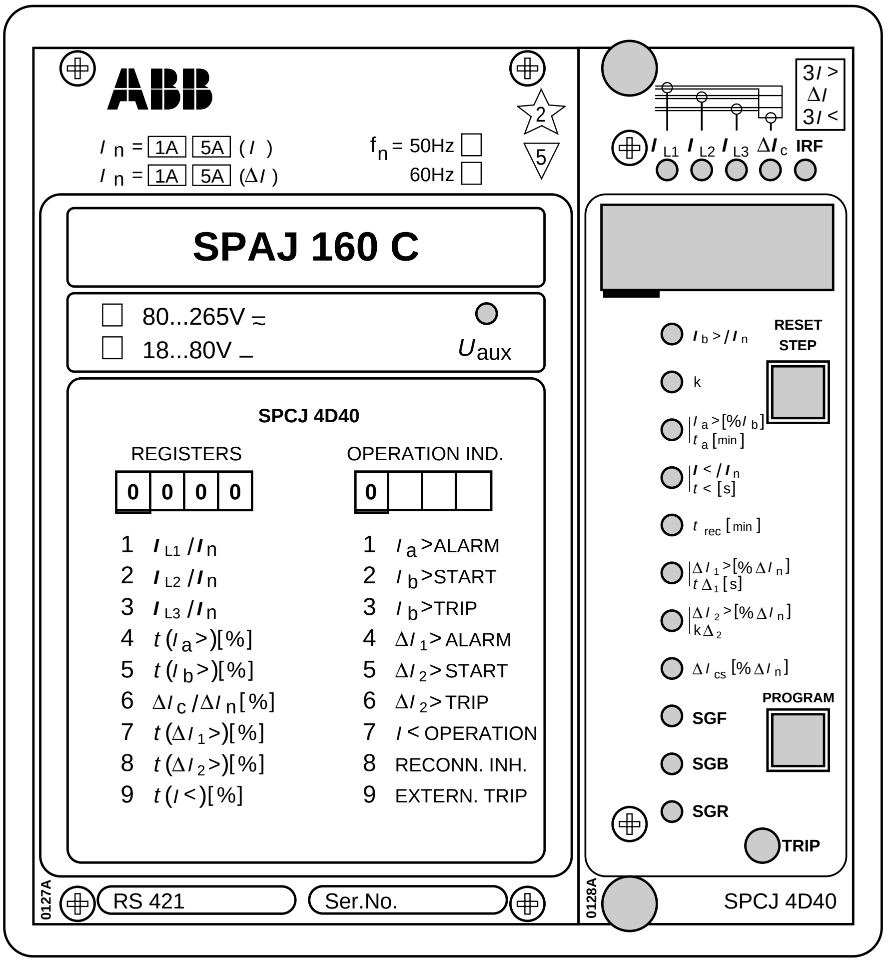
SPAJ 160 C
Capacitor protection relay

User´s manual and Technical description



1MRS 750064-MUM EN

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SPAJ 160 C
Capacitor protection relay

Contents

The complete user's manual also includes the following documents:

General characteristics of D-type relay module	1MRS 750066-MUM EN
Capacitor bank relay module type SPCJ 4D40	1MRS 750065-MUM EN

Characteristics

One-, two- and three-phase overload stage with definite time charcteristic

One-, two- and three-phase overload stage with inverse (ANSI) time charcteristic

Phase unbalance protection stage with definite time charcteristic

Phase unbalance protection stage with inverse time charcteristic

Undercurrent protection for detection of capacitor disconnection. Reconnection time with wide setting range

Compensation for natural unbalance current

Fully selectable output relay configuration

Easy selection of appropriate operational scheme for various applications

Numerical display of setting values, current measured values, memorized values etc.

Continuous self-supervision of hardware and software

Optical serial communication over the SPA bus provides access from a higher level central unit to all set and measured values and to memorized fault values. Various events can also be selected to be automatically read by a control data communicator and printed out.

Area of application
(modified 97-10)

The main application area for the relay is to protect capacitor banks intended for reactive power compensation and filtering of the harmonics.

The capacitor banks are usually protected against overload produced by harmonic currents and overvoltage caused by internal faults in the bank. A protection against reconnection of a charged capacitor to a live network should also be included. All these functions can be found in SPAJ 160 C.

An earth-fault and overcurrent protection is often used for selective network protection. In this case an overcurrent and earth-fault protection relay from the SPACOM-family can be connected to the same current transformer as SPAJ 160 C.

Application examples

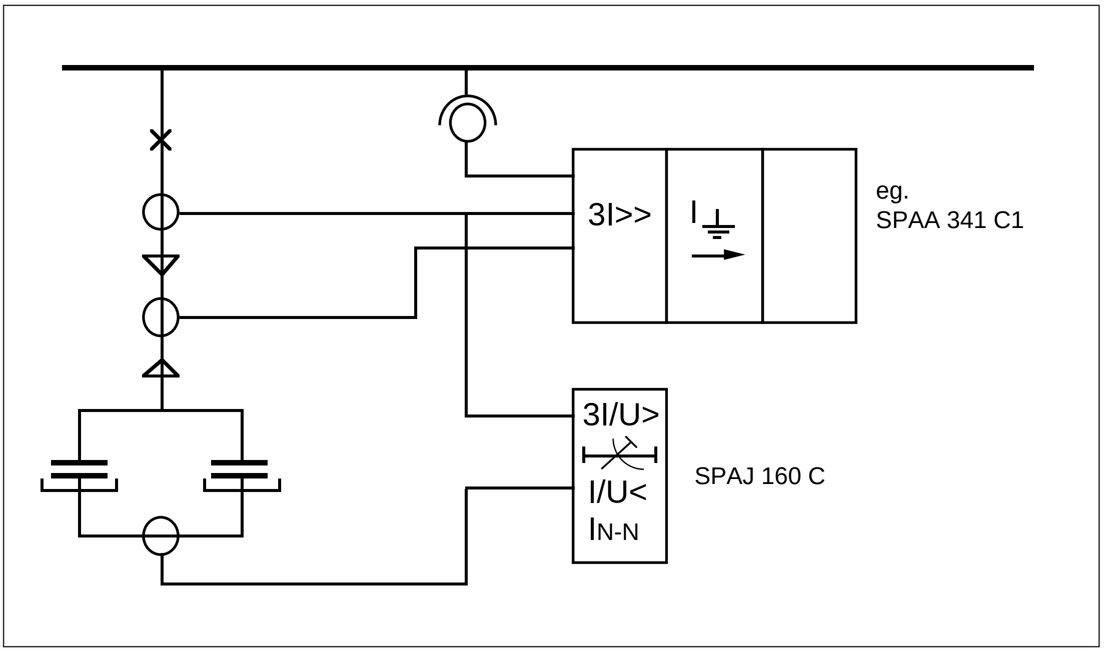


Fig.1. Protection of a capacitor bank connected as a double-star in a distribution network with three-phase current measurement.

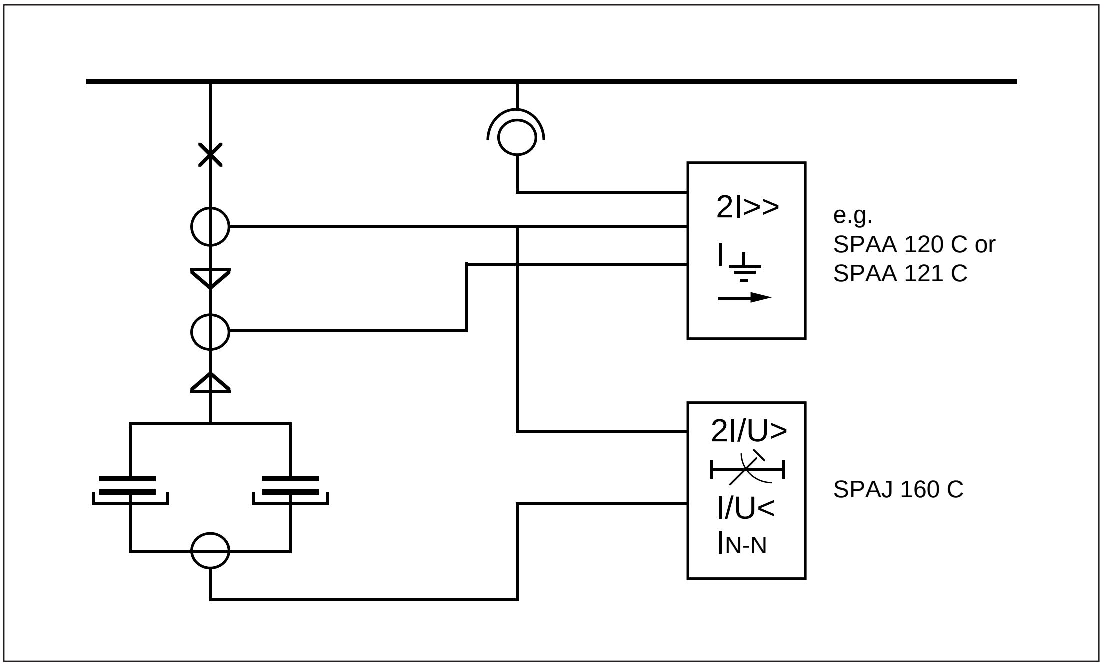


Fig.2. Protection of a capacitor bank connected as a double-star in a distribution network with two-phase current measurement.

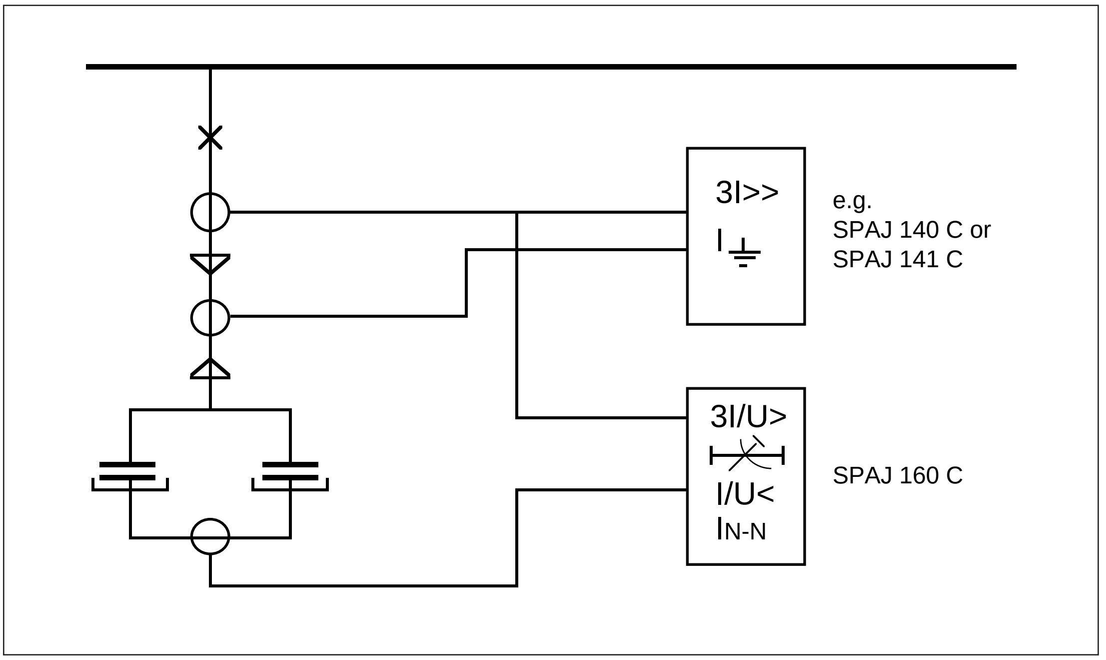


Fig.3. Protection of a capacitor bank connected as a double-star in an industrial network with two- or three-phase current measurement. In this case a non-directional earth-fault protection is used.

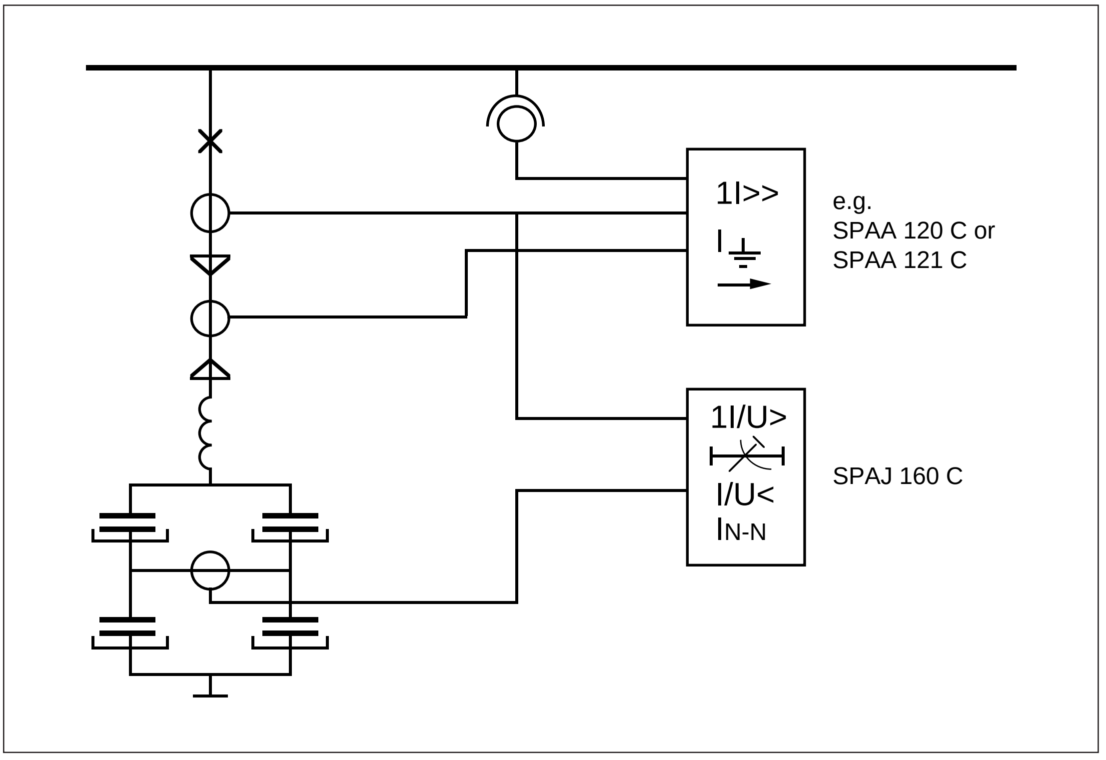


Fig.4. Protection of a one-phase bridge connected capacitor filter bank.

Description of operation

(modified 1996-11)

The protective relay measures the phase currents of the capacitor bank one-, two- or three phase. The currents are internally transformed by the relay to signals that will be directly proportionally to the voltages over the bank.

The relay is also measuring the unbalance current that may arise in a capacitor bank. The input current is in this case measured by a current transformer connected between the starpoints in a double-star connection according to fig. 5 or between the branches in a single-phase bridge connection according to fig. 6.

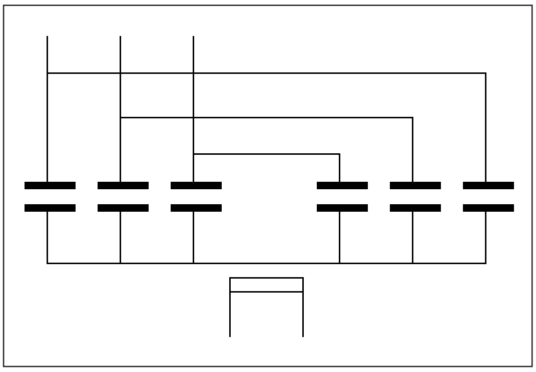


Fig. 5.

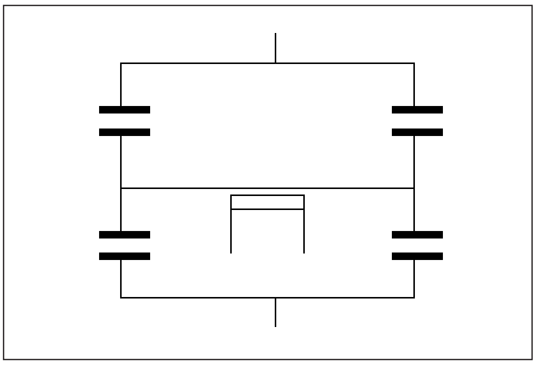


Fig. 6.

The protective relay is a multifunction type of relay and includes functions for overload protection, unbalance protection and undercurrent protection combined with reconnection inhibit to prevent reconnection of a charged capacitor bank to a live network.

The overload protection is mainly a overvoltage protection. It measures peak values with the measured harmonics up to and including the 13th order. The overload protection includes two stages. One stage is alarming and the other is for tripping. The trip stage is based on inverse time characteristic and the inverse curve is based on ANSI/IEEE C37.99 and IEC 60871-1 recommendations for the capacitor banks voltage withstand related to time. The gradient of the curve can be changed by a k-factor within the range 0.2...2.0.

The alarm stage has a definite time characteristic. Both the starting value and the operating time are available for setting. To match the relay to the rated current of the capacitor bank a correction setting value is available. By using this setting value it is possible to multiply the signal from the current transformers by a factor within the range 0.30...1.50.

The undercurrent protection, operating with definite time characteristic, is detecting a possible undercurent in the capacitor bank. When all three phase currents are opeating below the starting value and the operating time has elapsed the output alarm will be activated. The reconnection inhibit function connected to the undercurrent protection will be activated at the same time. The reconnection inhibit signal will be active until the set time has elapsed and is used to inhibit the reconnection of a charged capacitor bank to a live network. Both the starting value and the operating time for the undercurrent protection and the setting time for the reconnection inhibit are available for setting.

The unbalance protection measures only the basic frequency component of the current. The protection function includes two stages of which one is alarming and the other tripping. To improve unbalance detection in the capacitor bank the relay is provided with a settable compensation of natural unbalance. Both the amplitude and phase angle are compensated. The trip stage is based on inverse time characteristic and the curve has similar gradient to the normal inverse curve.The starting value can be set within the range 2...80% of the nominal input current of the relay. The gradient of the curve can be changed by the k-factor within the range 0.1...1. It is possible to increase the inverse characteristic time by a factor 10 by setting switch SGF/6 to position 1.

The signal stage has a definite time characteristic. Both the starting value and the operating time are available for setting. By using the unbalance compensation natural unbalance currents within the range 1...20% of the relays nominal input current can be compensated.

By appropriate programming of the output relay matrix, various starting, alarm or reconnection inhibit signals are received as contact functions. This contact information is used e.g. for the blocking of co-operating protective relays located upstream, for connection to annunciation units etc.

The capacitor bank relay contains one external logic control input, which is activated by a control signal of the auxiliary voltage level. The influence of the control input on the relay is determined by programming switches of the measuring module. The control input can be used either for blocking one or more of the protective stages, for carrying out an external trip order, for inhibiting a reconnection attempt or/ and for resetting a latched output relay in the manual reset mode.

The protective relay is provided with a man-machine interface on the front panel. The man-machine interface shows relay activation's, measured values, maximum value registrations, starting counters, time counters and setting values.

All changes of setting values can be made by using the push-buttons on the front panel. Through the serial bus the man-machine communication can be obtained either by using a PC with a setting tool program, a SCS local control system or a microSCADA remote control system.

