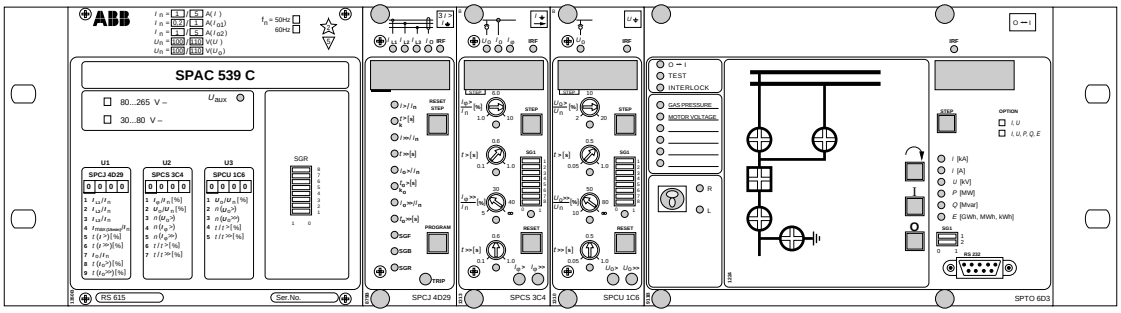
SPAC 539 C
Feeder terminal

User´s manual and Technical description



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SPAC 539 C
Feeder terminal

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Contents

The user´s manual for the feeder terminal SPAC 539 C is composed of the following partial manuals:

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Control module SPTO 6D3	1MRS 750202-MUM EN
General characteristics of D type relay modules	1MRS 750066-MUM EN
Combined overcurrent and earth-fault relay module SPCJ 4D29	1MRS 750119-MUM EN
General characteristics of C type relay modules	1MRS 750328-MUM EN
Directional neutral overcurrent relay module SPCS 3C4	1MRS 750350-MUM EN
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Features

Complete feeder terminal with protection functions, auto-reclosing, control functions and metering functions in one unit

Three-phase high-set phase overcurrent protection with instantaneous or definite time operation characteristic

Three-phase low-set phase overcurrent protection with definite time or inverse time operation characteristic

Directional and non-directional high-set earth-fault protection with instantaneous or definite time operation characteristic

Non-directional low-set earth-fault protection with definite time or inverse time operation characteristic and directional low-set earth-fault protection with definite time operation characteristic

Two-stage residual overvoltage protection with definite time operation characteristic

Local and remote status indication of seven objects and local or remote control of six objects

Seven user-programmable binary inputs with local and remote indication

Measurement and indication of phase currents, phase-to-phase voltages, energy, active and reactive power

Serial interface for remote control and data interchange

Continuous self-supervision for maximum system reliability

Area of application

The integrated feeder terminal SPAC 539 C is designed to be used as a cubicle-based protection and remote control interface units. In addition to protection, control and measurement functions the units are provided with data communication properties needed for the control of the feeder. Connection to higher level substation control equipment is carried out via a fibre-optic serial bus.

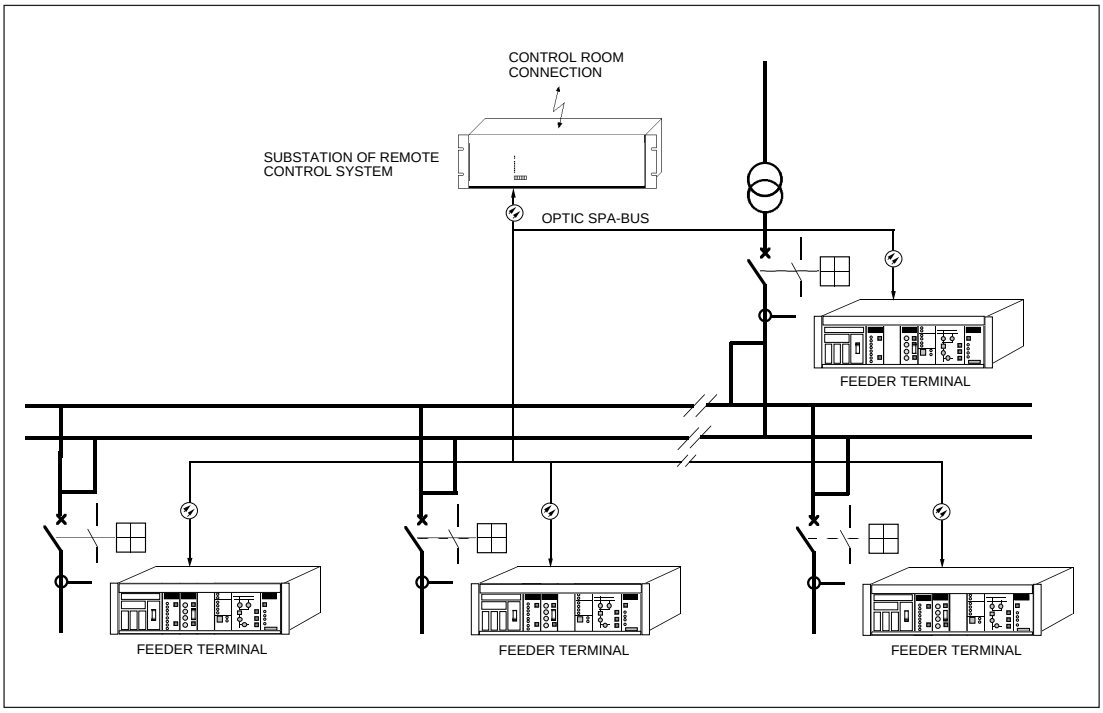


Fig. 1. Distributed protection and control system based on SPAC 539 C feeder terminals

The feeder terminal SPAC 539 C is designed to be used for selective short-circuit and earth-fault protection and for general earth-fault supervision in distribution networks. The feeder protection includes a combined overcurrent and earth-fault relay module SPCJ 4D29, a directional earth-fault relay module SPCS 3C4 and a residual voltage relay module SPCU 1C6.

The feeder terminal SPAC 539 C comprises separated neutral current measurement circuits for non-directional and directional earth-fault modules.

The control module SPTO 6D3 included in feeder terminal indicates locally by means of LED indicators the status of seven disconnectors or circuit breakers. Further, the module allows status information from the circuit breakers and the disconnectors to be transmitted to the remote control system, and six objects to be opened and closed over the remote control system. The status information and the control signals are transmitted over the serial bus. Also local control is possible using the push buttons on the front panel of the control module.

Auto-reclosing is integrated in the control module. Five successive auto-reclose cycles can be carried out.

The control module measures and indicates the three phase currents and the two phase-to-phase voltages, U_{23} and U_{31}. Active and reactive power can be measured via two mA inputs or by using the internal current and voltage signals. When the mA inputs are used, external measuring transducers are needed.

Energy can be calculated on the basis of the measured power values or by using one input as an energy pulse counter. The measured values can be indicated locally and remotely as scaled values.

The combined overcurrent and earth-fault relay module, the directional earth-fault relay module and the residual voltage relay module measure and record the three phase currents I_{L1}, I_{L2} and I_{L3}, the neutral currents I_{01} and I_{02} and the residual voltage U_0. All the measured and recorded values can be displayed locally and transmitted to the remote control system over the SPA bus.

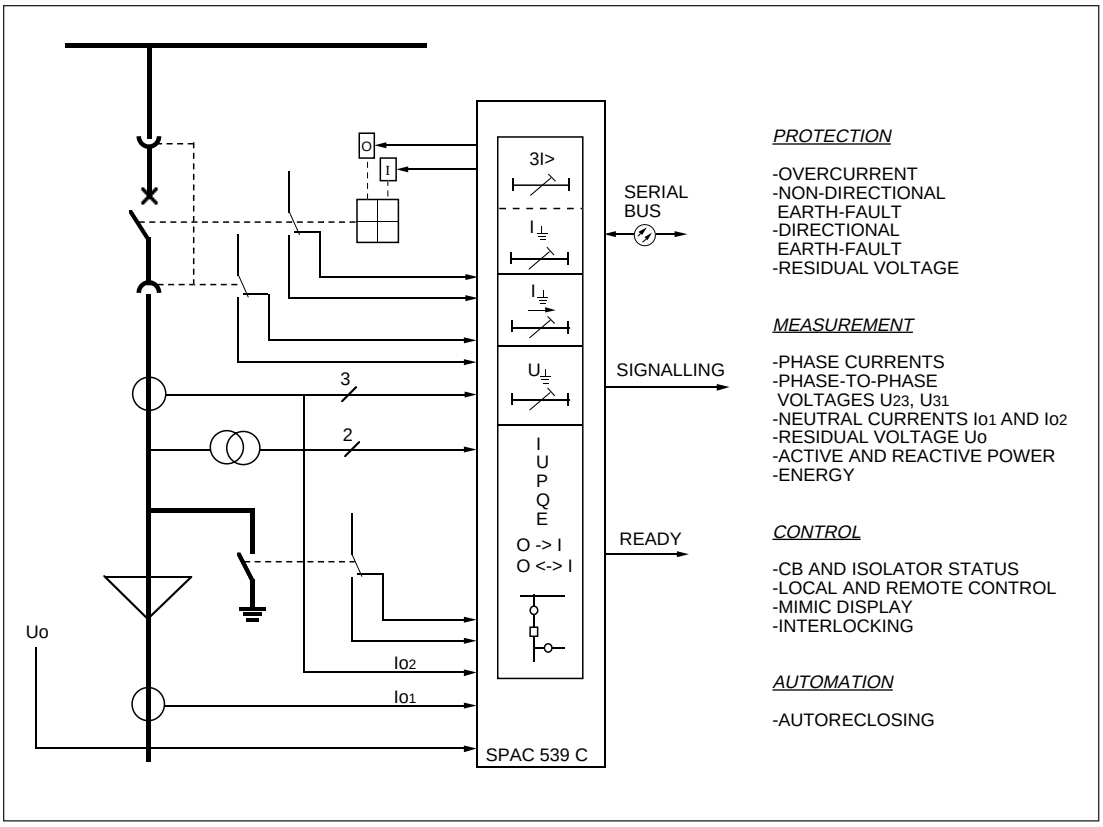


Fig. 2. Basic functions of the integrated feeder terminal SPAC 539 C

Description of function

Design

The feeder terminal SPAC 539 C is housed in a 19 inch subrack, height 3U (~133 mm). The rear of the subrack is provided with an extension frame of galvanized steel sheet.

The standard subrack is made of anodized aluminium section and includes ten operation modules. In addition, two alternative optional measuring modules are available.

The functions of the standard modules are explained in the table below.

Module	Function
Combined overcurrent and earth-fault relay module SPCJ 4D29	Three-, two- or single-phase overcurrent protection and two-stage non-directional earth-fault protection. Measures, records and displays the three phase currents and the neutral current locally and transmits the data to the remote control system.
Directional earth-fault relay module SPCS 3C4	Directional two-stage earth-fault protection. Measures, records and displays neutral current and residual voltage locally and transmits the data to the remote control system.
Residual voltage relay module SPCU 1C6	Two-stage earth-fault protection or supervision Measures, records and displays the residual voltage locally and transmits the data to the remote control system.
Control module SPTO 6D3	Reads and indicates the status data of seven disconnectors or circuit breakers locally and transmits the data to the remote control system. Reads seven external binary signals, indicates six of them locally, and transmits the data to the remote control system. Measures and indicates three phase currents, three phase-to-phase voltages, active and reactive power and energy locally and transmits the information to the remote control system. Executes local or remote open and close commands for a maximum of six circuit breakers or disconnectors. Performs up to five successive high-speed or delayed auto-reclosures.
I/O module SPTR 4D1 or SPTR 4D2 (3 pcs)	Includes 7 optically isolated binary inputs, two OPEN output contacts and two CLOSE output contacts controlled by the control module.
I/O module SPTR 6B11	Includes 3 optically isolated binary inputs and 5 output contacts controlled by the relay modules. Includes an IRF output contact which is common to the relay modules and the control module.
Power supply module SPGU 240A1 or SPGU 48B2	Forms the voltages required by the modules of the feeder terminal.
Energizing input module SPTE 8C5	Includes matching transformers and calibration electronics for three phase currents, two phase-to-phase voltages, two neutral currents and residual voltage.

To be able to measure analog signals the control module requires an optional module. The functions of the two optional modules available are as follows:

Module	Function
Measuring module SPTM 8A1 (optional module 1)	Rectifies three phase currents and two phase-to-phase voltages. Forms voltage signals of external mA-input signals.
Measuring module SPTM 6A3 (optional module 3)	Rectifies three phase currents and the two phase-to-phase voltages. Forms using one internal voltage signal and two current signals the signals corresponding to active and reactive power.

The combined overcurrent and earth-fault relay module SPCJ 4D29 and the directional earth-fault relay module SPCS 3C4 and the residual voltage relay module SPCU 1C6 are withdrawable Euro-size (100 x 160 mm) modules.

The control module type SPTO 6D3, too, is designed as a plug-in unit. This module includes two PC boards: a CPU board and a front PC board which are mechanically connected to each other. The three I/O modules SPTR 4D_ and the optional measuring module are located behind the module's front PC board. The I/O modules and the optional measuring modules can be withdrawn after the control module has been removed.

The input and output signals of the I/O module U7 (SPTR 4D_) are all linked via the multi-pole connector X3. In the same way the signals of I/O module U8 are linked via multi-pole connector X4 and the signals of I/O module U9 via multi-pole connector X5.

The power supply module SPGU 240A1 or SPGU 48B2 and the I/O module SPTR 6B11 are located behind the system front panel. The modules can be withdrawn after removal of the system panel.

The relay modules SPCJ 4D29, SPCS 3C4 and SPCJ 1C6 are fastened to the case with two finger screws and the control module SPTO 6D3 with four finger screws. These modules are of the plug-in type and can be pulled out of the subrack after the finger screws have been unwound.

Note !
Before a module is withdrawn from or inserted into the subrack the auxiliary supply should be switched off.

The energizing input module SPTE 8C5 is located behind the system panel in the left part of the case. This module includes the calibration resistors of the secondary burden as well as the matching transformers. A screw terminal block is fitted on the rear plate of the energizing input module.

The mother PC board holds the card connectors for the plug-in modules and the detachable multi-pole connectors X1…X6 for incoming and outgoing signal wirings.

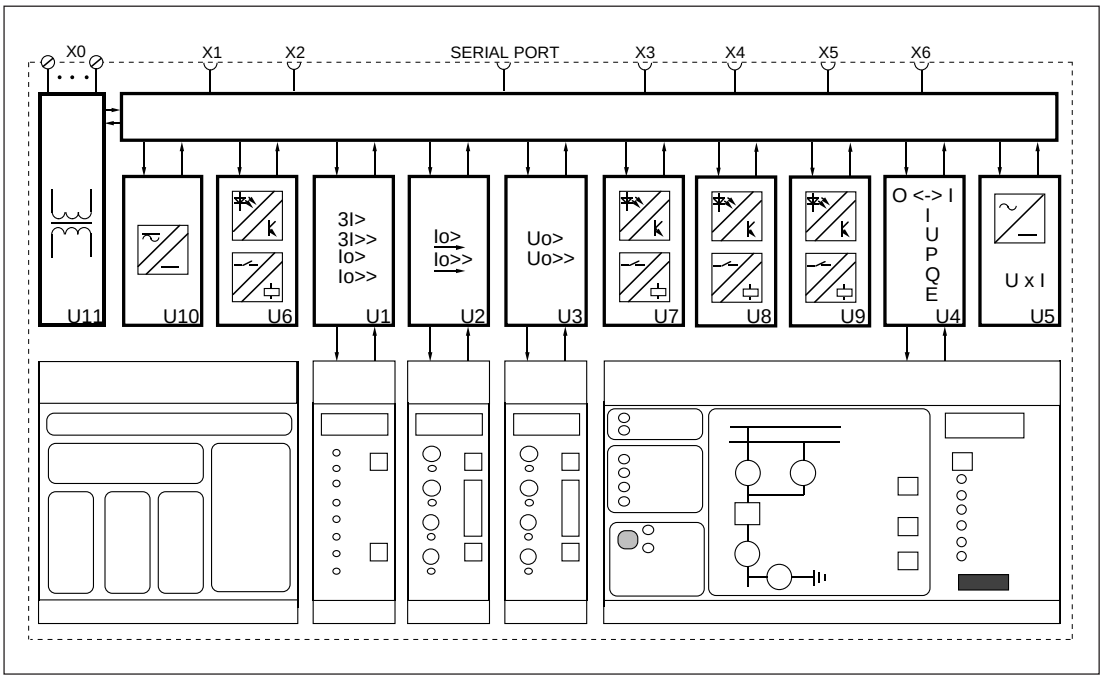


Fig. 3. Principle block diagram for feeder terminal SPAC 539 C

U1	Combined overcurrent and earth-fault relay module SPCJ 4D29
U2	Directional earth-fault relay module SPCS 3C4
U3	Residual voltage relay module SPCU 1C6
U4	Control module SPTO 6D3
U5	Optional measuring module SPTM 8A1 or SPTM 6A3
U6	I/O module SPTR 6B11 for the protection
U7…U9	I/O modules SPTR 4D1 or SPTR 4D2 for the control module (3 pcs)
U10	Power supply module SPGU 240 A1 or SPGU 48 B2
U11	Energizing input module SPTE 8C5
X0	Screw terminals
X1…X6	Multi-pole connectors

Protection functions

Phase overcurrent protection

The combined overcurrent and earth-fault relay module includes two overcurrent stages: a low-set stage I> and a high-set stage I>>. The low-set stage can be given a definite time or inverse definite minimum time (IDMT) characteristic, whereas the high-set stage can operate with definite time characteristic only.

The module measures the phase currents of the feeder to be protected. When a phase current exceeds the setting value of the low-set overcurrent stage I>, the overcurrent stage starts, simultaneously starting its timing circuit. When the set operate time has elapsed, a tripping command is delivered. In the same way the high-set overcurrent stage starts when its start value is exceeded. It starts its timing circuit and delivers a trip signal when the set operate time has elapsed.

Non-directional earth-fault protection

The combined overcurrent and earth-fault relay module includes two non-directional earth-fault stages: a low-set stage I_0> and a high-set stage I_0>>. The earth-fault unit measures the neutral current I_{02} and operates in the same way as the overcurrent unit. The low-set stage I_0> can be given definite time or inverse definite time characteristic whereas the high-set stage I_0>> can operate with definite time characteristic only.

Directional earth-fault protection

The two-stage directional earth-fault protection module SPCS 3C4 measures the neutral current I_{01} of the object to be protected and the residual voltage of the network. The earth-fault relay module starts when the residual voltage exceeds the set starting value and the measured current and phase angle are such that the set starting value of Iφ> is exceeded. When the operation time has elapsed the low-set stage of the earth-fault relay module delivers a tripping signal. The high-set stage operates in the same way; it starts when the residual voltage exceeds the set starting value and the neutral current and the phase angle between current and voltage are such that the set starting value Iφ>> is exceeded. When the selected operation time has elapsed the high-set stage delivers a tripping signal.

The high-set stage of the directional earth-fault protection can be selected to operate in the same direction as the low-set stage or, alternatively, the opposite direction can be selected.

Earth-fault protection and supervision

The residual voltage relay module SPCU 1C6 includes two protection stages. When the neutral displacement voltage of the busbar exceeds the set start voltage of the low-set stage U_0> the residual voltage relay module starts. After the set operate time has elapsed, the residual voltage relay module operates. The high-set stage of the residual voltage relay module operates in the same way.

I/O module SPTR 6B11 of protection modules

The I/O module SPTR 6B11 of feeder terminal is located behind the system panel. The module can be withdrawn after removal of the system panel. The I/O module includes three optically separated binary inputs (BS1, BS2, BACTRL), five output contacts controlled by the protection relay modules (output relays A, B, C, D, E) and an IRF output contact (output relay F) that is common to the protection relay modules and the control module and indicates internal feeder terminal fault.

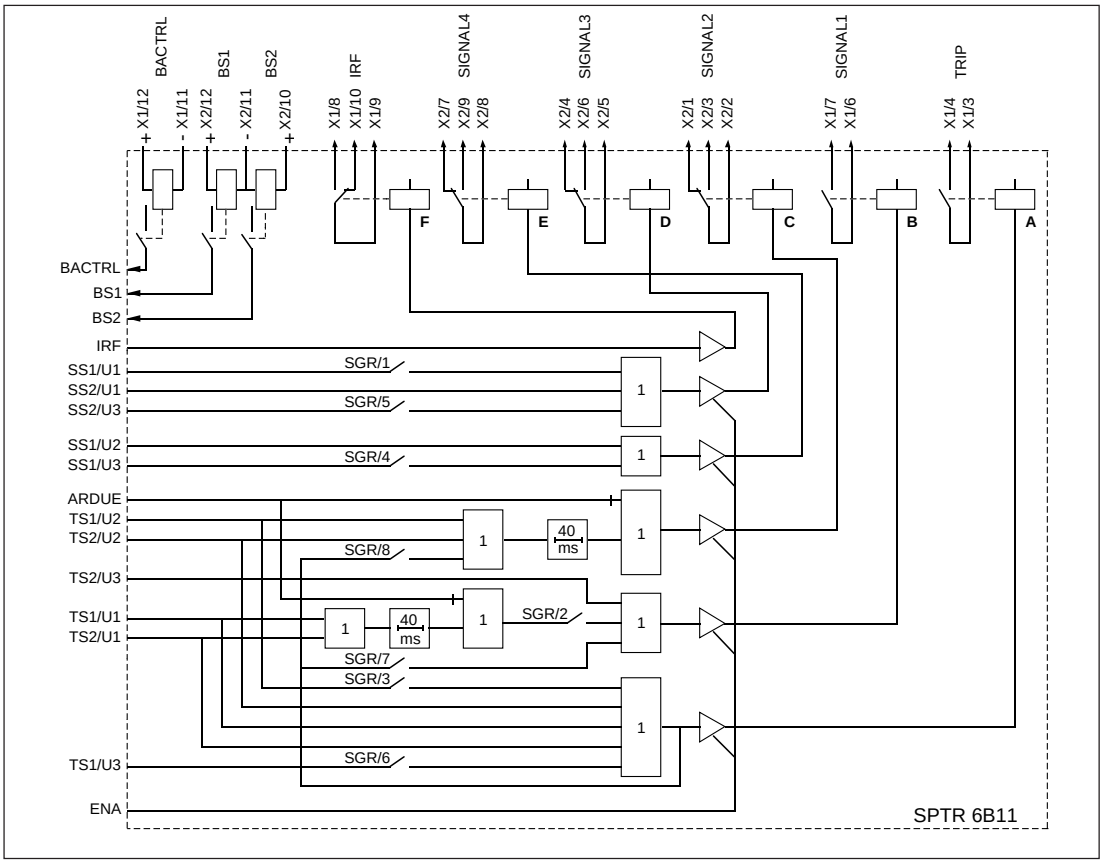


Fig. 4. Block diagram for I/O module SPTR 6B11.

SS1/U1	Overcurrent and earth-fault relay module; I>, I>>, I_0>, and I_0>> start signals
SS2/U1	Overcurrent and earth-fault relay module; I>, I>>, I_0>, and I_0>> operate signals
TS1/U1	Overcurrent and earth-fault relay module; I>, I>>, I_0>, and I_0>> start signals or operate signal, delayed operate signal; I>, I>>, I_0>,or I_0>>
TS2/U1	Overcurrent and earth-fault relay module; I>, I>>, I_0>, and I_0>> operate signals
SS1/U2	Start signal of earth-fault module, stage Iφ>
TS1/U2	Operate signal of earth-fault module, stage Iφ>
TS2/U2	Operate signal of earth-fault module, stage Iφ>>
SS1/U3	Start signal of residual voltage relay module, stage U_0>
SS2/U3	Start signal of residual voltage relay module, stage U_0>>
TS1/U3	Operate signal of residual voltage relay module, stage U_0>
TS2/U3	Operate signal of residual voltage relay module, stage U_0>
ARDUE	"Auto-reclosure due" signal from control module
IRF	Self-supervision
ENA	Enable signal for the output signals
A (TRIP)	Operate output 1 of protection relay modules; I>, I>>, I_0>, I_0>>, Iφ>, Iφ>> and U_0> operating, I>, I>>, I_0> and I_0>> starting, delayed operation signal from I>, I>>, I_0> or I_0>>
B (SIGNAL1)	Signal on final operation of combined overcurrent and earth-fault module, U_0>> operation output or operation output 2 of the protection relay modules
C (SIGNAL 2)	Signal on final operation of directional earth-fault module or general signal output, stages I>, I>>, I_0>, I_0>>, Iφ>, Iφ>> and U_0>
D (SIGNAL 3)	Output relay for start and operation signals of the combined overcurrent and earth-fault relay module, stages I>, I>>, I_0>, I_0>> and for the start signal of the residual voltage relay module, stage U_0>>
E (SIGNAL 4)	Output relay for the start signal of the earth-fault module, stage Iφ> and for the start signal of the residual voltage relay, stage U_0>
F (IRF)	Self-supervision alarm output
BACTRL	Selection of Isinφ/Icosφ operation for earth-fault module using an external control voltage
BS1	Blocking signal 1 for operation of protection relay modules
BS2	Blocking signal 2 for operation of protection relay modules

I/O module SPTR 6B11 has a fixed 40 ms delay for the control of output relays B and C. This delay is added to the normal operation delay. When output B is used as a second trip output the fixed 40 ms delay is by-passed by means of switch SGR/7.

The input signals and output signals of the I/O module are permanently wired to the card locations of the feeder terminal. Since the output signals are individually wired from each card location to the I/O module, the modules have to be plugged into the relay case as shown in the Fig. on the front page to secure that the connection diagram for the relay assembly corresponds to the physical function of the relay.

Auto-reclosing

The control module SPTO 6D3 also incorporates a flexible auto-reclose unit capable of five successive auto-reclose shots. Each auto-reclose shot can be started by three different signals (AR1, AR2 or AR3) from the protection relay modules of the feeder terminal.

The three start initiating signals are either starting or tripping signals of the protection relay modules. For the configuration of the signals see chapter "Signal diagram".

When the starting signals of the relay modules are used to start auto-reclosing, the start of the auto-reclosures can be delayed to avoid unnecessary auto-reclose functions. The dead time can be determined separately for each shot. The reclaim time, too, is adjustable.

For double-breaker arrangements (duplex) the auto-reclose programme includes a so called duplex logic, which always opens both circuit breakers but gives the closing command only to that circuit breaker which was the last one to be closed.

Control functions

General

The control module SPTO 6D3 is used to read the status information of circuit-breakers and disconnectors.The module indicates the status locally by means of LED indicators and transfers the information to station level equipment via the SPA bus. The status of seven objects can be indicated.

The control module is also used to control up to six objects, e.g. circuit breakers or disconnectors, either locally or through opening or closing commands received over the SPA bus.

In addition to status information the control module can read other binary data, indicate it locally and transfer the information to station level equipment. A maximum of seven external binary signals can be wired to the feeder terminals.

Input channels 1...7

The control module uses input channels 1…7 to read status information from circuit breakers and disconnectors. Each of these channels consists of two binary inputs, one for reading open status and the other for reading closed status of an object. This means that the status information must be wired to the feeder terminal as four-pole information.

The front panel of SPTO 6D3 has a 4x4 matrix of status indication LEDs. At a time seven of these LEDs can be used for status indication. The circuit breaker / disconnector configuration indicated by these LEDs is freely selectable by the user.

At the most six of the objects whose status is read via input channels 1…7 can be controlled. The outputs OPEN1…6 and CLOSE1…6 operate as the control outputs of the feeder terminal.

Input channels 8...14 and 15..17

Further, the control module can be used to read seven external and three internal binary signals. The external signals, channels 8…14, can be single contact data wired from the bay and the internal signals, channels 15…17, are starting and tripping signals of the protection relay modules. See Fig. 7 "Signal diagram" on page 16 in this manual.

The input for channels 8…17 can be selected to be activated at high state, i.e. when a control voltage is applied to the input, or at low state, i.e. when no control signal is applied to the input.

The activations of the external input channels 8...13 can individually be programmed to be memory controlled, which means that the LED corresponding to an input channel, which has been activated for more than 10 ms, remains lit until separately reset. Red light of a LED indicates that the concerned input channel is activated.

Local resetting is carried out by pressing the STEP and SELECT push-buttons simultaneously or remotely by giving parameter S5 the value 0 or 1 via the remote control system.

The input channels 8…17 can be used to control the OPEN1…6, CLOSE1…6 and SIGNAL 5 or 6 outputs. When an input channel is activated the OPEN or CLOSE output configured to the channel delivers a control pulse. The SIGNAL outputs are active as long as the input channels are active.

Interlocking

The control module includes a feeder oriented interlocking logic which can be freely programmed by the user. When writing an interlocking program the user defines when it is allowed to give an open or close signal to a specific object. When an open or close command is given, the interlocking system checks whether the operation is permitted or not. Thereafter the command is executed or cancelled.

The interlocking can be selected to be depending on the status of the four-pole input channels 1…7 or the input channels 8…17. The tripping signals of the relay modules are not affected by the interlocking system.

Direct output control

Normally the outputs OPEN1…6 and CLOSE 1…6 are controlled by open or close commands, either given locally with push-buttons or over the serial bus. When Direct Output Control has been selected all outputs, i.e. OPEN1…6, CLOSE1…6 and SIGNAL5 or 6, can be controlled without an open or close command. The outputs are controlled by a programmed logic and the status of input channels 1…7 and 8…17.

Measurement functions

The control module SPTO 6D3, the combined overcurrent and earth-fault relay module SPCJ 4D29, the directional earth-fault relay module SPCS 3C4 and the residual voltage relay module SPCU 1C6 measure analog signals.

The combined overcurrent and earth-fault relay module SPCJ 4D29 measures the three phase currents and the neutral current. The measured currents are shown locally on the display of the relay module and, on request, transmitted to higher-level systems over the SPA bus.

The directional earth-fault relay module SPCS 3C4 measures three analog signals: the neutral current I_0, the residual voltage U_0, and $I\varphi$, which is the resistive or reactive component of the neutral current. The three analog signals are presented locally on the display of the module and, if necessary, transmitted to higher-level systems over the SPA bus.

The residual voltage relay module SPCU 1C6 measures the neutral displacement voltage of the system. The measured value is presented locally on the display of the module and, if necessary, transmitted to higher-level systems over the SPA bus.

The relay modules also record the analog signals in a fault situation. The relay modules always indicate the measured values as multiples of the rated current and rated voltage of the feeder terminal.

The standard control module is provided with a pulse counter input for the counting of the energy pulses. To be able to measure analog signals the control module SPTO 6D3 requires an optional measuring module: type SPTM 8A1 or SPTM 6A3. When using the measuring module SPTM 8A1 the control module is able to measure three phase currents and two phase-to-phase voltages U_{23}, U_{31}. Active and reactive power are measured via the mA inputs and external measuring transducers.

When using the measuring module SPTM 6A3 the control module can measure three phase currents and two phase-to-phase voltages U_{23}, U_{31}. Active and reactive power are measured on the basis of the internal voltage of the module and two current signals. The voltage to be used and the corresponding currents are selected with switches.

The ratio of the primary current and voltage transformers can be selected with the control module. Based on these values the control module is able to indicate the currents, voltages and power as primary values. If the mA inputs are used for power measurement, the mA signals can be scaled as actual MW and Mvar values. These primary values can be indicated locally and, when needed, be transmitted to the higher-level system over the SPA bus.

Active energy can be measured in two ways; by calculating the value on the basis of the power value measured with one of the optional measuring modules, SPTM 8A1 or SPTM 6A3, or by employing input channel 11 as a pulse counter input. In the latter case an external energy meter with pulse output is needed. In both cases the amount of measured energy can be displayed locally and transmitted to the remote control system over the SPA bus.

Serial communication

The feeder terminal includes two serial communication ports, one on the front panel and the other on the rear panel.

The 9-pole RS 232 connection on the front panel is intended for the connection of a PC to be used for setting the CB/disconnector configuration, feeder oriented interlocking and other parameters of the control module with a PC.

The 9-pole RS 485 connection on the rear panel is used to connect the feeder terminal to the SPA bus via an interface module type SPA-ZC17_ or SPA-ZC21_.

Auxiliary power supply

For its operation the feeder terminal requires a secured auxiliary voltage supply. The feeder terminal's internal power supply module SPGU 240A1 or SPGU 48B2 forms the voltages required by the measuring relay modules, the control module and the input / output modules.

The power supply module is a transformer connected, i.e. galvanically isolated primary and secondary side, flyback-type DC/DC converter. 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).

A green LED indicator U_{aux} on the front panel is lit when the power supply module is in operation. There are two versions of power supply modules available. The secondary sides of the modules are identical, but the input voltage range is different. The input voltage range is marked on the front panel of the control module.

Mounting and dimension drawings

The feeder terminal SPAC 539 C is designed for flush mounting in a 19" instrument frame. The unit is fastened with four screws. The mounting depth can be reduced by using a raising frame type SPA-ZX 19, height 40 mm.

When the feeder terminal is mounted in a door and the door structure is weak, the door should be reinforced by suitable means.

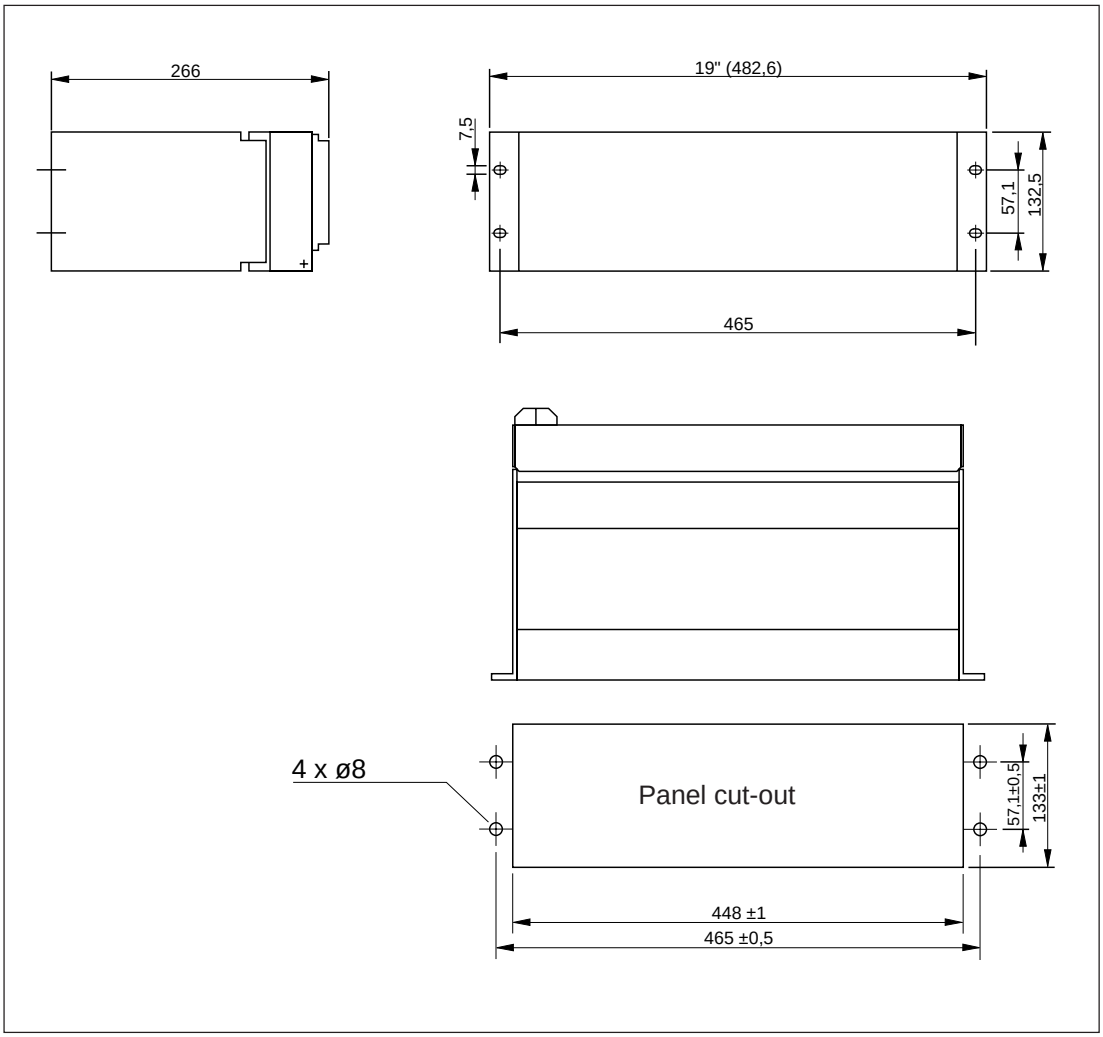


Fig. 5. Mounting and dimensional drawings of feeder terminal SPAC 539 C

Connection diagram

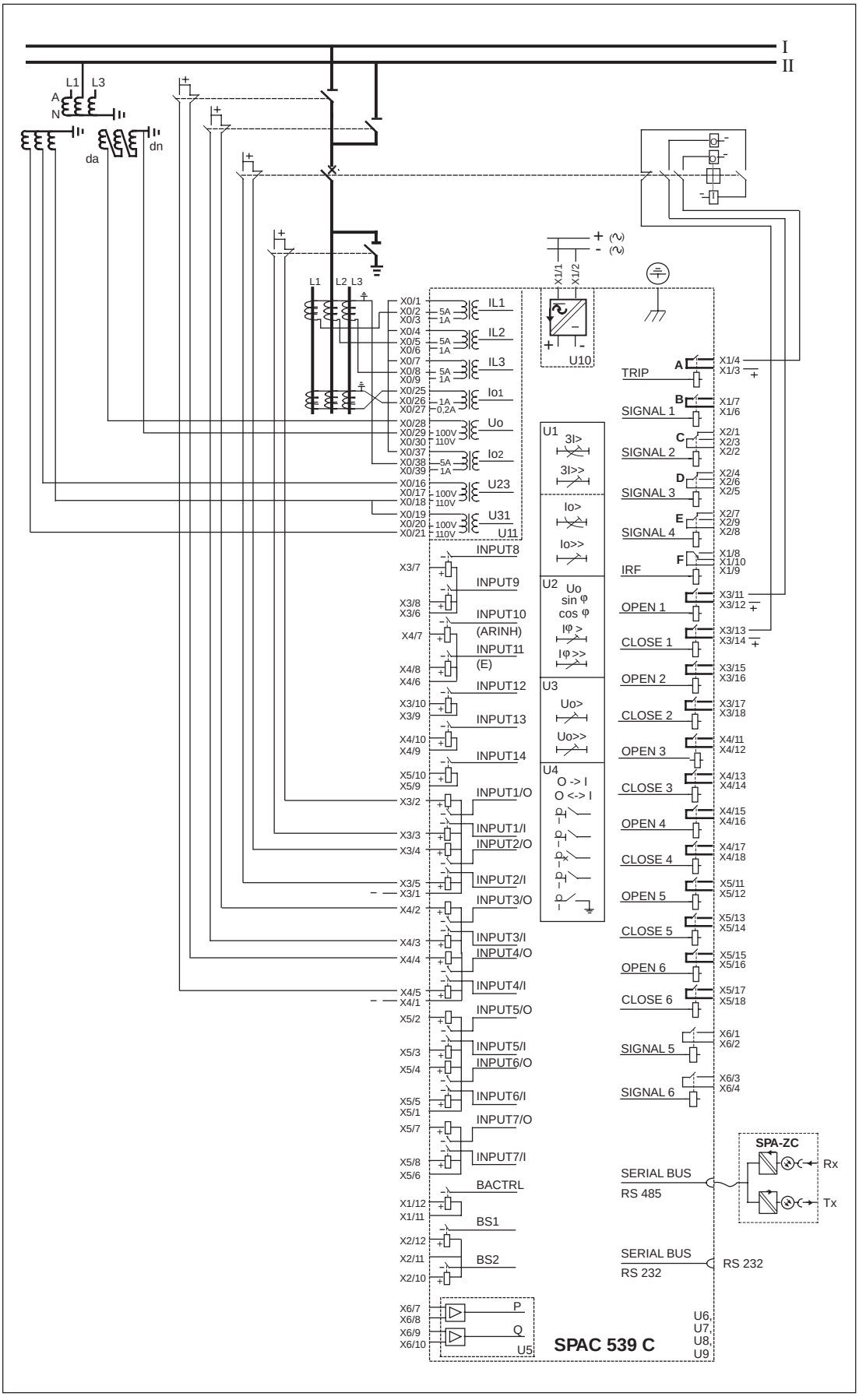


Fig. 6. Connection diagram for feeder terminal SPAC 539 C. Module U5 is optional

Numbering of terminals

Terminal group	Contact interval	Function
X0	1-2	Current I_{L1} (5A). Overcurrent protection and measurement
	1-3	Current I_{L1} (1A). Overcurrent protection and measurement
	4-5	Current I_{L2} (5A). Overcurrent protection and measurement
	4-6	Current I_{L2} (1A). Overcurrent protection and measurement
	7-8	Current I_{L3} (5A). Overcurrent protection and measurement
	7-9	Current I_{L3} (1A). Overcurrent protection and measurement
	16-17	Voltage U_{23} (100 V). Measurement
	16-18	Voltage U_{23} (110 V). Measurement
	19-20	Voltage U_{31} (100 V). Measurement
	19-21	Voltage U_{31} (110 V). Measurement
	25-26	Neutral current I_{01} (1 A). Earth-fault protection
	25-27	Neutral current I_{01} (0.2 A). Earth-fault protection
	28-29	Residual voltage U_0 (100 V). Earth-fault protection
	28-30	Residual voltage U_0 (110 V). Earth-fault protection
	37-38	Neutral current I_{02}> (5 A). Earth-fault protection
	37-39	Neutral current I_{02}> (1 A). Earth-fault protection
X1	1-2	Auxiliary power supply. The positive pole of the dc supply is connected to terminal 1
	3-4	Operation signal (TRIP) of relay modules, stages I>, I>>, I_0>, I_0>>, Iφ>, Iφ>>, U_0>
	6-7	Signal "Final trip on overcurrent or non-directional earth-fault; stages I>, I>>, I_0>, I_0>>", trip on stage U_0>> or operation output 2 (SIGNAL1)
	8-9-10	Self-supervision signalling contact (IRF). Operates on the closed circuit principle. Under normal conditions contact interval 8-9 is closed. Should the auxiliary power supply fail or an internal fault be detected, the contact interval 9-10 closes
	11-12	Selection of operation characteristic, i.e. Isinφ/Icosφ for the directional earth-fault module U2 (BACTRL)
X2	1-2-3	Signal "Final trip on directional earth-fault; stages Iφ>, Iφ>>" or signal "general protection operation; I>, I>>, I_0>, I_0>>, Iφ>, Iφ>>, U_0> " (SIGNAL 2)
	4-5-6	Start or operation signal, stages I>, I>>, I_0>, I_0>> from combined over-current and earth-fault relay module or start signal from residual voltage relay module, stage U_0>> (SIGNAL 3)
	7-8-9	Start signal from directional earth-fault relay module or residual voltage relay module, stages Iφ>, U_0> (SIGNAL 4)
	10-11	External blocking signal 2 for protection relay modules (BS2)
	11-12	External blocking signal 1 for protection relay modules (BS1)
X3	1-2	Input channel 1 of control module, open status (INPUT1/O). When e.g. the circuit breaker is open, voltage must be applied to the input
	1-3	Input channel 1 of control module, closed status (INPUT1/I). When e.g. the circuit breaker is closed, voltage must be applied to the input
	1-4	Input channel 2 of control module, open status (INPUT2/O)
	1-5	Input channel 2 of control module, closed status (INPUT2/I)
	6-7	Input channel 8 of control module (INPUT 8)
	6-8	Input channel 9 of control module (INPUT 9)
	9-10	Input channel 12 of control module (INPUT 12)
	11-12	Open output 1 of control module (OPEN 1)
	13-14	Close output 1 of control module (CLOSE 1)
	15-16	Open output 2 of control module (OPEN 2)
	17-18	Close output 2 of control module (CLOSE 2)

Terminal group	Contact interval	Function
X4	1-2	Input channel 3 of control module, open status (INPUT3/O)
	1-3	Input channel 3 of control module, closed status (INPUT3/I)
	1-4	Input channel 4 of control module, open status (INPUT4/O)
	1-5	Input channel 4 of control module, closed status (INPUT4/I)
	6-7	Input channel 10 of control module (INPUT 10) or external auto-reclose inhibit signal (ARINH)
	6-8	Input channel 11 of control module (INPUT 11) or energy pulse counter
	9-10	Input channel 13 of control module (INPUT 13)
	11-12	Open output 3 of control module (OPEN 3)
	13-14	Close output 3 of control module (CLOSE 3)
	15-16	Open output 4 of control module (OPEN 4)
	17-18	Close output 4 of control module (CLOSE 4)
X5	1-2	Input channel 5 of control module, open status (INPUT5/O)
	1-3	Input channel 5 of control module, closed status (INPUT5/I)
	1-4	Input channel 6 of control module, open status (INPUT6/O)
	1-5	Input channel 6 of control module, closed status (INPUT6/I)
	6-7	Input channel 7 of control module, open status (INPUT7/O)
	6-8	Input channel 7 of control module, closed status (INPUT7/I)
	9-10	Input channel 14 of control module (INPUT 14) or input for external autoreclose starting signal, not indicated by LED
	11-12	Open output 5 of control module (OPEN 5)
	13-14	Close output 5 of control module (CLOSE 5)
	15-16	Open output 6 of control module (OPEN 6)
	17-18	Close output 6 of control module (CLOSE 6)
X6	1-2	Signal output 5 of control module (SIGNAL 5)
	3-4	Signal output 6 of control module (SIGNAL 6)
	5-6	Not used
	7-8	mA input 1 (used only with optional measuring module SPTM 8A1)
	9-10	mA input 2 (used only with optional measuring module SPTM 8A1)

Protective earth is connected to its own screw on the rear panel. The screw is marked with the earth symbol.

The channel numbers above are equivalent to those used for setting the control module SPTO 6D3. The following codes are used for the outputs:

Output	Terminal numbers	Output code for inter-locking and configurat.	Output code for Direct Output Control
OPEN1	X3/11-12	20	220
CLOSE1	X3/13-14	21	221
OPEN2	X3/15-16	22	222
CLOSE2	X3/17-18	23	223
OPEN3	X4/11-12	24	224
CLOSE3	X4/13-14	25	225
OPEN4	X4/15-16	26	226
CLOSE4	X4/17-18	27	227
OPEN5	X5/11-12	28	228
CLOSE5	X5/13-14	29	229
OPEN6	X5/15-16	30	230
CLOSE6	X5/17-18	31	231
SIGNAL5	X6/1-2	40	40
SIGNAL6	X6/3-4	41	41

Note! When an object is opened and closed, the OPEN1 and CLOSE1, OPEN2 and CLOSE2 etc. always form pairs, e.g. OPEN1 output is used to open an object and CLOSE1 output is used to close the same object.

Signal diagram
(Modified 2000-10)

The initial factory settings of the feeder terminal may have to be changed in different applications. Fig. 7 below illustrates schematically how the input and output signals of the feeder terminal can be configured to obtain the required functions.

