent and earth-fault relay module SPCJ 3C48 is 1365. The events represented by the event codes E50…E54 cannot be excluded from the event reporting.

The buffer storage can hold eight events at a time. If new events are generated before earlier events have been transmitted to the communication device, the capacity of the buffer storage may be exceeded and an overflow event E51 will be generated. The event E51 is reset via the SPA bus by writing a value 0 to the relay module status parameter C.

The event codes of the combined overcurrent and earth-fault relay module SPCJ 3C48 are:

Code	Event	Weighting factor	Default selection
E1	Starting of stage I>	1	1
E2	Resetting of starting of stage I>	2	0
E3	Operation of stage I>	4	1
E4	Resetting of operation of stage I>	8	0
E5	Starting of stage I>>	16	1
E6	Resetting of starting of stage I>>	32	0
E7	Operation of stage I>>	64	1
E8	Resetting of operation of stage I>>	128	0
E9	Starting of stage I_0>	256	1
E10	Resetting of starting of stage I_0>	512	0
E11	Operation of stage I_0>	1024	1
E12	Resetting of operation of stage I_0>	2048	0
	Checksum Σ		1365
E50	Restarting of microprocessor	*	-
E51	Overflow of event register	*	-
E52	Temporary data communication disturbance	*	-
E53	No response from the relay module over the SPA bus	*	-
E54	Relay module responds again over the SPA bus	*	-

0 not included in the event reporting
1 included in the event reporting
* no weighting factor
- cannot be programmed

Note!
In the SPACOM system the events E52…E54 are generated by the substation level communication device, for instance, type SRIO 1000M.

Remote transfer data

Apart from the event codes (E events) the substation level communication device is capable of reading, via the SPA bus, all input data (=I data), set values (=S data), recorded values (=V data) and some other data from the relay module. Some of the data can also be altered by commands given via the SPA bus. Any information is available on the 0 channel which does not have to be written in the communication instructions.

R = data can be read from the relay module
W = data can be written to the relay module
(P) = password and alerted main settings (V150 = 0) required for writing.

Data	Code	Data direct.	Value or status
Current on phase L1 as a multiple of the rated current	I1	R	0…63 [x I_n]
Current on phase L3 as a multiple of the rated current	I2	R	0…63 [x I_n]
Neutral current I_0 as a multiple of the rated current	I3	R	0…21 [x I_n]
Starting of overcurrent stage I>	O1	R	0 = Stage I> has not started 1 = Stage I> has started
Operation of stage I>	O2	R	0 = Stage I> has not operated 1 = Stage I> has operated
Starting of overcurrent stage I>>	O3	R	0 = Stage I>> has not started 1 = Stage I>> has started
Operation of stage I>>	O4	R	0 = Stage I>> has not operated 1 = Stage I>> has operated
Starting of earth-fault stage I_0>	O5	R	0 = Stage I_0> has not started 1 = Stage I_0> has started
Operation of stage I_0>	O6	R	0 = Stage I_0> has not operated 1 = Stage I_0> has operated
Operation signal TS1	O7	R	0 = signal not active 1 = signal active
Operation signal TS2	O8	R	0 = signal not active 1 = signal active
Alerted settings			
Alerted start current I> of the low-set overcurrent stage I>	S1	R	0.5…2.5 [x I_n]
Alerted operate time t> or time multiplier k of the overcurrent stage I>	S2	R	0.05…100 [s] or 0.05…1.00
Alerted start current I_0> of the earth-fault stage	S3	R	0.1…0.8 [x I_n]
Alerted operate time t_0> or time multiplier k_0 of the earth-fault stage I_0>	S4	R	0.05…100 [s] or 0.05…1.00
Alerted checksum of switchgroup SG1	S5	R	0…255
Alerted checksum of switchgroup SG2	S6	R	0…255
Main settings			
Start current I> of stage I>, set with the setting knob	S11	R	0.5…2.5 [x I_n]
Operate time t> or time multiplier k of stage I>, set with the setting knob	S12	R	0.05…100 [s] or 0.05…1.00
Start current I_0> of stage I_0>, set with the setting knob	S13	R	0.1…0.8 [x I_n]
Operate time t_0> or time multiplier k_0 stage I_0>, set with the setting knob	S14	R	0.05…100 [s] or 0.05…1.00
Checksum of switchgroup SG1, set with the selector switches	S15	R	0…255
Checksum of switchgroup SG2	S16	R,W(P)	0…255