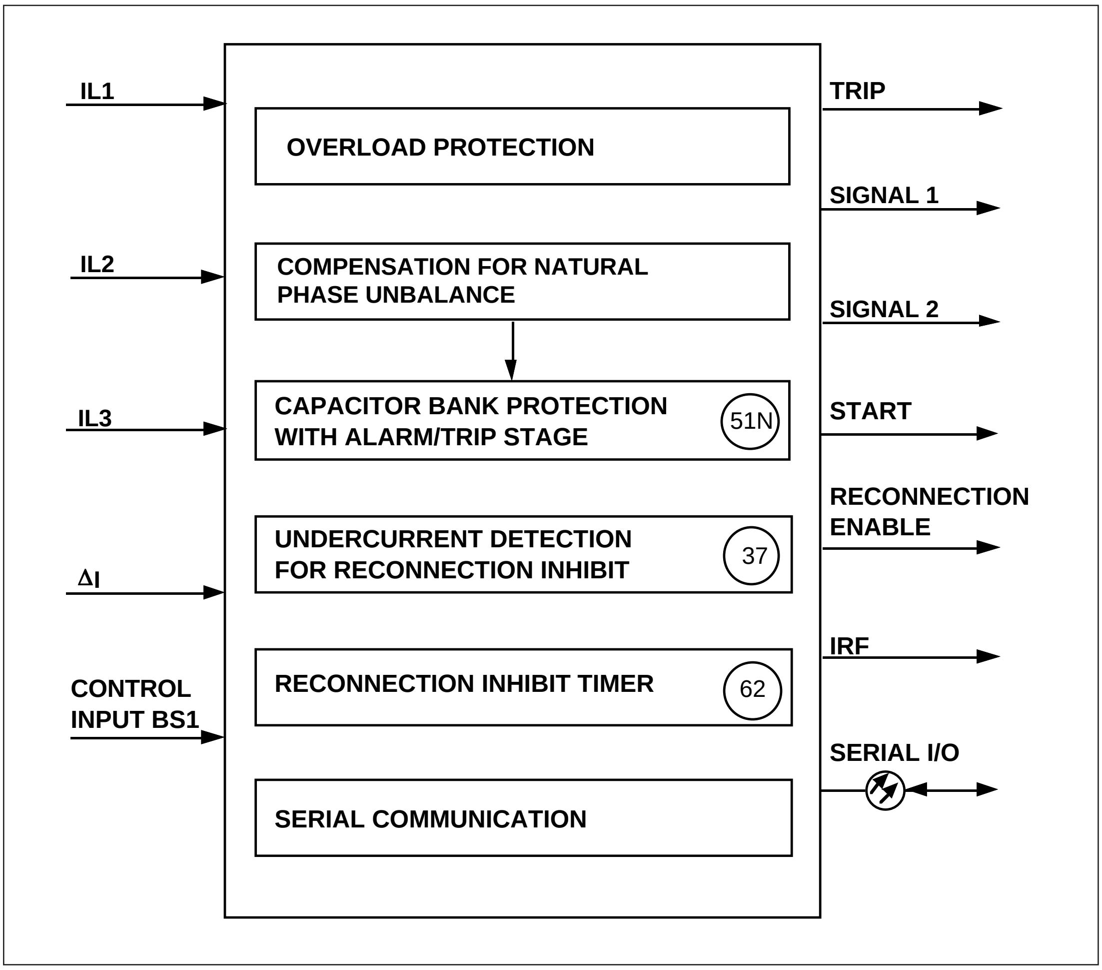


Fig. 7. Checking functions of the capacitor bank overload and unbalance prot. relay type SPAJ 160 C.

Connection diagram
(modified 2002-10)

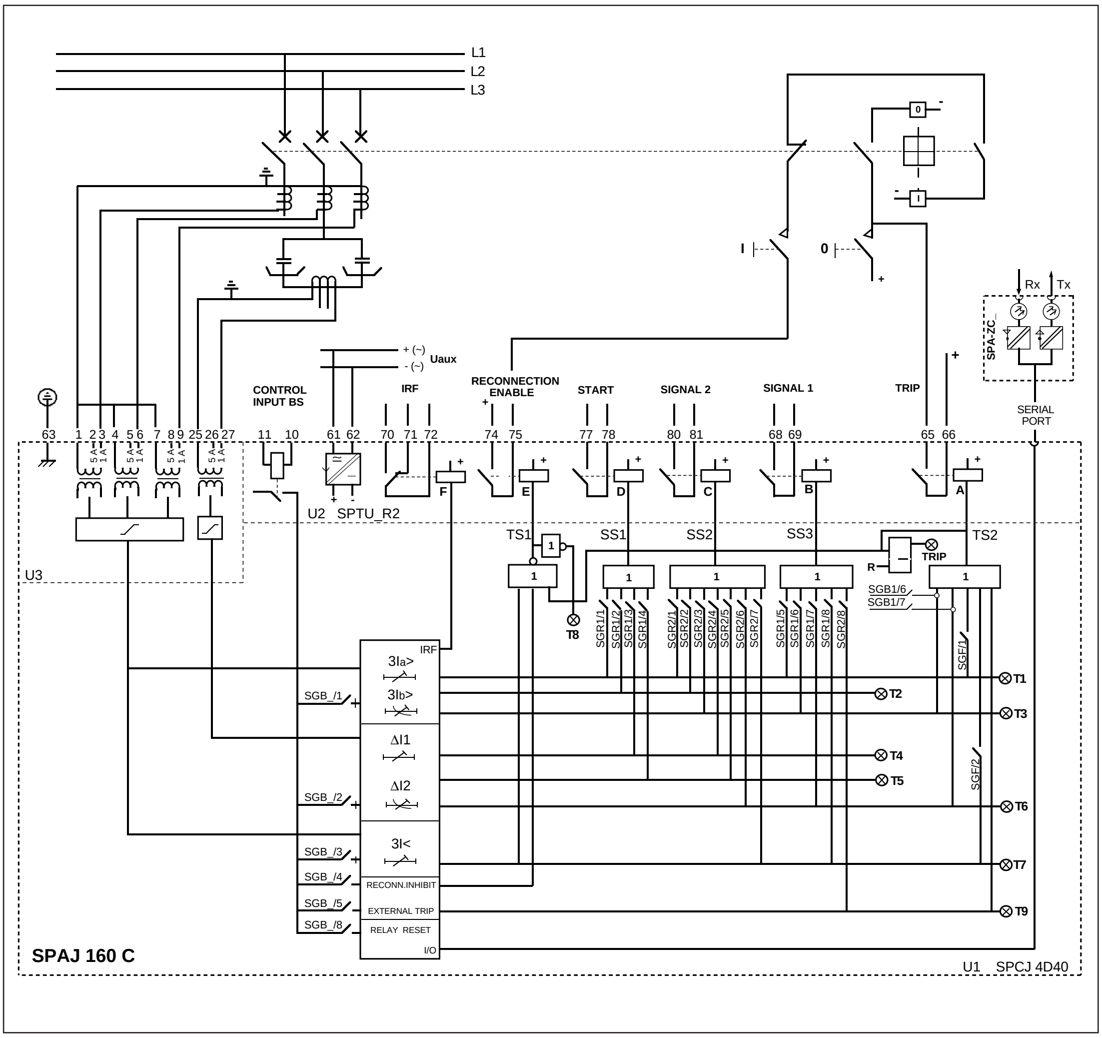


Fig. 8. Complete connection diagram for the capacitor bank protection relay SPAJ 160 C with all the relay matrix and blocking/control input programming switches shown.

U_{aux}	Auxiliary voltage
A, B, C, D, E, F	Output relays
IRF	Self-supervision
SGB1	Switchgroup for the configuration of the blocking and control signals
TRIP	Trip output relay, output 65-66
SIGNAL 1	Signal on tripping
SIGNAL 2	Signal on tripping
START	Signal on starting
RECONN. INHIBIT	Connection inhibited in fault conditions
U1	Capacitor bank protection relay module SPCJ 4D40
U2	Power supply and output relay module SPTU 240 R2 or SPTU 48 R2 with a normally open trip contact
U3	Input module SPTE 4E3
Rx Tx	Serial communication interface
T1...T9	Operation indications
SPA-ZC-	Bus connection module

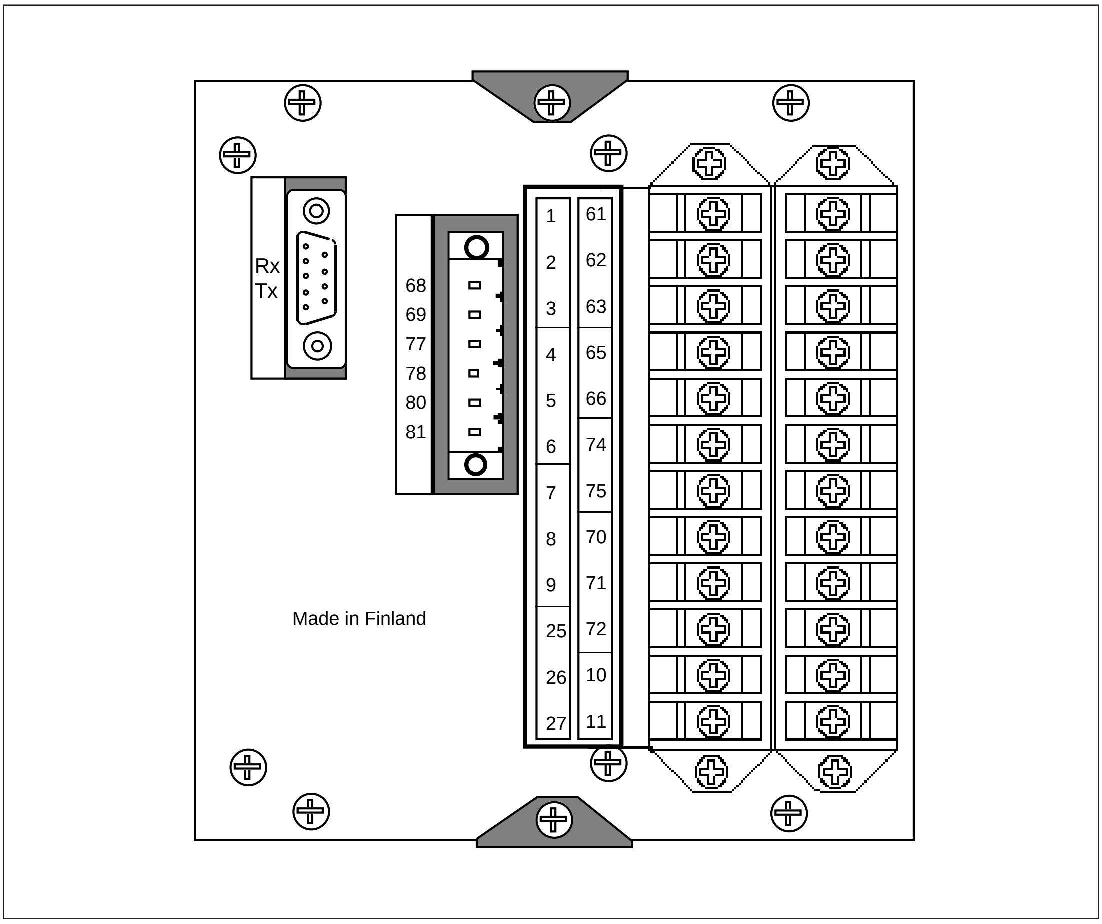


Fig. 9. Rear view of relay SPAJ 160 C

Connections

Terminal	Function
1-2 1-3 4-5 4-6 7-8 7-9 25-26 25-27	Phase current I_{L1}, 5 A Phase current I_{L1}, 1 A Phase current I_{L2}, 5 A Phase current I_{L2}, 1 A Phase current I_{L3}, 5 A Phase current I_{L3}, 1 A Phase unbalance current 5 A Phase unbalance current 1 A
61-62	Auxiliary supply voltage. At d.c. auxiliary supply voltage the positive lead is connected to terminal 61.
63	Protective earth
10-11	Blocking- and control input. Can be used as an external blocking input inhibiting overload, phase unbalance or undercurrent protection. As an control input it can be used for an external trip signal, for unlatching the trip relay and for the reconnection inhibit relay. The function is selected with SGB-switches in the protection relay module.
65-66	Output relay A is a heavy duty relay which provides CB tripping commands. A latching function of the output relay A can be selected by means of switches SGB1/6 and SGB1/7. Switch SGB1/6 gives a latching function after an overload tripping. Switch SGB1/7 provides a latching function after a phase unbalance trip. The latched output relay can be reset locally or by remote control. The undercurrent unit can be made tripping with switch SGF/2. Also the overload stage I_a> can be made tripping with switch SGF/1.
68-69	The signals to be routed to output relays B and C are selected with switches 5...8 of 80-81 switchgroup. The signals to be routed to output relays B and C are selected with switches 5...8 of switchgroup SGR1 and switches 1...8 of switchgroup SGR2 of the measuring module. Normally overload stage I_b> start signal is linked to relay C and the overload stage I_a> alarm signal is linked to output relay B.
77-78	The signals to be routed to the output relay D are selected by means of switches 1...4 of switchgroup SGR1. Switch SGR1/1 links the overload I_a> alarm, switch SGR2/2 links the oveload I_b> start, switch SGR2/3 links the phase unbalance alarm of stage ΔI_1> and switch SGR2/4 links the phase unbalance start signal of stage ΔI_2> to output relay D.
74-75	Output relay E is a heavy duty output relay capable of controlling a circuit breaker. Relay E is normally used for controlling the reconnection of the capacitor bank. If the reconnection inhibit signal is active the output relay E prevents a reconnection attempt of the capacitor bank. This also applies to a condition where the protective relay is out of auxiliary voltage or the relay is faulty.
70-71-72	Output relay F operates as an self-supervision output relay. Under normal conditions the relay is operated and the contact gap 70-72 is closed. If a fault is detected by the self-supervision system, or if the auxiliary supply fails, the output relay drops off, providing an alarm signal by closing the NO contact 71-72.

The relay is interfaced with the SPA serial communication bus through a 9-pole, D-type subminiature connector located at the rear panel of the relay. By means of the bus connection modules SPA-ZC21 or SPA-ZC17 the relay can be linked to the serial bus and further to a control data communicator, e.g. SACO 148D4 or SRIO 500/1000M.

Control signals between the modules

The figure below schematically illustrates how the closing and alarm signals are connected between measuring and output relay module.

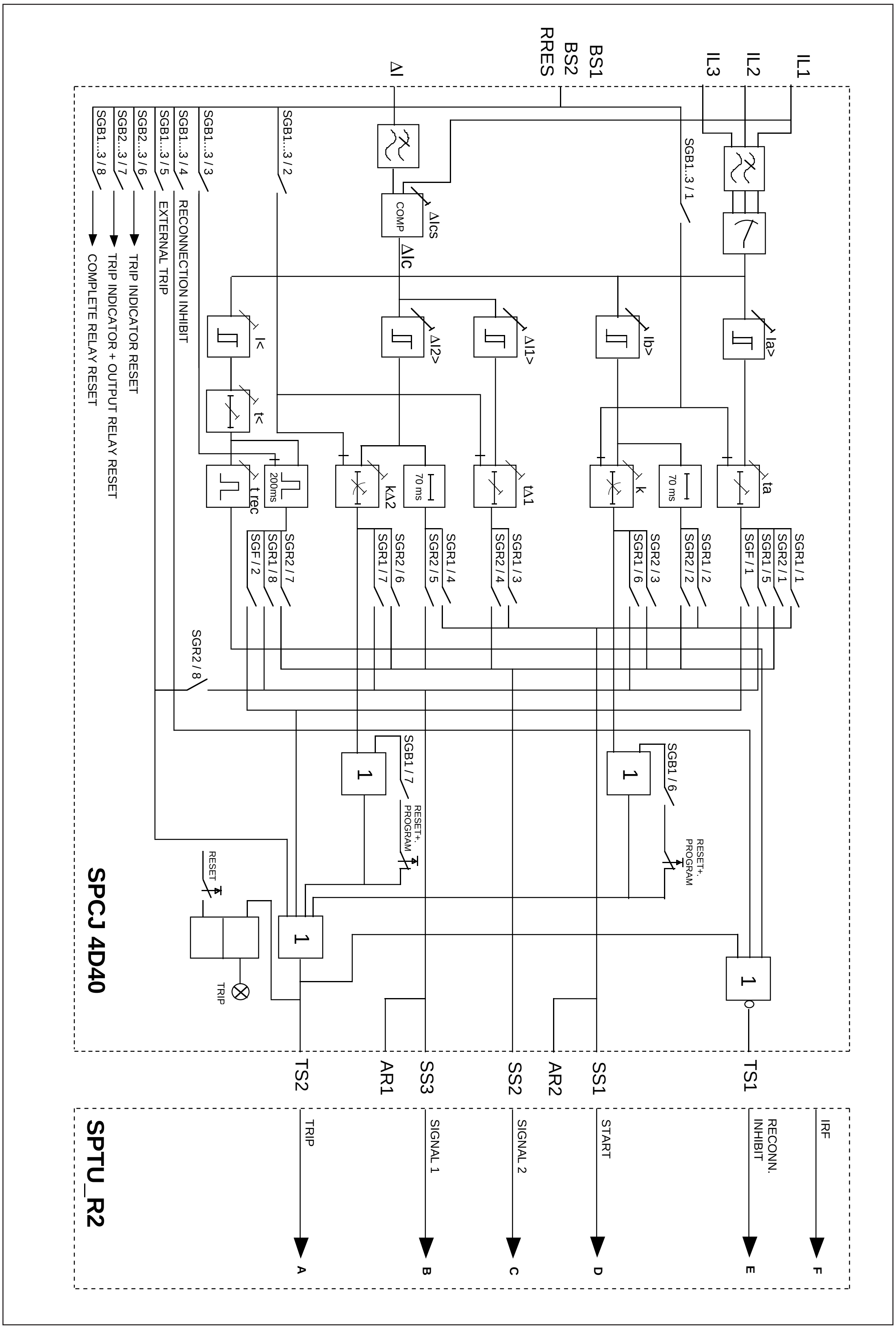


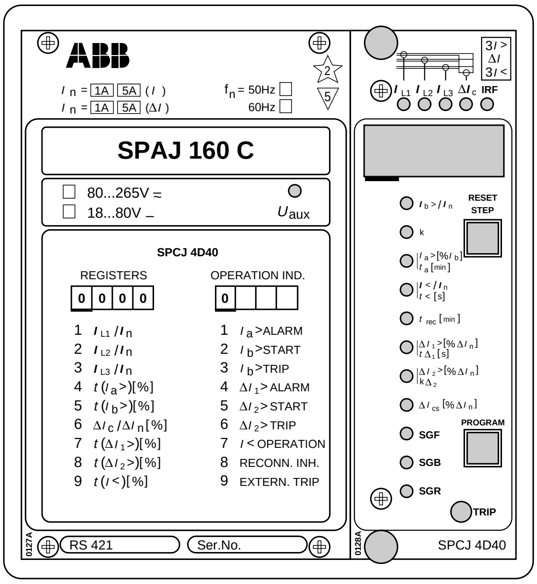
Fig. 10. Control signals between the modules of the capacitor bank relay SPAJ 160 C.

The functions of the blocking, starting and tripping signals are selected with the switches of switchgroups SGF, SGB1...3 and SGR1...2. The checksums of the switchgroups, are found in the setting menu of the measuring relay module. The functions of the different switches are explained in the user's manual of the measuring module SPCJ 4D40.

Abbreviations of signal names

I_{L1}, I_{L2}, I_{L3}	Phase currents
ΔI	Phase unbalance current
ΔI_c	Compensated phase unbalance current
BS1, BS2 ,RRES	External blocking or resetting signals
SS1	Starting Signal 1
SS2	Starting Signal 2
SS3	Starting Signal 3
TS1	Tripping Signal 1
TS2	Tripping Signal 2
AR1...3	Auto-Reclose starting signals (not used in SPAJ 160 C)
IRF	Internal Relay Fault signal
SS1	Starting Signal 1
SGF	Switch Groups for functions
SGB1...3	Switch Groups for blockings
SGR1...2	Switch Groups for relay configuration
Rx/Tx	Receiver/Transmitter channel

Operation indicators



A) The indicator TRIP is lit when one of the protection stages operates. When the protection stage returns, the red indicator remains alight.

B) If the display is dark when one of the protection stages I_a> or I_b> request for tripping, the faulty phase is indicated with a yellow LED. If, for instance, the TRIP indicator glows red, and the indicators I_{L1} and I_{L2} are ON at the same time, overcurrent has occurred on phase L1 and L2.

C) Besides being a code number at data presentation, the leftmost red digit in the display serves as a visual operation indicator. An operation indicator is recognized by the fact that the red digit alone is switched on. The operation indication from a start or the reconnection inhibit is always replaced by a new operation indication. On the other hand an operation indication from a stage connected to the trip relay A can not be replaced by a new operation indication. In order to enable reading of actual current levels etc. when reconnection time is running, it is possible to acknowledge the indication 8 while the unit is still activated. The same applies to the external trip indication 9. In these cases the indications are memorized and reappear when the display is dark. Operation indicator 8 is automatically reset when the capacitor bank is reconnected. The following table, named OPERATION IND. on the relay front panel, is a key to the operation indicator code numbers used.