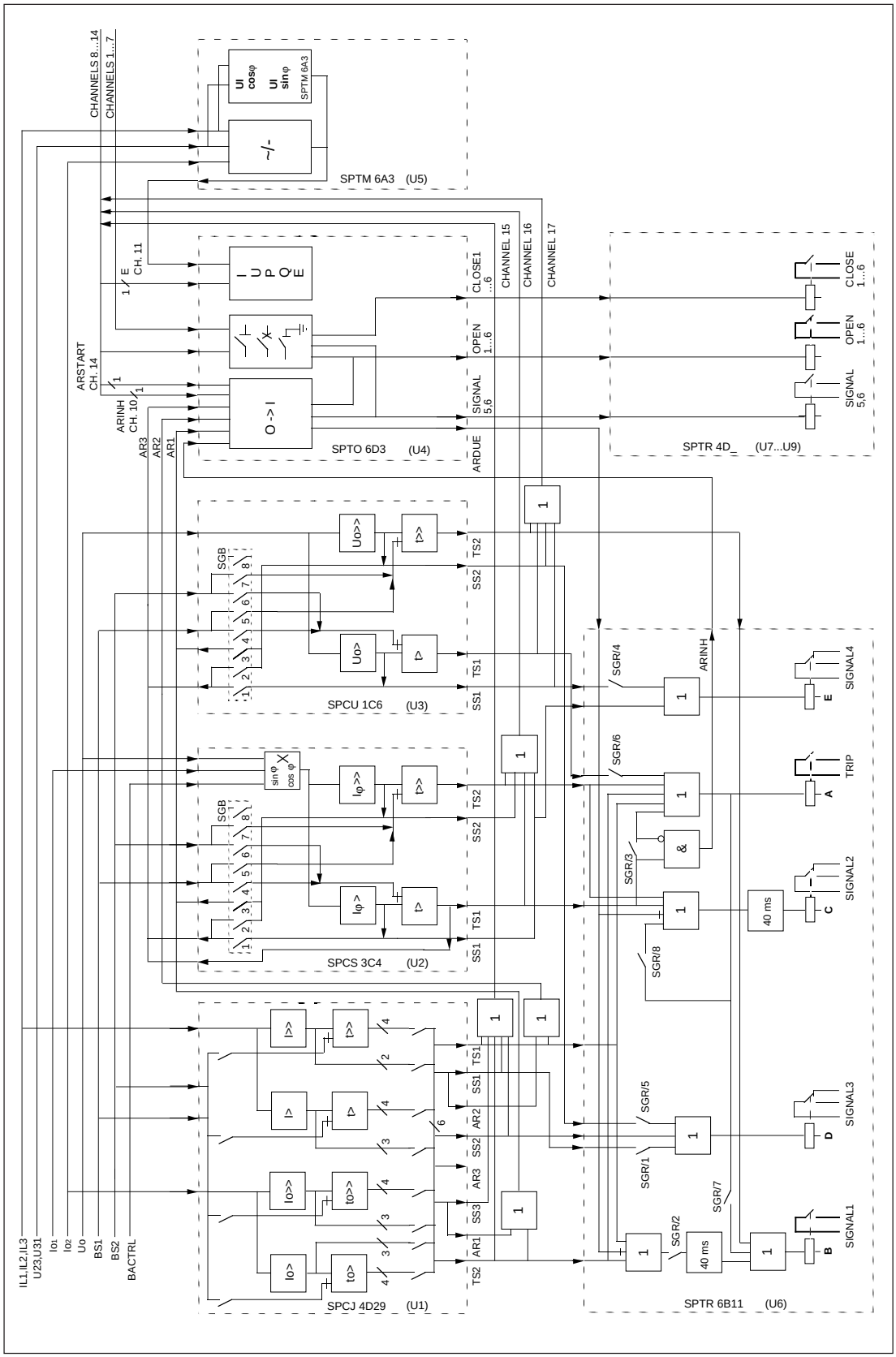


Fig. 7. Internal control signals between the modules in feeder terminal SPAC 539 C. The internal selector switches of the combined overcurrent and earth-fault relay module SPCJ 4D29 are shown in Fig. 8.

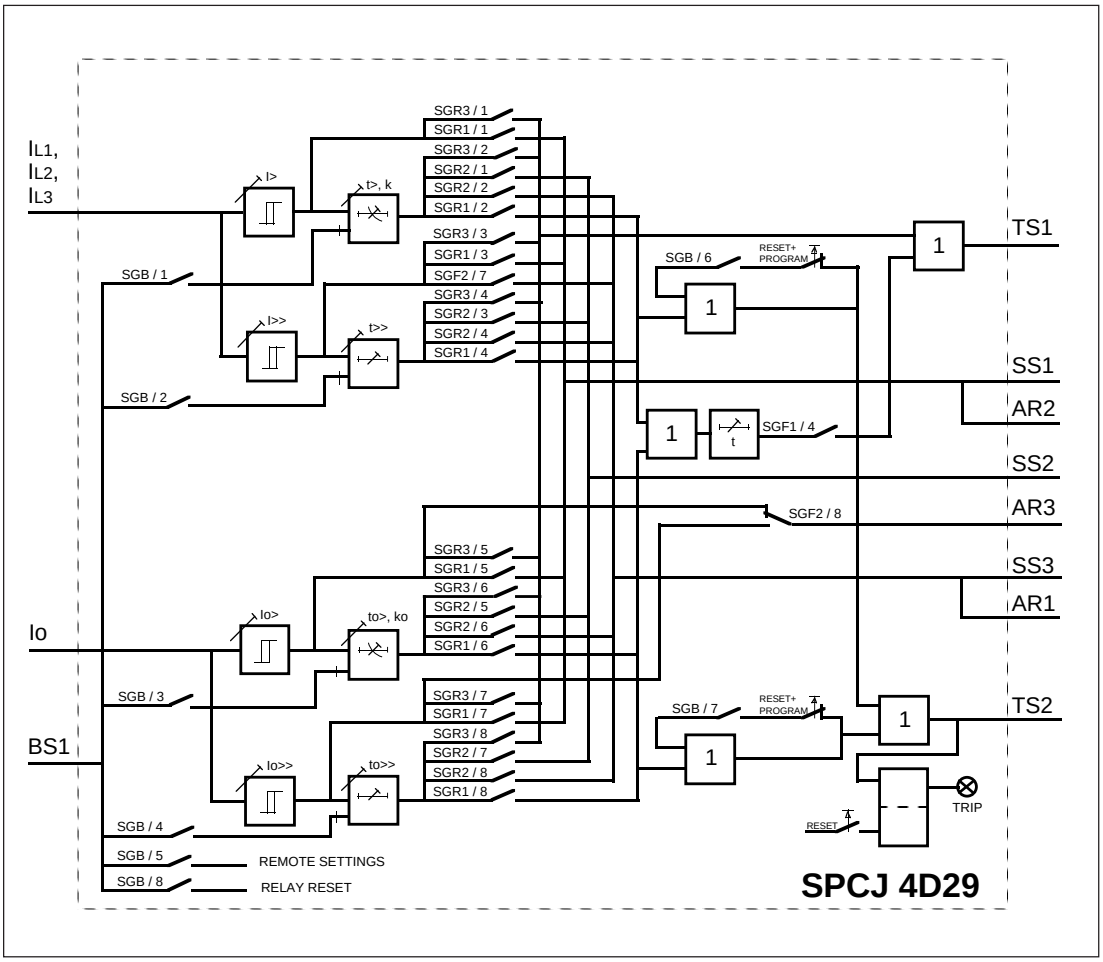


Fig. 8. Internal selector switches of the combined overcurrent and earth-fault relay module SPCJ 4D29

Part of the starting and tripping signals of the relay modules are permanently connected to control the outputs, whereas others are linked through switchgroup SGR situated at the front edge of the I/O module SPTR 6B11. The switches are set through the opening of the system front panel.

The following functions can be selected with the SGR switches:

Switch	Function	Default value
SGR/1	When SGR/1 = 1, the start signal SS1 of SPCJ 4D29 is routed to output SIGNAL3	1
SGR/2	When SGR/2 = 1, the signals TS1 and TS2 of SPCJ 4D29 are routed to output SIGNAL1	1
SGR/3	When SGR/3 = 1, the operate signal of stage Iφ> is routed to output TRIP	1
SGR/4	When SGR/4 = 1, the start signal of stage U_0> is routed to output SIGNAL4	0
SGR/5	When SGR5 = 1, the start signal of stage U_0>> is routed to output SIGNAL3	0
SGR/6	When SGR/6 = 1, the operate signal of stage U_0> is routed to output TRIP	1
SGR/7	When SGR/7 = 1, any signal connected to output TRIP is routed to output SIGNAL1	0
SGR/8	When SGR/8 = 1, any signal connected to output TRIP is routed to output SIGNAL2	0

Note!
Switch SGR/3: When SGR/3 = 0 and the Iφ> stage trips, the trip signal opens output SIGNAL2 and gives an internal auto-reclose inhibit signal. Thus the low-set earth-fault stage has a signalling function only.

Switch SGR/8: When SGR/8 = 1 the output SIGNAL2 can be used as a general alarm output for the protection relay modules, particulary when the output SIGNAL1 is used as a second trip output.

The operation of the outputs SIGNAL1 and 2 is delayed 40 ms when they are used to indicate that the overcurrent module and the earth-fault module have operated. This delay eliminates unnecessary signalling if auto-reclosing is started by the tripping signals of the relay modules. When an auto-reclose sequence has started the internal signal ARDUE inhibits the outputs SIGNAL1 and 2.

The switches of switchgroup SGB of the combined overcurrent and earth-fault relay module SPCJ 4D29 are used for configuration of the blocking and control inputs, and switchgroups SGR1, SGR2 and SGR3 for configuration of the output relay matrix. Relay module SPCJ 4D29 also includes the function selector switchgroups SGF1 and SGF2.

The selector switches of the combined overcurrent and earth-fault relay module type SPCJ 4D29 shown in Fig. 9 have the following functions which are alerted when the corresponding switches are set in position 1:

Switch in pos. 1	Function	Default setting	Weight factor
SGF1/4	The operation signal TS2 starts a timing circuit, which provides an operation signal TS1, which can be delayed 0.1…1.0 s	0	8
SGF2/7	Routes the start signal of the high-set overcurrent stage I>> to the auto-reclose start line AR1	0	64
SGF2/8	Routes the start signals of the low-set stage I_0> and high-set stage I_0>> of the earth-fault relay module to the auto-reclose start line AR3	0	128

SGB/1	Blocking of low-set stage I> via control input BS1	0	1
SGB/2	Blocking of high-set stage I>> via control input BS1	0	2
SGB/3	Blocking of low-set stage I_0> via control input BS1	0	4
SGB/4	Blocking of high-set stage I_0>> via control input BS1	0	8
SGB/5	Enables switching over from main settings to second settings by means of a control signal to the control input BS1	0	16
SGB/6	Latching on activation of the overcurrent signal TS2	0	32
SGB/7	Latching on activation of the earth-fault signal TS2	0	64
SGB/8	Remote resetting of latched output via control input BS1	0	128
	Checksum for the default settings of switchgroup SGB		0

SGR1/1	Routes the start signal of stage I> to SS1 and AR2	1	1
SGR1/2	Routes the operate signal of stage I> to TS2	1	2
SGR1/3	Routes the start signal of stage I>> to SS1 and AR2	0	4
SGR1/4	Routes the operate signal of stage I>> to TS2	1	8
SGR1/5	Routes the start signal of stage I_0> to SS1 and AR2	0	16
SGR1/6	Routes the operate signal of stage I_0> to TS2	1	32
SGR1/7	Routes the start signal of stage I_0>> to SS1 and AR2	0	64
SGR1/8	Routes the operate signal of stage I_0>> to TS2	1	128
	Checksum for the default settings of switchgroup SGR1		171

SGR2/1	Routes the operate signal of stage I> to SS2	1	1
SGR2/2	Routes the operate signal of stage I> to AR1	0	2
SGR2/3	Routes the operate signal of stage I>> to SS2	1	4
SGR2/4	Routes the operate signal of stage I>> to AR1	0	8
SGR2/5	Routes the operate signal of stage I_0> to SS2	0	16
SGR2/6	Routes the operate signal of stage I_0> to AR1	1	32
SGR2/7	Routes the operate signal of stage I_0>> to SS2	0	64
SGR2/8	Routes the operate signal of stage I_0>> to AR1	1	128
	Checksum for the default settings of switchgroup SGR2		165

Switch in pos. 1	Function	Default setting	Weight factor
SGR3/1	Routes the start signal of stage I> to TS1	0	1
SGR3/2	Routes the operate signal of stage I> to TS1	0	2
SGR3/3	Routes the start signal of stage I>> to TS1	0	4
SGR3/4	Routes the operate signal of stage I>> to TS1	0	8
SGR3/5	Routes the start signal of stage I_0> to TS1	0	16
SGR3/6	Routes the operate signal of stage I_0> to TS1	0	32
SGR3/7	Routes the start signal of stage I_0>> to TS1	0	64
SGR3/8	Routes the operate signal of stage I_0>> to TS1	0	128
	Checksum for the default settings of switchgroup SGR3		0

The output signal SS2 is directly connected and the output signal SS1 via switch SGR/1 connected to the output SIGNAL3. The output signals TS1 and TS2 are directly connected to the TRIP output and via switch SGR/2 to the output SIGNAL1.

The SGB switches on the PC board of the directional earth-fault module SPCS 3C4 and the residual voltage relay module SPCU 1C6 are used for routing the start signals of the relay module to the start initiation inputs of the auto-reclose unit. The SGB switches are also used for routing the incoming blocking signals to the protection stages.

Switch in pos. 1	Function	Default setting
SGB/1	Routes the starting signal of stage Iφ> to the start input AR3 of the auto-reclose unit (generally the start input of AR3 initiated by the low-set earth-fault stage)	1
SGB/2	Routes the starting signal of stage Iφ>> to the start input AR3 of the auto-reclose unit	0
SGB/3	Routes the starting signal of stage Iφ>> to the start input AR1 of the auto-reclose unit	0
SGB/4	Forms from the blocking input signal BS1 a blocking signal for the operation of stage Iφ>	0
SGB/5	Forms from the blocking input signal BS1 a blocking signal for the operation of stage Iφ>>	0
SGB/6	Forms from the blocking input signal BS2 a blocking signal for the operation of stage Iφ>	0
SGB/7	Forms from the blocking input signal BS2 a blocking signal for the tripping of stage Iφ>>	0
SGB/8	No function in SPAC 539 C. To be set in position 0	0

Note!
Only one of the switches SGB/2 and SGB/3 is allowed to be in position 1 at a time.

Switch in pos. 1	Function	Default setting
SGB/1	Routes the starting signal of stage U_0> to the start input AR3 of the auto-reclose unit	0
SGB/2	Routes the starting signal of stage U_0>> to the start input AR3 of the auto-reclose unit	0
SGB/3	Routes the starting signal of stage U_0>> to the start input AR1 of the auto-reclose unit	0
SGB/4	Forms from the blocking input signal BS1 a blocking signal for the operation of stage U_0>	0
SGB/5	Forms from the blocking input signal BS1 a blocking signal for the operation of stage U_0>>	0
SGB/6	Forms from the blocking input signal BS2 a blocking signal for the operation of stage U_0>	0
SGB/7	Forms from the blocking input signal BS2 a blocking signal for the tripping of stage U_0>>	0
SGB/8	No function in SPAC 539 C. To be set in position 0	0

Note!
Only one of the switches SGB/2 and SGB/3 is allowed to be in position 1 at a time.

All external conductors are connected to the terminal blocks on the rear panel. Terminal block X0 consists of fixed screw terminals fastened to the energizing input module. The connectors X1…X6 are detachable multi-pole connector strips with screw terminals.

The male part of the multi-pole connector strips are fastened to the mother PC board. The female parts with accessories are delivered together with the feeder terminal. The female connector part can be secured in place by means of fixing accessories and screws.

The measuring signal inputs are connected to terminal block X0. Each terminal is dimensioned for one max. 6 mm^2 or two max. 2.5 mm^2 wires.

Protective earth is connected to the screw, marked with the earth symbol.

The binary inputs and contact outputs of the protection relay modules are connected to the multi-pole connectors X1 and X2. The auxiliary power supply is connected to the multi-pole connector X1. The binary inputs, mA inputs and contact outputs of the control module are connected to the multi-pole connectors X3…X6. One max. 1.5 mm^2 wire or two max. 0.75 mm^2 wires can be connected to one screw terminal.

The serial interface RS 485 on the rear panel of the feeder terminal is intended for connection to the SPA bus (Rx/Tx). The SPA bus is connected by means of a connection module type SPA-ZC 17_ or SPA-ZC 21_. The bus connection module SPA ZC 21_ is fitted to the 9-pole D-type subminiature connector and screwed to the rear panel. The connection module type SPA-ZC 17_ is connected to the feeder terminal with the cable included in the delivery of the module and fastened to the wall of the switchgear cubicle with screws.

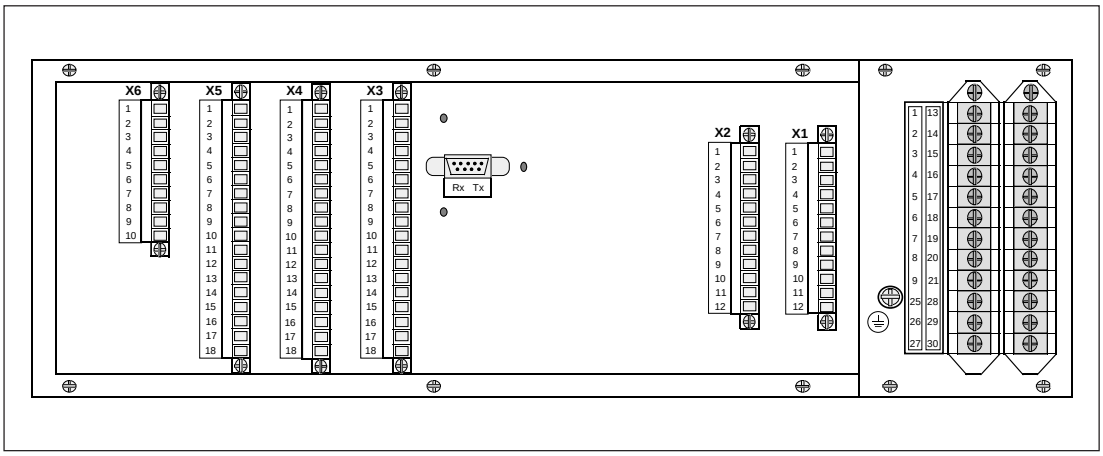


Fig. 9. Rear view of feeder terminal SPAC 539 C

The start-up should be done in accordance with the following instructions and advices. Checks 1 and 2 have to be done before the auxiliary power supply is connected.

1. Voltage ranges of the binary inputs

Before connecting a voltage to input channels 1…14, check the operative voltage range of the inputs. The voltage range, U_{aux} is marked on the front panel of the control module. See also chapter "Technical data".

2. Auxiliary supply voltage

Before switching on the auxiliary supply voltage, check the input voltage range of the power supply module. The voltage range, U_{aux} is marked on the front panel of the control module. See also chapter "Technical data".

3. Setting of the control module SPTO 6D3

All the nonvolatile EEPROM parameters have been given default values after factory testing. The default parameters are explained in the manual of the control module SPTO 6D3.

If the default parameters are not satisfactory, the following parameters can be set:

- Configuration; a user defined configuration
- Interlocking; a user defined interlocking
- OPEN and CLOSE outputs; pulse lenghts
- Auto-reclosing; auto-reclose sequence, dead times, reclaim time
- Measurements; ratio of primary current and voltage transformers, settings for active and reactive power measurement, settings for energy measurement
- Input channels 8…17; settings for polarity and output activation
- Event reporting; event masks, event delay times

The parameters can be set via the front panel RS 232 connection or the rear panel RS 485 connection using the SPA protocol. Instructions are given in the manual of the control module SPTO 6D3.

4. Settings of overcurrent and earth-fault modules SPCJ 4D29, the directional earth-fault relay module SPCS 3C4 and the residual voltage relay module SPCU 1C6

At the factory the switches of the protection relay modules have been given default values, see chapter "Signal diagram". In the combined overcurrent and earth-fault relay module SPCJ 4D29 all current and time settings are given their minimum values. The checksums of the default settings of the different switchgroups of SPCJ 4D29 are:

Switchgroup	Checksum
SGF1	0
SGF2	0
SGB	0
SGR1	171
SGR2	165
SGR3	0

During the factory tests the setting knobs of the directional earth-fault relay module SPCS 3C4 and the residual voltage relay module SPCU 1C6 are set in their middle position and the switches of switchgroup SG1 are set in position 0. The default settings of the switchgroups SGB on the PC boards of the modules are given in chapter "Signal diagram".

When auto-reclose functions or external blocking signals are to be used the positions of the switches of switchgroups SGB, SGR1…3 and SGF2 of the overcurrent and earth-fault relay module SPCJ 4D29 are to be checked. So are also the switches of switchgroup SGB of the directional earth-fault relay module SPCS 3C4 and the residual voltage relay module SPCU 1C6.

The settings of the overcurrent and earth-fault relay module SPCJ 4D29 can be given with the push buttons on the front panel of the relay module. The settings can also be given via the RS 232 port on the front panel or via the RS485 port on the rear panel of the feeder terminal.

Full information on the functions of the switches of the relay modules are given in the manuals of the combined overcurrent and earth-fault relay module SPCJ 4D29, the directional earth-fault relay module SPCS 3C4 and the residual voltage relay module SPCU 1C6 respectively.

Technical data
(Modified 2002-04)

Energizing inputs

Phase current inputs	1-3, 4-6, 7-9	1-2, 4-5, 7-8
Neutral current input (I_{02})	37-39	37-38
Rated current I_n	1 A	5 A
Thermal withstand capability		
- continuous	4 A	20 A
- for 1s	100 A	500 A
Dynamic current withstand,		
- half-wave value	250 A	1250 A
Input impedance	<100 mΩ	<20 mΩ
Neutral current inputs (I_{01})	25-27	25-26
Rated current I_n	0.2 A	1 A
Thermal withstand capability		
- continuous	2 A	4 A
- for 1s	50 A	100 A
Dynamic current withstand,		
- half-wave value	100 A	250 A
Input impedance	<750 mΩ	<100 mΩ
Input terminals	28-29	28-30
Rated voltage U_n	100 V	110 V
Continuous voltage withstand capacity	2 x U_n	2 x U_n
Rated burden at U_n	<0.5 VA	<0.5 VA
Rated frequency	50 Hz	
Rated frequency on request	60 Hz	

mA-inputs (only with measuring module SPTM 8A1)

Terminal numbers	
- active power	X6/7-8
- reactive power	X6/9-10
Input current range	-20…20 mA
Binary inputs of control module	
Terminal numbers	
- channels 1…7, four-pole inputs	X3/1-2, 1-3, 1-4, 1-5, X4/1-2, 1-3, 1-4, 1-5, X5/1-2, 1-3, 1-4, 1-5, 6-7, 6-8
- channels 8…14, single contact inputs	X3/6-7, 6-8, 9-10, X4/6-7, 6-8, 9-10, X5/9-10
Control voltage range	
- I/O module type SPTR 4D1	80…265 V dc
- I/O module type SPTR 4D2	30…80 V dc
Current drain	~2 mA

Binary inputs of relay modules

Terminal numbers	
- blocking inputs	X2/10-11, 11-12
- control input for operation mode Isinφ or Icosφ of earth-fault protection	X1/11-12
Control voltage range	18…265 Vdc or 80…265 Vac
Current drain	~2 mA

Energy pulse counter input (input channel 11)

Terminal numbers	X4/6-8
Maximum frequency	25 Hz
Control voltage range	
- I/O module type SPTR 4D1	80…265V dc
- I/O module type SPTR 4D2	30…80 V dc
Current drain	~2 mA

External auto-reclose inhibit input (input channel 10)

Terminal numbers	X4/6-7
Control voltage range	
- I/O module type SPTR 4D1	80…265 V dc
- I/O module type SPTR 4D2	30…80 V dc
Current drain	~2 mA

External auto-reclose start input (input channel 14)

Terminal numbers	X5/9-10
Control voltage range	
- I/O module type SPTR 4D1	80…265 V dc
- I/O module type SPTR 4D2	30…80 V dc
Current drain	~2 mA

Contact outputs

Control outputs	X1/3-4, 6-7, X3/11-12, 13-14, 15-16, 17-18, X4/11-12, 13-14, 15-16, 17-18, X5/11-12, 13-14, 15-16, 17-18
Rated voltage	250 V ac or dc
Contact capacity	
- continuous carry	5 A
- make and carry for 0.5 s	30 A
- make and carry for 3 s	15 A
Breaking capacity for dc, when the control circuit time constant L/R≤ 40 ms at the control voltage levels 48/110/220 V dc	5 A/3 A/1 A
Operating principle when controlled by the control module	pulse, pulse length 0.1…100 s
Signal outputs	X1/8-9-10, X2/1-2-3, 4-5-6, 7-8-9, X6/1-2, 3-4
Rated voltage	250 V ac or dc
Contact capacity	
- continuous carry	5 A
- make and carry for 0.5 s	10 A
- make and carry for 3 s	8 A
Breaking capacity for dc, when the control circuit time constant L/R≤ 40 ms at the control voltage levels 48/110/220 V dc	1 A/0.25 A/0.15 A

Auxiliary supply voltage

Built-in power supply module type and corresponding supply voltage range	
- type SPGU 240A1	80...265 V ac or dc
- type SPGU 48B2	18...80 V dc
Burden of auxiliary supply under quiescent/operating conditions	~15 W / ~20 W

Combined overcurrent and earth-fault relay module SPCJ 4D29

Low-set overcurrent stage I>	
Start current I>	0.5…5.0 x I_n
Selectable modes of operation	
- definite time operation	
- operate time t>	0.05…300 s
- inverse definite minimum time (IDMT)	
acc. to IEC 60255-3 and BS 142	Extremely inverse
	Very inverse
	Normal inverse
	Long-time inverse
- special type inverse characteristics	RI type inverse
	RXIDG type inverse
- time multiplier k	0.05…1.00
High-set overcurrent stage I>>	
Start current I>>	0.50…40.0 x I_n and ∞, infinite
Operate time t>>	0.04…300 s

Note! When the high-set stage starts the operation of the low-set stage is blocked, which means that on heavy fault currents the definite time high-set stage operates, rather than the IDMT low-set stage. Thus the operate time is determined by the t>> setting when the fault current exceeds the I>> setting. A precondition for the tripping of the I>> stage is that the output signal has been routed to the TRIP output.

Low-set neutral overcurrent stage I_0>	
Start current I_0>	0.10…0.80 x I_n
Seletable modes of operation	
- definite time operation	
- operate time t_0>	0.05…300 s
- inverse definite minimum time (IDMT)	
acc. to IEC 60255-3 and BS 142	Extremely inverse
	Very inverse
	Normal inverse
	Long-time inverse
- special type inverse characteristics	RI type inverse
	RXIDG type inverse
- time multiplier k_0	0.05…1.00
High-set neutral overcurrent stage I_0>>	
Start current I_0>>	0.10…10,0 x I_n and ∞, infinite
Operate time t_0>>	0.05…300 s

Directional earth-fault relay module SPCS 3C4

Low-set stage Iφ>	
Start current Iφ>	1.00…10.0% x I_n
Selectable modes of operation	I_0sinφ or I_0cosφ
Operate time t>	0.10…10.0 s
High-set stage Iφ>>	
Start current Iφ>>	1.00…40.0% I_n and ∞, infinite
Selectable modes of operation	I_0sinφ or I_0cosφ
Operate time t>>	0.10…1.00 s
Start level of the neutral displacement voltage U_0>	
- selectable values	2%, 5%, 10% or 20% of U_n

Residual voltage relay module SPCU 1C6

Low-set stage U_0>	
Start voltage U_0>	2.0…100% x U_n
Operate time t>	0.05…100 s
High-set stage U_0>>	
Start voltage U_0>>	2.0…80.0% x U_n and ∞, infinite
Operate time t>>	0.05…100 s

Control module SPTO 6D3

Control functions
- status indication for 7 objects, e.g. circuit breakers, disconnectors, earth switches
- circuit breaker/disconnector configuration freely selectable by the user
- remote or local control (open and close) for 6 objects
- setting range for output pulse lenght 0.1…100.0 s
- freely programmable feeder oriented interlocking

Measurement functions
- one pulse counter input for energy pulse counting, maximum pulse frequency 25 Hz
- other measurements require the use of an optional measuring module
- local and remote indication of measured data as scaled values

Measurement functions, with optional measuring module SPTM 8A1 (option 1)
- measurement of three phase currents and three phase-to-phase voltages
- measurement range for current 0...1,5 x I_n, for voltage 0...1,5 x U_n
- accuracy of current and voltage measurement ≥ ±1 % of rated value
- mA inputs for measurement of active and reactive power via external measuring transducers
- accuracy of power measurement ≥ ±1% of maximum value of measurement range
- the energy value can be integrated on the basis of the measured power, alternative to energy pulse counter

Measurement functions, with optional measuring module SPTM 6A3 (option 3)
- measurement of three phase currents and three phase-to-phase voltages
- measurement ranges, current 0...1,5 x I_n, voltage 0...1,5 x U_n
- accuracy of current and voltage measurement ≥ ±1% of rated value
- measurement of active and reactive power using one internal voltage signal and two current signals, the currents and voltage used are selected with switches
- power measurement range 0...1,1 x P_n and 0...1,1 x Q_n
- the energy value can be integrated by using the measured power, alternative to energy pulse counter

Auto-reclosing
- 5 auto-reclose shots
- starting time for auto-reclosing initiated by starting signals AR2 and AR3 0.00…5.00 s
- dead time, selectable 0.2…300.0 s
- reclaim time, selectable 0.2…300.0 s

Data communication

Rear panel	
- connection	RS-485, 9-pole, female
- fibre optic interface module	
- for plastic fibre cable	SPA-ZC17BB SPA-ZC21BB2
- for glass fibre cable	SPA-ZC17MM SPA-ZC21MM
Front panel	
- connection	RS 232, 9-pole, female
Data code	ASCII
Selectable data transfer rates	4800 or 9600 Bd

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	-10…+55 °C
Transport and storage temperature range	-40...+70 °C
Long term damp heat withstand according to IEC 60068- 2- 3	<95%, at 40 °C for 56 d
Degree of protection by enclosure when panel mounted	IP 20
Mass of the unit	about 8 kg

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

Maintenance and repairs

When the protective relay is used 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 abnormal physical or electrical wear under normal operating conditions.

If the environmental conditions differ from those specified, as to temperature and humidity, or if the atmosphere around the relay contains chemically active gases or dust, the relay should be visually inspected in association with the relay secondary testing. At the visual inspection the following things should be noted:

- Signs of mechanical damage to relay case and terminals
- Dust inside the relay cover or case; remove by blowing air carefully
- Rust spots or signs of erugo on terminals, case or inside the relay

If the relay fails in operation or if the operating values considerably differ from those mentioned in the relay specifications, the relay should be given a proper overhaul. Minor measures can be taken by personnel from the customer's instrument work-shop but 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 protection relays are measuring instruments and should be handled with care and protected against moisture and mechanical stress, especially during transport.

Exchance and spare parts

Control module	SPTO 6D3
Optional measuring module 1 (I, U, mA)	SPTM 8A1
Optional measuring module 3 (I, U, P, Q)	SPTM 6A3
Combined phase and neutral overcurrent relay module	SPCJ 4D29
Directional earth-fault relay module	SPCS 3C4
Residual voltage relay module	SPCU 1C6
I/O module for control signals, input voltage range 80…265 Vdc	SPTR 4D1
I/O module for control signals, input voltage range 30…80 Vdc	SPTR 4D2
I/O module for protection functions	SPTR 6B11
Power supply module, 80…265 V ac or dc	SPGU 240A1
Power supply module, 18…80 V dc	SPGU 48B2
Rack without plug-in modules	SPTK 8C5
Counter contacts for multi-pole connectors X1...X6 including accessories (included in relay delivery)	SPA-ZT6

Delivery alternatives

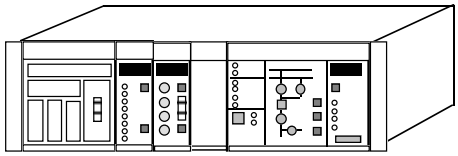
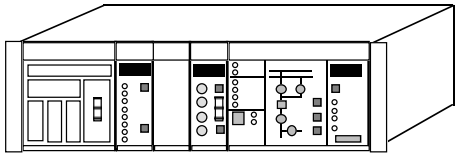
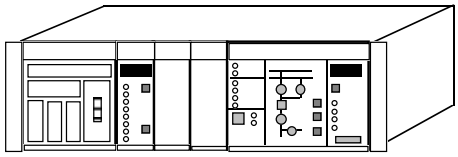
Illustration	Modules	Type
	Complete feeder terminal including a combined overcurrent and earth-fault module, a directional earth-fault module and a control module	SPAC 539 C1
	Partially equipped feeder terminal including a combined overcurrent and earth-fault module, a residual voltage module and a control module	SPAC 539 C2
	Partially equipped feeder terminal including a combined overcurrent and earth-fault module and a control module	SPAC 539 C3

Fig. 10. Delivery alternatives of feeder terminal SPAC 539 C

Order information

Please state the following information when ordering feeder terminals.

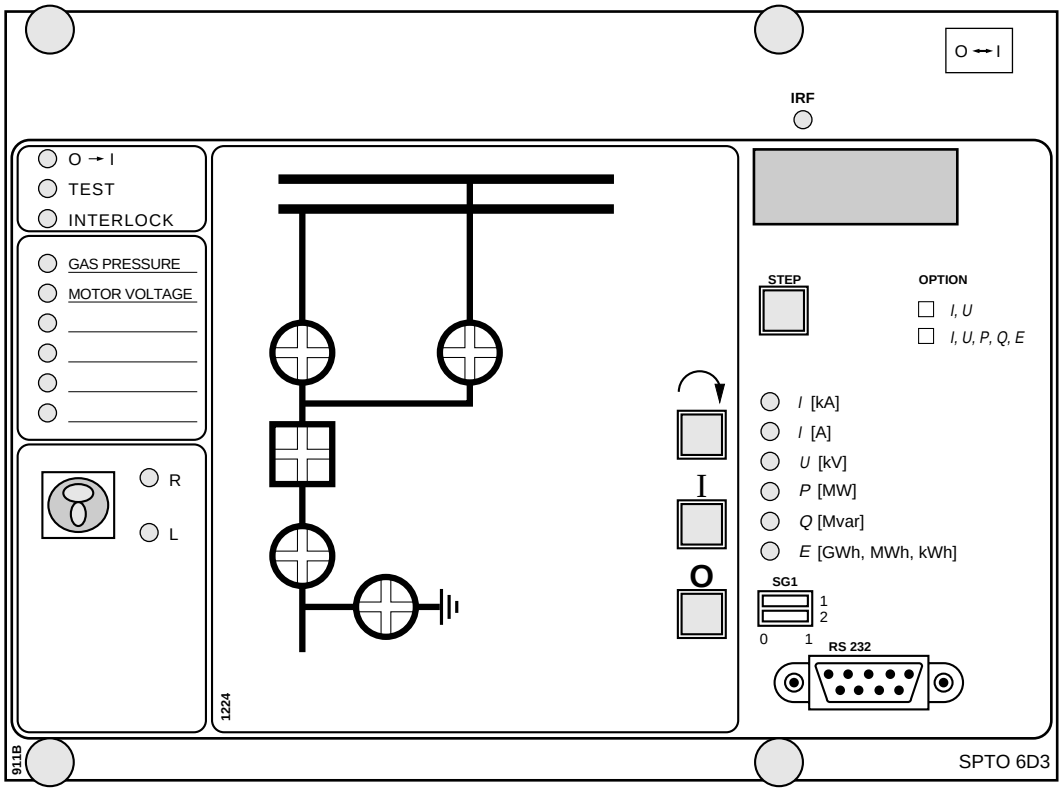
1. Quantity and type designation	15 units, SPAC	539 C1
2. Rated frequency	f_n = 50 Hz	
3. Auxiliary supply voltage	U_{aux}=110 V dc	
4. Type designation of configuration plate	15 pcs, SYKK 973	
5. Options	15 pcs, measuring module SPTM 8A1	
6. Accessories	15 pcs, bus connection module SPA-ZC17 MM2A	

The delivery includes 3 empty legend text films SYKU 997 for channels 8…13.

Different configuration plates are available for feeder terminals. The type designation of the configuration plate must be stated in the order.

SPTO 6D3
Control module

User´s manual and Technical description



1MRS 750202-MUM EN

Issued 96-03-06
Modified 96-12-30
Version B (replaces 34 SPTO 5 EN1)
Checked RH
Approved TLK

Data subject to change without notice

SPTO 6D3
Control module

Contents

Description of functions

Control functions

The control module type SPTO 6D3 is used for reading binary input signals and for local and remote status indication of the binary signals. The control module also executes open and close commands for controllable switching devices of the switchgear.

Input channels 1…7 are used for reading status information of the switching devices, i.e. circuit breakers and disconnectors here after called objects. Each of these channels include two physical inputs, one for the "object open" and one for the "object closed" information. The control module indicates the status information locally on the front panel by means of LED indicators and transfers the status information to the substation level communication equipment using the SPA serial bus.

The control module reads the status information of max. 7 objects. The front panel of the control module is provided with a LED matrix used for object status indication. The object status indication LEDs of the control module are freely configurable by the user to match the combinations of switching devices of the switchgear cubicles.

Input channels 8…17 consist of single binary input circuits. These channels are basically used for transferring binary signals, other than circuit breaker and disconnector status information signals, over the SPA bus to the substation level system. The status of input channels 8...13 is indicated locally by LEDs on the front panel of the control module.

The control module is capable of providing open and close commands for six objects. The commands may be given via the local push-buttons on the front panel, the SPA serial bus or the input channels 8…17. The length of the pulse-shaped OPEN or CLOSE signals can be determined by the user.

An enable signal must be given by the interlocking program before an OPEN or CLOSE pulse can be delivered. The enable signal is controlled by the status of input channels 1…7 and 8…17 and the interlocking program written by the user.

Signal outputs, SIGNAL5 and 6 can be used for indicating the status of the input channels 8…17.

The OPEN, CLOSE or SIGNAL outputs can be controlled by the Direct Output Control program. This program resembles the interlocking program. The user can define under which circumstances an output is to be activated. This control of an output is determined by the status of inputs 1…7 and 8…17, the position of the LOCAL/REMOTE key switch and the Direct Output Control Program written by the user.

Measurement functions

As a standard feature the control module SPTO 6D3 includes a pulse counter input by means of which energy pulse are counted. For additional measuring functions an optional measuring module is required. The optional module rectifies and processes the analog signals and forwards them to the control module, which incorporates the actual measuring software. Three types of optional measuring modules are available.

When the measuring module type SPTM 8A1 is used in combination with the control module SPTO 6D3 three phase currents, three phase-to-phase voltages and two mA signals can be measured. The mA inputs are used for measuring active and reactive power. External measuring transducers are needed.

When the measuring module type SPTM 6A2 is used in combination with the control module SPTO 6D3 three phase currents, three phase-to-phase voltages and active and reactive power can be measured. From the current and voltage input signals the measuring module forms the signals which are proportional to active power and reactive power using the Aron connection principle.

When the measuring module type SPTM 6A3 is used in combination with the control module SPTO 6D3 three phase currents, three phase-to-phase voltages as well as active and reactive power can be measured. From one voltage signal and two current signals the measuring module forms the signals which correspond to the three-phase active and three-phase reactive power. The voltage to be used and its related current signals can be selected by means of switches.

Input channel 11 can be used as a pulse counter input for energy pulses. Energy can also be calculated by integrating the measured power values over time.

The measured signals can be scaled for display locally and for remote transfer over the SPA bus as primary values.

Auto-reclosing

The control module SPTO 6D3 is capable of performing five auto-reclosings. Each auto-reclose cycle can be started by three different start initiation signals delivered by the protection relay modules of the feeder terminal. An auto-reclose system can deliver an open command to the breaker. Thus either the starting signal or the tripping signal of a particular protection relay module can be used for starting auto-reclose sequences.

In double busbar systems with two circuit breakers (duplex-systems) the auto-reclose function includes a so called duplex logic, which routes the closing command selectively to the circuit breaker last closed.

The dead times of the different auto-reclose cycles can be independently determined. The reclaim time can also be determined by the user.

Block schematic diagram *(modified 96-12)*

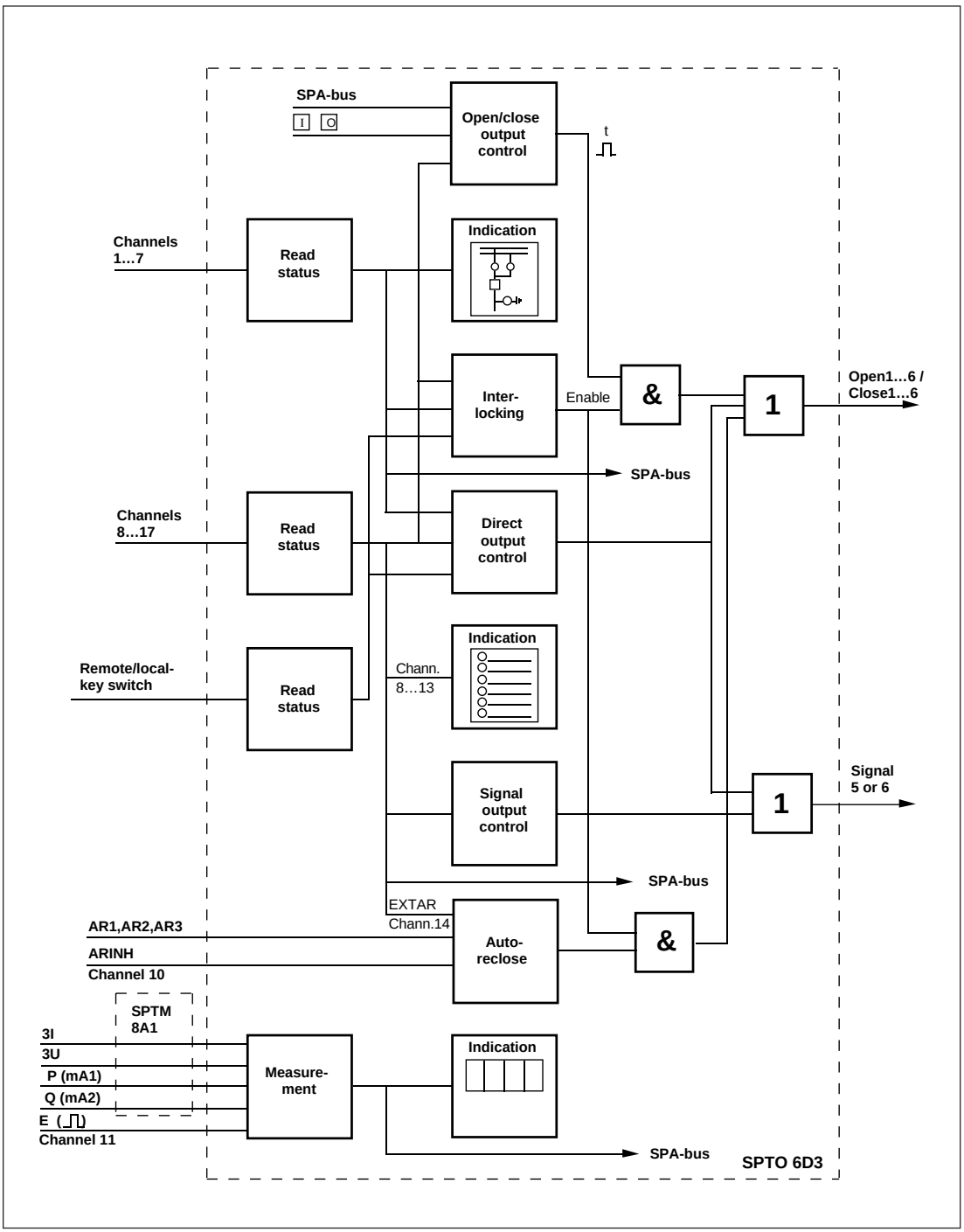


Fig. 1. Block schematic diagram for the control module SPTO 6D3 including an optional measuring module SPTM 8A1.

Front panel

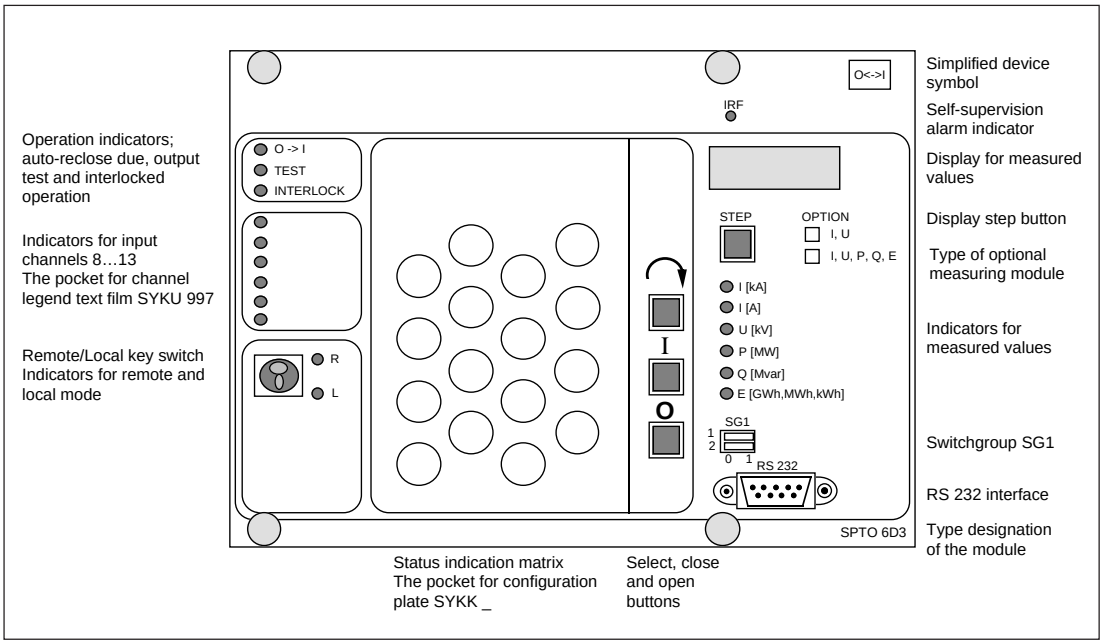


Fig. 2. Front panel of the control module SPTO 6D3 without the configuration plate SYKK _ and the channel legend text foil SYKU 997.

Object status indicators

The front panel includes 16 indicator units with each four rectangular LED indicators, two green and two red. The indicator units are used for local status indication of the circuit breakers and disconnectors of the switchgear cubicle. In the control module SPTO 6D3 seven of the 16 indicator units can be utilized at a time. The indicator units to be used are freely selectable by the user, see chapter "Configuration".

A plastic configuration plate type SYKK_ with a printed mimic diagram is inserted into a pocket in front of the object indicator units. The bottom of the pocket is open. By selecting a proper configuration plate and by configuring a new combination of indicator units different object configurations of the switchgear cubicle can be handled.

The configuration plate shows the combination of circuit breakers and disconnectors of the switchgear cubicle. The configuration plate features transparent windows for the status indicators that are in use. The status indicators not in use are hidden.

One indicator unit consists of four LEDs, two vertical and two horizontal. Two of the LEDs are red and two are green. The red LEDs are vertically and the green LEDs horizontally arranged in columns 1 and 3, see Fig. 6. In columns 2 and 4 the green LEDs are vertically and the red LEDs horizontally arranged. Due to this system both colours can be used to indicate either the open or closed status of a switching device.

