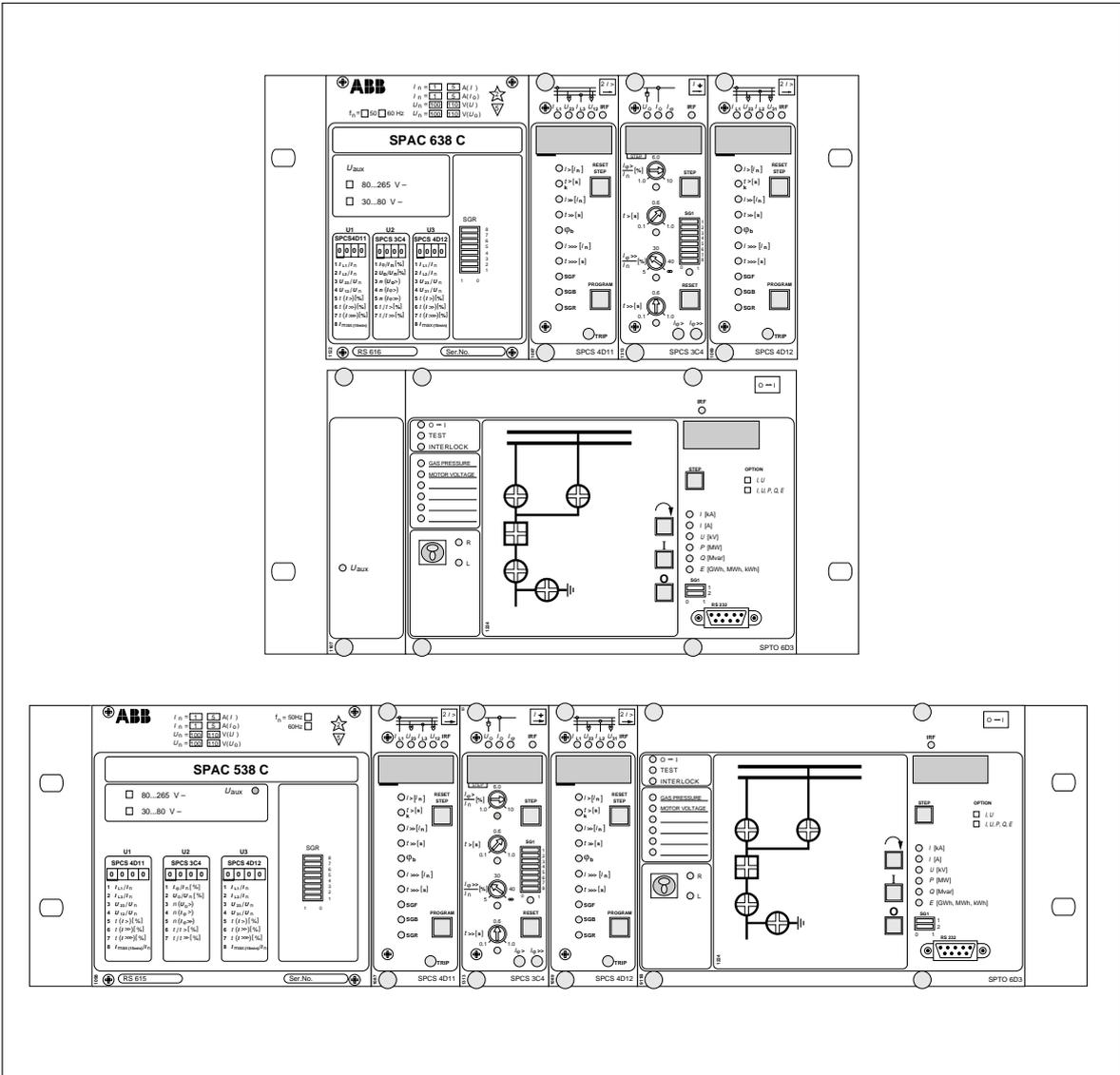


SPAC 538 C and SPAC 638 C Feeder terminal

User's manual and Technical description



Data subject to change without notice

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The complete manual for the feeder terminal is composed of the following submanuals:

Feeder terminal, introductory part and the whole document when printed together	1MRS 750349-MUM EN
Control module SPTO 6D3	1MRS 750202-MUM EN
General characteristics of D type relay modules	1MRS 750066-MUM EN
Directional overcurrent relay module SPCS 4D11 and SPCS 4D12	1MRS 750115-MUM EN
General characteristics of C type relay modules	1MRS 750328-MUM EN
Directional neutral current relay module SPCS 3C4	1MRS 750350-MUM EN

Features	<p>Complete feeder terminal including protection, control, measuring, blocking and communication functions</p> <p>User-programmable status indication and feeder level interlocking logic</p> <p>Local and remote status indication of a total of seven objects and local or remote control of a total of six objects</p> <p>Omits the use of separate protection relays, transducers, position indicators and remote control intermediate relays normally required in switchgear</p> <p>The feeder terminal can be connected to the fibre-optic SPA bus and via the bus to substation level data acquisition and reporting systems and to remote control systems</p>	<p>Seven user-programmable binary inputs with local and remote indication</p> <p>Measurement and display of phase currents, phase-to-phase voltages, energy, and active and reactive power</p> <p>Continuous self-supervision via integrated self-supervision and auto-diagnostic's system for maximum reliability</p> <p>A total economy solution for the planning, erection, testing and operation of an electrical distribution substation</p>
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Area of application

The integrated feeder terminals SPAC 538 C and SPAC 638 C are designed to be used as cubicle-based protection and remote control interface units. In addition to protection, control and measurement functions the unit is provided with data communication features needed for the control of the feeder. The feeder terminals connect to higher-level substation control equipment over optical fibres.

The feeder terminals are available in two versions of design: SPAC 538 C housed in a 19 inch subrack (height 3U), and SPAC 638 C housed in a half of a full width 19 inch subrack, height 6U.

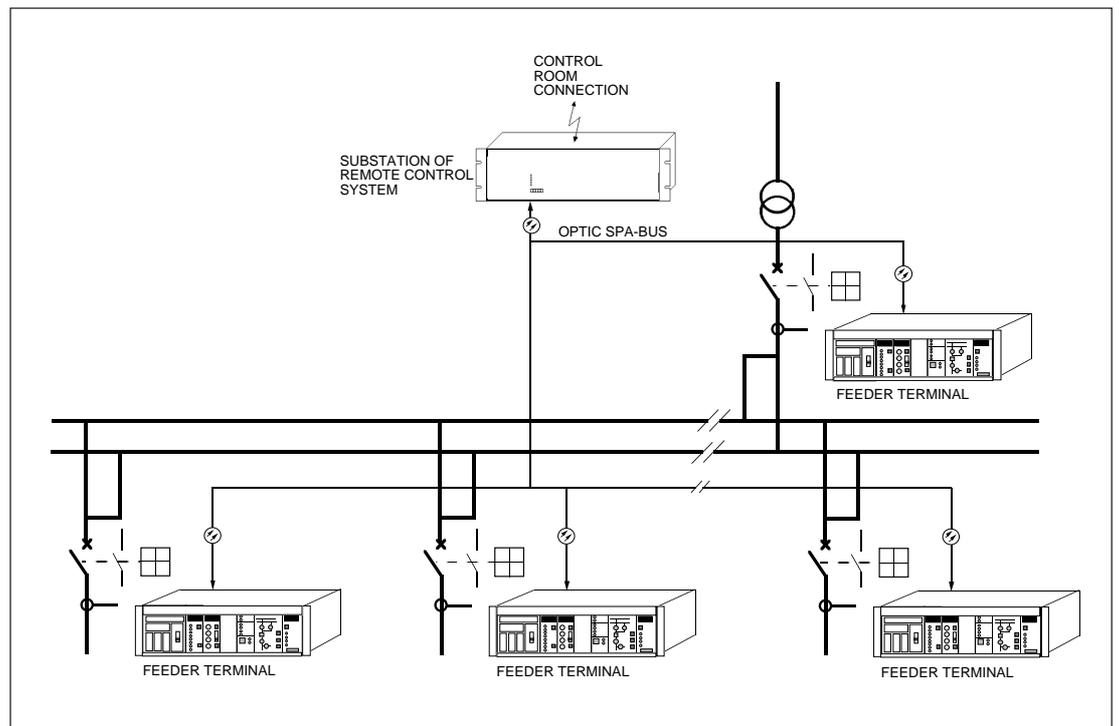


Fig. 1. Distributed protection and control system based on SPAC 538 C feeder terminals

The feeder terminal is intended to be used for directional and non-directional overcurrent protection and directional earth-fault protection. The feeder terminals include one or two three-phase directional overcurrent relay modules SPCS 4D11 and SPCS 4D12 and one two-stage directional neutral current module type SPCS 3C4.

The control module SPTO 6D3 included in the unit indicates locally by means of LED indicators the status of maximum seven disconnectors and/or circuit breakers. In addition, the module allows the status information of the circuit breakers and the disconnectors to be transferred to the remote control system, and maximum six objects to be opened and closed using the remote control system. The status information and the control signals are transmitted over the serial bus. The push-buttons on the front panel of the control module can be used for local control operations.

Auto-reclosing is integrated into the control module. Maximum five high-speed or delayed auto-reclose shots can be done.

The control module is able to measure and indicate the values of the three phase currents and the three phase-to-phase voltages. Active and reactive power can be measured via two mA inputs or using internal current and voltage signals. When the mA inputs are used, external measuring transducers are required.

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

The directional overcurrent modules and the directional earth-fault module measure the three phase currents of the feeder, the three phase-to-phase voltages, neutral current and residual voltage. All the values measured and recorded are indicated locally and can be transmitted to the remote control system over the SPA bus.

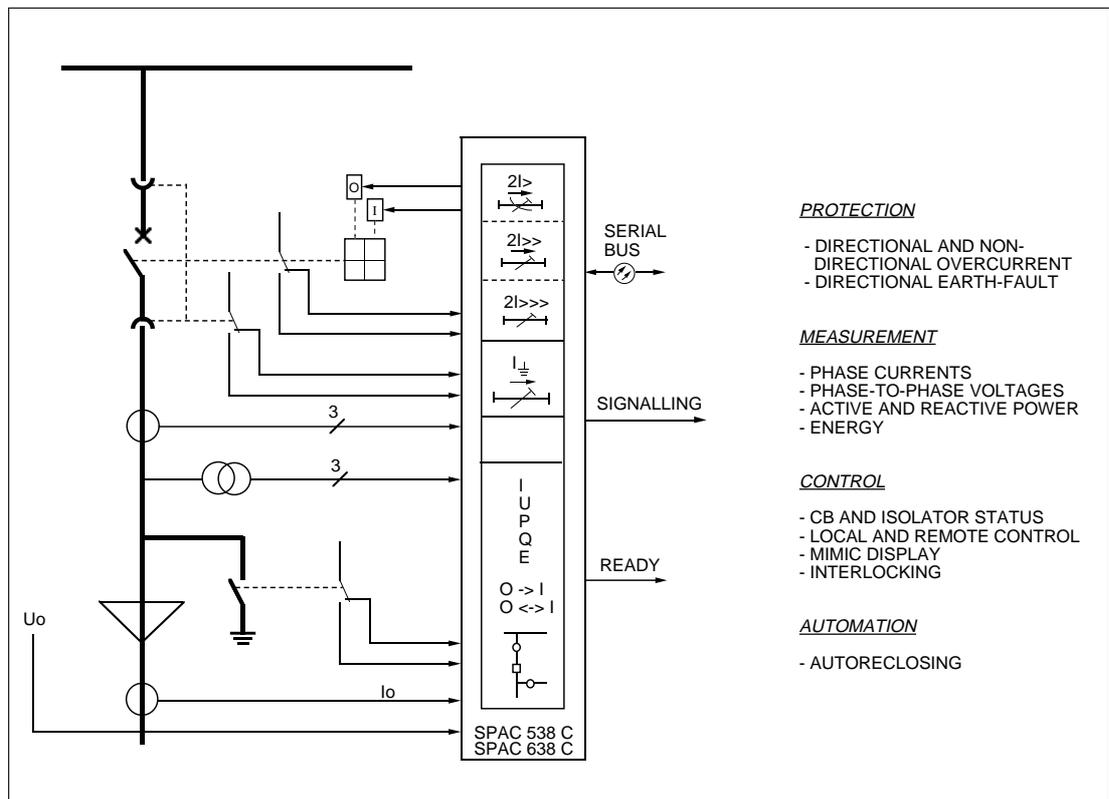


Fig. 2. Basic functions of the integrated feeder terminal SPAC 538 C and SPAC 638 C

Description of function

Design

The feeder terminal SPAC 538 C is housed in a 19 inch Euro-size subrack, height 3U (133 mm). The rear of the subrack is provided with an extension part, which is made of galvanized steel sheet. The rear panel is painted.

The standard subrack is made of anodized aluminium section and includes ten modules. In addition, three optional measuring modules are available. The functions of the standard modules are explained in the table below.

Module	Function
Overcurrent relay module SPCS 4D11, SPCS 4D12	Three-stage, two-phase directional and non-directional over-current protection Measures, records and indicates locally and remotely two phase currents and two phase-to-phase voltages
Directional neutral current module SPCS 3C4	Two-stage directional earth-fault protection Measures, records and indicates locally and remotely neutral current and residual voltage
Control module SPTO 6D3	Reads and indicates locally and remotely status data of seven disconnectors or circuit breakers Reads and indicates locally and remotely six external binary signals Measures and indicates locally and remotely the three phase currents, the three phase-to-phase voltages, active and reactive power and energy Transfers local or remote open and close commands for maximum six circuit breakers or disconnectors Performs maximum five consecutive high-speed and/or low-speed auto-reclosures
I/O module SPTR 4D1 or SPTR 4D2, (3 pcs)	Includes 7 optically isolated binary inputs, 2 OPEN and 2 CLOSE output contacts which are used by the control module
I/O module SPTR 6B19	Includes 3 optically isolated binary inputs and 5 output contacts which are used by the protection relay modules Includes the IRF output contact which is common to the protection and control modules
Power supply module SPGU 240A1 or SPGU 48B2	Forms the internal voltages required by the other modules
Energizing input module SPTE 8C3 (SPAC 538 C) SPTE 8C4 (SPAC 638 C)	Includes matching transformers and their tuning electronics for the three phase currents, the three phase-to-phase voltages, neutral current and residual voltage

To be able to measure analog signals the control module needs one of the following optional measuring modules:

Module	Function
Measuring module SPTM 8A1 (optional module 1)	Rectifies the three phase currents and the three phase-to-phase voltage signals Forms voltage signals of the external mA input signals
Measuring module SPTM 6A2 (optional module 2)	Rectifies the three phase currents and the three phase-to-phase voltages Forms signals proportional to active and reactive power using internal current and voltage signals
Measuring module SPTM 6A3 (optional module 3)	Rectifies the three phase currents and the three phase-to-phase voltages Forms signals proportional to active and reactive power using one internal voltage signal and two current signals

The directional overcurrent relay modules SPCS 4D11 and SPCS 4D12 and the directional neutral current module SPCS 3C4 are Euro-size (100 x 160 mm) withdrawable modules.

The control module type SPTO 6D3 is also withdrawable. The module includes two PC boards: a CPU board and a front PC board which are screwed to each other. The three I/O modules SPTR 4D_ and the optional measuring module are located behind the front PC board. The I/O modules and the optional measuring modules are plug-in units which can be withdrawn after removal of the control module.

With feeder terminal SPAC 538 C the power supply module SPGU 240 A1 or SPGU 48 B2 and the I/O module SPTR 6B19 are located behind the system panel. The modules can be withdrawn after the system panel has been removed.

In feeder terminal type SPAC 638 C the power supply module SPGU 240A1 or SPGU 48B2 is located in the left side of the bottom part behind the front panel and the system panel of the I/O

module SPTR 6B19. Before withdrawing the modules the front panel has to be removed.

The protective relay modules SPCS 4D11, SPCS 4D12 and SPCS 3C4 are fastened to the case by means of two finger screws and the control module SPTO 6D3 by means of four finger screws. These modules can be pulled out of the subrack after undoing the screws.

The energizing input module SPTE 8C3 (SPAC 538 C) or SPTE 8C4 (SPAC 638 C) is located behind the system panel on the left-hand side of the case. This module includes the tuning resistors of the secondary burden. The measuring module is provided with a screw terminal block and a rear plate.

The mother PC board contains the card connectors for the plug-in modules and the detachable multi-pole connector strips X1...X6 for inputs and outputs.

Note !

When modules are withdrawn or inserted the auxiliary supply should be switched off.

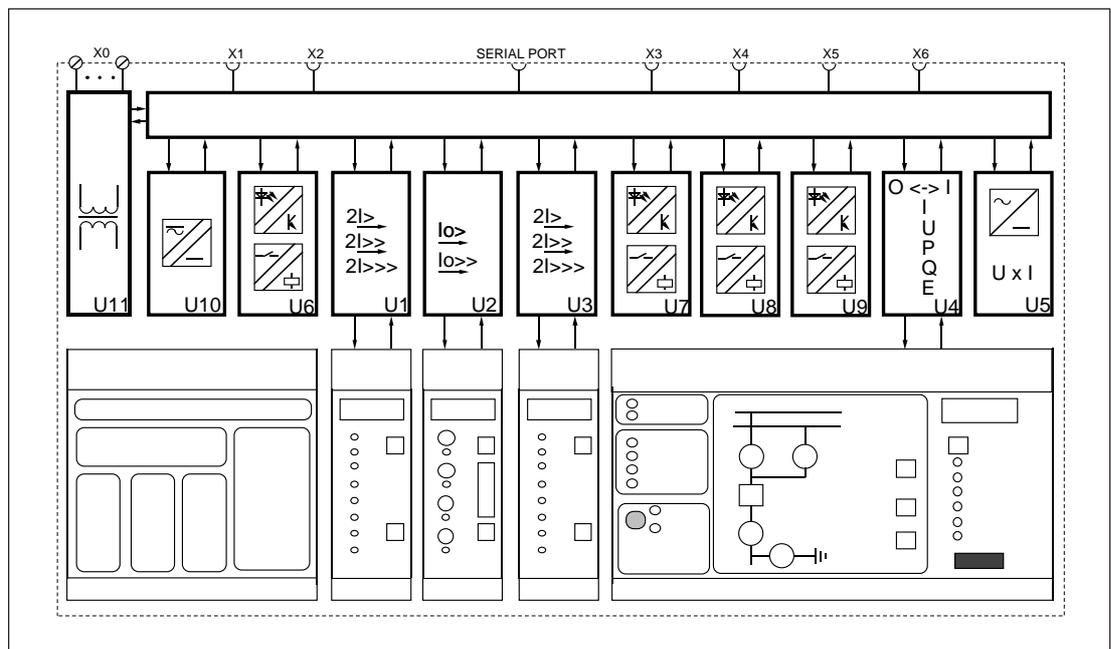


Fig. 3. Block diagram for feeder terminal SPAC 538 C

U1	Directional overcurrent relay module SPCS 4D11
U2	Directional neutral current module SPCS 3C4
U3	Directional overcurrent relay module SPCS 4D12
U4	Control module SPTO 6D3
U5	Optional measuring module SPTM 8A1, SPTM 6A2 or SPTM 6A3
U6	I/O module SPTR 6B19 for protection functions
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 8C3 (SPAC 538 C) or SPTE 8C4 (SPAC 638 C)
X0	Screw terminals
X1...X6	Multi-pole connectors

Protection functions

Two-phase directional overcurrent protection

The directional overcurrent relay module SPCS 4D11 provides three-stage overcurrent protection. It contains three overcurrent stages: two directional overcurrent stages, i.e. a low-set stage I> and a high-set stage I>>, and one non-directional high-set stage I>>>.

The operation of the low-set stage I> and the high-set stage I>> is based on measuring two phase currents (I_{L1} and I_{L3}) and the two opposite phase-to-phase voltages (U_{23} and U_{12}). The basic angle φ_b of the direction measurement forms an angle that has a $0 \dots -90^\circ$ displacement in negative direction from the opposite phase-to-phase voltage. Once the current on one of the phases exceeds the setting value and the phase angle between the base angle φ_b and current falls within the operation sector $\pm 80^\circ$ one of the directional overcurrent stages starts. When the set operate time of the stage that started expires, the overcurrent module issues a trip signal for the stage.

The stage I>> can be set to non-directional operation. The stage I>> start if the current measured on one of the two phases exceeds the setting value.

The non-directional high-set stage I>>> starts if the current measured on one of the two phases exceeds the setting value of the stage. When the set operate time expires, the stage provides a trip signal. The high-set stage I>>> is to operate at nearby short circuits when the voltage is too low to allow the direction of the current to be determined.

The operation of the low-set stage I> is based on definite time or inverse time characteristic, whereas the high-set stages I>> and I>>> operate momentarily or with a definite time characteristic.

The directional overcurrent modules SPCS 4D12 and SPCS 4D11 are identical except for the currents and voltages measured. The overcurrent module SPCS 4D12 measures the phase currents I_{L1} and I_{L2} and the phase-to-phase voltages U_{23} and U_{31} .

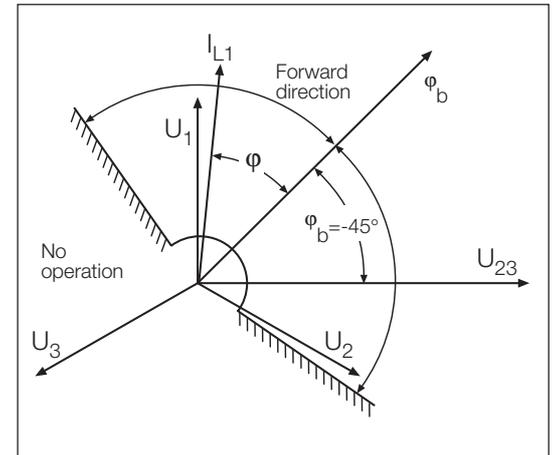


Fig. 4. Definition of the basic angle φ_b for the direction measurement by the directional overcurrent module SPCS 4D1_. The basic angle in the figure has been set to -45° . The value of the angle φ can be read in the display of the overcurrent module.

Directional neutral overcurrent protection

The two-stage directional earth-fault protection module SPCS 3C4 measures neutral current and neutral displacement voltage. The module starts if the neutral displacement voltage exceeds the set start value and the current and phase angle are such that the set start value of $I\varphi$ is exceeded. When the set operate time expires the low-set stage of the earth-fault protection module provides a trip signal. Correspondingly, the high-set stage of the earth-fault module starts, when the residual voltage exceeds the set value

and the current measured and the phase angle between the neutral current and the residual voltage are such that the set start current level $I\varphi$ is exceeded. When the selected operate time expires, the high-set stage of the earth-fault module issues a trip command.

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

*I/O module
SPTR 6B19 of
the protection relay
modules*

The I/O module SPTR 6B19 of feeder terminal SPAC 538 C is located behind the system panel together with the feeder supply module. The module can be withdrawn after the system panel has been removed. The I/O module includes three optically isolated binary inputs (BS1, BS2,

BACTRL9), five output contacts (output relays A, B, C, D, E) controlled by the relay modules and an IRF output contact (output relay F) which is shared by the relay modules and the control module and used to indicate internal feeder terminal faults.

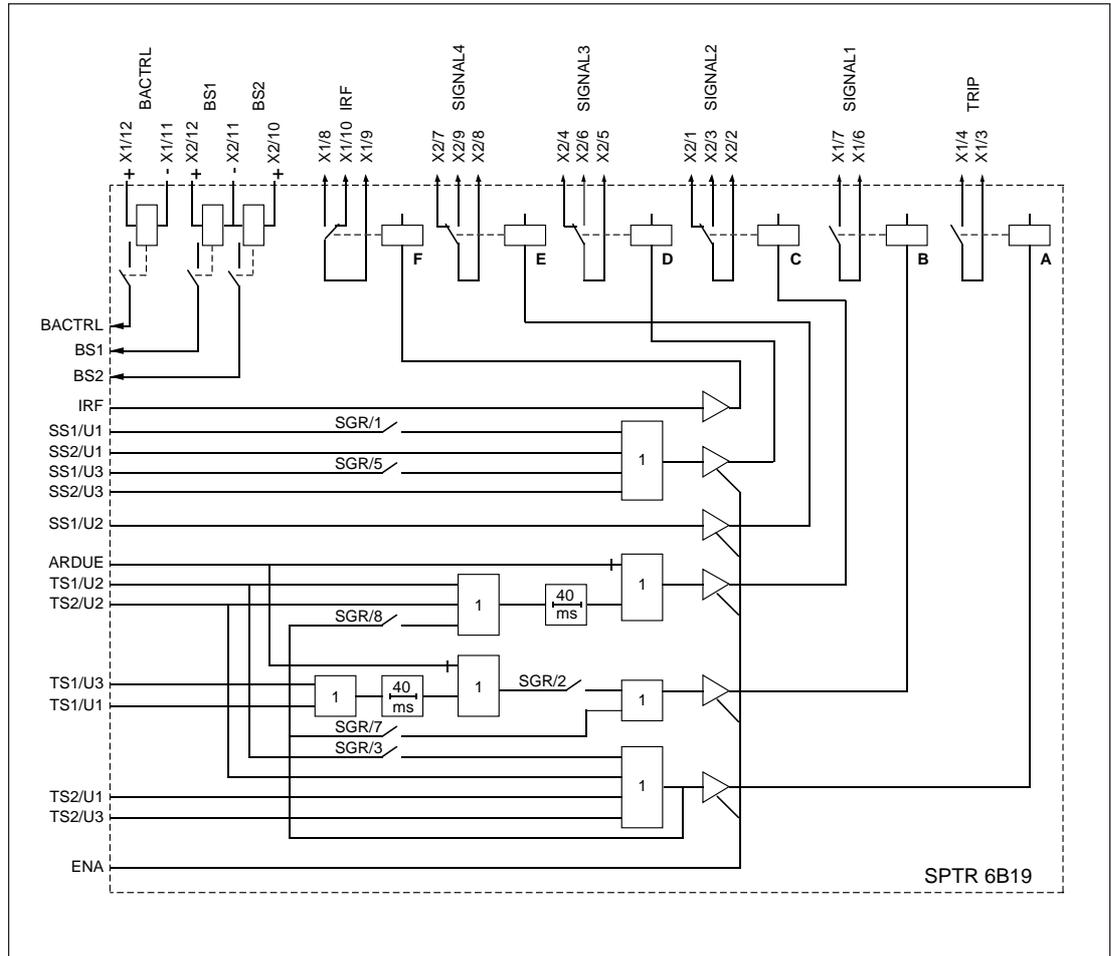


Fig. 5. Block diagram for I/O module SPTR 6B19

SS1/U1	Overcurrent relay module SPCS 4D11, I>, I>> start signals, data on operation direction of stage I>
SS2/U1	Overcurrent relay module SPCS 4D11, I>, I>>, I>>> operate signals, data on operation direction of stage I>>
TS1/U1	Overcurrent relay module SPCS 4D11, I>, I>>, I>>> start or operate signals, delayed I>, I>>, I>>> operate signal
TS2/U1	Overcurrent relay module SPCS 4D11, I>, I>>, I>>> operate signals
SS1/U2	Earth-fault relay module, Iφ> start signal
TS1/U2	Earth-fault relay module, Iφ> operate signal
TS2/U2	Earth-fault relay module, Iφ>> operate signal
SS1/U3	Overcurrent relay module SPCS 4D12, I>, I>> start signals, data on operation direction of stage I>
SS2/U3	Overcurrent relay module SPCS 4D12, I>, I>>, I>>> operate signals, data on operation direction of stage I>>
TS1/U3	Overcurrent relay module SPCS 4D12, I>, I>>, I>>> start or operate signals, delayed I>, I>>, I>>> operate signal
TS2/U3	Overcurrent relay module SPCS 4D12, I>, I>>, I>>> operate signals
ARDUE	"Autoreclosure due" signal
IRF	Self-supervision
ENA	Enable signal for output signals
A (TRIP)	Operate output 1 of protection relay modules (I>, I>>, I>>>, Iφ>, Iφ>>)
B (SIGNAL 1)	Signal and operate output of overcurrent modules (TS1/U1, TS1/U3) or operate output 2 of protection relay modules (I>, I>>, I>>>, Iφ>, Iφ>>)
C (SIGNAL 2)	Signal output for final operation of earth-fault relay module or general signal output (I>, I>>, I>>>, Iφ>, Iφ>>)
D (SIGNAL 3)	Output relay for signals SS1/U1, SS2/U1, SS1/U3 and SS2/U3 of the overcurrent relay modules
E (SIGNAL 4)	Output relay for the start signal of the earth-fault module stage Iφ>
F (IRF)	Self-supervision alarm output
BACTRL	Selection of $I_{sin\phi}/I_{cos\phi}$ for the earth-fault module using an external control voltage
BS1	Blocking signal 1 for the operation of the protection relay modules
BS1	Blocking signal 2 for the operation of the protection relay modules

The I/O module SPTR 6B19 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 the output relay B is used as a second trip output the fixed 40 ms delay is by-passed via 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 in as shown in the figure on the front page to secure that the connection diagram for the relay assembly corresponds to the physical operation of the relay.