Indication	Explanation	
1	I_a> alarm	= The overload stage I_a> has given an alarm
2	I_b> start	= The overload stage I_b> has started
3	I_b> trip	= The overload stage I_b> has tripped
4	ΔI_1> alarm	= The stage ΔI_1> has given an alarm
5	ΔI_2> start	= The stage ΔI_2> has started
6	ΔI_2> trip	= The stage ΔI_2> has tripped
7	I< operation	= The stage I< has operated
8	t_{rec}	= The reconnection inhibit is active, indication is self-reset
9	EXT.TRIP	= A trip from an external relay has been carried out via the relay

D) The operation indicator on the display and the "TRIP" indicator persist when the protective stage returns to normal. The indicators are reset by pushing the RESET/STEP push-button.

Further, the indicators may be reset via the external control input 10-11 by applying a control voltage to the input, provided that the switch SGB1/8 is in position 1.

The basic protective relay functions are not depending on the state of the operation indicators, i.e. reset or non-reset. The relay is permanently operative.

If stage I_b> or ΔI_2> starts, but no tripping occurs because the energizing quantity goes below the starting level before the delay circuit times out, the starting indications are automatically switched off. However, by means of the switches SGF/3...4 the starting indications may be persistent which means that they are to be reset by pushing the RESET/STEP push-button. The persistent indications are obtained through the following programming:

Switch SGF/3 = 1	Starting indication on I_b> persistent
Switch SGF/4 = 1	Starting indication on ΔI_2> persistent

On delivery from factory the switches SGF/3...4 = 0

E) The self-supervision alarm indicator IRF indicates that the self-supervision system has detected a permanent fault. The indicator activates with a red light about 1 minute after the fault has been detected. At the same time the plug-in module delivers a signal to the self-supervision system output relay of the protection assembly. Additionally, in most cases, a fault code showing the nature of the fault appears on the display of the module. The fault code, consists of a red figure one and a green code number, this cannot be erased from the display of the module by resetting. When a fault occurs, the fault code should be recorded and stated when service, is ordered.

Power supply and output relay module

To be able to operate the relay needs a secured auxiliary voltage supply. The power supply module forms the voltages required by the measuring relay module and the auxiliary relays. The withdrawable power supply and output relay module is located behind the system front panel, which is fixed by means of four cross-slotted screws. The power supply and output relay module contains the power supply unit, all output relays, the control circuits of the output relays and the electronic circuitry of the external control signals.

The power supply and output relay unit can be withdrawn after removing the system front panel. The primary side of the power supply module is protected with a fuse, F1, located on the PCB of the module. The fuse size is 1 A (slow).

The power supply unit is a transformer connected, i.e. galvanically isolated primary and secondary side, flyback-type dc/dc converter. It forms the dc secondary voltages required by the measuring relay module; that is +24 V, ±12 V and +8 V. The output voltages ±12V and +24 V are stabilized in the power supply module, while the +5 V logic voltage required by the measuring relay module is formed by the stabilizer of the relay module.

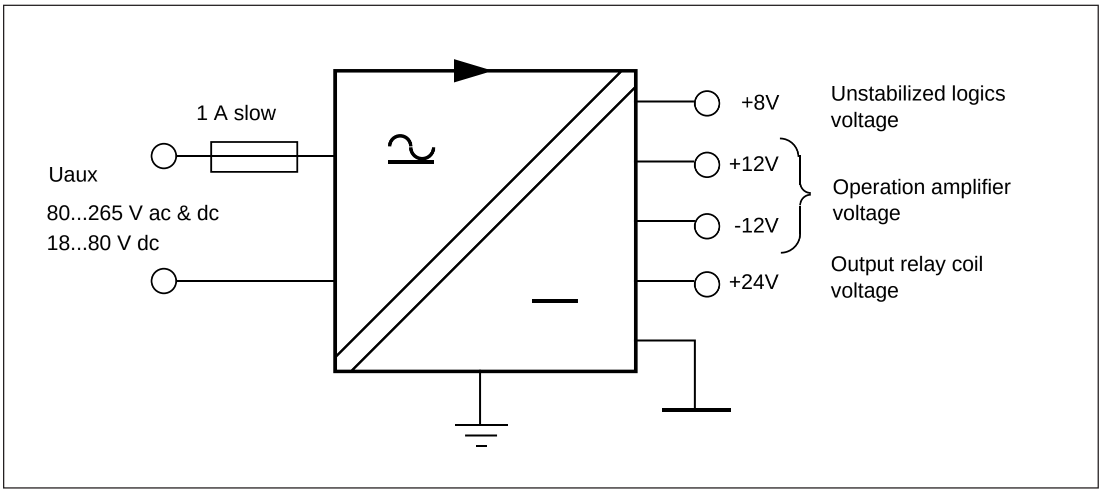


Fig. 11. Voltage levels of the power supply module.

A green LED indicator Uaux on the system front panel is illuminated when the power supply module is in operation. The supervision of the voltages supplying the electronics is placed in the measuring module. If a secondary voltage deviates from its rated value by more than 25 %, a selfsupervision alarm will be established. An alarm is also received when the power supply module is withdrawn from the relay case, or when the auxiliary power supply to the relay is interrupted.

There are two versions of the power supply and output relay modules available. For both types, the secondary sides and the relay configurations are identical, but the input voltage ranges differ.

Insulation test voltage between the primary and the secondary side and the protective earth.
2 kV, 50 Hz, 1min

Rated power P_n 5 W

Voltage ranges of the power supply modules:
- SPTU 240 R2 U_{aux} = 80 ... 265 V ac/dc
- SPTU 48 R2 U_{aux} = 18 ... 80 V dc (on request)

The module SPTU 240 R2 can be used with both ac and dc voltages. Module SPTU 48 R2 is designed for dc supply only. The auxiliary voltage range of the power supply module of the relay assembly is indicated on the system front panel.

Technical data
(modified 2002-04)

Energizing inputs

Phase and neutral current inputs, terminals	1-3, 4-6, 7-9, 25-27	1-2, 4-5, 7-8, 25-26
Rated current I_n	1 A	5 A
Thermal withstand capability		
- continuously	4 A	20 A
- for 1 s	100 A	500 A
Dynamic current withstand, half-wave value	250 A	750 A
Input impedance	< 100 mΩ	< 20 mΩ
Phase current monitoring range	0...8.5 x I_n	
Phase unbalance current monitoring range	0...212% ΔI_n	
Rated frequency	50/60 Hz	

Output contact ratings

Reconnection enable and trip contact	
Terminals	65-66, 74-75
- Rated voltage	250 V dc/ac
- Carry continuously	5 A
- Make and carry for 0.5 s	30 A
- Make and carry for 3.0 s	15 A
- Breaking capacity for dc, when the control circuit time-constant L/R < 40ms, at 48/110/220 V dc control circuit voltage	5 A / 3 A / 1 A
Start and signalling contacts	
Terminals	70-71-72, 68-69, 77-78, 80-81
- Rated voltage	250 V dc/ac
- Carry continuously	5 A
- Make and carry for 0.5 s	10 A
- Make and carry for 3.0 s	8 A
- Breaking capacity for dc, when the control circuit time-constant L/R < 40ms, at 48/110/220 V dc control circuit voltage	1A / 0.25A / 0.15A

External control inputs

Blocking and command inputs	10-11
External control voltage level	18...265 V dc or 80...265 V ac
Typical control current of input circuit	2 mA

Power supply and output relay module

Supply and relay module, type SPTU 240 R2	80...265 V dc/ac
Supply and relay module, type SPTU 48 R2	18...80 V dc (on request)
Power consumption under quiescent/operating conditions	4 W / 6 W

Protection units of module SPCJ 4D40

Overload stage I_b>

Starting current I_b>	0.30...1.50 x I_n
Starting time	<80 ms
Operation characteristic	ANSI inverse
Time multiplier k	0.2...2.0
Resetting time	<100 ms
Drop-off/pick-up ratio	>0.95
Operation time accuracy (k = 1.0 and I_b> = 0.50…1.50 x I_n)	±10% of theoretical value or ±50 ms
Operation accuracy	±3% of set value
Shortest possible trip time	~100 ms

Overload stage I_a>

Starting current I_a>	80...120% x I_b>
Operating time	0.50...100 min
Resetting time	<250 ms
Drop-off/pick-up ratio	>0.95
Operation time accuracy	±2% of set value
Operation accuracy	±3% of set value

Undercurrent stage I<

Starting current I<	0.10...0.70 x I_n
Operating time	1.0...100 s
Reconnection time	0.50...100 min
Pulse shaped tripping signal, pulse length	~200 ms
Pick-up/drop-off ratio	<1.1
Operation time accuracy	±2% of set value or ±75 ms
Operation accuracy	±3% of set value within range 0.25...0.70 x I_n

Phase unbalance ΔI_1>, Stage 1

Starting current ΔI_1>	1.0...100% ΔI_n *)
Operating time	1.0...300 s
Resetting time	<100 ms
Drop-off/pick-up ratio	>0.90
Operation time accuracy (ΔI_{cs} = 0)	±2% of set value or ±75 ms
Operation accuracy (ΔI_{cs} = 0)	±3% of set value within range 1.5...100% ΔI_n

Phase unbalance ΔI_2>, Stage 2

Starting current ΔI_2>	2.0...80.0% ΔI_n *)
Starting time	<70 ms
Operation characteristic	Inverse time
Time multiplier $k_{\Delta 2}$	0.1...1.0
Resetting time	<100 ms
Drop-off/pick-up ratio	>0.90
Operation time accuracy of theoretical characteristic (ΔI_{cs} = 0)	7.5% or ±35 ms
Operation accuracy (ΔI_{cs} = 0)	±3% of set value
Shortest possible trip time	~100 ms

Setting of compensation	0.0...20.0% ΔI_n
Operation accuracy	<3% of ΔI_n

*) minimum recommended: 3.0% ΔI_n

Data transmission

Transmission mode	Fibre optic serial bus
Data code	ASCII
Data transfer rate, selectable	4800 Bd or 9600 Bd
Electrical/optical bus connection module powered from the host relay	
- for plastic core cables	SPA-ZC 21 BB
- for glass fibre cables	SPA-ZC 21 MM
Electrical/optical bus connection module powered from the host relay or an external power source	
- for plastic core 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 ºC
Temperature influence on the operating values of the relay over the specified ambient service temperature range	< 0.2 %/ ºC
Long term damp heat withstand according to IEC 60068-2-3	< 95 % at 40 ºC for 56 d/a
Transport and storage temperature range	-40 ... +70 ºC
Degree of protecting by enclosure of the relay case as per IEC 60529 when panel mounted	IP 54
Mass of the relay	3.5 kg

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

Maintenance and repair

When the synchrocheck relay is operating under the conditions specified in the section "Technical data", the relay is practically maintenance-free. The relay modules include no parts or components subject to an abnormal physical or electical wear under normal operating conditions.

If the environmental conditions at the relay operating site differ from those specified, as to temperature, humidity, or if the athmosphere around the relay contains chemically active gases or dust, the relay should to be visually inspected in association with the relay secondary test or whenever the relay modules are withdrawn from the case. At the visual inspection the following things should be noted:

- Signs of mechanical damage on the relay modules, contacts and relay case
- Accumulation of dust inside the relay cover or case; remove by flowing air carefully
- Rust spots or signs of erugo on terminals, case or inside the relay

On request, the relay can be given a special treatment for the protection of the printed circuit boards against stress on materials, caused by abnormal environmental conditions.

If the relay fails in operation or if the operating values remarkable differ from those of the relay specifications, the relay should be given a proper overhaul. Minor measures can be taken by personnel from the instrument work-shop of the customer's company, e.g. replacement of auxiliary relay modules. All major measures involving overhaul of the electronics are to be taken by the manufacturer. Please contact the manufacturer or his nearest representative for further information about checking, overhaul and recalibration of the relay.

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

Spare parts

Capacitor bank protection relay module	SPCJ 4D40
Power and output relay module	
U_{aux} = 80 ... 265 V ac/dc	SPTU 240 R2 for NO trip contact
U_{aux} = 18 ... 80 V dc	SPTU 48 R2 for NO trip contact
Relay box, complete with input module	SPTK 4E3
Input module as separate part	SPTE 4E3
Bus connection module	SPA-ZC 17_ or SPA-ZC 21_

Ordering numbers

Capacitor bank protection without testswitch

SPAJ 160 C	RS 611 051 - AA, CA, DA, FA

Capacitor bank protection with testswitch type RTXP 18

SPAJ 160 C	RS 611 251 - AA, CA, DA, FA

The last letters of the ordering number indicate the rated frequency f_n and the auxiliary voltage range U_{aux} of the relay as follows:
AA equals f_n = 50 Hz and U_{aux} = 80...265 V ac/dc
CA equals f_n = 50 Hz and U_{aux} = 18...80 V ac/dc
DA equals f_n = 60 Hz and U_{aux} = 80...265 V ac/dc
FA equals f_n = 60 Hz and U_{aux} = 18...80 V ac/dc

Power supply and output relay modules:

SPTU 240 R2	RS 911 021 - AA
SPTU 48 R2	RS 911 021 - BA

Dimensions and instructions for mounting

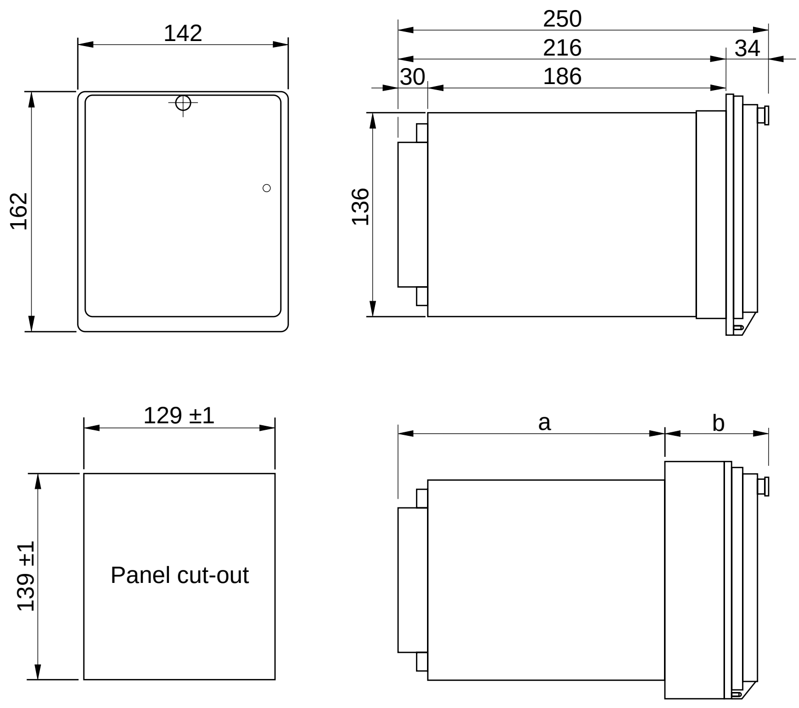
The relay is housed in a normally flush-mounted case. The relay can also be arranged for semi-flush mounting with the use of a 40 mm, 80 mm or 120 mm raising frame, which reduces the depth behind the panel by the same dimension. The type designation of the raising frames are SPA-ZX 111 for the 40 mm frame, SPA-ZX 112 for the 80 mm frame and SPA-ZX 113 for the 120 mm frame. A surface mounting case SPA-ZX 110 is also available.

The relay case is made of an extruded, beige aluminium profile.

A cast aluminium alloy mounting frame with rubber gasket provides a degree of protection by enclosure to IP 54 between the relay case and the panel surface when the relay is panel mounted.

The relay case is completely with a hinged gasketed, clear, UV-stabilized polycarbonate cover with a sealable fastening screw. The degree of protection by enclosure of the cover is also IP 54.

A terminal strip and two multipole connectors are mounted on the back of the relay case to facilitate all input and output connections. To each heavy duty terminal, i.e. measuring input, power or closing output, one 6 mm^2, one 4 mm^2 or one or two 2.5 mm^2 wires can be connected. No terminal lugs are needed. The three signalling inputs are available on a six pole detachable connector and the serial bus connection is using a 9-pin D-type connector.



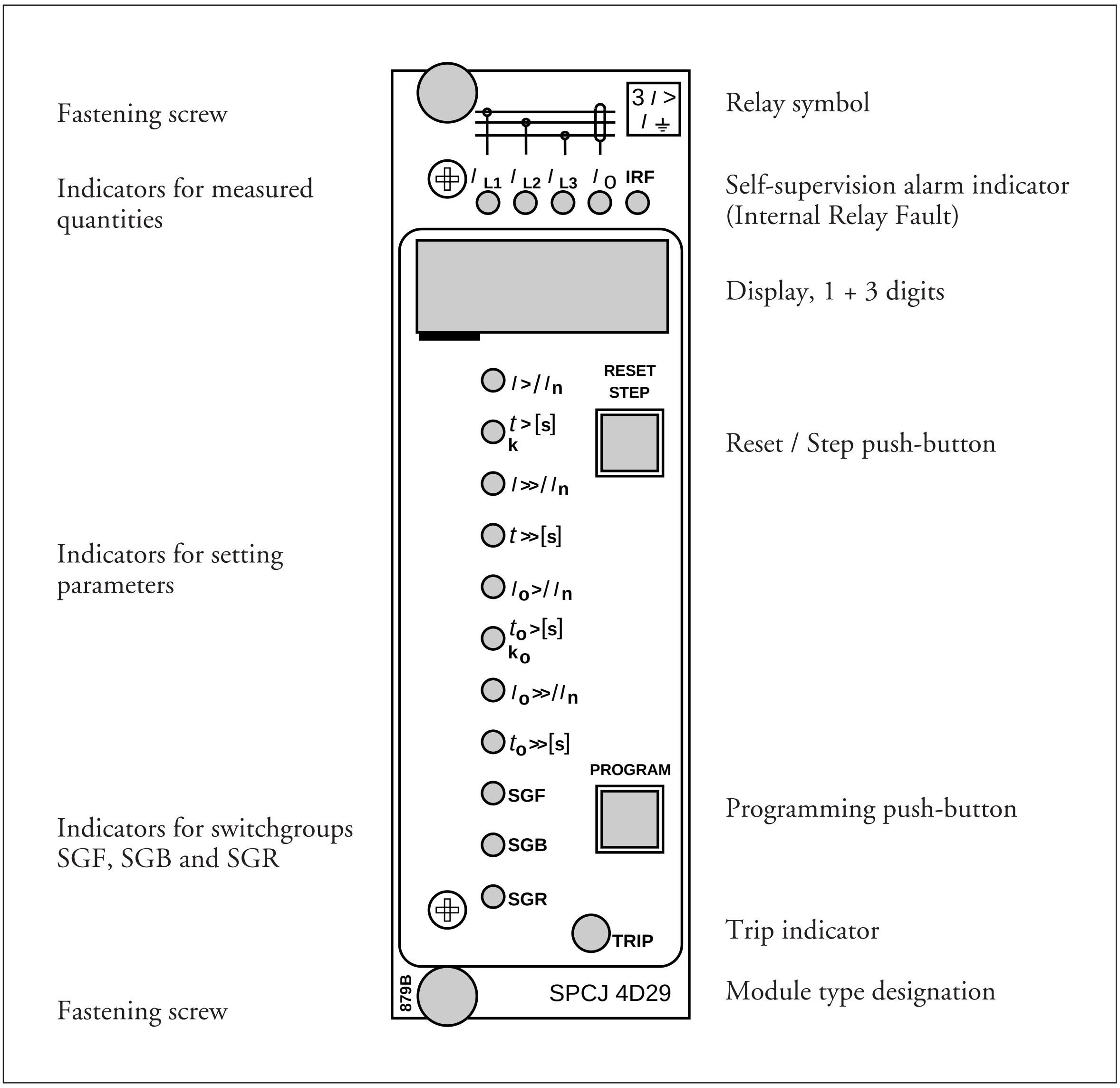
Raising frame	a	b
SPA-ZX 111	176	74
SPA-ZX 112	136	114
SPA-ZX 113	96	154

Information required with order

	Example
1. Quantity and type designation	15 pcs SPAJ 160 C
2. Ordering number	RS 611 051 - AA
3. Rated frequency	f_n = 50 Hz
4. Auxiliary voltage	U_{aux} = 110 V dc
5. Accessories	15 pcs matching modules SPA-ZC 21 MM 2 pcs fibre optical cables SPA-ZF MM 100
6. Special requirements	-

General characteristics of D-type relay modules

User´s manual and Technical description



ABB

1MRS 750066-MUM EN

Issued 95-04-12
Version A (replaces 34 SPC 3 EN1)
Checked JH
Approved TK

Data subject to change without notice

General characteristics of D type relay modules

Contents

Control push-buttons

The front panel of the relay module contains two push buttons. The RESET / STEP push button is used for resetting operation indicators and for stepping forward or backward in the display main menu or submenus. The PROGRAM push button is used for moving from a certain position in the main menu to the corresponding submenu, for entering the setting mode of a certain parameter and together with the STEP push button for storing the set values. The different operations are described in the subsequent paragraphs in this manual.