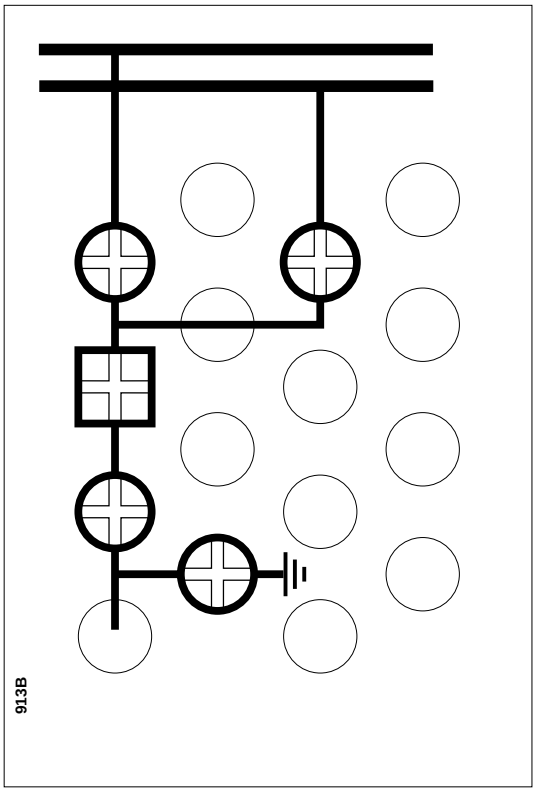


Fig. 3. Example of a plastic configuration plate SYKK __. The actual size of the configuration plate is 72mm x 106.5 mm.

Indicators for input channels 8…13

The status of the input channels 8…13 is indicated locally by LEDs on the front panel. Channel 8 is indicated by the topmost LED and channel 13 by the bottom LED.

An input can be defined to be active when the input signal is high (controlled by NO contact) or active when the input signal is low (controlled by NC contact). The LED is lit when the input is active.

The indication of the active status of the input channels 8...13 can be separately be programmed to be memory controlled. If an input channel indicator is memory controlled the LED indicator remains lit until the channel is locally reset by pressing the push-buttons STEP and SELECT simultaneously or by remote control via the serial interface using the parameter S5, which is given the value 0 or 1.

The front panel includes a pocket for the text legend foil SYKU 997 on which the user can write the input channel texts. An clear text foil is delivered with the feeder terminal.

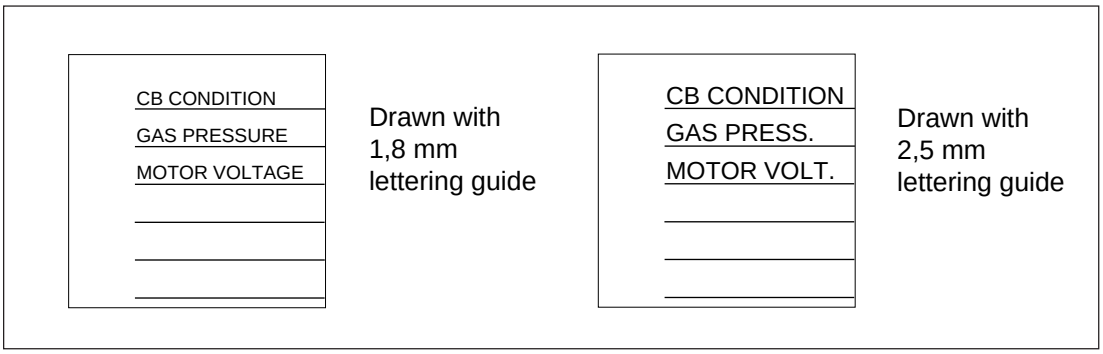


Fig. 4. Example of a text foil type SYKU 997. The foil is shown in its natural size, width 33.5 mm and height 34 mm.

Operation indicators

The control module features three red operation indicators which show the status of the module itself. These LEDs are normally dark. The indicators have the following functions:

Indicator	Function
O -> I	Indicates that an auto-reclose sequence is in progress. The LED is lit when an auto-reclose cycle starts and switched off when the auto-reclose programme delivers a close command.
TEST	The LED is lit when switch SG1/1=1. IN this switch position the interlocking function are out of use.
INTERLOCK	The LED is lit when a control command is given locally but the control of the object is prohibited by the interlocking program. The led indicator can be switched off by pushing the ∩ button but it is also automatically switched off after about 30 s. When the control module is in the programming mode and the interlockings are in use the indicator lights and it is switched off when the operation mode is entered or when the interlockings are set out of use.

LOCAL/REMOTE key switch

The local I and O push buttons, i.e. the OPEN and CLOSE push buttons, are made operative by turning the key switch into the position LOCAL, indicated by the yellow LED marked L. In this switch position all remote control signals via the serial interface are inhibited.

Accordingly, to be able to control an object via the serial interface, the key switch must be in the REMOTE position, indicated by the yellow LED marked R. When the key switch is in the REMOTE position, local push-button control is inhibited. Control signals via input channels 8...17 or the direct output control programme are allowed both in the LOCAL and the REMOTE position. The position information can also be included in the Direct Output Control function.

The key of the key switch can be removed in either position.

Push-buttons ∩, I and O

A local control sequence is started by pressing the ∩ push button. After that the indicator unit of the first object to be controllable starts flashing.

If the object is closed the indicator for the closed position starts flashing and if the object is open the indicator for the open position starts flashing. The indicator remains flashing until a control command is given or a timeout of 1 min has elapsed.

If the first object is not to be controlled, the ∩ push button is pressed again and the indicator of the second object to be controlled starts flashing.

The close and open commands are given with the I (close) and O (open) push-buttons. Depending on the status of inputs 1…7 and 8…17 and the interlocking function the control module either executes the selected command or switches on the INTERLOCK LED to indicate that the operation is inhibited.

The lenght of the control pulse can be set in the range 0.1…100 s.

Switchgroup SG1

Switch	Function
SG1/1	Switch SG1/1 is used to inhibit the interlockings during testing When SG1/1=0, the interlocking function is in use When SG1/1=1, the interlocking function is out of use and the red TEST LED is lit. All control operations are allowed. NOTE! Switch SG1/1 should be used only for test purposes!
SG1/2	Switch SG1/2 is used to inhibit autoreclosing When SG1/1=0, the auto-reclose function is in use. Also see parameter S78. When SG1/1=1, the auto-reclose function is inhibited.

Display of measured values and serial communication parameters

The displayed items can be stepped through by pressing the STEP push-button. The measured values are presented by the three rightmost green digits. A lit yellow LED indicator below the STEP push-button shows which measured value is indicated on the display.

Indicator	Data to be displayed
I [kA]	Measured phase currents I_{L1}, I_{L2} and I_{L3} in kiloamperes. The measuring range is 0.00…999 kA. The phase is indicated by the leftmost red digit 1, 2 or 3 on the display.
I [A]	Measured phase currents I_{L1}, I_{L2} and I_{L3} in amperes. The measuring range is 0.00…999 A. The phase is indicated by the leftmost red digit 1, 2 or 3 on the display.
U [kV]	Measured phase-to-phase voltages U_{12}, U_{23}, U_{31} in kilovolts. The measuring range is 0.00…999 kV. The measured voltage is indicated by the leftmost red digit 1, 2 or 3 on the display.
P [MW]	Measured active power in megawatts. Both positive and negative values are indicated. Positive values have no sign, negative values are indicated by a red minus sign.
Q [MVar]	Measured reactive power in megavars. Both positive and negative values are indicated. Positive values have no sign, negative values are indicated by a red minus sign.
E [GWh, MWh, kWh]	Measured active energy. The measured value is displayed in three parts; in gigawatthours, in megawatthours and in kilowatthours

The serial communication parameters, too, are presented on the four-digit display. The address of the data to be displayed is indicated by the leftmost red digit of the display.

Red digit	Data to be displayed
A	Serial communication address. Can have a value within the range 0…254. Default value 99.
B	Serial communication baudrate. Selectable transmission rates 4.8 or 9.6 kBd. Default value 9.6 kBd.
C	Serial communication monitor. If the module is connected to a higher level communicatin equipment and the communication system is operating, the monitor reading is 0, otherwise the numbers 0…255 are continuously scrolling in the display.

The display can be selected to show a measured value continuously or to be switched off after a 5 minutes timeout.

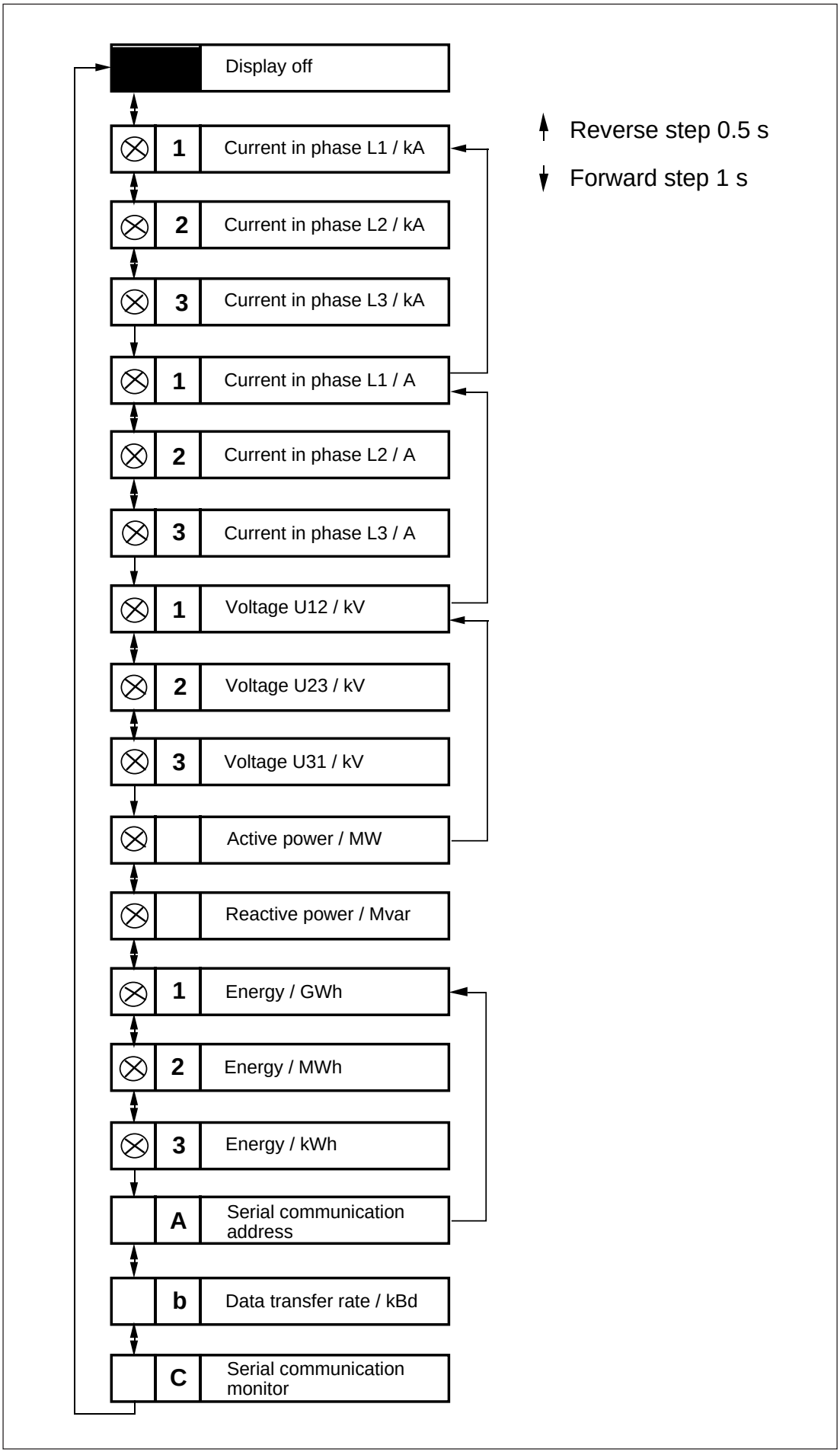


Fig. 5. Display menu of the control module SPTO 6D3.

RS 232 interface

The 9-pole RS 232 interface on the front panel is used for setting the control module via a PC. The entire serial communication of the feeder terminals goes over the control module. This means that also the relay modules of the feeder terminal are set via the RS 232 interface of the control module.

If a PC is connected to the RS 232 interface the RS 485 interface on the rear panel of the feeder terminal is disconnected. The use of the RS 232 interface requires a SPA bus protocol.

The following serial communication parameters should be used:

- Number of data bits, 7
- Number of stop bits, 1
- Parity, even
- Baudrate, 9.6 kilobauds as a default

The table below shows the signal names and pin numbers of the cable to be used between the RS 232 interface and the device used for setting.

RS 232 interface of SPTO 6D3		Setting device		
Signal name	Pin number 9-pin male conn.	Pin number 9-pin fem. conn.	Pin number 25-pin male conn.	Signal name
Data receive, Rx	2	3	2	Data transmit, Tx
Data transmit, Tx	3	2	3	Data receive, Rx
Earth	5	5	7	Earth
DSR	6	4	20	DTR
DTR, +12 V	4	-	-	-

Pin 4 of the RS 232 interface of the control module SPTO 6D3 can be used for feeding supply voltage to an optic modem. An optic modem may be necessary between the control module and the programming device if the possible potential difference cannot be eliminated.

Setting

Configuration

The control module SPTO 6D3 is capable of indicating status of seven objects (circuit breakers or disconnectors) and controlling (opening or closing) six objects.

The control module suits different circuit breaker/disconnector/earthing switch configurations within the above mentioned limits. The configuration can be freely selected by using the configuration commands explained below. After factory testing all indicators are set out of use and the user must select his own configuration.

The seven input channels 1…7 are used for reading status data of circuit breakers and disconnectors. The input channel numbers are used when the circuit breaker/disconnector configuration is set.

The code numbers of the indicatorm units on the front panel range from 101...116 and they are used when the feeder terminal is configured. The locatio and the code numbers of the indicator units in the matrix are shown in Fig. 6.

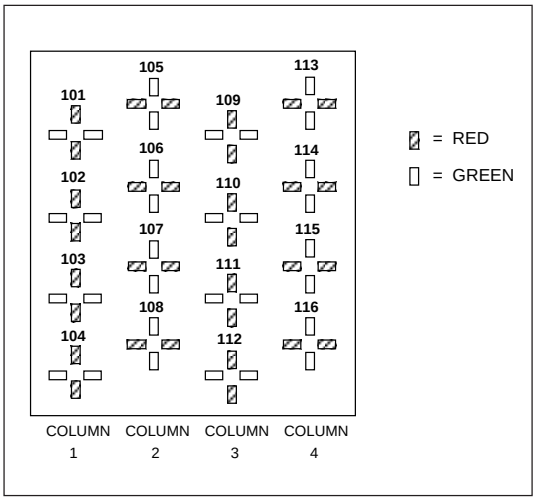


Fig. 6. Position, code number and colour of the indicator units on the front panel of the control module.

The control module has 12 control outputs, OPEN1…6 and CLOSE1…6 for the control of six objects. The control outputs have their own code numbers, 20...31, which have to be used when the control module is configured. The output code numbers correspond to the following functions:

Output code number	Function
20	OPEN1
21	CLOSE1
22	OPEN2
23	CLOSE2
24	OPEN3
25	CLOSE3
26	OPEN4
27	CLOSE4
28	OPEN5
29	CLOSE5
30	OPEN6
31	CLOSE6

For the correspondence between the input and output codes and the terminal numbers on the rear panel of the feeder terminal see chapter "Connection diagram" in the user´s manual for the feeder terminal.

A configuration is set by linking the indicator number, the four-pole input number and the output code number by using an SPA protrol command.

The setting parameters S101…S116 which correspond to the indicator code numbers 101…116 are reserved for the configuration commands. Either the OPEN code (e.g. 20) or the CLOSE code (e.g. 21) can be used as an output code number. Also some other parameters, such as object type and the location of open and closed status indicators, are specified in the SPA instruction.

Example 1:
Indicator 109 (parameter S109) indicates the status read via input channel 2. Output 20 is used to open the object and, consequently, output 21 must be used to close the same object. The object is a circuit breaker and closed status is indicated by vertical red LEDs.

Instruction format:

>99 WS 109:1,1,2,20,1:XX

- Type of object
  0 = not circuit breaker
  1 = circuit breaker
- Output code
  0 = object is not controlled
  20…31 = code of the OPEN or CLOSE output
- Input channel number
  Channels 1…7
- Defines the vertical/horizontal position of open/closed indication
  0 = vertical LEDs indicate open status (horizontal LEDs indicate closed status)
  1 = vertical LEDs indicate closed status (horizontal LEDs indicate open status)
- Specifies the use of the object indicator unit
  0 = not used
  1 = used
- Code number of object indicator unit
- Write Setting
- Data communication address
  Default value 99

Syntax rules for configuring the control module SPTO 6D3

1. The configuration work has to be done in the setting mode.
2. Up to seven objects can be configured (seven settings in the range of S101…S116)
3. Only the input channel numbers 1…7 are accepted. Any number can be used only once.
4. If no object indicator is used, no other values need to be given.
5. The output code numbers 20 …31 can be given only once. If the output code number is 0, the definition of the object (i.e. CB/other object) need not to be given.
6. Only two objects can be defined as circuit breakers

Normally, the control module is in the operation mode, which means that the interlocking program is in use. The configuration of the control module is made in the setting mode (S198=0).

When parameter S100 is 0, the configuration is freely selectable. For a freely selectable configuration, only those objects, which are to be used, need to be set.

Example 2:
To configure five objects (indicators 101, 109 and 103 for disconnectors, indicator 102 for a circuit breaker and indicator 108 for an earth switch), the following commands are required:

```
>99WS198:0:XX          ; Enter  into setting mode
>99WS100:0:XX          ; Enter into mode for free configuration
>99WS101:1,1,1,20,0:XX ; Disconnector 1:  vertical red LEDs indicate closed status
                                          for input channel 1.
                                          Control outputs OPEN1 and CLOSE1
>99WS109:1,1,2,22,0:XX ; Disconnector 2:  vertical red LEDs indicate closed status
                                          for input channel 2.
                                          Control outputs OPEN2 and CLOSE2
>99WS102:1,1,3,24,1:XX ; Circuit breaker: vertical red LEDs indicate closed status
                                          for input channel 3.
                                          Controloutputs OPEN3 and CLOSE3
>99WS103:1,1,4,0,0:XX  ; Disconnector 3:  vertical red LEDs indicate closed status
                                          for input channel 4.
                                          No control
>99WS108:1,0,5,0,0:XX  ; Earthing  switch: horizontal red LEDs indicate closed status
                                          for  input channel 5.
                                          No control
>99WV151:1:XX          ; Store the set parameters
```

After this the interlocking program has to be written before it is possible to open or close the circuit breaker and the disconnectors. See Chapter "Interlocking".

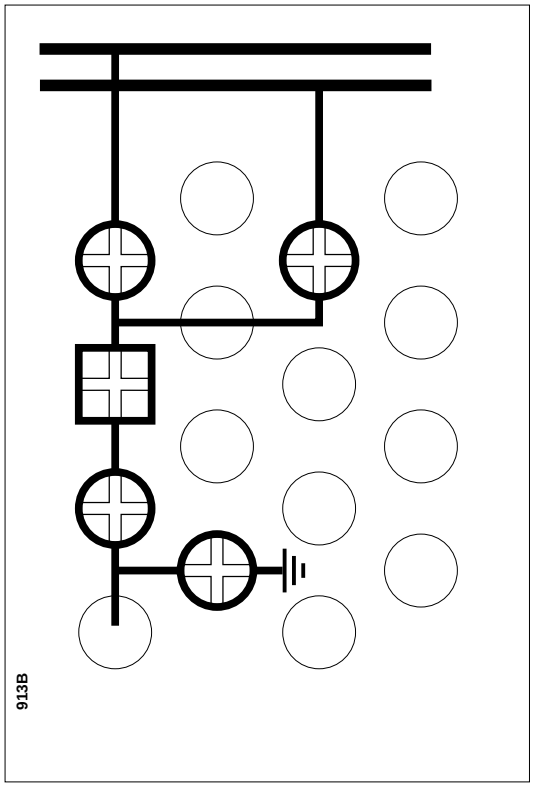


Fig. 7. Object configuration set in example 2.

The selected configuration can be read indicator by indicator or all together with one single instruction.

Example 3:
Reading the configurations of indicators 101… 116 by using one single instruction.

>99RS101/116:XX

This instruction will give the setting values of each indicator (101 to 116), including those not configured into the system. The parameter values of the indicators not in use are zero.

The interlocking program is used to inhibit the close or open command for a controllable object in certain situations. In practice the interlocking program of the control module SPTO 6D3 operates according to the permission principle, i.e. any control operation not enabled by the interlocking logic is inhibited.

The interlocking program of the control module reads the status of input channels 1…7 and 8…17 and enables the opening or closing of a controllable object when the actual open or close command is given with the local push-buttons or obtained via the serial bus or the input channels 8…17.

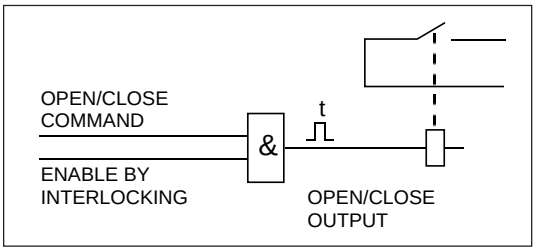


Fig. 8. Operation principle of the control functions.

When parameter S198 = 0, the control module is in the setting mode, and when parameter S198 = 1, the module is in the operation mode. When the control module is in the setting mode and the interlockings are in use the INTERLOCK indicator on the front panel is lit. In the operation mode the interlocking program is executed and it cannot be changed by the user. Only those operations enabled by the interlocking program can be executed.

In the setting mode the interlocking program is not executed and program changes can be made. In the setting mode the control of the objects is not allowed, except for the case that the interlockings are completely out of use.

The interlocking program, when used, is permanently operative both in the local and remote control mode, even when the control commands are given via input channels 8…17. The interlocking program is executed every 20 ms. The interlocking program can be taken completely out of use with setting S199 .

Example 4:
In example 2 a configuration was set. If no interlockings are to be used the setting continues with the following commands:

```
>99WS199:0:XX  ; Set interlockings out of
                 use
>99WV151:1:XX ; Store the set parameters
```

In this case when the interlocking program is not used, parameter S198 cannot be given the value 1. The status indication and object control is however operating normally.

The interlockings are set via the SPA bus by using a programming language according to the DIN 19239 standard. The structure of a program command is:

OPERATION is a logic command
OPERAND is the code number of an input or an output or the number of a temporary or a special register.

The following logic commands are used:

LOAD	Reads the status of an input or a register
LOADN	Reads the inverted status of an input or a register
AND	And operation
ANDN	And not operation
OR	Or operation
ORN	Or not operation
OUT	Writes to an output or a register
END	End of program

For inputs 1…7 a separate operand code is defined for each status, open, closed or undefined. The active status of inputs 8…17 can be used as operands in the logic.

In SPTO 6D3 the following operand values can be used with the operations LOAD, LOADN, AND, ANDN, OR, ORN :

```
1…7        = input channel number
             ; Input code, if the status " closed"
               is used in the logic
101…107 = input channel number  + 100
             ; Input code, if the status
               "undefined" is used in the logic
201…207 = input channel number  + 200
             ; Input code, if the status "open" is
               used in the logic
8…17       = input channel number
             ; Input code, if the status "active"
               is used in the logic
70…89      ; Number of a temporary register
60 and 61  ; Number of a special register
62         ; Position information of the L/R
               key switch
```

For the control module SPTO 6D3 the following operand values can be used with the OUT operation:

```
20…31      ;Output code number
70…89      ;Number of a temporary register
```

The input channel numbers and the output codes are the same as those defined when the configuration was set.

The two special registers, 60 and 61 have constant values; register 60 is always zero and register 61 is one. With register 62 the interlocking program is informed of the position of the L/R key switch. In the position L (Local) the value of the register is 0 and in the position R (Remote) the value is 1. The registers 70...89 are used as temporary data storages during the execution of an interlocking program.

Example 5:
How to store the result of a logic operation into a temporary register.

```
>99WM200:LOAD 201:XX
   ;Read the open status of an object wired
    to input 1
>99WM201:AND 202:XX
   ;Read the open status of an object wired
    to input 2
>99WM202:OUT 70:XX
   ;Write the result of the logic operation into
    register 70
```

After these commands the value of register 70 is 1, if both objects are open.

Example 6:
How to use input channels 8…17 in the logic.

```
>99WM200:LOAD 1:XX
   ;Read the closed status of an object wired
    to input 1
>99WM201:AND 8:XX
   ;Read the active status of input channel 8
>99WM202:OUT 20:XX
   ;Enable output 20
```

After these commands the output OPEN1 (code 20) is enabled if object 1 is closed and input channel 8 is active.

Syntax rules for setting the interlocking logic for the control module SPTO 6D3:

1. The setting has to be done in the setting mode.
2. With the interlocking program the user defines when it is allowed to open and close an object.
3. The setting parameters M200…M300 are used. A setting parameter is equal to the line number of the interlocking program.
4. The interlocking program always begins with M200. No empty lines are permitted.
5. The interlocking program always starts with a LOAD or LOADN command.
6. The last command of the program must be END.
7. One operand can be used only once with the OUT command.
8. Before the LOAD and LOADN commands, except for the first one, the OUT command should be used.
9. Before the END command the command OUT should be used

Example 7:
Setting of the interlocking logic. The configuration is the same as in example 2. The disconnectors 1 and 2 and the circuit breaker are to be controlled.

Opening of disconnector 1 is allowed only when the circuit breaker and disconnector 2 are open. Closing of disconnector 1 is allowed only when disconnector 2 is closed and the external input channel 8 is active.

Opening of disconnector 2 is allowed only when the circuit breaker and disconnector 1 are open. Closing of disconnector 2 is allowed only when disconnector 1 is closed and the external input channel 8 is active. This logic is not shown below because it is almost the same as that of disconnector 1.

Opening of the circuit breaker is always allowed. Circuit breaker closing is allowed when the status of disconnector 3 is not undefined and the earth switch is open.

Instead of these written interlocking conditions, the following logic diagram can be used:

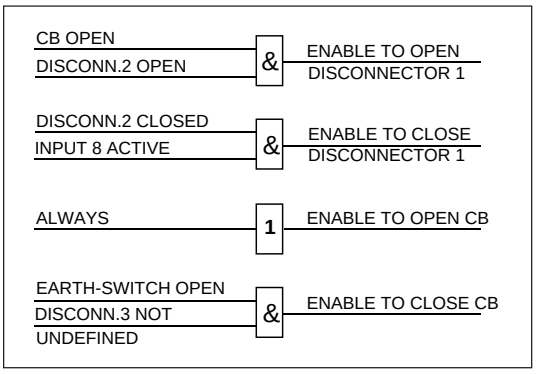


Fig. 9. Simplified logic diagram for the interlocking logic in example 7.

Below a detailed logic diagram is shown.

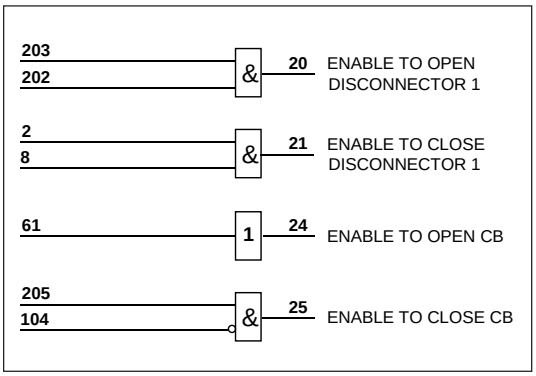


Fig. 10. Detailed logic diagram for the interlocking logic in example 7.

The program commands are written on the basis of the detailed logic diagram. As a default the program area M200…M300 is filled with END commands. The user overwrites these END commands with the actual interlocking program.

A configuration was set in example 2. If the interlockings described above are to be used the setting continues with the following commands.

The interlocking program for disconnector 2 is here not given:

```
>99WM200:LOAD 203:XX
   ;Read open status of CB
>99WM201:AND 202:XX
   ;Read open status of disconnector 2
>99WM202:OUT 20:XX
   ;Enable opening of disconnector 1 if CB
    and disconnector 2 are open
>99WM203:LOAD 2:XX
   ;Read the closed status of disconnector 2
>99WM204:AND 8:XX
   ;Read active status of input 8
>99WM205:OUT 21:XX
   ;Enable closing of disconnector 1 if  dis-
    connector 2 is closed and input 8 is active
>99WM206:LOAD 61:XX
   ;Read the value of special register 61
    (always 1)
>99WM207:OUT 24:XX
   ;Always enable open command of  CB
>99WM208:LOAD 205:XX
   ;Read open status of earth switch
>99WM209:ANDN 104:XX
   ;Read inverted undefined status (open or
    closed status) of disconnector 3
>99WM210:OUT 25:XX
   ;Enable closing  of CB if earth switch is
    open and disconnector 3 is open or closed
>99WM211:END:XX
   ;End of interlocking program

>99WS198:1:XX
   ;Change interlocking program into run
    mode
>99WS199:1:XX
   ;Starts interlocking program
>99WV151:1:XX
   ;Store the set parameters
```

The program is automatically compiled, when the operation mode is re-entered. If syntax errors are detected in the program, the interlocking program remains in the setting mode. When the syntax errors have been corrected the interlocking program can be changed to operation mode.

The interlocking program can be by-passed in two ways;

- For testing purposes the SG1/1 switch on the front panel can be turned into position 1. Then the interlocking program is interrupted and opening/closing of the object is always enabled.
- If the interlocking logic is to be taken out of use permanently variable S199 is set to 0. Then opening or closing of the object is always enabled.

The interlocking program does not affect the tripping signals of the protection relay modules.

Direct Output Control

The Direct Output Control logic controls the outputs OPEN1…6 and CLOSE1…6 plus the outputs SIGNAL5 and 6. Outputs that are not used for controlling an object or for signalling active status of inputs 8…17 can be controlled by the Direct Output Control function.

The outputs are activated in accordance with the selected logic diagram and the status of input channels 1…7 and 8…17. An output that has been controlled remains active as long as there is no such change in the status of the inputs, that the logic inhibits the control of the output.

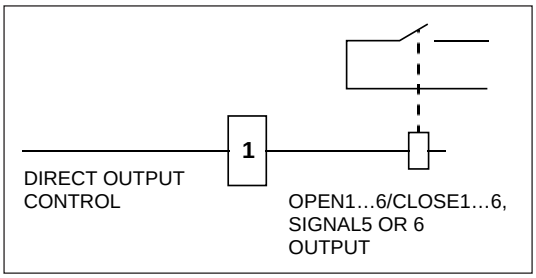


Fig. 11. Operation principle of the Direct Output Control.

The Direct Output Control program has the same setting principles and program structure as the interlocking program. The differencies between the two logic programs are;

- The codes of outputs OPEN1…6 and CLOSE 1…6
- The outputs SIGNAL5 and 6 can be controlled by the Direct Output Control program.

The output codes are:

Output code	Definition
220	OPEN1
221	CLOSE1
222	OPEN2
223	CLOSE2
224	OPEN3
225	CLOSE3
226	OPEN4
227	CLOSE4
228	OPEN5
229	CLOSE5
230	OPEN6
231	CLOSE6
40	SIGNAL5
41	SIGNAL6

The Direct Output Control program is written after the interlocking program using the SPA protocol commands M200…M300. These two programs have a common END command.

Example 8:
An interlocking logic was set in example 7. In this example a Direct Output Control logic program is added for the output SIGNAL5.

Output SIGNAL5 is to be activated if:

- Disconnector 3 is open and input channel 9 is activated

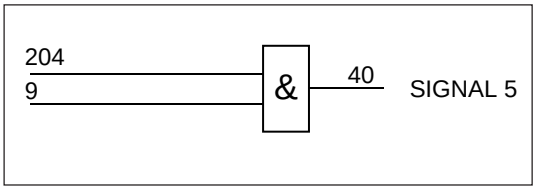


Fig. 12. Logic diagram for the Direct Output Control in example 8.

The Direct Output Control logic above is started with the following commands.

```
…
   ; Interlocking logic command lines
     M200…M210
>99WM211:LOAD 204:XX
   ; Read open status of disconnector 3
>99WM212:AND 9:XX
   ; Read active status of input 9
>99WM213:OUT 40:XX
   ; Activate SIGNAL5 output
>99WM214:END:XX
   ; End of program

>99WS198:1:XX
   ; Change program into run mode
>99WS199:1:XX
   ; Start program
>99WV151:1:XX
   ; Store the programmed parameters
```

Input channels 8…17
(modified 96-12)

The input channels 8…17 are used to read other binary signals than circuit breaker and disconnector status information. The binary signals can be external contact signals or internal binary signals e.g. starting and tripping signals of the protection relay modules. For the definition of internal and external signals see chapter "Intermodular control signal exchange" in the user´s manual of the feeder terminal.

The status of the binary inputs 8…17 can be read via the SPA-bus. The status of input channels 8…13 is also indicated locally with LEDs on the front panel. The LED of the activated input is lit and when the input is deactivated the indicator is switched off. The indicators of the input channels 8…13 can individually be set to be memory controlled, which means thatthe indicator of a channel activated once for at least 10 ms is not switched off until it has been reset.

Using parameter S2, each input channel can be selected to be active at high input signal state (1) or at low input signal state (0). High state activation means that an input is considered to be active if a voltage is applied on the corresponding external input or if a protection relay module has activated its output signal. Low state activation is the opposite to high state activation. As a default all the inputs are activated at high input signal state.

Characteristics of input channels 8…17:
- An events is formed by a status change
- The channels can be used to activate the outputs OPEN1…6 and CLOSE1…6
- The channels can be used to inhibit the outputs OPEN1…6 and CLOSE1…6
- The channels can be used to activate one of the outputs SIGNAL5 or 6
- The channels can be included in the interlocking logic
- The channels can be included in the Direct Output Control logic
- Channel 10 can be used as a control input for inhibiting auto-reclosings by means of an external control signal.
- Channel 11 can be used as an energy pulse counter input, see chapter "Scaling of measured values"
- Channel 14 can be used as external start initiation of auto-reclosing, see chapter "Auto-reclosing"

Via one input channel one signal output (SIGNAL5 or 6) and one control output (OPEN1…6 or CLOSE1…6) can be activated simultaneously. The interlocking logic is checked when the OPEN or CLOSE outputs are activated. The position of the REMOTE/LOCAL key switch has no effect when input channels 8…17 are used to activate the OPEN or CLOSE outputs.

Accordingly one SIGNAL output can be activated and one control output inhibited simultaneously. The output to be activated or inhibited is selected with parameters S3 and S4. The output to be activated or inhibited has to be configured to a circuit breaker or a disconnector.

If an input channel has been selected to control a SIGNAL output, the output is activated as long as the input is active. The length of the opening and closing pulse is defined by the SPA bus variables V5 and V6 and does not depend on the input pulse length.

Example 9:
Programming of input 8. The programming can be done in the operation mode.

```
>99W8S2:1:XX
   ;Define input 8 to be active at high
    state (1)
>99W8S3:40:XX
   ;Configure input 8 to activate output
    SIGNAL5
>99W8S4:20:XX
   ;Configure input 8 to activate output
    OPEN1
>99WV151:1:XX
   ;Store the programmed parameters
```

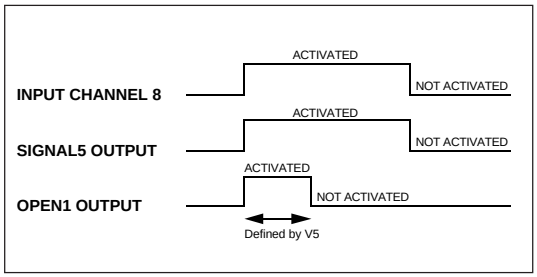


Fig. 13. Operation of outputs SIGNAL5 and OPEN1 when input channel 8 in example 9 is activated.

If an input channel is used to inhibit a control signal the opening or closing of an object is inhibited as long as the input is active. If the interlockings are set out of use (S199=0), input channels 8…17 cannot be used to inhibit the control of the OPEN and CLOSE outputs.

If input 11 operates as an energy pulse counter input or input 10 as a control input for inhibiting auto-reclose functions, these inputs cannot be used for other purposes. As a default input channels 8…17 operate as ordinary input channels, and do not activate or inhibit any outputs.

Outputs

The control module SPTO 6D3 has 14 outputs: two signal outputs (SIGNAL5 and 6) and 12 control outputs (OPEN1…6 and CLOSE1…6). For the purpose of setting the outputs are coded as follows:

Output	Output code for configuration and interlocking	Output code for Direct Output Control
OPEN1	20	220
CLOSE1	21	221
OPEN2	22	222
CLOSE2	23	223
OPEN3	24	224
CLOSE3	25	225
OPEN4	26	226
CLOSE4	27	227
OPEN5	28	228
CLOSE5	29	229
OPEN6	30	230
CLOSE6	31	231
SIGNAL5	40	40
SIGNAL6	41	41

The outputs OPEN1 and CLOSE1, OPEN2 and CLOSE2 etc. always form pairs. The OPEN output is used to open an object and the CLOSE output is used to close the same object.

The OPEN and CLOSE outputs can be controlled in four ways:
- Locally by means of the OPEN and CLOSE push buttons on the front panel of the control module
- Remotely with commands via the SPA bus
- Remotely via the binary inputs 8…17, see chapter "Input channels 8…17"
- By the Direct Output Control logic, see chapter "Direct Output Control"

In addition, the OPEN and CLOSE outputs are controlled by the auto-reclose unit, if the AR functions are in use.

For the selection of the objects to be controlled via the OPEN and CLOSE outputs, see chapter "Configuration".

When the first three ways of operation are used the OPEN and CLOSE outputs deliver pulses. Before an output can be activated the operation must be enabled by the interlocking logic.

The open and close pulse lengths of the outputs are determined by SPA bus variables V5 and V6. The pulse length has to be determined for the input channels to which the objects to be controlled are connected.

The pulse lenght can be set within the range 0.1…100 s with a time resolution of 0.1 s.

Example 10:
The pulse lenghts can be set in the operation mode. The following SPA bus commands are used to program the open and close pulse lengths. The object is configured to input channel 2.

```
>99W2V5:0.5:XX
   ; Set the open pulse length at 0.5 seconds
>99W2V6:0.2:XX
   ; Set the close pulse length at 0.2 seconds
>99WV151:1:XX
   ; Store the programmed parameters
```

The open and close commands are given via serial communication to the input channel on which the object to be controlled is located. The outputs OPEN1…6 and CLOSE1…6 can be controlled via serial communication according to two principles:

- Direct control: An output command is given by using parameter O1. When this parameter has been given the value 0 (open) or 1 (close) the corresponding output pulse is given provided the operation is enabled by the interlocking program.

- Secured control: Initially the output is set into a state of alert by means of parameter V1 for opening and parameter V2 for closing. After that the output command is executed by means of parameter V3, if enabled by the interlocking program. The state of alert is automatically cancelled when the execute command has been given. The state of alert can also be cancelled by parameter V4.

Example 11.
Open and close control via the serial bus. The object to be controlled has been configured to input channel 4 and the object is controlled by the outputs OPEN3 and CLOSE3. No interlockings are used.

```
>99WS198:0:XX
   ; Change into the setting mode
>99WS102:1, 1, 4, 24, 1:XX
   ; Object status information to input channel 4, control outputs OPEN3 and
     CLOSE3
>99WS199:0:XX
   ; Set interlockings out of use
>99WV151:1:XX
   ; Store set parameter values
>99W4V1:1:XX
   ; Open selection to the object of input
     channel 4 (secured control)
>99W4V3:1:XX
   ; Execute the selected open control
     command, i.e. OPEN3 activated
>99W4O1:1:XX
   ; Close the circuit breaker (direct control),
     i.e. CLOSE 3 activated
```

When the Direct Output Control logic is used to control the outputs OPEN1…6 and CLOSE 1…6, the output is activated as long as the control signal is active.

The operation of the outputs OPEN1…6 and CLOSE1…6 can be inhibited in two ways:
- By the interlocking program, see chapter "Interlocking"
- By input channels 8…17, see chapter "Input channels 8…17"

The outputs SIGNAL5 and 6 can be controlled in two ways:
- By input channels 8…17, see chapter "Input channels 8…17"
- By the Direct Output Control program, see chapter "Direct Output Control"

The control module SPTO 6D3 includes a self-supervision system which controls a signal output, IRF. The output is activated when the auxiliary power is connected and no fault has been detected by the self-supervision system. The output signal is deactivated, if the auxiliary power of the equipment is switched off or a permanent internal fault has been detected. The self -supervision output is connected to the common IRF output of the feeder terminal.

Scaling of measured values

The control module measures three phase currents, three phase-to-phase voltages, active and reactive power and energy. For energy pulse counting the control module includes a pulse counter input. Other measurements require an optional measuring module which rectifies and processes the analog measuring signals.

Measuring module SPTM 8A1 (optional)

The measuring module type SPTM 8A2 is used for processing the phase current and phase-to-phase voltage signals. This module also includes two mA inputs which are used for measuring active and reactive power via external measuring transducers. The module rectifies the phase current and the phase-to-phase voltage signals and converts the mA signals to voltage signals for further transfer to the control module.

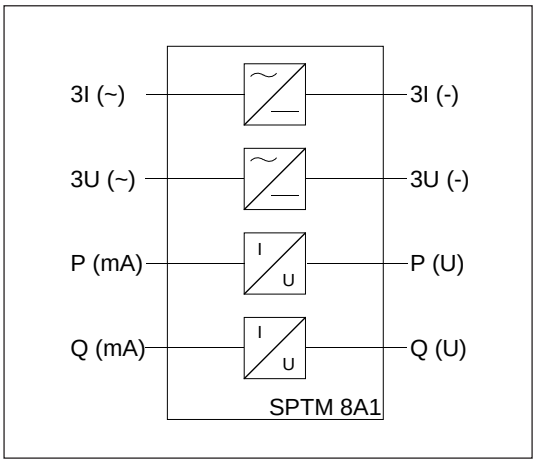


Fig. 14. Block diagram of measuring module SPTM 8A1.

Measuring module SPTM 6A2 (optional)

The optional measuring module type SPTM 6A2 is used for processing phase current and phase-to-phase voltage signals. This module also includes the electronics required to form, using internal current and voltage signals, measuring signals corresponding to active and reactive power, according to the Aron-connection principle. The measuring module SPTM 6A2 rectifies the phase current and the phase-to-phase voltage signals and routes them to the control module together with the signals proportional to the active and reactive power.

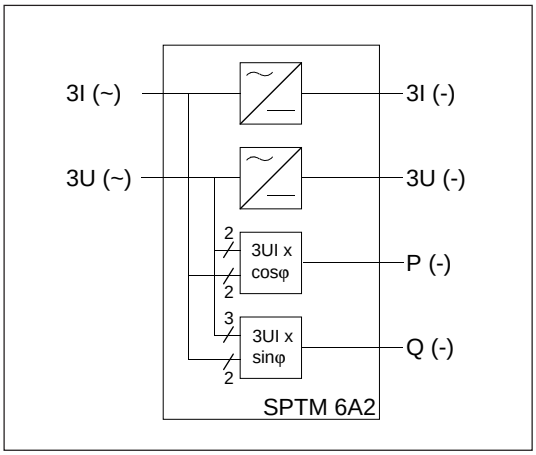


Fig. 15. Block diagram of measuring module SPTM 6A2.

Measuring module SPTM 6A3 (optional)

The measuring module type SPTM 6A3 is used for handling phase current and phase-to-phase voltage signals. This module also includes the electronics required to form signals which, using the internal current and voltage signals, generates signals corresponding to the active and reactive power. The power measurement is based on one voltage and two current signals. The voltage to be used and the corresponding currents can be selected with switches. The measuring module SPTM 6A3 rectifies the phase current and phase-to-phase voltage signals and transmits them to the control module together with the signals proportional to active and reactive power.

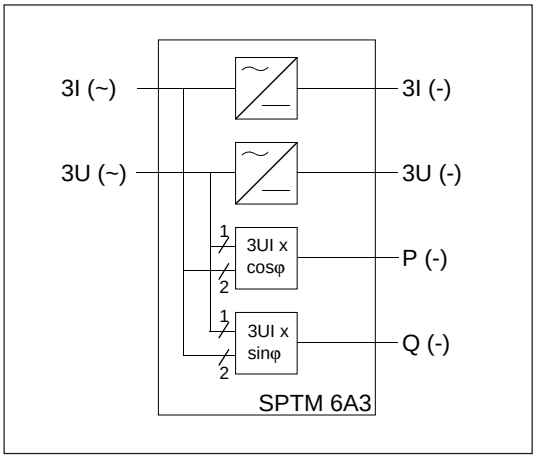


Fig. 16. Block diagram of measuring module SPTM 6A3.

Energy can be measured in two ways; by using input 11 as a pulse counter or by integrating the measured power. In the former case an external energy meter with pulse output is required.

Phase currents

The three phase currents are displayed locally as A and kA values and transferred via the SPA bus as ampere values. Prior to this, though, the measured values must be scaled, using the information about the rated current of the primary side of the current transformer.

Example 12:
Scaling of a measured phase current value.

The rated current of the primary side of the current transformers is 400 A. For scaling the current must be given in amperes. The scaling factor is 400.00.

```
>99WS9:400.00:XX
   ; Set scaling factor S9 at 400.00
>99WV151:1:XX
   ; Store the set parameters
```

The scaling factor can be set within the range 0.00…10000.00. Variable S9 has been given the default value 200.00 after factory testing.

Phase-to-phase voltages

The voltages are displayed locally and transferred via the SPA bus as kV values. Prior to this, though, the measured voltages have to be scaled by means of a scaling factor. The scaling factor is equal to the rated voltage of the primary side of the voltage transformers, divided by 100.

Example 13:
Scaling of a measured phase-to-phase voltage value.

The rated voltage of the primary side of the voltage transformers is 16 kV. For scaling the voltage must be given in volts. The scaling factor is 16000 / 100 = 160.00.

```
>99WS10:160.00:XX
   ; Set scaling factor S10 value 160.00
>99WV151:1:XX
   ; Store the set parameters
```

The scaling factor can be set within the range 0.00…10000.00. Variable S10 has been given the default value 210.00 after factory testing.

Active and reactive power

Active power is displayed locally and transferred via the serial bus as megawatt (MW) values. Correspondingly the value of reactive power is displayed locally and transferred via the serial bus as megavar (Mvar) values. The power is measured in both directions. Positive values have no sign and negative values are indicated by the red minus sign.

Power can be measured via an optional measuring module type SPTM 8A1 (option 1), SPTM 6A2 (option 2) or SPTM 6A3 (option 3). Because the measuring principle varies with the measuring modules, the possible option used must be programmed into the control module (parameter S90). In addition power measurement can be enabled or disabled with parameter S91. As a default power measurement is disabled (S91=0).

A) Power measurement via mA inputs (SPTM 8A1)

The input signal range of the mA-inputs is -20… 0...+20 mA. The following setting parameters are used for scaling the inputs:

S12 = Low limit of mA signal related to active power
S13 = High limit of mA signal related to active power
S14 = Low limit of mA signal related to reactive power
S15 = High limit of mA signal related to reactive power
S16 = Value of active power corresponding to mA signal at low limit
S17 = Value of active power corresponding to mA signal at high limit
S18 = Value of reactive power corresponding to mA signal at low limit
S19 = Value of reactive power corresponding to mA signal at high limit

When power measurement has been enabled the low and high limits of the mA signals are first given and then the corresponding values of active and reactive power.