Data	Code	Data direct.	Value or status
Remote settings			
Remote setting percentage p1 of the start current of stage I>	S21	R,W(P)	0…999 [%]
Remote setting percentage p2 of the operate time t> or time multiplier k of stage I>	S22	R,W(P)	0…999 [%]
Remote setting percentage p3 of the start current of stage I_0>	S23	R,W(P)	0…999 [%]
Remote setting percentage p4 of the operate time t_0> or time multiplier k_0 of stage I_0>	S24	R,W(P)	0…999 [%]
Remote setting of checksum of switchgroup SG1	S25	R,W(P)	0…255
Remote setting of checksum of switchgroup SG2	S26	R,W(P)	0…255
Remote setting of start current I> of overcurrent stage I>	S31	R	0.5…2.5 [x I_n]
Remote setting of operate time t> or time multiplier k of overcurrent stage I>	S32	R	0.05…100 [s] or 0.05…1.00
Remote setting of start current I_0> of earth-fault stage I_0>	S33	R	0.1…0.8 [x I_n] 999 = ∞, infinite
Remote setting of operate time t_0> or time multiplier k_0 of earth-fault stage I_0>	S34	R	0.05…100 [s] or 0.05…1.00
Remote setting of checksum of switchgroup SG1	S35	R	0…255
Remote setting of checksum of switchgroup SG2	S36	R	0…255
Recorded values			
Max. measured phase current value or phase current value at relay operation	V1	R	0…63 [x I_n]
Number of starts of stage I>	V2	R	0…255
Number of starts of stage I>>	V3	R	0…255
Duration of latest start of stage I>	V4	R	0…100 [%]
Duration of latest start of stage I>>	V5	R	0…100 [%]
Max. measured neutral current value or phase current value at relay operation	V6	R	0…21 [x I_n]
Number of starts of stage I_0>	V7	R	0…255
Duration of latest start of stage I_0>	V8	R	0…100 [%]
Data from previous relay operation in coded form	V9	R	see table on page 22

Data	Code	Data direct.	Value or status
Control parameters			
Remote resetting of latched output relays and operation indicators	V101	W	1 = output relays and operation indicators are reset
Remote resetting of latched output relays and operation indicators, erasing of recorded data	V102	W	1 = output relays and operation indicators are reset, recorded data erased (codes V1...V9)
Remote control of settings	V150	R,W	0 = main settings S11…S16 alerted 1 = remote settings S31…S36 alerted
Event mask	V155	R,W	0…255, see section "Event codes"
Programming push-buttons	V157	R, W	0…7
Opening password for remote setting of relay module parameters	V160	W	1…999
Renaming or closing password for remote setting of module parameters	V161	W(P)	0…999
Activation of self-supervision output	V165	W	1 = self-supervision output is activated and IRF indicator switched on in about 5 s, whereafter the self-supervision system and the IRF indicator reset
Internal relay fault code	V169	R	0...255
Address code of relay module	V200	W	1...254
Program version code	V205	R	E.g. 087 A
Relay module type designation	F	R	SPCJ 3C48
Reading of event register	L	R	Time, channel number and event code
Re-reading of event register	B	R	Time, channel number and event code
Reading of relay module status data	C	R	0 = normal status 1 = module has been subject to automatic reset 2 = overflow of event register 3 = events 1 and 2 together
Resetting of module status data	C	W	0 = resetting
Clock time reading and setting	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 substation level communication device.

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

Parameters S1...S6 contain the alerted set values currently used by the relay module. These values may originally have been set by means of the setting knobs and selector switches or by remote control. The main settings S11...S16 are given with the setting knobs and the selector switches of the relay module. The values S21...S24 are percentage factors to be multiplied by the set values given with the setting knobs. The settings S21...S26 can be both read and written. A condition for writing is that the password, V160, for remote setting has been opened and the potentiometer settings are alerted, V150=0. The variables S31...S36 contain the actual remotely set values.

The remote setting percentage of variables S21...S24 can be given a percentage value within the range 0...999. This means that certain parameters can be given set values outside the limits of the specified setting range. However, proper operation of the relay is guaranteed only for set values within the limits of the setting range specified in section "Technical data".

After operation the phase or relay stage involved is indicated by a value stored in variable V9. The same information is shown by the LED indicators of the relay module, see section "Start and operation indicators".