Auto-reclose functions	<p>The auto-reclose function integrated into the control module SPTO 6D3 allows maximum five auto-reclose shots. Each auto-reclose shot can be initiated by three signals (AR1, AR2 or AR3) given by the overcurrent and earth-fault modules of the feeder terminal.</p> <p>The three start initiating signals can be either start or trip signals of the protection relay modules. For the configuration of the signals see chapter "Intermodular control signal exchange".</p> <p>From program version 055 and later auto-reclosing can be started by an external signal over input channel 14 as well.</p>	<p>When the start signals of the protection relay modules are used to start an auto-reclose sequence, the start of the auto-reclose operation can be delayed to avoid unnecessary auto-reclosures. The dead times can be programmed independently for each shot. The reclaim time, too, is adjustable.</p> <p>For double busbar systems with two circuit breakers (duplex) the auto-reclose program includes a so called duplex logic, which always opens both circuit breakers but gives the closing command only to the last breaker to have been closed.</p>
Control functions <i>General</i>	<p>The control module SPTO 6D3 is used to read the status information of the circuit breakers and disconnectors. The module indicates the status locally through LED indicators and transfers the information to station level equipment via the SPA bus. The status of maximum seven objects can be indicated.</p>	<p>The control module is also capable of controlling up to six objects, e.g. circuit breakers or disconnectors, either locally or through opening or closing commands over the SPA bus.</p> <p>In addition to status information the control module reads other binary data, indicates it locally and transfers the information to station level equipment. Maximum seven external binary signals can be wired to the feeder terminal.</p>
<i>Input channels 1...7</i>	<p>The control module uses the input channels 1...7 to read the status information of circuit breakers and disconnectors. Each of these channels is formed by two binary inputs, one for reading open status and the other for reading closed status of an object. This means that the status information has to be wired to the feeder terminal as four-pole information.</p>	<p>The front panel of SPTO 6D3 has a 4x4 matrix of status indication LEDs. At a time maximum seven of these LEDs can indicate status. The circuit breaker / disconnector configuration to be indicated by these LEDs is freely programmable by the user.</p> <p>Maximum six of the objects whose status data is read via input channels 1...7 can be operated using the outputs OPEN1...6 and CLOSE1...6.</p>
<i>Input channels 8...14 and 15...17</i>	<p>In addition, 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 start and trip signals of the protection relay modules. See the chapter "Signal diagram".</p> <p>The input signal type for the channels 8...17 can be selected to be active 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.</p>	<p>The indications of the activated external input channels 8...13 can be individually programmed to be memory controlled. This means that the LED indicator for a certain input channel, which has been activated for more than 10 ms, remains lit until separately reset, either by pressing the push-buttons STEP and RESET simultaneously or giving the parameter S5 the value of 0 or 1.</p> <p>The input channels 8...17 can be used to control the outputs OPEN1...6, CLOSE 1...6 and the outputs SIGNAL5 and SIGNAL6. When an input channel is activated the OPEN or CLOSE output configured to the channel delivers a control signal. The SIGNAL outputs are active as long as the input channels are active.</p>

<i>Interlocking</i>	The control module includes a feeder-oriented interlocking logic which can be freely programmed by the user. The interlocking program defines when the control of an object is allowed. When an open or close command is given, the interlocking logic checks whether the operation is permitted or not, and then it executes the command or cancels it.	The interlocking can be programmed to depend on the status of the four-pole input channels 1...7 and the status of input channels 8...17. The trip signals of the relay modules are not affected by the interlocking system.
<i>Direct output control</i>	Normally the outputs OPEN1...6 and CLOSE 1...6 are controlled by open or close commands, given locally with push-buttons or over the serial bus. When Direct Output Control has been selected all the 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 the programmed logic and the status of the input channels 1...7 and 8...17.
Measurement functions	<p>The control module SPTO 6D3, the directional overcurrent relay modules SPCS 4D11 and SPCS 4D12 and the directional earth-fault module SPCS 3C4 measure analog input signals.</p> <p>The two-phase directional overcurrent relay module SPCS 4D11 measures two phase currents (I_{L1}, I_{L3}) and two phase-to-phase voltages (U_{12}, U_{23}). The overcurrent relay module SPCS 4D12 measures the phase currents $IL1$ and $IL2$ and the phase-to-phase voltages U_{23} and U_{31}. The current values are indicated locally on the display and can be transmitted to the remote control system over the SPA bus.</p> <p>The directional neutral current module SPCS 3C4 measures three analog signals, neutral current I_0, residual voltage U_0 and $I\phi$, which is the resistive or capacitive component of the neutral current. This module indicates the three analog values locally on the front panel display and transmits the data to the remote control system over the SPA bus, when required.</p> <p>The protection relay modules record the values of the analog signals measured in a fault situation. The overcurrent and earth-fault modules always indicate the measured values as a multiple of the rated current or voltage of the relay.</p> <p>The standard control module is provided with a pulse counter input for the counting of energy pulses. To be able to measure analog signals the control module SPTO 6D3 needs an optional measuring module SPTM 8A1, SPTM 6A2 or SPTM 6A3. Provided with the measuring module SPTM 8A1 the control module is able to measure the three phase currents and the three phase-to-phase voltages. Active and reactive power are measured via two mA inputs and external measuring transducers.</p>	<p>The measuring module SPTM 6A2 allows the control module to measure the three phase currents and the three phase-to-phase voltages. Active and reactive power are measured over an Aron connection and internal current and voltage signals of the module.</p> <p>When using the measuring module SPTM 6A3 the control module measures the three phase currents and the three phase-to-phase voltages. Active and reactive power are measured on the basis of one internal signals: one voltage signal and two current signals. The voltage to be used and the corresponding currents are selected with switches.</p> <p>The ratio of the primary current and voltage transformers can be programmed into the control module. Using these values the control module is able to indicate the actual primary values of the phase currents, phase-to-phase voltages and power. When power is measured via mA inputs, the mA signals can be scaled to actual MW and MVar values. These primary values can be indicated locally and, when required, transmitted to the remote control system over the SPA bus .</p> <p>Active energy can be measured in two ways; by calculating the value on the basis of the power measured or using input channel 11 as a pulse counter. In the former case one of the measuring modules, SPTM 8A1, SPTM 6A2 or SPTM 6A3, is required and in the latter case an external energy meter with pulse output needed. In both cases the energy measured can be displayed locally and transmitted to higher-level equipment over the SPA bus.</p>

Serial communication	<p>The feeder terminal is provided with two serial communication ports, one on the front panel and one on the rear panel.</p> <p>The 9-pin RS 232 connection on the front panel is intended for connecting a PC to be used for programming the CB/disconnector configura-</p>	<p>tion, the feeder-oriented interlocking logic and other parameters for the control module.</p> <p>The 9-pin RS 485 connection on the rear panel connects the feeder terminal to the SPA bus over a bus connection module type SPA-ZC 17_ or SPA-ZC21_.</p>
Auxiliary power supply	<p>For its operation the feeder terminal needs a secured auxiliary voltage supply. The internal power supply module SPGU __ of the feeder terminal forms the voltages required by the measuring relay modules, the control module and the input / output modules.</p> <p>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</p>	<p>protected by a fuse, F1, located on the PCB of the module. The fuse size is 1 A (slow).</p> <p>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 are identical except for the input voltage range. The input voltage range is marked on the front panel of the relay.</p>

Mounting and dimension drawings

SPAC 538 C

The feeder terminal SPAC 538 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 40 mm raising frame type SPA-ZX 19.

When the unit is mounted in the door, the door should be reinforced inside.

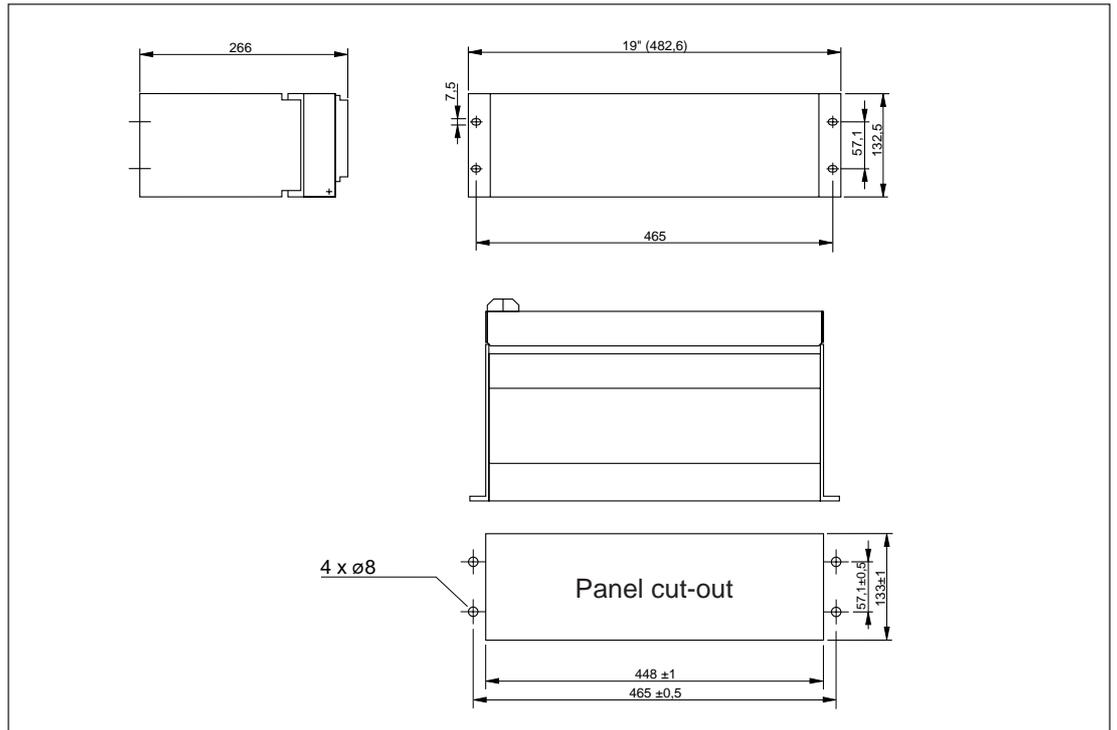


Fig. 6. Mounting and dimension drawings for feeder terminal SPAC 538 C

SPAC 638 C

The feeder terminal SPAC 638 C can be used in switchgear cubicles with limited width. The mounting depth of feeder terminal SPAC 538 C is smaller than that of SPAC 538 C.

The feeder terminal is fixed to the frame with four screws. When the feeder terminal is mounted in the door, the door should be reinforced inside.

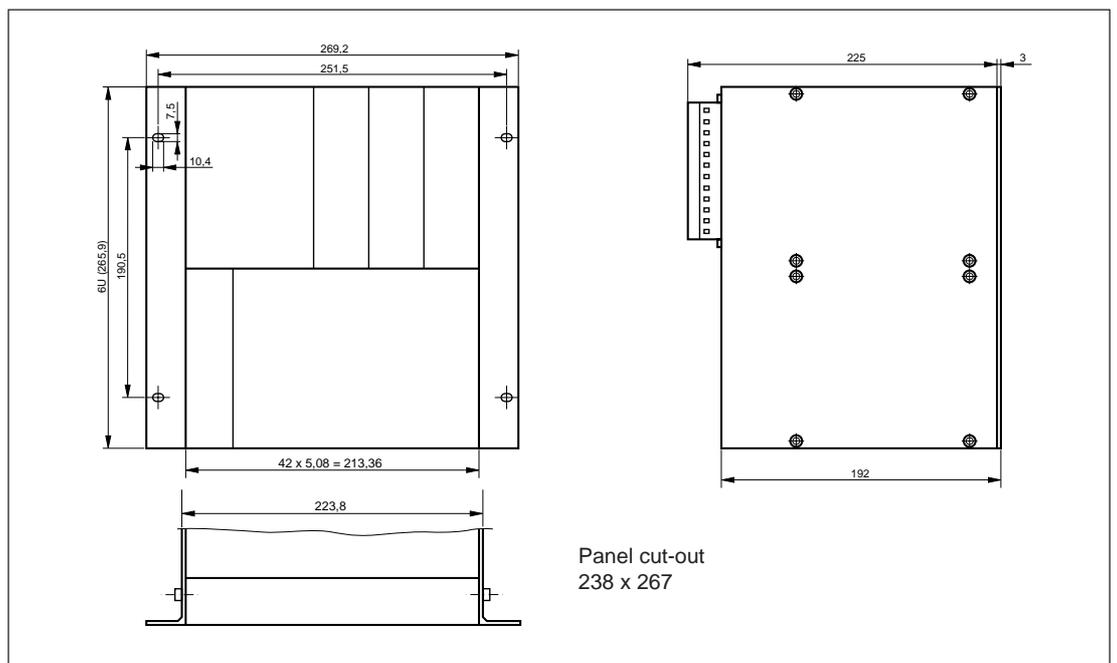


Fig. 7. Mounting and dimension drawings for feeder terminal SPAC 638 C

Numbering of the terminals:

Terminal group	Contact gap	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
	13-14	Voltage U_{12} (100 V). Overcurrent protection and measurement
	13-15	Voltage U_{12} (110 V). Overcurrent protection and measurement
	16-17	Voltage U_{23} (100 V). Overcurrent protection and measurement
	16-18	Voltage U_{23} (110 V). Overcurrent protection and measurement
	19-20	Voltage U_{31} (100 V). Measurement
	19-21	Voltage U_{31} (110 V). Measurement
	25-26	Residual current I_0 (5 A). Earth-fault protection
	25-27	Residual current I_0 (1 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
X1	1-2	Auxiliary power supply. The positive pole of the DC supply is connected to terminal 1
	3-4	Trip output 1 (TRIP) of protection stages ($I>$, $I>>$, $I>>>$, $I\phi>$, $I\phi>>$)
	6-7	Output signals TS1/U1 and TS1/U3 or trip output 2 (SIGNAL1) of the overcurrent modules.
	8-9-10	Self-supervision signalling contact (IRF). In normal conditions the contact interval 8-9 is closed. When the auxiliary power supply fails or an internal fault is detected, the contact interval 9-10 is closed
	11-12	Selection of $I_{sin\phi}/I_{cos\phi}$ for the directional earth-fault module U2 (BACTRL)
X2	1-2-3	Signal "Final trip on earth fault; $I\phi>$, $I\phi>>$ " or "general protection operation; $I>$, $I>>$, $I>>>$, $I\phi>$, $I\phi>>$ " (SIGNAL 2)
	4-5-6	Output signals SS1/U1, SS2/U1, SS1/U3 and SS2/U3 (SIGNAL 3)
	7-8-9	Start signal of directional earth-fault module, stage $I\phi>$ (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
1-3		Input channel 1 of control module, closed status (INPUT1/I). When a circuit breaker is closed voltage must be connected to this 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 module (OPEN 2)
17-18		Close output 2 of the control module (CLOSE 2)

Terminal group	Contact gap	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 the control module (OPEN 3)
	13-14	Close output 3 of the control module (CLOSE 3)
	15-16	Open output 4 of the control module (OPEN 4)
	17-18	Close output 4 of the 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 external AR start input, no LED indication!
	11-12	Open output 5 of the control module (OPEN 5)
	13-14	Close output 5 of the control module (CLOSE 5)
X6	1-2	Signal output 5 of the control module (SIGNAL 5)
	3-4	Signal output 6 of the control module (SIGNAL 6)
	5-6	Not used
	7-8	mA input 1 (used with optional measuring module SPTM 8A1)
	9-10	mA input 2 (used with optional measuring module SPTM 8A1)

Protective earth is connected to its own screw on the rear panel. The screw is marked with the ground symbol. The channel numbers mentioned above are the same as those used when

programming the control module SPTO 6D3. When programming the control module the following codes are used for the outputs:

Output	Terminal numbers	Output code for interlocking and configuration	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 or closed, the outputs OPEN1 and CLOSE1, OPEN2 and CLOSE2, etc. always form a pair, i.e. output

OPEN1 is used to open an object and CLOSE1 is used to close it.

Intermodular control signal exchange
(Modified 2000-10)

The initial factory settings of the feeder terminal may have to be changed in different applications.

Fig. 9 illustrates schematically how the input and output signals can be configured to obtain the required functions.

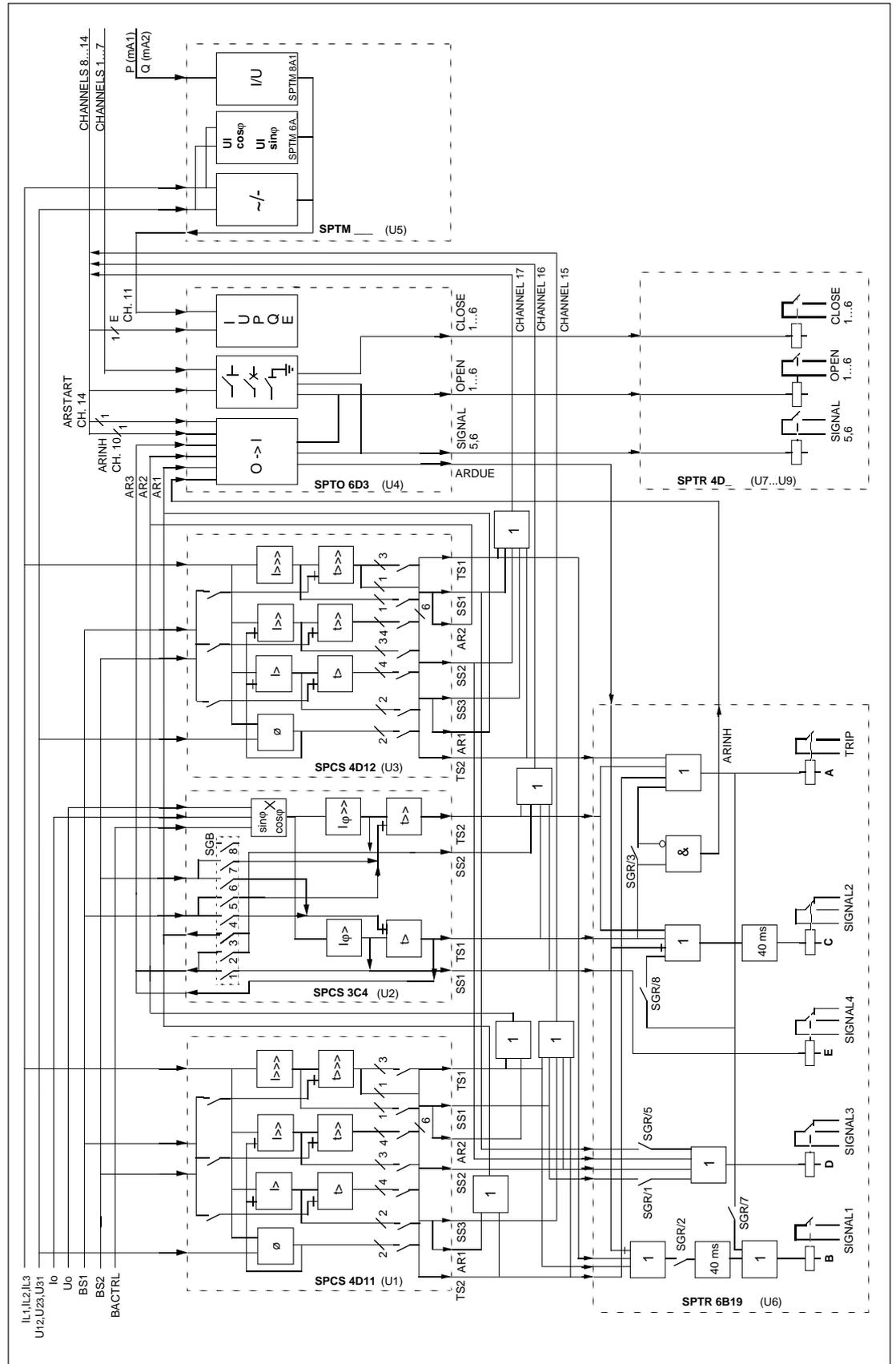


Fig. 9. Intermodular control signals of feeder terminal SPAC 538 C and SPAC 638 C. The internal switches of the directional overcurrent modules SPCS 4D11 and SPCS 4D12 are shown in fig. 10.

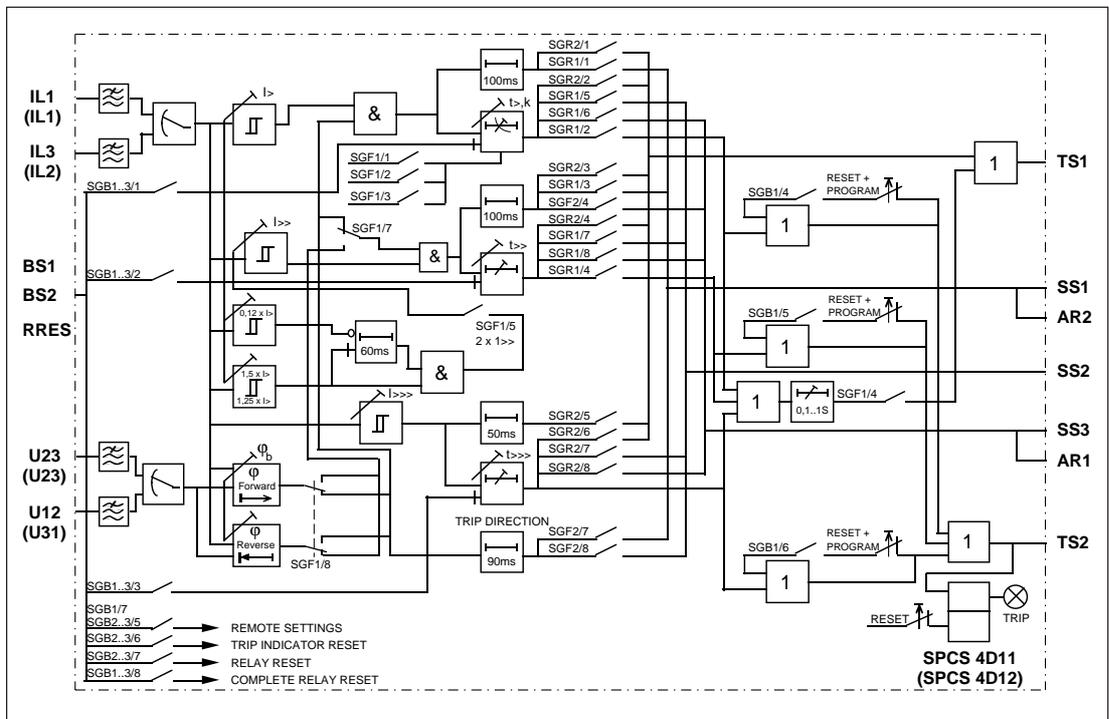


Fig. 10. The internal switches of the two-phase directional overcurrent relay module SPCS 4D11

Part of the start and trip signals of the relay modules is permanently connected to control the outputs, and part of the signals is linked through switchgroup SGR, located at the front edge of the I/O module SPTR 6B19.

The switches are set through the opening of the system panel.

The SGR switches have the following functions:

Switch	Function	Factory setting
SGR/1	Links the signal SS1/U1 of SPCS 4D11 to output SIGNAL3	1
SGR/2	Links the signals TS1/U1 and TS1/U3 of SPCS 4D11 to output SIGNAL1	1
SGR/3	Links the signal TS1/U2 of SPCS 3C4 to output TRIP	1
SGR/4	No function in SPAC 538 C. Has to be in position 0	0
SGR/5	Links the signal SS1/U3 of SPCS 4D12 to output SIGNAL3	1
SGR/6	No function in SPAC 538 C. Has to be in position 0	0
SGR/7	Links all the signals connected to TRIP output to SIGNAL1 output	0
SGR/8	Links all the signals which are connected to the TRIP output to output SIGNAL2	0

Note!

Switch SGR/3: If this switch is open and the $I_{\phi} >$ stage trips, the trip signal controls the output SIGNAL2 and gives an internal auto-reclose inhibit signal to the auto-reclose unit. Thus the low-set earth-fault stage only has a signalling function when an earth fault occurs.

Switch SGR/7: By closing this switch the output SIGNAL1 can be used as a second trip output, for instance, in applications with two circuit breakers.

Switch SGR/8: By closing this switch the output SIGNAL2 can be used as a general alarm output for the protection relay modules, especially when SIGNAL1 is used as a second trip output.

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

The switchgroups presented in the tables below are used for configuring the directional overcurrent relay modules SPCS 4D11 and SPCS 4D12. The tables also show the checksum for the

default values of the individual switchgroups. The available functions are described in detail in the manual for the overcurrent relay modules SPCS 4D11 and SPCS 4D12.

Switch-group	Function	Checksum
SGB1	Configuration of blocking and control inputs	0
SGB2	Configuration of blocking and control inputs	0
SGB3	No function in SPAC 538 C/SPAC 638 C. Has to be in the position 0.	0
SGR1	Programming of output relay matrix	155
SGR2	Programming of output relay matrix	128
SGF1	Selection of protection functions	0
SGF2	Selection of protection functions	0

The switches of the SGB switchgroup of the directional earth-fault relay module are used to route the start signals of the module to the auto-reclose starting inputs. The switches are also used for linking external blocking signals to the relay modules.

The SGB switches on the PC board of the directional earth-fault module SPCS 3C4 have the following functions:

Switch-group	Function	Checksum
SGB/1	Routes the start signal of stage I ϕ > to the auto-reclose starting input AR3. Typically used as the starting input for auto-reclosures initiated by the low-set stage of the earth-fault module.	1
SGB/2	Links the start signal of stage I ϕ >> to auto-reclose starting input AR3	0
SGB/3	Links the start signal of stage I ϕ >> to auto-reclose starting input AR1	0
SGB/4	Forms from the blocking input signal BS1 a blocking signal for the operation of stage I ϕ >	0
SGB/5	Forms from the blocking input signal BS1 a blocking signal for the operation of stage I ϕ >>	0
SGB/6	Forms from the blocking input signal BS2 a blocking signal for the operation of stage I ϕ >	0
SGB/7	Forms from the blocking input signal BS2 a blocking signal for the operation of stage I ϕ >>	0
SGB/8	No function in SPAC 538 C/SPAC 638 C. Has to be 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.

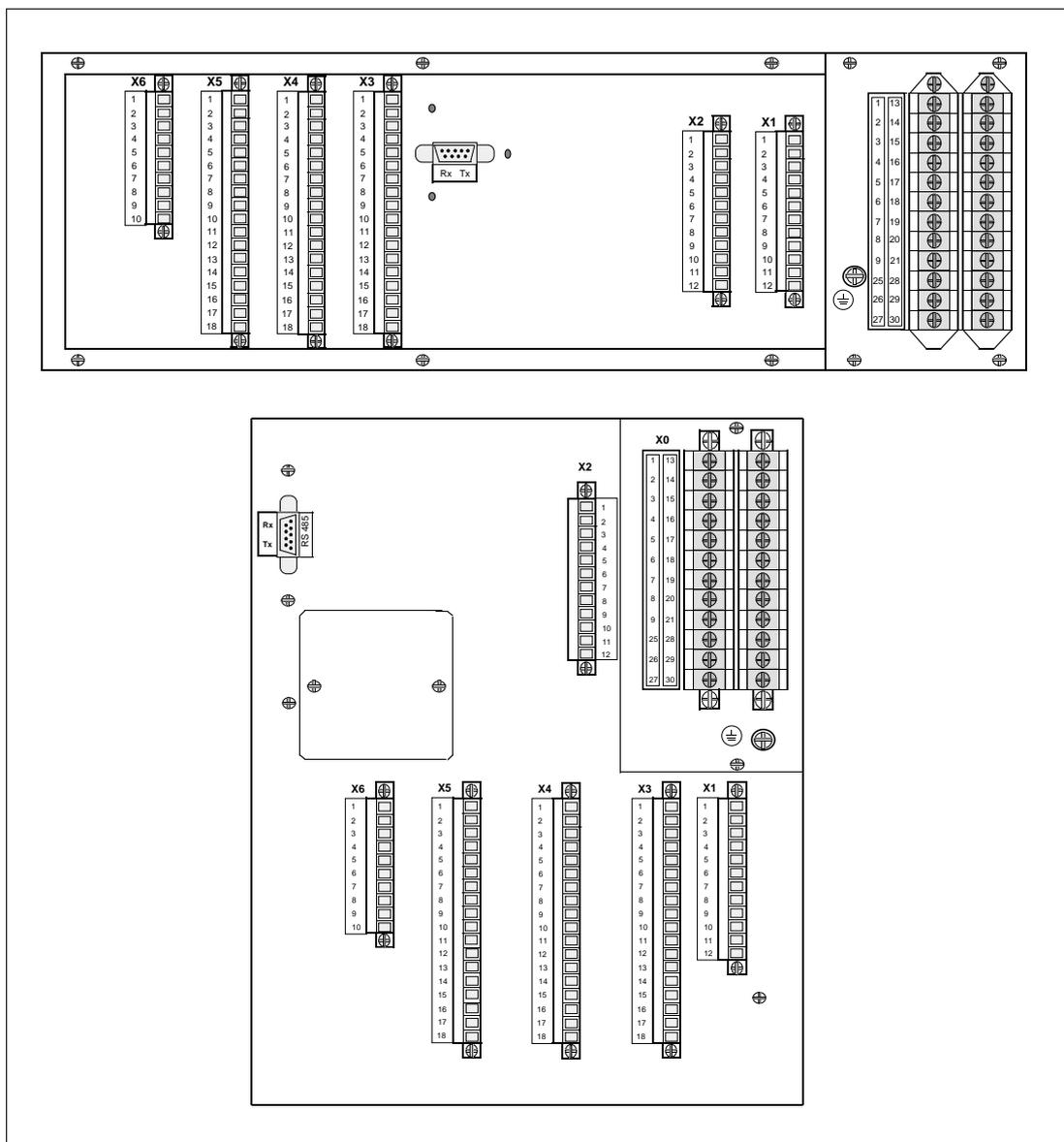


Fig. 11. Rear view of feeder terminal SPAC 538 C and SPAC 638 C.

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 fixing accessories are to be used for securing the female connector part.

The measuring signal inputs are connected to the terminal block X0. Each terminal is dimensioned for one max. 6 mm² or two max. 2.5 mm² wires.

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

The binary inputs and contact outputs of the overcurrent and earth-fault modules are connected to the multi-pole connectors X1 and X2. The auxiliary power supply is connected to the multi-pole connector X1. Other binary inputs, the mA inputs and contact outputs of the control module are connected via multi-pole connectors X3...X6. One max. 1.5 mm² wire or two max. 0.75 mm² wires can be connected to one screw terminal.

The RS 485 interface (Rx/Tx) on the rear panel connects the feeder terminal to the SPA bus over a bus connection module, type SPA-ZC 17_ or SPA-ZC 21_. The 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 using the cable included in the delivery and then attached to the wall of the switchgear cubicle with screws.

Start-up

The start-up should be done according to the following instructions. The checks 1 and 2 have to be done before the auxiliary power supply is switched on.

1. Voltage ranges of the binary inputs

Before connecting voltage to the input channels 1...14, check the operating voltage range of the inputs. The voltage range, U_{aux} is marked on the front panel of the feeder terminal. See 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 feeder terminal. See chapter "Technical data".

3. Configuring 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 for the control module SPTO 6D3.

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

- Configuration; user-defined configuration
- Interlocking; user-defined interlocking
- OPEN and CLOSE outputs; pulse lengths
- Auto-reclosing; auto-reclose sequence, dead times, reclaim time, start delays
- Measurements; primary current and voltage transformer ratios, 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 via the rear panel RS 485 connection using the SPA protocol. Instructions are given in the manual for the control module SPTO 6D3.

4. Settings of the protection modules SPCS 4D11, SPCS 4D12 and SPCS 3C4

During testing at the factory the switches of the overcurrent and earth-fault relay modules have been given default values, see the chapter "Intermodular control signal exchange". All the current and time settings of the directional overcurrent relay module SPCS 4D11 and SPCS 4D12 are set at their minimum values. The checksums for the default values of SPCS 4D11 and SPCS 4D12 are as follows:

Switchgroup	Σ
SGF1	0
SGF2	0
SGR1	155
SGR2	128
SGB1	0
SGB2	0
SGB3	0

During factory testing the setting knobs on the front panel of the directional earth-fault module SPCS 3C4 are set in their middle position and all the front panel switches SG1 in position 0. For the default values of the switches SGB on the printed circuit board of SPCS 3C4, see the chapter "Intermodular control signal exchange".

When auto-reclose functions or external blocking signals are to be used, the positions of the switches SGB1, SGB2, SGR1 and SGR2 of the overcurrent modules SPCS 4D11 and SPCS 4D12 and the positions of the switches SGB on the PC board of the earth-fault relay module SPCS 3C4 should be checked.

The overcurrent relay modules SPCS 4D11 and SPCS 4D12 can be configured using the push-buttons on the front panels of the modules. In addition, the RS 232 connection on the front panel of the control module or the RS 485 connection on the rear panel of the feeder terminal can be used for setting the overcurrent relay modules.

The functions of the switches are described in the manuals for the directional overcurrent protection module SPCS 4D1_ and the earth-fault protection module SPCS 3C4.

Technical data
(Modified 2002-04)

Energizing inputs

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 m Ω	<20 m Ω
Rated voltage	100 V	110 V
Continuous voltage withstand capacity	$2 \times U_n$	
Rated burden at U_n	<0.5 VA	
Rated frequency	50 Hz	
Rated frequency on request	60 Hz	

mA inputs (only when option SPTM 8A1 is used)

Terminal numbers	
- active power	X6/7-8
- reactive power	X6/9-10
Input current range	-20...20 mA

Binary inputs for 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
Input voltage range, permissible variation $\pm 10\%$	
- input module type SPTR 4D1	90...240 V dc
- input module type SPTR 4D2	35...70 V dc
Current drain	about 2 mA

Binary inputs for protection relay modules

Terminal numbers	
- blocking inputs	X2/10-11, 11-12
- base angle control for earth-fault protection	X1/11-12
Input voltage range	20...240 V dc or 90...240 V ac
Current drain	about 2 mA

Energy pulse counter input (input channel 11)

Terminal numbers	X4/6-8
Maximum frequency	25 Hz
Input voltage range	
- input module type SPTR 4D1	90...240 V dc
- input module type SPTR 4D2	35...70 V dc
Current drain	about 2 mA

External auto-reclose inhibit input (input channel 10)

Terminal numbers	X4/6-7
Input voltage range, permissible variation $\pm 10\%$	
- input module type SPTR 4D1	90...240 V dc
- input module type SPTR 4D2	35...70 V dc
Current drain	about 2 mA

External auto-reclose starting input (input channel 14)

Terminal numbers	X5/9-10
Input voltage range, permissible variation $\pm 10\%$	
- input module type SPTR 4D1	90...240 V dc
- input module type SPTR 4D2	35...70 V dc
Current drain	about 2 mA

Contact outputs

Control type 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
- 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 $L/R \leq 40$ ms at the control voltage levels 48/110/220 V dc	5 A/3 A/1 A
- operating principle when operated by the control module	pulse, pulse length 0.1...100 s
Signalling type 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
- 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 $L/R \leq 40$ ms at the control voltage levels 48/110/220 V dc	1 A/0.25 A/0.15 A

Auxiliary supply voltage

Type of built-in power supply module and supply voltage range	
- type SPGU 240 A1	90...240 V ac or dc
- type SPGU 48 B2	20...70 V dc
Burden of auxiliary supply under quiescent/ operating conditions	
- at DC current	about 16 W/22 W
- at AC current	about 40 VA/45 VA

Directional overcurrent relay modules SPCS 4D11 and SPCS 4D12

Low-set directional stage I>

- operating mode	Directional
- current setting range	0.3...5.0 x I_n
- operation modes to be selected	
- definite time operation	
- operate time t>	0.1...300 s
- inverse definite minimum time (IDMT) mode as per 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 directional stage I>>

- operating mode	Directional or non-directional
- current setting range	0.5...40 x I_n and ∞ , infinite
- operate time t>>	
- directional operation	0.1...300 s
- non-directional operation	0.04... 300 s

Basic angle ϕ_b for measurement of direction

Setting range of basic angle ϕ_b	0...-90°
Operation sector	$\phi_b \pm 80^\circ$

High-set stage I>>>

- operating mode	Non-directional
- current setting range	2...40 x I_n and ∞ , infinite
- operate time t>>>	0.04...30 s

Note!