Display

The measured and set values and the recorded data are shown on the display of the protection relay module. The display consists of four digits. The three green digits to the right show the measured, set or recorded value and the leftmost red digit shows the code number of the register. The measured or set value displayed is indicated by the adjacent yellow LED indicator on the front panel. When a recorded fault value is being displayed the red digit shows the number of the corresponding register. When the display functions as an operation indicator the red digit alone is shown.

When the auxiliary voltage of a protection relay module is switched on the module initially tests the display by stepping through all the segments of the display for about 15 seconds. At first the corresponding segments of all digits are lit one by one clockwise, including the decimal points. Then the center segment of each digit is lit one by one. The complete sequence is carried out twice. When the test is finished the display turns dark. The testing can be interrupted by pressing the STEP push button. The protection functions of the relay module are alerted throughout the testing.

Display main menu

Any data required during normal operation are accessible in the main menu i.e. present measured values, present setting values and recorded parameter values.

The data to be shown in the main menu are sequentially called up for display by means of the STEP push button. When the STEP push button is pressed for about one second, the display moves forward in the display sequence. When the push button is pressed for about 0.5 seconds, the display moves backward in the display sequence.

From a dark display only forward movement is possible. When the STEP push button is pushed constantly, the display continuously moves forward stopping for a while in the dark position.

Unless the display is switched off by stepping to the dark point, it remains lit for about 5 minutes from the moment the STEP push button was last pushed. After the 5 minutes' time-out the dispaly is switched off.

Display submenus

Less important values and values not very often set are displayed in the submenus. The number of submenus varies with different relay module types. The submenus are presented in the description of the concerned protection relay module.

A submenu is entered from the main menu by pressing the PROGRAM push button for about one second. When the push button is released, the red digit of the display starts flashing, indicating that a submenu has been entered. Going from one submenu to another or back to the main menu follows the same principle as when moving from the main menu display to another; the display moves forward when the STEP push button is pushed for one second and backward when it is pushed for 0.5 seconds. The main menu has been re-entered when the red display turns dark.

When a submenu is entered from a main menu of a measured or set value indicated by a LED indicator, the indicator remains lit and the address window of the display starts flashing. A submenu position is indicated by a flashing red address number alone on the dispaly without any lit set value LED indicator on the front panel.

Selector switchgroups SGF, SGB and SGR

Part of the settings and the selections of the operation characteristic of the relay modules in various applications are made with the selector switchgroups SG_ . The switchgroups are software based and thus not physically to be found in the hardware of the relay module. The indicator of the switchgroup is lit when the checksum of the switchgroup is shown on the display. Starting from the displayed checksum and by entering the setting mode, the switches can be set one by one as if they were real physical switches. At the end of the setting procedure, a checksum for the whole switchgroup is shown. The checksum can be used for verifying that the switches have been properly set. Fig. 2 shows an example of a manual checksum calculation.

When the checksum calculated according to the example equals the checksum indicated on the display of the relay module, the switches in the concerned switchgroup are properly set.

Switch No	Pos.		Weigth		Value
1	1	x	1	=	1
2	0	x	2	=	0
3	1	x	4	=	4
4	1	x	8	=	8
5	1	x	16	=	16
6	0	x	32	=	0
7	1	x	64	=	64
8	0	x	128	=	0
	Checksum		Σ	=	93

Fig. 2. Example of calculating the checksum of a selector switchgroup SG_.

The functions of the selector switches of the different protection relay modules are described in detail in the manuals of the different relay modules.

Settings

Most of the start values and operate times are set by means of the display and the push buttons on the front panel of the relay modules. Each setting has its related indicator which is lit when the concerned setting value is shown on the display.

In addition to the main stack of setting values most D type relay modules allow a second stack of settings. Switching between the main settings and the second settings can be done in three different ways:

1) By command V150 over the serial communication bus
2) By an external control signal BS1, BS2 or RRES (BS3)
3) Via the push-buttons of the relay module, see submenu 4 of register A.

Setting mode

Generally, when a large number of settings is to be altered, e.g. during commissioning of relay systems, it is recommended that the relay settings are entered with the keyboard of a personal computer provided with the necessary software. When no computer nor software is available or when only a few setting values need to be altered the procedure described below is used.

The registers of the main menu and the submenus contain all parameters that can be set. The settings are made in the so called setting mode, which is accessible from the main menu or a submenu by pressing the PROGRAM push button, until the whole display starts flashing. This position indicates the value of the parameter before it has been altered. By pressing the PROGRAM push button the programming sequence moves forward one step. First the rightmost digit starts flashing while the rest of the display is steady. The flashing digit is set by means of the STEP push button. The flashing cursor is moved on from digit to digit by pressing the PROGRAM push button and in each stop the setting is performed with the STEP push button. After the parameter values have been set, the decimal point is put in place. At the end the position with the whole display flashing is reached again and the data is ready to be stored.

A set value is recorded in the memory by pressing the push buttons STEP and PROGRAM simultaneously. Until the new value has been recorded a return from the setting mode will have no effect on the setting and the former value will still be valid. Furthermore *any attempt to make a setting outside the permitted limits for a particular parameter will cause the new value to be disqualified and the former value will be maintained.* Return from the setting mode to the main menu or a submenu is possible by pressing the PROGRAM push button until the green digits on the display stop flashing.

NOTE! During any local man-machine communication over the push buttons and the display on the front panel a five minute time-out function is active. Thus, if no push button has been pressed during the last five minutes, the relay returns to its normal state automatically. This means that the display turns dark, the relay escapes from a display mode, a programming routine or any routine going on, when the relay is left untouched. This is a convenient way out of any situation when the user does not know what to do.

Before a relay module is inserted into the relay case, one must assure that the module has been given the correct settings. If there however is any doubt about the settings of the module to be inserted, the setting values should be read using a spare relay unit or with the relay trip circuits disconnected. If this cannot be done the relay can be sett into a non-tripping mode by pressing the PROGRAM push button and powering up the relay module simultaneously. The display will show three dashes "- - -" to indicate the non-tripping mode. The serial communication is operative and all main and submenues are accessible. In the non-tripping mode unnecessary trippings are avoided and the settings can be checked. *The normal protection relay mode is entered automatically after a timeout of five minutes or ten seconds after the dark display position of the main menu has been entered.*

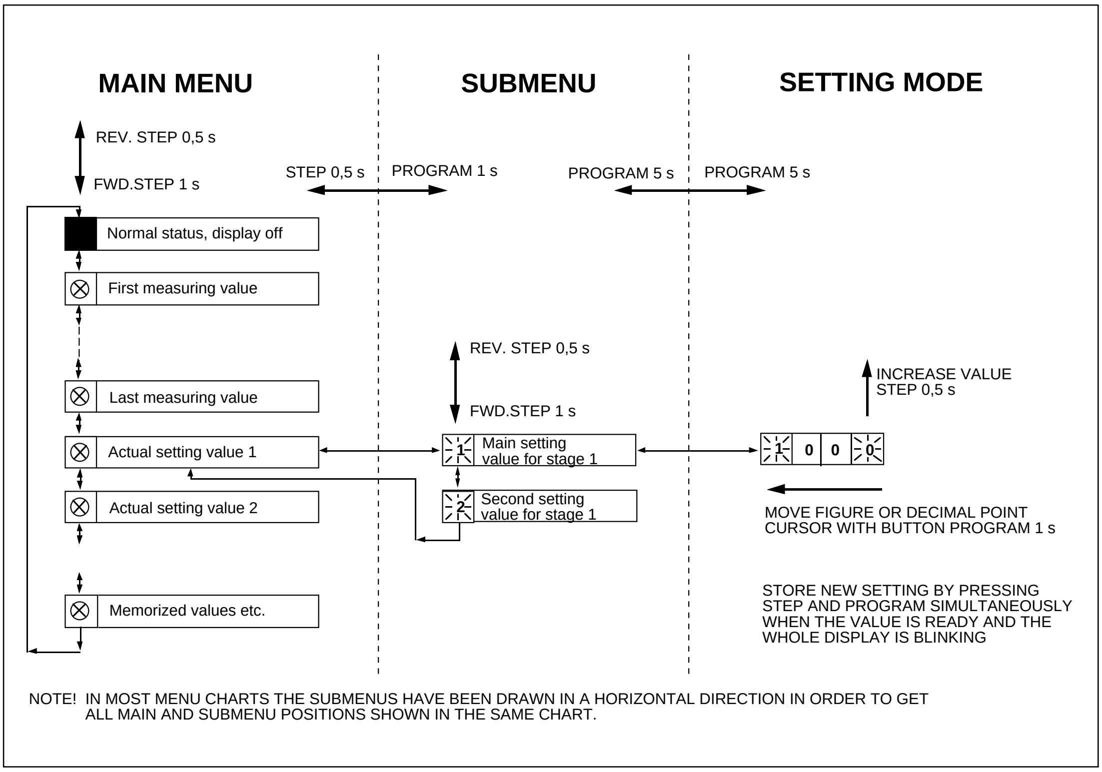


Fig.3. Basic principles of entering the main menus and submenus of a relay module.

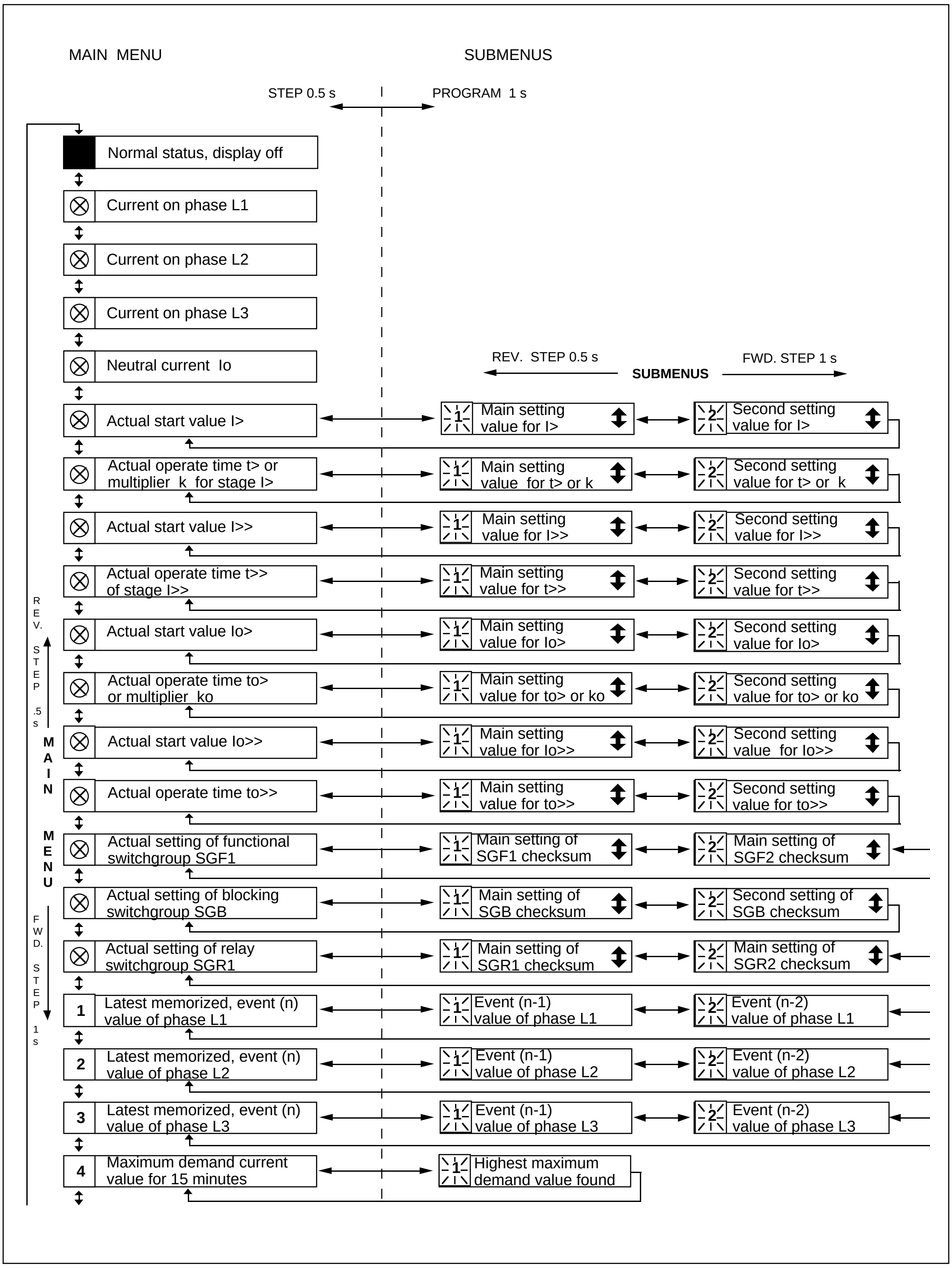
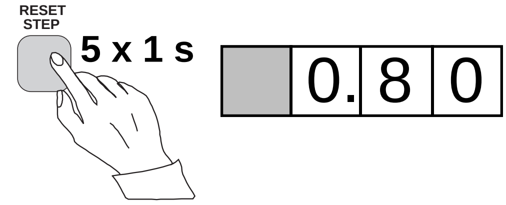


Fig. 4. Example of part of the main and submenus for the settings of the overcurrent and earth-fault relay module SPCJ 4D29. The settings currently in use are in the main manu and they are displayed by pressing the STEP push button. The main menu also includes the measured current values, the registers 1...9, 0 and A. The main and second setting values are located in the submenus and are called up on the display with the PROGRAM push button.

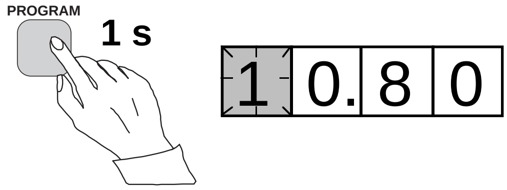
Example 1

Operation in the setting mode. Manual setting of the main setting of the start current value I> of an overcurrent relay module. The initial value for the main setting is 0.80 x I_n and for the second setting 1.00 x I_n. The desired main start value is 1.05 x I_n.

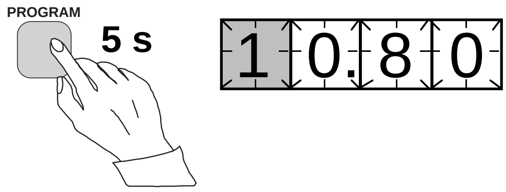
a)
Press push button STEP repeatedly until the LED close to the I> symbol is lit and the current start value appears on the display.



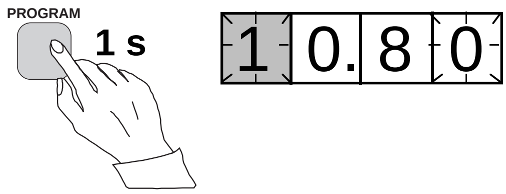
b)
Enter the submenu to get the main setting value by pressing the PROGRAM push button more than one second and then releasing it. The red display digit now shows a flashing number 1, indicating the first submenu position and the green digits show the set value.



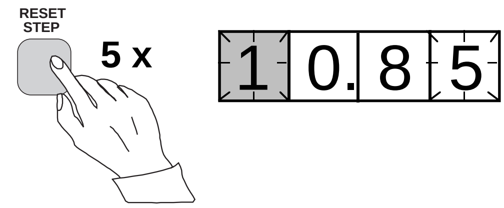
c)
Enter the setting mode by pressing the PROGRAM push button for five seconds until the display starts flashing.



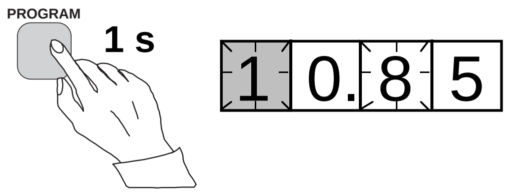
d)
Press the PROGRAM push button once again for one second to get the rightmost digit flashing.



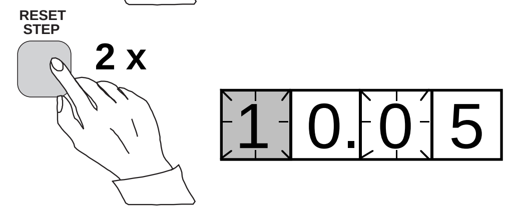
e)
Now the flashing digit can be altered. Use the STEP push button to set the digit to the desired value.



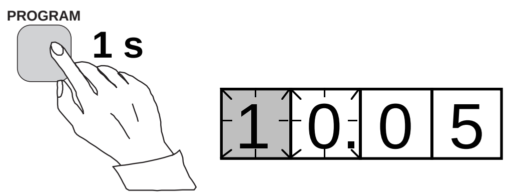
f)
Press the PROGRAM push button to make the middle one of the green digits flash.



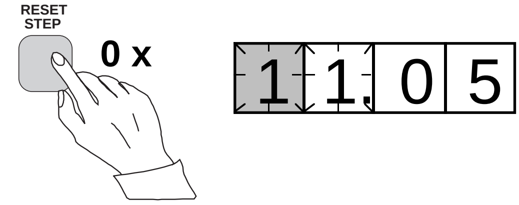
g)
Set the middle digit with of the STEP push button.



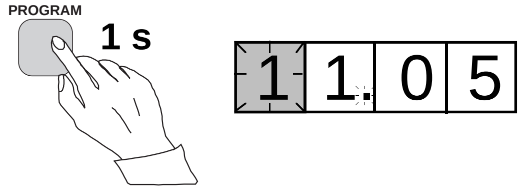
h)
Press the PROGRAM push button to make the leftmost green digit flash.



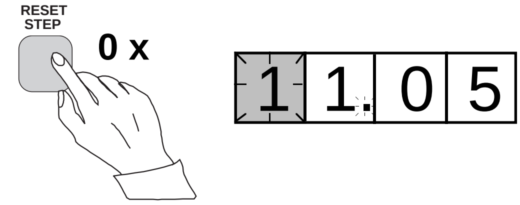
i)
Set the digit with the STEP push button.



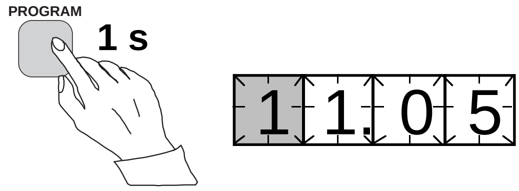
j)
Press the PROGRAM push button to make the decimal point flash.



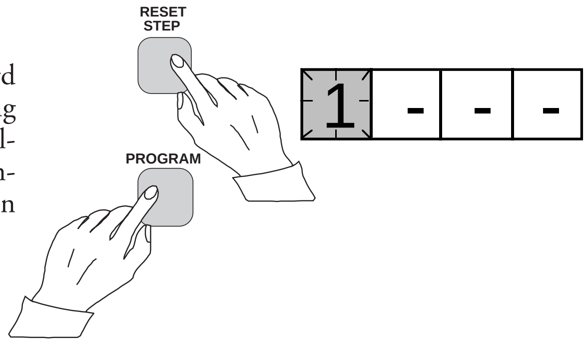
k)
If needed, move the decimal point with the STEP push button.