Example 14:
Measurement of active power via optional measuring module SPTM 8A1.

Active power is to be measured in the range -50MW...+135 MW and the corresponding mA range is -20mA…20 mA.

```
>99WS90:1:XX
   ; Measuring module SPTM 8A1 is used
>99WS91:1:XX
   ; Enable power measurement
>99WS12:-20:XX
   ; Set low limit of mA signal
>99WS13:+20:XX
   ; Set high limit of  mA signal
>99WS16:-50.00:XX
   ; Set value of power corresponding to set
     low mA signal limit
>99WS17:+135.00:XX
   ; Set value of power corresponding to high
     mA signal limit
>99WV151:1:XX
   ; Store set parameters
```

Example 15:
Measurement of reactive power via optional measuring module SPTM 8A1. Reactive power is to be measured in the range 0... 2.2 Mvar and the corresponding mA signal range is 4...20 mA.

```
>99WS90:1:XX
   ; Measuring module SPTM 8A1 is used
>99WS91:1:XX
   ; Enable power measurement
>99WS14:+4:XX
   ; Set low limit of mA signal
>99WS15:+20:XX
   ; Set high limit of mA signal
>99WS18:+0.00:XX
   ; Set value of power corresponding to low
     mA signal limit
>99WS19:+2.20:XX
   ; Set value of power corresponding to high
     mA signal limit
>99WV151:1:XX
   ; Store set parameters
```

B) Power measurement using internal current and voltage signals, measuring modules SPTM 6A2 or SPTM 6A3.

In this case the measured power is automatically scaled when the measured current and voltage values are scaled. The correct measuring module must be selected and power measurement must be enabled.

Example 16:
Measurement of active and reactive power via optional measuring module SPTM 6A2 or SPTM 6A3. The current and voltage signals have been scaled already.

```
>99WS90:2:XX
   ; Measuring module SPTM 6A2 or
     SPTM 6A3 is used
>99WS91:1:XX
   ; Enable power measurement
>99WV151:XX
   ; Store the set parameters
```

The scaled active and reactive power values can be transmitted to remote control systems over the SPA, variable V3 for active power and variable V4 for reactive power.

Energy

Energy can be measured in two ways; either by using input channel 11 as an energy pulse counter or by integrating energy the measured power over time. The measured energy is displayed locally with three digits in three parts; in kilowatthours, in megawatthours and in gigawatthours. Correspondingly the energy value can be read via the serial bus in three parts with three digits (parameters V8…V10) but also as one part in kilowatthours with nine digits (parameter V5).

A. Use of input channel 11 as a pulse counter

Before input channel 11 can be used as a pulse counter input energy measurement must be enabled. The default setting of variable S92 is 0, which means that energy measurement is disabled.

The following parameters must be defined for channel 11:

S1 = definition of channel 11
- 0 = general binary input (default)
- 1 = pulse counter input without local LED indication on front panel
- 2 = pulse counter input with local LED indication on front panel

S2 = contact type
- 0 = break contact (NC contact)
- 1 = make contact (NO contact) (default)

The following parameters must be defined for channel 0:

S3 = definition of kWh value per pulse, setting range 0.00…1000 kWh. Default setting 1

Example 17:
Energy measurement via input 11 defined as pulse counter input.

```
>99WS92:1:XX
   ;Enable energy measurement
>99WS3:5:XX
   ;Set energy value 5 kWh per pulse
>99W11S1:1:XX
   ;Define  input 11 as a pulse counter input
    without local LED indication
>99W11S2:1:XX
   ;Make contact
>99WV151:1:XX
   ;Store set parameters
```

B. Energy measurement by integration.

Energy can also be measured by integrating the measured active and reactive power over time. In this case the measured active energy in one direction is displayed locally, whereas both positive and negative active and reactive energy values can be read over the SPA bus.

The integration is used automatically if energy measurement is enabled by parameter S92 and input channel 11 has not been defined as a pulse counter input.

Example 18:
Energy measurement by integrating the measured power value over time. First the power measurement must be enabled and the power values scaled, see examples 14…16.

```
>99WS92:1:XX
   ;Enable energy measurement
>99WV151:1:XX
   ;Store the set parameters
```

Auto-reclosing
(modified 96-12)

The control module SPTO 6D3 features an auto-reclose unit for five auto-reclose cycles. The unit obtains its start initiation signals from the protection relay modules. The start initiation signals are named AR1, AR2 and AR3.

The signals AR1, AR2 and AR3 are generated by the starting or tripping signals of the protection relay modules. The detailed function of the signals and their configuration are described in the general description of the feeder terminal, in chapter "Intermodular control signal exchange". Under the control of these signals the auto-reclose unit of the control module executes the required auto-reclose shots.

If the starting signals of the protection relay modules are used to initiate the auto-reclosing the control module opens the breaker after a preset time, the so called starting time. If the tripping signals of the protection relay modules are used to initiate auto-reclosing, the concerned protection relay module opens the breaker. In both cases the control module closes the circuit breaker after the preset dead time (see Fig. 17).

If required, external start initiation of auto-reclosing can be achieved via input channel 14. This input can be logically connected to one of the three initiation signals, AR1, AR2 or AR3. Setting parameter S1 is used for selecting the signal.

Each auto-reclose cycle has the following parameters, x = the number of the cycle + 1:

- Sx1 Defines if the auto-reclose cycle is to be started or inhibited when signal AR1 is activated
- Sx2 Defines if the auto-reclose cycle is to be started or not started when signal AR2 is activated
- Sx3 Defines if the auto-reclose cycle is to be started or not started when signal AR3 is activated
- Sx4 Defines the time (starting time) after which the control module opens the circuit breaker when signal AR2 is activated. Setting range 0.00…5.00 s in 0.1 s steps. If a tripping signal is used to initiate the auto-reclose cycle the starting time should be 0.00
- Sx5 Defines the time (starting time) after which the control module opens the circuit breaker when signal AR3 is activated. Setting range 0.00…5.00 s in 0.1 s steps. If a tripping signal is used to initiate the auto-reclose cycle the starting time should be 0.00
- Sx6 Defines the dead time of the auto-reclose cycle. Setting range 0.2…300.0 s in steps of 0.1 s.

Auto-reclose parameters and event codes for the auto-reclose functions.

	cycle 1	cycle 2	cycle 3	cycle 4	cycle 5
AR1 inhibits/starts	S21	S31	S41	S51	S61
AR2 does not start/starts	S22	S32	S42	S52	S62
AR3 does not start/starts	S23	S33	S43	S53	S63
Starting time from AR2	S24	S34	S44	S54	S64
Starting time from AR3	S25	S35	S45	S55	S65
Dead time	S26	S36	S46	S56	S66
AR in progress	E11	E16	E21	E26	E31
CB closed by AR	E12	E17	E22	E27	E32
AR from AR1 in progress	E13	E18	E23	E28	E33
AR from AR2 in progress	E14	E19	E24	E29	E34
AR from AR2 in progress	E15	E20	E25	E30	E35
Reclaim time	S77				
AR out of use/in use	S78				
Storing	V151				

If the control module is to carry out the final trip, the following parameters are to be set:

Function	Parameter
Final trip after AR from AR1 (0 or 1)	S71
Final trip after AR from AR2 (0 or 1)	S72
Final trip after AR from AR3 (0 or 1)	S73
Final trip time after AR from AR1	S74
Final trip time after AR from AR2	S75
Final trip time after AR from AR3	S76

Via the SPA bus the event codes E36…E38 of the final trip can be read.

Event	Code
Final trip after AR from AR1	E36
Final trip after AR from AR2	E37
Final trip after AR from AR3	E38

The reclaim time, parameter S77, is the same for all auto-reclose cycle. The setting range is 0.2…300.0 s. The auto-reclose function can be set out of use or alerted with parameter S78.

Each auto-reclose cycle can be started by any of the three start initiating signals AR1, AR2 and AR3. The signals to start the auto-reclose cycles are selected with the setting parameters Sx1…Sx3 via the SPA bus. If the setting Sx1 has the value 0, and signal AR1 becomes active the concerned cycle is inhibited. The cycles are always performed in the order 1, 2, 3, 4, 5 and final trip.

When the auto-reclose cycles are started by the signal AR1, the control module provides the CB opening command immediately, without a preceding start delay. The starting signals AR2 and AR3 can be given separate starting times for the separate auto-reclose cycles.

When lit the red LED marked O -> I on the front panel indicates that an auto-reclose cycle is in progress. The LED is lit when the starting time has elapsed and goes out when a CB close command is given. The output SIGNAL5 or 6 can be used to indicate that an auto-reclose cycle is in progress. The output is selected with parameter S80 and it operates in parallel with the LED indication.

The auto-relose function also carries out a final trip of the circuit breaker if the last programmed AR cycle also proves unsuccessful. The final trip function is selected with the setting parameters S71, S72 and S73 for the start initiating signals AR1, AR2 and AR3, in which case the auto-reclose function uses the control module's control outputs for tripping.

Final tripping by the auto-reclose module can be used when the start signals of the protection relay modules are used for initiating auto-reclosing. In this case the operation times of the protection relay modules must be longer than the corresponding trip time of the auto-reclose function. Each start initiating signal has its own trip delay, setting parameters S74…S76.

Outputs SIGNAL5 or 6 can be used to indicate that the control module has given a final trip signal. The output is selected with parameters S81…S83 for the initiating signals AR1…AR3. The length of the output pulse is the same as that of the open pulse.

For its operation the auto-reclose programme requires information about the circuit breaker status. When a signal from one of the protection relay modules requests starting of an auto-reclose cycle, the status of the circuit breaker is checked. If the circuit breaker is closed, an auto-reclose cycle starts.

When the dead time of the cycle has elapsed, the status of the circuit breaker is checked again. If the CB is open a closing command is delivered. Before the auto-reclose program opens or closes the circuit breaker it checks the interlocking program and if the operation is enabled the command is executed. During the dead time the closing of the circuit breaker is inhibited.

When an auto-reclose cycle (e.g. cycle 3) has been performed, the cycle in question and all previous cycles (cycle 1 and 2) will be blocked for the reclaim time. During the reclaim time a new start request after an unsuccessful cycle automatically starts the following cycle that has been programmed to start. The reclaim time following the auto-reclose cycle is effective as long as one of the protection relay modules continues requesting starting.

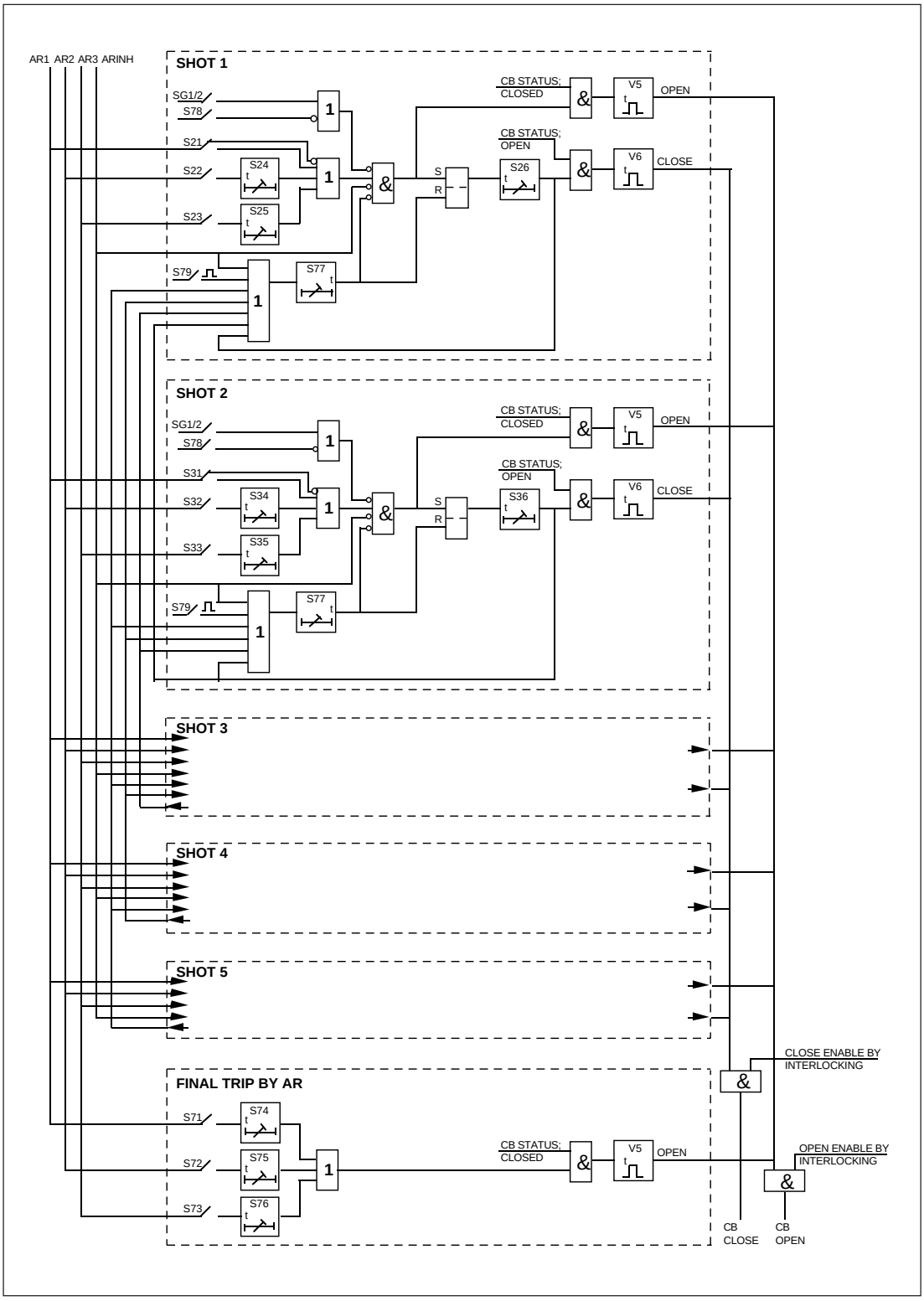


Fig. 17. Simplified block diagram for the auto-reclose functions in the control module SPTO 6D3.

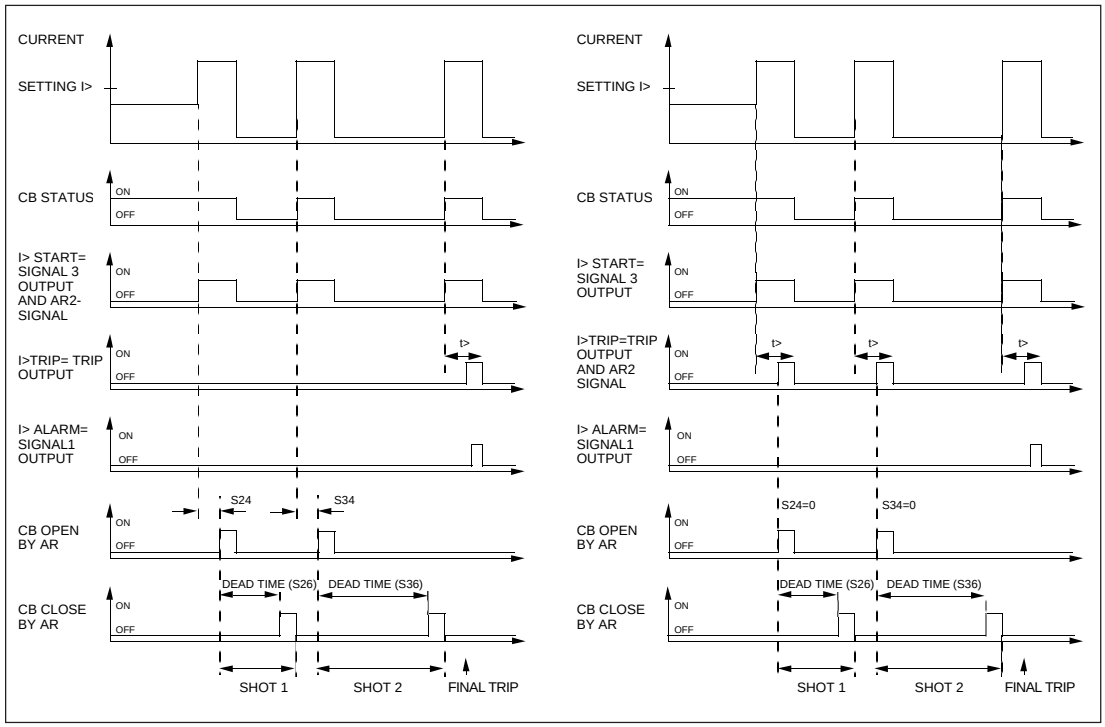


Fig. 18. a) Signal flow diagram for an AR cycle started by the start signal of the I> stage
b) Signal flow diagram for an AR cycle started by the trip signal of the I> stage

Auto-reclosing can be inhibited in the following ways;

- By setting input 10 in a special mode and applying an external voltage to the input. The inhibit function is active as long as a control voltage is applied to the input. When the voltage disappears the reclaim time starts.
- By giving the SPA bus variable S78 the value 0.
- By turning the front panel switch SG1/2 to position 1.

An auto-reclose sequence that has started can be interrupted in the following ways;

- By setting input 10 in a special mode and applying an external voltage signal to the input (signal ARINH).
- Via the SPA bus by means of variable S79.
- By giving an open command to a circuit breaker that is already open, during the dead time.

The reclaim time always starts when an auto-reclose sequence is interrupted.

When the circuit breaker is closed locally or via the serial bus the reclaim time starts and auto-reclosing is inhibited. Before the auto-reclose program opens or closes the circuit breaker the interlocking program is checked and if the operation is enabled it is executed.

For double busbar systems with two circuit breakers (duplex systems) the auto-reclose program includes a so called duplex logic. The duplex logic operates according to the following rules:

- The auto-reclose program always gives an open command to both circuit breakers
- The circuit breaker is considered to be closed if one of the breakers is closed, i.e. the closed status data is an or-function of the circuit breaker closed data
- The circuit breaker that was the last one to be closed will be closed by the auto-reclose program

Each auto-reclose cycle has four counters. One counter counts the total number of cycles. The other three counters are used for counting the cycles started by the start initiating signals AR1, AR2 and AR3. The counter value is incremented by one when the circuit breaker is closed.

Five event codes have been reserved for each auto-reclose cycle. One event code indicates that an auto-reclose cycle is in progress and another that a close pulse has been given. The other three codes indicate that an auto-reclose cycle is in progress and that it has been started by AR1, AR2 or AR3. The event "AR in progress" event is generated when the starting time of an AR cycle has elapsed.

The control module also gives a separate event code if a final trip has been performed, either by the protection relay modules or the auto-reclose function. Interruption of an auto-reclose cycle, too, generates an event code.

In addition to the event codes the auto-reclose function activates output data O1…O5 or O10 during an auto-reclose sequence.

Example19:
Setting of an auto-reclose sequence.

- Auto-reclosing is initiated by starting signals of the protection relay modules.
- Signal AR1 inhibits cycle 1 and 2 when activated
- Signal AR2 initiates cycle 1 when activated. Starting time 0.10 s
- Signal AR3 initiates cycle 1 and cycle 2 when activated. The starting time for both cycles is 0.50 s
- Dead time of cycle 1 is 0.3 s
- Dead time of cycle 2 is 120 s
- Reclaim time 5 s.

As a default setting the auto-reclose functions have been set out of operation (S78). Cycles 1 and 2 can be made operative just by giving parameter S78 the value 1. Then both cycles are initiated by the signals AR2 and AR3 and inhibited by signal AR1. Cycles 3…5 are not initiated by signals AR1…AR3.

Only parameters relating to auto-reclose cycles 1 and 2 are to be set. The default values for the parameters of the other cycles may be kept unchanged.

```
>99WS78:1:XX
   ; Take AR into use
>99WS21:0:XX
   ; Inhibit cycle 1 if AR1 is activated
>99WS22:1:XX
   ; Initiate cycle 1 if AR2 is activated
>99WS23:1:XX
   ; Initiate cycle 1 if AR3 is activated
>99WS24:0.10:XX
   ; Set AR2 starting time for cycle 1 at 0.1 s
>99WS25:0.50:XX
   ; Set AR3 starting time for cycle 1 at 0.5 s
>99WS26:0.3:XX
   ; Set cycle 1 dead time at 0.3 s
>99WS31:0:XX
   ; Inhibit cycle 2 if AR1 is activated
>99WS32:0:XX
   ; Cycle 2 not initiated if AR2 is activated
>99WS33:1:XX
   ; Initiate cycle 3 if AR3 is activated
>99WS35:0.50:XX
   ; Set AR3 starting time for cycle 2 at 0.5 s
>99WS36:120.00:XX
   ; Set cycle 2 dead time at 120 s
>99WS77:5.0:XX
   ; Set reclaim time at 5 s
>99WV151:1:XX
   ; Store set parameters
```

Note! It is not necessary to set parameter S34, AR2 starting time for cycle 2, because the AR2 signal does not initiate cycle 2.

Event codes

Over the SPA bus a substation level data communicator can read event data, such as status changes, transmitted by the control module SPTO 6D3. The events are represented, for instance, by the event codes E1…E11. The control module transmits its event data in the format:

<time> <channel number><event code>

where
time = ss.sss (seconds and parts of a second)
channel number = 0...17
event code = E1...E54, depending on the channel

Most of the event codes and the corresponding events can be included in or excluded from the event reporting by writing an event mask (V155…V158) to the control module. The event mask is a binary number coded to a decimal number. Each channel (0...17) has its own event mask.

Each event code is represented by a number. An event mask is formed by multiplying the corresponding number by either 1, which means that event is included in the reporting, or 0, which means that event is not included in the reporting and, finally, adding up the results of the multiplications.

Example 20: Calculation of an event mask value.

Channel	Event code	Event	Number representing the event	Event factor	Result of multiplication
2	E1	Change in status: xx ->10 (open)	1	x 1	= 1
2	E2	Change in status: xx ->01 (close)	2	x 1	= 2
2	E3	Change in status: xx ->11 (undefined)	4	x 0	= 0
2	E4	Change in status: xx ->00 (undefined)	8	x 1	= 8
2	E5	OPEN output activated	16	x 1	= 16
2	E6	OPEN output reset	32	x 0	= 0
2	E7	CLOSE output activated	64	x 1	= 64
2	E8	CLOSE output reset	128	x 0	= 0
2	E9	Output activation inhibited	256	x 1	= 256
2	E10	Failed to open or close	512	x 0	= 0
2	E11	Attempt to activate an output	1024	x 0	= 0
Event mask V155 for channel 2					347

The event masks V155…V157 of channel 0 may have a value within the range 0…1023 and the event mask V158 of channel 0 within the range 0…2047.

The event mask V155 of channels 8…17 may have a value within the range 0…15 and the event mask of channels 1…7 within the range 0…2047. The default values are shown in the next table.

Channels 1...17 have a setting S20, which enables or inhibits the event reporting of the concerned channel. The default value is 0, which means that event reporting is allowed according to the event mask.

The settings S10...S13 for channels 1...7 and the settings S10 and S11 for channels 8…17 define the event delays. The event delays are used to filter out unwanted events when status data is changing. An event code is generated only if the status data is stable for a longer time than the corresponding event delay, e.g. the event code E4 "change in status: xx -> 00" can be filtered out, when the status of an object is changing from open to close or vice versa. The time marking of a delayed event is the actual event time plus the delay time. The capacity of the event register is 100 events.

The control module has the following event codes:

Channel	Code	Event	Number representing the event	Default value of the event factor
0	E1	Key switch in position LOCAL	1	1
0	E2	Key switch in position REMOTE	2	1
0	E3	Output test switch (SG1/1) ON	4	0
0	E4	Output test switch (SG1/1) OFF	8	0
0	E5	Auto-reclosing ON	16	0
0	E6	Auto-reclosing OFF	32	0
0	E7	Auto-reclose interrupted	64	1
0	E8	AR interrupted by open command	128	0
0	E9	AR interrupted by ARINH input (external, variable S79)	256	0
0	E10	Close or open command by AR failed	512	0
				V155 = 67

0	E11	AR cycle 1 in progress	1	1
0	E12	CB closed by AR cycle 1	2	1
0	E13	Cycle 1 initiated by signal AR1 in progress	4	0
0	E14	Cycle 1 initiated by signal AR2 in progress	8	0
0	E15	Cycle 1 initiated by signal AR3 in progress	16	0
0	E16	Cycle 2 in progress	32	1
0	E17	CB closed by AR cycle 2	64	1
0	E18	Cycle 2 initiated by signal AR1 in progress	128	0
0	E19	Cycle 2 initiated by signal AR2 in progress	256	0
0	E20	Cycle 2 initiated by signal AR3 in progress	512	0
				V156 = 99

Channel	Code	Event	Number representing the event	Default value of the event factor
0	E21	AR cycle 3 in progress	1	1
0	E22	CB closed by AR cycle 3	2	1
0	E23	Cycle 3 initiated by signal AR1 in progress	4	0
0	E24	Cycle 3 initiated by signal AR2 in progress	8	0
0	E25	Cycle 3 initiated by signal AR3 in progress	16	0
0	E26	Cycle 4 in progress	32	1
0	E27	CB closed by AR cycle 4	64	1
0	E28	Cycle 4 initiated by signal AR1 in progress	128	0
0	E29	Cycle 4 initiated by signal AR2 in progress	256	0
0	E30	Cycle 4 initiated by signal AR3 in progress	512	0
				V157 = 99

0	E31	AR cycle 5 in progress	1	1
0	E32	CB closed by AR cycle 5	2	1
0	E33	Cycle 5 initiated by signal AR1 in progress	4	0
0	E34	Cycle 5 initiated by signal AR2 in progress	8	0
0	E35	Cycle 5 initiated by signal AR3 in progress	16	0
0	E36	Final trip by AR via signal AR1	32	0
0	E37	Final trip by AR via signal AR2	64	0
0	E38	Final trip by AR via signal AR3	128	0
0	E39	Final trip by signal AR1	256	1
0	E40	Final trip by signal AR2	512	1
0	E41	Final trip by signal AR3	1024	1
				V158 = 1795

1…7	E1	Change in status; xx -> 10 (open)	1	1
1…7	E2	Change in status; xx -> 01 (closed)	2	1
1…7	E3	Change in status; xx ->11 (undefined)	4	0
1…7	E4	Change in status; xx ->00 (undefined)	8	0
1…7	E5	OPEN output activated [1)]	16	1
1…7	E6	OPEN output reset	32	0
1…7	E7	CLOSE output activated	64	1
1…7	E8	CLOSE output reset	128	0
1…7	E9	Output activation inhibited [2)]	256	1
1…7	E10	Failed to open or close [3)]	512	1
1…7	E11	Attempt to activate an output without open/close selection [4)]	1024	1
				V155 = 1875

Channel	Code	Event	Number representing the event	Default value of the event factor
8…17	E1	Input channel activated	1	1
8…17	E2	Input channel reset	2	1
8…17	E3	SIGNAL5 or 6 output activated	4	0
8…17	E4	SIGNAL5 or 6 output reset	8	0
				V155 = 3

0	E50	Restarting	*	-
0	E51	Overflow of event register	*	-
0	E52	Temporary disturbance in data communication		-
0	E53	No response from the module over the data communication	*	-
0	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 set

In the SPACOM system the event codes E52…E54 are generated by the substation level control data communicator.

1) No event codes E5…E8 are obtained if the outputs are controlled by the Direct Output Control function.
2) Event E9, output activation inhibited, is obtained if the operation is inhibited by the interlocking program or by an input channel 8…17.
3) Event E10, open or close command failed, is obtained if the status of the controlled object does not change within the time of the output pulse.
4) Event E11, attempt to activate an output without open/close selection is obtained when a secured control is made in a situation where the state of alert has not been defined.

Quick reference for setting

If all the parameters are set at the same time, you should follow the instructions below when changing between setting and run mode and when storing the parameters.

The default values of the parameters relating to interlocking and configuration are:

S100 = 0
Freely selectable configuration and interlocking system
S198 = 0
The interlocking program is in setting mode
S199 = 1
Interlockings are in use

The following example shows the setting procedure.

Example 21:
To select a user-specific configuration and interlocking system.

```
>99WS198:0:XX
   ; Change into setting mode
>99WS100:0:XX
   ; Change into freely selectable mode
>99WS101:…
   ; Configuration commands
:
>99WM200:…
   ; Interlocking program
:
>99WS198:1:XX
   ; Change into run mode
:
Other parameters
:
>99WV151:1:XX
   ; Store set parametres
```

Serial communication parameters *(modified 96-12)*

Apart from the event codes the substation level data communicator is able to read, over the SPA bus, 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.

Data	Channel	Code	Data direction	Values
Current on phase L_1 (x I_n)	0	I1	R	0.00…1.50 x I_n (opt. 1, 2 or 3)
Current on phase L_2 (x I_n)	0	I2	R	0.00…1.50 x I_n (opt. 1, 2 or 3)
Current on phase L_3 (x I_n)	0	I3	R	0.00…1.50 x I_n (opt. 1, 2 or 3)
Voltage U_{12} (x U_n)	0	I4	R	0.00…1.50 x U_n (opt. 1, 2 or 3)
Voltage U_{23} (x U_n)	0	I5	R	0.00…1.50 x U_n (opt. 1, 2 or 3)
Voltage U_{31} (x U_n)	0	I6	R	0.00…1.50 x U_n (opt. 1, 2 or 3)
Active power (bits)	0	I7	R	-1023…1023 bits (opt. 1, 2 or 3)
Reactive power (bits)	0	I8	R	-1023…1023 bits (opt. 1, 2 or 3)
Current on phase L_1 (A)	0	I11	R	0…9999 A (opt. 1, 2 or 3)
Current on phase L_2 (A)	0	I12	R	0…9999 A (opt. 1, 2 or 3)
Current on phase L_3 (A)	0	I13	R	0…9999 A (opt. 1, 2 or 3)
Voltage U_{12} (kV)	0	I14	R	0.00…999.99 kV (opt. 1, 2 or 3)
Voltage U_{23} (kV)	0	I15	R	0.00…999.99 kV (opt. 1, 2 or 3)
Voltage U_{31} (kV)	0	I16	R	0.00…999.99 kV (opt. 1, 2 or 3)
AR start signal AR1	0	I21	R	0=not active 1=active
AR start signal AR2	0	I22	R	0=not active 1=active
AR start signal AR3	0	I23	R	0=not active 1=active
Internal ARINH signal	0	I24	R	0=not active 1=active
Object status	1…7	I1	R	0=undefined (inputs 00) 1=closed 2=open 3=undefined (inputs 11)
Closed status of an object	1…7	I2	R	0=not closed 1=closed
Open status of an object	1…7	I3	R	0=not open 1=open
Status of inputs 8…17	8…17	I1	R	0=not active 1=active
AR cycle1 in progress	0	O1	R	0=not in progress 1=in progress
AR cycle 2 in progress	0	O2	R	0=not in progress 1=in progress
AR cycle 3 in progress	0	O3	R	0=not in progress 1=in progress
AR cycle 4 in progress	0	O4	R	0=not in progress 1=in progress
AR cycle 5 in progress	0	O5	R	0=not in progress 1=in progress
AR in progress	0	O10	R	0=AR not in progress 1=AR cycle 1 in progress 2=AR cycle 2 in progress 3=AR cycle 3 in progress 4=AR cycle 4 in progress 5=AR cycle 5 in progress

Data	Channel	Code	Data direction	Values
Direct output control	1…7	O1	W	0=open 1=close
Open select (secured operation)	1…7	V1	RW	0=open 1=closed
Close select (secured operation)	1…7	V2	RW	0=open 1=closed
Execute selected open/close operation	1…7	V3	W	1=execute selected operation
Cancel selected open/close operation	1…7	V4	W	1=cancel selected operation
Open pulse length	1…7	V5	RW(e)	0.1…100.0 s
Close pulse length	1…7	V6	RW(e)	0.1…100.0 s
Execute selected open/close operation (common addr. 900)	0	V251	W	1=execute all selected operations
Cancel selected open/close operation (common addr. 900)	0	V252	W	1=cancel all selected operations
kWh value per pulse	0	S3	RW(e)	0.01…1000 kWh per pulse
Position of switch SG1/2	0	S5	R	0=AR in use (SG1/2=0) 1=AR out of use (SG1/2=1)
Position of switch SG1/1	0	S6	R	0=operation position (SG1/1=0) 1=interlockings off (SG1/1=1)
Object indication mode	0	S7	RW(e)	0=continuous display 1=automatic switch off after 10 min.
Display indication mode	0	S8	RW(e)	0=continuous display 1=automatic switch off after 5 min.
Scaling of current measurement	0	S9	RW(e)	0.00…10000.00 (opt. 1, 2 or 3)
Scaling of voltage measurement	0	S10	RW(e)	0.00…10000.00 (opt. 1, 2 or 3)
Low limit for mA signal of active power	0	S12	RW(e)	-20…+20 mA (opt. 1)
High limit for mA signal of active power	0	S13	RW(e)	-20…+20 mA (opt. 1)
Low limit for mA signal of react. power	0	S14	RW(e)	-20…+20 mA (opt. 1)
High limit for mA signal of react. power	0	S15	RW(e)	-20…+20 mA (opt. 1)
Active power corresponding to mA signal at low limit	0	S16	RW(e)	-999.99…+999.99 MW (opt. 1)
Active power corresponding to mA signal at high limit	0	S17	RW(e)	-999.99…+999.99 MW (opt. 1)
Reactive power corresponding to mA signal at low limit	0	S18	RW(e)	-999.99…+999.99 Mvar (opt. 1)
Reactive power corresponding to mA signal at high limit	0	S19	RW(e)	-999.99…+999.99 Mvar (opt. 1)

Data	Channel	Code	Data direction	Values
AR cycle 1 initiated by signal AR1	0	S21	RW(e)	0=AR cycle 1 inhibited by signal AR1 1=AR cycle 1 started by signal AR1
AR cycle 1 initiated by signal AR2	0	S22	RW(e)	0=AR cycle 1 not started by signal AR2 1=AR cycle 1 started by signal AR2
AR cycle 1 initiated by signal AR3	0	S23	RW(e)	0=AR cycle 1 not started by signal AR3 1=AR cycle 1 started by signal AR3
Start time of AR cycle 1 initiated by AR2	0	S24	RW(e)	0.00 ... 5.00 s
Start time of AR cycle 1 initiated by AR3	0	S25	RW(e)	0.00 ... 5.00 s
Dead time of AR cycle 1	0	S26	RW(e)	0.2 ... 300 s
AR cycle 2 initiated by signal AR1	0	S31	RW(e)	0=AR cycle 2 inhibited by signal AR1 1=AR cycle 2 started by signal AR1
AR cycle 2 initiated by signal AR2	0	S32	RW(e)	0=AR cycle 2 not started by signal AR2 1=AR cycle 2 started by signal AR2
AR cycle 2 initiated by signal AR3	0	S33	RW(e)	0=AR cycle 2 not started by signal AR3 1=AR cycle 2 started by signal AR3
Starting time of AR cycle 2 initiated by AR2	0	S34	RW(e)	0.00 ... 5.00 s
Starting time of AR cycle 2 initiated by AR3	0	S35	RW(e)	0.00 ... 5.00 s
Dead time of AR cycle 2	0	S36	RW(e)	0.2 ... 300.0 s
AR cycle 3 initiated by signal AR1	0	S41	RW(e)	0=AR cycle 3 inhibited by signal AR1 1=AR cycle 3 started by signal AR1
AR cycle 3 initiated by signal AR2	0	S42	RW(e)	0=AR cycle 3 not started by signal AR2 1=AR cycle 3 started by signal AR2
AR cycle 3 initiated by signal AR3	0	S43	RW(e)	0=AR cycle 3 not started by signal AR3 1=AR cycle 3 started by signal AR3
Starting time of AR cycle 3 initiated by AR2	0	S44	RW(e)	0.00 ... 5.00 s
Starting time of AR cycle 3 initiated by AR3	0	S45	RW(e)	0.00 ... 5.00 s
Dead time of AR cycle 3	0	S46	RW(e)	0.2 ... 300.0 s

Data	Channel	Code	Data direction	Values
AR cycle 4 initiated by signal AR1	0	S51	RW(e)	0=AR cycle 4 inhibited by signal AR1 1=AR cycle 4 started by signal AR1
AR cycle 4 initiated by signal AR2	0	S52	RW(e)	0=AR cycle 4 not started by signal AR2 1=AR cycle 4 started by signal AR2
AR cycle 4 initiated by signal AR3	0	S53	RW(e)	0=AR cycle 4 not started by signal AR3 1=AR cycle 4 started by signal AR3
Starting time of AR cycle 4 initiated by AR2	0	S54	RW(e)	0.00 ... 5.00 s
Starting time of AR cycle 4 initiated by AR3	0	S55	RW(e)	0.00 ... 5.00 s
Dead time of AR cycle 4	0	S56	RW(e)	0.2 ... 300.0 s
AR cycle 5 initiated by signal AR1	0	S61	RW(e)	0=AR cycle 5 inhibited by signal AR1 1=AR cycle 5 started by signal AR1
AR cycle 5 initiated by signal AR2	0	S62	RW(e)	0=AR cycle 5 not started by signal AR2 1=AR cycle 5 started by signal AR2
AR cycle 5 initiated by signal AR3	0	S63	RW(e)	0=AR cycle 5 not started by signal AR3 1=AR cycle 5 started by signal AR3
Starting time of AR cycle 5 initiated by AR2	0	S64	RW(e)	0.00 ... 5.00 s
Starting time of AR cycle 5 intitated by AR3	0	S65	RW(e)	0.00 ... 5.00 s
AR 5 dead time	0	S66	RW(e)	0.2 ... 300.0 s
Final AR trip via signal AR1	0	S71	RW(e)	0=no final trip by AR from signal AR1 1=final trip by AR from signal AR1
Final AR trip via signal AR2	0	S72	RW(e)	0=no final trip by AR from signal AR2 1=final trip by AR from signal AR2
Final AR trip via signal AR3	0	S73	RW(e)	0=no final trip by AR from signal AR3 1=final trip by AR from signal AR3
Final trip time via AR1	0	S74	RW(e)	0.0 ... 300.0 s
Final trip time via AR2	0	S75	RW(e)	0.0 ... 300.0 s
Final trip time via AR3	0	S76	RW(e)	0.0 ... 300.0 s
AR reclaim time	0	S77	RW(e)	0.2 ... 300.0 s
Auto-reclosure ON/OFF	0	S78	RW(e)	0=AR out of use 1=AR in use
AR interruption	0	S79	W	1=interruption

Data	Channel	Code	Data direction	Values
Contact alarm "AR in progress"	0	S80	RW(e)	0=no contact alarm 40=alarm via SIGNAL5 output 41=alarm via SIGNAL6 output
Contact alarm for final trip by AR initiated by signal AR1	0	S81	RW(e)	0=no contact alarm 40=alarm via SIGNAL5 output 41=alarm via SIGNAL6 output
Contact alarm for final trip by AR initiated by signal AR2	0	S82	RW(e)	0=no contact alarm 40=alarm via SIGNAL5 output 41=alarm via SIGNAL6 output
Contact alarm for final trip by AR initiated by signal AR3	0	S83	RW(e)	0=no contact alarm 40=alarm via SIGNAL5 output 41=alarm via SIGNAL6 output
Measuring module	0	S90	RW(e)	0=no optional module 1=measuring module 1, SPTM 8A1 2=measuring module 2 or 3, SPTM 6A2 or SPTM 6A3
Power measurement	0	S91	RW(e)	0=no power measurement 1=power is measured
Energy measurement	0	S92	RW(e)	0=no energy measurement 1=energy is measured
Configuration and interlocking	0	S100	RW(e)	0=freely selectable configuration and interlocking program 1… =for future use
Configuration of objects (format; value 1, value 2, input No, output code, value 3)	0	S101 : S116	RW(e)	- value 1; 0=indicator not used 1=indicator used - value 2; 0=vertical LEDs indicate open status 1=vertical LEDs indicate closed status - input No; 1…7=input number 1…7 - output code; 0=not controlled object 20…31=output codes 20…31 - value 3; 0=object other than CB 1=object is a CB
Selection of setting/operation mode	0	S198	RW(e)	0=setting mode 1=run mode
Interlocking selection	0	S199	RW(e)	0=no interlockings 1=interlockings in use 2=for future use

Data	Channel	Code	Data direction	Values
Interlocking and Direct Output Control program (format; operation, operand)	0	M200 : M300	RW(e)	commands = LOAD, LOADN AND, ANDN OR, ORN OUT END interlocking variables = status closed (1…7) or active (8…17) status undefined (101…107) status open (201…207) Output code (20…31) Special register (60, 61) L/R key switch position information (62) Memory No. (70…89) variables for Direct Output Control = status closed (1…7) or active (8…17) status undefined (101…107) status open (201…207) Output code (40 or 41, 220…231) L/R key switch position information (62) Memory No. (70…89)
Event delay; —>10 (open)	1…7	S10	RW(e)	0.0, or 0.1…60.0 s
Event delay; —>01 (close)	1…7	S11	RW(e)	0.0, or 0.1…60.0 s
Event delay; —>11 (undefined)	1…7	S12	RW(e)	0.0, or 0.1…60.0 s
Event delay; —>00 (undefined)	1…7	S13	RW(e)	0.0, or 0.1…60.0 s
Use of input 10	10	S1	RW(e)	0=general mode 1=ARINH -input
Use of input 11	11	S1	RW(e)	0=general mode 1=pulse counter without indication 2=pulse counter with indication
Use of input 14	14	S1	RW(e)	0=general mode 1=external AR initiation, connected to AR1 2=external AR initiation, connected to AR2 3=external AR initiation, connected to AR3
Operation principle of inputs 8…17	8…17	S2	RW(e)	0=active at low state 1=active at high state
Signal output activation via inputs 8…17	8…17	S3	RW(e)	0=no SIGNAL output 40=SIGNAL5 output is activated 41=SIGNAL6 output is activated

Data	Channel	Code	Data direction	Values
Operation of OPEN and CLOSE outputs via inputs 8…17	8…17	S4	RW(e)	0=no activation or inhibit 20 = activate OPEN1 output 21 = activate CLOSE1 output 22 = activate OPEN2 output 23 = activate CLOSE2 output 24 = activate OPEN3 output 25 = activate CLOSE3 output 26 = activate OPEN4 output 27 = activate CLOSE4 output 28 = activate OPEN5 output 29 = activate CLOSE5 output 30 = activate OPEN6 output 31 = activate CLOSE6 output 120 = inhibit OPEN1 output 121 = inhibit CLOSE1 output 122 = inhibit OPEN2 output 123 = inhibit CLOSE2 output 124 = inhibit OPEN3 output 125 = inhibit CLOSE3 output 126 = inhibit OPEN4 output 127 = inhibit CLOSE4 output 128 = inhibit OPEN5 output 129 = inhibit CLOSE5 output 130 = inhibit OPEN6 output 131 = inhibit CLOSE6 output
Memory controlled function of the indicators of the binary inputs	8...13	S5	RW(e)	0=not memory controlled 1=memory controlled
Event delay; —>activated	8…17	S10	RW(e)	0.0, or 0.1…60.0 s
Event delay; —>reset	8…17	S11	RW(e)	0.0, or 0.1…60.0 s
Event reporting	1…17	S20	RW(e)	0=event reporting enabled 1=event reporting inhibited
Active power (MW)	0	V3	R	-999.99…+999.99 MW
Reactive power (Mvar)	0	V4	R	-999.99…+999.99 Mvar
Active energy (kWh)	0	V5	RW	0…999999999 kWh
Position of local/remote key switch	0	V6	R	0=local 1=remote
Active energy (kWh)	0	V8	RW	0…999 kWh
Active energy (MWh)	0	V9	RW	0…999 MWh
Active energy (GWh)	0	V10	RW	0…999 GWh
Active energy; reversed (kWh)	0	V11	RW	0…999 kWh
Active energy; reversed (MWh)	0	V12	RW	0…999 MWh
Active energy; reversed (GWh)	0	V13	RW	0…999 GWh
Reactive energy (kvarh)	0	V14	RW	0…999 kvarh
Reactive energy (Mvarh)	0	V15	RW	0…999 Mvarh
Reactive energy (Gvarh)	0	V16	RW	0…999 Gvarh
Reactive energy; reversed (kvarh)	0	V17	RW	0…999 kvarh
Reactive energy; reversed (Mvarh)	0	V18	RW	0…999 Mvarh
Reactive energy; reversed (Gvarh)	0	V19	RW	0…999 Gvarh
Total number of AR cycles 1	0	V20	R	0…999
No. of AR cycles 1 initiated by AR1	0	V21	RW	0…999
No. of AR cycles 1 initiated by AR2	0	V22	RW	0…999
No. of AR cycles 1 initiated by AR3	0	V23	RW	0…999
Total number of AR cycles 2	0	V24	R	0…999

Data	Channel	Code	Data direction	Values
No. of AR cycles 2 initiated by AR1	0	V25	RW	0…999
No. of AR cycles 2 initiated by AR2	0	V26	RW	0…999
No. of AR cycles 2 initiated by AR3	0	V27	RW	0…999
Total number of AR cycles 3	0	V28	R	0…999
No. of AR cycles 3 initiated by AR1	0	V29	RW	0…999
No. of AR cycles 3 initiated by AR2	0	V30	RW	0…999
No. of AR cycles 3 initiated by AR3	0	V31	RW	0…999
Total number of AR cycles 4	0	V32	R	0…999
No. of AR cycles 4 initiated by AR1	0	V33	RW	0…999
No. of AR cycles 4 initiated by AR2	0	V34	RW	0…999
No. of AR cycles 4 initiated by AR3	0	V35	RW	0…999
Total number of AR cycles 5	0	V36	R	0…999
No. of AR cycles 5 initiated by AR1	0	V37	RW	0…999
No. of AR cycles 5 initiated by AR2	0	V38	RW	0…999
No. of AR cycles 5 initiated by AR3	0	V39	RW	0…999
Store data into EEPROM	0	V151	W	1=storing, takes about 5 s
Load default values after EEPROM failure	0	V152	RW(e)	0=enable loading of default values 1=inhibit loading of default values
Event mask	0	V155	RW(e)	0…1023
Event mask	0	V156	RW(e)	0…1023
Event mask	0	V157	RW(e)	0…1023
Event mask	0	V158	RW(e)	0…2047
Event mask	1…7	V155	RW(e)	0…2047
Event mask	8…17	V155	RW(e)	0…15
Activation of self-supervision output	0	V165	W	0=reset 1=activate
Internal fault code	0	V169	R	Fault code
Data communication address	0	V200	RW(e)	1…254
Data transfer rate	0	V201	RW(e)	4800, 9600
Program version symbol	0	V205	R	E.g. 055 M
Type designation of the module	0	F	R	SPTO 6D3
Reading of event register	0	L	R	Time, channel number and event code
Re-reading of event register	0	B	R	Time, channel number and event code
Reading of module status information	0	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 status information	0	C	W	0=resetting
Time reading and setting	0	T	RW	0.000…59.999 s

R = Data which can be read from the module
W = Data which can be written to the module
(e) = Data which has to be stored in EEPROM (V151) after it has been changed

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

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

Default values of the parameters *(modified 96-12)*

The parameters which are stored in the EEPROM are given default values after factory testing. All the default values are copied from the PROM to the RAM by pressing the STEP and ∩ push buttons simultaneously while the auxiliary power supply is switched on. The push-buttons have to be kept depressed until the display is switched on.