The high-current end of any inverse time characteristic is determined by the high-set stage I>>> which, when started, inhibits the low-set stage operation. Thus the trip time is equal to

the set t>>> for any current higher than I>>>. In order to get a trip signal, the stage I>>> must be linked to a trip output.

Directional earth-fault module SPCS 3C4

Low-set earth-fault stage I ϕ >

- current setting range	1.0...10.0% x I_n
- operation modes to be selected	$I_0 \sin \phi$ or $I_0 \cos \phi$
- operate time t>	0.10...10.0 s

High-set earth-fault stage I ϕ >>

- current setting range	1.0...40.0% x I_n and ∞
- operation modes to be selected	$\pm I_0 \sin \phi$ or $\pm I_0 \cos \phi$
- operate time t>>	0.10...1.00 s

Starting level of neutral displacement voltage U_0

- selectable values	2, 5, 10 or 20% x U_n
---------------------	-------------------------

Control module SPTO 6D3

Control functions

- status indication for maximum 7 objects, e.g. circuit breakers, disconnectors, earth switches
- configuration freely programmable by the user
- remote or local control (open and close) for 6 objects
- output pulse length adjustable, 0.1...100.0 s
- feeder oriented interlocking logic freely programmable

Measurement functions

- one pulse counter input for energy pulse counting, maximum frequency 25 Hz
- for other measurements an optional measuring module is required
- 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 ranges, measurement of current $0...1.5 \times I_n$, measurement of voltage $0...1.5 \times U_n$
- accuracy of current and voltage measurement better than $\pm 1\%$ of the rated value
- mA inputs for measurement of active and reactive power, external measuring transducers are needed
- accuracy of the power measurement better than $\pm 1\%$ of the maximum value of the measurement range
- the energy value can be integrated on the basis of the power measured, alternative to energy pulse counter

Measurement functions, with optional measuring module SPTM 6A2 (option 2)

- measurement of three phase currents and three phase-to-phase voltages
- measurement ranges, measurement of current $0...1.5 \times I_n$, measurement of voltage $0...1.5 \times U_n$
- accuracy of current and voltage measurement better than $\pm 1\%$ of the rated value
- measurement of active and reactive power using internal current and voltage signals, measurement is based on the Aron-connection
- range of the power measurement $0...1.1 \times P_n$ and $0...1.1 \times Q_n$
- accuracy of the positive power measurement better than $\pm 2\%$ of rated value
- accuracy of the negative power measurement better than $\pm 3\%$ of rated value
- the energy value can be integrated on the basis of the power measured, 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, measurement of current $0...1.5 \times I_n$, measurement of voltage $0...1.5 \times U_n$
- accuracy of current and voltage measurement better than $\pm 1\%$ of the rated value
- measurement of active and reactive power using one internal voltage and two current signals, the currents and voltages to be used can be selected with the switches
- range of the power measurement $0...1.1 \times P_n$ and $0...1.1 \times Q_n$
- the energy value of energy can be integrated on the basis of the power measured, alternative to energy pulse counter

Auto-reclosing

- maximum 5 auto-reclose shots
- adjustable start time for start signals AR2 and AR3 0.00...5.00 s
- adjustable dead time 0.2...300.0 s
- adjustable reclaim time 0.2...300.0 s

Data communication

Rear panel	
- connection	RS-485, 9-pin, female
- fibre optic bus connection modules	
- for plastic fibre cables	SPA-ZC 17 BB SPA-ZC 21 BB SPA-ZC 17 MM SPA-ZC 21 MM
- for glass fibre cables	
Front panel	
- connection	RS 232, 9-pin, 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 μ s, 0.5 J
Insulation resistance measurement IEC 60255-5	>100 M Ω , 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
Temperature dependence	0.1%/°C
Long term damp heat withstand according to IEC 60068- 2- 3	<95%, at 40 °C for 96 h
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 feeder terminal is used under the conditions specified in "Technical data", the relay requires practically no maintenance. The feeder terminal includes no parts or components that are sensitive to physical or electrical wear, when the feeder terminal is used under normal operating conditions.

Should the temperature and humidity at the operating site differ from the values specified, or the atmosphere contain chemically active gases or dust, the relay should be visually inspected in association with the secondary testing of the relay. This visual inspection should focus on:

- Signs of mechanical damage to relay case and terminals
- Accumulation of dust inside the relay case; remove with compressed air
- Signs of corrosion on terminals, case or inside the relay

If the relay malfunctions or the operating values differ from those specified, the relay should be overhauled. Minor measures can be taken by the customer but any major measure involving the electronics are to be taken by the manufacturer. Please contact the manufacturer or his nearest representative for further information about checking, overhaul and recalibration of the relay.

Note!

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

Exchange and spare parts

Control module	SPTO 6D3
Optional measuring module 1 (I, U, mA)	SPTM 8A1
Optional measuring module 2 (I, U, P, Q)	SPTM 6A2
Optional measuring module 3 (I, U, P, Q)	SPTM 6A3
Directional overcurrent relay module	SPCS 4D11
Directional overcurrent relay module	SPCS 4D12
Directional neutral current module	SPCS 3C4
I/O module for control, input voltage range 90...240 V dc	SPTR 4D1
I/O module for control, input voltage range 35...70 V dc	SPTR 4D2
I/O module for protection	SPTR 6B19
Power supply module, 90...240 V ac or dc	SPGU 240A1
Power supply module, 20...70 V dc	SPGU 48B2
Housing without plug-in modules (SPAC 538 C)	SPTK 8C3
Housing without plug-in modules (SPAC 638 C)	SPTK 8C4
Counter contacts for multi-pole connectors X1...X6 with accessories (included in relay delivery)	SPA-ZT6

Order information

Please state the following data when ordering feeder terminals:

1. Quantity and type designation	15 units, SPAC 538 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 modules SPA-ZC17 MM2A

The delivery of a feeder terminal includes three empty legend text films SYKU 997 for the channels 8...13.

Different types of configuration plate are available for feeder terminals SPAC 538 C and SPAC 638 C. The type designation of the configuration plate should always be given in the order.

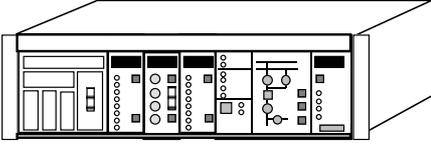
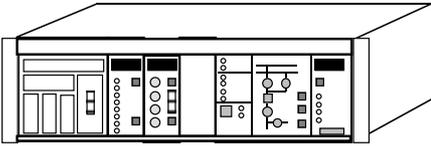
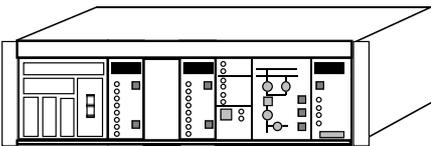
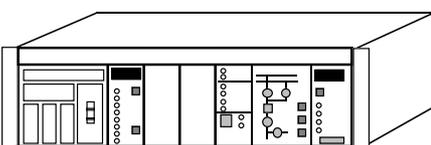
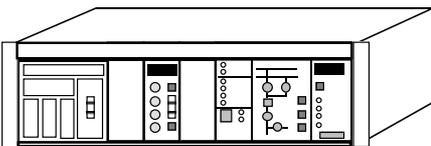
Illustration	Modules	Type
	<p>Complete feeder terminal including two directional overcurrent modules, a directional earth-fault module and a control module</p>	<p>SPAC 538 C</p>
	<p>Partially equipped feeder terminal including a directional overcurrent module, a directional earth-fault module and a control module</p>	<p>SPAC 538 C1</p>
	<p>Partially equipped feeder terminal including two directional overcurrent modules and a control module</p>	<p>SPAC 538 C2</p>
	<p>Partially equipped feeder terminal including a directional overcurrent module and a control module</p>	<p>SPAC 538 C3</p>
	<p>Partially equipped feeder terminal including a directional earth-fault module and a control module</p>	<p>SPAC 538 C5</p>

Fig. 12. Available versions of feeder terminal SPAC 538 C.

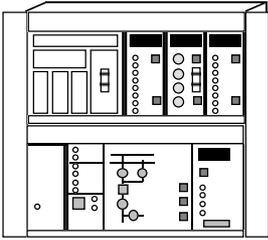
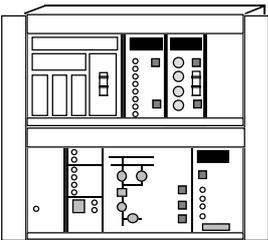
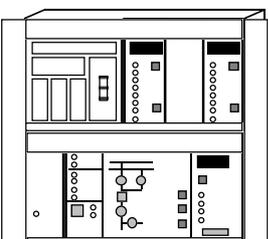
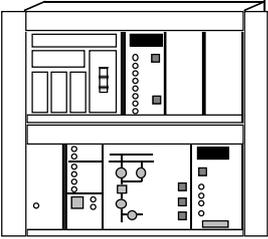
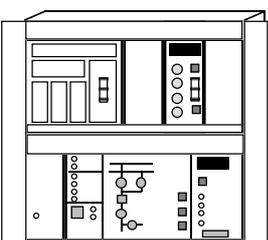
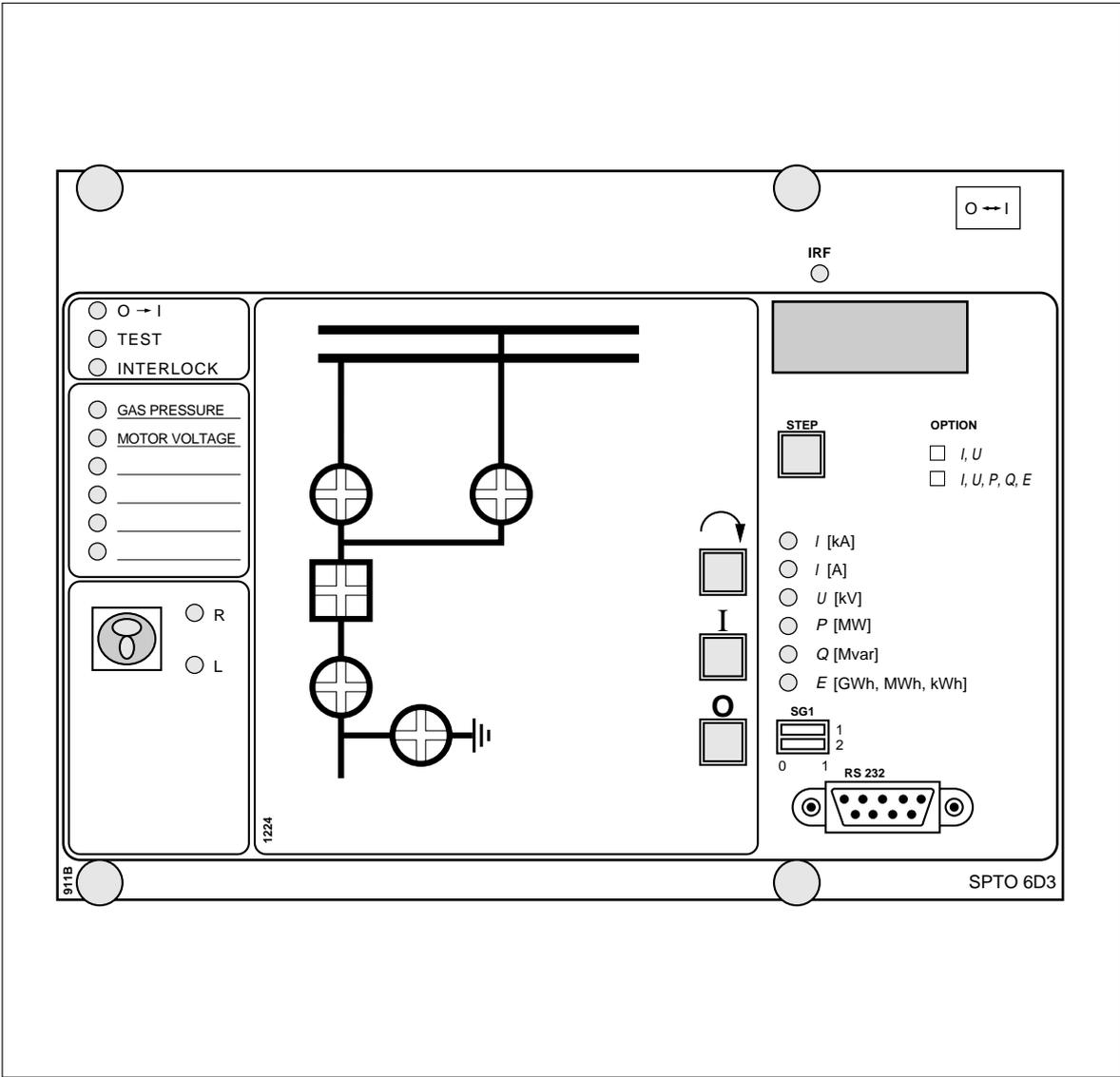
Illustration	Modules	Type
	<p>Complete feeder terminal including two directional overcurrent modules, a directional earth-fault module and a control module</p>	<p>SPAC 638 C</p>
	<p>Partially equipped feeder terminal including a directional overcurrent module, a directional earth-fault module and a control module</p>	<p>SPAC 638 C1</p>
	<p>Partially equipped feeder terminal including two directional overcurrent modules and a control module</p>	<p>SPAC 638 C2</p>
	<p>Partially equipped feeder terminal including a directional overcurrent module and a control module</p>	<p>SPAC 638 C3</p>
	<p>Partially equipped feeder terminal including a directional earth-fault module and a control module</p>	<p>SPAC 638 C5</p>

Fig. 13. Available versions of feeder terminal SPAC 638 C.

SPTO 6D3

Control module

User's manual and Technical description



Data subject to change without notice

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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.

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)

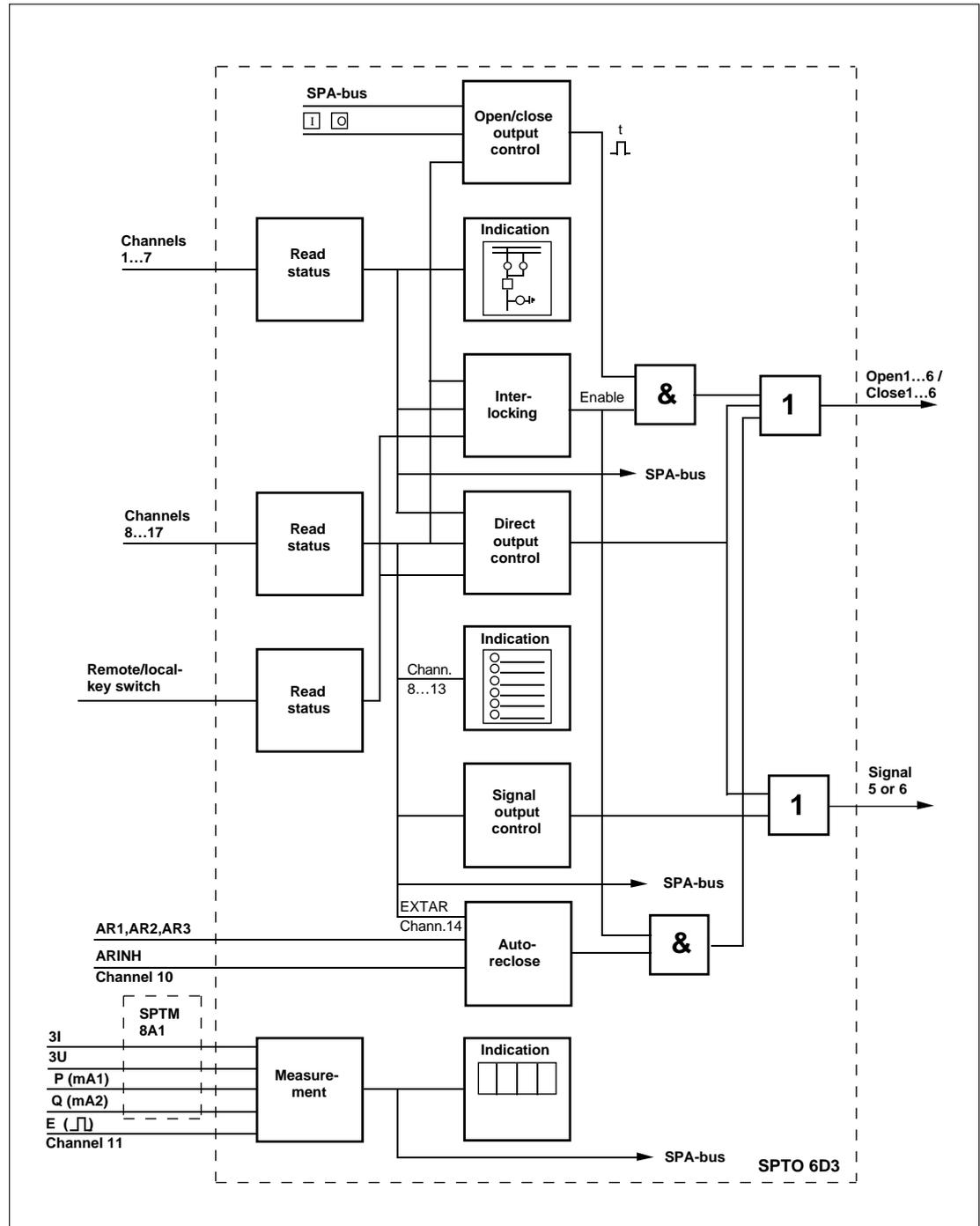


Fig. 1. Block schematic diagram for the control module SPTO 6D3 including an optional measuring module SPTM 8A1.

Front panel

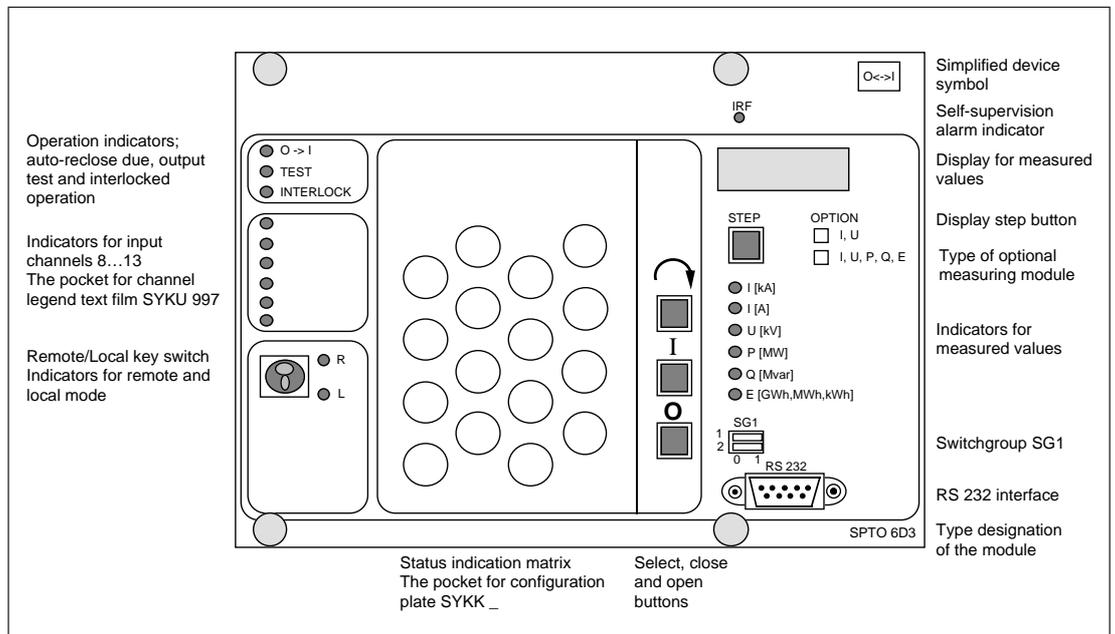


Fig. 2. Front panel of the control module SPTO 6D3 without the configuration plate SYKK_ and the channel legend text foil SYKU 997.

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.

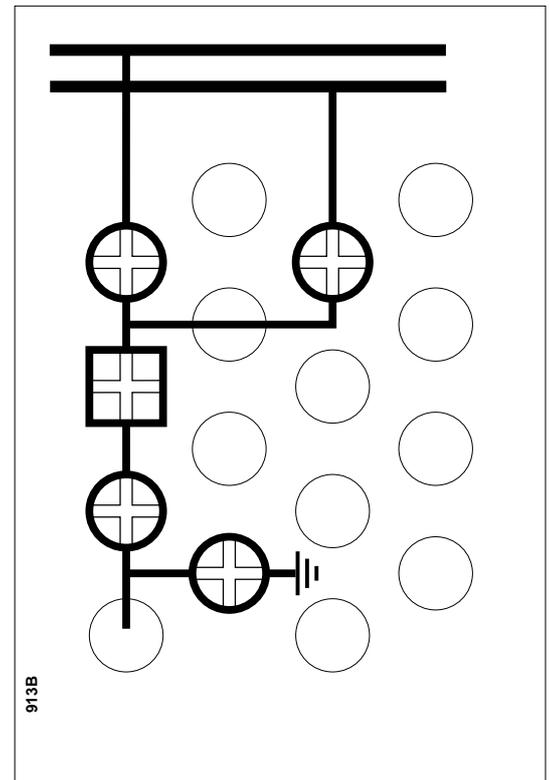


Fig. 3. Example of a plastic configuration plate SYKK_. The actual size of the configuration plate is 72mm x 106.5 mm.

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.

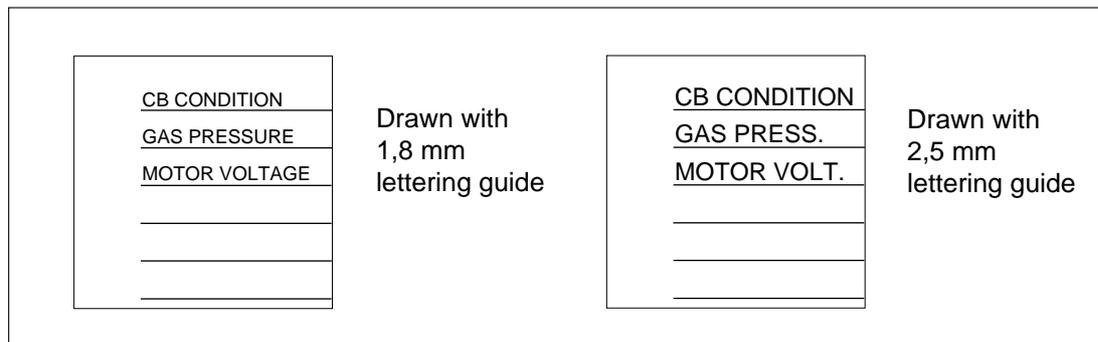


Fig. 4. Example of a text foil type SYKU 997. The foil is shown in its natural size, width 33.5 mm and height 34 mm.

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 \cap 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.

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.

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

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

Push-buttons \cap , I and O

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

the second object to be controlled 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.

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.

If the first object is not to be controlled, the \cap push button is pressed again and the indicator of

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

Switchgroup SG1

Switch	Function
SG1/1	<p>Switch SG1/1 is used to inhibit the interlockings during testing</p> <p>When SG1/1=0, the interlocking function is in use</p> <p>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!</p>
SG1/2	<p>Switch SG1/2 is used to inhibit autoreclosing</p> <p>When SG1/1=0, the auto-reclose function is in use. Also see parameter S78.</p> <p>When SG1/1=1, the auto-reclose function is inhibited.</p>

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 communication 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.

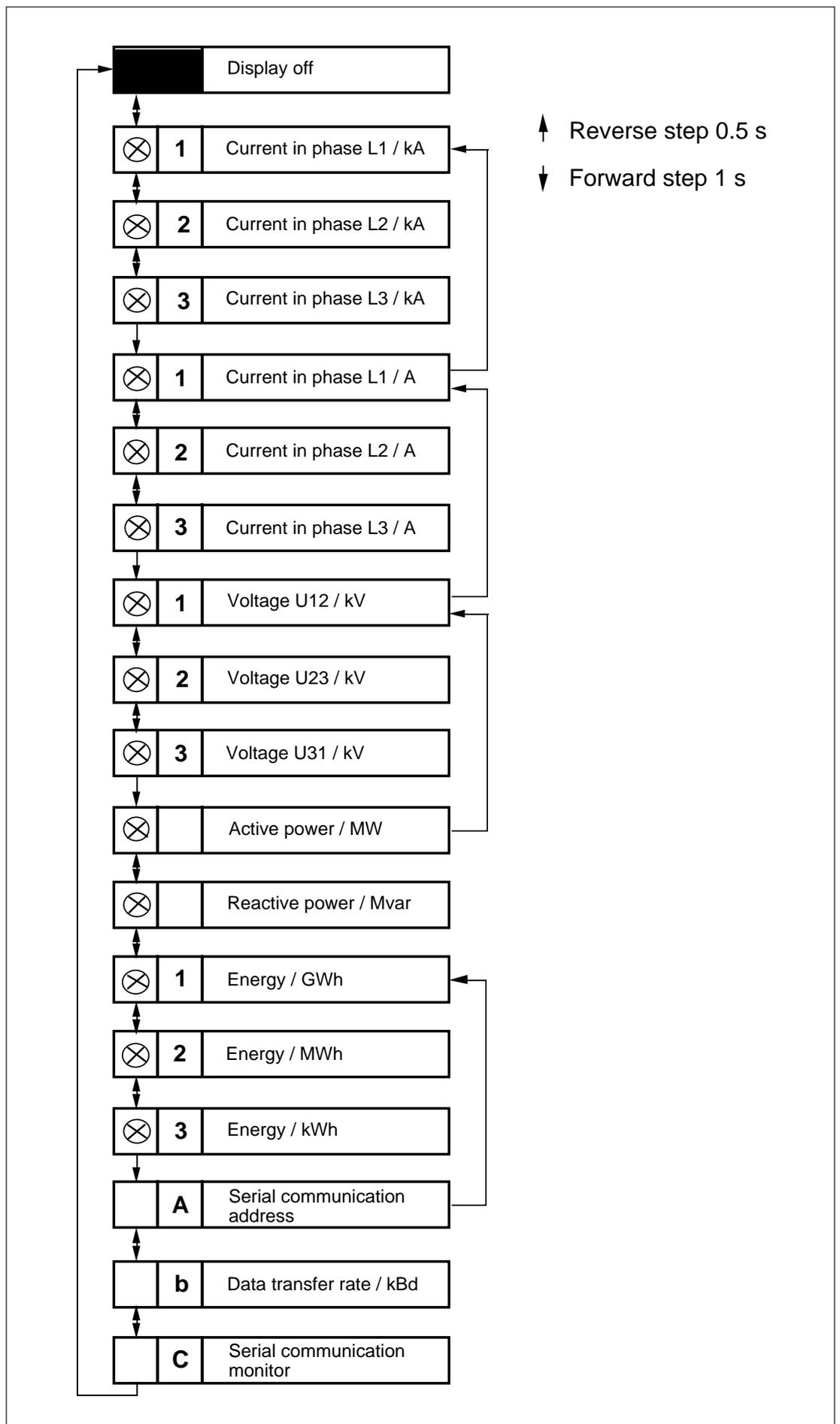


Fig. 5. Display menu of the control module SPTO 6D3.

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

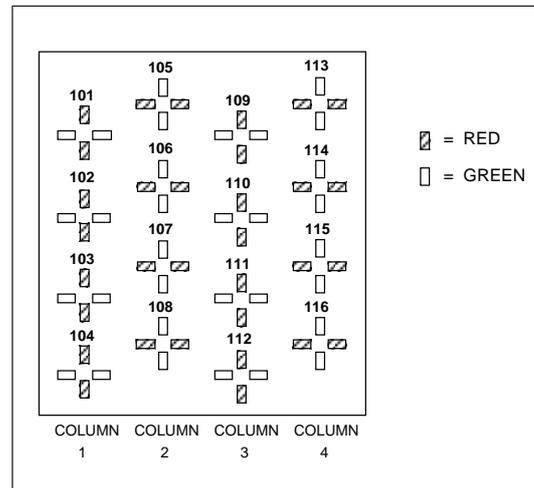


Fig. 6. Position, code number and colour of the indicator units on the front panel of the control module.

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.

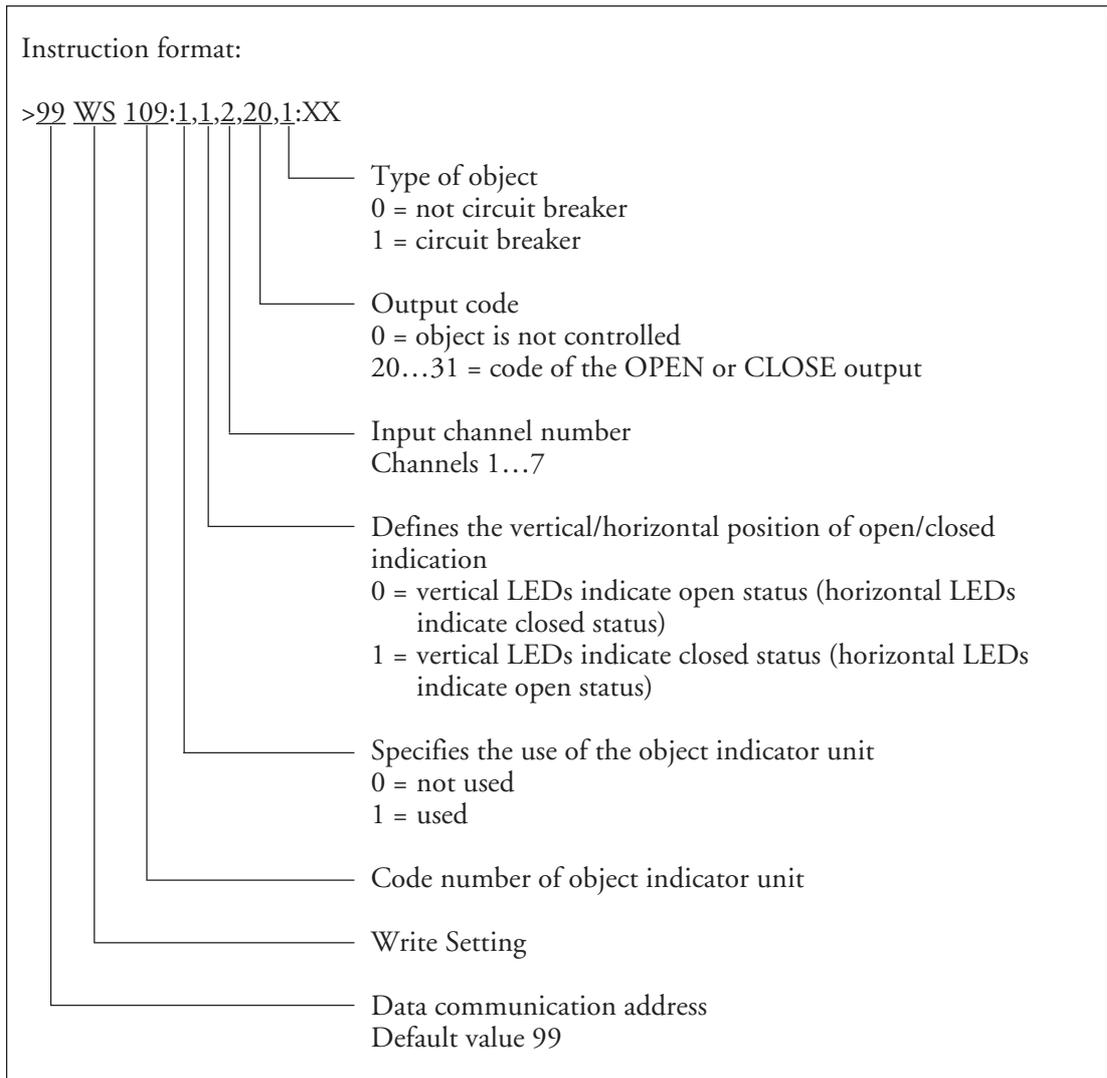
A configuration is set by linking the indicator number, the four-pole input number and the output code number by using an SPA protocol command.

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.



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.
                                Control outputs 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".

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.