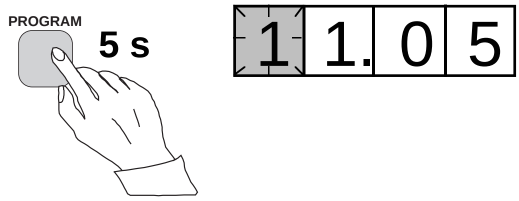
l)
Press the PROGRAM push button to make the whole display flash. In this position, corresponding to position c) above, one can see the new value before it is recorded. If the value needs changing, use the PROGRAM push button to alter the value.



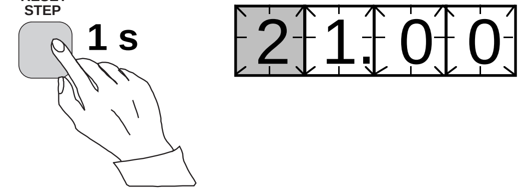
m)
When the new value has been corrected, record it in the memory of the relay module by pressing the PROGRAM and STEP push buttons simultaneously. At the moment the information enters the memory, the green dashes flash once in the display, i.e. 1 - - -.



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



o)
If the second setting is to be altered, enter submenu position 2 of the setting I> by pressing the STEP push button for approx. one second. The flashing position indicator 1 will then be replaced by a flashing number 2 which indicates that the setting shown on the display is the second setting for I>.

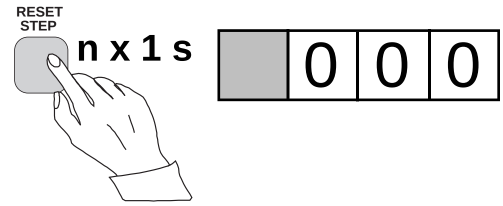


Enter the setting mode as in step c) and proceed in the same way. After recording of the requested values return to the main menu is obtained by pressing the STEP push button until the first digit is switched off. The LED still shows that one is in the I> position and the display shows the new setting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

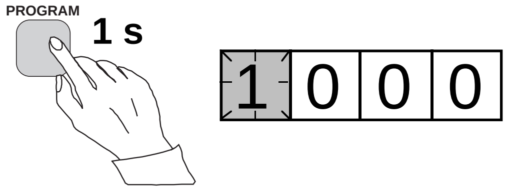
Example 2

Operation in the setting mode. Manual setting of the main setting of the checksum for the switchgroup SGF1 of a relay module. The initial value for the checksum is 000 and the switches SGF1/1and SGF1/3 are to be set in position 1. This means that a checksum of 005 should be the final result.

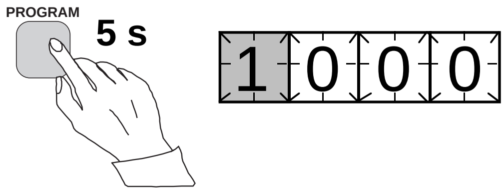
a)
Press push button STEP until the LED close to the SGF symbol is lit and the checksum appears on the display.



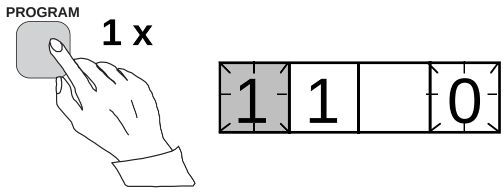
b)
Enter the submenu to get the main checksum of SGF1 by pressing the PROGRAM push button for more than one second and then releasing it. The red display now shows a flashing number 1 indicating the first submenu position and the green digits show the checksum.



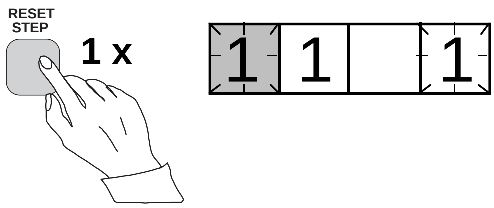
c)
Enter the setting mode by pressing the PROGRAM push button for five seconds until the display starts flashing.



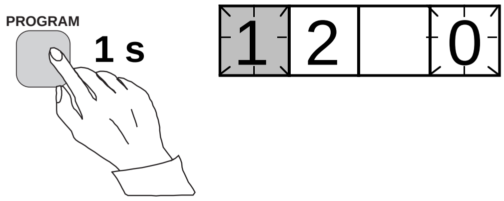
d)
Press the PROGRAM push button once again to get the first switch position. The first digit of the display now shows the switch number. The position of the switch is shown by the rightmost digit.



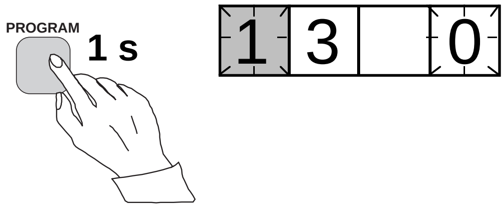
e)
The switch position can now be toggled between 1 and 0 by means of the STEP push button and it is left in the requested position 1.



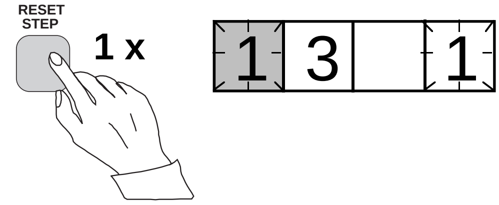
f)
When switch number 1 is in the requested position, switch number 2 is called up by pressing the PROGRAM push button for one second. As in step e), the switch position can be altered by using the STEP push button. As the desired setting for SGF1/2 is 0 the switch is left in the 0 position.



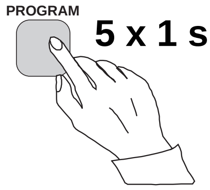
g)
Switch SGF1/3 is called up as in step f) by pressing the PROGRAM push button for about one second.



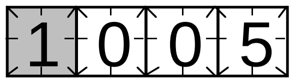
h)
The switch position is altered to the desired position 1 by pressing the STEP push button once.



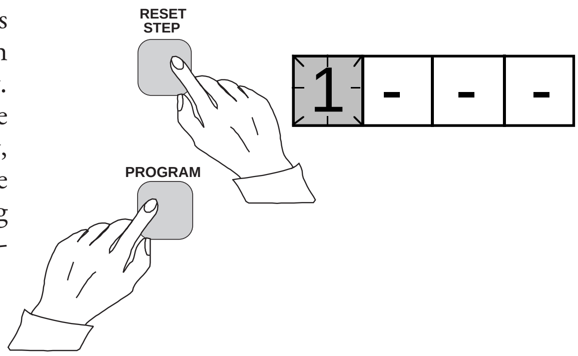
i)
Using the same procedure the switches SGF 1/ 4...8 are called up and, according to the example, left in position 0.



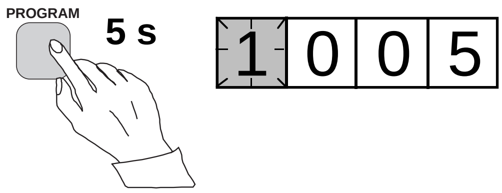
j)
In the final setting mode position, corresponding to step c), the checksum based on the set switch positions is shown.



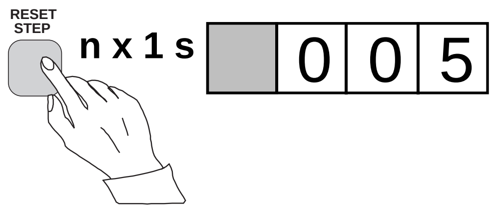
k)
If the correct checksum has been obtained, it is recorded in the memory by pressing the push buttons PROGRAM and STEP simultaneously. At the moment the information enters the memory, the green dashes flash in the display, i.e.1 - - -. If the checksum is incorrect, the setting of the separate switches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



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



m)
After recording the desired values return to the main menu is obtained by pressing the STEP push button until the first digit is turned off. The LED indicator SGF still shows that one is in the SGF position and that the display shows the new checksum for SGF1 currently in use by the relay module.



Recorded information

The parameter values measured at the moment when a fault occurs or at the trip instant are recorded in the registers. The recorded data, except for some parameters, are set to zero by pressing the push buttons STEP and PROGRAM simultaneously. The data in normal registers are erased if the auxiliary voltage supply to the relay is interrupted, only the set values and certain other essential parameters are maintained in non-volatile registers during a voltage failure.

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

All D type relay modules are provided with two general registers: register 0 and register A.

Register 0 contains, in coded form, the information about e.g. external blocking signals, status information and other signals. The codes are explained in the manuals of the different relay modules.

Register A contains the address code of the relay modul which is reqiured by the serial communication system.

Submenu 1 of register A contains the data transfer rate value, expressed in kilobaud, of the serial communication.

Submenu 2 of register A contains a bus communication monitor for the SPAbus. If the protection relay, which contains the relay module, is linked to a system including a contol data communicatoe, for instance SRIO 1000M and the data communication system is operating, the counter reading of the monitor will be zero. Otherwise the digits 1...255 are continuously scrolling in the monitor.

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

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

In order to secure the setting values, all settings are recorded in two separate memory banks within the non-volatile memory. Each bank is complete with its own checksum test to verify the condition of the memory contents. If, for some reason, the contents of one bank is disturbed, all settings are taken from the other bank and the contents from here is transferred to the faulty memory region, all while the relay is in full operation condition. If both memory banks are simultaneously damaged the relay will be be set out of operation, and an alarm signal will be given over the serial port and the IRF output relay

Trip test function

Register 0 also provides access to a trip test function, which allows the output signals of the relay module to be activated one by one. If the auxiliary relay module of the protection assembly is in place, the auxiliary relays then will operate one by one during the testing.

When pressing the PROGRAM push button for about five seconds, the green digits to the right start flashing indicating that the relay module is in the test position. The indicators of the settings indicate by flashing which output signal can be activated. The required output function is selected by pressing the PROGRAM push button for about one second.

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

Setting I>	Starting of stage I>
Setting t>	Tripping of stage I>
Setting I>>	Starting of stage I>>
Setting t>>	Tripping of stage I>>
etc.	
No indication	Self-supervision IRF

The selected starting or tripping is activated by simultaneous pressing of the push buttons STEP and PROGRAM. The signal remains activated as long as the two push butttons are pressed. The effect on the output relays depends on the configuration of the output relay matrix switches.

The self-supervision output is activated by pressing the STEP push button 1 second when no setting indicator is flashing. The IRF output is activated in about 1 second after pressing of the STEP push button.

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

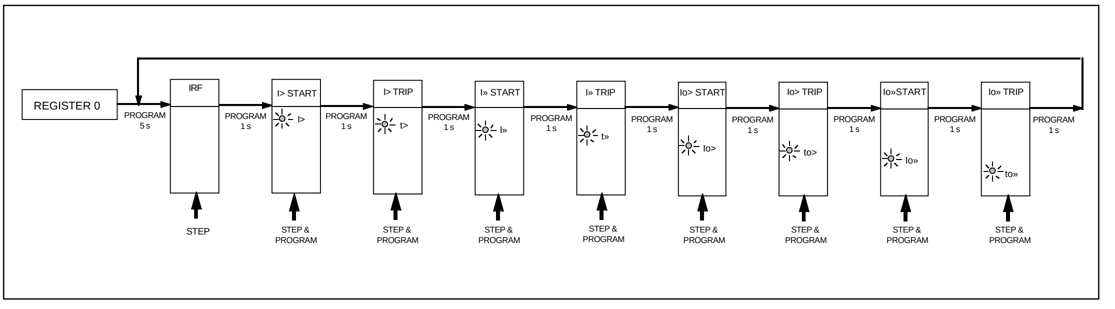


Fig. 5. Sequence order for the selection of output signals in the Trip test mode

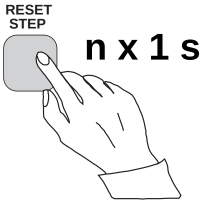
If, for instance, the indicator of the setting t> is flashing, and the push buttons STEP and PROGRAM are being pressed, the trip signal from the low-set overcurrent stage is activated. Return to the main menu is possible at any stage of the trip test sequence scheme, by pressing the PROGRAM push button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

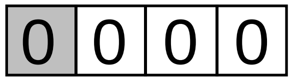
Note!
The effect on the output relays then depends on the configuration of the output relay matrix switchgroups SGR 1...3.

Example 3

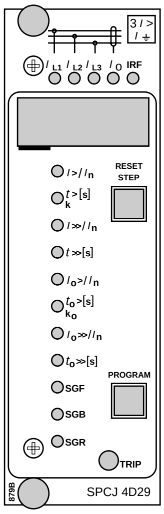
Trip test function. Forced activation of the outputs.

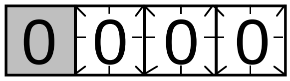
a)
Step forward on the display to register 0.

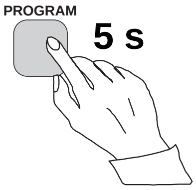




b)
Press the PROGRAM push button for about five seconds until the three green digits to the right.

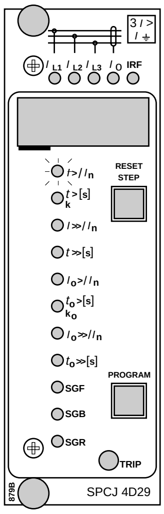


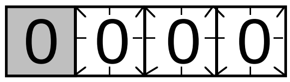




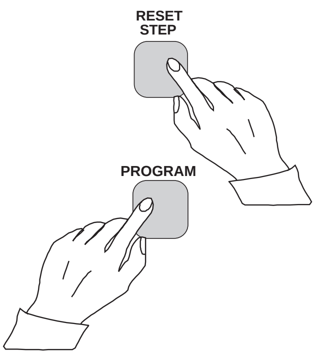
c)
Hold down the STEP push button. After one second the red IRF indicator is lit and the IRF output is activated. When the step push button is released the IRF indicator is switched off and the IRF output resets.

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

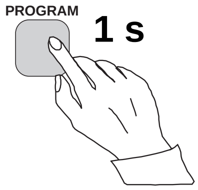


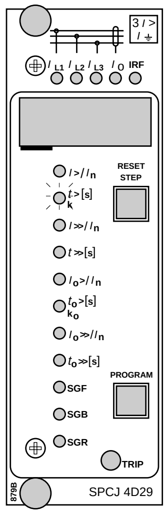


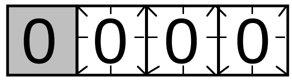
e)
If a start of the first stage is required, now press the push-buttons PROGRAM and STEP simultaneously. The stage output will be activated and the output relays will operate according to the actual programming of the relay output switchgroups SGR.



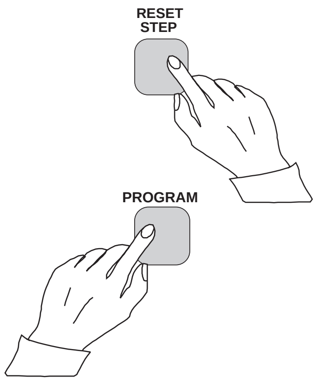
f)
To proceed to the next position press the PROGRAM push button for about 1 second until the indicator of the second setting starts flashing.

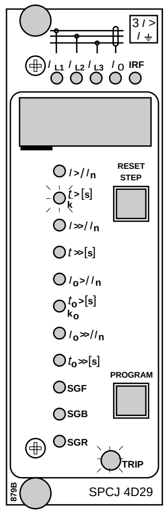


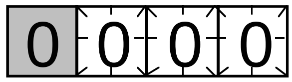




g)
Press the push buttons PROGRAM and STEP simultaneously to activate tripping of stage 1 (e.g. the I> stage of the overcurrent module SPCJ 4D29). The output relays will operate according to the actual programming of the relay switchgroups SGR. If the main trip relay is operated the trip indicator of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







h)
The starting and tripping of the remaining stages are activated in the same way as the first stage above. The indicator of the corresponding setting starts flashing to indicate that the concerned stage can be activated by pressing the STEP and PROGRAM buttons simultaneously. For any forced stage operation, the output relays will respond according to the setting of the relay output switchgroups SGR. Any time a certain stage is selected that is not wanted to operate, pressing the PROGRAM button once more will pass by this position and move to the next one without carrying out any operation of the selected stage.

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

Operation indication

A relay module is provided with a multiple of separate operation stages, each with its own operation indicator shown on the display and a common trip indicator on the lower part of the front plate of the relay module.

The starting of a relay stage is indicated with one number which changes to another number when the stage operates. The indicator remains glowing although the operation stage resets. The indicator is reset by means of the RESET push button of the relay module. An unreset operation indicator does not affect the function of the protection relay module.

In certain cases the function of the operation indicators may deviate from the above principles. This is described in detail in the descriptions of the separate modules.

Fault codes

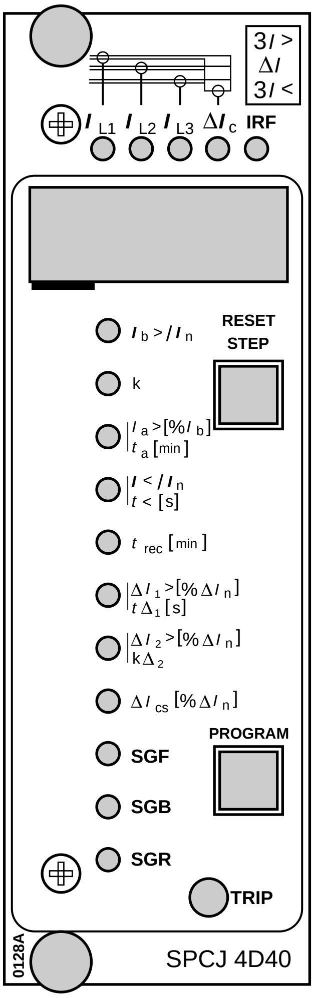
In addition to the protection functions the relay module is provided with a self-supervision system which continuously supervises the function of the microprocessor, its program execution and the electronics.

Shortly after the self-supervision system detects a permanent fault in the relay module, the red IRF indicator on the front panel is lit . At the same time the module puts forward a control signal to the output relay of the self-supervision system of the protection relay.

In most fault situations a fault code, indicating the nature of the fault, appears on the display of the module. The fault code, which consists of a red figure "1" and a three digit green code number, cannot be removed from the display by resetting. When a fault occurs, the fault code should be recorded and stated when service is ordered. When in a fault mode, the normal relay menus are operative, i.e. all setting values and measured values can be accessed although the relay operation is inhibited. The serial communication is also operative making it possible to access the relay information also from a remote site. The internal relay fault code shown on the display remains active until the internal fault possibly disappears and can also be remotely read out as variable V 169.

SPCJ 4D40
Capacitor relay module

User´s manual and Technical description



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SPCJ 4D40
Capacitor bank protection relay module

Contents

Characteristics

Two overload stages I_b> and I_a>. Stage I_b>: setting range 0.30...1.50 x I_n, based on inverse time characteristic, setting range 0.2...2.0 for time multiplier k. Stage I_a>: setting range 80...120 % I_b, based on definite time characteristic, operating time 0.5...100 min

Two phase unbalance protection stage ΔI_1> and stage ΔI_2>. Stage ΔI_1>: setting range 1.0...100 % ΔI_n, based on definite time characteristic, operating time 1.0...300 s. Stage ΔI_2>: setting range 2.0...80 % ΔI_n, based on an inverse time characteristic, setting range 0.1...1.0 for time multiplier $k\Delta_2$

Undercurrent protection I< for detection of capacitor disconnection, setting range 0.10... 0.70 x I_n. I< operates with a definite time characteristic, range 1.0...100 s. Reconnection time setting t_{rec} for complete capacitor discharging is 0.5...100 min

Compensation for natural unbalance current within the setting 0...20 % ΔI_n

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

All settings may be keyed in using the push-buttons of the front panel or they may be set using a personal computer

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

Description of function

(modified 97-10)

Overload unit

The purpose of the overload unit is to protect the capacitor bank against overload and harmonic currents. The faults that may occur are normally caused by overvoltages that may lead to dielectric breakdown, i.e. short-circuit in an capacitor element.

The phase currents I_{L1}, I_{L2} and I_{L3} are filtered with a damp factor directly proportional to the frequency. Thus the input signals used will be directly proportional to the voltage over the capacitor. The peak values, including harmonics, are calculated from the input signals.

According to the standards (IEC 70) a high voltage capacitor shall be able to withstand 10 % overload. This margin should be used only in fault situations and during such operating conditions which continue for a few days only.

The overload unit is designed for single-phase, two phase or three-phase operation. It contains two overload stages; I_a> and I_b>.

Note!
If the phase unbalance unit is used with compensation the phase input I_{L1} must be connected.