The following table lists the default values of the parameters.

Data	Channel	Code	Default value
Open pulse length	1…7	V5	0.1 s for CB and 10.0 s for other than CB
Close pulse length	1…7	V6	0.1 s for CB and 10.0 s for other than CB
kWh value per pulse	0	S3	1 kWh per pulse
Object indication mode	0	S7	0=continuous display
Display indication mode	0	S8	0=continuous display
Scaling of current measurement	0	S9	200.00
Scaling of voltage measurement	0	S10	210.00
Low limit of mA signal of active power	0	S12	+4 mA
High limit of mA signal of active power	0	S13	+20 mA
Low limit of mA signal of react. power	0	S14	+4 mA
High limit of mA signal of react. power	0	S15	+20 mA
Active power corresponding to the mA signal at low limit	0	S16	+0.00
Active power corresponding to the mA signal at high limit	0	S17	+999.99
Reactive power corresponding to the mA signal at low limit	0	S18	+0.00
Reactive power corresponding to the mA-signal at high limit	0	S19	+999.99
AR cycle 1 initiated by signal AR1	0	S21	0=AR cycle 1 inhibited by signal AR1
AR cycle 1 initiated by signal AR2	0	S22	1=AR cycle 1 started by signal AR2
AR cycle 1 initiated by signal AR3	0	S23	1=AR cycle 1 started by signal AR3
Starting time of AR cycle 1 initiated by AR2	0	S24	0.00 s
Starting time of AR cycle 1 initiated by AR3	0	S25	0.00 s
Dead time of AR cycle 1	0	S26	0.3 s
AR cycle 2 initiated by signal AR1	0	S31	0=AR cycle 2 inhibited by signal AR1
AR cycle 2 initiated by signal AR2	0	S32	1=AR cycle 2 started by signal AR2
AR cycle 2 initiated by signal AR3	0	S33	1=AR cycle 2 started by signal AR3
Starting time of AR cycle 2 initiated by AR2	0	S34	0.00 s
Starting time of AR cycle 2 initiated by AR3	0	S35	0.00 s
Dead time of AR cycle 2	0	S36	120.0 s
AR cycle 3, initiated by signal AR1	0	S41	0=AR cycle 3 inhibited by signal AR1
AR cycle 3, initiated by signal AR2	0	S42	0=AR cycle 3 not started by signal AR2
AR cycle 3, initiated by signal AR3	0	S43	0=AR cycle 3 not started by signal AR3
Starting time of AR cycle 3 initiated by AR2	0	S44	0.00 s
Starting time of AR cycle 3 initiated by AR3	0	S45	0.00 s
Dead time of AR cycle 3	0	S46	120.0 s

Data	Channel	Code	Default value
AR cycle 4 initiated by signal AR1	0	S51	0=AR cycle 4 inhibited by signal AR1
AR cycle 4 initiated by signal AR2	0	S52	0=AR cycle 4 not started by signal AR2
AR cycle 4 initiated by signal AR3	0	S53	0=AR cycle 4 not started by signal AR3
Starting time of AR cycle 4 initiated by AR2	0	S54	0.00 s
Starting time of AR cycle 4 initiated by AR3	0	S55	0.00 s
Dead time of AR cycle 4	0	S56	120.0 s
AR cycle 5 initiated by signal AR1	0	S61	0=AR cycle 5 inhibited by signal AR1
AR cycle 5 initiated by signal AR2	0	S62	0=AR cycle 5 not started by signal AR2
AR cycle 5 initiated by signal AR3	0	S63	0=AR cycle 5 not started by signal AR3
Starting time of AR cycle 5 initiated by AR2	0	S64	0.00 s
Starting time of AR cycle 5 initiated by AR3	0	S65	0.00 s
Dead time of AR cycle 5	0	S66	120.0 s
Final trip by AR initiated by signal AR1	0	S71	0=no final trip by AR, initiated by signal AR1
Final trip by AR initiated by signal AR2	0	S72	0=no final trip by AR, initiated by signal AR2
Final trip by AR initiated by signal AR3	0	S73	0=no final trip by AR, initiated by signal AR3
Final trip time via AR1	0	S74	300.0 s
Final trip time via AR2	0	S75	300.0 s
Final trip time via AR3	0	S76	300.0 s
AR reclaim time	0	S77	5.0 s
Auto-reclose function ON/OFF	0	S78	0=AR out of use
AR due contact alarm	0	S80	0=no contact alarm
Contact alarm for final trip by AR initiated by signal AR1	0	S81	0=no contact alarm
Contact alarm for final trip by AR initiated by signal AR2	0	S82	0=no contact alarm
Contact alarm for final trip by AR initiated by signal AR3	0	S83	0=no contact alarm
Measuring module	0	S90	0=no optional measuring module
Power measurement	0	S91	0=no power measurement
Energy measurement	0	S92	0=no energy measurement
Configuration and interlocking	0	S100	0=freely selectable configuration and interlocking program
Configuration of objects	0	S101 : S116	0,0,0,0,0=indicator not used

Data	Channel	Code	Default value
Setting/run mode selection	0	S198	0=setting mode
Interlocking selection	0	S199	1= interlockings in use
Interlocking program	0	M200 : M300	END
Event delay; —>10 (open)	1…7	S10	0.0 s
Event delay; —>01 (close)	1…7	S11	0.0 s
Event delay; —>11	1…7	S12	0.2 s for CB and 10.0 s for non CB
Event delay; —>00	1…7	S13	0.2 s for CB and 10.0 s for non CB
Use of input 10	10	S1	0=general mode
Use of input 11	11	S1	0=general mode
Use of input 14	14	S1	0=general mode
Operation direction of inputs 8…17	8…17	S2	1=active at high state
Signal output activation by inputs 8…17	8…17	S3	0=no signal output
Operation of OPEN and CLOSE outputs by inputs 8…17	8…17	S4	0=no activation or inhibit
Memory controlled function of the indicators of the binary inputs	8...13	S5	0=not memory controlled
Event delay; —>activated	8…17	S10	0.0 s
Event delay; —>reset	8…17	S11	0.0 s
Event reporting	1…17	S20	0=event reporting enabled
Load default values after EEPROM failure	0	V152	1=inhibited
Event mask	0	V155	67
Event mask	0	V156	99
Event mask	0	V157	99
Event mask	0	V158	1795
Event mask	1…7	V155	1875
Event mask	8…17	V155	3
Data communication address	0	V200	99
Data transfer rate	0	V201	9600

Control functions

- status indication for 7 objects, e.g. circuit breakers, disconnectors, earthing switches
- configuration freely selectable by the user
- remote or local control (open and close) for 6 objects
- output pulse lenght selectable, range 0.1…100.0 s
- 10 binary inputs for reading contact data other than status information
- freely selectable feeder oriented interlocking system, the 7 status inputs plus 10 other binary inputs
- the binary input channels can be used to control the OPEN and CLOSE outputs
- two signal outputs, which can be controlled by the binary input channels

Measurements

- one pulse counter input for energy pulse counting, maximum input signal frequency 25 Hz
- energy can also be calculated on the basis of the measured power value by using an optional measuring module
- all measured values can be scaled as actual primary values
- local display or remote indication of measured values

With optional measuring module SPTM 8A1
- measurement of three phase currents and three phase-to-phase voltages, measurement range 0...1,5 x I_n and 0...1,5 x U_n
- accuracy of current and voltage measurement better than ± 1 % of rated value
- two mA inputs for measurement of active and reactive power
- accuracy of power measurement better than ± 1 % of the maximum value of the measurement range
- mA input range -20 mA…0...20 mA, can be limited by setting

With optional measuring module SPTM 6A2
- measurement of three phase currents and three phase-to-phase voltages, measurement range 0...1,5 x I_n and 0...1,5 x U_n
- accuracy of current and voltage measurement better than ± 1 % of rated value
- measurement of active and reactive power using the current and voltage signals. The measurement is based on the Aron connection, measurement range 0...1,1 x P_n and 0...1,1 x Q_n.
- accuracy of the positive power measurement better than ±2 % of the rated value
- accuracy of the negative power measurement better than ±3 % of the rated value

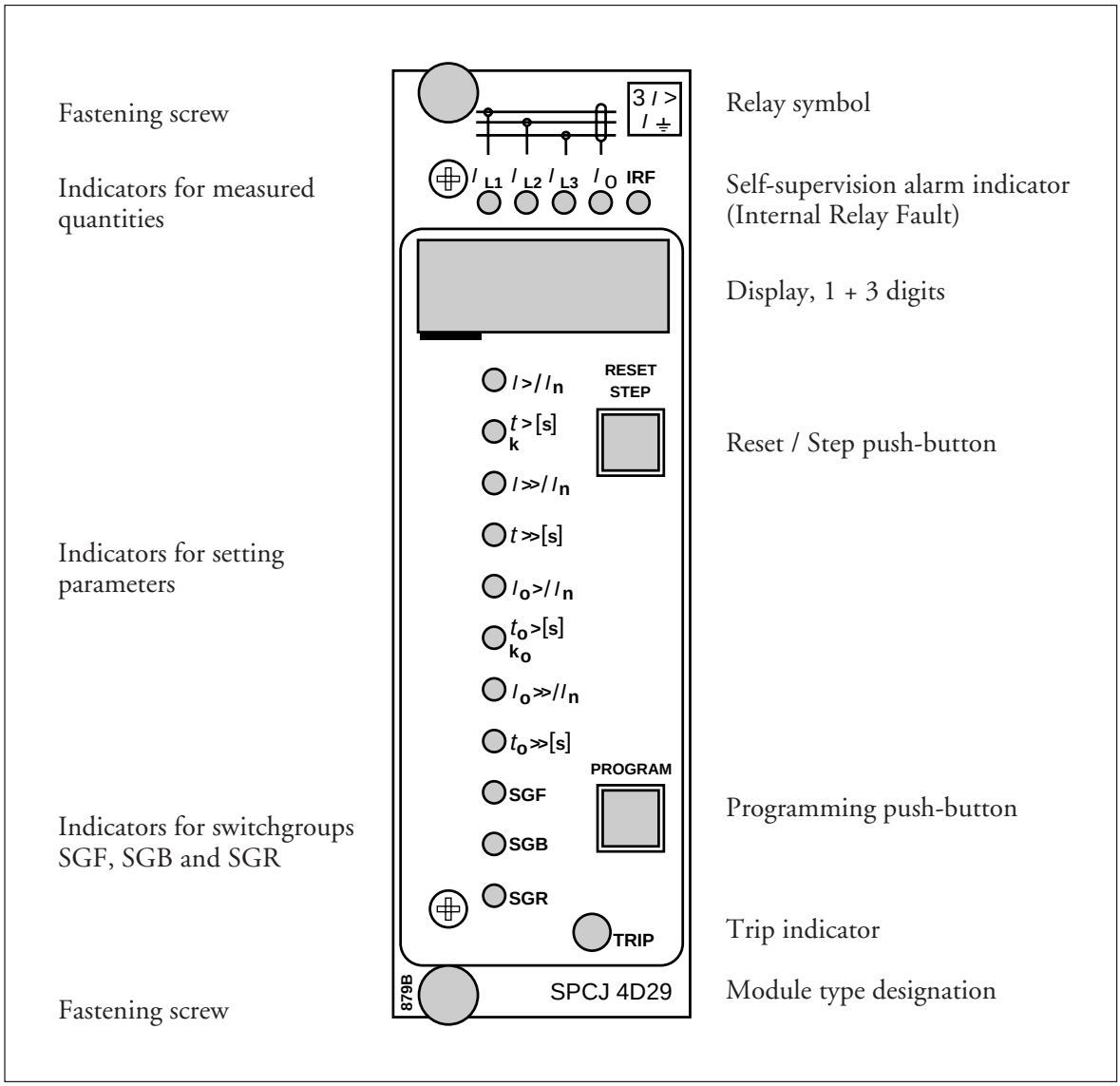
With optional measuring module SPTM 6A3
- measurement of three phase currents and three phase-to-phase voltages, measurement range 0...1,5 x I_n and 0...1,5 x U_n
- accuracy of current and voltage measurement better than ± 1 % of rated value
- measurement of active and reactive power using one internal voltage and two current signals.The currents and voltage used can be selected with the switches, measurement range 0...1,1 x P_n and 0...1,1 x Q_n

Auto-reclosing

- 5 consecutive auto-reclose cycles
- each cycle can be initiated by three starting or tripping signals
- selectable starting time for two starting signals, 0.00…5.00 s
- selectable dead time, 0.2…300.0 s
- selectable reclaim time, 0.2…300.0 s

General characteristics of D-type relay modules

User´s manual and Technical description



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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 switch-groups 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.*

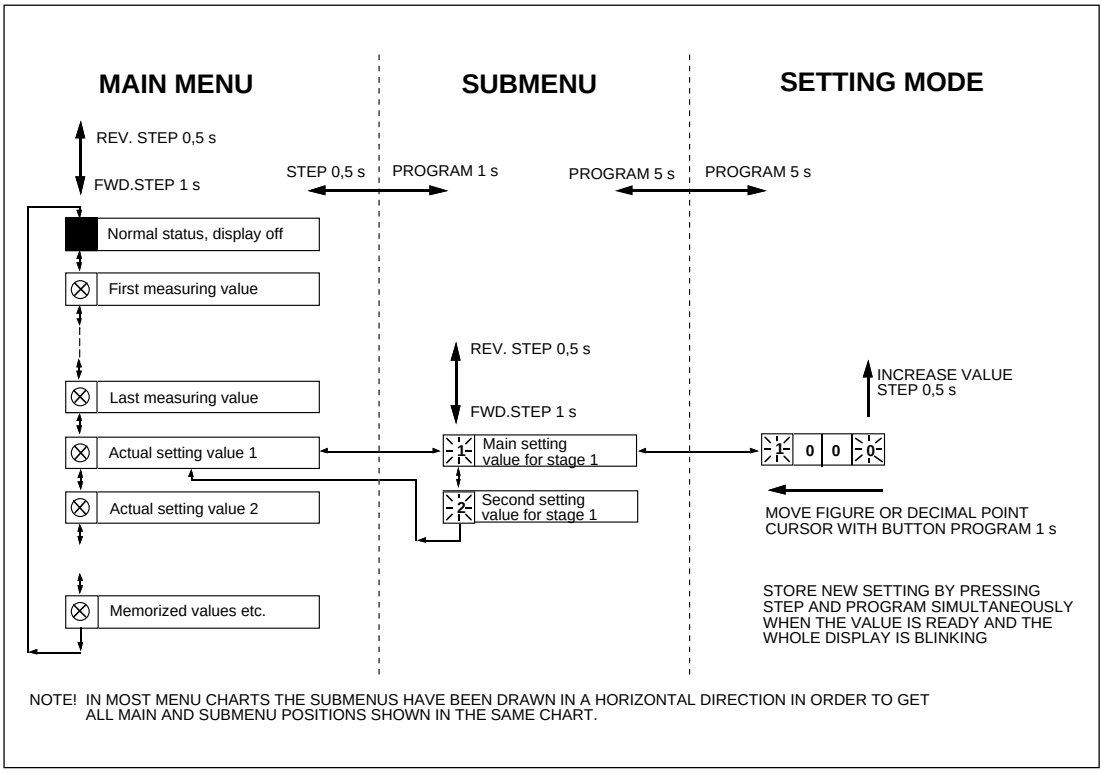


Fig.3. Basic principles of entering the main menus and submenus of a relay module.

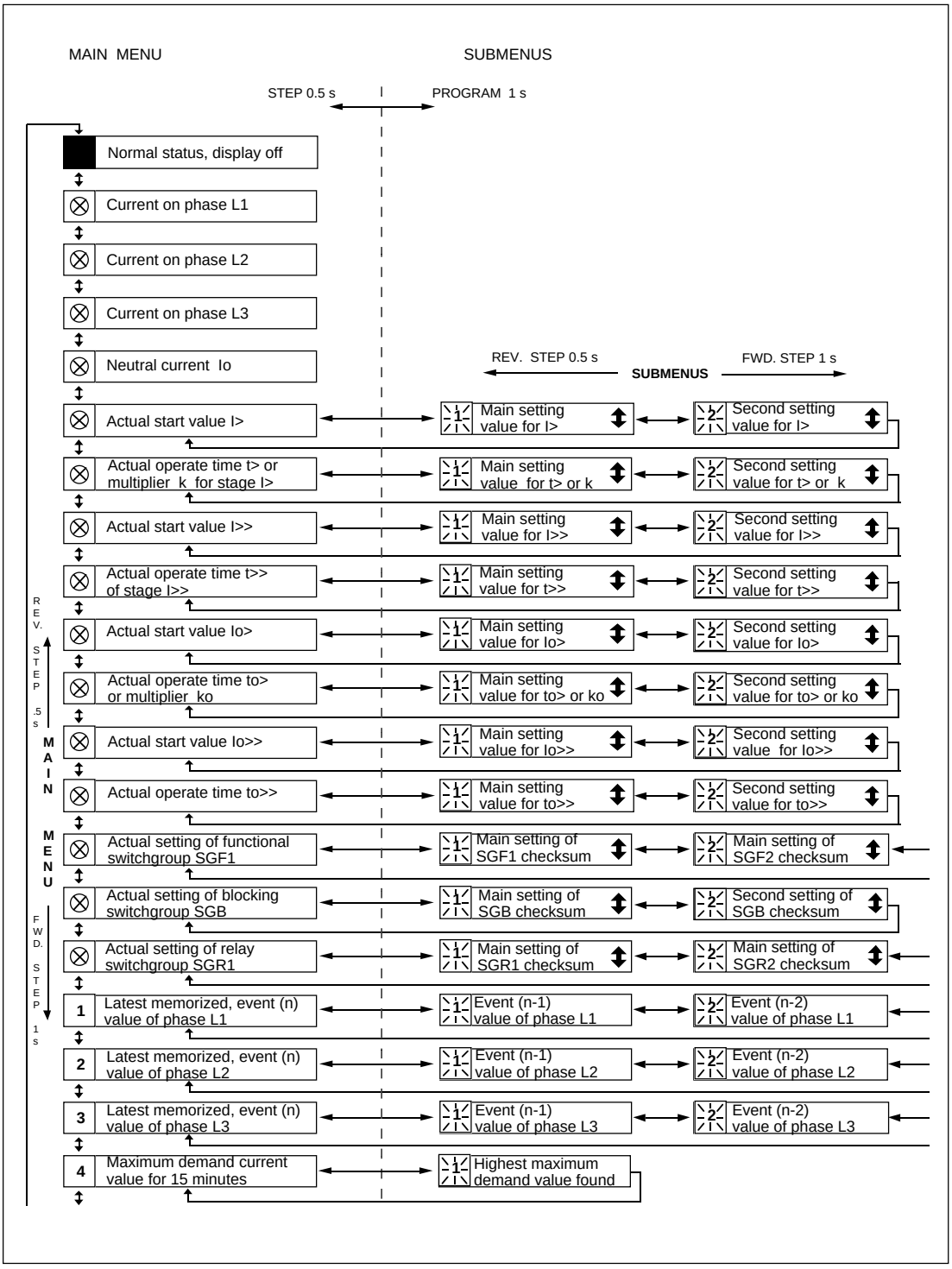
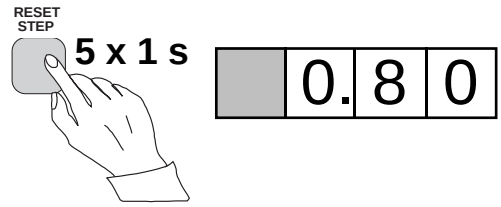


Fig. 4. Example of part of the main and submenus for the settings of the overcurrent and earth-fault relay module SPCJ 4D29. The settings currently in use are in the main manu and they are displayed by pressing the STEP push button. The main menu also includes the measured current values, the registers 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.

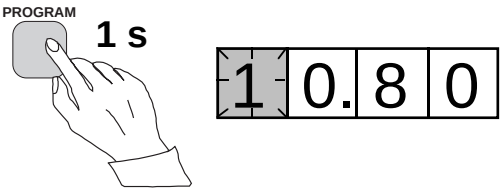
Example 1

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.

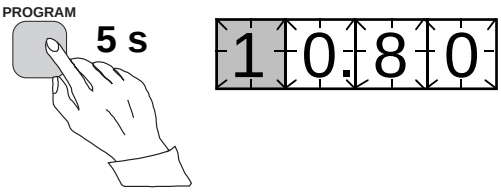
a)
Press push button STEP repeatedly until the LED close to the I> symbol is lit and the current start value appears on the display.



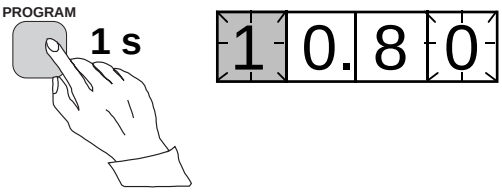
b)
Enter the submenu to get the main setting value by pressing the PROGRAM push button more than one second and then releasing it. The red display digit now shows a flashing number 1, indicating the first submenu position and the green digits show the set value.



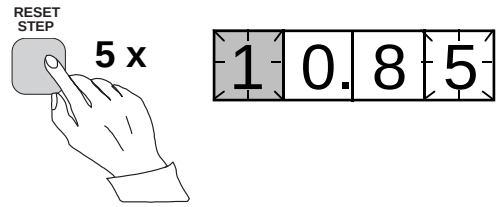
c)
Enter the setting mode by pressing the PROGRAM push button for five seconds until the display starts flashing.



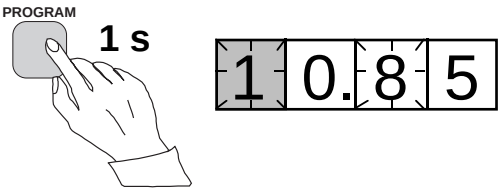
d)
Press the PROGRAM push button once again for one second to get the rightmost digit flashing.



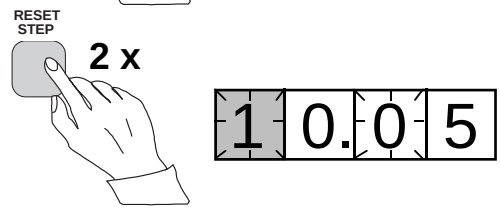
e)
Now the flashing digit can be altered. Use the STEP push button to set the digit to the desired value.



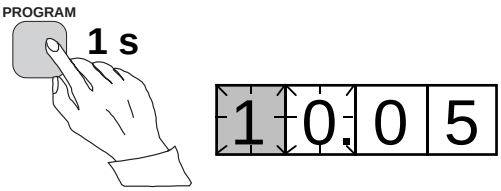
f)
Press the PROGRAM push button to make the middle one of the green digits flash.



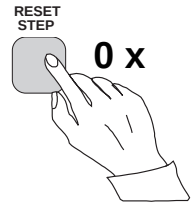
g)
Set the middle digit with of the STEP push button.

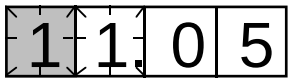


h)
Press the PROGRAM push button to make the leftmost green digit flash.

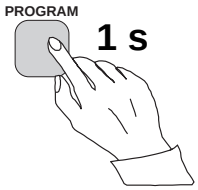


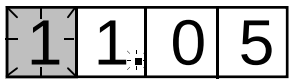
i)
Set the digit with the STEP push button.



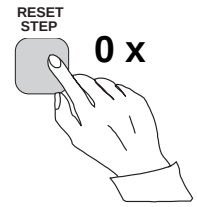


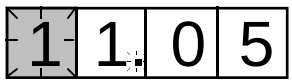
j)
Press the PROGRAM push button to make the decimal point flash.



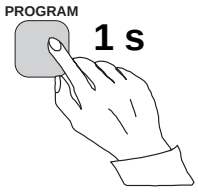


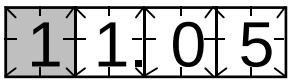
k)
If needed, move the decimal point with the STEP push button.



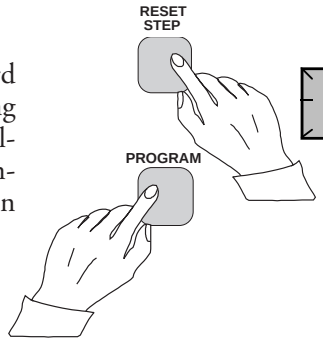


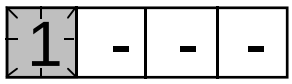
l)
Press the PROGRAM push button to make the whole display flash. In this position, corresponding to position c) above, one can see the new value before it is recorded. If the value needs changing, use the PROGRAM push button to alter the value.



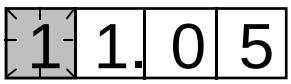


m)
When the new value has been corrected, record it in the memory of the relay module by pressing the PROGRAM and STEP push buttons simultaneously. At the moment the information enters the memory, the green dashes flash once in the display, i.e. 1 - - -.

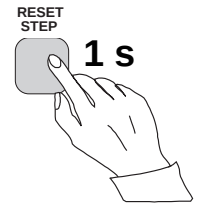


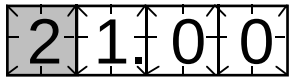


n)
Recording of the new value automatically initiates a return from the setting mode to the normal submenu. Without recording one can leave the setting mode any time by pressing the PROGRAM push button for about five seconds, until the green display digits stop flashing.



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>.



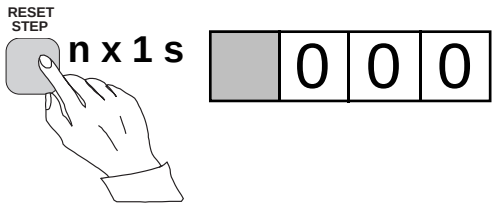


Enter the setting mode as in step c) and proceed in the same way. After recording of the requested values return to the main menu is obtained by pressing the STEP push button until the first digit is switched off. The LED still shows that one is in the I> position and the display shows the new setting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

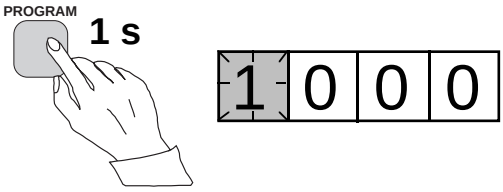
Example 2

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.

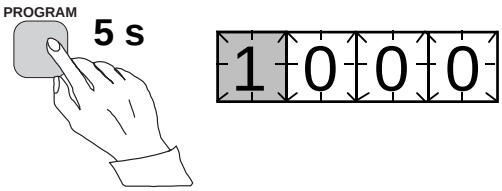
a)
Press push button STEP until the LED close to the SGF symbol is lit and the checksum appears on the display.



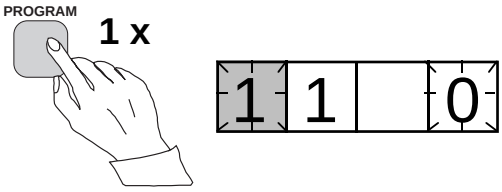
b)
Enter the submenu to get the main checksum of SGF1 by pressing the PROGRAM push button for more than one second and then releasing it. The red display now shows a flashing number 1 indicating the first submenu position and the green digits show the checksum.



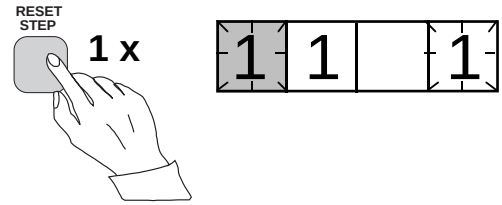
c)
Enter the setting mode by pressing the PROGRAM push button for five seconds until the display starts flashing.



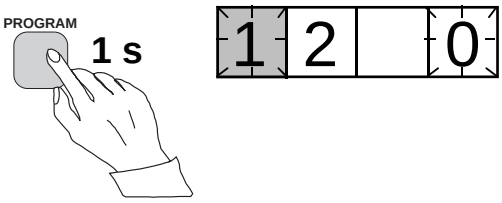
d)
Press the PROGRAM push button once again to get the first switch position. The first digit of the display now shows the switch number. The position of the switch is shown by the rightmost digit.



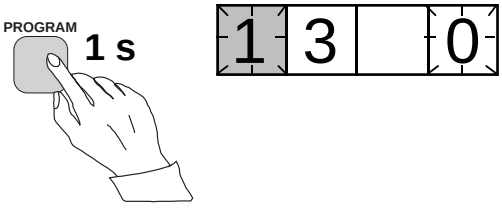
e)
The switch position can now be toggled between 1 and 0 by means of the STEP push button and it is left in the requested position 1.



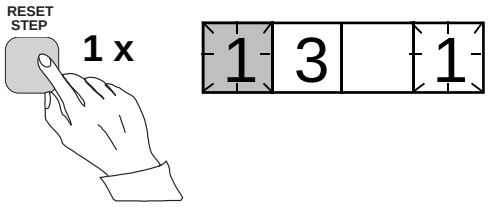
f)
When switch number 1 is in the requested position, switch number 2 is called up by pressing the PROGRAM push button for one second. As in step e), the switch position can be altered by using the STEP push button. As the desired setting for SGF1/2 is 0 the switch is left in the 0 position.



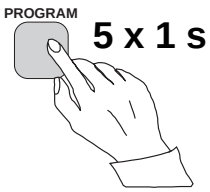
g)
Switch SGF1/3 is called up as in step f) by pressing the PROGRAM push button for about one second.



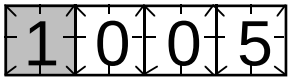
h)
The switch position is altered to the desired position 1 by pressing the STEP push button once.



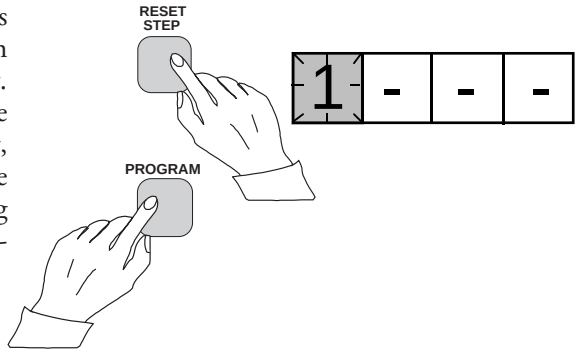
i)
Using the same procedure the switches SGF 1/ 4...8 are called up and, according to the example, left in position 0.



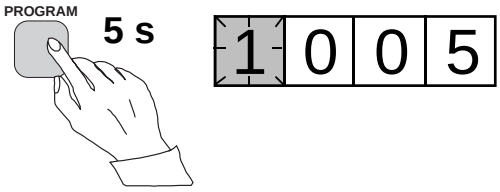
j)
In the final setting mode position, corresponding to step c), the checksum based on the set switch positions is shown.



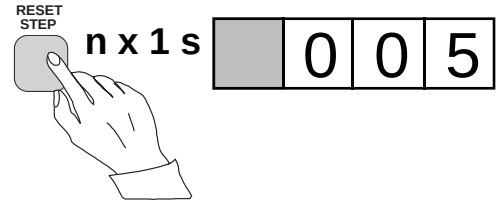
k)
If the correct checksum has been obtained, it is recorded in the memory by pressing the push buttons PROGRAM and STEP simultaneously. At the moment the information enters the memory, the green dashes flash in the display, i.e.1 - - -. If the checksum is incorrect, the setting of the separate switches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

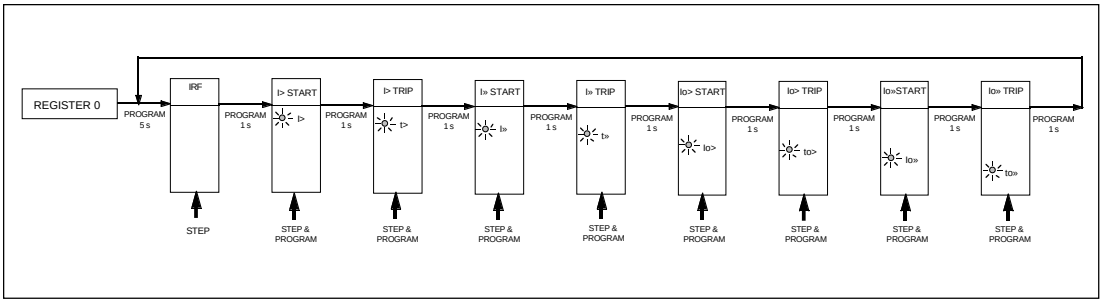


Fig. 5. Sequence order for the selection of output signals in the Trip test mode

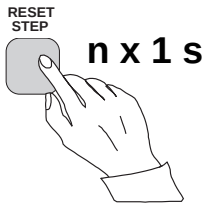
If, for instance, the indicator of the setting t> is flashing, and the push buttons STEP and PROGRAM are being pressed, the trip signal from the low-set overcurrent stage is activated. Return to the main menu is possible at any stage of the trip test sequence scheme, by pressing the PROGRAM push button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

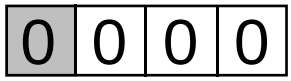
Note!
The effect on the output relays then depends on the configuration of the output relay matrix switchgroups SGR 1...3.

Example 3

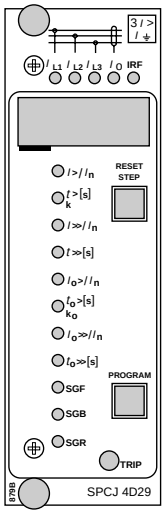
Trip test function. Forced activation of the outputs.

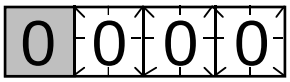
a)
Step forward on the display to register 0.





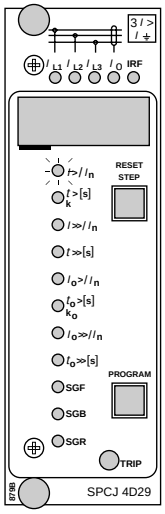
b)
Press the PROGRAM push button for about five seconds until the three green digits to the right.

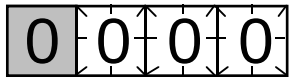




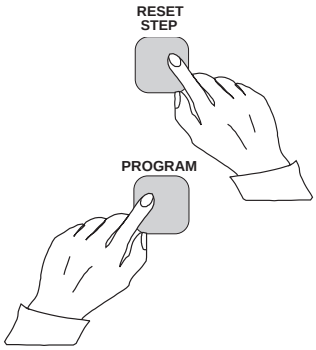
c)
Hold down the STEP push button. After one second the red IRF indicator is lit and the IRF output is activated. When the step push button is released the IRF indicator is switched off and the IRF output resets.

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

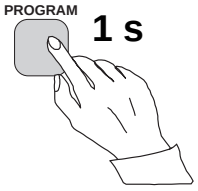


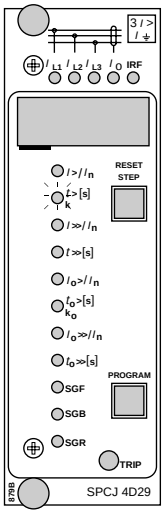


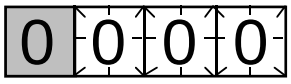
e)
If a start of the first stage is required, now press the push-buttons PROGRAM and STEP simultaneously. The stage output will be activated and the output relays will operate according to the actual programming of the relay output switchgroups SGR.



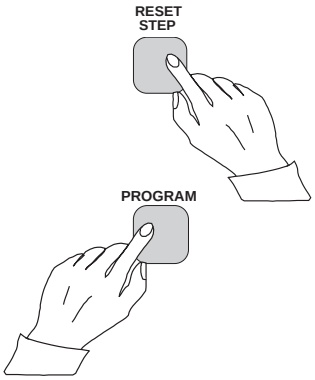
f)
To proceed to the next position press the PROGRAM push button for about 1 second until the indicator of the second setting starts flashing.

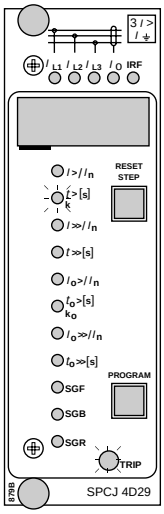


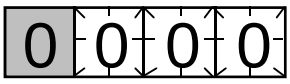




g)
Press the push buttons PROGRAM and STEP simultaneously to activate tripping of stage 1 (e.g. the I> stage of the overcurrent module SPCJ 4D29). The output relays will operate according to the actual programming of the relay switchgroups SGR. If the main trip relay is operated the trip indicator of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

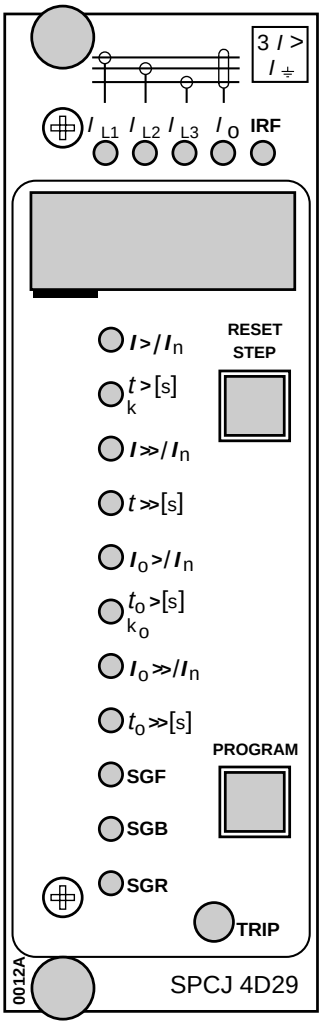
In addition to the protection functions the relay module is provided with a self-supervision system which continuously supervises the function of the microprocessor, its program execution and the electronics.

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 4D29
Overcurrent and earth-fault relay module

User´s manual and Technical description



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SPCJ 4D29
Combined overcurrent and earth-fault relay module

Contents

Features

Low-set phase overcurrent stage I> with definite time or inverse time characteristic

High-set phase overcurrent stage I>> with instantaneous function or definite time characteristic

Low-set earth-fault stage I_0> with definite time or inverse time characteristic

High-set earth-fault stage I_0>> with definite time characteristic

Six time/current curve sets at inverse time characteristic of the overcurrent stage I> and the earth-fault stage I_0>

Digital display of measured and set values and data sets recorded at the moment of relay operation

Parametrization of the module by push-buttons on the front panel or via the serial port using a portable PC and a suitable software

Continuous hardware and software supervision including auto-diagnosis

Description of function

Phase overcurrent unit

The phase overcurrent unit of the relay module SPCJ 4D29 is designed for single-phase, two-phase or three-phase overcurrent protection. It includes two overcurrent stages, i.e. a low-set overcurrent stage I> and a high-set overcurrent stage I>>.

The low-set or high-set phase overcurrent stage starts if the current on one or several of the phases exceeds the set start current value of the stage concerned. When the stage starts it generates a start signal SS1 or TS1 and simultaneously the digital display on the front panel indicates starting. If the overcurrent situation lasts long enough to exceed the set operate time, the stage operates and generates a trip signal TS2. At the same time the operation indicator is lit with red light. The red operation indicator remains lit although the stage resets. The indicator is reset by pushing the RESET push-button. By proper configuration of the output relay switchgroups an additional auxiliary trip signal TS1 can be obtained.

The operation of the low-set phase overcurrent stage I> or the high-set phase overcurrent stage I>> can be blocked by routing a blocking signal BS to the unit. The blocking configuration is set with switchgroup SGB.

The operation of the low-set phase overcurrent stage can be based on definite time or inverse time characteristic. The operation characteristic is selected with the SGF1/1…3 switches. At definite time operation characteristic the operate time t> is set in seconds within the range, 0.05...300 s. When the inverse time operation characteristic (IDMT) is selected, four internationally standardized and two complementary time/current curves are available. The selector switches SGF1/1...3 are also used for selecting the desired operation characteristic.

Note!
The maximum continuous current carrying capacity of the energizing inputs is 4 x I_n, which must be observed when relay settings are calculated.

Note!
At inverse time characteristic the effective setting range of the low-set overcurrent stage is 0.5…2.5 x I_n, although start current settings within the range 2.5…5.0 x I_n can be set on the relay. At inverse time characteristic any start current setting above 2.5 x I_n of the low-set stage will be regarded as being equal to 2.5 x I_n.

Note!
The operation of the low-set stage based on inverse time characteristic will be blocked by starting of the high-set stage. Then the operate time of the overcurrent unit is determined by the set operate time of the high-set stage at heavy fault currents.

The setting range of the operate time t>> of the high-set phase overcurrent stage is 0.04...300 s.

The operate signal of the two overcurrent stages is provided with a latching feature (switch SGB/6) which means that the operate signal TS2 is kept high after an operation, although the overcurrent stage resets. The latched TS2 signal is reset by pushing the RESET and PROGRAM push-buttons simultaneously or via the serial port using the command V101, see also chapter "Selector switches".

The set start current value I>> of the high-set phase overcurrent stage can be doubled automatically on connection of the protected object to the network, i.e. at starting. In this way the start current of the high-set phase overcurrent stage can be given a lower value than the level of the connection inrush current. The automatic doubling function is selected with switch SGF1/5. The starting, which activates the doubling function, is defined as a situation where the phase currents rise from a value below 0.12 x I> to a value exceeding 1.5 x I> in less than 60 ms. The function stops when the currents fall below 1.25 x I>.

The setting range of the start current of the high-set phase overcurrent stage is 0.5...40 x I_n. When the high-set stage is given a start current setting in the lower end of the setting range, the relay module will contain two almost identical overcurrent stages. This enables the overcurrent unit of the SPCJ 4D29 module to be used, for example, in two-stage load shedding applications.

The high-set phase overcurrent stage can be set out of operation with switch SGF2/5. When the high-set stage is set out of operation the display shows "- - -", indicating that the start current setting is infinite.

Earth-fault unit

The non-directional earth-fault unit of the relay module SPCJ 4D29 is a single-pole earth-fault unit. It contains two earth-fault stages, i.e. a low-set earth-fault stage $I_0>$ and a high-set earth-fault stage $I_0>>$.

The low-set or high-set earth-fault stage starts, if the measured current exceeds the set start current value. When the stage starts it generates a start signal SS1 or TS1 and simultaneously the digital display on the front panel indicates starting. If the earth-fault situation lasts long enough to exceed the set operate time, the stage operates and generates a trip signal TS2. At the same time the operation indicator TRIP is lit with red light. The red operation indicator remains lit although the stage resets. The indicator is reset by pushing the RESET push-button. By proper configuration of the output relay switchgroups an additional auxiliary trip signal TS1 can be obtained.

The operation of the low-set earth-fault stage $I_0>$ or the high-set earth-fault stage $I_0>>$ can be blocked by routing a blocking signal BS to the earth-fault unit. The blocking configuration is set with switchgroup SGB.

The operation of the low-set earth-fault stage can be based on definite time or inverse time characteristic. The operation characteristic is selected with the SGF/6…8 switches. At definite time operation characteristic the operate time $t_0>$ is directly set in seconds within the range, 0.05...300 s. When the inverse time operation characteristic (IDMT) is selected, four internationally standardized and two complementary time/current curves are available. The selector switches SGF1/ 6...8 are also used for selecting the desired operation characteristic.

The setting range of the operate time $t_0>>$ of the high-set earth-fault stage is 0.05…300 s.

Note!
The operation of the low-set stage based on inverse time characteristic will be blocked by starting of the high-set stage. Then the operate time of the earth-fault unit is determined by the set operate time of the high-set stage at heavy fault currents.

The operate signal of the two earth-fault stages is provided with a latching feature (switch SGB/7) which means that the operate signal TS2 is kept high after an operation, although the earth-fault stage resets. The TS2 signal is reset by pushing the RESET and PROGRAM push-buttons simultaneously or via the serial port using the command V101, see chapter "Selector switches", page 9.

The high-set earth-fault stage can be set out of operation with switch SGF2/6. When the high-set stage is set out of operation the display shows "- - -", indicating that the start current setting is infinite.

Circuit breaker failure protection unit

The relay module features a circuit breaker failure protection (CBFP) unit. The CBFP unit generates a trip signal via TS1 after a set operate time 0.1...1 s, following the main trip signal TS2, if the fault has not been cleared before the set operate time has elapsed. The output contact of the CBFP unit is normally used for tripping an upstream circuit breaker. The CBFP unit can also be used for tripping via redundant trip circuits of the same circuit breaker, if the circuit breaker is provided with two trip coils. The circuit breaker failure protection unit is alerted/ set out of operation with switch SGF1/4.

Remote setting

The relay can be given two sets of setting values, the main settings and the second settings. Switching between main settings and second settings can be done in three different ways, i) with a command V150 via the serial port, ii) with a command via the external control input BS or manually by changing a parameter in submenu 4 of register A.