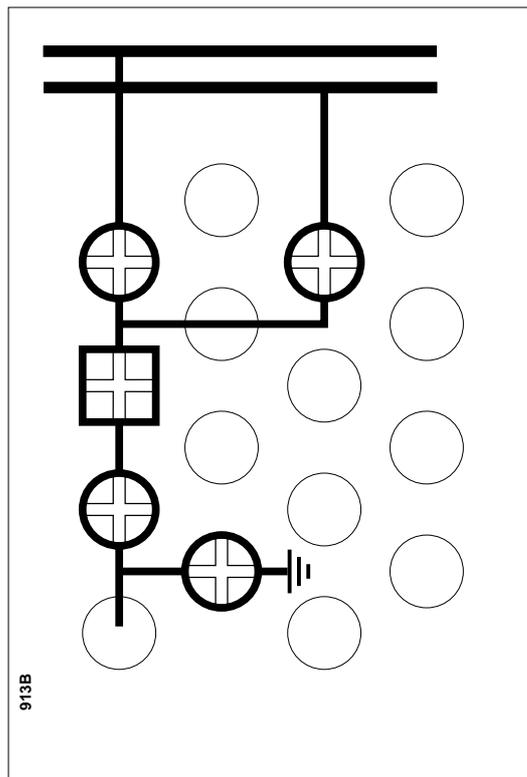


Fig. 7. Object configuration set in example 2.

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.

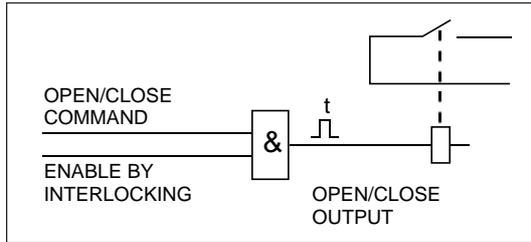


Fig. 8. Operation principle of the control functions.

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:

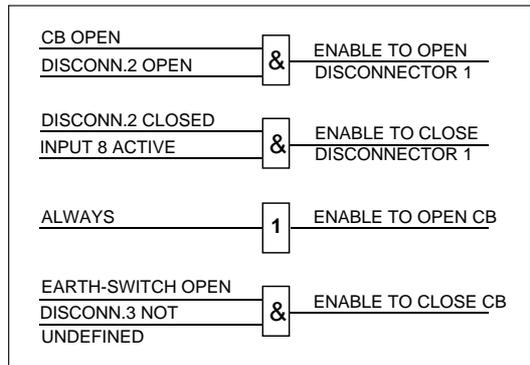


Fig. 9. Simplified logic diagram for the interlocking logic in example 7.

Below a detailed logic diagram is shown.

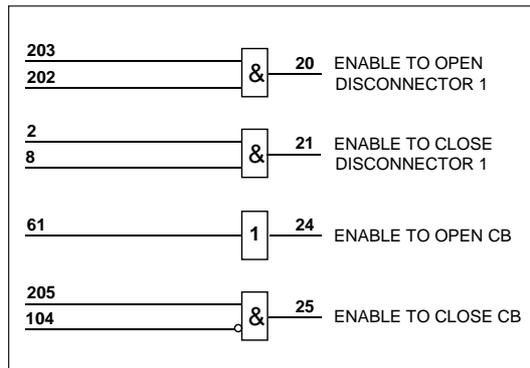


Fig. 10. Detailed logic diagram for the interlocking logic in example 7.

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.

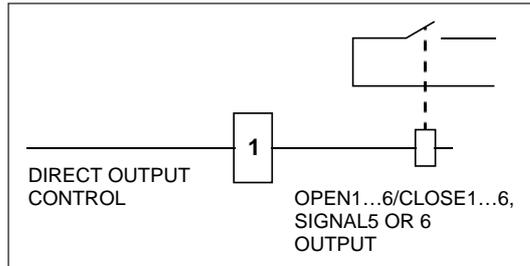


Fig. 11. Operation principle of the Direct Output Control.

The Direct Output Control program has the same setting principles and program structure as the interlocking program. The differences 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

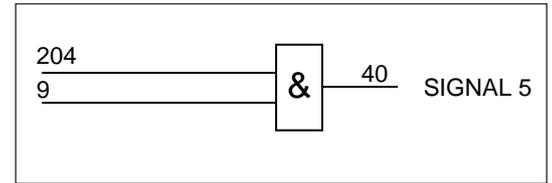


Fig. 12. Logic diagram for the Direct Output Control in example 8.

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 that the 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 event 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
```

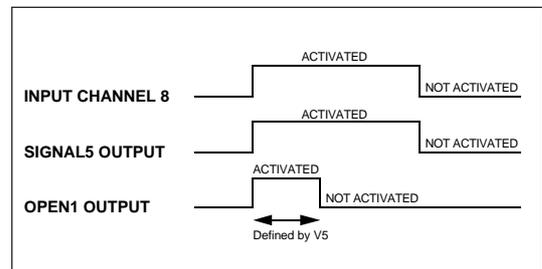


Fig. 13. Operation of outputs SIGNAL5 and OPEN1 when input channel 8 in example 9 is activated.

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.

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 length can be set within the range 0.1...100 s with a time resolution of 0.1 s.

Example 10:

The pulse lengths 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.

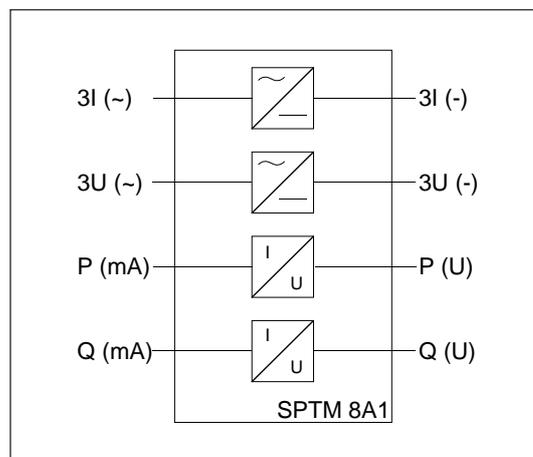


Fig. 14. Block diagram of measuring module SPTM 8A1.

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.

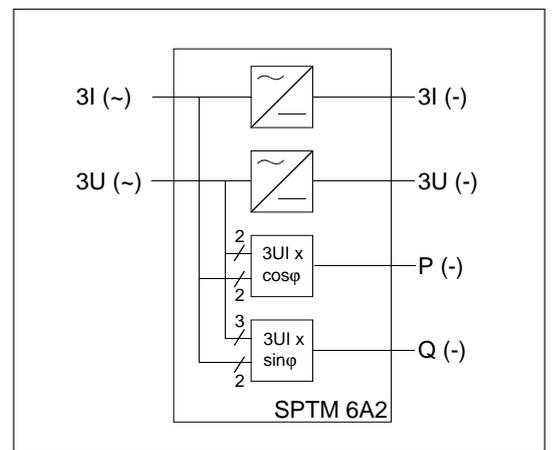


Fig. 15. Block diagram of measuring module SPTM 6A2.

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.

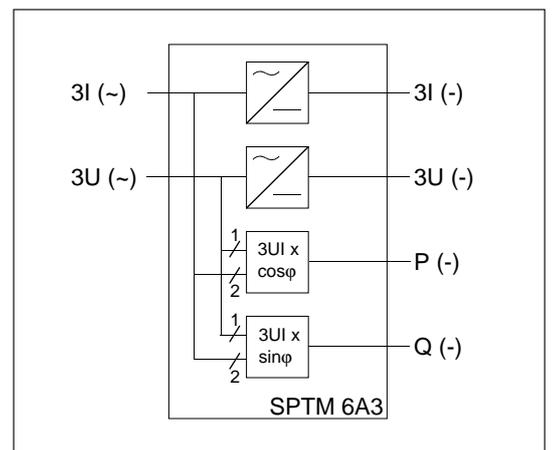


Fig. 16. Block diagram of measuring module SPTM 6A3.

Energy can be measured in two ways; by using input I1 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
```

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 AR3 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-reclose 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.

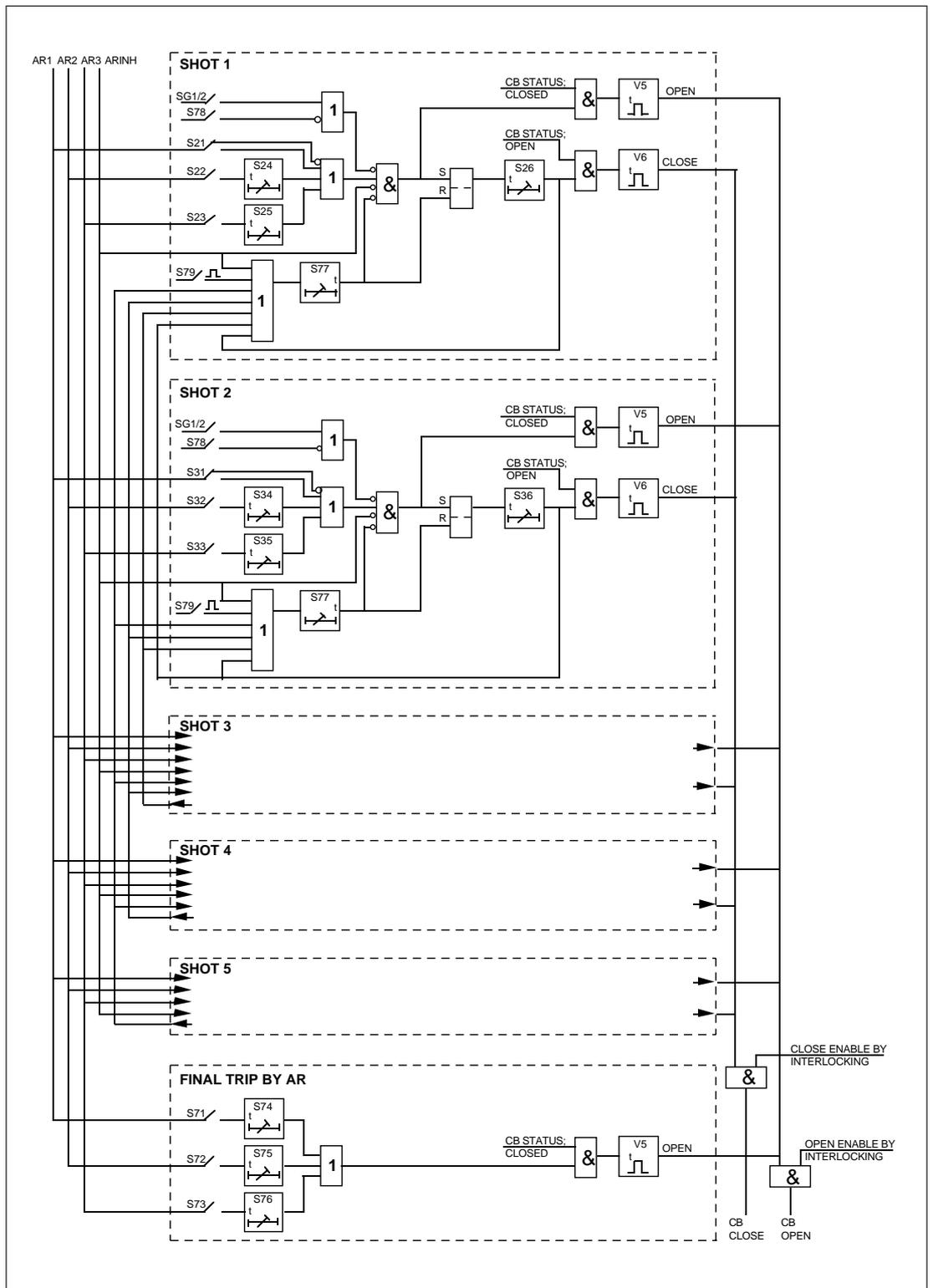


Fig. 17. Simplified block diagram for the auto-reclose functions in the control module SPTO 6D3.

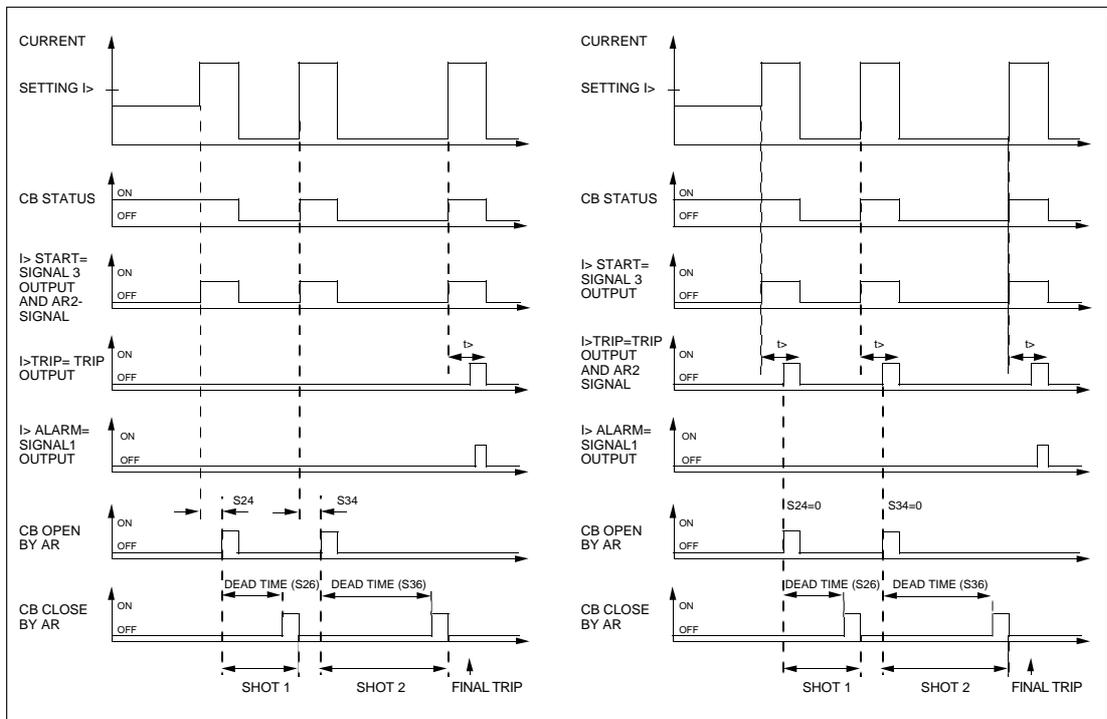


Fig. 18. a) Signal flow diagram for an AR cycle started by the start signal of the I> stage
 b) Signal flow diagram for an AR cycle started by the trip signal of the I> stage