The coding of the fault data of the combined overcurrent and earth-fault relay module is explained in the following table:

Fault	Fault code
Overcurrent stage I>, overcurrent on phase L3	1
Overcurrent stage I>, overcurrent on phase L1	2
Earth-fault stage I_0>, overcurrent on earth path	4
Overcurrent stage I>>, overcurrent on phase L3	8
Overcurrent stage I>>, overcurrent on phase L1	16

For instance when V9 = 3 (1 + 2), the low-set current stage I> has operated (tripped) on overcurrent on phases L1 and L3. If V9 = 1 the relay has operated on overcurrent on phase L3.

The content of register V9 is composed of three separate parts, one for each protection stage. If, for instance, the low-set overcurrent stage I> operates only the first part of the register is updated, that is fault codes 1 and 2. Correspondingly, if the earth-fault stage I_0> operates the second part of the register is updated and if the high-set overcurrent stage I>> operates the third part of the register is updated.

Register V9 can be set to zero either by pressing push-buttons STEP and RESET simultaneously or by writing number 1 to variable V102 via the SPA bus.

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

Fault codes

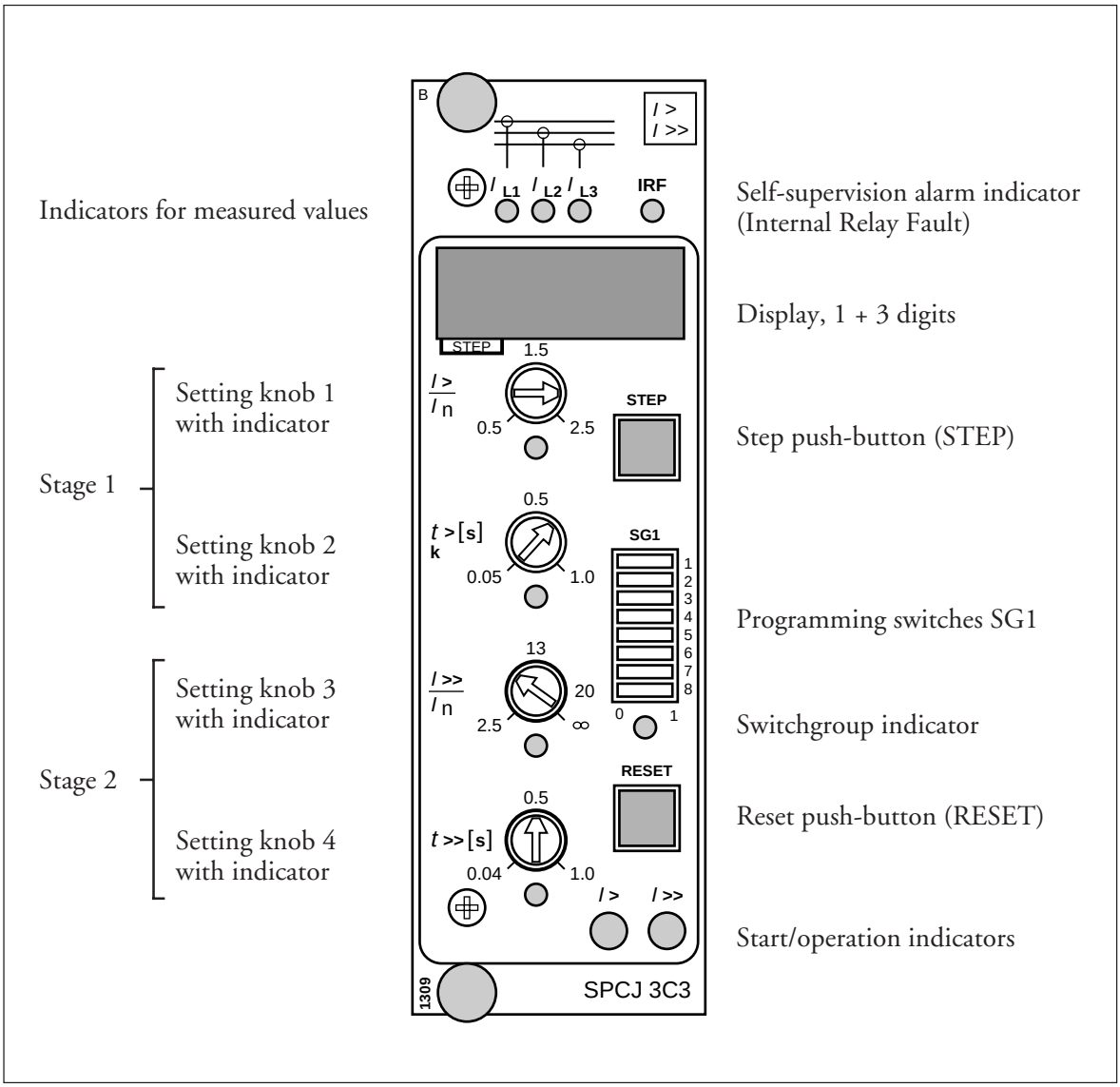
Shortly after the self-supervision system has detected a permanent internal fault the red fault indicator IRF on the relay module front panel is lit. At the same time the self-supervision system generates a control signal to the output relay of the self-supervision system. Further, in most fault situations a self-diagnostic fault code is shown on the display of the relay module. The fault code is composed of a red figure one (1) and a green, one-, two- or three-digit code number. It is recommended that the fault code number is noted down and passed forward to the service shop when overhaul and repair of a faulty relay module is ordered.