Block diagram

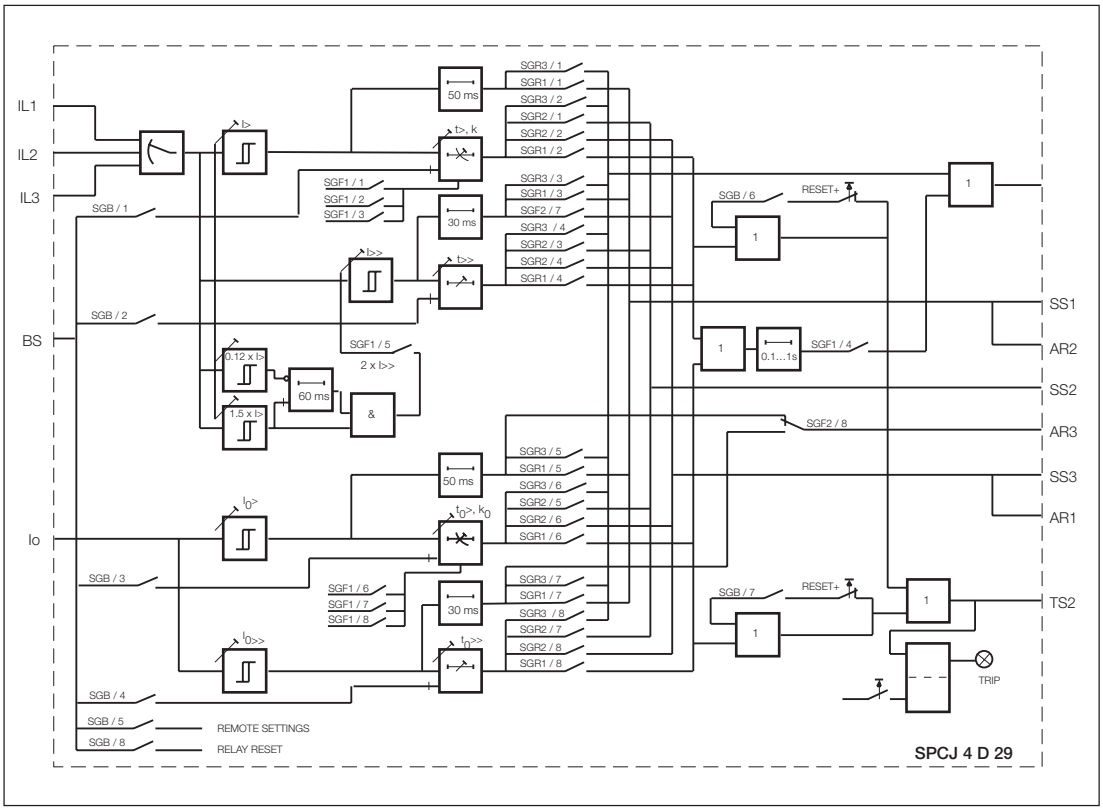
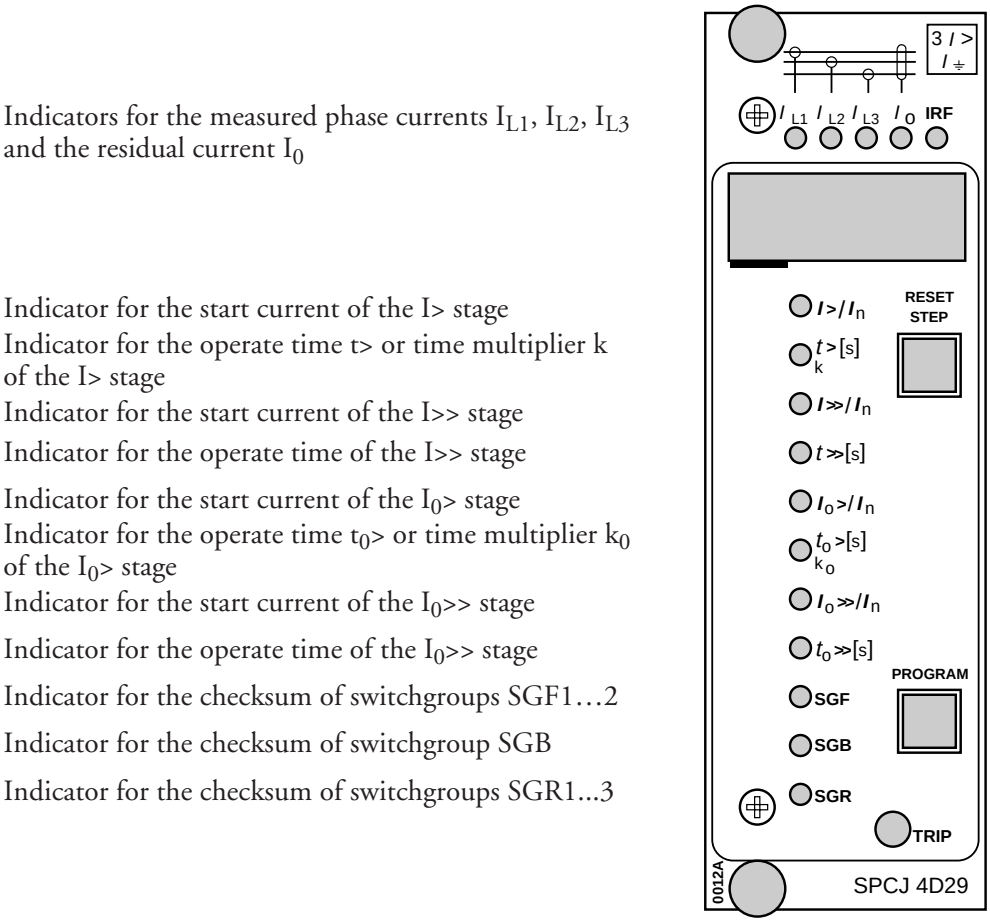


Fig. 1. Block diagram for the combined overcurrent and earth-fault relay module SPCJ 4D29.

I_{L1}, I_{L2}, I_{L3}	Energizing currents
I_0	Residual current
BS	External control signal
SGF1…2	Selector switchgroup SGF for operational relay functions
SGB	Selector switchgroup SGB for special relay functions
SGR1...3	Selector switchgroups SGR for configuration of output relays
TS1	Start signal 1 or auxiliary trip signal configured with switchgroup SGR3
SS1	Start signal configured with switchgroup SGR1
SS2	Trip signal 1 configured with switchgroup SGR2
SS3	Trip signal 2 configured with switchgroup SGR2
TS2	Trip signal configured with switchgroup SGR1
AR1, AR2, AR3	Start signals to possible external optional auto-reclose relays
TRIP	Red operation (trip) indicator

Note!
All input and output signals of the relay module are not necessarily wired to the terminals of a particular relay. The signals wired to the terminals of a particular protection relay are shown in the signal diagram in the general part of the relay manual.



Indicators for the measured phase currents I_{L1}, I_{L2}, I_{L3} and the residual current I_0

Indicator for the start current of the I> stage

Indicator for the operate time t> or time multiplier k of the I> stage

Indicator for the start current of the I>> stage

Indicator for the operate time of the I>> stage

Indicator for the start current of the I_0> stage

Indicator for the operate time t_0> or time multiplier k_0 of the I_0> stage

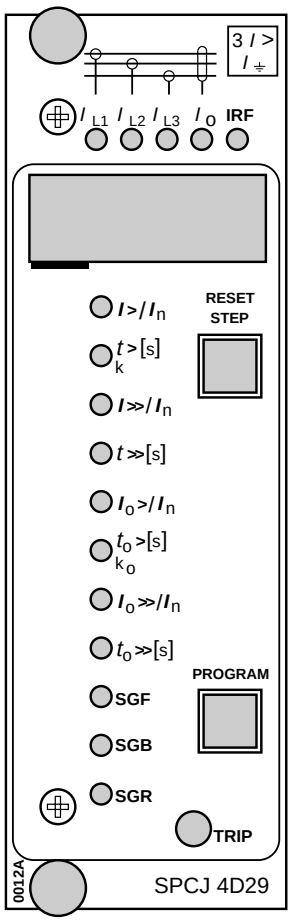
Indicator for the start current of the I_0>> stage

Indicator for the operate time of the I_0>> stage

Indicator for the checksum of switchgroups SGF1…2

Indicator for the checksum of switchgroup SGB

Indicator for the checksum of switchgroups SGR1...3



Relay module symbol

Self-supervision alarm indicator

Digital display

Reset and display step push-button

Selector push-button

TRIP indicator

Type designation of the module

Fig. 2. Front panel of the combined overcurrent and earth-fault relay module SPCJ 4D29.

Start and operation indicators

Both overcurrent stages have their own start indicators and operation indicators shown as figures on the digital display. Further, all the protection stages share a common red LED indicator marked "TRIP" which is located in the lower right corner of the front panel and which is lit on operation of a stage.

The figure on the display indicating starting or operation remains lit when the current stage resets, thus indicating which protection stage has operated. The start or operation indicators are reset by pushing the RESET push-button. The function of the relay module is not affected by an unreset indicator. If the starting of a stage is short enough not to cause an operation of the relay, the start indication is normally self-reset when the stage resets. By means of switches SGF2/1…4 the start indicators can be configured for manual resetting. The following table shows a guide to the start and trip indicators of the relay module.

Indication	Explanation	
1	I> START	= the low-set stage I> of the overcurrent unit has started
2	I> TRIP	= the low-set stage I> of the overcurrent unit has operated
3	I>> START	= the high-set stage I>> of the overcurrent unit has started
4	I>> TRIP	= the high-set stage I>> of the overcurrent unit has operated
5	I_0> START	= the low-set stage I_0> of the earth-fault unit has started
6	I_0> TRIP	= the low-set stage I_0> of the earth-fault unit has operated
7	I_0>> START	= the high-set stage I_0>> of the earth-fault unit has started
8	I_0>> TRIP	= the high-set stage I_0>> of the earth-fault unit has operated
9	CBFP	= the circuit breaker failure protection has operated

When one of the protection stages of the relay module operates, the indicators for the energizing current of the module show the faulty phase, i.e. in which phase(s) the current has exceeded the set start value of the stage (so called phase fault indication). If, for instance, the operation indicator "2" of the low-set stage is lit , as are the indicators I_{L1} and I_{L2} also, the relay operation has been caused by overcurrent on the L1 and L2 phases. The fault indications are reset by pushing the RESET push-button.

The self-supervision alarm indicator IRF indicates, when lit, that the self-supervision system has detected a permanent internal relay fault. The indicator is lit with red light shortly after a fault has been detected. At the same time the relay module generates a control signal to the output relay of the self-supervision system IRF. Additionally, in most fault cases, an auto-diagnostic fault code showing the nature of the fault appears on the display. The fault code, consists of a red figure one (1) and a green code number. When a fault code is obtained it should be recorded for statistical and maintenance purposes.

The setting values are shown by the right-most three digits of the display. When lit, the LED indicators on the front panel adjacent to the symbol of the setting quantity shows the quantity currently being displayed.

$I>/I_n$	Start current of the I> stage as a multiple of the rated current of the used energizing input. Setting range 0.5...5.0 x I_n at definite time characteristic and 0.5…2.5 x I_n at inverse time characteristic. Note! At inverse time characteristic any setting above 2.5 x I_n will be regarded as being equal to 2.5 x I_n.
t>	Operate time of the I> stage expressed in seconds, at definite time characteristic (SGF1/1-2-3 = 0-0-0). Setting range 0.05...300 s.
k	Time multiplier of the I> stage at inverse time characteristic. Setting range 0.05...1.00.
$I>>/I_n$	Start current of the I>> stage as a multiple of the rated current of the used energizing input. Setting range 0.5...40.0 x I_n. Additionally the setting "infinite" (displayed as n - - -) can be selected with switch SGF2/5, which means that the high-set stage I>> is out of operation.
t>>	Operate time of the I>> stage expressed in seconds. Setting range 0.04...300 s.
$I_0>/I_n$	Start current of the I_0> stage as a multiple of the rated current of the used energizing input. Setting range 0.1...0.8 x I_n.
$t_0>$	Operate time of the I_0> stage, expressed in seconds, at definite time characteristic (SGF1/6-7-8 = 0-0-0). Setting range 0.05...300 s.
k_0	Time multiplier k_0 of the I_0> stage at inverse time characteristic. Setting range 0.05...1.00.
$I_0>>/I_n$	Start current of the I_0>> stage as a multiple of the rated current of the used energizing input. Setting range 0.1...10.0 x I_n. Additionally the setting "infinite" (displayed as n - - -) can be selected with switch SGF2/6, which means that the earth-fault stage I_0>> is out of operation.
$t_0>>$	Operate time of the I_0>> stage expressed in seconds. Setting range 0.05...300 s.

Further, the checksums of switchgroups SGF1, SGB and SGR1 are shown on the display when the indicators adjacent to the switchgroup symbols on the front panel are lit. The checksums for switchgroups SGF2, SGR2 and SGR3 are found in the submenus under the main menu of the first switchgroup. For further information, see chapter "Menus and registers". An example of how the checksum can be calculated manually is given in manual "General characteristics of D type relay modules..

Selector switches

Additional functions required in various applications are selected with switchgroups SGF, SGB and SGR indicated on the front panel. The numbering of the switches, 1...8, and the switch positions 0 and 1 are shown when the switchgroups are set. Under normal service conditions only the checksums are shown. Switchgroups SGF2, SGR2 and SGR3 are found in the submenus of the main menus of switchgroups SGF and SGR.

Function switchgroup SGF1

<table>
<tr><th>Switch</th><th>Function</th></tr>
<tr><td>SGF1/1
SGF1/2
SGF1/3</td><td>Switches SGF1/1...3 are used for selecting the characteristic of the low-set overcurrent stage I>, i.e. definite time operation characteristic or inverse definite minimum time (IDMT) characteristic. At IDMT characteristic the switches are also used for selecting the required current/time characteristic for the stage.
<table>
<tr><th>SGF1/1</th><th>SGF1/2</th><th>SGF1/3</th><th>Characteristic</th><th>Time or curve set</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>Definite time</td><td>0.05...300 s</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>IDMT</td><td>Extremely inverse</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>IDMT</td><td>Very inverse</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>IDMT</td><td>Normal inverse</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>IDMT</td><td>Long-time inverse</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>IDMT</td><td>RI-characteristic</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>IDMT</td><td>RXIDG-characteristic</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>---</td><td>(Long-time inverse)</td></tr>
</table></td></tr>
<tr><td>SGF1/4</td><td>Circuit breaker failure protection (CBFP).

When SGF1/4 =1 the trip signal TS2 will start a timer which will generates a delayed operate signal via TS1, if the fault has not been cleared before the operate time has elapsed.
When switch SGF1/4 = 0 the circuit breaker failure protection is out of operation.</td></tr>
<tr><td>SGF1/5</td><td>Automatic doubling of the set start current of the high-set overcurrent stage I>> when the protected object is energized.

When SGF1/5 = 0, no doubling of the start current setting of stage I>> is obtained.
When SGF1/5 = 1, the start current setting of stage I>> doubles automatically.
The doubling feature makes it possible to give the high-set stage a setting value below the connection inrush current level.</td></tr>
<tr><td>SGF1/6
SGF1/7
SGF1/8</td><td>Switches SGF1/6...8 are used for selecting the operation characteristic of the low-set earth-fault stage I_0>, i.e. definite time characteristic or inverse definite minimum time (IDMT) characteristic. At inverse definite minimum time characteristic the switches are also used for selecting the current/time characteristic of the stage.
<table>
<tr><th>SGF1/6</th><th>SGF1/7</th><th>SGF1/8</th><th>Characteristic</th><th>Time or curve</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>Definite time</td><td>0.05…300 s</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>IDMT</td><td>Extremely inverse</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>IDMT</td><td>Very inverse</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>IDMT</td><td>Normal inverse</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>IDMT</td><td>Long-time inverse</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>IDMT</td><td>RI-characteristic</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>IDMT</td><td>RXIDG-characteristic</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>IDMT</td><td>Not in use (long-time inverse)</td></tr>
</table></td></tr>
</table>

On delivery from the factory all switches SGF1 are set at zero, i.e. the checksum for SGF1 is 0.

Function switch-group SGF2

Switch	Function
SGF2/1 SGF2/2 SGF2/3 SGF2/4	Switches SGF2/1...4 are used for selecting the operation characteristic of the start indicators of the different stages. When the switches are in position 0 the start signals are all automatically reset when the fault is cleared. To give the indicator of a stage the hand reset mode of operation, the corresponding switch is set in position 1: SGF2/1 = 1 equals manual reset mode for the start indication of stage I> SGF2/2 = 1 equals manual reset mode for the start indication of stage I>> SGF2/3 = 1 equals manual reset mode for the start indication of stage I_0> SGF2/4 = 1 equals manual reset mode for the start indication of stage I_0>>
SGF2/5	Operation of the high-set phase overcurrent stage I>>. When SGF2/5 = 0 the high-set stage I>> is alerted When SGF2/5 = 1 the high-set stage I>> is out of operation and the display shows "- - -"
SGF2/6	Operation of the high-set earth-fault stage I_0>>. When SGF2/6 = 0 the high-set stage I_0>> is alerted When SGF2/6 = 1 the high-set stage I_0>> is out of operation and the display shows "- - -"
SGF2/7	Start signal of the high-set stage I>> to the auto-reclose signal output AR1. When SGF2/7 = 1, the start signal of the I>> stage is routed to output AR1. Note! Outputs AR1 and SS3 are interconnected and they always carry the same signal. Therefore, if AR1 is used for starting auto-reclose functions, SS3 cannot be used for any other purpose. When SGF2/7 =0, the start signal of the I>> stage is not routed to output AR1 nor SS3. Thus the signal output SS3 is available for other purposes.
SGF2/8	Start signal of the low-set stage I_0> or high-set stage I_0>> to auto-reclose signal output AR3. When SGF2/8 = 0 the start signal from the I_0> stage is routed to output AR3 When SGF2/8 = 1 the start signal from the I_0>> stage is routed to output AR3

When the relay is delivered from the factory the SGF2 switches are set at zero, i.e. the checksum for SGF2 is 0.

Blocking or control signal configuration switchgroup SGB

Switch	Function
SGB/1 SGB/2 SGB/3 SGB/4	Switches SGB/1...4 are used for routing an external blocking signal BS to one or more of the protection stages of the relay module. When the switches all are in position 0 no stage is blocked. When SGB/1 = 1 the I> stage is blocked by the external control signal BS When SGB/2 = 1 the I>> stage is blocked by the external control signal BS When SGB/3 = 1 the I_0> stage is blocked by the external control signal BS When SGB/4 = 1 the I_0>> stage is blocked by the external control signal BS
SGB/5	Selection of main settings or second settings with an external control signal BS or via the serial interface using command V150. When SGB/5 = 0 the settings can be controlled via the serial port but not via the external control input BS When SGB/5 = 1, the settings can be controlled via the external control input. The main values are enforced when the control input is not energized and the second settings are enforced when the control input is energized. Note! When the application includes switching between main and second settings, it should be noted that switch SGB/5 must have the same position in the main set of settings and the second set of settings. Otherwise a conflict situation might occur when the settings are switched by external control or via the serial port.
SGB/6	Latching of the trip signal TS2 of the phase overcurrent unit. When SGB/6 = 0 the trip signal returns to its initial state (= the output relay drops off), when the energizing signal causing the operation falls below the set start current. When SGB/6 = 1 the trip signal is latched (= the output relay remains picked up after operation), although the energizing signal falls below the start current. The trip signal is to be manually reset by pushing the push-buttons RESET and PROGRAM simultaneously. [1)]
SGB/7	Latching of the trip signal TS2 of the earth-fault unit. When SGB/7 = 0 the trip signal returns to its initial state (= the output relay drops off), when the measuring signal causing the operation falls below the set start current. When SGB/7 = 1 the trip signal is latched (= the output relay remains picked up after operation), although the energizing signal falls below the start current. The trip signal is to be manually reset by pushing the push-buttons RESET and PROGRAM simultaneously. [1)]
SGB/8	Remote resetting of a latched output relay and memorized values. When the output TS2 has been given the latching mode with switch SGB/6 or SGB/7, a remote reset can be performed using the external control input BS, when switch SGB/8 =1.

When the relay is delivered from the factory the SGB switches are set at zero, i.e. the checksum for SGB is 0.

[1)] From the program versions 037F or 056A and later versions an additional feature has been incorporated into the relay module SPCJ 4D29. When the latching function is used the latched output can be reset by pushing the PROGRAM button alone, in which case the stored information of the module is not erased.

Output relay matrix switchgroups SGR1, SGR2 and SGR3

SGR1	The switches of switchgroup SGR1 are used to select the start and operate signals to be routed to outputs SS1 and TS2.
SGR2	The switches of switchgroup SGR2 are used for routing the operate signals of the protection stages to the outputs SS2 and SS3.
SGR3	The switches of switchgroup SGR3 are used to route the start and operate signals to the start or auxiliary trip output TS1. Note! If the circuit breaker failure protection has been taken in use with switch SGF1/4, it will also occupy the TS1 output.

Switch number	Function	Factory setting	Checksum value
SGR1/1	When SGR1/1 = 1, the start signal of the I> stage is routed to SS1	1	1
SGR1/2	When SGR1/2 = 1, the operate signal of the I> stage is routed to TS2	1	2
SGR1/3	When SGR1/3 = 1, the start signal of the I>> stage is routed to SS1	0	4
SGR1/4	When SGR1/4 = 1, the operate signal of the I>> stage is routed to TS2	1	8
SGR1/5	When SGR1/5 = 1, the start signal of the I_0> stage is routed to SS1	0	16
SGR1/6	When SGR1/6 = 1, the operate signal of the I_0> stage is routed to TS2	1	32
SGR1/7	When SGR1/7 = 1, the staring signal of the I_0>> stage is routed to SS1	0	64
SGR1/8	When SGR1/8 = 1, the operate signal of the I_0>> stage is routed to TS2	1	128
	Checksum for the factory settings of switchgroup SGR1		171

SGR2/1	When SGR2/1 = 1, the operate signal of the I> stage is routed to SS2	1	1
SGR2/2	When SGR2/2 = 1, the operate signal of the I> stage is routed to SS3	0	2
SGR2/3	When SGR2/3 = 1, the operate signal of the I>> stage is routed to SS2	1	4
SGR2/4	When SGR2/4 = 1, the operate signal of the I>> stage is routed to SS3	0	8
SGR2/5	When SGR2/5 = 1, the operate signal of the I_0> stage is routed to SS2	0	16
SGR2/6	When SGR2/6 = 1, the operate signal of the I_0> stage is routed to SS3	1	32
SGR2/7	When SGR2/7 = 1, the operate signal of the I_0>> stage is routed to SS2	0	64
SGR2/8	When SGR2/8 = 1, the operate signal of the I_0>> stage is routed to SS3	1	128
	Checksum for the factory settings of switchgroup SGR2		165

Switch number	Function	Factory setting	Checksum value
SGR3/1	When SGR3/1 = 1, the start signal of the I> stage is routed to TS1	0	1
SGR3/2	When SGR3/2 = 1, the trip signal of the I> stage is routed to TS1	0	2
SGR3/3	When SGR3/3 = 1, the start signal of the I>> stage is routed to TS1	0	4
SGR3/4	When SGR3/4 = 1, the trip signal of the I>> stage is routed to TS1	0	8
SGR3/5	When SGR3/5 = 1, the start signal of the I_0> stage is routed to TS1	0	16
SGR3/6	When SGR3/6 = 1, the trip signal of the I_0> stage is routed to TS1	0	32
SGR3/7	When SGR3/7 = 1, the start signal of the I_0>> stage is routed to TS1	0	64
SGR3/8	When SGR3/8 = 1, the trip signal of the I_0>> stage is routed to TS1	0	128
	Checksum for the factory settings of switchgroup SGR3		0

Measured data

The measured current values are shown by the three right-most digits of the display. The value displayed at the present time is indicated by a LED indicator on the front panel.

Indicator	Measured data
I_{L1}	Line current on phase L1 as a multiple of the rated current I_n of the used energizing input (0…63 x I_n).
I_{L2}	Line current on phase L2 as a multiple of the rated current I_n of the used energizing input (0…63 x I_n).
I_{L3}	Line current on phase L3 as a multiple of the rated current I_n of the used energizing input (0…63 x I_n).
I_0	Residual current as a multiple of the rated current I_n of the used energizing input (0…21 x I_n).

Recorded information

The left-most red digit shows the address of the register and the right-most three digits the recorded value.

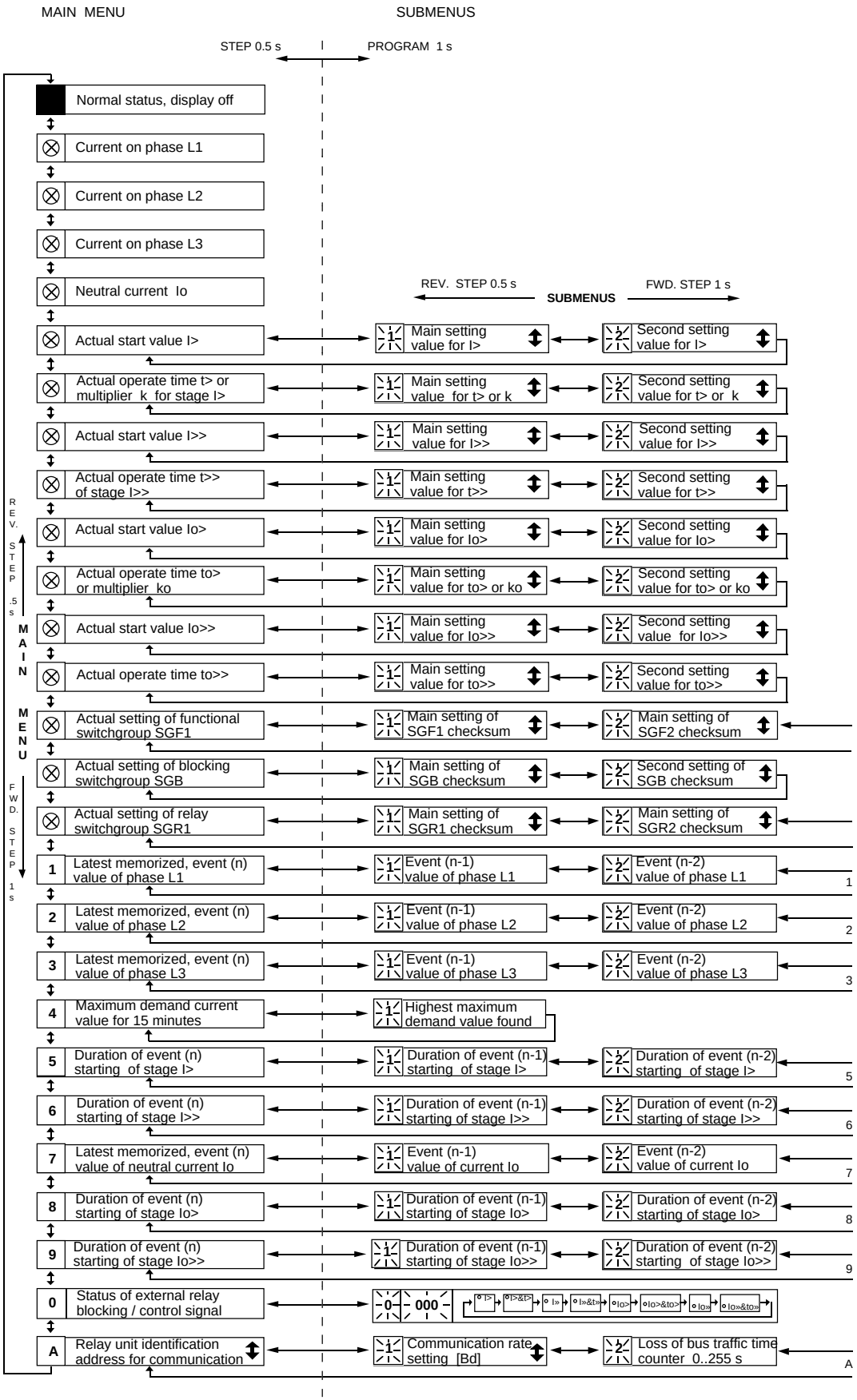
The // symbol in the text indicates that the item following the symbol is found in a submenu.

Register/ STEP	Recorded information
1	Phase current I_{L1} displayed as a multiple of the rated current of the used input of the overcurrent unit. If the overcurrent unit starts or operates, the current value at the moment of operation is recorded in a memory stack. Any new operation adds a new value to the stack and moves the old values one place forward. Five values are memorized. If a sixth value is recorded, the oldest value is lost.
2	Phase current I_{L2} measured as a multiple of the rated current of the used input of the overcurrent unit. If the overcurrent unit starts or operates, the current value at the moment of operation is recorded in a memory stack. Any new operation adds a new value to the stack and moves the old values one place forward. Five values are memorized. If a sixth value is recorded, the oldest value is lost.
3	Phase current I_{L3} measured as a multiple of the rated current of the used input of the overcurrent unit. If the overcurrent unit starts or operates, the current value at the moment of operation is recorded in a memory stack. Any new operation adds a new value to the stack and moves the old values one place forward. Five values are memorized. If a sixth value is recorded, the oldest value is lost.
4	Maximum demand current value for a period of 15 minutes expressed in multiples of the rated current I_n of the used energizing input and based on the highest phase current. // Highest maximum demand current value recorded after the last relay reset.
5	Duration of the last start situation of the I> stage as a percentage of the set operate time t> or at IDMT characteristic the calculated operate time. At any new start the time counter starts from zero. Five start times are memorized. If a sixth start occurs the oldest start time is lost. When the concerned stage has operated, the counter reading is 100. // Number of starts of the low-set overcurrent stage I>, n (I>) = 0...255.
6	Duration of the last start situation of the I>> stage as a percentage of the set operate time t>>. At any new start the time counter starts from zero. Five start times are memorized. If a sixth start occurs the oldest start time is lost. When the concerned stage has operated, the counter reading is 100. // Number of starts of the high-set overcurrent stage I>>, n (I>>) = 0...255.
7	Neutral current I_0 displayed as a multiple of the rated current of the used energizing input of the earth-fault unit. If the earth-fault unit starts or operates, the current value at the moment of operation is recorded in a memory stack. Any new operation adds a new value to the memory stack and moves the old values forward one place. Five values are memorized - if a sixth value is recorded, the oldest value will be lost.
8	Duration of the latest start situation of stage I_0> as a percentage of the set operate time t_0> or in IDMT operation characteristic the calculated operate time. At any new start the time counter starts from zero. Five start times are memorized. If a sixth start is recorded the oldest start time is lost. When the concerned stage has operated, the counter reading is 100. // Number of starts of the high-set overcurrent stage I>>, n (I>>) = 0...255.
9	Duration of the latest start situation of stage I_0>> as a percentage of the set operate time t_0>>. At any new start the time counter starts from zero. Five start times are memorized. If a sixth start is recorded the oldest start time will be lost. When the concerned stage has operated, the counter reading is 100. // Number of starts of the high-set earth-fault stage I_0>>, n (I_0>>) = 0...255.

Register/ STEP	Recorded information
0	Display of blocking signals and other external control signals. The right-most digit indicates the state of the blocking input of the module. The following states may be indicated: 0 = no blocking signal 1 = blocking or control signal BS active. The function of the external control signal on the relay unit is determined by the settings of switchgroup SGB From register "0" the TEST mode can be reached. In the TEST mode the start and trip signals of the relay module can be activated one by one. For further details see description "General characteristics of D type relay modules".
A	The address code of the protection relay module, required by the serial communication system. The address code is set at zero when no serial communication is to be used. The submenus of this register include the following settings or functions. - 1st submenu. Selection of data transfer rate for the communication system. Selectable values 4800 Bd or 9600 Bd. - 2nd submenu. Bus communication monitor. If the relay is connected to bus communication unit, e.g. type SRIO 1000M, and the communication system is working properly, the monitor shows the value zero. When the communication system is out of operation the values 0…255 scroll in the monitor. - 3rd submenu. Password for allowing remote changing of setting values. The password must always be given via the serial port. - 4th submenu. Selection of main settings versus second settings. - 5th submenu. Setting of the operate time of the circuit breaker failure protection unit.
-	Display dark. By pushing the STEP push-button the beginning of the display sequence is reached.

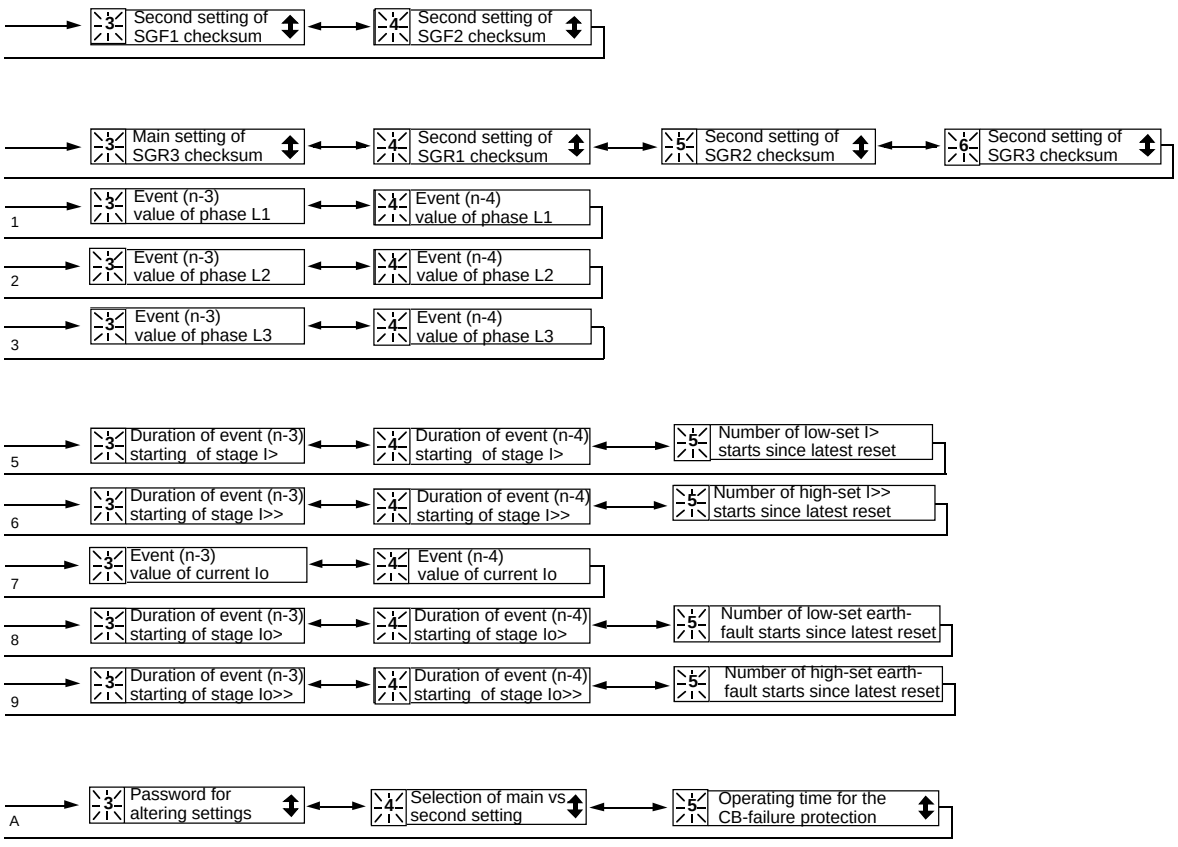
Registers 1...9 are erased by pushing the RESET and PROGRAM push-buttons simultaneously. The contents of the registers are also erased if the auxiliary power supply of the module is interrupted. The address code of the relay module, the data transfer rate of the serial communication system, the password and the status of the main/second setting bank switch are not erased by a voltage failure. Instructions for setting the address and the data transfer rate are given in manual "General characteristics of D type relay modules".

Menu and register chart



The procedures for entering a submenu or a setting mode and the method of performing the settings and the use of the TEST mode are described in detail in the manual "General characteristics of D type relay modules". A short form guide to the operations is shown below.

Desired step or setting operation	Push-button	Action
Forward step in main menu or submenu	STEP	Push for more than 0.5 s
Rapid scan forward in main menu	STEP	Keep pushing
Reverse step in main menu or submenu	STEP	Push less than about 0.5 s
Entering submenu from main menu	PROGRAM	Push for 1 s (Active on release)
Entering or leaving setting mode	PROGRAM	Push for 5 s
Increasing value in setting mode	STEP	
Moving the cursor in setting mode	PROGRAM	Push for about 1 s
Storing a value in setting mode	STEP&PROGRAM	Push simultaneously
Erasing of memorized values and resetting of latched output relays	STEP&PROGRAM	
Resetting of latched output relays	PROGRAM	Note! Display must be off
Note! All parameters which can be set in the setting mode are indicated with the symbol ⇕.		



Time/current characteristic

(modified 2002-05)

The operation of the low-set overcurrent stage I> and the low-set earth-fault stage I_0> is based on definite time or inverse time characteristic, as selected by the user. The operation characteristic is selected with switches 1...3 of switchgroup SGF1 for the overcurrent stage I> and with switches SGF1/6...8 for the earth-fault stage I_0> (see chapter "Selector switches", page 7).

When IDMT characteristic has been selected, the operate time of the stage will be a function of the current; the higher the current, the shorter the operate time.The stage includes six time/current curve sets - four according to the BS 142 and IEC 60255 standards and two special curve sets, named RI type and RXIDG type, according to ABB standards.

IDMT characteristic

Four standard curves named extremely inverse, very inverse, normal inverse and long- time inverse are available. The relationship between current and time complies with the BS 142.1966 and IEC 60255-3 standards and can be expressed as follows:

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

where
t = operate time in seconds
k = time multiplier
I = measured current value
I> = set start current value

The relay includes four time/current curve sets according to BS 142.1966 and IEC 60255-3.

The slope of the time/current curve sets is determined by the constants α and β as follows:

Slope of the time/ current curve set	α	β
Normal inverse	0.02	0.14
Very inverse	1.0	13.5
Extremely inverse	2.0	80.0
Long-time inverse	1.0	120.0

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

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

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

In the defined normal current ranges, the inverse-time stages of the overcurrent and earth-fault unit SPCJ 4D29 comply with the tolerances of class 5 for all time/current curves.

The time/current curves specified in the BS-standards are illustrated in Fig. 3, 4, 5 and 6.

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

RI-type characteristic

The RI-type characteristic is a special characteristic used mainly in combination with existing mechanical relays. The characteristic is based on the following mathematical expression:

$$t\,[s] = \frac{k}{0.339 - 0.236 \times \frac{I>}{I}}$$

where
t = operate time in seconds
k = time multiplier
I = measured phase current
I> = set start current

The graph of the characteristic is shown in Fig.7.

RXIDG-type characteristic

The RXIDG-type characteristic is a special characteristic used mainly for earth-fault protection, where a high degree of selectivity is needed also for high-resistance faults. With this characteristic, the protection relay need not to be directional and the scheme can operate without a pilot communication.

The characteristic is based on the following mathematical expression:

$$t\,[s] = 5.8 - 1.35 \times \log_e \left(\frac{I}{k \times I>} \right)$$

where
t = operate time in seconds
k = time multiplier
I = measured phase current
I> = set start current

The graph of the characteristic is shown in Fig. 8.

Note!

If the set start current exceeds 2.5 x I_n, the maximum permitted continuous current carrying capacity of the energizing inputs (4 x I_n) must be observed.

At inverse time characteristic the effective setting range of the low-set overcurrent stage is 0.5…2.5 x I_n, although start current settings within the range 2.5…5.0 x I_n can be set on the relay. At inverse time characteristic any start current setting above 2.5 x I_n of the low-set stage will be regarded as being equal to 2.5 x I_n.

The operation of the low-set stage based on inverse time characteristic will be blocked by starting of the high-set stage. Then the operate time of the overcurrent or earth-fault unit is determined by the set operate time of the high-set stage at heavy fault currents.

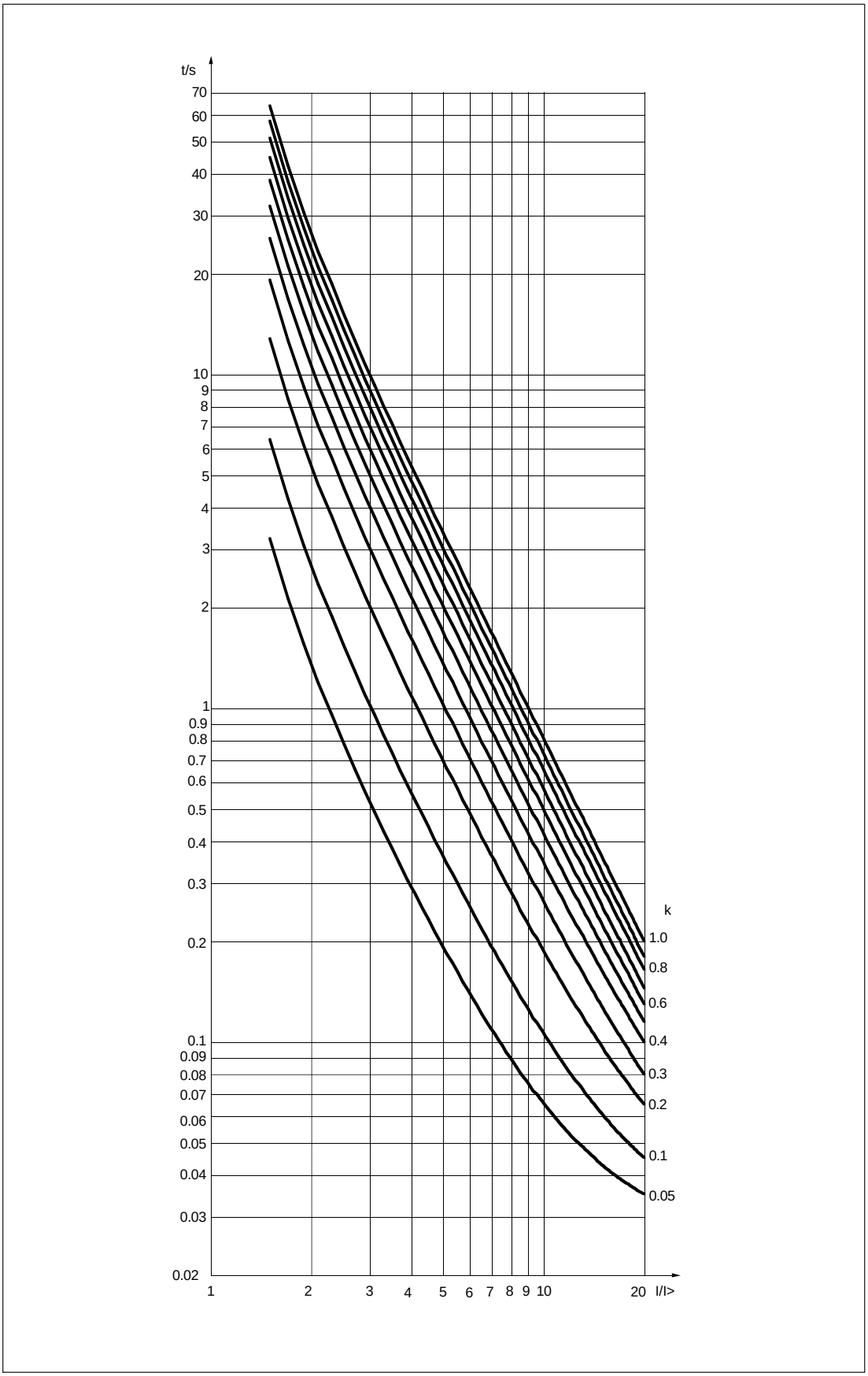


Fig. 3. Extremely inverse-time characteristics of the overcurrent and earth-fault unit SPCJ 4D29.

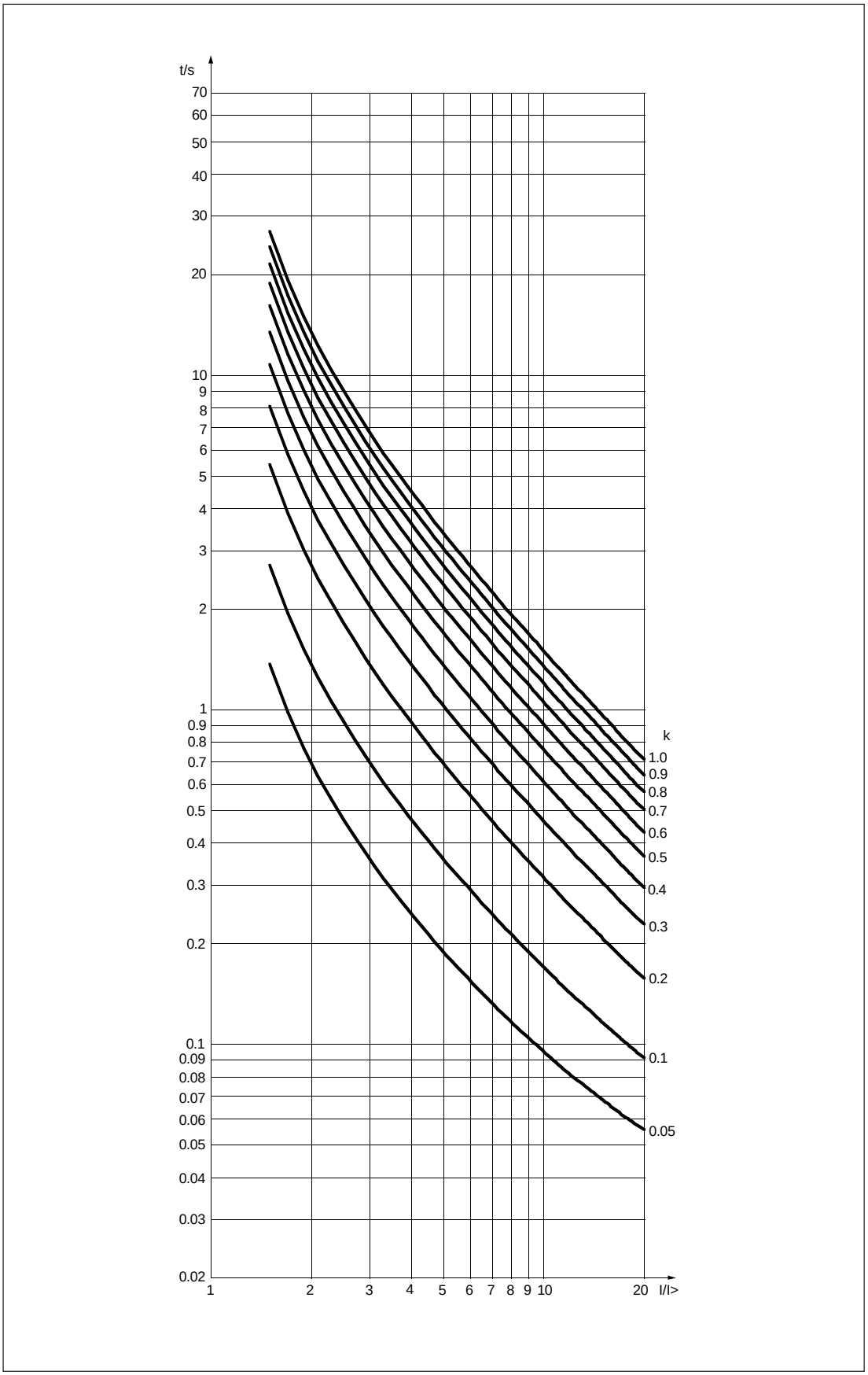


Fig. 4. Very inverse-time characteristics of the overcurrent and earth-fault unit SPCJ 4D29.

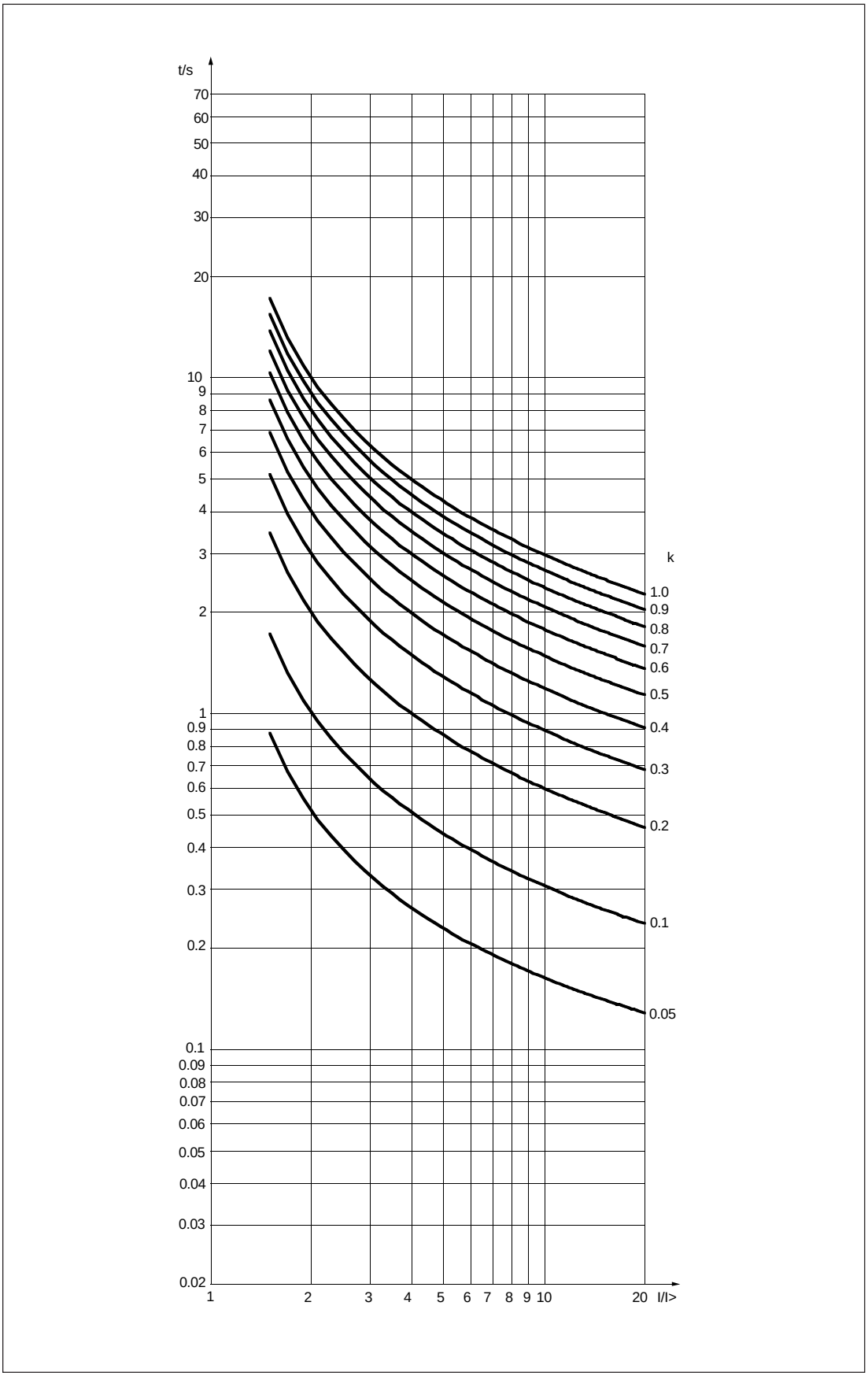


Fig. 5. Normal inverse-time characteristics of the overcurrent and earth-fault unit SPCJ 4D29.