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 parameters

```

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 initiated 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 \cap 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

Technical data

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 length 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 $0...1,5 \times I_n$ and $0...1,5 \times U_n$
- 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 $0...1,5 \times I_n$ and $0...1,5 \times U_n$
- 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 $0...1,1 \times P_n$ and $0...1,1 \times Q_n$.
- 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

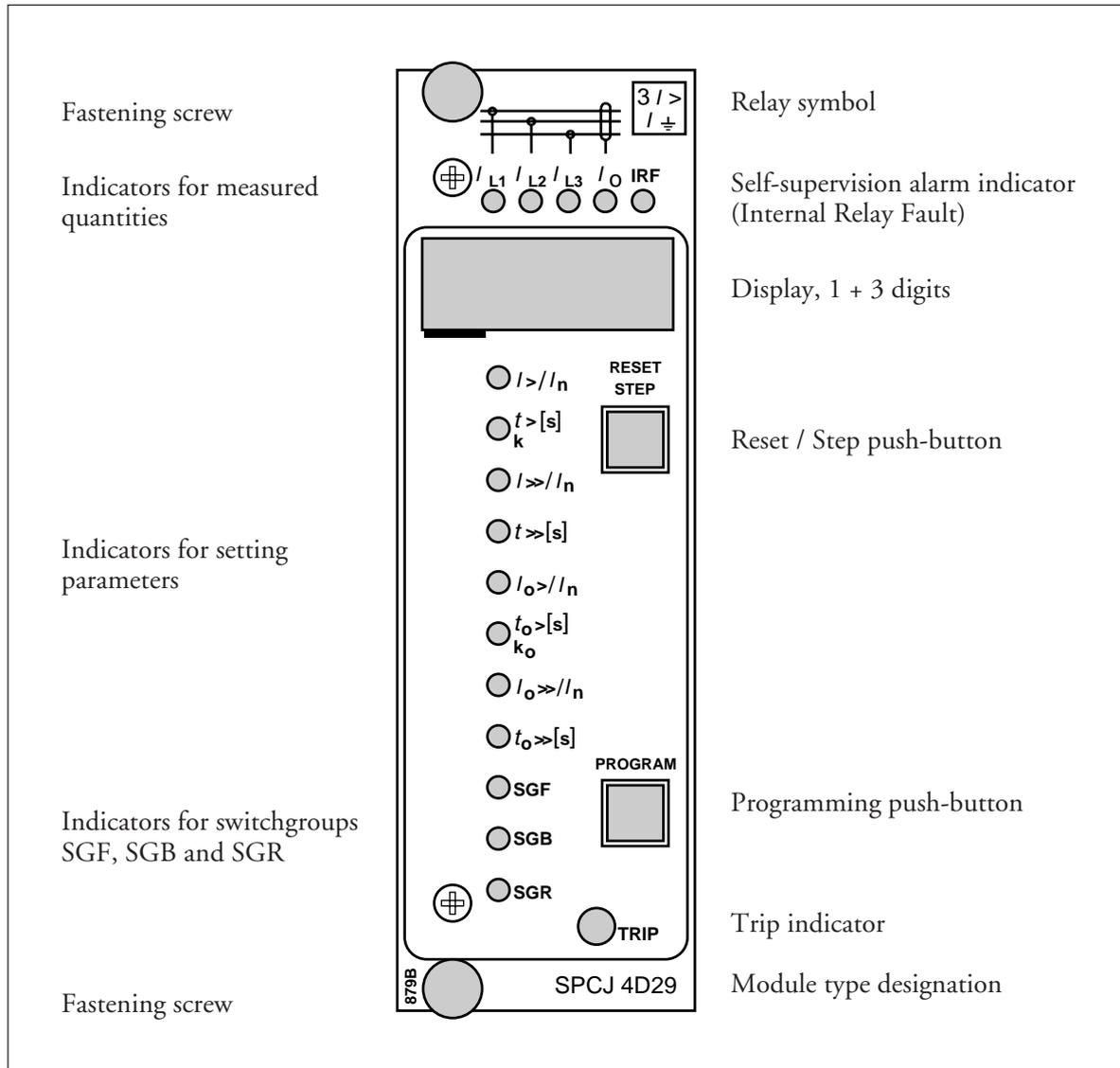
- measurement of three phase currents and three phase-to-phase voltages, measurement range $0...1,5 \times I_n$ and $0...1,5 \times U_n$
- accuracy of current and voltage measurement better than ± 1 % of rated value
- measurement of active and reactive power using one internal voltage and two current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

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



General characteristics of D type relay modules

Data subject to change without notice

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Control push-buttons	<p>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</p>	<p>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.</p>
Display	<p>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.</p>	<p>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.</p>
Display main menu	<p>Any data required during normal operation are accessible in the main menu i.e. present measured values, present setting values and recorded parameter values.</p> <p>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.</p>	<p>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.</p> <p>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 display is switched off.</p>
Display submenus	<p>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.</p> <p>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;</p>	<p>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.</p> <p>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 display without any lit set value LED indicator on the front panel.</p>

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.		Weight	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 set 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 submenus 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.*

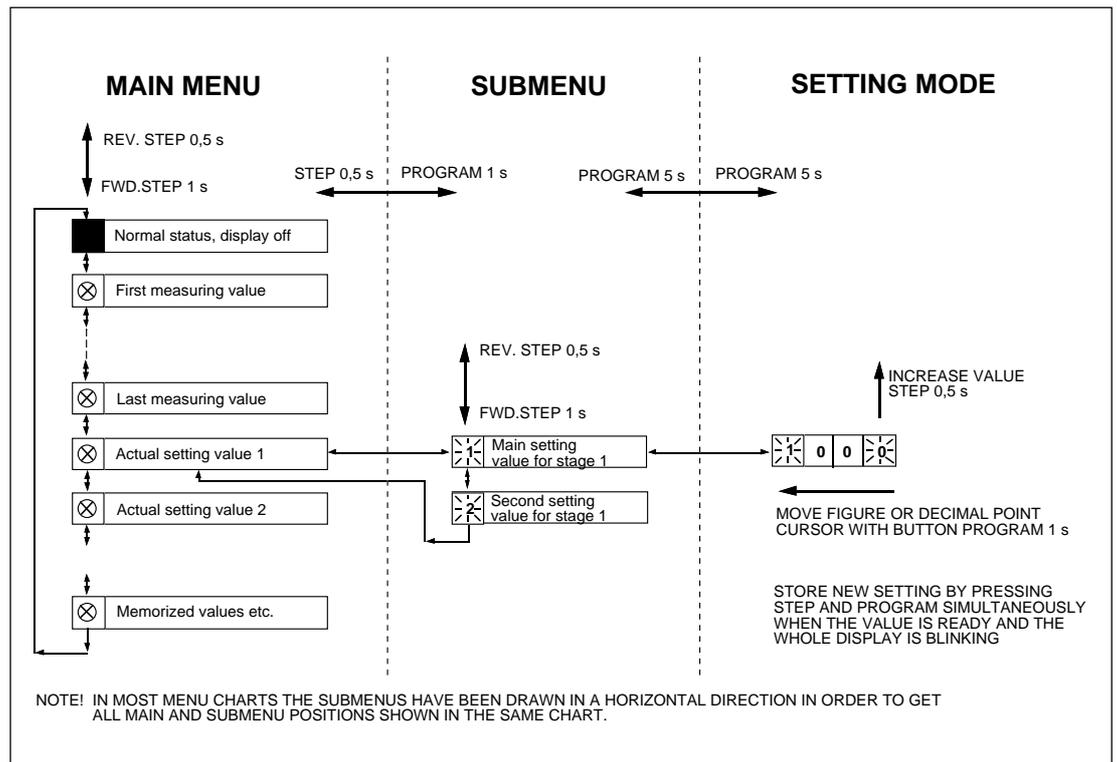


Fig.3. Basic principles of entering the main menus and submenus of a relay module.

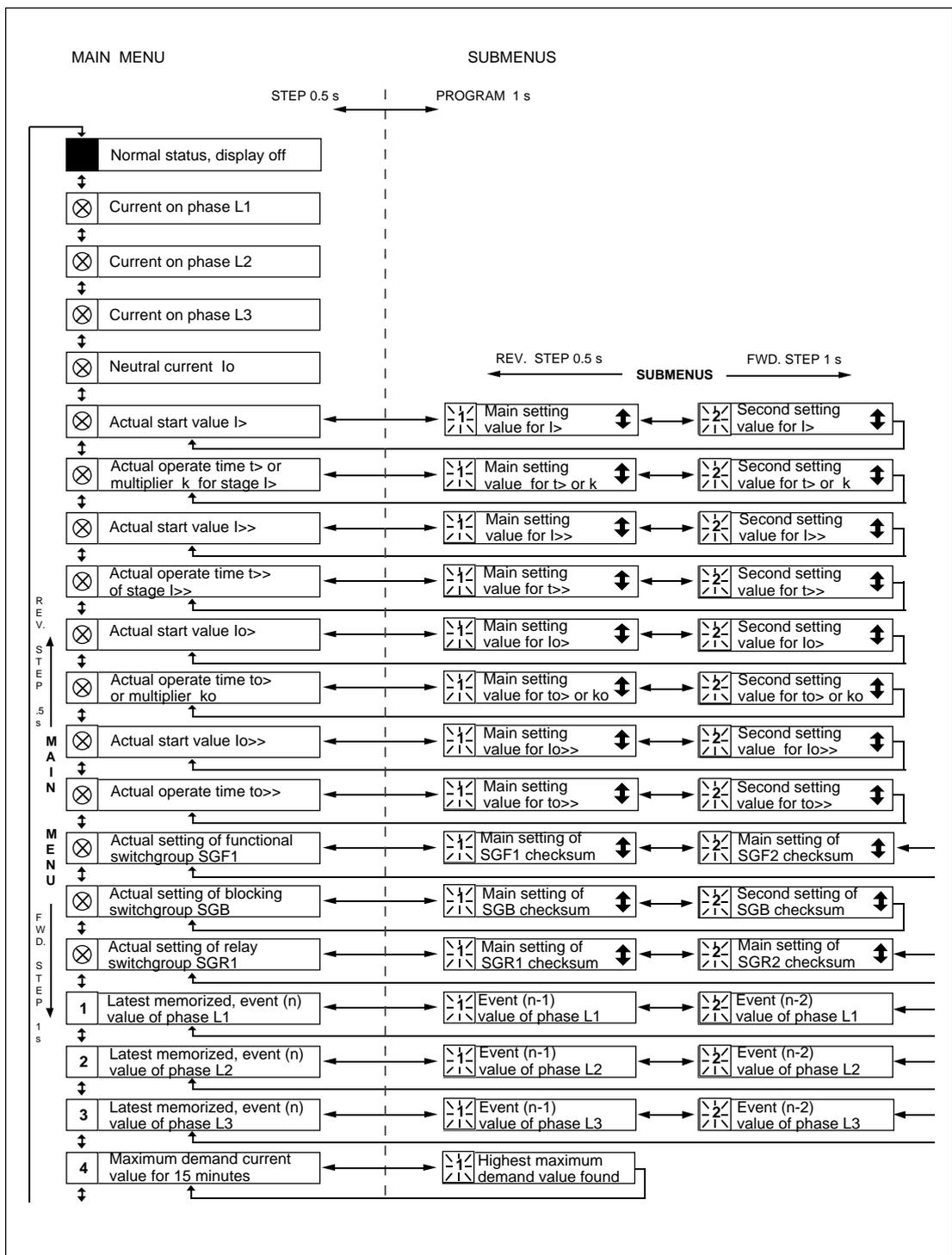


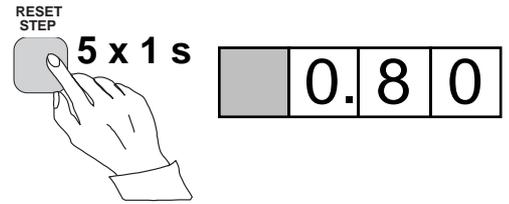
Fig. 4. Example of part of the main and submenus for the settings of the overcurrent and earth-fault relay module SPCJ 4D29. The settings currently in use are in the main menu and they are displayed by pressing the STEP push button. The main menu also includes the measured current values, the registers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

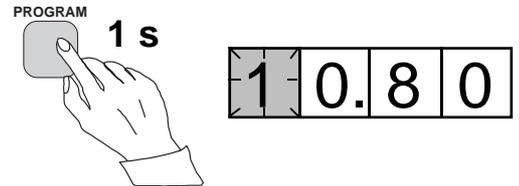
Operation in the setting mode. Manual setting of the main setting of the start current value $I>$ of an overcurrent relay module. The initial value

for the main setting is $0.80 \times I_n$ and for the second setting $1.00 \times I_n$. The desired main start value is $1.05 \times I_n$.

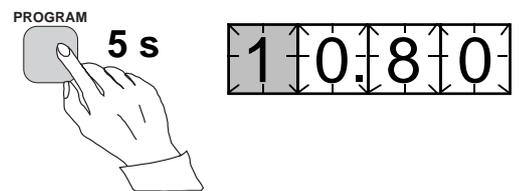
a) Press push button STEP repeatedly until the LED close to the $I>$ symbol is lit and the current start value appears on the display.



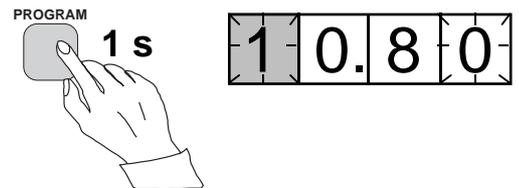
b) Enter the submenu to get the main setting value by pressing the PROGRAM push button more than one second and then releasing it. The red display digit now shows a flashing number 1, indicating the first submenu position and the green digits show the set value.



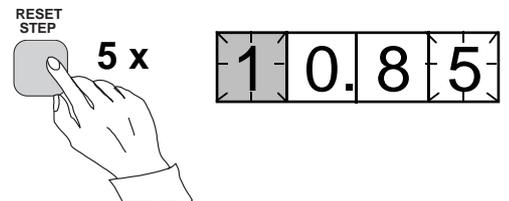
c) Enter the setting mode by pressing the PROGRAM push button for five seconds until the display starts flashing.



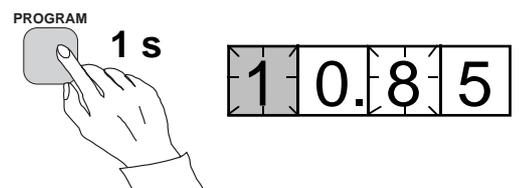
d) Press the PROGRAM push button once again for one second to get the rightmost digit flashing.



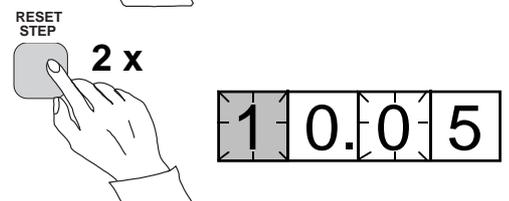
e) Now the flashing digit can be altered. Use the STEP push button to set the digit to the desired value.



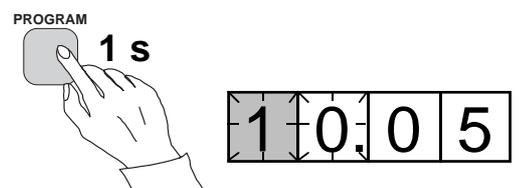
f) Press the PROGRAM push button to make the middle one of the green digits flash.



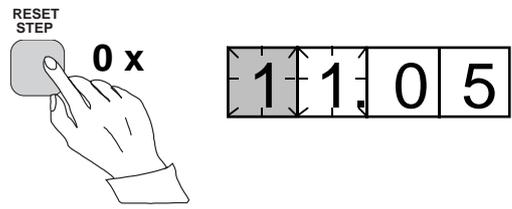
g) Set the middle digit with of the STEP push button.



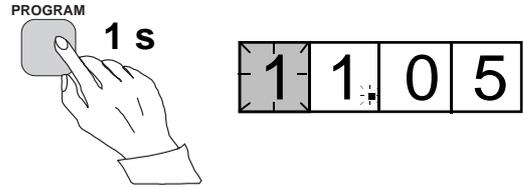
h) Press the PROGRAM push button to make the leftmost green digit flash.



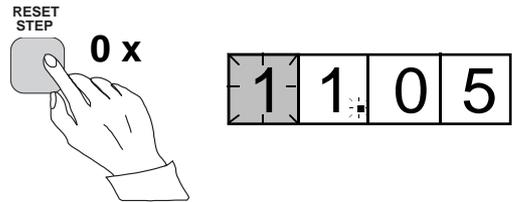
i) Set the digit with the STEP push button.



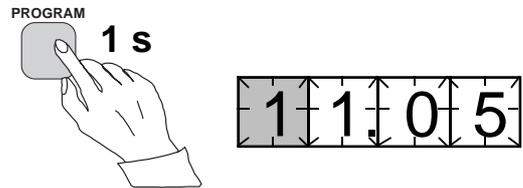
j) Press the PROGRAM push button to make the decimal point flash.



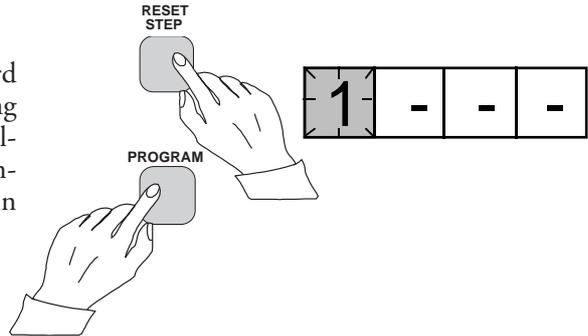
k) If needed, move the decimal point with the STEP push button.



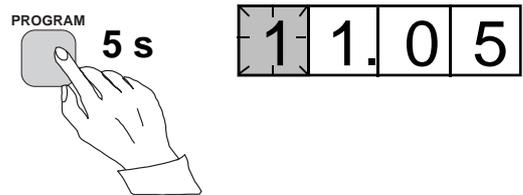
l) Press the PROGRAM push button to make the whole display flash. In this position, corresponding to position c) above, one can see the new value before it is recorded. If the value needs changing, use the PROGRAM push button to alter the value.



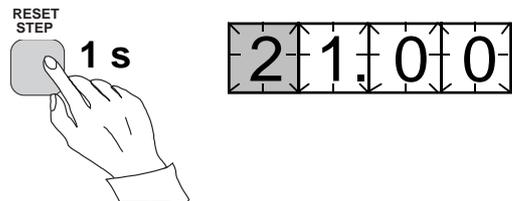
m) When the new value has been corrected, record it in the memory of the relay module by pressing the PROGRAM and STEP push buttons simultaneously. At the moment the information enters the memory, the green dashes flash once in the display, i.e. 1 - - -.



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

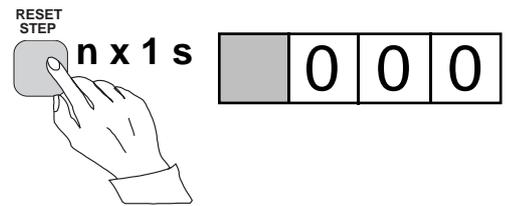
until the first digit is switched off. The LED still shows that one is in the I> position and the display shows the new setting value currently in use by the relay module.

Example 2

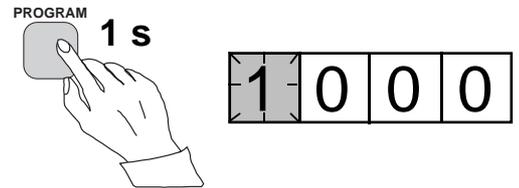
Operation in the setting mode. Manual setting of the main setting of the checksum for the switchgroup SGF1 of a relay module. The initial value for the checksum is 000 and the switches

SGF1/1and SGF1/3 are to be set in position 1. This means that a checksum of 005 should be the final result.

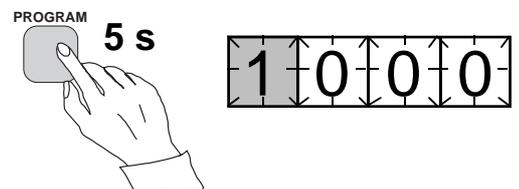
a) Press push button STEP until the LED close to the SGF symbol is lit and the checksum appears on the display.



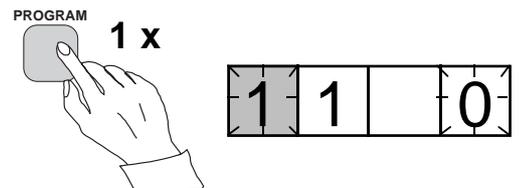
b) Enter the submenu to get the main checksum of SGF1 by pressing the PROGRAM push button for more than one second and then releasing it. The red display now shows a flashing number 1 indicating the first submenu position and the green digits show the checksum.



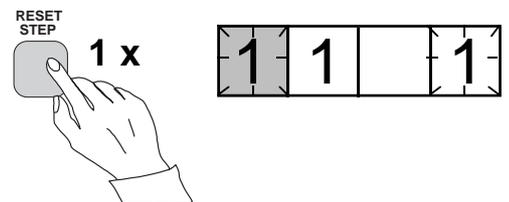
c) Enter the setting mode by pressing the PROGRAM push button for five seconds until the display starts flashing.



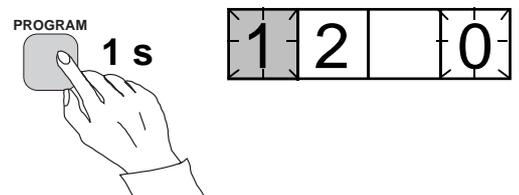
d) Press the PROGRAM push button once again to get the first switch position. The first digit of the display now shows the switch number. The position of the switch is shown by the rightmost digit.



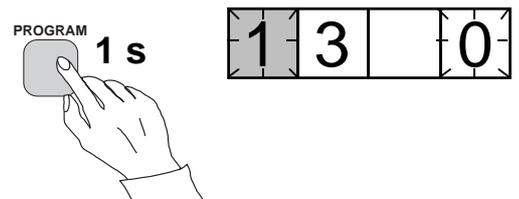
e) The switch position can now be toggled between 1 and 0 by means of the STEP push button and it is left in the requested position 1.



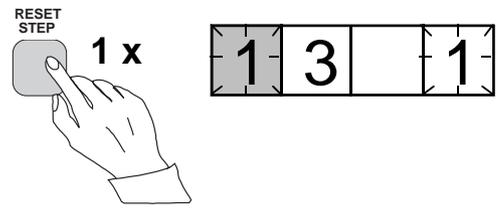
f) When switch number 1 is in the requested position, switch number 2 is called up by pressing the PROGRAM push button for one second. As in step e), the switch position can be altered by using the STEP push button. As the desired setting for SGF1/2 is 0 the switch is left in the 0 position.



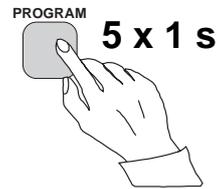
g) Switch SGF1/3 is called up as in step f) by pressing the PROGRAM push button for about one second.



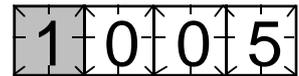
h)
The switch position is altered to the desired position 1 by pressing the STEP push button once.



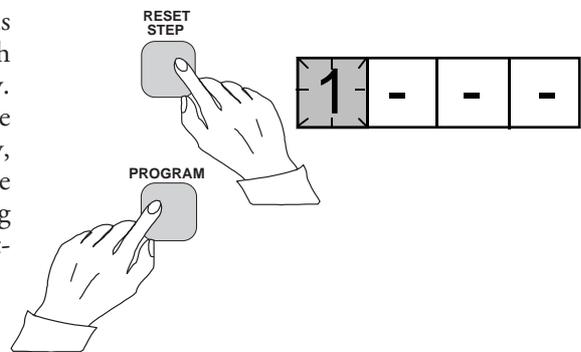
i)
Using the same procedure the switches SGF 1/4...8 are called up and, according to the example, left in position 0.



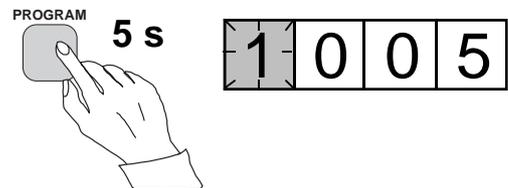
j)
In the final setting mode position, corresponding to step c), the checksum based on the set switch positions is shown.



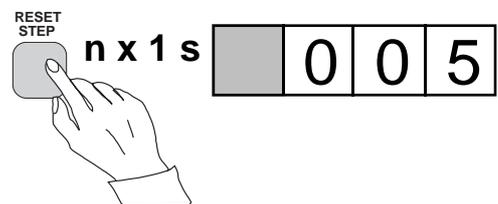
k)
If the correct checksum has been obtained, it is recorded in the memory by pressing the push buttons PROGRAM and STEP simultaneously. At the moment the information enters the memory, the green dashes flash in the display, i.e. 1 - - -. If the checksum is incorrect, the setting of the separate switches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

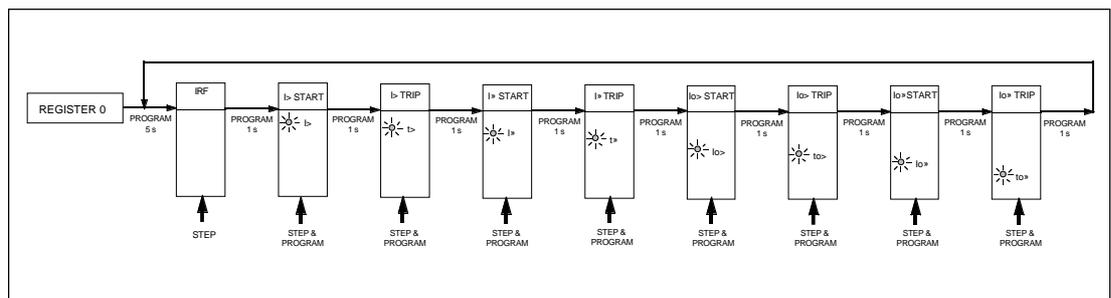


Fig. 5. Sequence order for the selection of output signals in the Trip test mode

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.

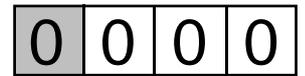
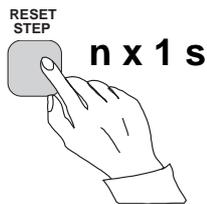
Note!

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

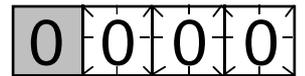
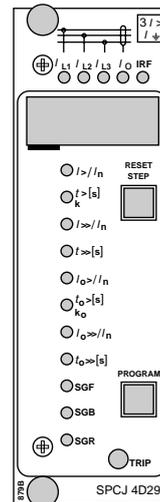
Example 3

Trip test function. Forced activation of the outputs.

- a)
Step forward on the display to register 0.



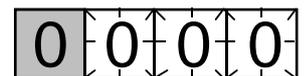
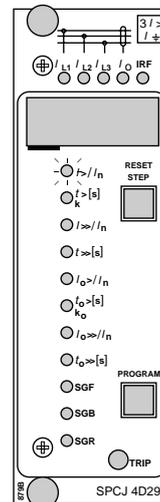
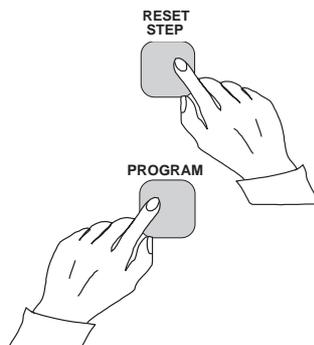
- b)
Press the PROGRAM push button for about five seconds until the three green digits to the right.



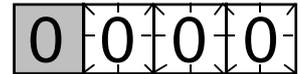
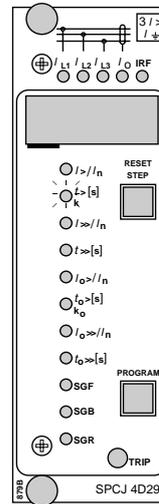
- c)
Hold down the STEP push button. After one second the red IRF indicator is lit and the IRF output is activated. When the step push button is released the IRF indicator is switched off and the IRF output resets.

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

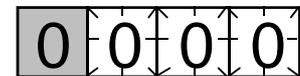
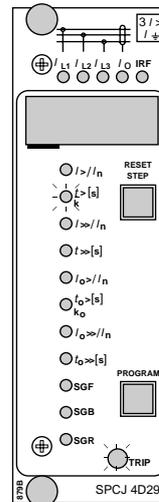
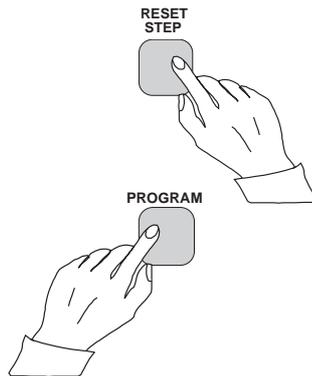
- e)
If a start of the first stage is required, now press the push-buttons PROGRAM and STEP simultaneously. The stage output will be activated and the output relays will operate according to the actual programming of the relay output switchgroups SGR.



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.

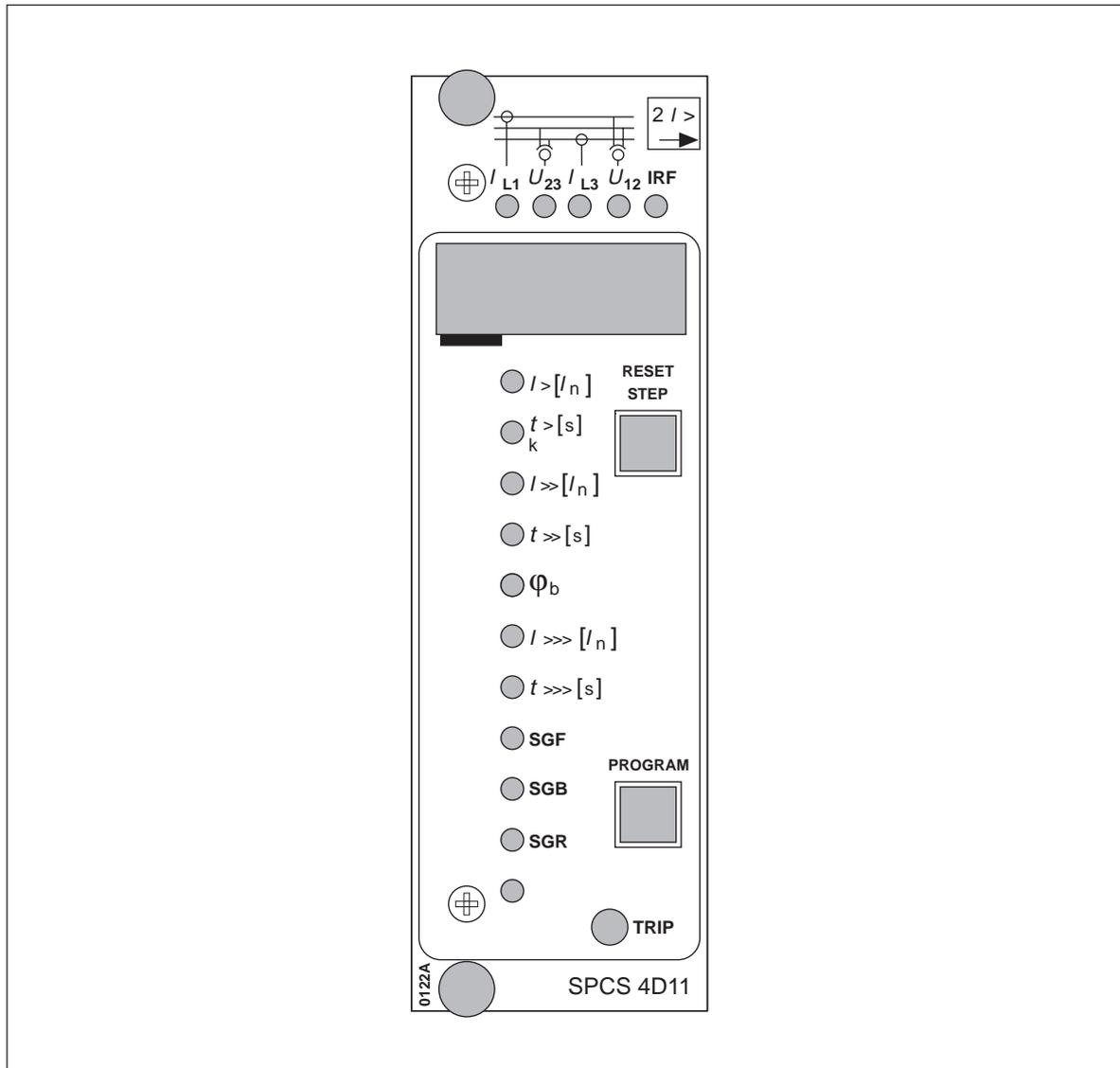
In most fault situations a fault code, indicating the nature of the fault, appears on the display of

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.

SPCS 4D11 and SPCS 4D12

Two-phase directional overcurrent relay modules

User's manual and Technical description



SPCS 4D11 and SPCS 4D12

Two-phase directional overcurrent relay module

Data subject to change without notice

Contents

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Characteristics

Three overcurrent stages

A directional low-set stage I> with definite time and inverse time mode of operation.

A directional high-set stage I>> with a setting range of 0.5...40 x I_N.

A non-directional high-set stage I>>> with a setting range of 2...40 x I_N.

The high-set stages can be set out of operation.

Memory circuit for maintaining the stability and reliability of the directional operation at close three-phase faults.

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

The settings may be keyed in via the push-buttons on the front panel or from higher level systems over the serial interface and the fiberoptic bus.

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

Description of function

General

The directional overcurrent relay modules SPCS 4D11 and SPCS 4D12 are designed for two-phase directional operation. Each module contains two directional overcurrent stages and one non-directional high-set stage.

The directional overcurrent modules SPCS 4D11 and SPCS 4D12 are identical except for the phase currents and phase-to-phase voltages measured by the modules.

Module	current and voltage	current and voltage
SPCS 4D11	I_{L1} and U_{23}	I_{L3} and U_{12}
SPCS 4D12	I_{L1} and U_{23}	I_{L2} and U_{31}

When a stage exceeds the current setting and if directional operation has been selected the directional criteria should be fulfilled, a start signal is provided and, simultaneously, the digital display on the front panel indicates start. If the overcurrent situation lasts long enough to exceed the set operate time, the stage that started provides a trip signal. At the same time the red

operation indicator is lit.

The operation of the overcurrent stages can be blocked by a blocking signal BS1, BS2 or RRES linked to the module. The blocking configuration is set by means of switchgroups SGB1, SGB2 and SGB3.

Directional low-set stage I>

The operation of the low-set stage I> is based on definite time or inverse time characteristic. The mode of operation is programmed with the SGF1 switch. At definite time mode of operation the operating time t> is set in seconds. At inverse time mode of operation (I.D.M.T.) four internationally standardized and two special type time/current characteristics are available. The programming switch SGF1 is also used for selecting the desired operation characteristic. An

operation stage starts, if the current on one of the phases exceeds the setting value and the phase angle between the current and base angle falls within the operation sector $\pm 80^\circ$.

The inverse time function of stage I> is inhibited, when the second high-set stage I>>> starts. In this case the operate time is determined by the operate time t>>> of stage I>>>.

Directional high-set stage I>>

The operation of the high-set stage I>> is based on definite time characteristic and can be either directional or non-directional. When directional operation is selected, the start and operate times are slightly dependent on how the voltage is measured. For more information; see section "Technical data". The stage can also be set out of operation by means of switch SGF2/5. When the high-set stage is out of operation, the set value in the display shows three dashes "- - -", indicating that the operating value is infinite.

to-phase voltages are below 7% and one of the phase currents exceeds the set value of the high-set stage I>>, the stage will trip non-directionally after the set operate time.

The setting value of the high-set stage I>> may be subject to automatic doubling when the protected object is connected to the network, i.e. in a start situation. Thus the setting value of the I>> stage may be below the connection inrush current. The automatic doubling function is selected with switch SGF1/5. The start situation is a situation where the phase currents rise from a value below $0.12 \times I>$ to a value above $1.5 \times I>$ in less than 60 ms. The start situation ends when the currents fall below $1.25 \times I>$.

If the circuit breaker is closed against a fault, for example, if the system earthing has not been removed after maintenance, the directional high-set stage I>> will operate non-directionally. For example, in a start situation, if both phase-

Directional element

The directional control is based on measuring the phase current and the opposite phase-to-phase voltage, because then each phase of the relay is polarized with a voltage which, during a fault situation, will not be reduced excessively

except, at close three-phase faults. The module is a two-phase module, which means that there are two independent directional elements, one for each phase current.

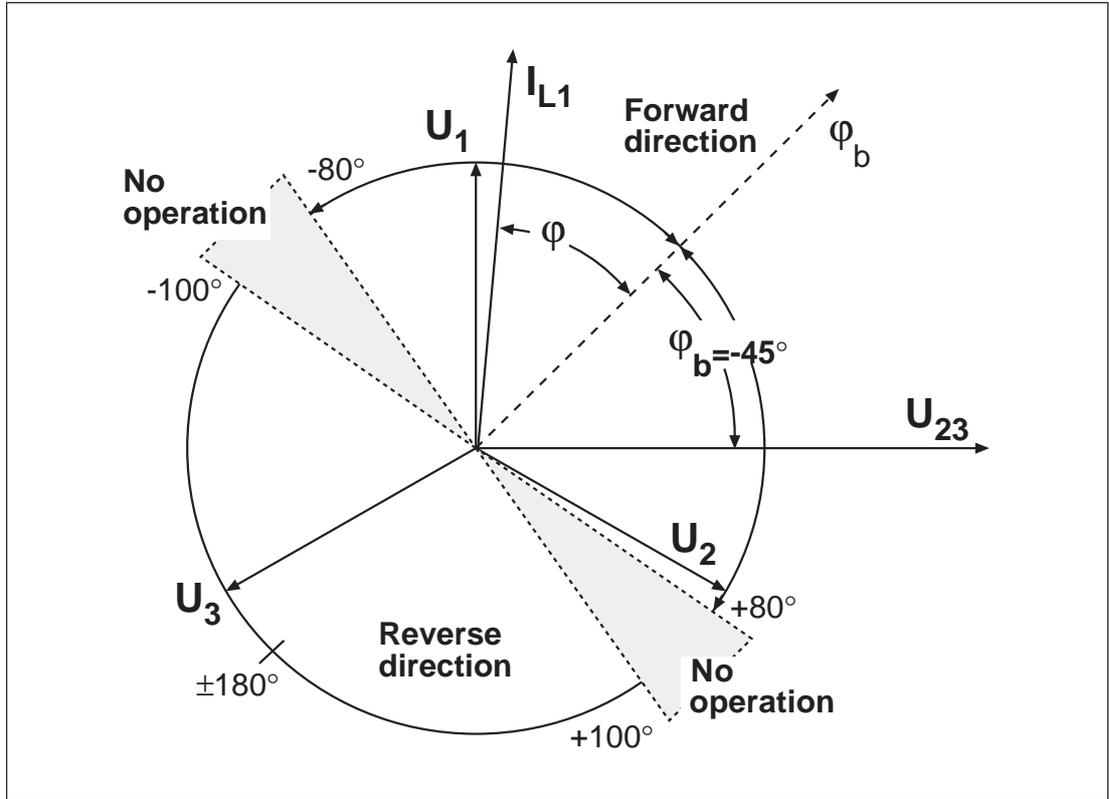


Fig. 1. Operation characteristic, when the base angle $\phi_b = -45^\circ$

Fig. 1. describes the operation of the directional element for phase L_1 . The relay module measures the phase difference between current and voltage, but the phase angle ϕ shown in the display is the angle between current and the base angle setting ϕ_b . In this way it is easy to determine whether the actual angle shown in the display is within the operating sector or not. If the display shows a number between -80 and $+80$, the phase angle is within the operation sector and the current is flowing in "forward" direction. A phase angle reading between 80 and 100 means the directional element cannot determine the direction of the current and, when the read-

ing is above 100 , the current is flowing in "reverse" direction. In most applications the base angle setting is either -30° or -45° , depending on the neutral point arrangements of the network.

The operation direction of the directional stages can be selected to be "forward" or "reverse" using the switches SGF1/7 and SGF1/8. The switch SGF1/7 is used to change the operation direction of the high-set stage $I_{>>}$ and the switch SGF1/8 is used to change the operation direction of the complete module, see section programming switches.

Memory function

To secure reliable relay operation at a close three-phase fault characterized by an extremely low phase-to-phase voltage, a memory function for each directional element is implemented. At sudden loss of voltage at a close three-phase fault,

the angle between voltage and current is calculated on the basis of a fictive voltage. This memory function gives the directional stages a possibility to operate up to 2.5 s after a total loss of voltage.

The criteria for starting a memory function is that the voltage has been above 8% and when the voltage of the concerned memory function drops below 7% for a time of 40ms the memory function is activated. As soon as the voltages again rise above 8% the directional element returns to its normal state and the measured voltage is used. Normally, the module can perform a trip if one directional element is within the operation sector. However, when the memory function of both directional elements is activated (both voltages suddenly drops below 7%), the current vector on both directional elements has to be within the operation sector before tripping is allowed.

The memory functions are activated for max. 2.5 s, which means that if the set operate times of the directional stages are longer than 2.5 s the second high-set stage I>>> must be used to ensure operation of the module in situations of a close three-phase fault.