If the current on one of the phases exceeds the setting value of the stage I_a>, the stage starts and a timer ta is started. If the overload period exceeds the set operating time, the stage provides an alarm signal. At the same time the display shows the red figure 1.

If the current on one of the phases exceeds the setting value of stage I_b> by 10%, the stage starts and a timer is started. Simultaneously it provides a starting signal and the digital display on the front panel indicates starting with the red figure 2. The operation time depends on two factors, the degree of overload and the inverse time multiplier k. If the overload situation lasts long enough to exceed the operating time, the stage calls for CB tripping by providing a tripping signal. At the same time the operation indicator goes on with a red light and the display shows the red figure 3. The indicators are reset with the RESET push-button.

The operation of both overload stages can be blocked by bringing a blocking signal BS1, BS2 or RRES to the unit. The blocking configuration is set by means of switchgroups SGB1...3.

The starting setting range of the overload stage I_b> is 0.30...1.50 x I_n. The operation of stage I_b> is based on an inverse time characteristic. The inverse curve is using an ANSI-curve for time/current characteristics.

The starting setting range of the overload stage I_a> is 80...120% I_b>. The operating time ta> of the stage is set separately within the range 0.5...100 min.

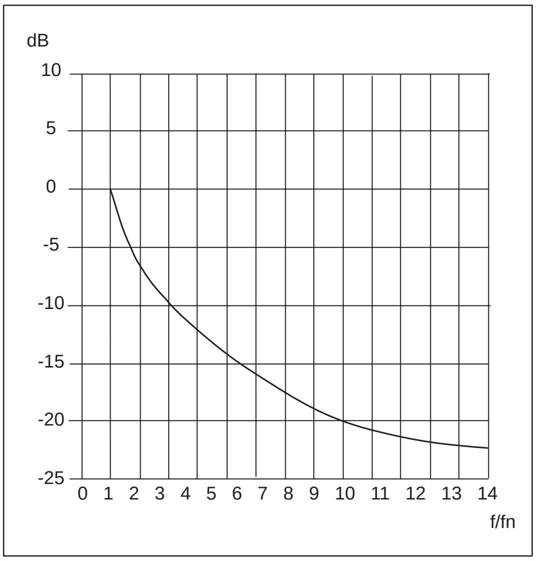


Fig.1. Filtercharacteristic for filtered phase current inputs I_{L1}, I_{L2} and I_{L3}.

The operation of overload stage I_b> is provided with a latching facility (SGB1/6) keeping the tripping output energized, although the signal which caused the operation disappears. The output relays may be reset in five different ways; a) by pressing the PROGRAM push-button, b) by pressing the RESET and PROGRAM push-buttons simultaneously, by remote control over the SPA bus using c) the command V101 or δ) the command V102 and further e) by remote control over the external control input. When resetting according to a) or c) no stored data will be erased, but when resetting according to b), d) or e) the recorded data will be erased.

Undercurrent unit

The undercurrent unit is intended to be used for the detection of capacitor disconnection. With loss of voltage in the feeding bus the capacitor has to be disconnected from the system to prevent reapplication of the voltage of the capacitors before they are fully discharged.

The relay includes a timer (t_{rec}), that blocks the breaker reclosing until the capacitor bank is discharged to an acceptable level for switching in. The discharge time set value (t_{rec}) must be sufficient to prevent reclosing before the capacitor bank voltage is discharged down to 10% of the rated voltage. After a loss of auxiliary supply or whenever powered up, the timer t_{rec} is always started to ensure that the relay will not reclose the breaker until the capacitor bank is discharged to an acceptable level. The operation indicator 8 is lit when t_{rec} is running.

The stage starts if all the three phase currents falls below the set level. If the undercurrent condition persists for a time longer than the set operating time t<, the unit calls for CB tripping by providing a tripping signal. At the same time the operation indicator is lit with red light and the display shows a red figure 7. The red operation indicators remain lit although the stage resets. The indicators are reset with the RESET push-button.

The starting current setting range of the stage is 0.10...0.70 x I_n. The operating time t< is set within the range 1.0...100 s.

Phase unbalance unit

The purpose of the unbalance protection is to disconnect a faulty bank to prevent any unit from being exposed to more than 10% overvoltage. The protection for capacitor units with internal fuses can be made with a very high degree of sensitivity, due to the two stage unbalance protection and compensation facility for natural unbalance.

In the unbalance unit the harmonics are suppressed. The frequency is 50 or 60 Hz.

The phase current unbalance unit includes two protection stages; ΔI_1> and ΔI_2>.

If the compensated phase unbalance current ΔI_c exceeds the setting value of the stage ΔI_1>, the stage starts and a timer $t_{\Delta I}$ is started. If the phase unbalance situation lasts long enough to exceed the set operating time, the stage provides an alarm signal. At the same time the display shows the red figure 4.

If the compensated phase unbalance current ΔI_c exceeds the setting value of the stage ΔI_2>, the stage starts and a timer is started. Simultaneously it provides a starting signal and the digital display on the front panel indicates starting with the red figure 5. The operation time depends on the degree of unbalance and the inverse time multiplier $k_{\Delta 2}$. If the phase unbalance situation lasts long enough to exceed the operating time, the stage calls for CB tripping by providing a tripping signal. At the same time the operation indicator goes on with a red light and the display shows the red figure 6. The indicators are reset with the RESET push-button.

The operation of both phase unbalance stages can be blocked by bringing a blocking signal BS1, BS2 or RRES to the unit. The blocking configuration is set by means of switchgroups SGB1...3.

The starting setting range of the stage ΔI_1> is 1.0...100% ΔI_n. The operating time $t_{\Delta 1}$ of the stage is set separately within the range 1.0...300 s.

The starting setting range of the stage ΔI_2> is 2.0...80% ΔI_n. The operation of stage ΔI_2> is based on an inverse time characteristic. The inverse curve has similar gradient as normal inverse. It is possible to increase the inverse characteristic time with a factor 10 by setting SGF/6 to position 1.

The operation of phase unbalance stage ΔI_2> is provided with a latching facility (SGB1/7) keeping the tripping output energized, although the signal which caused the operation disappears. The output relays may be reset in five different ways; a) by pressing the PROGRAM push-button, b) by pressing the RESET and PROGRAM push-buttons simultaneously, by remote control over the SPA bus using c) the command V101 or d) the command V102 and further e) by remote control over the external control input. When resetting according to a) or c) no stored data are erased, but when resetting according to b), d) or e) the recorded data will be erased.

When phase current I_{L1} is under 0.06 x I_n and the setting value ΔI_{cs} is different from 0% ΔI_n the phase unbalance unit is inert (ΔI_c displayed as n - - -).

Compensation for natural unbalance	Usually there are some natural unbalance in a three phase reactive compensation capacitor bank. An unbalance compensation facility has therefore been implemented in the protective relay. A compensation setting area from 0 to 20.0% ΔI_n is used. The capacitor bank natural unbalance current is compensated for both amplitude and phase angle. Phase current input I_{L1} is used as synchronizing input for the compensation.	

Block diagram

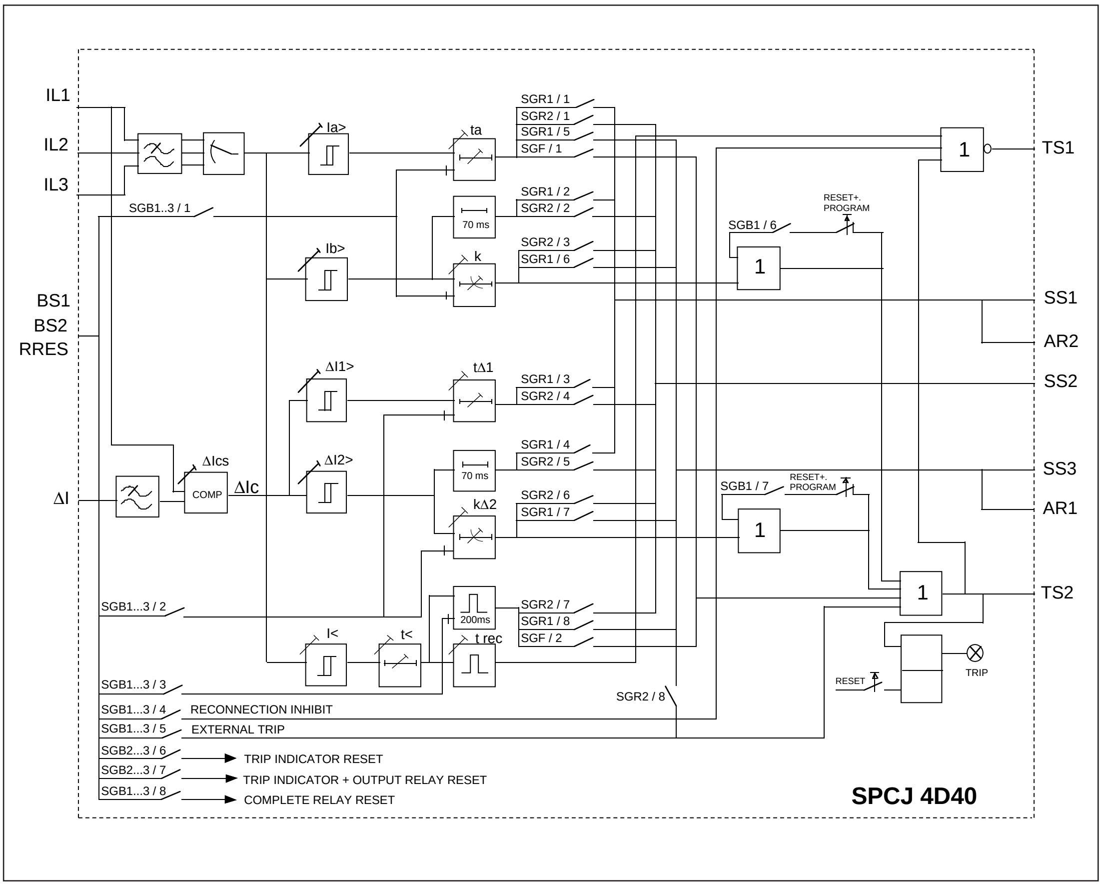


Fig 2. Block diagram for capacitor bank module type SPCJ 4D40

I_{L1}, I_{L2}, I_{L3}	Measured phase currents
ΔI	Measured phase unbalance
ΔI_c	Compensated phase unbalance
BS1, BS2 and RRES	External blocking or resetting signals
SGF, SGB1...3 and SGR1...2	Programming switchgroups
SS1...SS3, TS1...TS2	Output signals
TRIP	Red trip indicator

Front panel

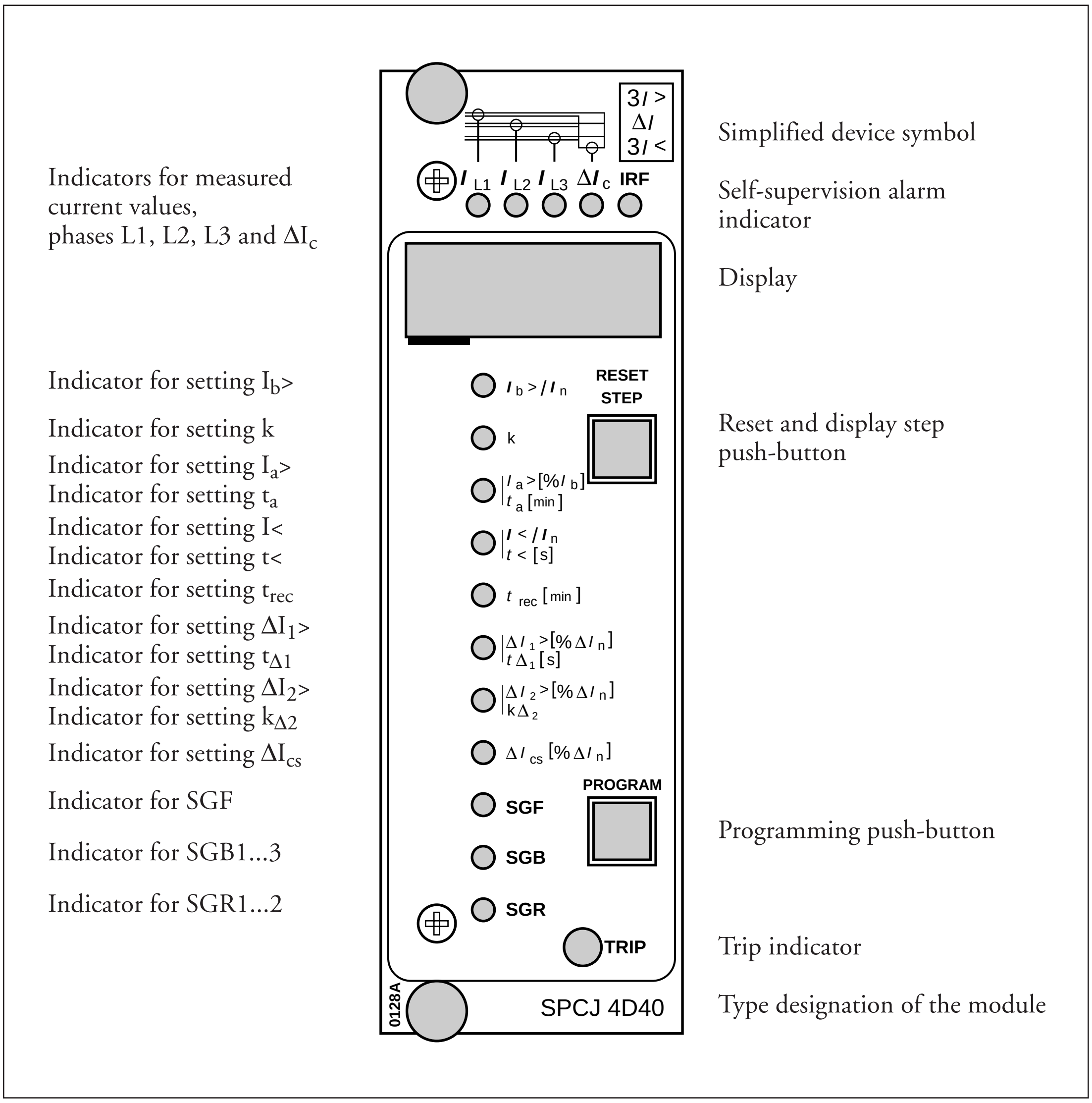


Fig 3. Front panel of the capacitor bank module type SPCJ 4D40

Operation indicators

Each stage has its own operation indicator shown as a red figure to the left in the digital display. Further, all stages have a common indicator named "TRIP"; a red led indicates that the module has delivered a tripping signal.

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

If start of a stage does not last long enough to cause a trip, the start indication on the display is normally self-reset when the stage is reset. If needed, the start indicators can be given a latching function by means of switches SGF/3...4.

The following table shows the start and trip indicators on the display and their meanings.

Indication	Explanation	
1	I_a> alarm	= The overload stage I_a> has given an alarm
2	I_b> start	= The overload stage I_b> has started
3	I_b> trip	= The overload stage I_b> has tripped
4	ΔI_1> alarm	= Stage ΔI_1> has given an alarm
5	ΔI_2> start	= Stage ΔI_2> has started
6	ΔI_2> trip	= Stage ΔI_2> has tripped
7	I< operation	= Stage I< has operated
8	t_{rec}	= Reconnection inhibit is active, indication is self-reset
9	EXT.TRIP	= A trip from an external relay has been carried out via the relay

The self-supervision alarm indicator IRF indicates that the self-supervision system has detected a permanent fault. The indicator is lit with red light about 1 minute after the fault has been detected. At the same time the plug-in module delivers a signal to the self-supervision system output relay of the protection assembly. Additionally, in most cases, a fault code showing the nature of the fault appears on the display of the module. The fault code, consists of a red figure one and a green code number, cannot be erased from the display of the module by resetting. When a fault occurs, the fault code should be recorded and stated when service, is ordered.

Settings

The setting values are shown by the right-most three digits of the display. A lit indicator close to a setting value symbol shows which setting value is indicated on the display.

Setting	Parameter	Setting range	Factory setting
I_b>	The starting value of the overload stage I_b> as a multiple of the rated current of the protection.	0.30...1.50 x I_n	0.40 x I_n
k	Inverse time multiplier k (k= 1.00 = ANSI-curve).	0.2...2.0	0.2
I_a>	The starting value of the overload stage I_a> in per cent of the setting value I_b>.	80...120% I_b>	80% I_b>
ta	The operating time of the Ia> stage, expressed in minutes, based on definite time mode of operation.	0.50...100 min	0.5 min
I<	The starting value of the undercurrent stage I< as a multiple of the rated current of the protection.	0.10...0.70 x I_n	0.10 x I_n
t<	The operating time of the I< stage, expressed in seconds.	1.0...100 s	1 s
t_{rec}	Setting of reconnection inhibit time, expressed in minutes.	0.50...100 min	100 min
ΔI_1>	Setting ΔI_1> for the unbalance protection in per cent of ΔI_n.	1.0...100% ΔI_n	1% ΔI_n
$t_{\Delta 1}$	The operating time of the ΔI_1> stage, expressed in seconds.	1.0...300 s	1 s
ΔI_2>	Setting ΔI_2> for the unbalance protection in per cent of ΔI_n.	2.0...80.0%ΔI_n	2.0% ΔI_n
$k_{\Delta 2}$	Inverse time multiplier $k_{\Delta 2}$ for the stage ΔI_2>.	0.1...1.0	0.1
ΔI_{cs}	Setting ΔI_{cs} for the unbalance compensation in per cent of ΔI_n.	0.0...20.0%ΔI_n	0% ΔI_n
	Note! If a setting for ΔI_{cs} greater than ΔI is stored, the module will automatically store ΔI amplitude to setting ΔI_{cs}.		

Further the checksums of the programming switchgroups SGF, SGB1...3 and SGR1...2 are indicated on the display when the indicators adjacent to the switchgroup symbols on the front panel are illuminated. An example of calculating the checksum is given in the general description of the D-type SPC relay modules.

Programming switches

Additional functions required by individual applications are selected by means of the switchgroups SGF, SGB1...3 and SGR1...3 indicated on the front panel. The numbering of the switches, 1...8, and the switch positions, 0 and 1, are indicated when the switchgroups are being set. In normal service only the checksums are shown.