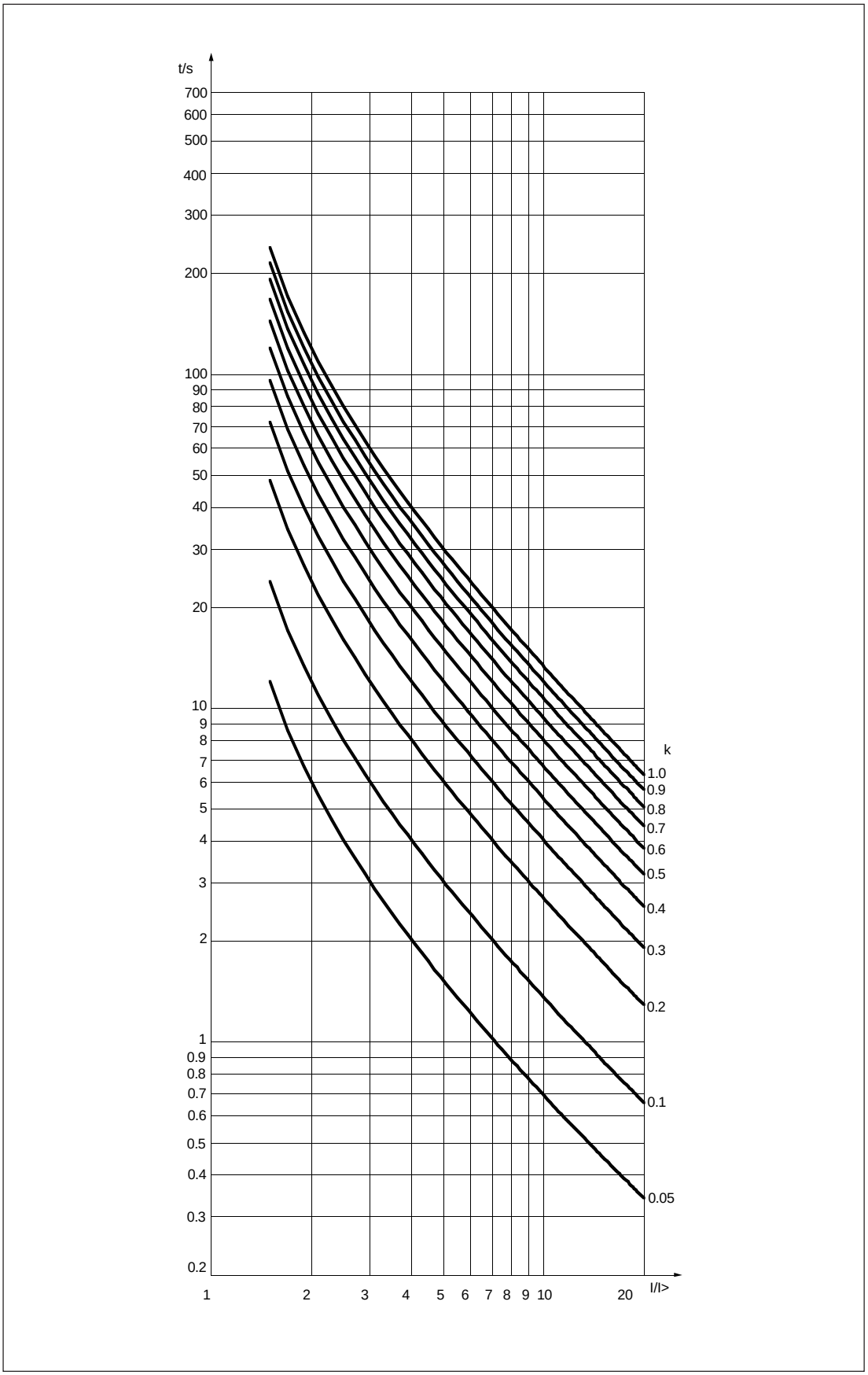


Fig. 6. Long-time inverse-time characteristics of the overcurrent and earth-fault unit SPCJ 4D29.

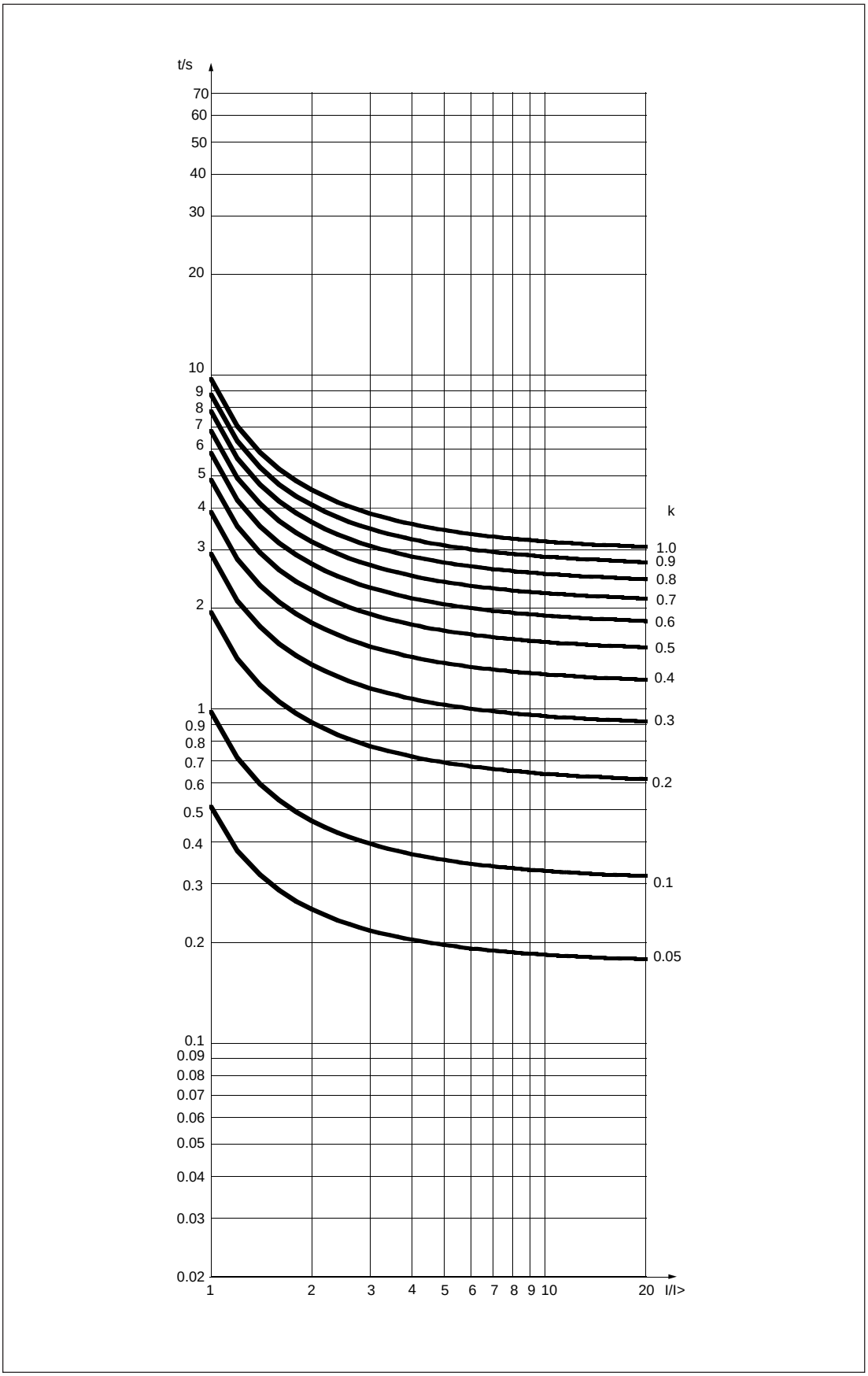


Fig. 7. RI-type inverse-time characteristics of the overcurrent and earth-fault unit SPCJ 4D29.

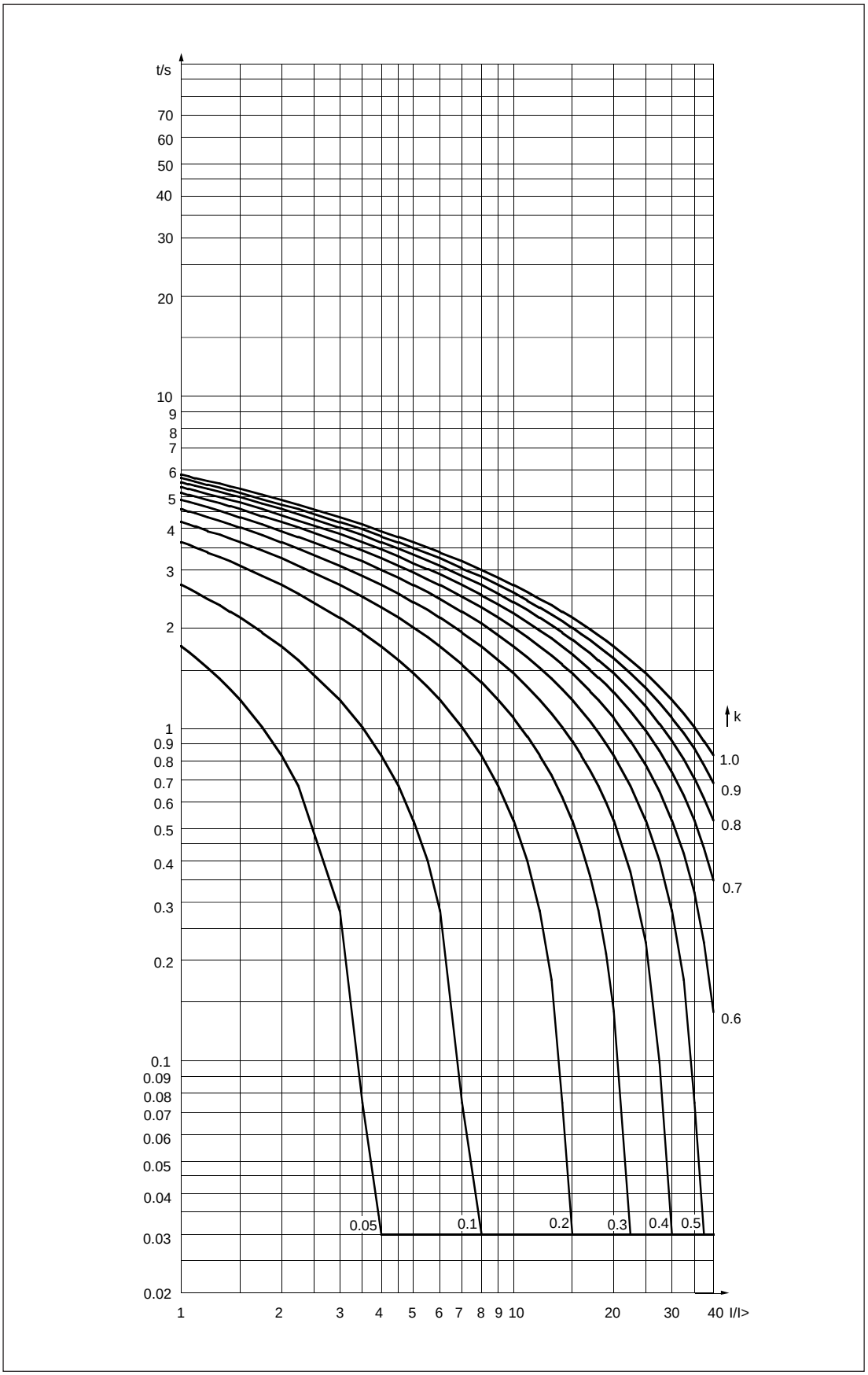


Fig. 8. RXIDG-type inverse-time characteristics of the overcurrent and earth-fault unit SPCJ 4D29.

Low-set overcurrent stage I>

Start current	
- definite time characteristic	0.5...5.0 x I_n
- inverse time characteristic	0.5…2.5 x I_n
Start time, typ.	50 ms
Operation characteristic	
- definite time characteristic	
- operate time	0.05...300 s
- Inverse time characteristic acc. to BS 142 and IEC 60255-3	Extremely inverse Very inverse Normal inverse Long-time inverse
- special characteristic acc. to ABB standards	RI-type inverse RXIDG-type inverse
- time multiplier k	0.05...1.00
Reset time, typ.	40 ms
Retardation time	<30 ms
Drop-off/pick-up ratio, typ.	0.96
Operate time accuracy at definite time operation characteristic	±2 % of set value or ±25 ms
Operate time accuracy class E at inverse time characteristic	5
Operation accuracy	±3% of set value

High-set overcurrent stage I>>

Start current I>>	0.5...40.0 x I_n or ∞, infinite
Start time, typ.	40 ms
Operate time	0.04...300 s
Reset time, typ.	40 ms
Retardation time	<30 ms
Drop-off/pick-up ratio, typ.	0.98
Operate time accuracy	±2% of set value or ±25 ms
Operation accuracy	±3% of set value

Low-set earth-fault stage I_0>

Start current I_0>	0.1…0.8 x I_n
Start time, typ.	60 ms
Operation characteristic	
- definite time characteristic	
- operate time	0.05...300 s
- Inverse time characteristic acc. to BS 142 and IEC 60255-3	Extremely inverse Very inverse Normal inverse Long-time inverse
- special characteristic acc. to ABB standards	RI-type inverse RXIDG-type inverse
- time multiplier k_0	0.05...1.00
Reset time, typ.	40 ms
Retardation time	<30 ms
Drop-off/pick-up ratio, typ.	0.96
Operate time accuracy at definite time operation characteristic	±2 % of set value or ±25 ms
Operate time accuracy class E at inverse time characteristic	5
Operation accuracy	±3% of set value

High-set earth-fault stage I_0>>

Start current I_0>>	0.1...10.0 x I_n or ∞, infinite
Start time, typ.	40 ms
Operate time	0.05...300 s
Reset time, typ.	40 ms
Drop-off/pick-up ratio, typ.	0.98
Operate time accuracy	±2% of set value or ±25 ms
Operation accuracy	±3% of set value

Serial communication parameters

Event codes

When the combined overcurrent and earth-fault relay module SPCJ 4D29 is connected to a data communication unit. e.g. SRIO 1000M, over a fibre-optic SPA bus, the module will spontaneously generate event markings e.g. for a printer. The events are printed out in the format: time, text and event code. The text can be defined and written by the user into the communication unit.

The events coded E1...E16 can be included in or excluded from the event reporting by writing an event mask V155 for the overcurrent events and V156 for earth-fault events to the module over the SPA bus. The event masks are binary numbers coded to decimal numbers. The event codes E1...E8 are represented by the numbers 1, 2, 4...128. An event mask is formed by multiplying the above numbers either by 0, event not included in reporting, or 1, event included in reporting and by adding the numbers received. Check for the procedure of a manual calculation of the checksum.

The event masks V155 and V156 may have a value within the range 0...255. The default value of the combined overcurrent and earth-fault relay module SPCJ 4D29 is 85 both for overcurrent and earth-fault events, which means that all start and operate events are included in the reporting, but not the resetting. Check for the procedure of a manual calculation of the checksum.

The output signals are monitored by codes E17...E26 and these events can be included in or excluded from the event reporting by writing an event mask V157 to the module. The event mask is a binary number coded to a decimal number. The event codes E17...E26 are represented by the numbers 1, 2, 4...512. An event mask is formed by multiplying the above numbers either by 0, event not included in reporting or 1, event included in reporting and by adding the numbers received. Check for the procedure of a manual calculation of the checksum.

The event mask V157 may have a value within the range 0...1024. The default value of the combined overcurrent and earth-fault relay module SPCJ 4D29 is 768 which means that only the operations are included in the reporting.

Codes E50...E54 and the events represented by these cannot be excluded from the reporting.

More information about the serial communication over the SPA bus can be found in the manual "SPA bus communication protocol", code No 34 SPACOM 2 EN1.

Event codes of the combined overcurrent and earth-fault relay module SPCJ 4D29:

Code	Event	Weight factor	Default value of the factor
E1	Starting of stage I>	1	1
E2	Resetting of starting of stage I>	2	0
E3	Operation of stage I>	4	1
E4	Resetting of operation of stage I>	8	0
E5	Starting of stage I>>	16	1
E6	Resetting of starting of stage I>>	32	0
E7	Operation of stage I>>	64	1
E8	Resetting of operation of stage I>>	128	0
	Default checksum for mask V155		85

Code	Event	Weight factor	Default value of the factor
E9	Starting of stage I_0>	1	1
E10	Resetting of starting of stage I_0>	2	0
E11	Operation of stage I_0>	4	1
E12	Resetting of operation of stage I_0>	8	0
E13	Starting of I_0>> stage	16	1
E14	Resetting of starting of stage I_0>>	32	0
E15	Operation of stage I_0>>	64	1
E16	Resetting of operation of stage I_0>>	128	0
	Default checksum for mask V156		85

E17	Output signal TS1 activated	1	0
E18	Output signal TS1 reset	2	0
E19	Output signal SS1 activated	4	0
E20	Output signal SS1 reset	8	0
E21	Output signal SS2 activated	16	0
E22	Output signal SS2 reset	32	0
E23	Output signal SS3 activated	64	0
E24	Output signal SS3 reset	128	0
E25	Output signal TS2 activated	256	1
E26	Output signal TS2 reset	512	1
	Default checksum for mask V157		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 event codes E52-E54 are generated by the data communication unit (SACO 100M, SRIO 500M, SRIO 1000M, etc.)

Data to be transferred via the fibre-optic serial bus

In addition to the spontaneous data transfer the SPA bus allows reading of all input values (I-values), setting values (S-values), information recorded in the memory (V-values), 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.

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

Data	Code	Data direction	Values
INPUTS			
Current on phase L1	I1	R	0...63 x I_n
Current on phase L2	I2	R	0...63 x I_n
Current on phase L3	I3	R	0...63 x I_n
Neutral current	I4	R	0...21 x I_n
Blocking or control signal	I5	R	0 = no blocking 1 = external blocking or control signal active
OUTPUTS			
Starting of stage I>	O1	R	0 = I> stage not started 1 = I> stage started
Operation of stage I>	O2	R	0 = I> stage not tripped 1 = I> stage tripped
Starting of stage I>>	O3	R	0 = I>> stage not started 1 = I>> stage started
Operation of stage I>>	O4	R	0 = I>> stage not tripped 1 = I>> stage tripped
Starting of stage I_0>	O5	R	0 = I_0> stage not started 1 = I_0> stage started
Operation of stage I_0>	O6	R	0 = I_0> stage not tripped 1 = I_0> stage tripped
Starting of stage I_0>>	O7	R	0 = I_0>> stage not started 1 = I_0>> stage started
Operation of stage I_0>>	O8	R	0 = I_0>> stage not tripped 1 = I_0>> stage tripped
Signal START1 TS1	O9	R, W (P)	0 = signal not active 1 = signal active
Signal START2 SS1	O10	R, W (P)	0 = signal not active 1 = signal active
Signal ALARM1 SS2	O11	R, W (P)	0 = signal not active 1 = signal active
Signal ALARM2 SS3	O12	R, W (P)	0 = signal not active 1 = signal active
Signal TRIP TS2	O13	R, W (P)	0 = signal not active 1 = signal active
Operate output relays	O41	R, W (P)	0 = not operated 1 = operated

Data	Code	Data direction	Values
Memorized I> start signal	O21	R	0 = signal not active 1 = signal active
Memorized I> operate signal	O22	R	0 = signal not active 1 = signal active
Memorized I>> start signal	O23	R	0 = signal not active 1 = signal active
Memorized I>> operate signal	O24	R	0 = signal not active 1 = signal active
Memorized I_0> start signal	O25	R	0 = signal not active 1 = signal active
Memorized I_0> operate signal	O26	R	0 = signal not active 1 = signal active
Memorized I_0>> start signal	O27	R	0 = signal not active 1 = signal active
Memorized I_0>> operate signal	O28	R	0 = signal not active 1 = signal active
Memorized output signal TS1	O29	R	0 = signal not active 1 = signal active
Memorized output signal SS1	O30	R	0 = signal not active 1 = signal active
Memorized output signal SS2	O31	R	0 = signal not active 1 = signal active
Memorized output signal SS3	O32	R	0 = signal not active 1 = signal active
Memorized output signal TS2	O33	R	0 = signal not active 1 = signal active
PRESENT SETTING VALUES			
Present start value for stage I>	S1	R	0.5...5.0 x I_n
Present operate time or time multiplier for stage I>	S2	R	0.05...300 s 0.05…1.0
Present start value for stage I>>	S3	R	0.5...40 x I_n 999 = not in use (∞)
Present operate time for stage I>>	S4	R	0.04...300 s
Present start value for stage I_0>	S5	R	0.1...0.8 x I_n
Present operate time or time multiplier for stage I_0>	S6	R	0.05...300 s 0.05…1.0
Present start value for stage I_0>>	S7	R	0.1...10.0 x I_n 999 = not in use (∞)
Present operate time for stage I_0>>	S8	R	0.05...300 s
Present checksum of switchgroup SGF1	S9	R	0...255
Present checksum of switchgroup SGF2	S10	R	0...255
Present checksum of switchgroup SGB	S11	R	0...255
Present checksum of switchgroup SGR1	S12	R	0...255
Present checksum of switchgroup SGR2	S13	R	0...255
Present checksum of switchgroup SGR3	S14	R	0...255

Data	Code	Data direction	Values
MAIN SETTING VALUES			
Start current of stage I>, main setting	S21	R, W (P)	0.5...5.0 x I_n
Operate time or time multiplier of stage I>, main setting	S22	R, W (P)	0.05...300 s 0.05…1.0
Start current of stage I>>, main setting	S23	R, W (P)	0.5...40.0 x I_n
Operate time of stage I>>, main setting	S24	R, W (P)	0.04...300 s
Start current of stage I_0>, main setting	S25	R, W (P)	0.1...0.8 x I_n
Operate time or time multiplier of stage I_0>, main setting	S26	R, W (P)	0.05...300 s 0.05…1.0
Start current of stage I_0>>, main setting	S27	R, W (P)	0.1...10.0 x I_n
Operate time of stage I_0>>, main setting	S28	R, W (P)	0.05...300 s
Checksum of switchgroup SGF1, main setting	S29	R, W (P)	0...255
Checksum of switchgroup SGF2, main setting	S30	R, W (P)	0...255
Checksum of switchgroup SGB, main setting	S31	R, W (P)	0...255
Checksum of switchgroup SGR1, main setting	S32	R, W (P)	0...255
Checksum of switchgroup SGR2, main setting	S33	R, W (P)	0...255
Checksum of switchgroup SGR3, main setting	S34	R, W (P)	0...255
SECOND SETTING VALUES			
Start current of stage I>, second setting	S41	R, W (P)	0.5...5.0 x I_n
Operate time or time multiplier of stage I>, second setting	S42	R, W (P)	0.05...300 s 0.05…1.0
Start current of stage I>>, second setting	S43	R, W (P)	0.5...40.0 x I_n
Operate time of stage I>>, second setting	S44	R, W (P)	0.04...300 s
Start current of stage I_0>, second setting	S45	R, W (P)	0.1...0.8 x I_n
Operate time or time multiplier of stage I_0>, second setting	S46	R, W (P)	0.05...300 s 0.05…1.0
Start current of stage I_0>>, second setting	S47	R, W (P)	0.1...10.0 x I_n
Operate time of stage I_0>>, second setting	S48	R, W (P)	0.05...300 s

Data	Code	Data direction	Values
Checksum of switchgroup SGF1, second setting	S49	R, W (P)	0...255
Checksum of switchgroup SGF2, second setting	S50	R, W (P)	0...255
Checksum of switchgroup SGB, second setting	S51	R, W (P)	0...255
Checksum of switchgroup SGR1, second setting	S52	R, W (P)	0...255
Checksum of switchgroup SGR2, second setting	S53	R, W (P)	0...255
Checksum of switchgroup SGR3, second setting	S54	R, W (P)	0...255
Operate time for the circuit breaker failure protection	S61	R, W (P)	0.1...1.0 s
RECORDED AND MEMORIZED PARAMETERS			
Current on phase L1 at starting or operation	V11...V51	R	0...63 x I_n
Current on phase L2 at starting or operation	V12...V52	R	0...63 x I_n
Current on phase L3 at starting or operation	V13...V53	R	0...63 x I_n
Neutral current I_0 at starting or operation	V14...V54	R	0...21 x I_n
Duration of the latest start situation of stage I>	V15...V55	R	0...100%
Duration of the latest start situation of stage I>>	V16...V56	R	0...100%
Duration of the latest start situation of stage I_0>	V17...V57	R	0...100%
Duration of the latest start situation of stage I_0>>	V18...V58	R	0...100%
Maximum demand current for 15 min.	V1	R	0...2.5 x I_n
Number of starts of stage I>	V2	R	0...255
Number of starts of stage I>>	V3	R	0...255
Number of starts of stage I_0>	V4	R	0...255
Number of starts of stage I_0>>	V5	R	0...255
Phase conditions during trip	V6	R	1 = I_{L3}>, 2 = I_{L2}>, 4 = I_{L1}>, 8 = I_0> 16 = I_{L3}>>, 32 = I_{L2}>> 64 = I_{L1}>>, 128 = I_0>>
Operation indicator	V7	R	0...9
Highest maximum demand current 15 minute value	V8	R	0…2.55 x I_n
CONTROL PARAMETERS			
Resetting of output relays at latched output	V101	W	1 = output relays and all information from the display are reset
Resetting of output relays and recorded data	V102	W	1 = output relays and registers are reset

Data	Code	Data direction	Values
Remote control of settings	V150	R, W	0 = main settings activated 1 = second settings activated, see chapter "Description of function"
Event mask word for overcurrent events	V155	R, W	0...255, see chapter "Event codes"
Event mask word for earth-fault events	V156	R, W	0...255, see chapter "Event codes"
Event mask word for output signal events	V157	R, W	0...1023, see chapter "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 (will restore factory settings)	V167	W (P)	2 = formatting, to be followed by power reset
Internal fault code	V169	R	0...255
Data comm. 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)
Software version symbol	V205	R	037_ or 056_
Event register reading	L	R	time, channel number and event code
Re-reading of event register	B	R	time, channel number and event code
Type designation of the module	F	R	SPCJ 4D29
Reading of module status data	C	R	0 = normal state 1 = module been subject to automatic reset 2 = overflow of event regist. 3 = events 1 and 2 together
Resetting of module state data	C	W	0 = resetting
Time reading and setting	T	R, W	00.000...59.999 s

The event register can be read by L-command only once. Should a fault occur e.g. in the data transfer, the contents of the event register may be re-read using the B-command. When required, the B-command can be repeated. Generally, the control data communicator SACO 100M reads the event data and forwards them to the output device continuously. Under normal conditions the event register of the module is empty. The data communicator also resets abnormal status data, so this data is normally a zero.

The setting values S1...S14 are the setting values used by the protection functions. All the settings can be read or written. A condition for writing is that remote set password has been opened.

When changing settings, the relay unit will check that the variable values are within the ranges specified in the technical data of the module. If a value beyond the limits is given to the unit, either manually or by remote setting, the unit will not perform the store operation but will keep the previous setting.

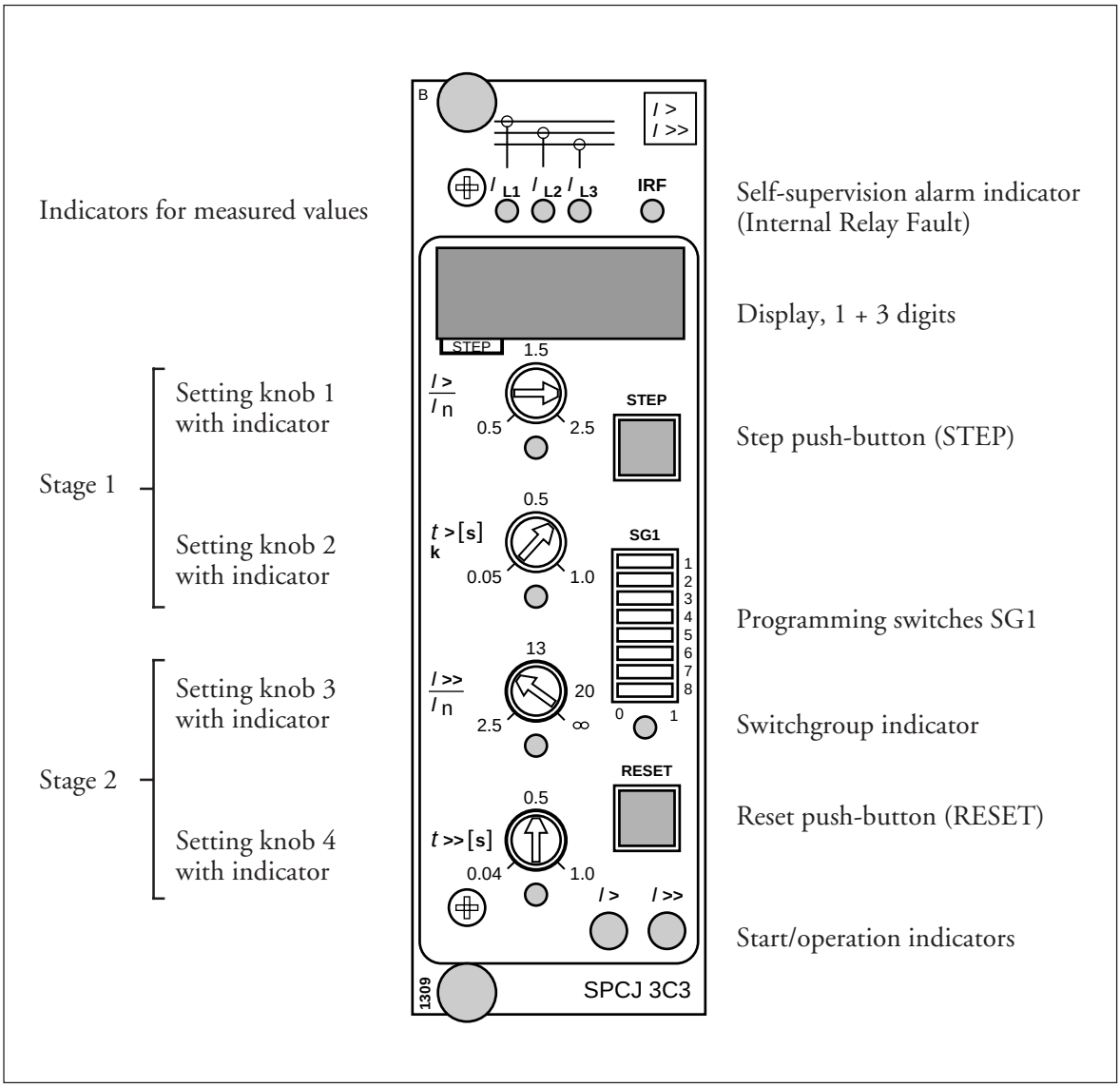
Fault codes

Shortly 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 and given to the authorized repair shop when overhaul is ordered. In the table below some fault codes that might appear on the display of the SPCJ 4D29 module are listed:

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 I_0 channel
253	No interruptions from the A/D-converter

General characteristics of C-type relay modules

User´s manual and Technical description



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General characteristics of C-type relay modules

Contents

Push-buttons

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

Programming switches SG1

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

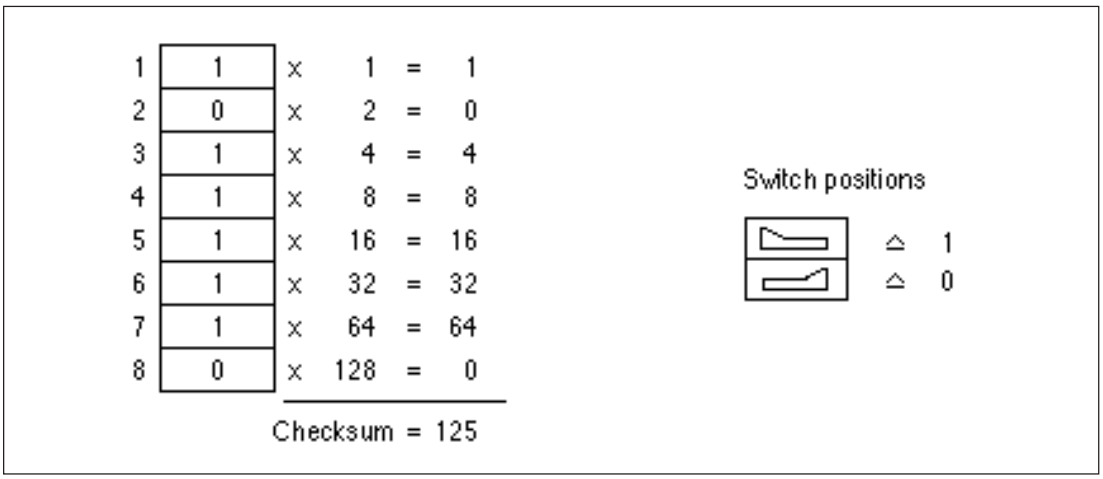


Fig. 2. Example of calculating the checksum of programming switchgroup SG1.

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

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

Setting knobs

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

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

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

Display

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

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

Display main menu

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

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

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

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

Display submenu

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

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

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

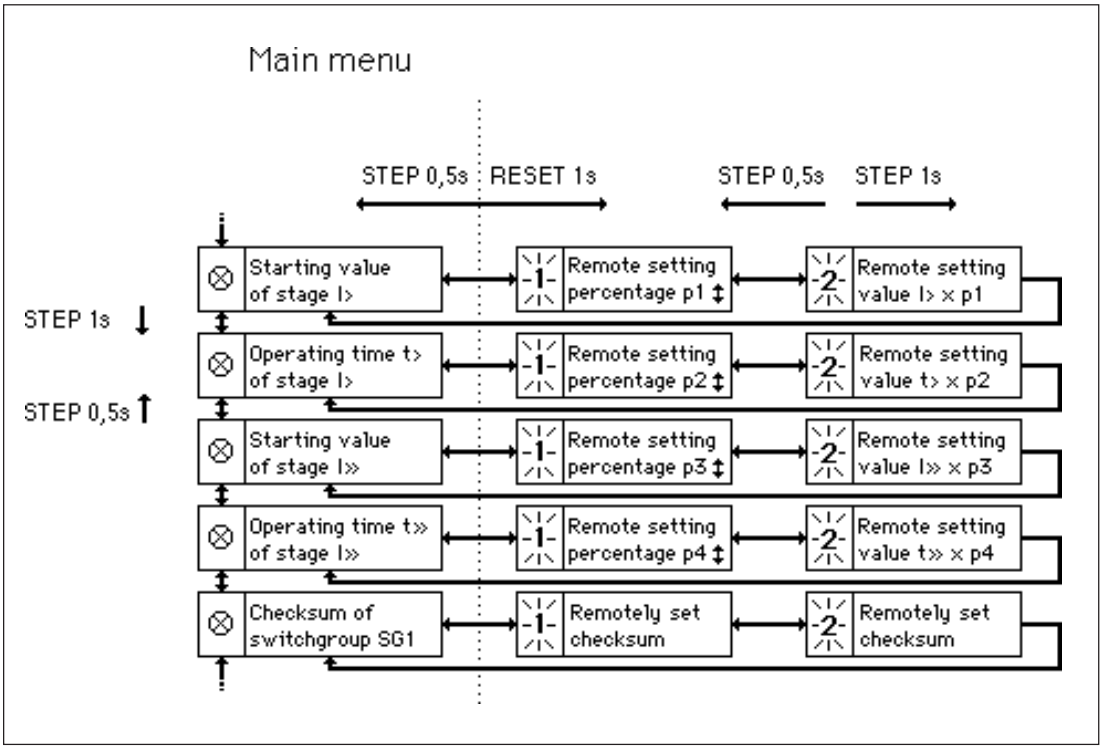


Fig. 3. Example of the main and submenus for the settings of the overcurrent relay module SPCJ 3C3. The settings made with the setting knobs are in the main menu and they are displayed by pressing the STEP button. In addition to the setting knob settings the main menu contains the measured current values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

Setting mode

The registers of the main menu and the submenus also contain parameters to be set. The settings are made in the so called setting mode, which is accessible from the main menu or a submenu by pressing the RESET button, until the digit at the extreme right starts flashing (about 10 s). The flashing digit is set by means of the STEP button. The flashing is moved on from digit to digit by pressing the RESET button.

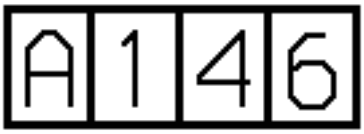
A set value is stored in the memory by pressing the push-buttons STEP and RESET simultaneously. In practice the RESET button must be pressed slightly in excess of the STEP button. Return from the setting mode to the main menu or submenu is possible by pressing (for about 10 s) the RESET button until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

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

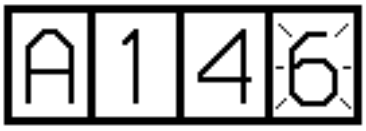
Example 1:

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

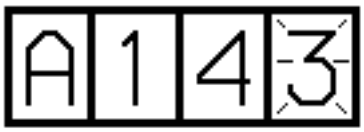
a)
Press push-button STEP until register address A appears on the display.



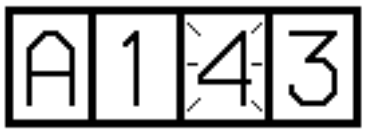
b)
Press the RESET button for about 10 s until the right most digit starts flashing.



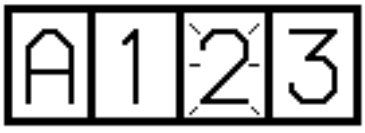
c)
Press the STEP button repeatedly to set the digit to the value desired.



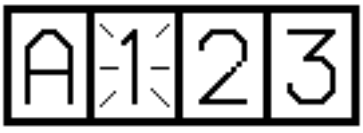
d)
Press the RESET button to make the middle of the green digits flash.



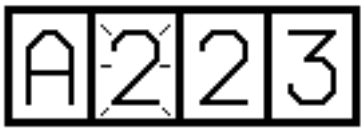
e)
Set the middle address digit by means of the STEP button.



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

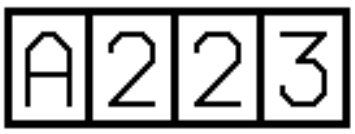


g)
Set the digit by means of the STEP button.



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

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



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

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

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

Stored information

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

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

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

Register 0 contains, in coded form, the information about e.g. external blocking signals and status information for the circuit breaker. The codes are explained in the descriptions of the relay modules.

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

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

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

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

Trip-test mode

Register 0 also allows access to the so called Trip-test function, which allows the output signals of the relay module to be activated one by one. If the auxiliary relay module of the protection assembly is in place, the auxiliary relays will be included in the testing.

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

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

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

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

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

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

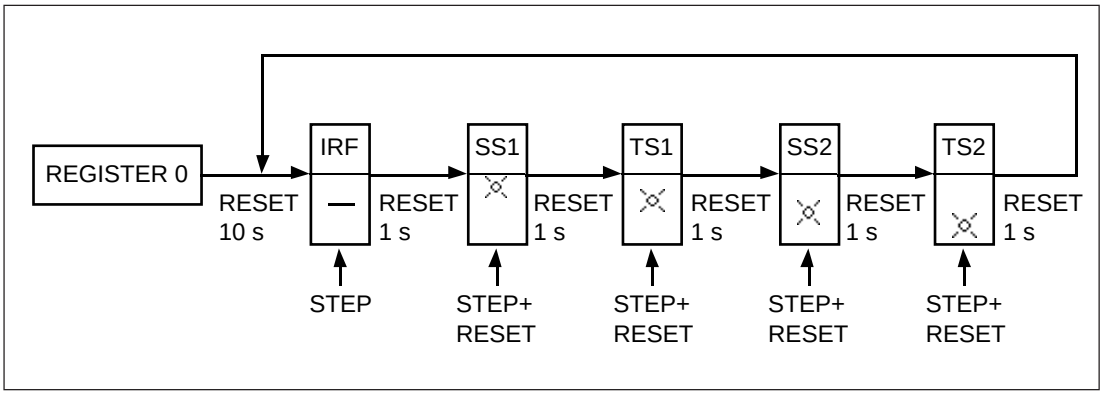


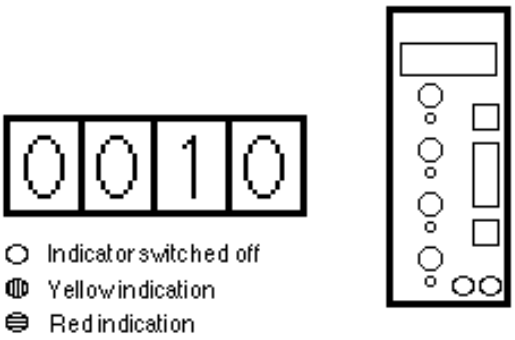
Fig. 4. Sequence order for selecting the output signals in the Trip-test mode.

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

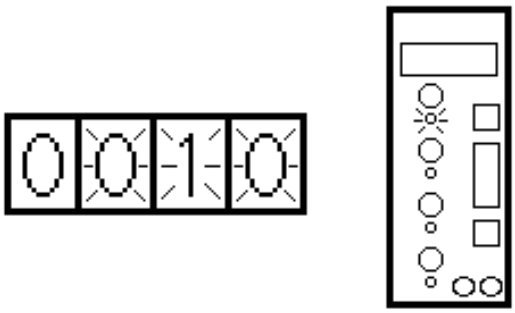
Example 2:

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

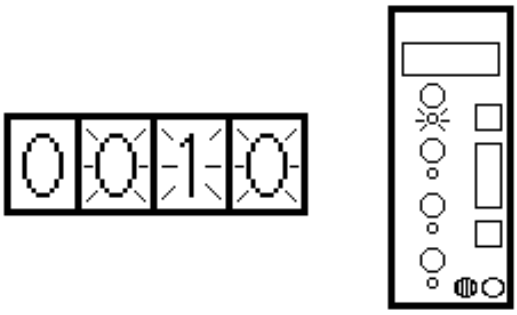
a)
Step forward on the display to register 0.



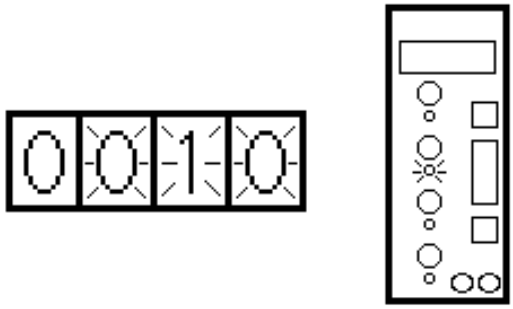
b)
Press the RESET button for about 10 seconds until the three green digits to the right and the LED indicator of the uppermost setting knob start flashing.



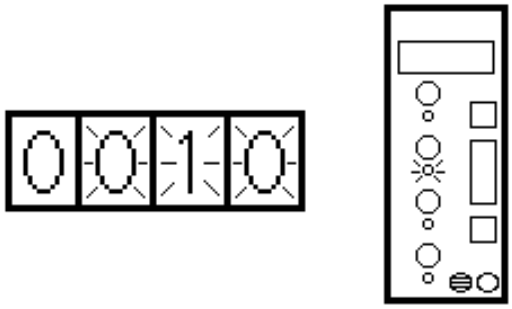
c)
Press the push-buttons RESET and STEP simultaneously. Then the starting of stage 1 (e.g. the I>-stage of the overcurrent module SPCJ 3C3) is activated and, simultaneously, the indicator of the stage starts glowing yellow.



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



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



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

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

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

Operation indicators

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

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

Fault codes

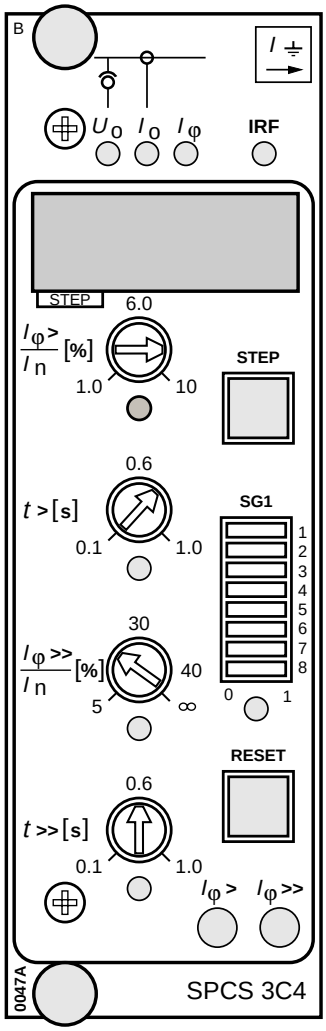
In addition to the protective functions the relay module is provided with a self-supervision system which continuously supervises the function of the microprocessor, its program execution and the electronics.

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

In most fault situations a fault code, indicating the nature of the fault, appears on the display of the module. The fault code, which consists of a red digit (1) and a three digit green code number, cannot be removed from the display by resetting. When a fault occurs, the fault code should be recorded and stated when service is ordered.

SPCS 3C4
Overcurrent relay module

User´s manual and Technical description



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SPCS 3C4
Overcurrent relay module

Contents

Features

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

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

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

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

Four selectable start values for the residual voltage

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

Continuous self-supervision with autodiagnostics including both hardware and software

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

Description of operation

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

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

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

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

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

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

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

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

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

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

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

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

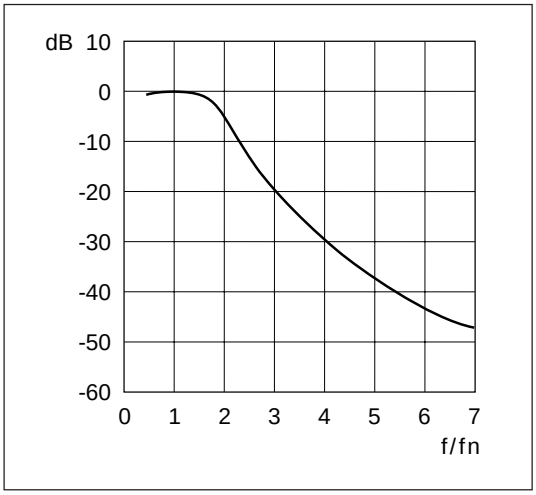


Fig. 1. Filter characteristics of the energizing inputs of the relay module SPCS 3C4.