In an isolated environment, at three-phase short circuit, the frequency of the voltage behaves abnormally. To secure the directional operation in these situations, the frequency is measured continuously.

Non-directional high-set stage I>>>

The non-directional high-set stage I>>> can be used as back-up protection for the directional stages. An important consideration is that if the set operate time of the directional stages exceeds 2.5 s and the voltage has collapsed, the directional stages will not perform a trip. Then the second high-set stage I>>> should be set to take care of the tripping.

been selected. This feature prevents unselective trips at high fault currents when the inverse time characteristics would operate faster than the selectivity scheme allow. The trip time is thus equal to set t>>> for any current higher than I>>>.

The high-set stages I>>> can be set out of operation by means of switch SGF2/6. Then the display shows " - - - " indicating that the operating value is infinite.

When the non-directional high-set stage I>>> starts, it will block the operation of the low-set stage if inverse time characteristics operation has

Trip direction information

The trip direction information signal is activated when the current is flowing in the operation direction of the low-set stage I>. Apart from the operation of the low-set stage I>, a condition for the activation of the trip direction informa-

tion is that both phase currents are within the operation sector. To get an output signal as contact information the trip direction information should be linked to an output relay by means of the SGF2 switch.

Circuit-breaker failure protection

The directional overcurrent module is provided with a circuit-breaker failure protection unit (CBFP) which provides a trip signal TS1 within 0.1...1 s after the normal trip signal TS2 has been delivered, provided the fault still persists when the time elapses. The CBFP normally controls an upstream circuit breaker. The CBFP

can also be used to establish a redundant trip system by using two trip coils in the circuit breaker and controlling one of the coils with TS2 and the other with TS1. The circuit-breaker failure protection is selected by means of switch SGF1/4. The operate time is set in submenu 5 of register A.

Latched output relays and resetting

The operation of the overcurrent stages is provided with a latching facility keeping the tripping output energized, although the signal which caused the operation disappears. The output relays can be reset in five different ways; a) by pressing the PROGRAM push-button, b) by pressing the RESET and PROGRAM push-

buttons simultaneously, by remote control over the SPA bus using c) the command V101 or d) the command V102 and further e) by remote control over the external control input. Resetting according to a) or c) does not affect the stored data, whereas resetting according to b), d) or e) erases the recorded data.

Second settings

Either the main settings or the second settings can be selected as currently used settings. Switching between main settings and second settings can be done in three different ways:

- 1) By using the command V150 over the serial communication bus
- 2) By using an external control signal BS1, BS2 or RRES (BS3)
- 3) Via the push-buttons of the relay module, see submenu 4 of register A. When the value of submenu 4 is 0 the main settings are used and when the value of submenu 4 is 1 the second settings are used.

The main and second settings can be read and set via the serial bus using the S parameters or with the push-buttons and the display on the front panel. When the second settings are used the indicators of the settings are flashing.

Note!

If external control signals have been used for selecting the main or second settings, it is not possible to switch between the settings over the serial bus or using the push-buttons on the front panel.

Resettings

The LED operation indicators, the operation code numbers of the display, the latched output relays and the registers of the module can be

reset with the push-buttons on the front panel, with an external control signal or by a command via the serial bus, see table below.

Way of resetting	Resetting of indicators	Unlatching of output relays	Erasing of registers
RESET	x		
PROGRAM (dark display)	x	x	
RESET & PROGRAM	x	x	x
External control signal BS1, BS2 or RRES (BS3), when			
SGB2...3/6 = 1	x		
SGB2...3/7 = 1	x	x	
SGB1...3/8 = 1	x	x	x
Parameter V101	x	x	
Parameter V102	x	x	x

Block diagram

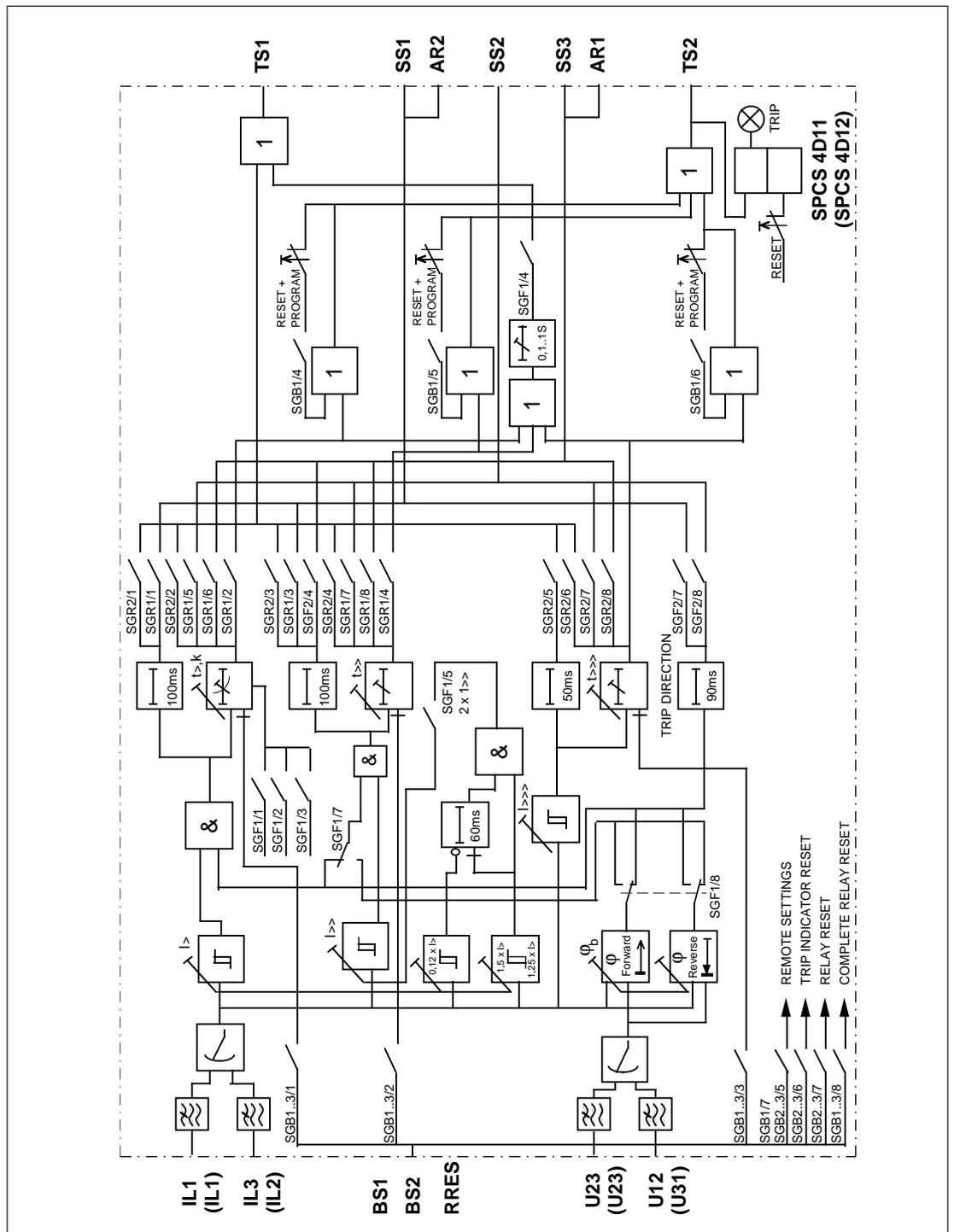


Fig. 2. Block diagram for two-phase directional o/v module type SPCS 4D11

I_{L1}, I_{L3}	Measured phase currents
U_{23}, U_{12}	Measured voltage
BS1, BS2 and RRES	External blocking or resetting signals
SGF1...2	Programming switchgroups SGF1...SGF2
SGB1...3	Programming switchgroups SGB1...SGB3
SGR1...2	Programming switchgroups SGR1...SGR2
SS1...SS3, TS1, TS2	Output signals
TRIP	Red trip indicator

Note !

All input and output signals of the module are not necessarily wired to the terminals of every relay assembly using this module. The signals

wired to the terminals are shown in the diagram illustrating the flow of signals between the plug-in modules of the relay assembly.

Front panel

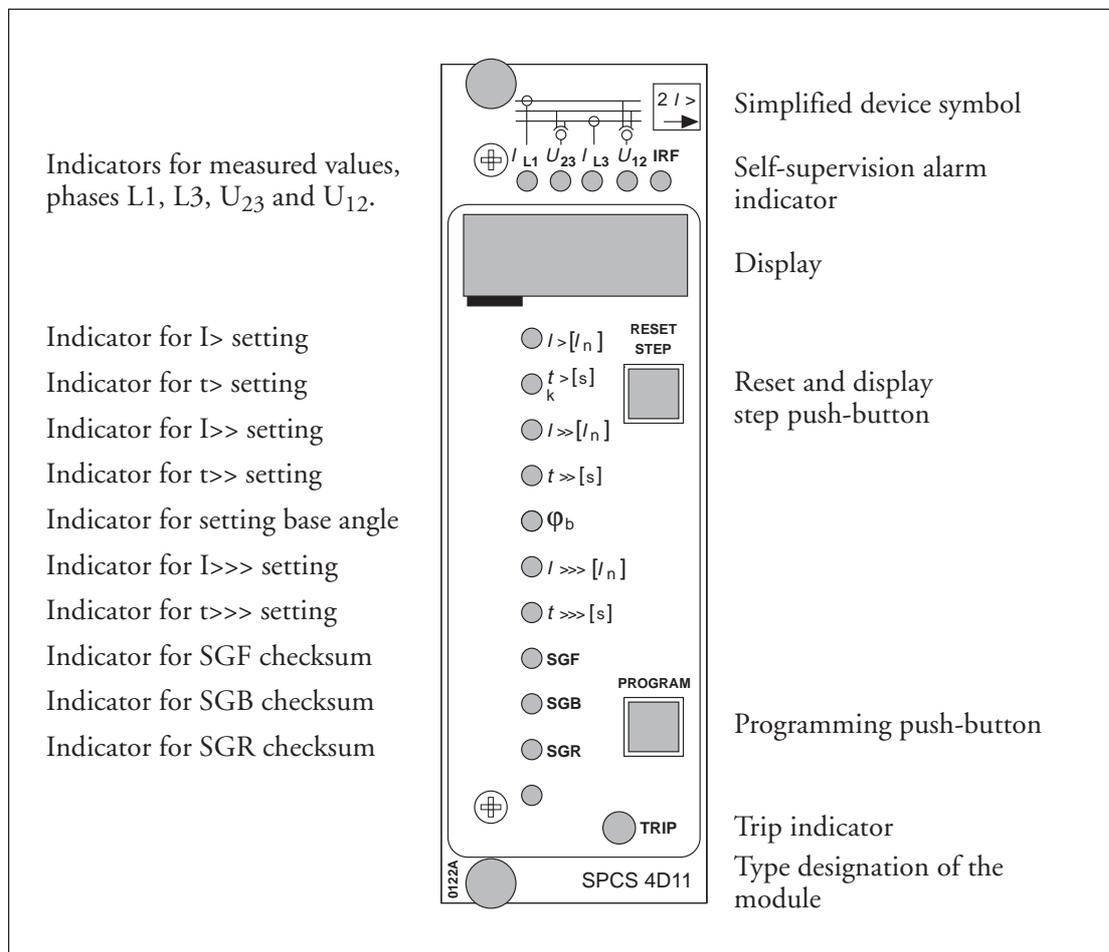


Fig. 3. Front panel of the two-phase directional o/v module type SPCS 4D11

Operation indicators

Each stage has its own start indicator and operation indicator shown as a figure on the digital display. Further all stages share an operation indicator named "TRIP", red light indicates that the module has delivered a trip signal.

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

If the start of a stage does not last long enough to cause tripping, the start indication normally resets, when the stage is reset. If required, the start indicators can be given a latching function by means of switches SGF2/1...3.

The following table shows the start and trip indicators and their messages.

Indication	Explanation
1	I> start The low-set stage of the overcurrent unit has started in reverse direction
2	I> start The low-set stage of the overcurrent unit has started in forward direction
3	I> trip The low-set stage of the overcurrent unit has tripped
4	I>> start The high-set stage of the overcurrent unit has started
5	I>> trip The high-set stage of the overcurrent unit has tripped
6	I>>> start The high-set stage of the overcurrent unit has started
7	I>>> trip The high-set stage of the overcurrent unit has tripped
9	CBFP The circuit breaker failure protection has operated

The self-supervision alarm indicator IRF indicates that the self-supervision system has detected a permanent fault. The red indicator is lit about 1 minute after the fault has been detected. At the same time the relay module delivers a signal to the self-supervision system output relay of the protection assembly. Addi-

tionally, in most cases, a fault code showing the nature of the fault appears on the display of the module. The fault code consist of a red figure one and a green code number. When a fault occurs, the fault code should be recorded and stated when service, is ordered.

Relay settings

The setting values are shown by the right-most three digits of the display. A LED in front of the setting value symbol indicates the setting value presented on the display.

Setting	Parameter	Setting range	Default values
$I>(I_n)$	The start current of the low-set stage as a multiple of the rated current of the protection. - at definite time operation - at inverse time operation	$0.3...5.0 \times I_n$ $0.3...2.5 \times I_n$	$0.3 \times I_n$
$t>(s)$, k	The operate time of the $I>$ stage, expressed in seconds, at definite time mode of operation (SGF1/1, 2, 3 = 0). At inverse definite minimum time mode of operation the time multiplier k is used.	0.1...300 s 0.05...1.00	0.1 s 0.10
$I>>(I_n)$	The start current of the high-set stage as a multiple of the rated current of the protection. The setting "infinite" (displayed as - - -), to be selected with switch SGF2/5, makes the stage $I>>$ non-operational.	$0.5...40.0 \times I_n$	$0.5 \times I_n$
$t>>(s)$	The operate time of the $I>>$ stage, expressed in seconds.	0.04...300s	0.05 s
φ_b	Base angle setting	$0^\circ \dots -90^\circ$	-30°
$I>>>(I_n)$	The start current of the high-set stage as a multiple of the rated current of the protection. The setting "infinite" (- - -) to be selected with switch SGF2/6, makes the stage $I>>>$ non-operational.	$2...40.0 \times I_n$	$2 \times I_n$
$t>>>(s)$	The operating time of the $I>>>$ stage, expressed in seconds.	0.04...30s	0.04 s

In addition, the checksums of the programming switchgroups SGF1, SGB1 and SGR1 are indicated on the display when the indicators in front of the switchgroup symbols on the front panel are lit. The checksums for SGF2, SGB2, SGB3 and SGR2 are found in the submenus of the

switchgroups SGF1, SGB1 and SGR1. See section "Main menus and submenus of settings and registers". An example of calculating the checksum is given in the general description of the D-type SPC relay modules.

Programming switches

The switchgroups SGF, SGB and SGR are used for selecting additional functions required by individual applications. The numbering of the switches, 1...8, and the switch positions, 0 and 1, are indicated when the switchgroups are be-

ing set. In normal service only the checksums are shown. The switchgroups SGF2, SGB2, SGB3 and SGR2 are found in the submenus of the switchgroups SGB, SGF and SGR.

Switch	Function	Factory setting																																													
SGF1/1 SGF1/2 SGF1/3	Selection of the operation characteristic for the low-set stage I>, i.e. definite time mode of operation or inverse definite minimum time (I.D.M.T.) mode of operation. At inverse definite minimum time mode of operation the switches are also used for selecting the current/time characteristic of the stage.	0 0 0																																													
	<table border="1"> <thead> <tr> <th>SGF1/1</th> <th>SGF1/2</th> <th>SGF1/3</th> <th>Mode of operation</th> <th>Characteristics</th> </tr> </thead> <tbody> <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>I.D.M.T.</td> <td>Extremely inv.</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> <td>"</td> <td>Very inverse</td> </tr> <tr> <td>1</td> <td>1</td> <td>0</td> <td>"</td> <td>Normal inverse</td> </tr> <tr> <td>0</td> <td>0</td> <td>1</td> <td>"</td> <td>Long-time inv.</td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> <td>"</td> <td>RI-character.</td> </tr> <tr> <td>0</td> <td>1</td> <td>1</td> <td>"</td> <td>RXIDG-character.</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> <td>"</td> <td>Not used (long-t. i.)</td> </tr> </tbody> </table>	SGF1/1	SGF1/2	SGF1/3	Mode of operation	Characteristics	0	0	0	Definite time	0.05...300 s	1	0	0	I.D.M.T.	Extremely inv.	0	1	0	"	Very inverse	1	1	0	"	Normal inverse	0	0	1	"	Long-time inv.	1	0	1	"	RI-character.	0	1	1	"	RXIDG-character.	1	1	1	"	Not used (long-t. i.)	
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0	1	1	"	RXIDG-character.																																											
1	1	1	"	Not used (long-t. i.)																																											
SGF1/4	Selection of the circuit-breaker failure protection. When SGF1/4=1 the trip signal TS2 will start a timer that produces a delayed trip signal via TS1, unless the fault has been cleared within the CBFP time. When switch SGF1/4=0, the CBFP is not used	0																																													
SGF1/5	Selection of automatic doubling of the setting value of the high-set stage I>>, when the protected object is energized. When SGF1/5=0, the setting value I>> will not be doubled. When SGF1/5=1, the setting value of the I>> stage doubles automatically. This makes it possible to give the high-set stage a setting value below the connection inrush current level.	0																																													
SGF1/6	Selection of directional or non-directional operation for the stage I>>. When SGF1/6=0, the stage I>> is non-directional When SGF1/6=1, the stage I>> is directional	0																																													
SGF1/7 SGF1/8	Selection of reverse biased direction for stage I>> Change direction for both directional stages	0 0																																													
	<table border="1"> <thead> <tr> <th>SGF1/7</th> <th>SGF1/8</th> <th>Stage I ></th> <th>Stage I>></th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>forward</td> <td>forward</td> </tr> <tr> <td>1</td> <td>0</td> <td>forward</td> <td>backward</td> </tr> <tr> <td>0</td> <td>1</td> <td>backward</td> <td>backward</td> </tr> <tr> <td>1</td> <td>1</td> <td>backward</td> <td>forward</td> </tr> </tbody> </table>	SGF1/7	SGF1/8	Stage I >	Stage I>>	0	0	forward	forward	1	0	forward	backward	0	1	backward	backward	1	1	backward	forward																										
SGF1/7	SGF1/8	Stage I >	Stage I>>																																												
0	0	forward	forward																																												
1	0	forward	backward																																												
0	1	backward	backward																																												
1	1	backward	forward																																												

Switch	Function	Factory setting
SGF2/1 SGF2/2 SGF2/3	<p>Switches SGF2/1...3 are used for selecting the operation mode for the start indicators of the different stages. When the switches are in position 0, the start indicators are automatically reset, when the fault is cleared. When the switches are in position 1 the start indicators require manual resetting:</p> <p>When SGF2/1=1 the start indicator of the I> stage is to be manually reset When SGF2/2=1 the start indicator of the I>> stage is to be manually reset When SGF2/3=1 the start indicator of the I>>> stage is to be manually reset</p>	0 0 0
SGF2/4	<p>The start signal of the high-set stage linked to the output AR1</p> <p>When SGF2/4=0 the start signal of I>> stage does not affect the output signal AR1 When SGF2/4=1 the start signal of I>> stage controls the output signal AR1</p>	0
SGF2/5	<p>High-set stage I>> can be set out of operation by means of this switch</p> <p>When switch SGF2/5=0, the high-set stage I>> is operative When switch SGF2/5=1, the high-set stage I>> is non-operational</p>	0
SGF2/6	<p>High-set stage I>>> can be set out of operation by means of this switch</p> <p>When switch SGF2/6=0, the high-set stage I>>> is operative When switch SGF2/6=1, the high-set stage I>>> is non-operational</p>	0
SGF2/7	<p>Linking of trip direction info to SS1</p> <p>When SGF2/7=0, the trip direction info is not linked to SS1 When SGF2/7=1, the output from SS1 is energized if the relay measures energy flowing in the operation direction of the low-set stage I>.</p>	0
SGF2/8	<p>Linking of trip direction info to SS2</p> <p>When SGF2/8=0, the trip direction info is not linked to SS2 When SGF2/8=1, the output from SS2 is energized if the relay measures energy flowing in the operation direction of the low-set stage I>.</p>	0

The switchgroup SGB1 is used for configuring the external control input BS1.

Switch	Function	Factory setting
SGB1/1 SGB1/2 SGB1/3	<p>Switches SGB1/1...3 are used when the external control signal BS1 is to be used for blocking one or more of the current stages of the module.</p> <p>When all the switches are in position 0, no stage is blocked</p> <p>When SGB1/1=1, the tripping of stage I> is blocked, when the input signal BS1 is energized</p> <p>When SGB1/2=1, the tripping of stage I>> is blocked, when the input signal BS1 is energized</p> <p>When SGB1/3=1, the tripping of stage I>>> is blocked, when the input signal BS1 is energized</p>	0 0 0
SGB1/4 SGB1/5 SGB1/6	<p>Selection of latching function for the trip output signal TS2, from I></p> <p>Selection of latching function for the trip output signal TS2, from I>></p> <p>Selection of latching function for the trip output signal TS2, from I>>></p> <p>When the switch is =0 the trip signal of the stage resets, when the stage resets</p> <p>When the switch =1, the trip signal of the stage must be manually reset by pressing the RESET and PROGRAM push-buttons simultaneously. (or by signal BS1 using switch SGB1/8). When the display is off the signals can also be reset by pressing PROGRAM push-button.</p>	0 0 0
SGB1/7	<p>This switch enables switching between main settings and second settings, using the external control input signal BS1.</p> <p>When SGB1/7=0, the setting banks are not controlled via the external control input BS1.</p> <p>When SGB1/7=1, the settings are remotely controlled via the external input BS1. The main setting values are in force when there is no control voltage on the input, and the second settings are valid when a control voltage is connected to the control input.</p> <p>Note! Whichever setting is used, it is important that the switch SGB1/7 is in the same position in the main and second setting bank. Otherwise there may be conflict situation when switching from one setting bank to another. SGB1/7 must be in position 0 if serial parameter V150 or the push-buttons are used to switch between the setting banks.</p>	0
SGB1/8	<p>Complete remote relay reset, including trip indicators, latched relays and memorized values</p> <p>The relay can be remotely reset via the control input signal BS1.</p> <p>When SGB1/8=1, The relay is remotely reset by the control input signal BS1.</p>	0

The switchgroup SGB2 is used for controlling the external control input BS2. The switchgroup SGB3 has the same function as described in the table below, except for the external control signal that is RRES instead of BS2. Also see section "Block diagram".

Switch	Function	Factory setting
SGB2/1 SGB2/2 SGB2/3	<p>Switches SGB2/1...3 are used when the external control signal BS2 is to be used for blocking one or more of the current stages of the module.</p> <p>When all the switches are in position 0, no stage is blocked</p> <p>When SGB2/1=1, the tripping of stage I> is blocked, when the input signal BS2 is energized</p> <p>When SGB2/2=1, the tripping of stage I>> is blocked, when the input signal BS2 is energized</p> <p>When SGB2/3=1, the tripping of stage I>>> is blocked, when the input signal BS2 is energized</p>	0 0 0