Functional switchgroup SGF/1 to SGF/8

Switch	Function	Factory setting
SGF/1	The overload stage I_a> can be linked to tripping relay TS2 by means of this switch When SGF/1=0, the overload stage I_a> is not linked to TS2 When SGF/1=1, the overload stage I_a> is linked to TS2	0
SGF/2	The undercurrent stage I< can be linked to tripping relay TS2 by means of this switch When SGF/2=0 the undercurrent stage I< is not linked to TS2 When SGF/2=1 the undercurrent stage I< is linked to TS2	0
SGF/3 SGF/4	Switches SGF/3...4 are used for selecting the mode of operation of the start indicators of the different stages. When the switches are in position 0 the start indicators are all automatically reset when the fault is cleared. In order to get a hand reset start indication for the stages, their respective switches have to be in position 1: When SGF/3=1, the start indicator of the overload stage I_b> is to be manually reset When SGF/4=1, the start indicator of the unbalance stage ΔI_2> is to be manually reset	0 0
SGF/5	The reconnection inhibit output can be disabled by means of this switch Note! This switch is only to be used if the module SPCJ 4D40 is used elsewere than in SPAJ 160 C. When SGF/5=0, the reconnection inhibit relay is in use When SGF/5=1, the reconnection inhibit relay is disabled	0
SGF/6	Increase the inverse time characteristic for phase unbalance stage ΔI_2> by a factor 10. When SGF/6 = 1 increase the inverse time by a factor 10. This feature has been implemented from the program version 081 C and later versions.	0
SGF/7	Reserved for future use	0
SGF/8	Reserved for future use	0

Blocking or control input switchgroups SGB1, SGB2 and SGB3

Switch	Function	Factory setting
SGB1/1 SGB1/2 SGB1/3	Switches SGB1/1...3 are used when the external control signal BS1 is to be used for blocking one or more of the current stages of the module. When all the switches are in position 0 no stage is blocked When SGB1/1=1, the tripping of overload stages I_b> and I_a> are blocked by the input signal BS1. When SGB 1/2=1, the tripping of phase unbalance stages ΔI_1> and ΔI_2> are blocked by the input signal BS1 When SGB1/3=1, the tripping of undercurrent stage I< is blocked by the input signal BS1.	0 0 0
SGB1/4	External control of reconnection inhibit output using the input signal BS1 When SGB1/4=0, the external control is disabled. When SGB1/4=1, the external control is enabled.	0
SGB1/5	When SGB1/5=1, the external trip command is carried out to output relay A. External protective relays can be connected to the trip path using this feature. Note! The trip signalling is not handled by the SPCJ-module and must be arranged using a contact on the external protective relay.	0
SGB1/6	Latching function for the trip signal TS2 of overload stage I_b> When SGB1/6=0, the trip signal returns to its initial state, i.e. the output relay drops off, when the measuring signal causing the operation falls below the starting level. When SGB1/6=1, the trip signal remains on, i.e. the output relay operates although the measuring signal falls below the starting level. Then the trip signal of overload stage I_b> must be resetted by pressing the RESET and PROGRAM push-buttons simultaneously. (also by signal BS1. Note switch SGB1/8). When the display is off the signals can also be resetted by pressing only PROGRAM.	0
SGB1/7	Latching function for the trip signal TS2 of unbalance stage ΔI_2> When SGB1/7=0, the trip signal returns to its initial state, i.e. the output relay drops off, when the measuring signal causing the operation falls below the starting level. When SGB1/7=1, the trip signal remains on, i.e. the output relay operated although the measuring signal falls below the starting level. Then the trip signal of phase unbalance stage ΔI_2> must be reset by pressing the RESET and PROGRAM push-buttons simultaneously. (also by signal BS1. Note switch SGB1/8). When the display is off the signals can also be reset by pressing only PROGRAM.	0
SGB1/8	When SGB1/8=1, an external relay reset is performed by input signal BS1. This makes it possible to have a manual master reset button outside the relay. The same button can serve all relays in a station. Another possibility is to link the reset to some automation.	0

Switch	Function	Factory setting
SGB2/1 SGB2/2 SGB2/3	Switches SGB2/1...3 are used when the external control signal BS2 is to be used for blocking one or more of the current stages of the module. When all the switches are in position 0 no stage is blocked When SGB2/1=1, the tripping of overload stages $I_b>$ and $I_a>$ are blocked by the input signal BS2. When SGB2/2=1, the tripping of phase unbalance stages $\Delta I_1>$ and $\Delta I_2>$ are blocked by the input signal BS2. When SGB2/3=1, the tripping of undercurrent stage $I<$ is blocked by the input signal BS2.	0 0 0
SGB2/4	External control of reconnection inhibit output using the input signal BS2 When SGB2/4=0, the external control is disabled. When SGB2/4=1, the external control is enabled.	0
SGB2/5	When SGB2/5=1, the external trip command is carried out to output relay A. External protective relays can be connected to the trip path using this feature. Note! The trip signalling is not handled by the SPCJ-module and must be arranged using a contact on the external protective relay.	0
SGB2/6	Remote reset of the trip indicators When SGB2/6=0, the trip indicators are not reset by signal BS2 When SGB2/6=1, the trip indicators are reset by signal BS2	0
SGB2/7	Remote reset of the trip indicators and output relays When SGB2/7=0, the trip indicators and output relays are not reset by signal BS2 When SGB2/7=1, the trip indicators and output relays are reset by signal BS2	0
SGB2/8	When SGB2/8=1, an external relay reset is performed by input signal BS2. This makes it possible to have a manual master reset button outside the relay. The same button can serve all relays on a station. Another possibility is to link the reset to some automation.	0

Switch	Function	Factory setting
SGB3/1 SGB3/2 SGB3/3	Switches SGB3/1...3 are used when the external control signal RRES is to be used for blocking one or more of the current stages of the module. When all the switches are in position 0 no stage is blocked When SGB3/1=1, the tripping of overload stages $I_b>$ and $I_a>$ are blocked by the input signal RRES. When SGB3/2=1, the tripping of phase unbalance stages $\Delta I_1>$ and $\Delta I_2>$ are blocked by the input signal RRES. When SGB3/3=1, the tripping of undercurrent stage $I<$ is blocked by the input signal RRES.	0 0 0
SGB3/4	External control of reconnection inhibit output using the input signal RRES When SGB3/4=0, the external control is disabled. When SGB3/4=1, the external control is enabled.	0
SGB3/5	When SGB3/5=1, the external trip command is carried out to output relay A. External protective relays can be connected to the trip path using this feature. Note! The trip signalling is not handled by the SPCJ-module and must be arranged using a contact on the external protective relay.	0
SGB3/6	Remote reset of the trip indicators When SGB3/6=0, the trip indicators are not reset by signal RRES When SGB3/6=1, the trip indicators are reset by signal RRES	0
SGB3/7	Remote reset of the trip indicators and output relays When SGB3/7=0, the trip indicators and output relays are not reset by signal RRES When SGB3/7=1, the trip indicators and output relays are reset by signal RRES	0
SGB3/8	When SGB3/8=1, an external relay reset is performed by input signal RRES. This makes it possible to have a manual master reset button outside the relay. The same button can serve all relays on a station. Another possibility is to link the reset to some automation.	0

Output relay matrix switchgroups SGR1 and SGR2

Switch	Function	Factory setting
SGR1/1	When SGR1/1=1, the overload stage I_a> alarm output is linked to SS1	0
SGR1/2	When SGR1/2=1, the overload stage I_b> start signal is linked to SS1	0
SGR1/3	When SGR1/3=1, the unbalance stage ΔI_1> alarm signal is linked to SS1	0
SGR1/4	When SGR1/4=1, the unbalance stage ΔI_2> start signal is linked to SS1	1
SGR1/5	When SGR1/5=1, the overload stage I_a> alarm output is linked to SS3	1
SGR1/6	When SGR1/6=1, the overload stage I_b> trip signal is linked to SS3	0
SGR1/7	When SGR1/7=1, the unbalance stage ΔI_2> trip signal is linked to SS3	0
SGR1/8	When SGR1/8=1, the undercurrent I< trip signal is linked to SS3	0

SGR2/1	When SGR2/1=1, the overload stage I_a> alarm output is linked to SS2	0
SGR2/2	When SGR2/2=1, the overload stage I_b> start signal is linked to SS2	1
SGR2/3	When SGR2/3=1, the overload stage I_b> trip signal is linked to SS2	0
SGR2/4	When SGR2/4=1, the unbalance stage ΔI_1> alarm signal is linked to SS2	0
SGR2/5	When SGR2/5=1, the unbalance stage ΔI_2> start signal is linked to SS2	0
SGR2/6	When SGR2/6=1, the unbalance stage ΔI_2> trip signal is linked to SS2	0
SGR2/7	When SGR2/7=1, the undercurrent I< trip signal is linked to SS2	0
SGR2/8	When SGR2/8=1, the external trip is linked to SS3	0

Measured data

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

Note!
A symbol "//" in the text indicates that the following item is found in a submenu.

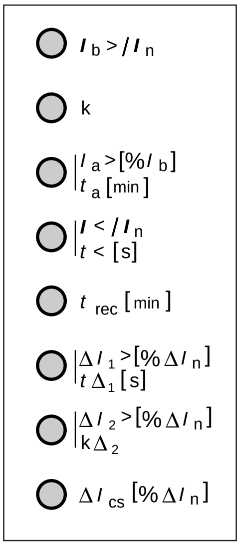
Indicator	Measured data
I_{L1} I_{L2} I_{L3}	Filtered current on phase L1 as a multiple of the rated current I_n Filtered current on phase L2 as a multiple of the rated current I_n Filtered current on phase L3 as a multiple of the rated current I_n Note! The filtered phase currents are proportional to the phase voltages over the capacitor bank.
ΔI_c	Compensated unbalance current ΔI_c as a percentage of unbalance input rated current ΔI_n. // Unbalance current ΔI as a percentage of unbalance input rated current ΔI_n.

Recorded data

When the relay performs a tripping, the current values at the moment of tripping, the duration of the starting for different units and other parameters are stored in a two place memory stack. A new operation moves the old values up to the second place and adds a new value to the first place of the stack consisting of registers 1...9. Two value pairs are memorized - if a third trip occurs, the oldest set of values will be lost. A master reset of the relay erases all the contents of both of the register blocks.

The left-most red digit displays the register address and the other three digits the recorded information.

Register	Recorded information
1	Filtered phase current I_{L1} (n) measured as a multiple of the rated input current I_n of the protective relay. // Event (n-1) value of filtered phase current I_{L1}.
2	Filtered phase current I_{L2} (n) measured as a multiple of the rated input current I_n of the protective relay. // Event (n-1) value of filtered phase current I_{L2}.
3	Filtered phase current I_{L3} (n) measured as a multiple of the rated input current I_n of the protective relay. // Event (n-1) value of filtered phase current I_{L3}.
4	Duration of the latest starting situation (n) of overload stage $I_a>$ as a percentage of the set operating time t_a. When the concerned stage has tripped the counter reading is 100 percentage. // Duration of event (n-1) starting of stage $I_a>$. // Number of startings of the stage $I_a>$ in the range 0...255.
5	Duration of the latest starting situation (n) of overload stage $I_b>$ as a percentage of the operation time-lag . When the concerned stage has tripped the counter reading is 100 percentage. // Duration of event (n-1) starting of stage $I_b>$. // Number of startings of the stage $I_b>$ in the range 0...255.
6	Compensated phase unbalance current ΔI_c (n) measured as a percentage of the rated input current ΔI_n of the protective relay. // Uncompensated phase unbalance current ΔI (n) measured as a percentage of the rated input current ΔI_n of the protective relay. // Event (n-1) value of compensated phase unbalance current ΔI_c. // Event (n-1) value of uncompensated phase unbalance current ΔI.
7	Duration of the latest starting situation (n) of stage $\Delta I_1>$ as a percentage of the set operating time $t_{\Delta 1}$. When the concerned stage has tripped the counter reading is 100 percentage. // Duration of event (n-1) starting of stage $\Delta I_1>$. // Number of startings of the stage $\Delta I_1>$ in the range 0...255.
8	Duration of the latest starting situation (n) of stage $\Delta I_2>$ as a percentage of the operation time-lag. When the concerned stage has tripped the counter reading is 100 percentage. // Duration of event (n-1) starting of stage $\Delta I_2>$. // Number of startings of the stage $\Delta I_2>$ in the range 0...255.
9	Duration of the latest starting situation (n) of stage $I<$ as a percentage of the set operating time $t<$. When the concerned stage has tripped the counter reading is 100 percentage. // Duration of event (n-1) starting of stage $I<$. // Number of startings of the stage $I<$ in the range 0...255.

Register	Recorded information
0	Display of blocking signals and other external control signals. The right-most digit indicates the state of the blocking inputs of the unit. The following states may be indicated: 0 = no blocking signal 1 = the control or block signal BS1 is active 2 = the control or block signal BS2 is active 3 = the control or block signals BS1 and BS2 are active 4 = the control or block signal RRES is active 5 = the control or block signals RRES and BS1 are active 6 = the control or block signals RRES and BS2 are active 7 = the control or block signals RRES, BS1 and BS2 are active From this register "0" it is possible to move on to the TEST mode, where the starting and tripping signals of the module are activated one by one in the following order and indicated by the flashing setting indication LED:  Start from I_b> Trip from I_b> Trip from I_a> Trip from I< Reconnection inhibit Trip from ΔI_1> Start from ΔI_2> Trip from ΔI_2> The led positions adjacent to SGF, SGB and SGR are not tied to any test function. For further details see the description "General characteristics of D-type SPC relay units".
A	The address code of the measuring relay module, required by the serial communication system. // The selection of the data transfer rate of the serial communication. // The bus traffic monitor indicating the operating state of the serial communication system. If the module is connected to a system including a control data communicator and if the communication system is operating, the counter reading of the bus traffic monitor will be zero. Otherwise the numbers 0...255 are continuously rolling in the display. // Password required for the remote control of the settings. The password must always be entered via the serial communication before setting can be remotely altered.

The registers 1...9 are set to zero by pressing the push-buttons RESET and PROGRAM simultaneously. The registers are also cleared if the auxiliary power supply module is interrupted. The address code of the plug-in module, the data transfer rate of the serial communication and the password are not erased by a voltage failure. Instructions for setting the address and the data transfer rate are given in the manual "General characteristics of D type SPC relay units".

Main menus and submenus of settings and registers

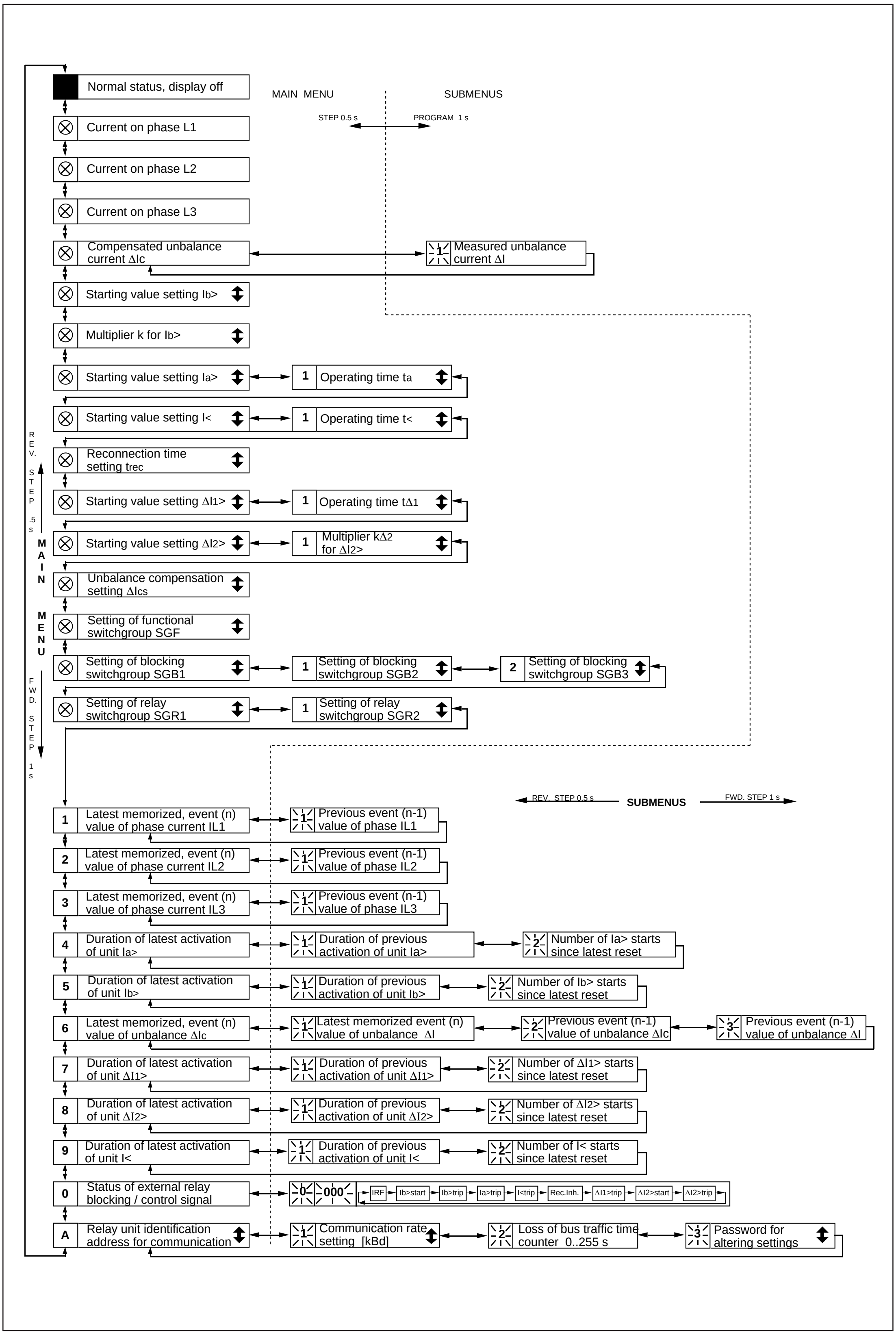


Fig 4. Main menus and submenus of the capacitor bank module SPCJ 4D40

The measures required for entering a submenu or a setting mode and how to perform the setting and use the TEST mode are described in detail on data sheet "General characteristics of the D-type plug-in units". Below a short guide.

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

Time/current characteristics

The operation of the overload stage I_b> is based on ANSI and IEC inverse time characteristic.

ANSI-type characteristic

I/Ib>	t [s]	standard durations [s]	
1.15	1620	1800	IEC 871-1
1.20	270	300	IEC 871-1
1.30	54	60	ANSI 18-1980, IEC 871-1
1.40	13.5	15	ANSI 18-1980
1.70	0.9	1	ANSI 18-1980
2.00	0.27	0.3	ANSI 18-1980
2.20	0.10	0.12	ANSI 18-1980

Minimum operating time is 100 ms.

The graph of the characteristic is shown in Fig.5.

Phase unbalance-type characteristic *(modified 99-10)*

The operation of the phase unbalance stage ΔI_2> is based on inverse time characteristic near to normal inverse. The characteristic is based on the following mathematical expression:

$t[s] = k \times 101.2/[(100 \times \Delta I/\Delta I_2>)-97]+0.02$

where
t = operating time in seconds
k = time multiplier
ΔI = current value
ΔI_2> = set current value

Note!
It is possible to increase the inverse time characteristic by a factor 10 by setting switch SGF/6 to position 1.

The normal current range is defined as 1...2 times the setting current. Additionally the relay must start at the latest when the current exceeds a value of 1.05 times the setting current.

Minimum operating time is 100 ms. For currents above two times the rated current ΔI the relay levels out to definite time operation.

The graph of the characteristic is shown in Fig.6.

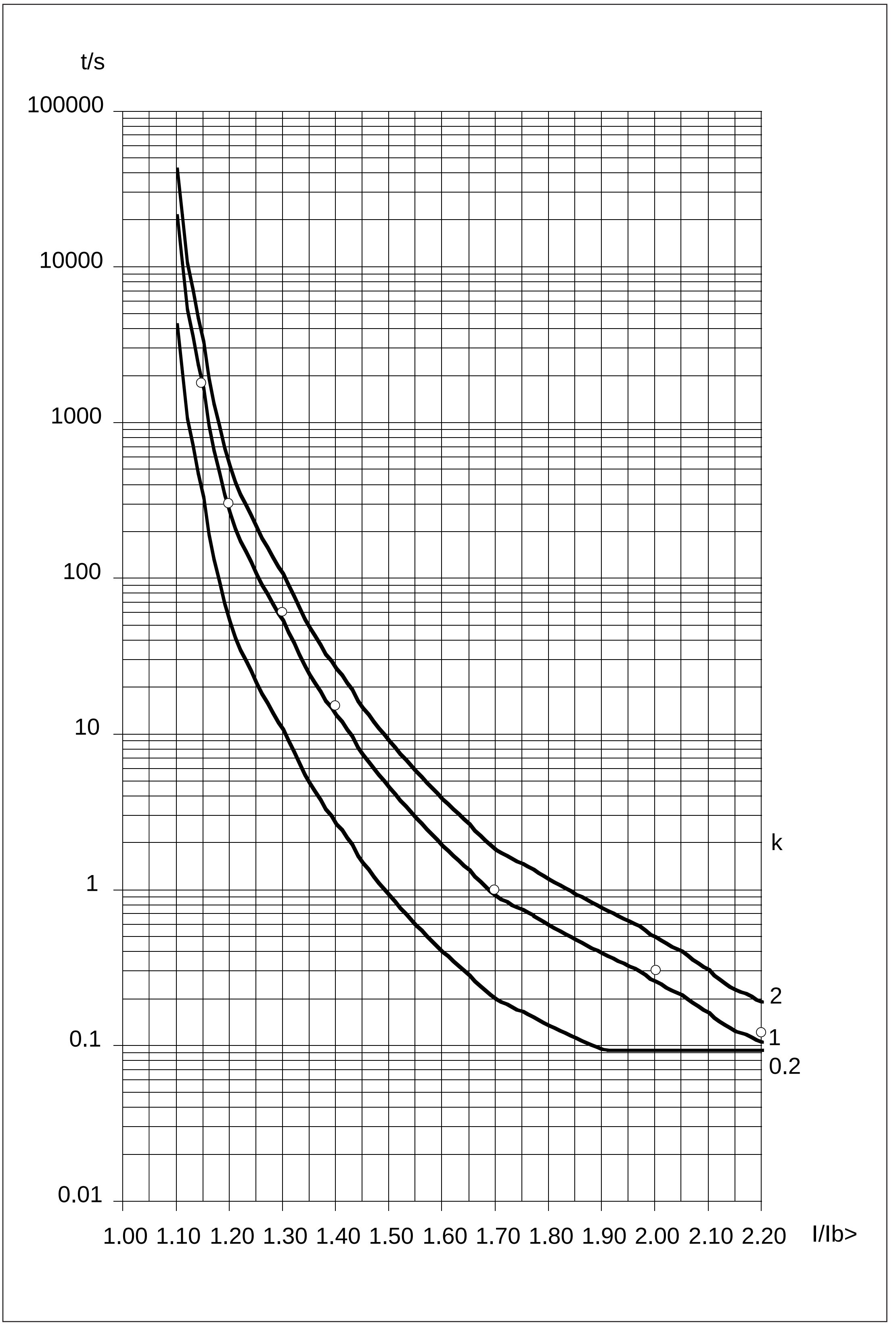


Fig 5. ANSI-time characteristics of the capacitor bank protection module SPCJ 4D40

Durations specified in the ANSI and IEC standards are marked with "o" in the figure.