Block schematic diagram

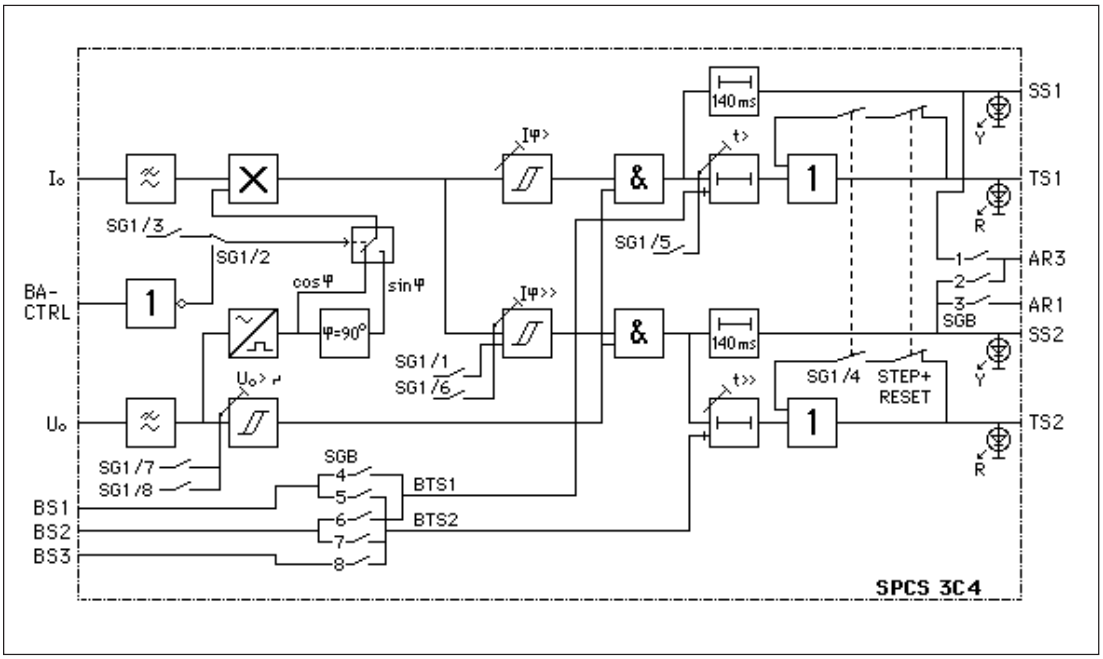


Fig. 2. Block diagram for the directional neutral current relay module SPCS 3C4.

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

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

Front panel

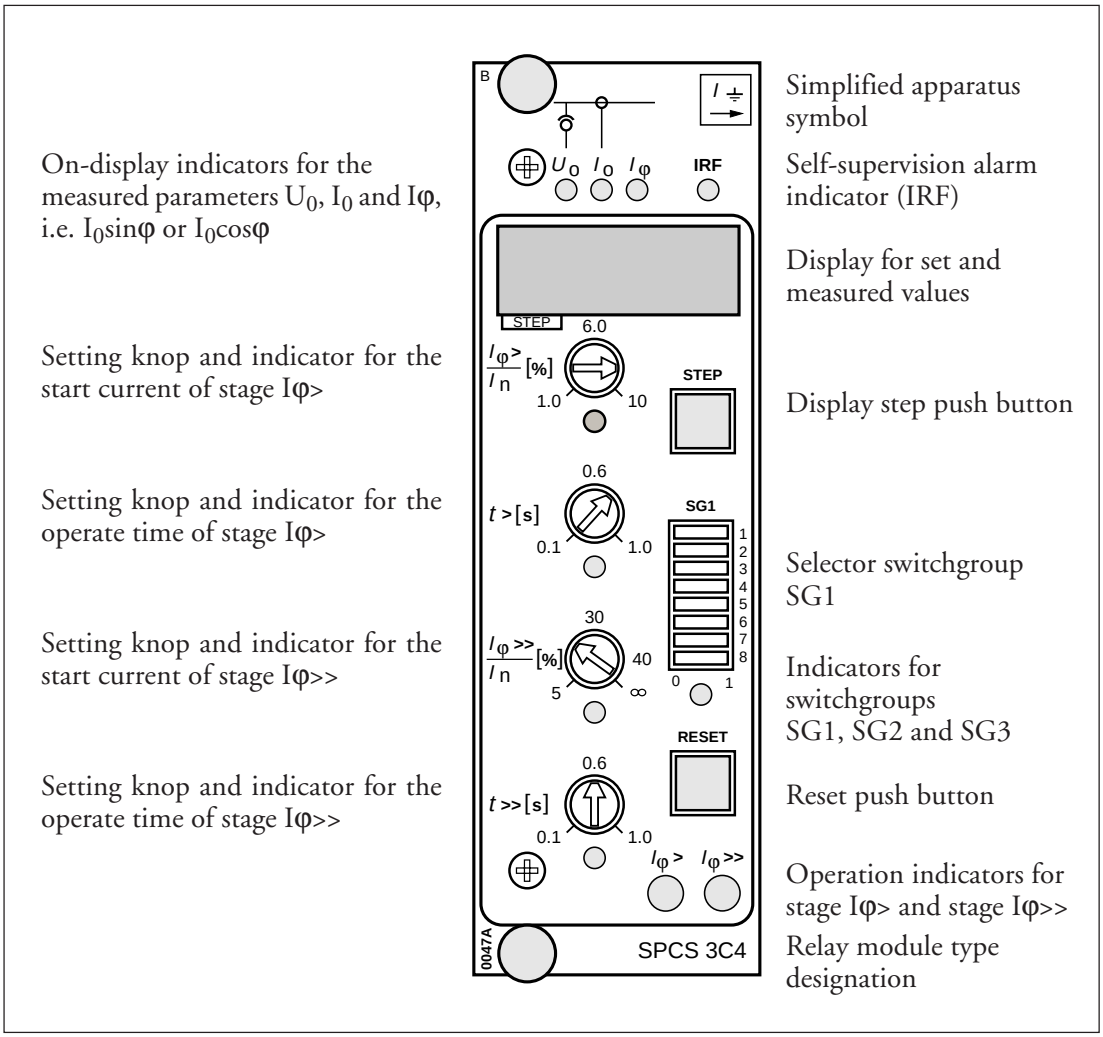


Fig. 3. Front panel of the directional neutral overcurrent relay module SPCS 3C4.

Operation indicators

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

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

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

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

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

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

Selector switches

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

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

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

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

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

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

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

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

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

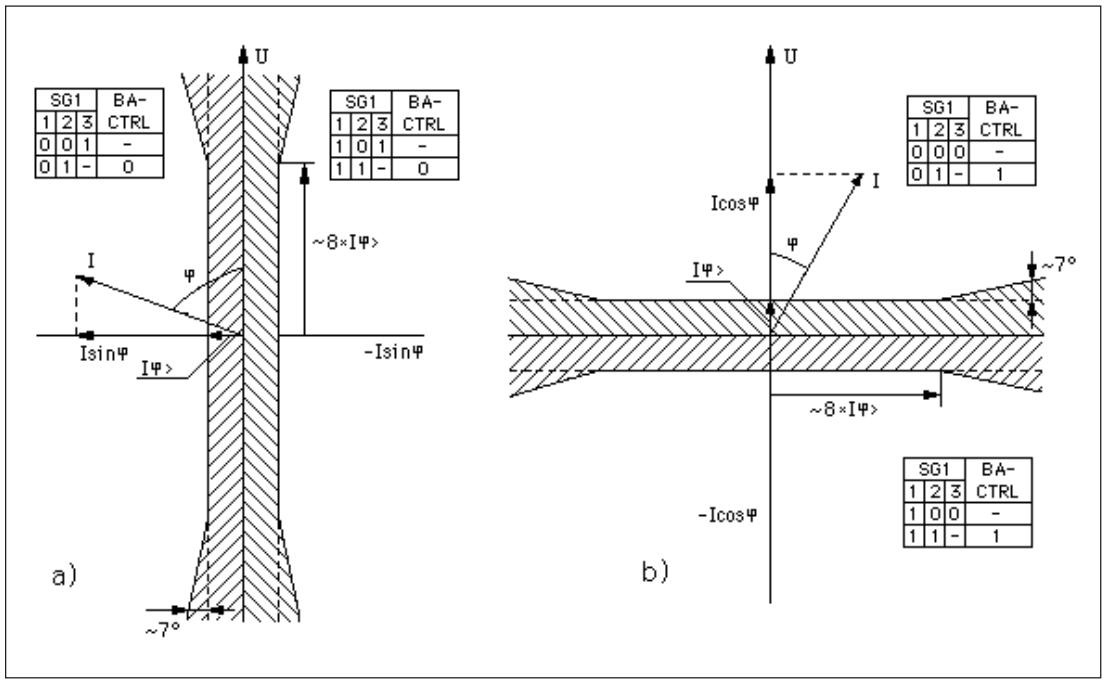


Fig. 4. Operation characteristic of the directional neutral overcurrent relay module SPCS 3C4. Fig. 4a shows the $I_0 \sin\varphi$ characteristic, Fig. 4b the $I_0 \cos\varphi$ characteristic.

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

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

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

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

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

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

Measured data

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

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

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

Recorded information
(modified 2000-02)

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

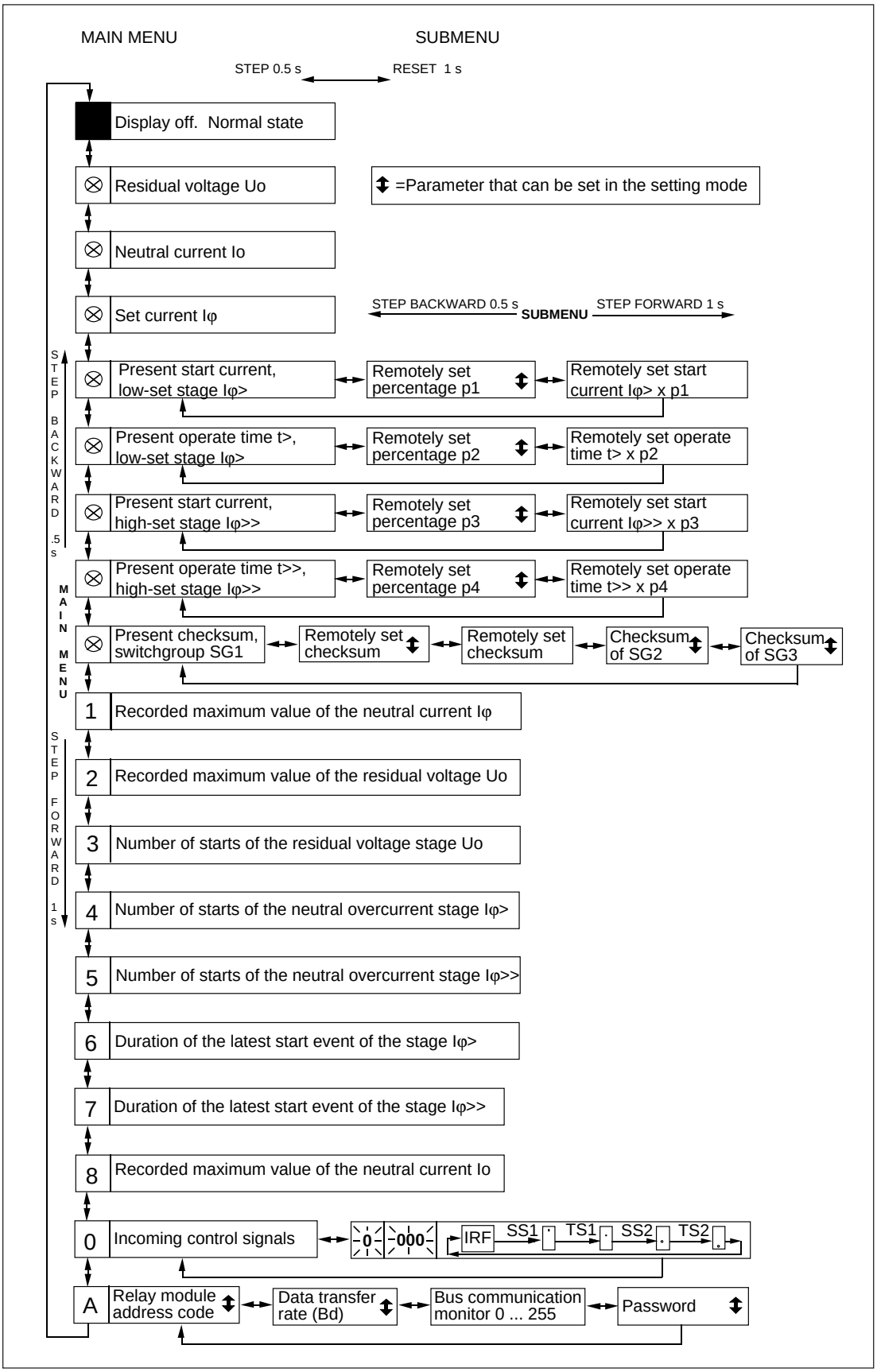
Register/ STEP	Recorded information
1	Measured $I_0 \sin\varphi$ or $I_0 \cos\varphi$ value as a percentage of the rated current. If Iφ has a negative sign, a red minus sign appears in the leftmost position in the display. If the measured value exceed 100% x I_n, the recorded value is expressed as 1-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

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

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

Main menus and submenus for settings and registers

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



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

Technical data
(modified 2000-02)

Low-set neutral overcurrent stage Iφ>

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

High-set neutral overcurrent stage Iφ>>

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

Event codes

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

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

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

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

Code	Event	Number representing the event	Definite value of the factor
E1	Start of stage Iφ>	1	1
E2	Reset of start of stage Iφ>	2	0
E3	Tripping of stage Iφ>	4	1
E4	Reset of tripping of stage Iφ>	8	0
E5	Start of stage Iφ>>	16	1
E6	Reset of start of stage Iφ>>	32	0
E7	Tripping of Iφ>>-stage	64	1
E8	Reset of tripping of stage Iφ>>	128	0
E50	Restart	*	-
E51	Overflow of event register	*	-
E52	Temporary disturbance in data communication	*	-
E53	No response from the module over the data communication	*	-
E54	The module responds again over the data communication	*	-

0 not included in event reporting
1 included in event reporting
* no code number
- cannot be programmed

NOTE!
In the SPACOM system the event codes E52...E54 are formed by the data communication equipment.

Remote transfer data

(modified 2000-02)

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

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

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

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

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

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

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

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

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

Fault codes

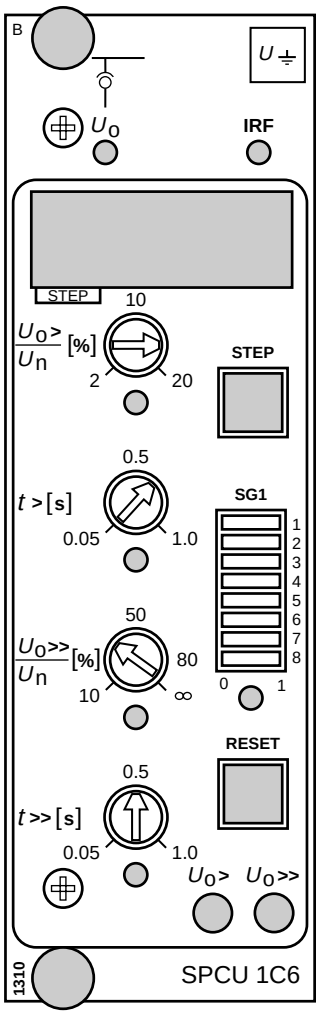
Shortly after that the self-supervision system has detected a permanent internal fault the red IRF indicator is lit. Simultaneously the relay module puts forward a control signal to the output relay of the self-supervision system. In most fault situations an autodiagnostic fault code appears on the display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

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

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

SPCU 1C6
Residual overvoltage relay module

User´s manual and Technical description



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SPCU 1C6
Residual overvoltage relay module

Contents

Features

Low-set residual overvoltage stage U_0> with definite time operation characteristic, setting ranges 2...20% x U_n and 10...100% x U_n

High-set residual overvoltage stage U_0>> with definite time operation characteristic, setting ranges 10...80% x U_n or 2...16% x U_n

The operation of the high-set residual overvoltage stage can be set out of function by selecting the setting ∞, infinitive

Effective suppression of harmonics of the input energizing voltages

Local display of measured and set values as well as data recorded at the moment of a relay operation

Flexible selection of special operational features for particular applications

Continuous self-supervision of hardware and software. At a permanent fault the alarm output relay picks up and the other outputs are blocked.

Description of operation

The residual overvoltage relay module type SPCU 1C6 is used in a variety of different protection relay units where it constitutes a non-directional general earth-fault protection module which measures the residual voltage of the electrical power system.

The residual overvoltage module contains two overvoltage stages,that is a low-set stage U_0> and a high-set stage U_0>>.

The low-set or high-set voltage stage starts if the measured voltage exceeds the set start value of the stage concerned. When starting, the concerned stage delivers a starting signal SS1 or SS2 and simultaneously the operation indicator of the stage is lit with yellow colour. If the overvoltage situation lasts long enough to exceed the set operation delay, the stage that started also operates generating a trip signal, TS1 alt. TS2. The operation indicator of the stage that operated turns red. The start and operation indicators are provided with memory control, which means that they can be given the self-reset or the latching mode of operation. The latching indicators are reset with the RESET push-button on the front panel or by means of the command V101 or V102 via the serial port.

The tripping of the low-set overvoltage stage U_0> can be blocked by routing a blocking signal BTS1 to the low-set stage. Similarly, the tripping of the high-set stage U_0>> is blocked by a blocking signal BTS2. The blocking signals are routed by means of switchgroup SGB on the PC board of the relay module.

The setting range of the operation time t> of the low-set overvoltage stage U_0> is selected with switches SG1/1 and SG1/2. Three setting ranges are available.

Switches SG1/7 and SG1/8 are used for selecting the setting range for the operation time t>> of the high-set stage U_0>>. Three setting ranges are available.

The setting range of the start value of the low-set stage U_0> is selected with switch SG1/5. Two setting ranges are available, that is 2...20% x U_n and 10...100% x U_n.

The setting range of the start value of the high-set stage U_0>> is selected with switch SG1/6. Two setting ranges are available, that is 2...16% x U_n or 10...80% x U_n.

The operation of the two operating stages is provided with a so called latching facility, which means that the operation output is kept alerted, although the signal which caused the operation disappears. The latching function is selected with switch SG1/4. The latched output and the output relay can be reset in three different ways; (i) by pressing push buttons STEP and RESET simultaneously, (ii) via the serial inter-face using the command V101 or (iii) via the serial interface using the command V102. When alternative (ii) is used all recorded information is maintained but if the alternatives (i) or (iii) is used the recorded information is erased.

The residual voltage signal input is provided with an effective filter by means of which hamonics of the measured residual voltage is suppressed, see Fig. 1.

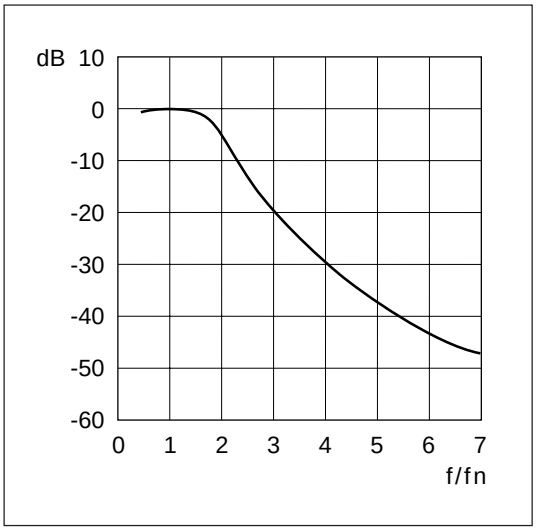

Fig. 1. Filter characteristics of the residual voltage input circuit.

Block diagram

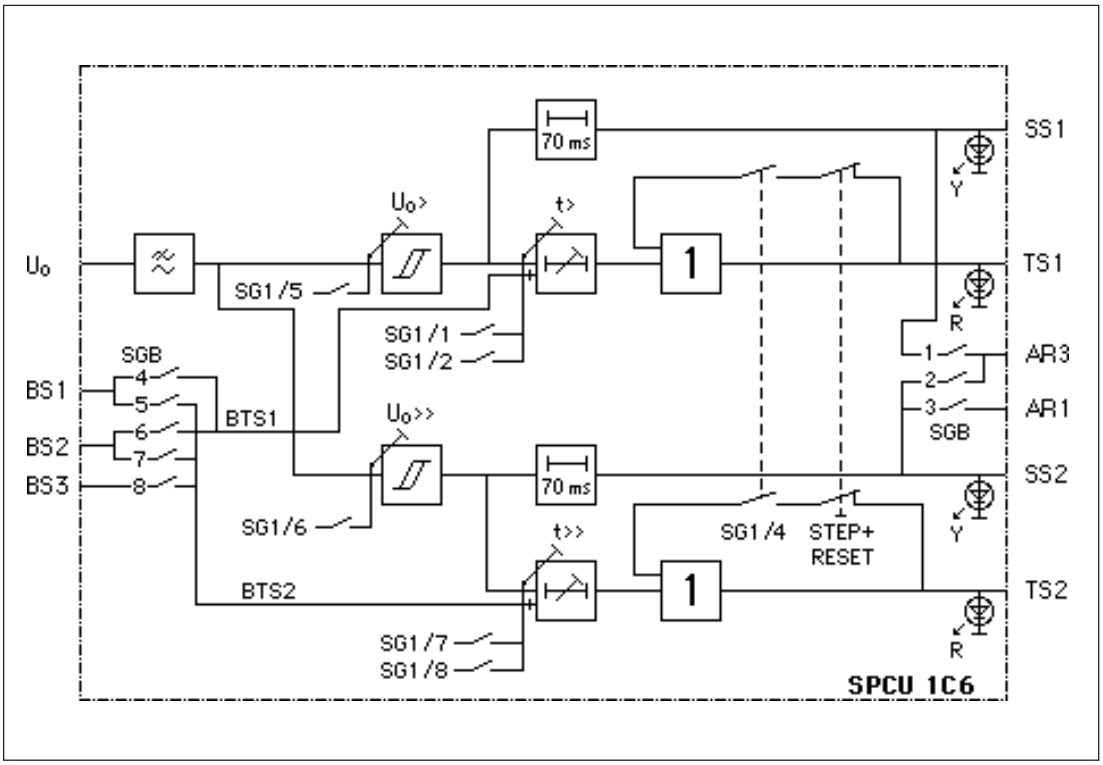

Fig. 2. Block schematic diagram of the residual overvoltage relay module SPCU 1C6.

U_0	Measured residual voltage
BS1, BS2, BS3	Incoming external blocking signals
BTS1	Blocking of tripping of stage U_0>
BTS2	Blocking of tripping of stage U_0>>
SG1	Selector switchgroup on the relay module front panel
SG2	Function selector switchgroup for the operation indicators
SGB	Selector switchgroup on the PC board for blocking signals
SS1	Start signal of stage U_0>
TS1	Trip signal of stage U_0>
SS2	Start signal of stage U_0>>
TS2	Trip signal of stage U_0>>
Y	Yellow indicator, starting
R	Red indicator, tripping

NOTE!
All input and output signals of the relay module are not necessarily wired to the terminals of every protection relay unit utilizing this module. The signals wired to the terminals are shown in the signal diagram in the manual of the concerned protection relay unit.

Front panel

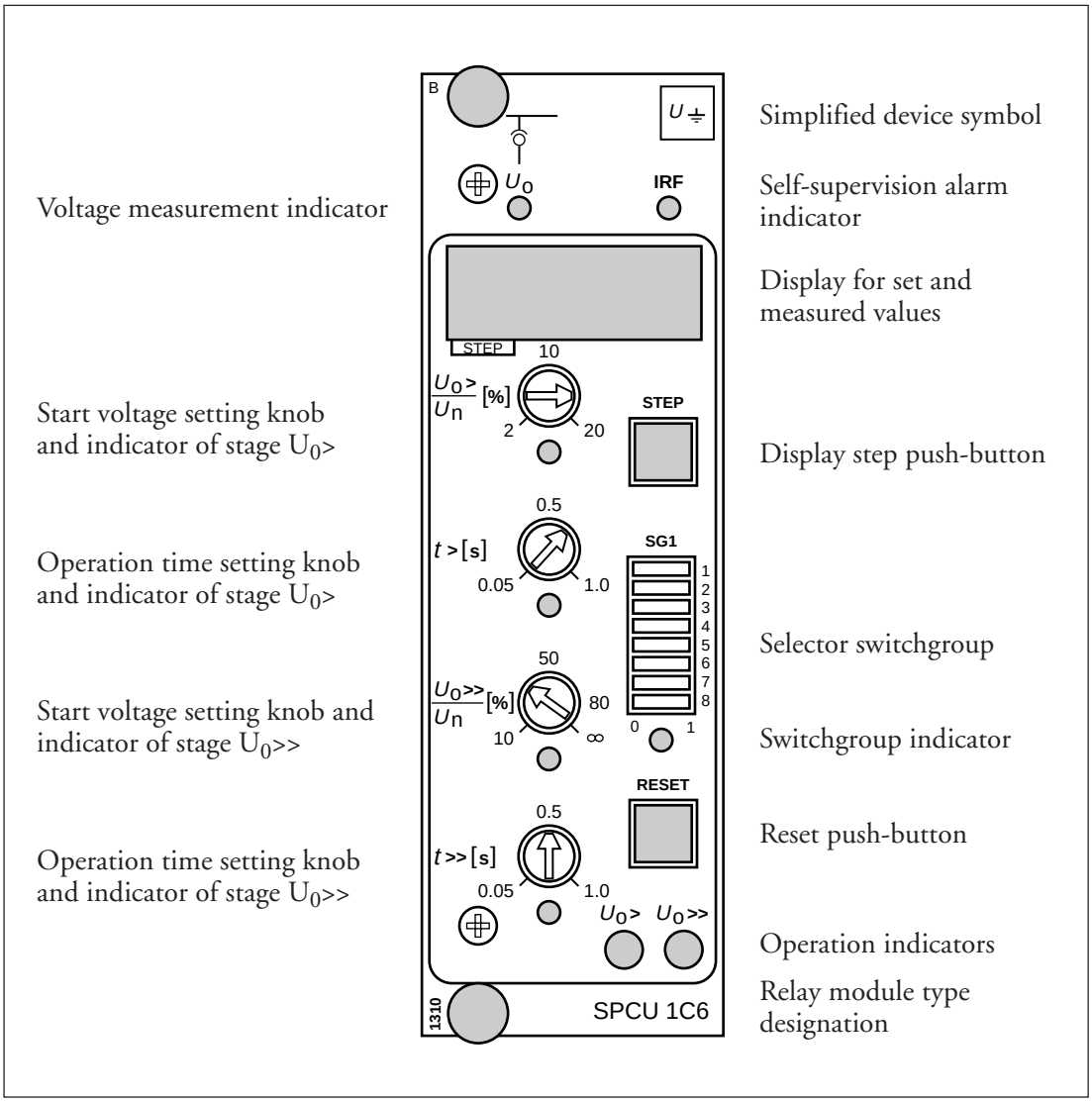

Fig. 3. Front panel of the residual overvoltage relay module SPCU 1C6.

Operation indicators

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

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

An unreset operation indicator does not affect the protective functions of the relay module.

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

Additionally, in most fault cases, a fault code showing the nature of the fault appears on the display of the module. The fault code, consisting of a red number one (1) and a green three-digit code number, indicates what type of internal fault that has been detected. When a fault message appears, the fault code should be noted down for later use when relay overhaul or repair is to be carried out.

Settings

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

$U_0>/U_n$	Start voltage value of the $U_0>$ stage, expressed as a percentage of the rated voltage of the energizing input used. The setting range is 2...20% x U_n when SG1/5 = 0, and 10...100% x U_n when SG1/5 = 1.
t> [s]	Operate time of the $U_0>$ stage, expressed in seconds. The setting range is determined by the position of switches SG1/1 and SG1/2. Selectable operate time setting ranges 0.05...1.00 s, 0.5...10.0 s and 5...100 s.
$U_0>>/U_n$	Start voltage value of the $U_0>>$ stage, expressed as a percentage of the rated voltage of the energizing input used. The setting range is 10...80% x U_n when SG1/6 = 0, and 2...16% x U_n when SG1/6 = 1. The setting ∞, infinite, (displayed as - - -) sets the high-set stage $U_0>>$ out of operation.
t>> [s]	Operate time of the $U_0>>$ stage, expressed in seconds. The required setting range, 0.05...1.00 s, 0.5...10.0 s or 5.00...100 s, is selected with switches SG1/7 and SG1/8.

Further, the checksum of the selector switchgroup SG1 is shown on the display when the LED indicator below the switchgroup is lit. By means of the displayed checksum and the checksum manually calculated the proper operation of the switchgroup SG1 can be verified. An example of how the checksum is calculated is shown in the manual "General characteristics of C type relay modules".

Selector switches

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

<table>
<tr><th>Switch</th><th>Function</th></tr>
<tr><td>SG1/1
SG1/2</td><td>Selection of setting range for the operate time t> of low-set stage $U_0>$.
<table>
<tr><th>SG1/1</th><th>SG1/2</th><th>Operate time t></th></tr>
<tr><td>0
1
0
1</td><td>0
0
1
1</td><td>0.05...1.00 s
0.5...10.0 s
0.5...10.0 s
5...100 s</td></tr>
</table></td></tr>
<tr><td>SG1/3</td><td>Not in use. Has to be set in position 0.</td></tr>
<tr><td>SG1/4</td><td>Selection of latching function for the tripping signals TS1 and TS2.

When SG1/4 = 0, the trip signals reset to the initial state (= the output relay drops off), when the measuring signal causing the operation falls below the set start voltage level. When SG1/4 = 1, the trip signals remain activated (= the output relay remains picked up), although the measuring signal falls below the set start voltage level. Then the trip signals are reset by pressing the push-buttons STEP and RESET simultaneously or with the commands V101 or V102 via the serial port.</td></tr>
<tr><td>SG1/5</td><td>Selection of setting range for the start voltage value of the low-set stage $U_0>$.

When SG1/5 = 0, the setting range is 2...20% x U_n.
When SG1/5 = 1, the setting range is 10...100% x U_n.</td></tr>
</table>

<table>
<tr><th>Switch</th><th>Function</th></tr>
<tr><td>SG1/6</td><td>Selection of setting range for the start voltage value of the high-set stage U_0>>.

When SG1/6 = 0, the setting range is 10...80% x U_n and ∞, infinite.
When SG1/6 = 1, the setting range is 2...16% x U_n and ∞, infinite.</td></tr>
<tr><td>SG1/7
SG1/8</td><td>Selection of setting range for the operate time t>> of the high-set stage U_0>>.
<table>
<tr><th>SG1/7</th><th>SG1/8</th><th>Operate time t>></th></tr>
<tr><td>0</td><td>0</td><td>0.05...1.00 s</td></tr>
<tr><td>1</td><td>0</td><td>0.5...10.0 s</td></tr>
<tr><td>0</td><td>1</td><td>0.5...10.0 s</td></tr>
<tr><td>1</td><td>1</td><td>5...100 s</td></tr>
</table></td></tr>
</table>

Switchgroup SG2 is a so called software switchgroup, which is located in the third submenu of switchgroup SG1. The mode of operation, i.e. self-reset or manually reset, of the LED indicators U_0> and U_0>> is determined by the switches of switchgroup SG2. The mode of operation can be separately set for each indicator. The mode of operation is set by means of the checksum, which can be calculated from the following table. Normally the start indications are self-reset and the operation indications manually reset.

Indicator	Manually reset	Factory default
Start indicator U_0>	1	0
Operation indicator U_0>	2	2
Start indicator U_0>>	4	0
Operation indicator U_0>>	8	8
Checksum	15	10

The PC board of the relay module contains a switchgroup SGB including switches 1...8. The switches 1...3 are used for selecting the starting signals, whereas switches 4...8 are used for routing the blocking signals to the voltage module in various protection relay units. Instructions for setting of switchgroup SGB are given in the user's manual of the different protection relay units.

Measured data

The measured values are displayed by the three rightmost digits on the display. The measured data to be displayed are indicated by a lit LED indicator.

Indicator	Measured data
U_0	Residual voltage measured by the relay module, expressed as a percentage of the rated voltage of the energizing input used.

Recorded information

The leftmost red digit displays the address number of the register, the rightmost three green digits display the recorded data.

Register/ STEP	Recorded data
1	Maximum residual voltage measured by the module, as a percentage of the rated voltage U_n of the used energizing input. If the module operates, the voltage value at the moment of operation is stored in the memory. Any new operation erases the old value and updates the register with the new value. The same thing happens if the measured voltage exceeds a previously recorded maximum value.
2	Number of starts of the low-set overvoltage stage U_0>, n (U_0>) = 0...255.
3	Number of starts of the high-set overvoltage stage U_0>>, n (U_0>>) = 0...255.
4	Duration of the latest start situation of stage U_0> as a percentage of the set operate time t>. Any new start resets the counter, which then starts counting from zero. When the stage has operated, the counter reading is 100.
5	Duration of the latest start situation of stage U_0>> as a percentage of the set operate time t>>. Any new start resets the counter, which then starts recounting from zero. When the stage has operated, the counter reading is 100.
0	Display of blocking signals and other external control signals. The rightmost digit indicates the state of the blocking inputs of the relay module. The following states may be indicated: 0 = no blockings 1 = operation of the U_0> stage blocked 2 = operation of the U_0>> stage blocked 3 = operation of both stages blocked In this register the second digit from he right is constantly zero. The leftmost digit indicates the state of the remote reset control input, if applicable. The following states may be indicated: 0 = remote reset control input not energized 1 = remote reset control input energized From this register it is possible to move on to the TEST mode, where the start and operation signals of the module can be activated one by one. For further details see manual "General characteristics of C type relay modules".
A	The address code of the protection relay module in the serial communication system. The serial communication is broken if the relay module is given the address code 0 (zero). Register A is provided with the following subregisters: 1. Selection of data transfer rate for the serial communication. Selectable values 300, 1200, 2400, 4800 and 9600 Bd. Default value 9600 Bd. 2. Bus communication monitor. If the relay module is connected to a serial communication system and the serial communication system is in operation the counter of the bus communication monitor will show the value 0 (zero). If the communication is broken the numbers 0…255 are scrolling in the counter. 3. Password required when changing relay module settings via remote control

Registers 1...5 are set to zero by pressing the push buttons STEP and RESET simultaneously or by remote control using the command V102. The register values are also erased if the auxiliary power supply of the module is interrupted. The address code of the relay module, the set data transfer rate of the serial communication and the password are not erased by a supply voltage interruption. Instructions for setting the address code and the data transfer rate are given in the manual "General characteristics of C type relay modules".

Menu chart

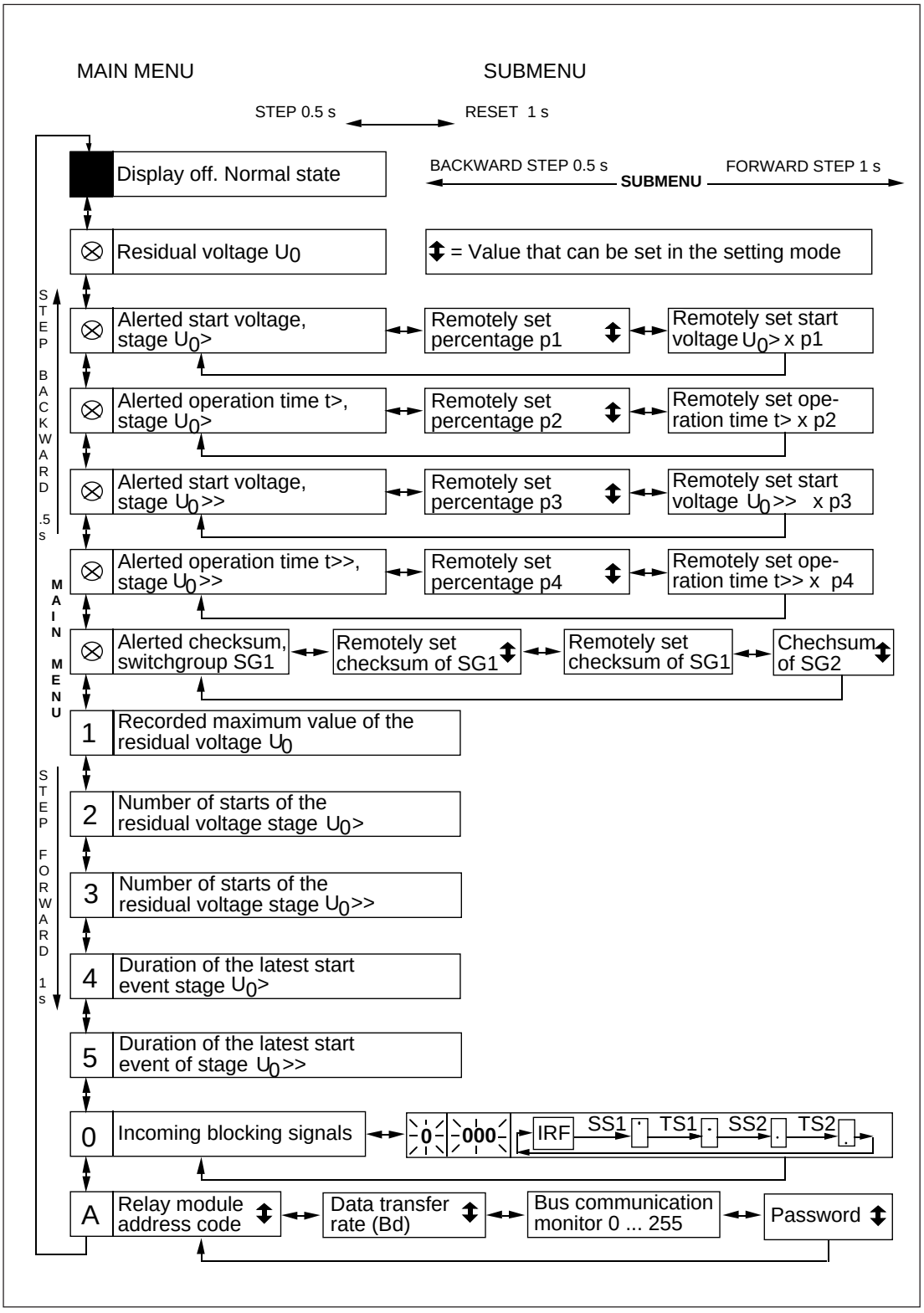

Fig. 4. Main menu and submenus of the residual overvoltage relay module SPCU 1C6.

The procedure for entering a submenu or a setting mode and configuring the module is described in detail in "General characteristics of C type relay modules".

Low-set overvoltage stage U_0>

Start voltage U_0>	2...20% x U_n or 10...100% x U_n
Start time, typically	70 ms
Operate time	0.05...1.00 s, 0.5...10.0 s or 5...100 s
Reset time	<100 ms
Drop-off/pick-up ratio, typically	0.96
Operate time accuracy	±2% of set value or ±40 ms
Operation accuracy	
- 10...100% x U_n	±3% of set value
- 2...20% x U_n	±5% of set value

High-set overvoltage stage U_0>>

Start voltage U_0>>	10...80% x U_n and ∞, infinite or 2...16% x U_n and ∞, infinite
Start time, typically	70 ms
Operate time	0.05...1.00 s, 0.5...10.0 s or 5...100 s
Reset time	<100 ms
Drop-off/pick-up ratio, typically	0.96
Operate time accuracy	±2% of set value or ±40 ms
Operation accuracy	
- 10...80% x U_n	±3% of set value
- 2...16% x U_n	±5% of set value

Serial communication parameters

Event codes

The substation level control data communicator is able to read, over the SPA serial bus, the event messages of the relay module, e.g. start and trip messages, from the residual overvoltage relay module SPCU 1C6. The events can be printed out in the format: time (ss.sss) and event code. The event codes of the relay module are E1...E8 , E50 and E51. Additional event codes relating to the data communication are generated by the data communication equipment.

The event codes E1...E8 and the events represented by these can be included in or excluded from the event reporting by writing, via the SPA bus, an event mask (V155) to the relay module. The event mask is a binary number coded to a decimal number. The event codes E1...E8 are represented by the numbers 1, 2, 4...128. The event mask is formed by multiplying the above numbers either with 0, event not included or 1, event included in reporting and by adding the products, see instructions for checksum calculation.

The event mask may take a value within the range 0...255. The default value of the residual overvoltage relay module SPCU 1C6 is 85, which means that any start or operation event is included in the reporting, but no resettings. The event codes E50...E54 and the events represented by these cannot be excluded from the reporting.

Event codes of residual voltage relay module SPCU 1C6:

Code	Event	Weighting coefficient	Default setting
E1	Starting of stage U_0>	1	1
E2	Starting of stage U_0> reset	2	0
E3	Tripping of stage U_0>	4	1
E4	Operation of stage U_0> reset	8	0
E5	Starting of stage U_0>>	16	1
E6	Starting of stage U_0>> reset	32	0
E7	Tripping of stage U_0>>	64	1
E8	Operation of stage U_0>> reset	128	0
	Default value of event mask V155		85

E50	Restart of microprocessor	*	-
E51	Overflow of event register	*	-
E52	Temporary interruption in the data communication	*	-
E53	No response from the relay module over the data communication bus	*	-
E54	The relay module responds again over the data communication bus	*	-

0 not included in the event reporting
1 included in the event reporting
* no code number, always included in event reporting
\- cannot be set

NOTE!
In the SPACOM system the event codes E52... E54 are generated by the station level control data communicator, e.g. type SRIO 1000M.

Data to be transferred over the serial bus

In addition to the event code data transfer, the input data (I data), output data (O data), setting values (S), memorized data (V data) and some other data can be read from the relay module over the serial communication bus. Further, part of the data can be changed over the SPA bus by separate commands. All data information is available in channel 0.

Data	Code	Data direct.	Values
Input data			
Energizing input voltage	I1	R	0...250% x U_n
Blocking of operation of stage U_0>	I2	R	0 = no blocking 1 = operation of stage U_0> blocked
Blocking of operation of stage U_0>>	I3	R	0 = no blocking 1 = operation of stage I_0>> blocked
Output data			
Starting of stage U_0>	O1	R	0 = stage U_0> not started 1 = stage U_0> started
Operation of stage U_0>	O2	R	0 = stage U_0> not tripped 1 = stage U_0> tripped
Starting of stage U_o>>	O3	R	0 = stage U_0>> not started 1 = stage U_0>> started
Operation of stage U_0>>	O4	R	0 = stage U_0>> not tripped 1 = stage U_0>> tripped
Setting values			
Alerted start value of stage U_0>	S1	R	2...100% x U_n
Alerted operate time of stage U_0>	S2	R	0.05...100 s
Alerted start value of stage U_0>>	S3	R	2...80% x U_n 999 = ∞, infinite
Alerted operate time of stage U_0>>	S4	R	0.05...100 s
Alerted checksum of switchgroup SG1	S5	R	0...255
Start value of stage U_0>, set with the setting knob	S11	R	2...100% x U_n
Operate time of stage U_0>, set with the setting knob	S12	R	0.05...100 s
Start value of stage U_0>>, set with the setting knob	S13	R	2...80% x U_n 999 = ∞, infinite
Operate time of stage U_0>>, set with the setting knob	S14	R	0.05...100 s
Checksum of switchgroup SG1, set with the switches	S15	R	0...255
Remotely setting percentage of the start value of stage U_0>	S21	R, W	0...999%
Remotely setting percentage of the operate time of stage U_0> or time multiplier	S22	R, W	0...999%
Remotely set percentage for the start value of stage U_0>>	S23	R, W	0...999%
Remotely setting percentage for the operate time of stage U_0>>	S24	R, W	0...999%
Remotely set checksum of switchgroup SG1	S25	R, W	0...255

Data	Code	Data direct.	Values
Remotely set start value of stage U_0>	S31	R	2...100% x U_n
Remotely set operate time of stage U_0>	S32	R	0.05...100 s
Remotely set start value of stage U_0>>	S33	R	2...80% x U_n 999 = ∞, infinite
Remotely set operate time of stage U_0>>	S34	R	0.05...100 s
Remotely set checksum of switchgroup SG1	S35	R	0...255
Max. measured voltage or voltage at operation	V1	R	0...250% x U_n
Number of starts of stage U_0>	V2	R	0...255
Number of starts of stage U_0>>	V3	R	0...255
Duration of the latest start situation of stage U_0>	V4	R	0...100%
Duration of the latest start situation of stage U_0>>	V5	R	0...100%
Resetting of output relays and operation indicators	V101	W	1 = output relays and operation indicators reset
Resetting of output relays and operation indicators and erasing of recorded data	V102	W	1 = output relays and operation indicators reset and registers (codes V1…V5) erased
Remote control of settings	V150	R, W	0 = setting with knobs S11...S15 activated 1 = remote settings S31...S35 activated
Event mask word	V155	R, W	0...255, see section "Event codes"
Manual reset or self-reset mode of operation of the LED indicators	V156	R, W	0…15, see section "Selector switches"
Opening of password for remote settings	V160	W	1...999
Changing or closing of password for remote settings	V161	W	0...999
Activation of self-supervision function	V165	W	1 = self-supervision output is activated and the IRF indicator turns on in about 5 seconds, whereafter the self-supervision system and the IRF indicator reset
Internal fault code	V169	R	0…255
Data communication address of the relay module	V200	R	1...254
Program version	V205	R	070_

Data	Code	Data direct.	Values
Type designation of the relay module	F	R	SPCU 1C6
Reading of event register	L	R	Time, channel number and event code
Re-reading of event register	B	R	Time, channel number and event code
Reading of 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 status data	C	W	0 = resetting
Time reading or setting	T	R, W	00.000...59.999 s

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

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

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

The setting values S1...S5 are the alerted set values currently used by the protection relay module. These values are set either by remote control or by means of the setting knobs. The values S11...S15 are set with the setting knobs and the selector switches. Variables S21...S25 are set as percentage values via remote control.

The settings S21...S25 allow reading or writing. A condition for writing is that the password V160, for remote setting has been opened. The variables S31...S35 contain the remote setting values.

When the values of the variables S21...S24 are to be changed, the variables can be given a percentage factor within the range 0...999. It is possible to alter a setting value beyond the setting ranges specified in the technical data of the relay module. However, the validity of the setting values are guaranteed only within the setting ranges specified in the technical data.

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

Fault codes

Once the self-supervision system has detected a permanent relay fault, the IRF LED on the front panel of the module is lit, and at the same time the normally operated signal relay of the self-supervision system drops off.

In most fault situations an auto-diagnostic fault code is shown on the relay display. The fault code cannot be reset. The fault code consists of a red digit one (1) and a green code number that indicates the fault type. The fault code should be recorded and stated when service is ordered.

The fault codes of the residual overvoltage relay module SPCU 1C6 are explained in the following table:

Fault code	Explanation
4	Faulty output relay path or missing output relay card
30	Faulty program memory (ROM)
50	Faulty working memory (RAM)
195	Too low a value in reference channel with multiplier 1
131	Too low a value in reference channel with multiplier 5
67	Too low a value in reference channel with multiplier 25
203	Too high a value in reference channel with multiplier 1
139	Too high a value in reference channel with multiplier 5
75	Too high a value in reference channel with multiplier 25
253	No interruptions from the A/D-converter

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

1MRS 750746-MUM EN