The combined overcurrent and earth-fault relay module SPCJ 3C48 displays the following fault codes:

Fault code	Fault specification
4	Trip signal path broken or output relay module missing
30	Faulty program memory (ROM)
50	Faulty random access memory (RAM)
195	Too low a value on the reference channel with multiplier 1
131	Too low a value on the reference channel with multiplier 5
67	Too low a value on the reference channel with multiplier 25
203	Too high a value on the reference channel with multiplier 1
139	Too high a value on the reference channel with multiplier 5
75	Too high a value on the reference channel with multiplier 25
253	No interruptions from the D/A converter

General characteristics of C-type relay modules

User´s manual and Technical description



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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.

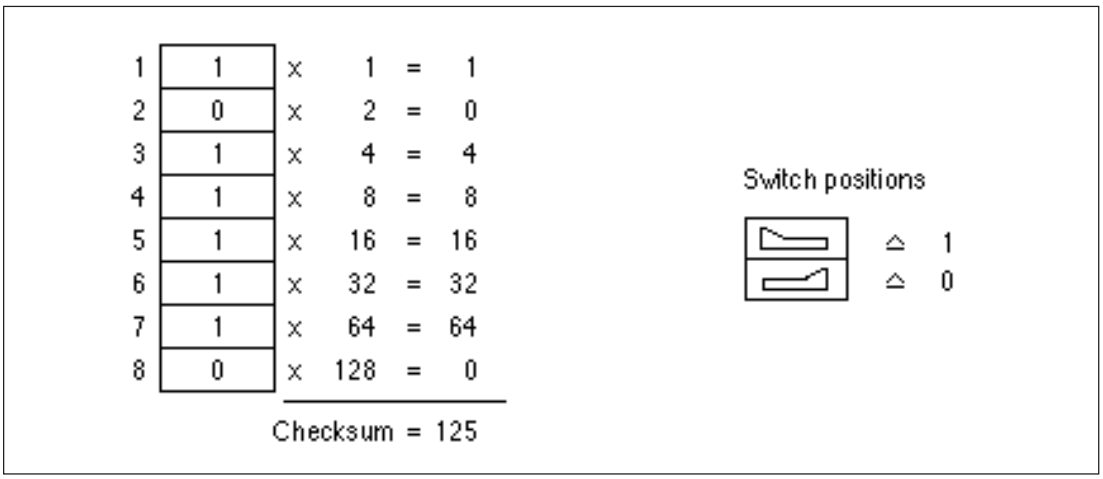


Fig. 2. Example of calculating the checksum of programming switchgroup SG1.

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.