SGB2/4	Not used	0
SGB2/5	<p>This switch enables switching between main and second settings even without serial communication, using the external control input signal BS2.</p> <p>When SGB2/5=0, the setting banks are not controlled via the external control input.</p> <p>When SGB2/5=1, the settings are remotely controlled via the external input BS2. The main setting values are in force when there is no control voltage on the input, and the second settings are valid when a control voltage is connected to the control input.</p> <p>Note! Whichever setting is used, it is important that the switch SGB2/5 is in the same position in the main and second setting bank. Otherwise there may be conflict situation when switching from one setting bank to another. SGB2/5 must be in position 0 if serial parameter V150 or the push-buttons are used to switch between the setting banks.</p>	0
SGB2/6	<p>Remote reset of the trip indicators</p> <p>When SGB2/6=0, the trip indicators are not reset by signal BS2</p> <p>When SGB2/6=1, the trip indicators are reset by signal BS2</p>	0
SGB2/7	<p>Remote reset of trip indicators and output relays</p> <p>When SGB2/7=0, the trip indicators and output relays are not reset by signal BS2</p> <p>When SGB2/7=1, the trip indicators and output relays are reset by signal BS2</p>	0
SGB2/8	<p>Complete remote relay reset, including trip indicators, latched relay and memorized values</p> <p>The control input signal BS2 can be used to reset the relay remotely.</p> <p>When SGB2/8=1, the relay is remotely reset by the control input signal BS2</p>	0

Output relay matrix
switchgroups SGR1,
SGR2

Switch	Function	Factory setting
SGR1/1	When SGR1/1=1, the start signal of stage I> is linked to SS1 + AR2	1
SGR1/2	When SGR1/2=1, the trip signal of stage I> is linked to TS2	1
SGR1/3	When SGR1/3=1, the start signal of stage I>> is linked to SS1 + AR2	0
SGR1/4	When SGR1/4=1, the trip signal of stage I>> is linked to TS2	1
SGR1/5	When SGR1/5=1, the tri signal of stage I> is linked to SS2	1
SGR1/6	When SGR1/6=1, the trip signal of stage I> is linked to SS3	0
SGR1/7	When SGR1/7=1, the trip signal of stage I>> is linked to SS2	0
SGR1/8	When SGR1/8=1, the trip signal of stage I>> is linked to SS3	1
Default checksum		155

SGR2/1	When SGR2/1=1, the start signal of stage I> is linked to TS1	0
SGR2/2	When SGR2/2=1, the trip signal of stage I> is linked to TS1	0
SGR2/3	When SGR2/3=1, the start signal of stage I>> is linked to TS1	0
SGR2/4	When SGR2/4=1, the trip signal of stage I>> is linked to TS1	0
SGR2/5	When SGR2/5=1, the start signal of stage I>>> is linked to TS1	0
SGR2/6	When SGR2/6=1, the trip signal of stage I>>> is linked to TS1	0
SGR2/7	When SGR2/7=1, the trip signal of stage I>>> is linked to SS2	0
SGR2/8	When SGR2/8=1, the trip signal of stage I>>> is linked to SS3 + AR1	1
Default checksum		128

Note !The trip signal of stage I>>> is always linked to TS2

Measured data

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

Indicators SPCS 4D11 SPCS 4D12		Measured data	Measuring range
I_{L1}, I_{L3}	I_{L1}, I_{L2}	Measured line current as a multiple of the rated current I_n of the energizing input used. Submenu 1: The phase angle φ between the current and base angle φ_b .	$0 \dots 52 \times I_n$ $\pm 180^\circ$
U_{23}, U_{12}	U_{23}, U_{31}	Measured phase-to-phase voltage as a percentage the rated voltage U_n .	$0 \dots 152\% U_n$

Recorded data

The left-most red digit displays the register address and the other three digits the recorded information. A symbol "/" in the text indicates that the following item is found in a submenu.

Register	Recorded information
1	Phase current I_{L1} measured as a multiple of the rated current of the protection. If the overcurrent protection trips the CB, the current value at the moment of tripping is stored in the memory stack. A new trip moves the old value up one place in the stack and adds the new value to the stack. A maximum of five values are memorized - if a sixth tripping occurs, the oldest value will be lost.
2	Register 2 records the events of phase L2. The operation principle is the same as that of register 1.
3	Highest measured line voltage U_{23} during the latest start situation as a percentage of the rated voltage. If the overcurrent protection trips the CB, the line voltage at the moment of tripping is stored in the memory stack. A new trip moves the old value up one place in the stack and adds the new value to the stack. A maximum of five values are memorized - if a sixth tripping occurs, the oldest value will be lost.
4	Register 4 records the events of the voltage U_{12} . The operation principle is the same as that of register 3.
5	Duration of the latest start situation of stage I> as a percentage of the set operate time $t_{>}$ or at I.D.M.T. mode of operation, the calculated operate time. A new start resets the counter, which then starts counting from zero, and moves the previous value up in the memory stack. A maximum of five values are memorized - if a sixth start occurs the oldest value will be lost. When the stage has tripped the counter reading is 100. The fifth sub-menu contains 'Number of startings' of the stage I> in the range 0...255.
6	Duration of the latest starting situation of stage I>> as a percentage of the set operate time $t_{>>}$ or, at I.D.M.T. mode of operation the calculated operation time. A new start resets the counter, which then starts counting from zero, and moves the old value up in the memory stack. A maximum of five values are memorized - if a sixth start occurs the oldest value will be lost. When the concerned stage has tripped the counter reading is 100. The fifth sub-menu contains 'Number of startings' of stage I>> in the range 0...255.

Register	Recorded information
7	Duration of the latest starting situation of stage I>>> as a percentage of the set operating time t>>> or, at I.D.M.T. mode of operation, the calculated operate time. A new start resets the counter, which then starts counting from zero, and moves the old value up in the memory stack. A maximum of five values are memorized - if a sixth start occurs the oldest value will be lost. When the concerned stage has tripped the counter reading is 100. The fifth sub-menu contains 'Number of startings' of stage I>>> in the range 0...255.
8	Maximum demand current value for a period of 15 minutes, expressed in multiples of the relay rated current I_n and based on the highest phase current. // Highest maximum demand value obtained since the latest complete relay reset.
9	Phase angle between phase current L1 and the base angle. The operation principle is the same as that of register 1.
11	Phase angle between phase current L3 and the base angle. The operation principle is the same as that of register 1.
0	<p>Status of blocking signals and other external control signals.</p> <p>The right-most digit indicates the state of the blocking inputs of the module. Each of the three input signals is represented by a number and the displayed number is the sum of the numbers of the inputs activated. The following numbers are used to indicate the states of the inputs:</p> <p>0 = no blocking 1 = blocking or control signal BS1 is active 2 = blocking or control signal BS2 is active 4 = blocking or control signal RRES is active</p> <p>From this register "0" it is possible to enter the TEST mode, where the start and trip signals of the module are activated one by one. For further details, see the section "General characteristics of D-type SPC relay modules".</p>
A	<p>Address code of the relay module, required by the serial communication system. In addition, the following submenus are available in register A:</p> <ol style="list-style-type: none"> 1. Selection of the data transfer rate, 4.8 kBd or 9.6 kBd, of the relay module. Default setting 9.6 kBd. 2. Bus traffic counter indicating the operating state of the serial communication system. If the relay module is connected to a system including a control data communicator and the communication system is operating, the counter reading is 0. Otherwise the numbers 0...255 are continuously rolling in the counter. 3. Password required for remote setting. Settings cannot be changed over the serial communication system unless a password (remote setting parameter V160) has been given. 4. Selection of main and second settings (0 = main settings, 1 = second settings). Default setting 0. 5. Selection of operate time for the circuit-breaker failure protection, setting range 0.1...1.0 s. Default setting 0.2 s

The registers 1...11 are set to zero by pressing the push-buttons RESET and PROGRAM simultaneously. The registers are also cleared if the auxiliary power supply module is interrupted. The address code of the relay module, the data transfer rate of the serial communica-

tion and the password are not erased by a voltage failure. Instructions for setting the address and the data transfer rate are given in the section "General characteristics of D-type SPC relay modules".

Main menus and submenus of settings and registers

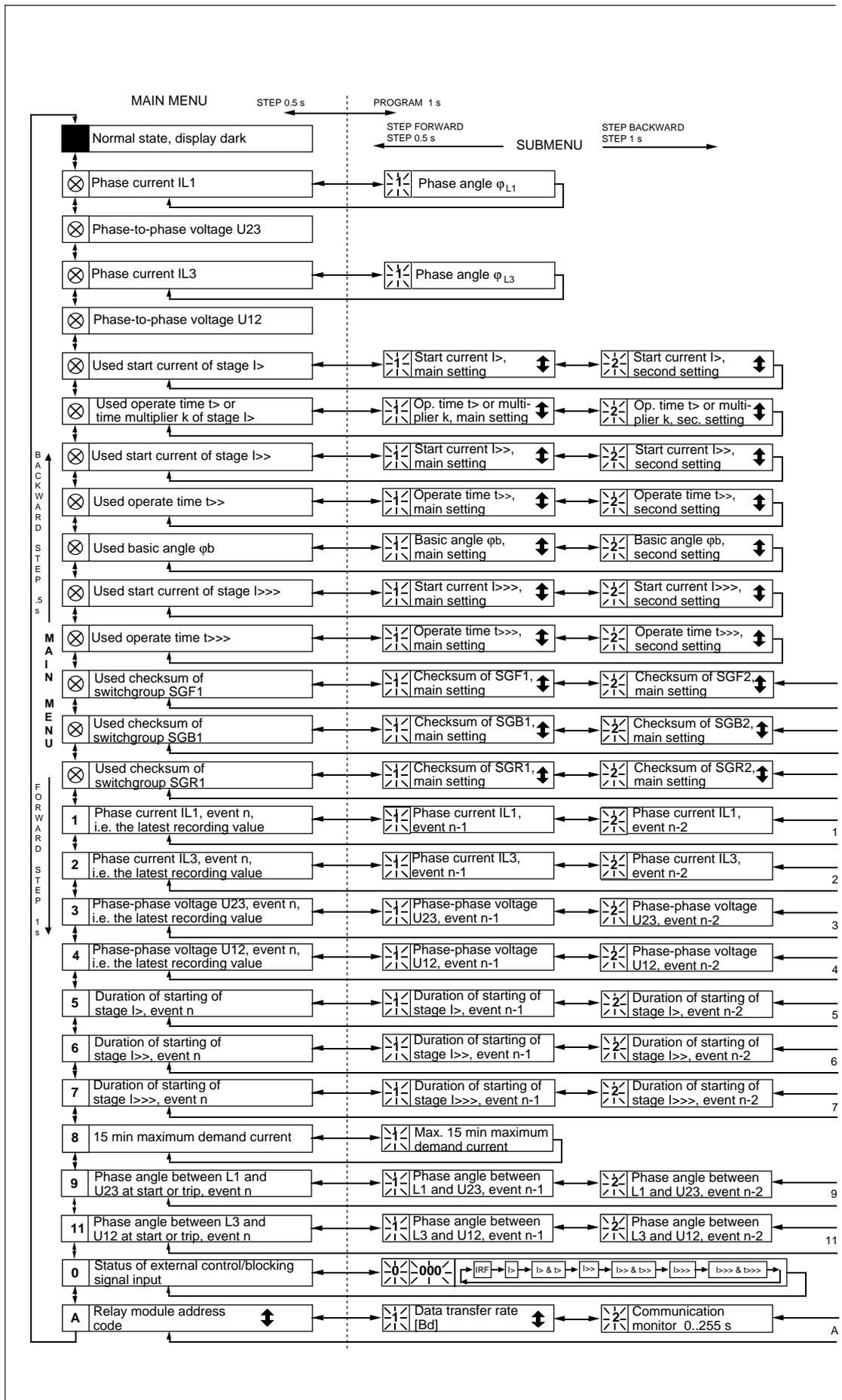
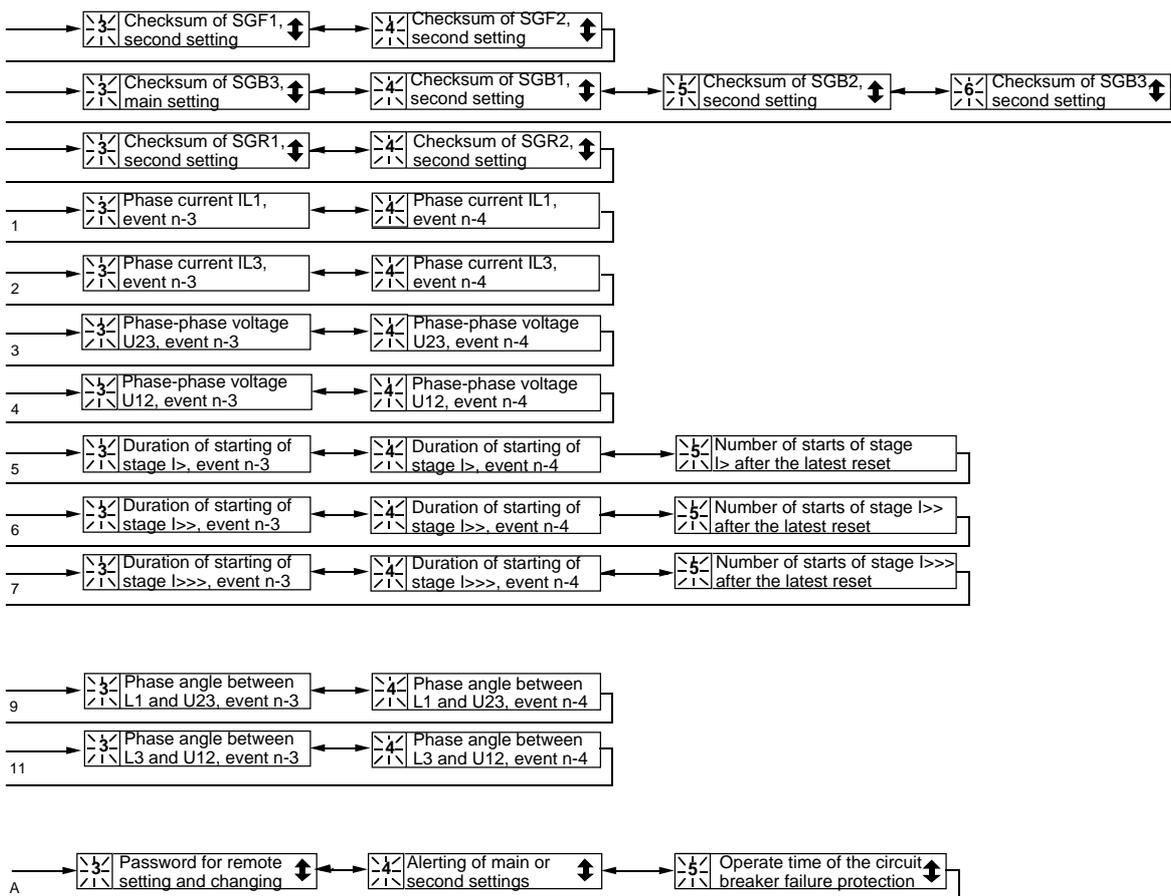


Fig. 4. Main menus and submenus of the module SPCS 4D11

How to perform the setting and use the TEST mode are described in detail in the section "General characteristics of the D-type relay modules". Below a short guide.

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



Time/current characteristics

The operation of the low-set stage I> is based on either definite time or inverse time characteristics. The switches SGF1/1...3 are used for selecting the desired mode of operation.

At I.D.M.T. mode of operation, the operate

time of the stage is a function of the current; the higher the current, the shorter the operate time. The unit has six different time/current characteristics - four according to the BS 142 standard and two special type characteristics, called RI and RXIDG .

BS-type characteristics

There are four standard curves, extremely, very, normal and long time inverse. The relationship between current and time complies with the standards BS 142.1966 and IEC 255-4 and may generally be expressed as:

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

where

t = operating time in seconds

k = time multiplier

I = current value

I> = set current value

The module includes four BS 142 specified characteristics with different characteristic. The characteristics is determined by the values of the constants α and β

Degree of inversity of the characteristics	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 setting current. Additionally the relay must start at the latest when the current exceeds a value of 1.3 times the setting, when the time/current characteristic is normal inverse, very inverse or extremely inverse. When the characteristic is long time inverse, the normal range in accordance with the standards is 2...7 times the setting and the relay is to start when the current exceeds 1.1 times the setting.

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

I / I>	Normal inverse	Very inverse	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 normal current ranges defined, the inverse time stages of the two-phase o/c module

SPCS 4D11 comply with the tolerances of class 5 at all degrees of inversity.

RI-type characteristic

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

$$t = \frac{k}{0.339 - 0.236 \times \frac{I_{>}}{I}}$$

where

t = operate time in seconds

k = time multiplier

I = phase current

I> = set starting current.

RXIDG-type characteristic

The RXIDG characteristic is a special characteristic where a high degree of selectivity is needed also for high resistance faults.

Time/current characteristic can be expressed as:

$$t = 5.8 - 1.35 \times \log_e \left(\frac{I}{k \times I_{>}} \right)$$

where

t = operate time in seconds

k = time multiplier

I = phase current

I> = set starting current.

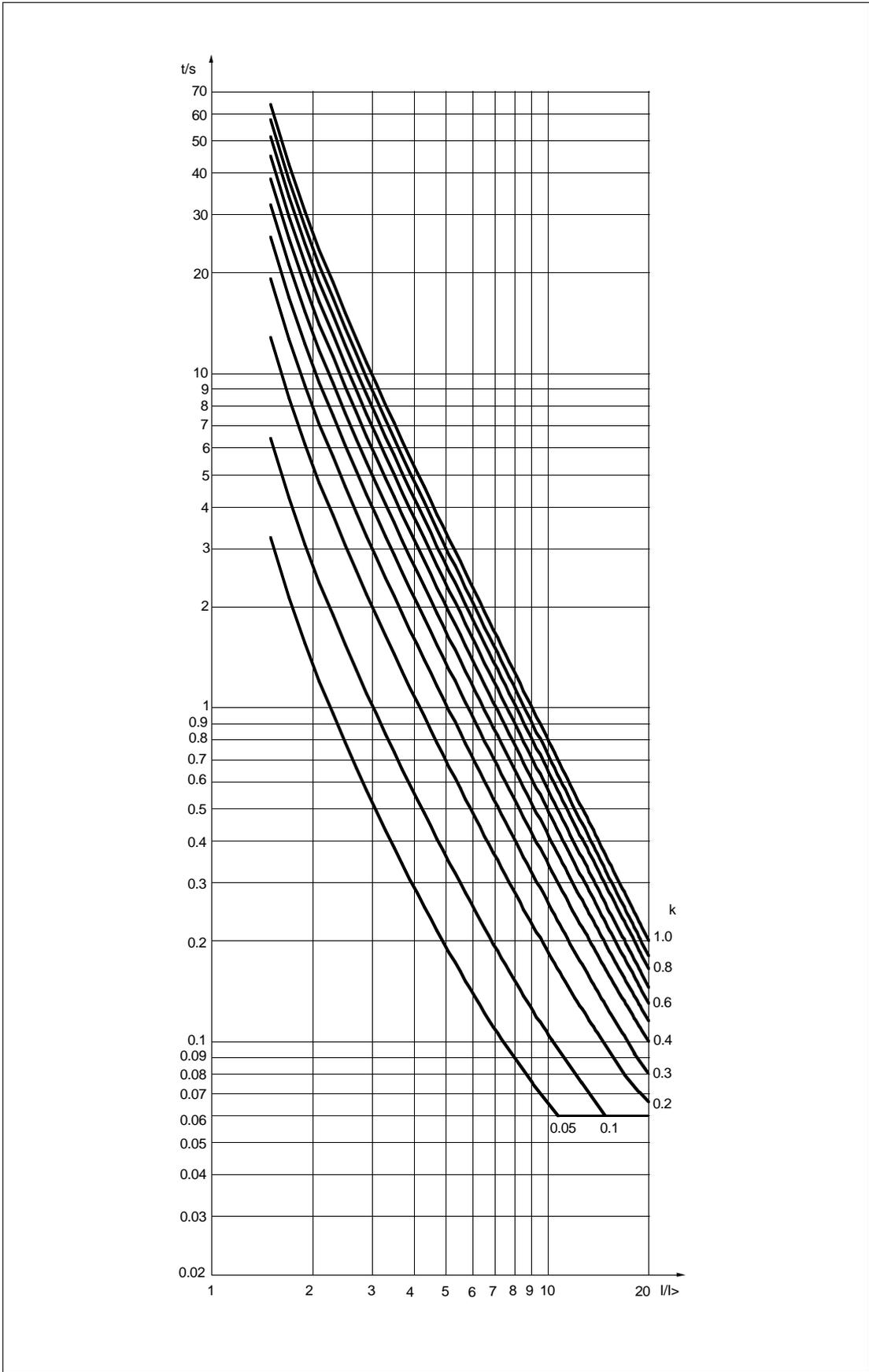


Fig. 5. Extremely inverse-time characteristics of the two-phase directional o/c module SPCS 4D11

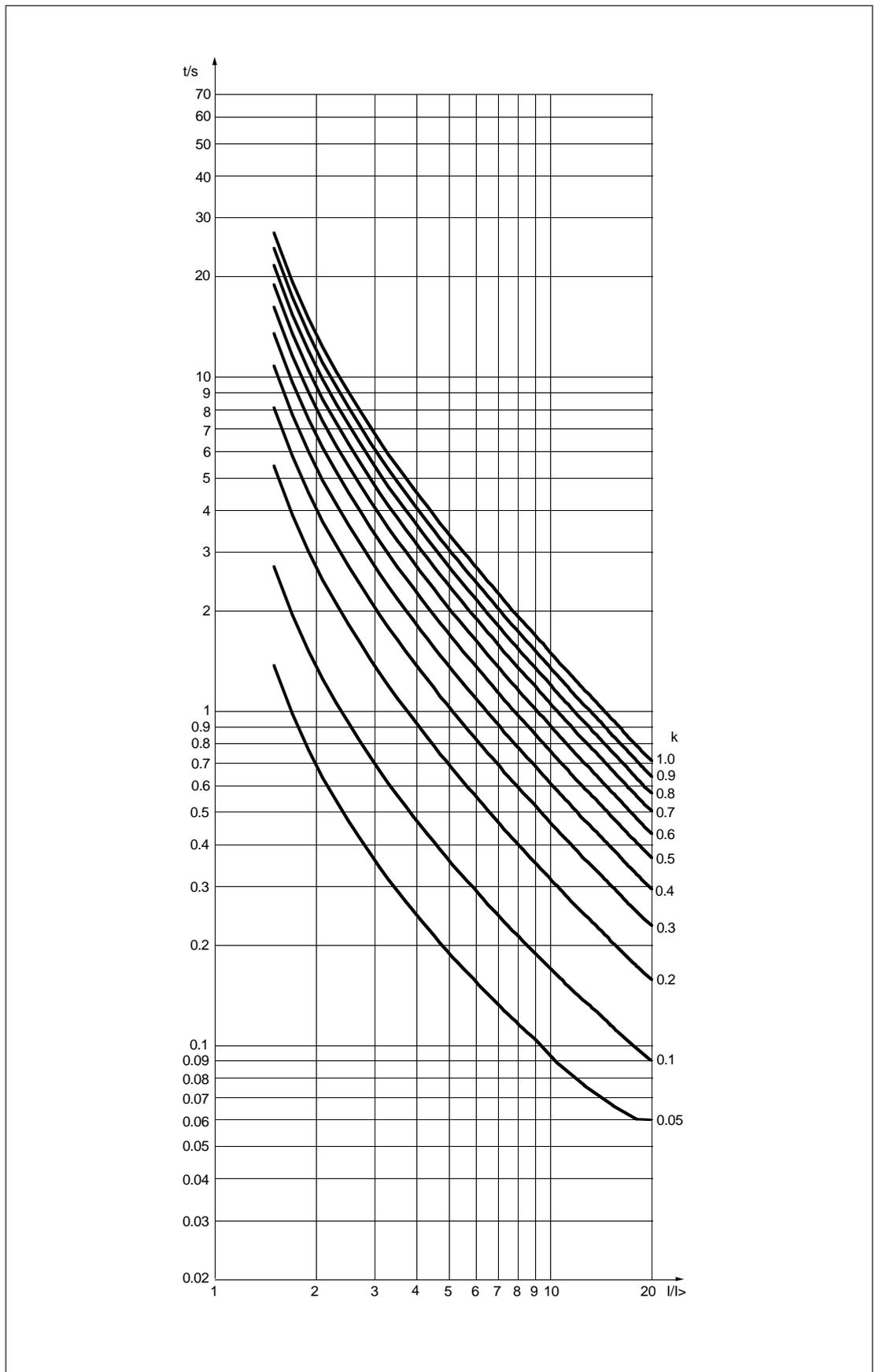


Fig. 6. Very inverse-time characteristics of the two-phase directional o/c module SPCS 4D11

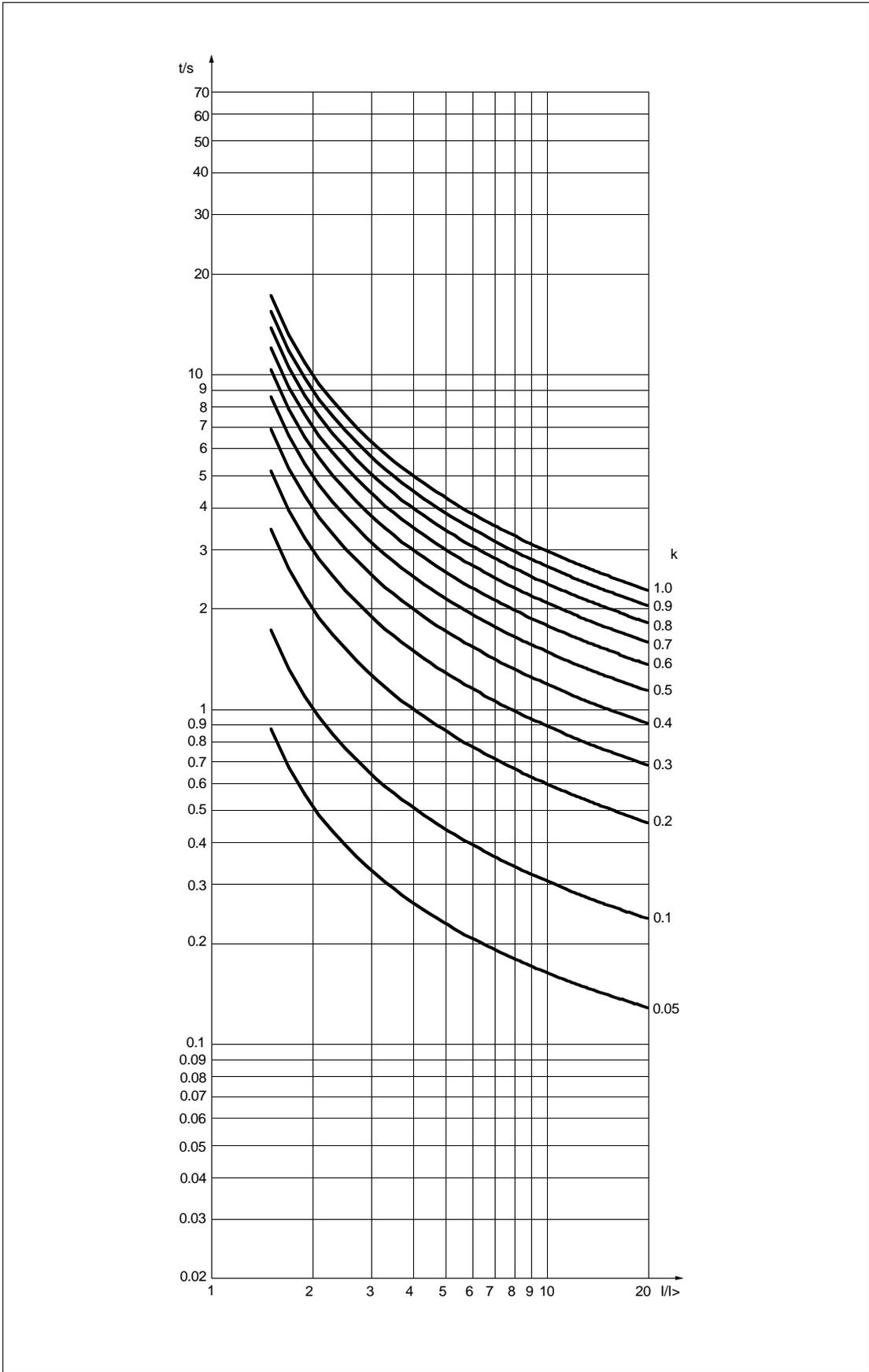


Fig. 7. Normal inverse-time characteristics of the two-phase directional o/c module SPCS 4D11

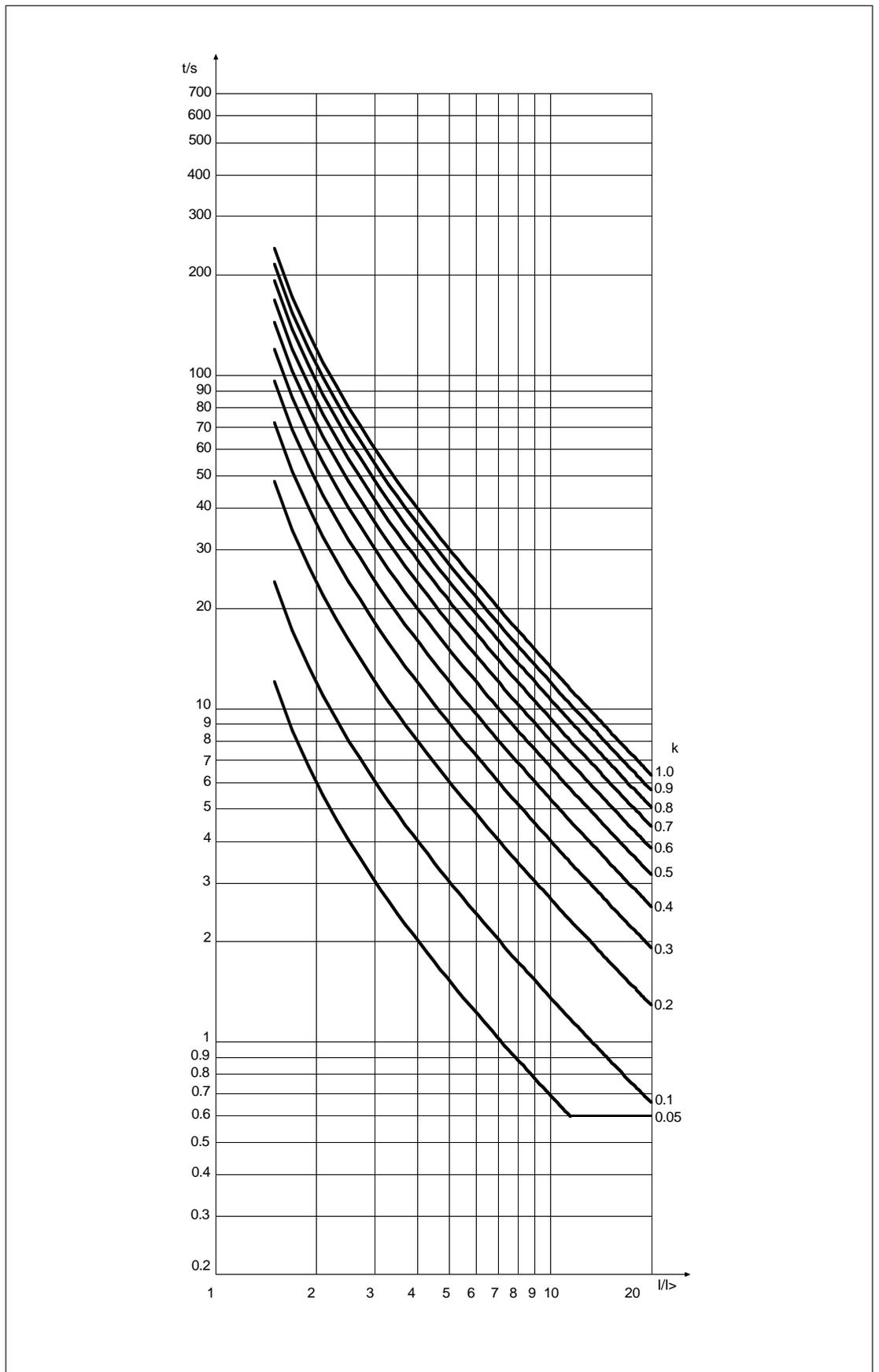


Fig. 8. Long-time inverse-time characteristics of the two-phase directional o/c module SPCS 4D11

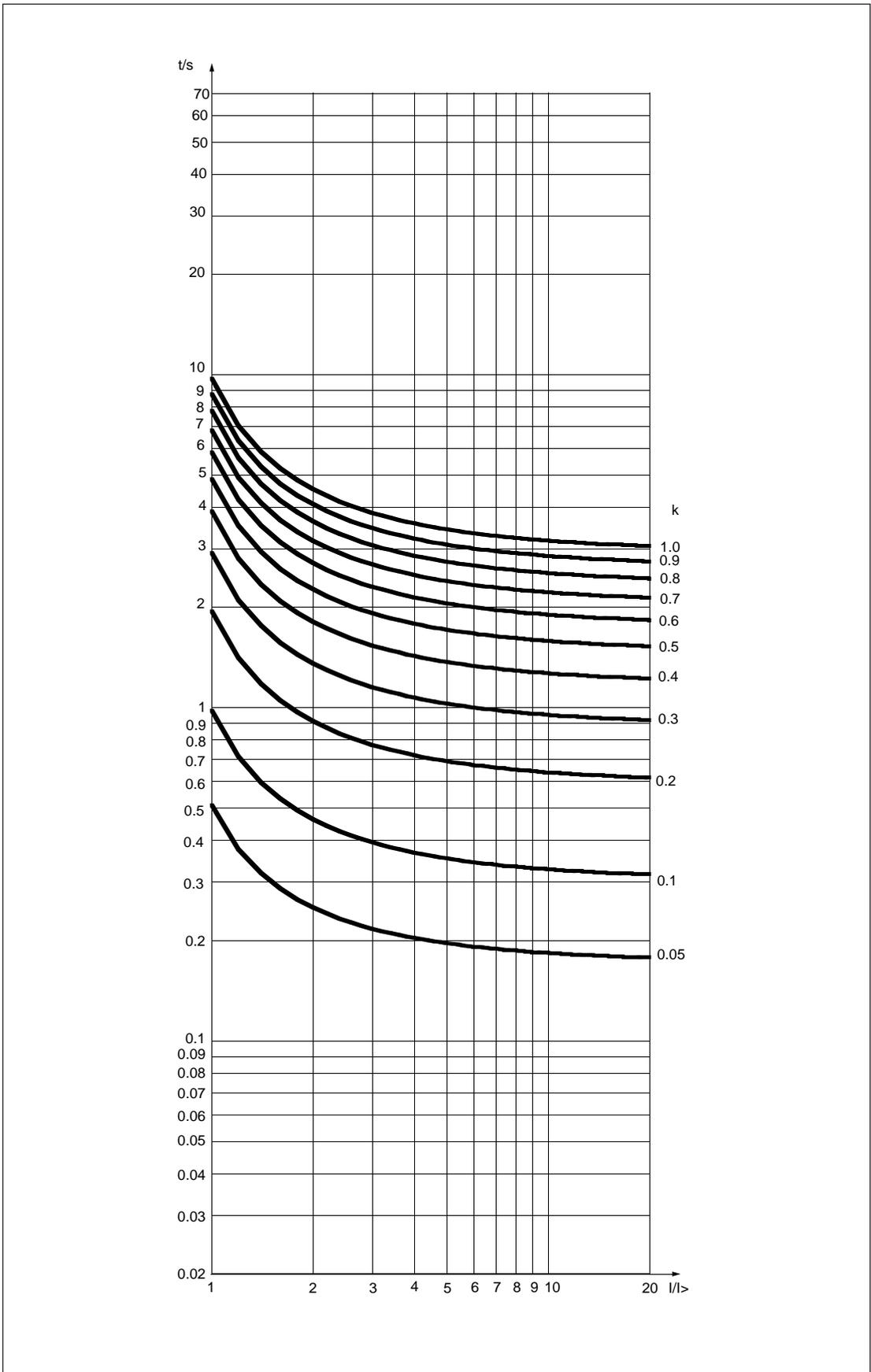


Fig. 9. RI-type inverse-time characteristics of the two-phase directional o/c module SPCS 4D11

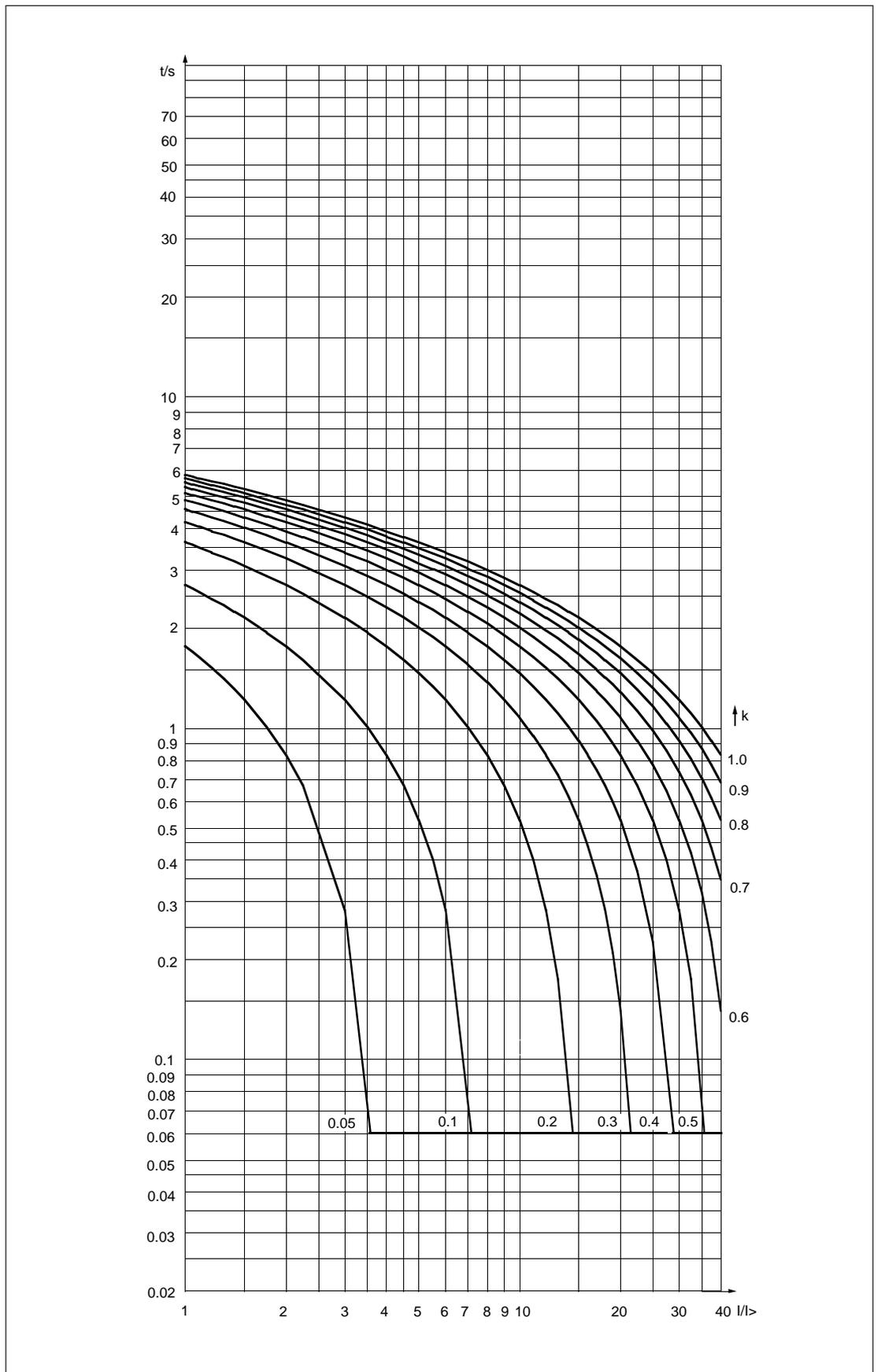


Fig. 10. RXIDG-type inverse-time characteristics of the two-phase o/c module SPCS 4D11

Technical data

Low-set stage I>

Operating mode	directional
Start current I>	
– definite time characteristic	0.3...5.0 x I _n
– inverse time characteristic	0.3...2.5 x I _n
Start time, typ.	60 ms (100 ms)**
Operation characteristic	
– definite time characteristic	
– operate time	0.1...300 s
– inverse time characteristic	
acc. to BS 142 and IEC 255-4	Extremely inverse Very inverse Normal inverse Long time inverse
– special characteristic acc. to ABB practice	RI-type inverse RXIDG-type inverse
– time multiplier k	0.05...1.00
Reset time, typ.	60 ms
Drop-off/pick-up ratio, typ.	0.96
Operate time accuracy at definite time operation	±2% of set value or ±25 ms
Operate time accuracy class E at inverse time mode of operation	5
Operation accuracy	±3% of set value

High-set stage I>>

Operating mode	directional or non-directional
Start current	0.5...40.0 x I _n or infinite
Start time, typ.	60 ms (100 ms)**
Operate time	0.04...300 s *
Reset time, typ.	60 ms
Drop-off/pick-up ratio, typ.	0.96
Operate time accuracy	±2% of set value or ±25 ms
Operation accuracy	±3% of set value

Directional element

Setting range of basic angle φ_b	0°...-90°
Operation sector	$\varphi_b \pm 80^\circ$
Operation sector accuracy	±5°
Start delay of trip direction information, typ.	50 ms (90 ms)
Threshold current for angle measurement	
– pick-up / drop-off	13% I _n / 10% I _n
Threshold voltage for angle measurement	
– pick-up / drop-off	8% U _n / 7% U _n
Memory at sudden voltage drop	~2.5 s

High-set stage I>>>

Operating mode	non-directional
Start current	2...40.0 x I _n or infinite
Start time, typ.	50 ms
Operate time	0.04...30 s
Reset time	60 ms
Drop-off/pick-up ratio, typ.	0.96
Operate time accuracy	±2% of set value or ±25 ms
Operation accuracy	±3% of set value

* With a directional operation, the minimum operate time is not faster than the start time.

** The start time 100 ms is used when voltage and current are applied simultaneously. If the module has been measuring a voltage signal at least 40 ms before the current setting is exceeded the start time is typically 60 ms.

Event codes

When the two-phase directional o/c module SPCS 4D11 is linked to the control data communicator over the SPA bus, the module will, for instance, provide event markings to a printer. The events are printed out in the format: time, text which the user may have programmed, and event code.

The codes E1...E16 and the events representing these can be included in or excluded from the event reporting by writing an event mask V155 and V156 for the events.

The event masks V155 may have a value in the range 0...63 and V156 a value within the range 0...255. The default value of the directional two-phase o/c module SPCS 4D11 is 21 for V155 and 85 for V156, which means that all starts and trips of stage I> , I>> and I>>> are included in the reporting, but not the resetting.

The output signals are monitored by codes E17...E26 and the events represented by these can be included in or excluded from 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 reported or 1, event reported, and adding up the numbers received. Compare checksum calculation.

The event mask V157 may have a value in the range 0...1023. The default value is 768 which means that only the operations of the trip relay TS2 are included in the reporting.

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

Code	Event	Number representing the event	Default value of the factor
E1	Starting of stage I> in forward direction	1	1
E2	Starting of stage I> in forward direction reset	2	0
E3	Starting of stage I> in reverse direction	4	1
E4	Starting of stage I> in reverse direction reset	8	0
E5	Tripping of stage I>	16	1
E6	Tripping of stage I> reset	32	0
			21
E7	Starting of stage I>>	1	1
E8	Starting of stage I>> reset	2	0
E9	Tripping of stage I>>	4	1
E10	Tripping of stage I>> reset	8	0
E11	Starting of stage I>>>	16	1
E12	Starting of stage I>>> reset	32	0
E13	Tripping of stage I>>>	64	1
E14	Tripping of stage I>>> reset	128	0
			85

Code	Event	Number representing the event	Default value of the factor
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
			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 event reporting
1 included in event reporting
* No code number
- Cannot be programmed

Note!

The event codes E52... E54 are generated by the control data communicator unit. (SACO 100M, SRIO 1000M etc).

Data to be transferred over the bus

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

module. Further, part of the data can be altered by commands given over the SPA bus. All the data are available in channel 0.

Data	Code	Data direct.	Values
INPUTS			
Current measured on phase L1	I1	R	0...52 x I _n
Measured voltage U23	I2	R	0...152% U _n
Phase angle between IL1 and U23	I3	R	0...±180°
Current measured on phase L3	I4	R	0...52 x I _n
Measured voltage U12	I5	R	0...152% U _n
Phase angle between IL3 and U12	I6	R	0...±180°
Blocking or control signal BS1	I7	R	0 = no blocking 1 = BS1 signal active
Blocking or control signal BS2	I8	R	0 = no blocking 1 = BS2 signal active
Blocking or control signal RRES	I9	R	0 = no blocking 1 = RRES signal active

Data	Code	Data direct.	Values
OUTPUTS			
Starting of stage I> forward direction	O1	R	0 = I>-stage not started 1 = I>-stage started
Starting of stage I> backward direction	O2	R	0 = I>-stage not started 1 = I>-stage started
Tripping of stage I>	O3	R	0 = I>-stage not tripped 1 = I>-stage tripped