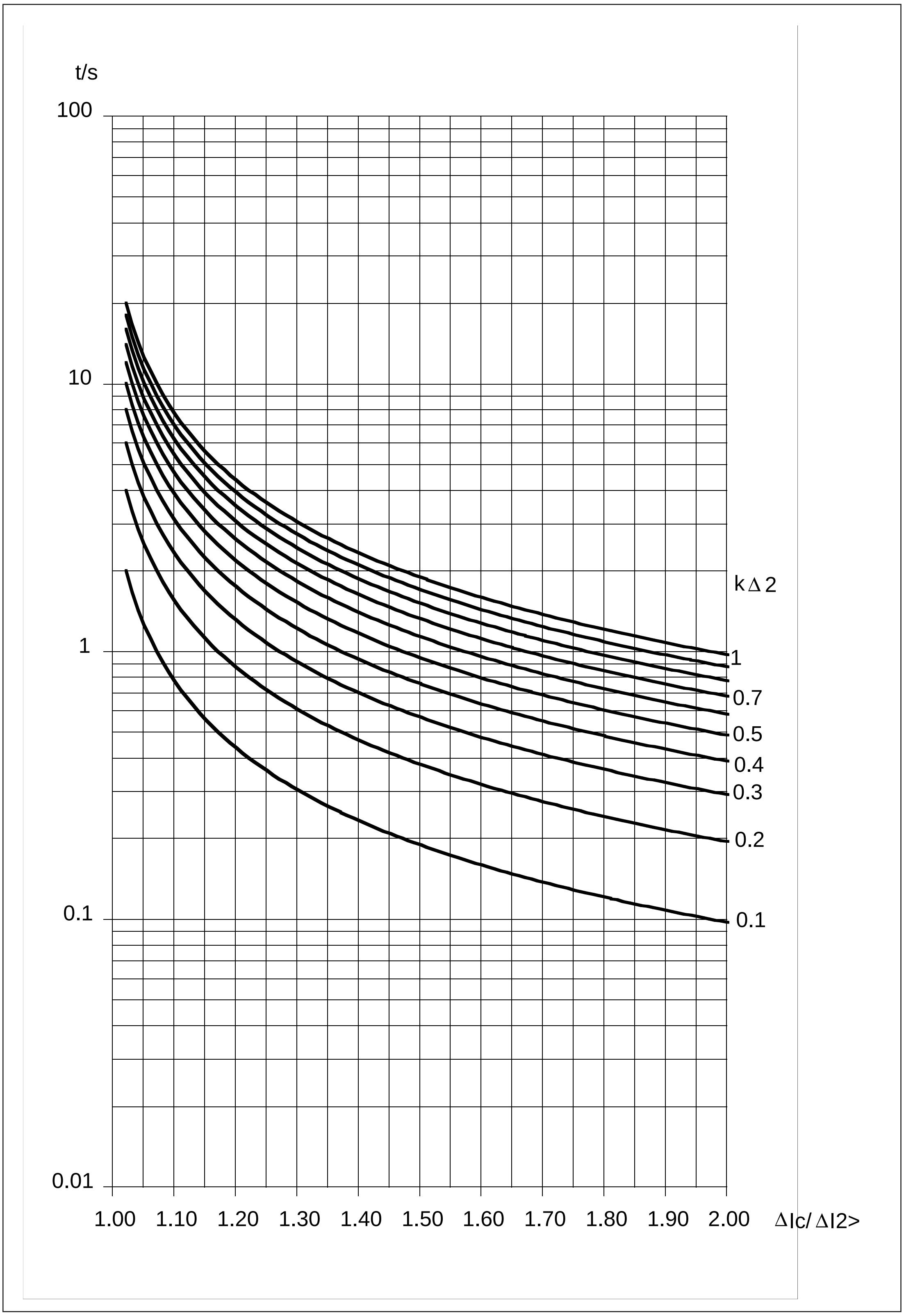


Fig 6. Phase unbalance inverse-time characteristics of the capacitor bank protection module SPCJ 4D40.

When the switch SGF/6 is in position 0 the operating times are according fig 6. In position 1 the operating times are increased by a factor 10.

Technical data

Overload stage I_b>

Starting current I_b>	0.30...1.50 x I_n
Starting time	<80 ms
Operation characteristic	ANSI inverse
Time multiplier k	0.2...2.0
Resetting time	<100 ms
Drop-off/pick-up ratio	>0.95
Operation time accuracy (k = 1.0 and I_b> = 0.50…1.50 x I_n)	±10% of theoretical value or ±50 ms, see Fig. 5
Operation accuracy	±3% of set value
Shortest possible trip time	~100 ms

Overload stage I_a>

Starting current I_a>	80...120 % x I_b>
Operating time	0.50...100 min
Resetting time	<250 ms
Drop-off/pick-up ratio	>0.95
Operation time accuracy	±2% of set value
Operation accuracy	±3% of set value

Undercurrent stage I<

Starting current I<	0.10...0.70 x I_n
Operating time	1.0...100 s
Reconnection time	0.50...100 min
Pulse shaped tripping signal, pulse length	~200 ms
Pick-up/drop-off ratio	<1.1
Operation time accuracy	±2% of set value or ±75 ms
Operation accuracy	±3% of set value within range 0.25...0.70 x I_n

Phase unbalance ΔI_1>, Stage 1

Starting current ΔI_1>	1.0...100% ΔI_n *)
Operating time	1.0...300 s
Resetting time	<100 ms
Drop-off/pick-up ratio	>0.90
Operation time accuracy (ΔI_{cs} = 0)	±2% of set value or ±75 ms
Operation accuracy (ΔI_{cs} = 0)	±3% of set value within range 1.5...100% ΔI_n

Phase unbalance ΔI_2>, Stage 2

Starting current ΔI_2>	2.0...80.0% ΔI_n *)
Starting time	<70 ms
Operation characteristic	Inverse time
Time multiplier $k_{\Delta 2}$	0.1...1.0
Resetting time	<100 ms
Drop-off/pick-up ratio	>0.90
Operation time accuracy of theoretical characteristic (ΔI_{cs} = 0)	7.5% or ±35 ms
Operation accuracy (ΔI_{cs} = 0)	±3% of set value
Shortest possible trip time	~100 ms
Setting of compensation	0.0...20.0% ΔI_n
Operation accuracy	<3% of ΔI_n

*) minimum recommended: 3.0% ΔI_n

Event codes

When the capacitor bank protection module SPCJ 4D40 is linked to a control data communicator over the SPA bus, the module will provide time stamped event markings e.g. to a printer. The events are printed out in the format: time, user specified text and an event code.

The events are generated on starts, trips, resettings and output relay operations. Every function has their own code designation from E1... E34.

Masking parameters can be used to inhibit event generations from one or several functions.

An event buffer is capable to memorize up to eight events. If more than eight events occure before the content of the buffer is send to the communicator an overflow event "E51" is generated. This event has to be resetted by writing a command "0" to parameter C over the SPA-bus.

More information about the serial communication over the SPA-bus can be found in the pamphlet "SPA-BUS COMMUNICATION PROTOCOL", 34 SPACOM 2 EN1.

Code	Event	Number representing the event	Default value of the factor
E1	Starting of stage I_b>	1	0
E2	Starting of stage I_b> reset	2	0
E3	Tripping of stage I_b>	4	4
E4	Tripping of stage I_b> reset	8	0
E5	Starting of stage I_a>	16	0
E6	Starting of stage I_a> reset	32	0
E7	Tripping of stage I_a>	64	64
E8	Tripping of stage I_a> reset	128	0
	Default checksum for mask V155		68
E9	Starting of stage I<	1	0
E10	Starting of stage I< reset	2	0
E11	Tripping of stage I<	4	4
E12	Tripping of stage I< reset	8	0
E13	Starting of stage ΔI_1>	16	0
E14	Starting of stage ΔI_1> reset	32	0
E15	Tripping of stage ΔI_1>	64	64
E16	Tripping of stage ΔI_1> reset	128	0
	Default checksum for mask V156		68
E17	Starting of stage ΔI_2>	1	0
E18	Starting of stage ΔI_2> reset	2	0
E19	Tripping of stage ΔI_2>	4	4
E20	Tripping of stage ΔI_2> reset	8	0
E21	Beginning of external trip signal	16	16
E22	External trip signal reset	32	0
E23	Beginning of reconnection inhibit	64	0
E24	End of reconnection inhibit	128	0
	Default checksum for mask V157		20

Code	Event	Number representing the event	Default value of the factor
E25	Output signal TS1 activated	1	0
E26	Output signal TS1 reset	2	0
E27	Output signal SS1 activated	4	0
E28	Output signal SS1 reset	8	0
E29	Output signal SS2 activated	16	0
E30	Output signal SS2 reset	32	0
E31	Output signal SS3 activated	64	0
E32	Output signal SS3 reset	128	0
E33	Output signal TS2 activated	256	256
E34	Output signal TS2 reset	512	512
	Default checksum for mask V158		768
E50	Restarting	*	-
E51	Overflow of event register	*	-
E52	Temporary interruption in data communication	*	-
E53	No response from the module over the data communication	*	-
E54	The module responds again over the data communication	*	-

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

Note!
The eventcodes E52...E54 are only generated by the datacommunicator unit. (SACO 100M, SRIO 1000M etc.)

Data to be transferred over the bus

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

Data	Code	Data flow direction	Value range
INPUTS			
Filtered current measured on phase L1	I1	R	0...8.5 x I_n
Filtered current measured on phase L2	I2	R	0...8.5 x I_n
Filtered current measured on phase L3	I3	R	0...8.5 x I_n
Compensated unbalance current ΔI_c	I4	R	0...232% x ΔI_n 999 = Unbalance prot. inhibited
Measured unbalance current ΔI	I5	R	0...212% x ΔI_n
Blocking or control signal BS1	I6	R	0 = no blocking 1 = BS1-signal active
Blocking or control signal BS2	I7	R	0 = no blocking 1 = BS2-signal active
Blocking or control signal RRES	I8	R	0 = no blocking 1 = RRES-signal active

Data	Code	Data flow direction	Value range
OUTPUTS			
Starting of stage $I_b>$	O1	R	0 = $I_b>$-stage not started 1 = $I_b>$-stage started
Tripping of stage $I_b>$	O2	R	0 = $I_b>$-stage not tripped 1 = $I_b>$-stage tripped
Starting of stage $I_a>$	O3	R	0 = $I_a>$-stage not started 1 = $I_a>$-stage started
Tripping of stage $I_a>$	O4	R	0 = $I_a>$-stage not tripped 1 = $I_a>$-stage tripped
Starting of stage $I<$	O5	R	0 = $I<$-stage not started 1 = $I<$-stage started
Tripping of stage $I<$	O6	R	0 = $I<$-stage not tripped 1 = $I<$-stage tripped
Starting of stage $\Delta I_1>$	O7	R	0 = $\Delta I_1>$-stage not started 1 = $\Delta I_1>$-stage started
Tripping of stage $\Delta I_1>$	O8	R	0 = $\Delta I_1>$-stage not tripped 1 = $\Delta I_1>$-stage tripped
Starting of stage $\Delta I_2>$	O9	R	0 = $\Delta I_2>$-stage not started 1 = $\Delta I_2>$-stage started
Tripping of stage $\Delta I_2>$	O10	R	0 = $\Delta I_2>$-stage not tripped 1 = $\Delta I_2>$-stage tripped
External trip signal	O11	R	0 = signal not active 1 = signal active
Reconnection inhibit signal	O12	R	0 = signal not active 1 = signal active
Reconnection inhibit output TS1	O13	R	0 = signal not active 1 = signal active
Signal SS1	O14	R,W(P)	0 = signal not active 1 = signal active
Signal SS2	O15	R,W(P)	0 = signal not active 1 = signal active
Signal SS3	O16	R,W(P)	0 = signal not active 1 = signal active
Signal TS2	O17	R,W(P)	0 = signal not active 1 = signal active
Output relays	O18	R,W(P)	0 = not operated 1 = operated
Reconnection inhibit output control	O19	W(P)	0 = not affecting reconn. enable 1 = reconnection remotely inhibited
Memorized starting of stage $I_b>$	O21	R	0 = $I_b>$-stage not started 1 = $I_b>$-stage started
Memorized tripping of stage $I_b>$	O22	R	0 = $I_b>$-stage not tripped 1 = $I_b>$-stage tripped
Memorized starting of stage $I_a>$	O23	R	0 = $I_a>$-stage not started 1 = $I_a>$-stage started
Memorized tripping of stage $I_a>$	O24	R	0 = $I_a>$-stage not tripped 1 = $I_a>$-stage tripped
Memorized starting of stage $I<$	O25	R	0 = $I<$-stage not started 1 = $I<$-stage started
Memorized tripping of stage $I<$	O26	R	0 = $I<$-stage not tripped 1 = $I<$-stage tripped
Memorized starting of stage $\Delta I_1>$	O27	R	0 = $\Delta I_1>$-stage not started 1 = $\Delta I_1>$-stage started
Memorized tripping of stage $\Delta I_1>$	O28	R	0 = $\Delta I_1>$-stage not tripped 1 = $\Delta I_1>$-stage tripped

Data	Code	Data flow direction	Value range
Memorized starting of stage ΔI_2>	O29	R	0 = ΔI_2>-stage not started 1 = ΔI_2>-stage started
Memorized tripping of stage ΔI_2>	O30	R	0 = ΔI_2>-stage not tripped 1 = ΔI_2>-stage tripped
Memorized external trip signal	O31	R	0 = signal not active 1 = signal active
Memorized reconnection inhibit signal	O32	R	0 = signal not active 1 = signal active
Memorized signal TS1	O33	R	0 = signal not active 1 = signal active
Memorized signal SS1	O34	R	0 = signal not active 1 = signal active
Memorized signal SS2	O35	R	0 = signal not active 1 = signal active
Memorized signal SS3	O36	R	0 = signal not active 1 = signal active
Memorized signal TS2	O37	R	0 = signal not active 1 = signal active
Memorized output ENA-signal	O38	R	0 = signal not active 1 = signal active
SETTING VALUES			
Starting value for stage I_b>	S1	R,W(P)	0.30...1.50 x I_n
Time multiplier k for stage I_b>	S2	R,W(P)	0.2...2.0
Starting value for stage I_a>	S3	R,W(P)	80...120% I_b>
Operating time for stage I_a>	S4	R,W(P)	0.50...100 min
Starting value for stage I<	S5	R,W(P)	0.10...0.70 x I_n
Operating time for stage I<	S6	R,W(P)	1.0...100 s
Setting of reconnection inhibit time t_{rec}	S7	R,W(P)	0.50...100 min
Starting value for stage ΔI_1>	S8	R,W(P)	1.0...100 % ΔI_n
Operating time for stage ΔI_1>	S9	R,W(P)	1.0...300 s
Starting value for stage ΔI_2>	S10	R,W(P)	2.0...80.0% ΔI_n
Time multiplier $k_{\Delta 2}$ for stage ΔI_2>	S11	R,W(P)	0.1...1.0
Setting of unbalance compensation ΔI_{cs}	S12	R,W(P)	0.0...20.0% ΔI_n
Checksum of switchgroup SGF	S13	R,W(P)	0...255
Checksum of switchgroup SGB1	S14	R,W(P)	0...255
Checksum of switchgroup SGB2	S15	R,W(P)	0...255
Checksum of switchgroup SGB3	S16	R,W(P)	0...255
Checksum of switchgroup SGR1	S17	R,W(P)	0...255
Checksum of switchgroup SGR2	S18	R,W(P)	0...255
RECORDED AND MEMORIZED PARAMETERS			
Filtered current in phase L1 at tripping	V21 & V41	R	0...8.5 x I_n
Filtered current in phase L2 at tripping	V22 & V42	R	0...8.5 x I_n
Filtered current in phase L3 at tripping	V23 & V43	R	0...8.5 x I_n
Compensated unbalance current ΔI_c at tripping	V24 & V44	R	0...232% x ΔI_n
Uncompensated unbalance current ΔI at tripping	V25 & V45	R	0...212 % x ΔI_n
Duration of starting of stage I_a>	V26 & V46	R	0...100 %
Duration of starting of stage I_b>	V27 & V47	R	0...100 %
Duration of starting of stage ΔI_1>	V28 & V48	R	0...100 %
Duration of starting of stage ΔI_2>	V29 & V49	R	0...100 %
Duration of starting of stage I<	V30 & V50	R	0...100 %

Data	Code	Data flow direction	Value range
Number of startings of stage I_a>	V1	R	0...255
Number of startings of stage I_b>	V2	R	0...255
Number of startings of stage ΔI_1>	V3	R	0...255
Number of startings of stage ΔI_2>	V4	R	0...255
Number of startings of stage I<	V5	R	0...255
Phase condition during trip	V6	R	1 = I_b>(L3), 2 = I_b>(L2), 4 = I_b>(L1), 16 = I_a>(L3), 32 = I_a>(L2), 64 = I_a>(L1)
Operation indicator	V7	R	0...9
CONTROL PARAMETERS			
Resetting of output relays at self-holding	V101	W	1 = reset
Resetting of output relays and registers	V102	W	1 = reset
Event mask word for I_a> and I_b> stage events	V155	R,W	0...255, see "Event codes"
Event mask word for ΔI_1> and ΔI_2> stage events	V156	R,W	0...255, see "Event codes"
Event mask word for I< or externally controlled events	V157	R,W	0...255, see "Event codes"
Event mask word for output signal events	V158	R,W	0...1023, see "Event codes"
Opening of password for remote settings	V160	W	1...999
Changing or closing of password for remote settings	V161	W(P)	0...999
Activating of self-supervision output	V165	W	1 = self-supervision output is activated and IRF led turned on 0 = normal mode
EEPROM formatting	V167	W(P)	2 = formatted
Internal error code	V169	R	0...255
Data communication address of the module	V200	R,W	1...254
Data transfer rate	V201	R,W	4800 or 9600 Bd (R) 4.8 or 9.6 kBd (W)
Programme version number	V205	R	081_
Event register reading	L	R	time, channel number and event code
Re-reading of event register	B	R	time, channel and event code
Type designation of the module	F	R	SPCJ 4D40
Reading of module status data	C	R	0 = normal state 1 = module been subject to automatic reset 2 = overflow of event register 3 = events 1 and 2 together
Resetting of module state data	C	W	0=resetting
Time reading and setting	T	R,W	0.000...59.999 s

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

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

The setting values S1...S18 are the setting values used by the protection stages. All the settings can be read or written. A condition for writing is that a remote set password has been opened.

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

Fault codes

A short time after the internal self-supervision system has detected a permanent relay fault the red IRF indicator is lit and the output relay of the self-supervision system operates. Further, in most fault situations, an auto-diagnostic fault code is shown on the display. This fault code consists of a red figure 1 and a green code number which indicates the fault type. When a fault code appears on the display, the code number should be recorded for statistical and maintenance purposes. Below are some fault codes that might be displayed by the unit SPCJ 4D40:

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

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