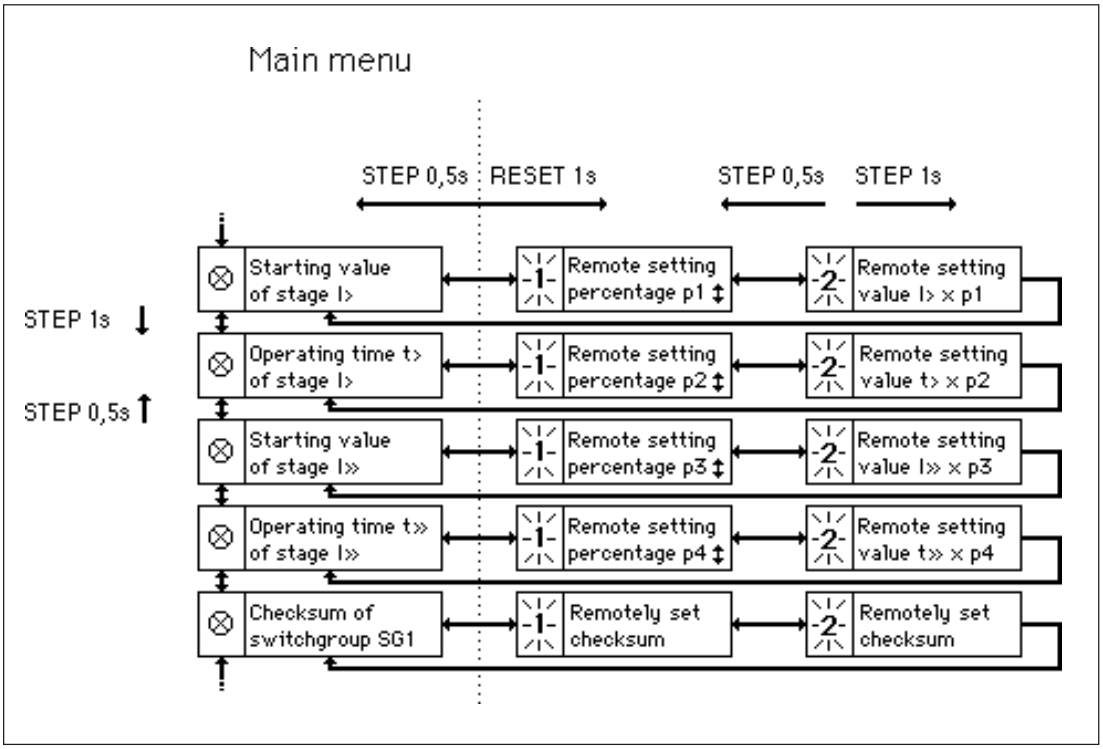


Fig. 3. Example of the main and submenus for the settings of the overcurrent relay module SPCJ 3C3. The settings made with the setting knobs are in the main menu and they are displayed by pressing the STEP button. In addition to the setting knob settings the main menu contains the measured current values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

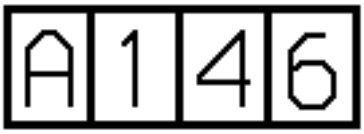
A set value is stored in the memory by pressing the push-buttons STEP and RESET simultaneously. In practice the RESET button must be pressed slightly in excess of the STEP button. Return from the setting mode to the main menu or submenu is possible by pressing (for about 10 s) the RESET button until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

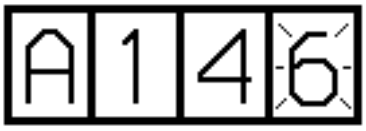
Example 1:

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.

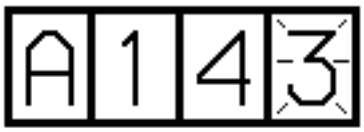
a)
Press push-button STEP until register address A appears on the display.



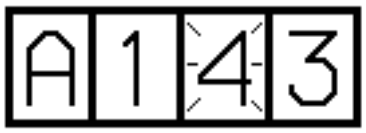
b)
Press the RESET button for about 10 s until the right most digit starts flashing.



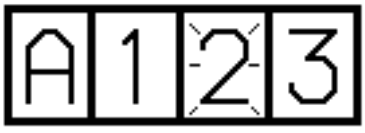
c)
Press the STEP button repeatedly to set the digit to the value desired.



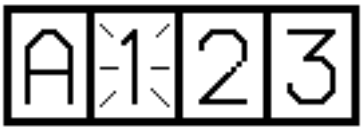
d)
Press the RESET button to make the middle of the green digits flash.



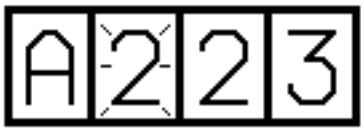
e)
Set the middle address digit by means of the STEP button.



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

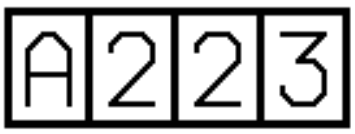


g)
Set the digit by means of the STEP button.



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.

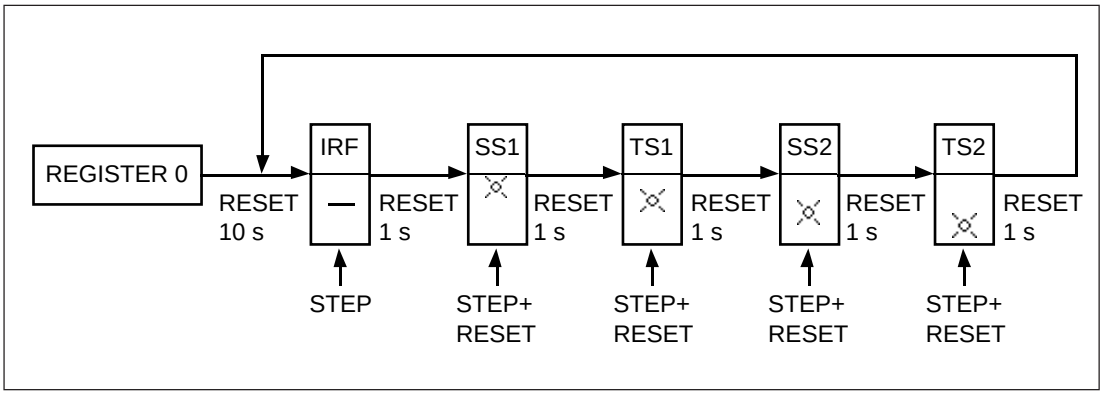


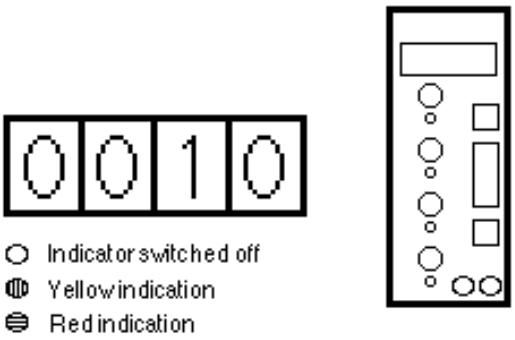
Fig. 4. Sequence order for selecting the output signals in the Trip-test mode.

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.

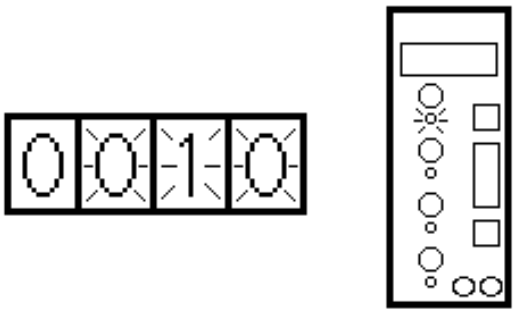
Example 2:

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

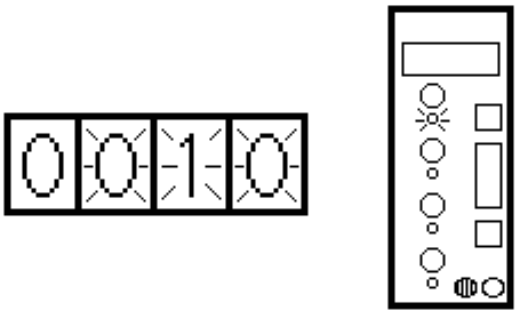
a)
Step forward on the display to register 0.



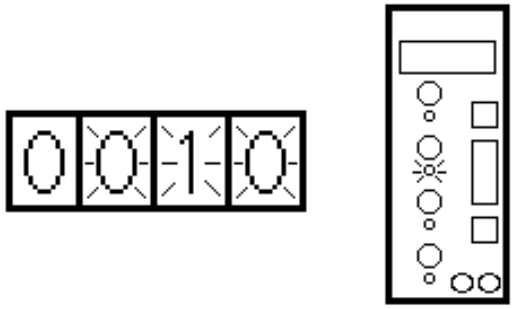
b)
Press the RESET button for about 10 seconds until the three green digits to the right and the LED indicator of the uppermost setting knob start flashing.



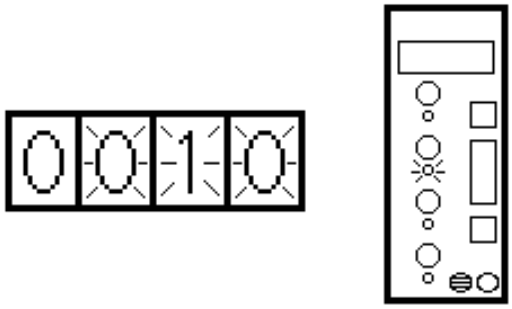
c)
Press the push-buttons RESET and STEP simultaneously. Then the starting of stage 1 (e.g. the I>-stage of the overcurrent module SPCJ 3C3) is activated and, simultaneously, the indicator of the stage starts glowing yellow.



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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