Starting of stage I>>	O4	R	0 = I>>-stage not started 1 = I>>-stage started
Tripping of stage I>>	O5	R	0 = I>>-stage not tripped 1 = I>>-stage tripped
Starting of stage I>>>	O6	R	0 = I>>>-stage not started 1 = I>>>-stage started
Tripping of stage I>>>	O7	R	0 = I>>>-stage not tripped 1 = I>>>-stage tripped
Signal TS1	O8	R,W(P)	0 = signal not active 1 = signal active
Signal SS1	O9	R,W(P)	0 = signal not active 1 = signal active
Signal SS2	O10	R,W(P)	0 = signal not active 1 = signal active
Signal SS3	O11	R,W(P)	0 = signal not active 1 = signal active
Signal TS2	O12	R,W(P)	0 = signal not active 1 = signal active
Output relays	O41	R,W(P)	0 = not operated 1 = operated
Memorized I> start, forward direction	O21	R	0 = signal not active 1 = signal active
Memorized I> start, backward direction	O22	R	0 = signal not active 1 = signal active
Memorized I> trip	O23	R	0 = signal not active 1 = signal active
Memorized I>> start	O24	R	0 = signal not active 1 = signal active
Memorized I>> trip	O25	R	0 = signal not active 1 = signal active
Memorized I>>> start	O26	R	0 = signal not active 1 = signal active
Memorized I>>> trip	O27	R	0 = signal not active 1 = signal active
Memorized output signal TS1	O28	R	0 = signal not active 1 = signal active
Memorized output signal SS1	O29	R	0 = signal not active 1 = signal active
Memorized output signal SS2	O30	R	0 = signal not active 1 = signal active
Memorized output signal SS3	O31	R	0 = signal not active 1 = signal active
Memorized output signal TS2	O32	R	0 = signal not active 1 = signal active

Data	Code	Data direct.	Values
PRESENT SETTING VALUES			
Present start value for stage I>	S1	R	0.3...5.0 x I _n
Present operate time for stage I>	S2	R	0.05...300 s
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
Base angle setting	S5	R	0... - 90°
Present start value for stage I>>>	S6	R	2.0...40x I _n 999 = not in use
Present operate time for stage I>>>	S7	R	0.04...30 s
Present checksum of switchgroup SGF1	S8	R	0...255
Present checksum of switchgroup SGF2	S9	R	0...255
Present checksum of switchgroup SGB1	S10	R	0...255
Present checksum of switchgroup SGB2	S11	R	0...255
Present checksum of switchgroup SGB3	S12	R	0...255
Present checksum of switchgroup SGR1	S13	R	0...255
Present checksum of switchgroup SGR2	S14	R	0...255
MAIN SETTING VALUES			
Main start value for stage I>	S21	R,W(P)	0.3...5.0 x I _n
Main operate time for stage I>	S22	R,W(P)	0.05...300 s
Main start value for stage I>>	S23	R,W(P)	0.5...40 x I _n
Main operate time for stage I>>	S24	R,W(P)	0.04...300 s
Main base angle setting	S25	R,W(P)	0... - 90°
Main start value for stage I>>>	S26	R,W(P)	2.0...40 x I _n
Main operate time for stage I>>>	S27	R,W(P)	0.04...30 s
Main checksum of switchgroup SGF1	S28	R,W(P)	0...255
Main checksum of switchgroup SGF2	S29	R,W(P)	0...255
Main checksum of switchgroup SGB1	S30	R,W(P)	0...255
Main checksum of switchgroup SGB2	S31	R,W(P)	0...255
Main checksum of switchgroup SGB3	S32	R,W(P)	0...255
Main checksum of switchgroup SGR1	S33	R,W(P)	0...255
Main checksum of switchgroup SGR2	S34	R,W(P)	0...255
SECOND SETTING VALUES			
Second start value for stage I>	S41	R,W(P)	0.3...5.0 x I _n
Second operate time for stage I>	S42	R,W(P)	0.05...300 s
Second start value for stage I>>	S43	R,W(P)	0.5...40 x I _n
Second operate time for stage I>>	S44	R,W(P)	0.04...300 s
Second base angle setting	S45	R,W(P)	0... - 90°
Second start value for stage I>>>	S46	R,W(P)	2.0...40 x I _n
Second operate time for stage I>>>	S47	R,W(P)	0.04...30 s
Second checksum of switchgroup SGF1	S48	R,W(P)	0...255
Second checksum of switchgroup SGF2	S49	R,W(P)	0...255
Second checksum of switchgroup SGB1	S50	R,W(P)	0...255
Second checksum of switchgroup SGB2	S51	R,W(P)	0...255
Second checksum of switchgroup SGB3	S52	R,W(P)	0...255
Second checksum of switchgroup SGR1	S53	R,W(P)	0...255
Second checksum of switchgroup SGR2	S54	R,W(P)	0...255
Operate time for circuit-breaker failure protection	S61	R,W(P)	0.1...1.0 s

Data	Code	Data direct.	Values
RECORDED AND MEMORIZED PARAMETERS			
Current in phase L1 at start or trip	V11, V21..V51	R	0...52 x I _n
Current in phase L3 at start or trip	V12, V22..V52	R	0...52 x I _n
Line voltage U ₂₃ at start or trip	V13, V23..V53	R	0...152% U _n
Line voltage U ₁₂ at start or trip	V14, V24..V54	R	0...152% U _n
Phase angle between L1 and U ₂₃ at starting or tripping	V15, V25.. V55	R	0... ±180°
Phase angle between L3 and U ₁₂ at starting or tripping	V16, V26.. V56	R	0... ±180°
Duration of the latest start situation of stage I>	V17, V27.. V57	R	0...100 %
Duration of the latest start situation of stage I>>	V18, V28.. V58	R	0...100 %
Duration of the latest start situation of stage I>>>	V19, V29.. V59	R	0...100 %
Maximum demand current for 15 min. Highest maximum demand current 15 min. value	V1 V2	R R	0...2.5 x I _n 0...2.55 x I _n
Number of starts of stage I>	V3	R	0...255
Number of starts of stage I>>	V4	R	0...255
Number of starts of stage I>>>	V5	R	0...255
Phase condition during trip	V6	R	1 = I _{L3} >, 2 = I _{L1} > 4 = I _{L3} >>, 8 = I _{L1} >> 16 = I _{L3} >>>, 64 = I _{L1} >>>
Operation indicator	V7	R	0...9
CONTROL PARAMETERS			
Resetting of latched output relays	V101	W	1 = reset
Resetting of output relays and registers	V102	W	1 = reset
Remote control of settings	V150	R,W	0 = main settings activated 1 = second settings activated
Event mask word for low-set stage events	V155	R,W	0...63, see "Event codes"
Event mask word for high-set stage events	V156	R,W	0...255, see "Event codes"
Event mask word for output signal events	V157	R,W	0...1023, see "Event codes"
Opening of password for remote settings	V160	W	1...999
Changing or closing of password for remote settings	V161	W(P)	0...999
Activation of self-supervision output	V165	W	1 = self-supervision output is activated and IRF LED lit 0 = off

Data	Code	Data direct.	Values
Eeprom formatting	V167	W(P)	2 = format EEPROM
Internal error code	V169	R	0...255
Relay rated frequency	V180	R,W(P)	50 Hz or 60 Hz
Data communication address of the module	V200	R,W	1...254
Data transfer rate	V201	R,W	4.8 or 9.6 KBd (W) 4800 or 9600 (R)
Programme version number	V205	R	123_
Event register reading	L	R	time, channel number and event code
Re-reading of event register	B	R	time, channel and event code
Type designation of the module	F	R	SPCS 4D11
Reading of module status data	C	R	0 = normal state 1 = module been subject to automatic reset 2 = overflow of event register 3 = events 1 and 2 together
Resetting of module state data	C	W	0 = resetting
Time reading and setting	T	R,W	0.000...59.999 s

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

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

The setting values S1...S14 are the setting values used by the protection programs. These values are set in the same way as main settings and switchgroup checksums S21...S34 or as the second settings S41...S54. All the settings can be read or written. A condition for writing is that the remote set password has been opened.

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

Fault codes

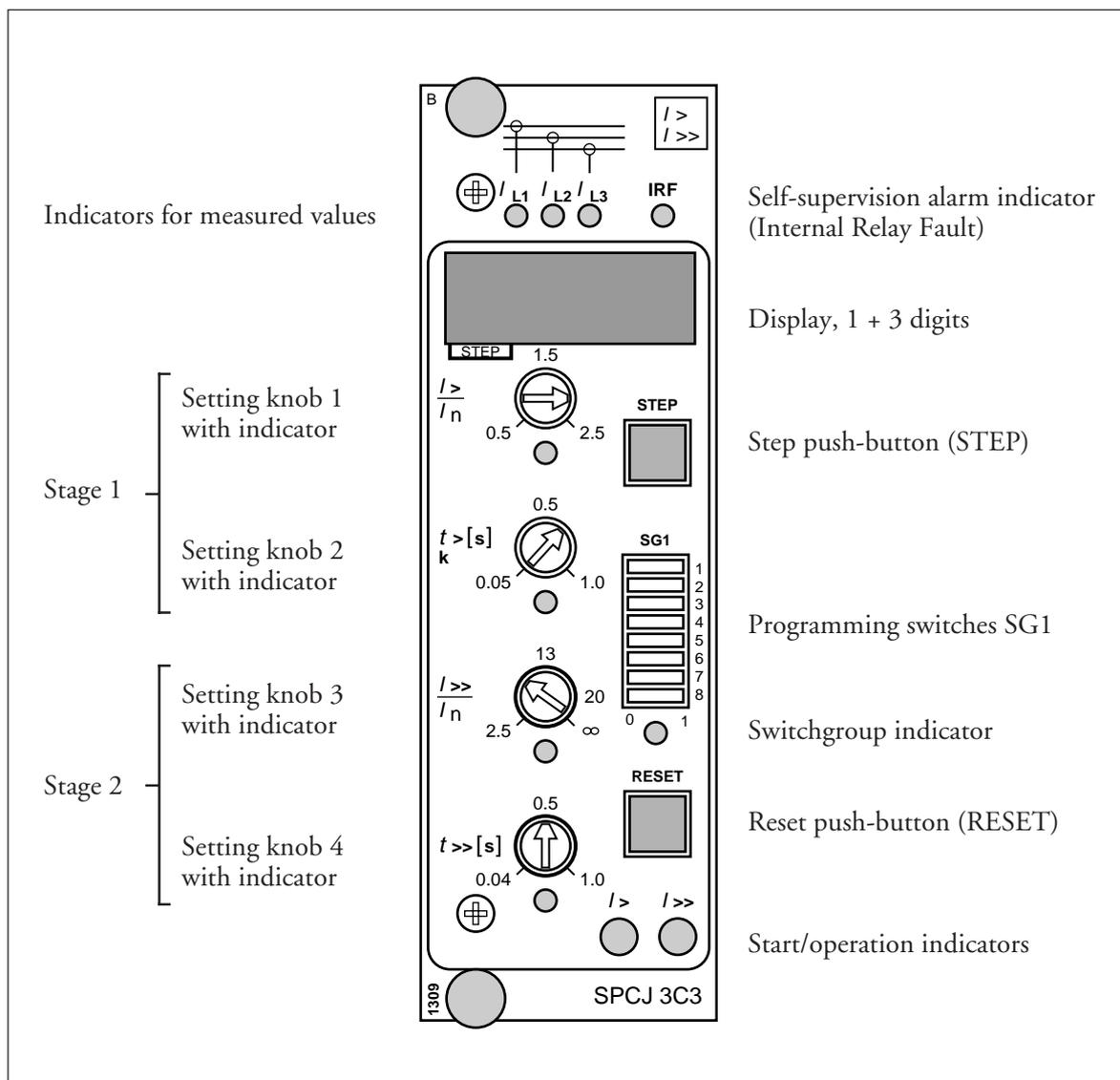
A short time after the internal self-supervision system has detected a permanent relay fault the red IRF indicator is lit and the output relay of the self-supervision system operates. Further, in most fault situations, an auto diagnostic fault code is shown on the display. This fault code consists of a red figure 1 and a green code

number which indicates the fault type. When a fault code appears on the display, the code number should be recorded and stated to the authorized repair shop when repair is ordered. Below some fault codes that might appear with the module SPCS 4D11:

Fault code	Type of error in module
1	Power reset
4	Faulty trip relay path or missing output relay card
30	Faulty program memory (ROM)
50	Faulty work memory (RAM)
51	Parameter memory (EEPROM) faulty
52	Parameter memory (EEPROM) faulty
53	Parameter memory (EEPROM) faulty
54	Parameter memory (EEPROM) faulty
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
253	No interruptions from the A/D-converter

General characteristics of C-type relay modules

User's manual and Technical description



Data subject to change without notice

Contents		
	Push-buttons	2
	Programming switches SG1	2
	Setting knobs	3
	Display	3
	Display main menu	3
	Display submenu	4
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	Example: Operation in setting mode	5
	Stored information	6
	Trip-test mode.....	7
	Example: Trip-test function	8
	Operation indicators	9
	Fault codes.....	9

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.

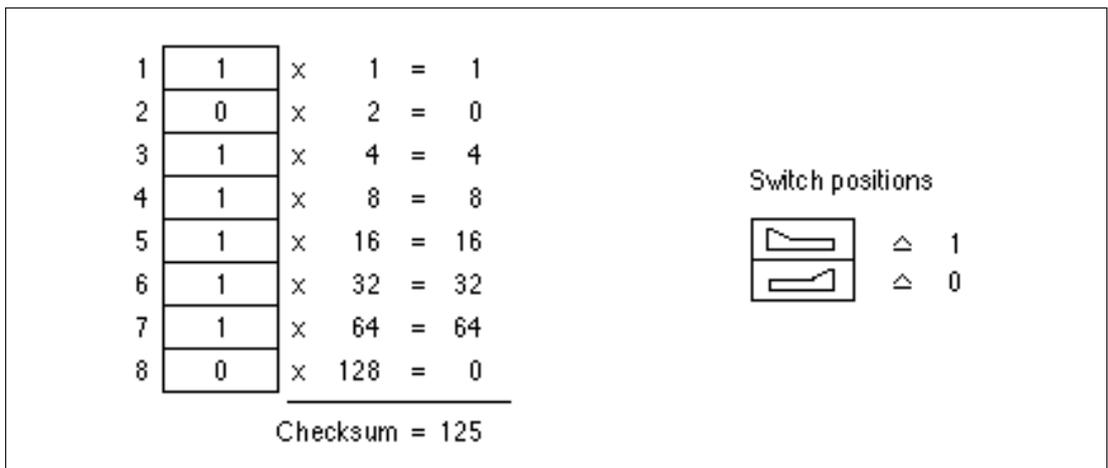


Fig. 2. Example of calculating the checksum of programming switchgroup SG1.

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.

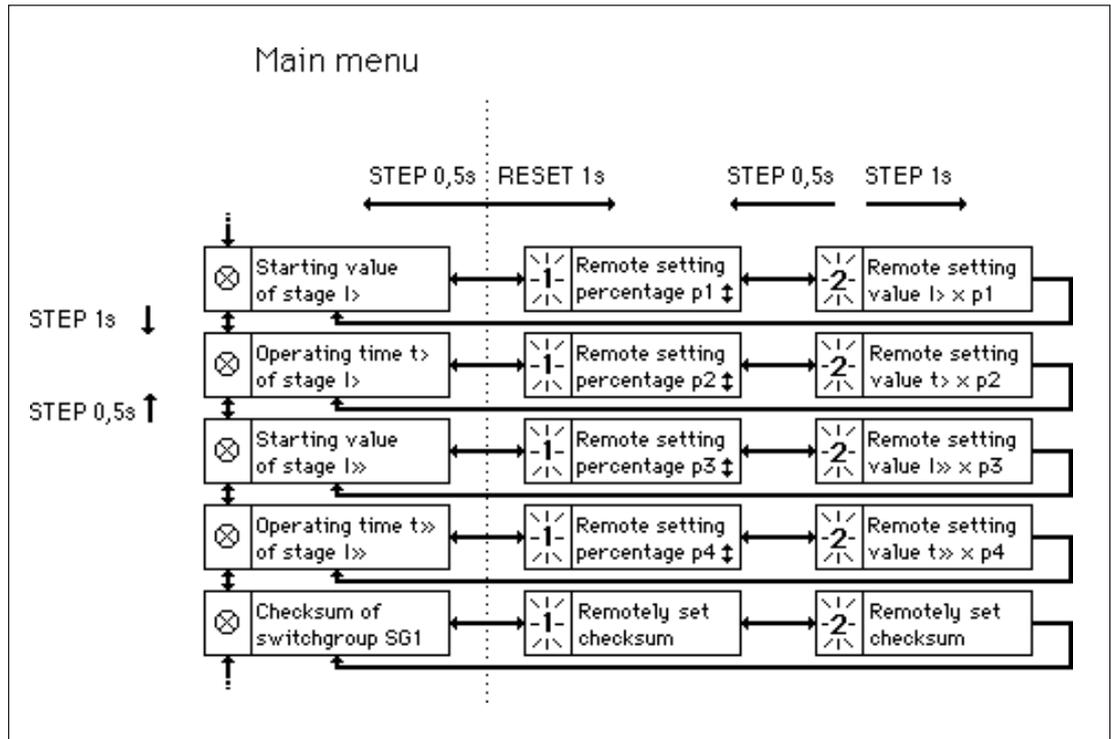


Fig. 3. Example of the main and submenus for the settings of the overcurrent relay module SPCJ 3C3. The settings made with the setting knobs are in the main menu and they are displayed by pressing the STEP button. In addition to the setting knob settings the main menu contains the measured current values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

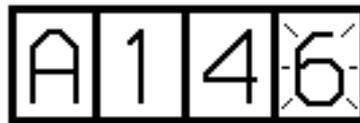
Example 1:

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.

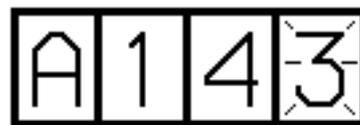
a) Press push-button STEP until register address A appears on the display.



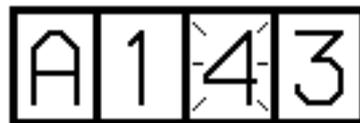
b) Press the RESET button for about 10 s until the right most digit starts flashing.



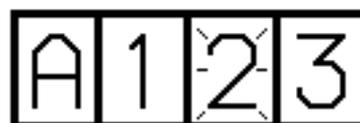
c) Press the STEP button repeatedly to set the digit to the value desired.



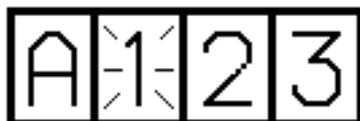
d) Press the RESET button to make the middle of the green digits flash.



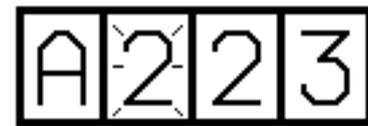
e) Set the middle address digit by means of the STEP button.



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



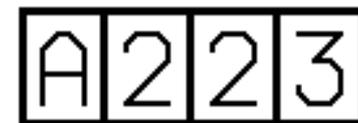
g) Set the digit by means of the STEP button.



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 simultaneously. 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.

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.

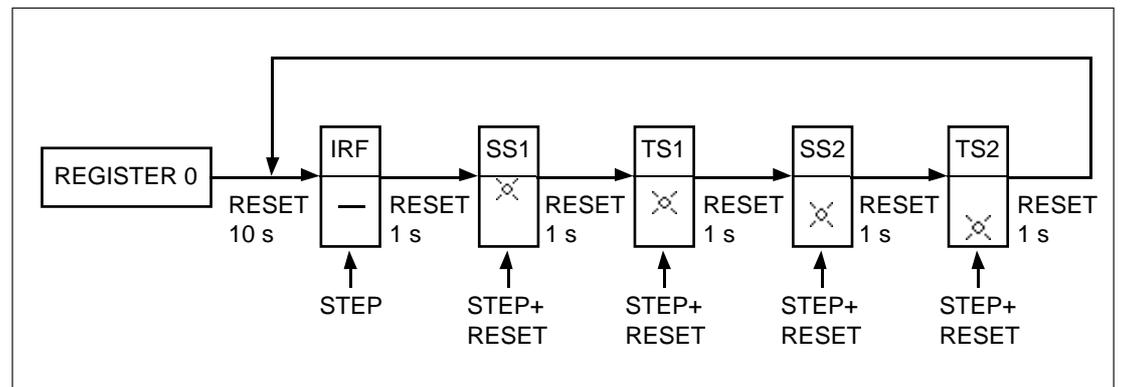


Fig. 4. Sequence order for selecting the output signals in the Trip-test mode.

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.

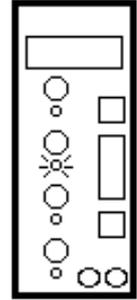
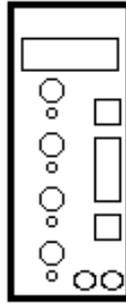
Example 2:

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

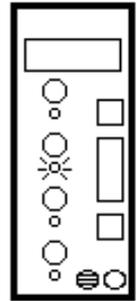
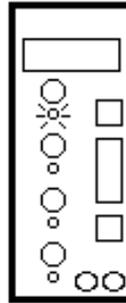
a) Step forward on the display to register 0.



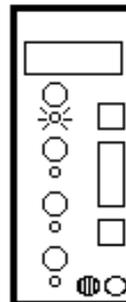
- Indicator switched off
- Yellow indication
- Red indication



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.



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.

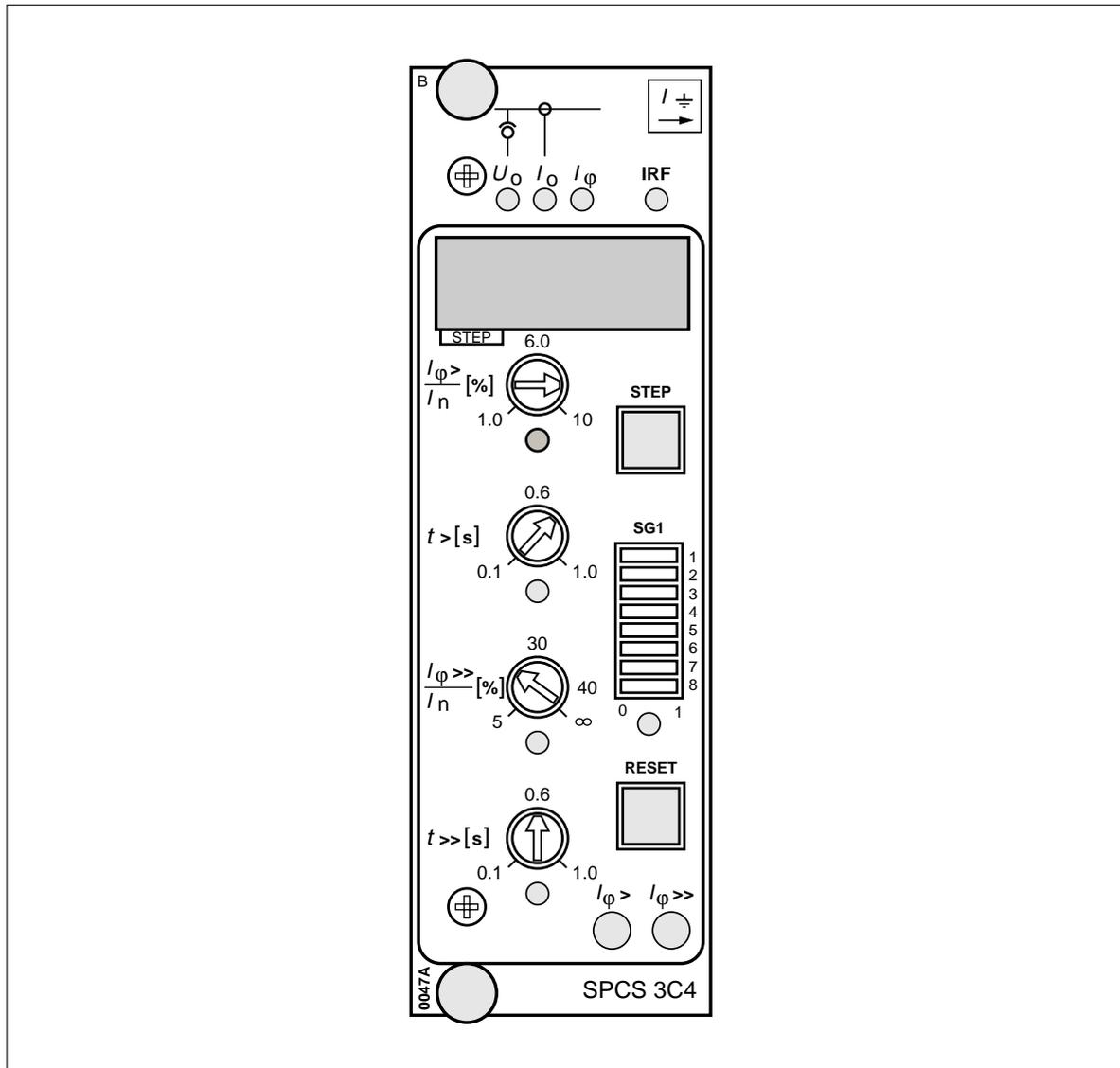
When the self-supervision system has detected a permanent fault in the relay module, the red IRF indicator on the panel starts glowing soon after the fault was discovered. At the same time the module puts forward a signal to the self-supervision contact of the relay assembly.

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



Issued 1996-03-14
 Modified 2000-02-16
 Version C (replaces 34 SPCS 1 EN1)
 Checked
 Approved

Data subject to change without notice

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Features

<p>Directional neutral overcurrent relay module with definite time characteristic for earth fault protection</p> <p>Two neutral overcurrent stages, a low-set stage $I_{\phi>}$ and a high-set stage $I_{\phi>>}$</p> <p>The high-set stage can be given the same or the opposite direction of operation as compared with the low-set stage</p> <p>$I_0\sin\phi$ or $I_0\cos\phi$ operation characteristic selected locally by switches or by remote control over the external control input</p>	<p>Four selectable start values for the residual voltage</p> <p>Digital display of measured values, set values and recorded fault values</p> <p>Continuous self-supervision with autodiagnos- tics including both hardware and software</p> <p>Serial communication capability for extensive data exchange between the relay module and the substation level communication or control system</p>
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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 $I_{\varphi >}$ or $I_{\varphi >>}$, 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 $I_{\varphi >}$ can be blocked by routing a blocking signal BTS1 to the stage. In the same way the operation of stage $I_{\varphi >>}$ 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 $I_{\varphi >}$ operates in the forward direction only, the high-set stage $I_{\varphi >>}$ 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 $I_{\varphi >}$ is selected with switch SG1/5. Two setting ranges are available.

The setting range of the start current of the high-set stage $I_{\varphi >>}$, i.e. 5...40% $\times I_n$ or 1...8% $\times I_n$, 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.

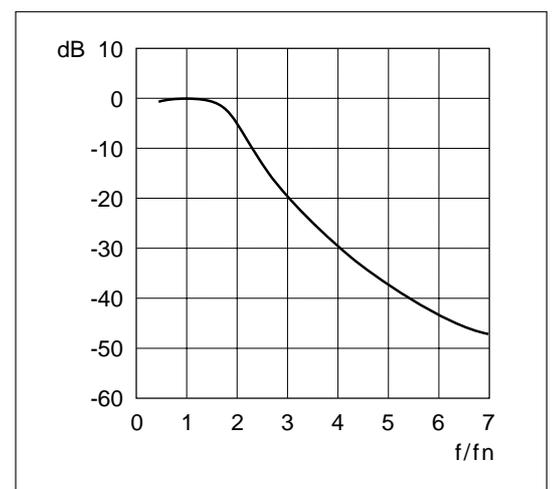


Fig. 1. Filter characteristics of the energizing inputs of the relay module SPCS 3C4.

Block schematic diagram

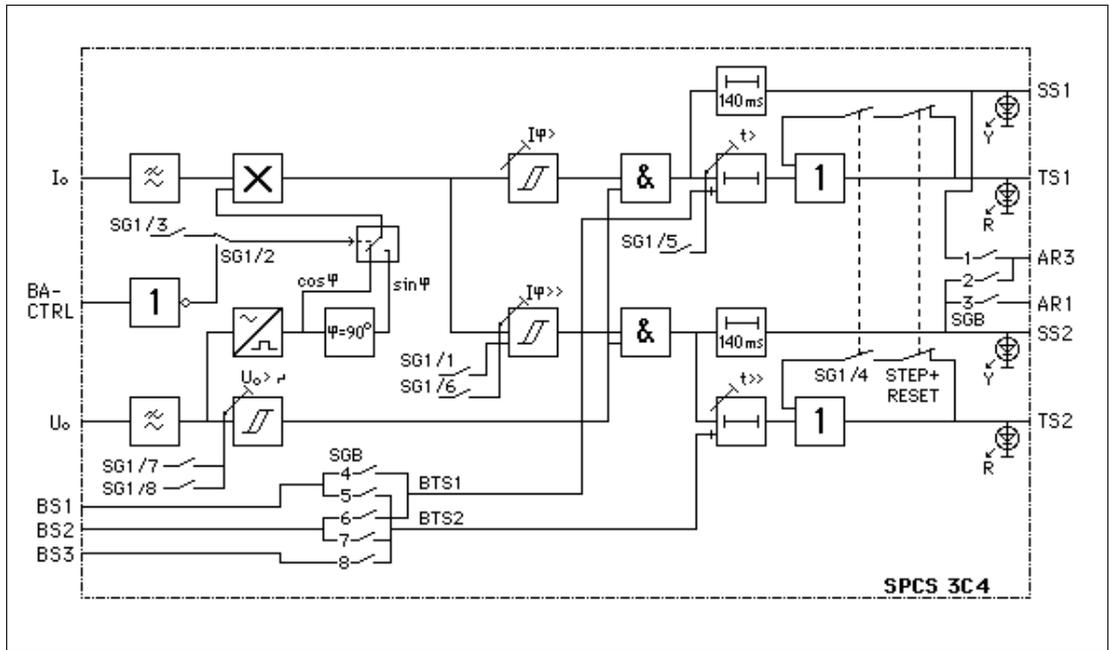


Fig. 2. Block diagram for the directional neutral current relay module SPCS 3C4.

U_0	Residual voltage
I_0	Neutral current
BS1, BS2, BS3	External blocking signals
BTS1	Blocking signal for the operation of stage $I\phi>$
BTS2	Blocking signal for the operation of stage $I\phi>>$
BACTRL	External control signal for selection of the operation characteristic $I_0\sin\phi$ or $I_0\cos\phi$
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 $I\phi>$
TS1	Trip signal of the low-set stage $I\phi>$
SS2	Start signal of the high-set stage $I\phi>>$
TS2	Trip signal of the high-set stage $I\phi>>$
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 sig-

nals wired to the terminals are shown in the paragraph "Signal diagram" in the general manual of the protection relay.

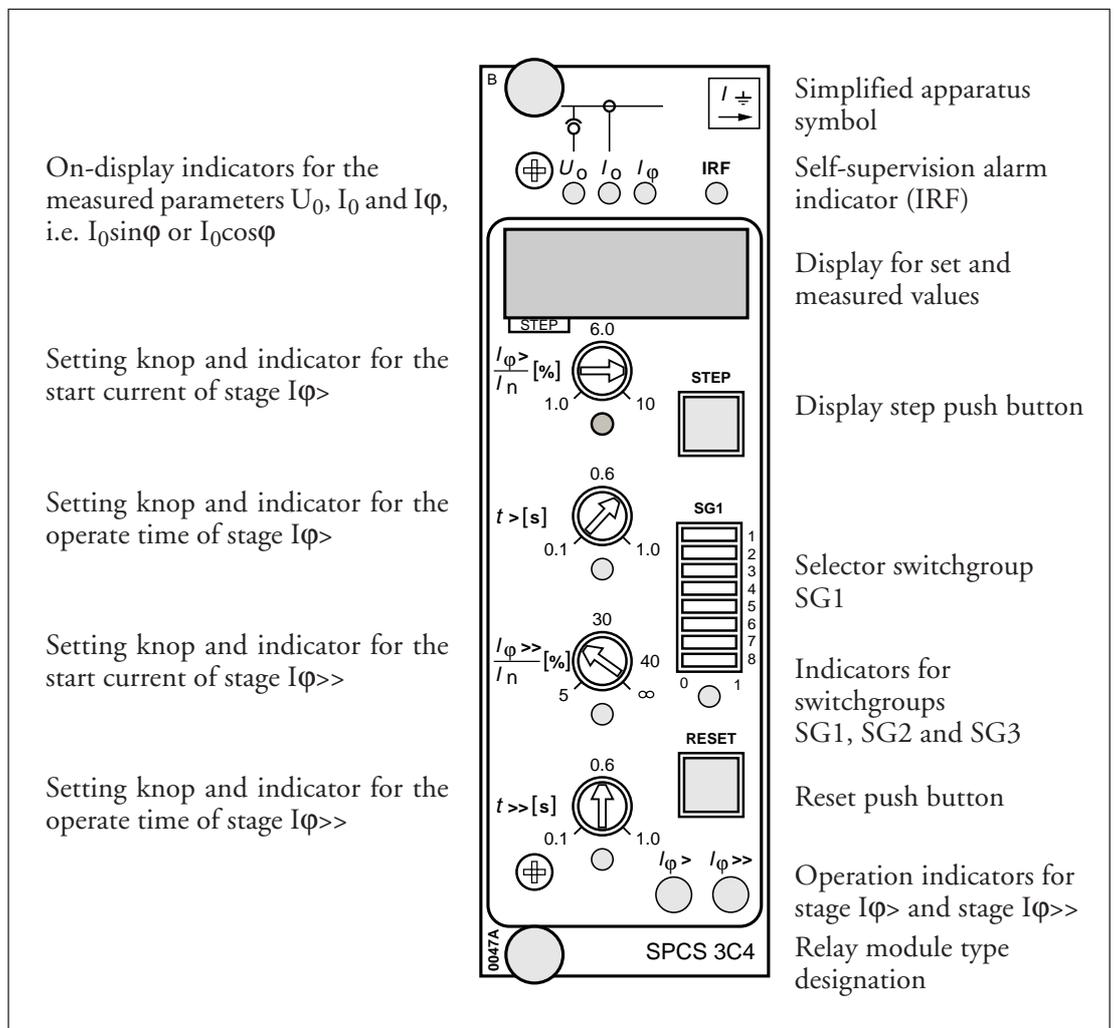


Fig. 3. Front panel of the directional neutral overcurrent relay module SPCS 3C4.

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 by 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.

Settings

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 currently being shown on the display.

$I\phi>/I_n$	Start current of stage $I\phi>$, expressed as a percentage of the rated current of the energized relay input. Setting range $1...10\% \times I_n$.
$t> [s]$	Operate time of stage $I\phi>$, expressed in seconds. The setting range is $0.1...1.0$ seconds when $SG1/5 = 0$, and $1.0...10.0$ seconds when $SG1/5 = 1$.
$I\phi>>/I_n$	Start current of stage $I\phi>>$, expressed as a percentage of the rated current of the energized relay input. The setting range is $5...40\% \times I_n$ when $SG1/6 = 0$, and $1...8\% \times I_n$ when $SG1/6 = 1$. Additionally, the setting ∞ , infinite (displayed as - -) can be selected, which means that stage $I\phi>>$ has been set out of function. If the high-set stage $I\phi>>$ 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 $I\phi>>$, expressed in seconds. Setting range $0.1...1.0$ seconds.

Further, the checksum of the selector switch-group 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.

Switch	Function																				
SG1/1	<p>Selection of operation direction for the high-set stage $I\phi>>$.</p> <p>Switch SG1/1 = 0 corresponds to the forward operation direction, i.e. the same direction as that of the low-set stage $I\phi>$.</p> <p>Switch SG1/1 = 1 corresponds to the reverse operation direction, also see Fig. 4 on page 8.</p>																				
SG1/2	<p>Selection of manual or external control of the operation characteristic, i.e. $I_0\sin\phi$ or $I_0\cos\phi$.</p> <table border="1"> <thead> <tr> <th>SG1/2</th> <th>SG1/3</th> <th>Method of controlling the operation characteristic</th> <th>Obtained characteristic</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>Manual selection</td> <td>$I_0\cos\phi$</td> </tr> <tr> <td>0</td> <td>1</td> <td>Manual selection</td> <td>$I_0\sin\phi$</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> </tbody> </table>	SG1/2	SG1/3	Method of controlling the operation characteristic	Obtained characteristic	0	0	Manual selection	$I_0\cos\phi$	0	1	Manual selection	$I_0\sin\phi$	1	0	By external control	Controlled by BACTRL	1	1	By external control	Controlled by BACTRL
SG1/2	SG1/3	Method of controlling the operation characteristic	Obtained characteristic																		
0	0	Manual selection	$I_0\cos\phi$																		
0	1	Manual selection	$I_0\sin\phi$																		
1	0	By external control	Controlled by BACTRL																		
1	1	By external control	Controlled by BACTRL																		
SG1/4	<p>Selection of the latching function for the trip signals TS1 and TS2.</p> <p>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. *)</p>																				
SG1/5	<p>Selection of setting range for the operate time $t>$ of the low-set stage $I\phi>$.</p> <p>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.</p>																				
SG1/6	<p>Selection of setting range of the start value of the high-set stage $I\phi>>$.</p> <p>When SG1/6 = 0, the setting range of stage $I\phi>>$ is 5...40% $\times I_n$ or ∞, infinite. When SG1/6 = 1, the setting range of stage $I\phi>>$ is 1...8% $\times I_n$ or ∞, infinite.</p>																				
SG1/7 SG1/8	<p>Setting of the start value for the residual voltage as a percentage of the rated voltage of the energizing voltage input.</p> <table border="1"> <thead> <tr> <th>SG1/7</th> <th>SG1/8</th> <th>Set start value for U_0</th> </tr> </thead> <tbody> <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> </tbody> </table>	SG1/7	SG1/8	Set start value for U_0	0	0	2%	1	0	5%	0	1	10%	1	1	20%					
SG1/7	SG1/8	Set start value for U_0																			
0	0	2%																			
1	0	5%																			
0	1	10%																			
1	1	20%																			

*) 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.

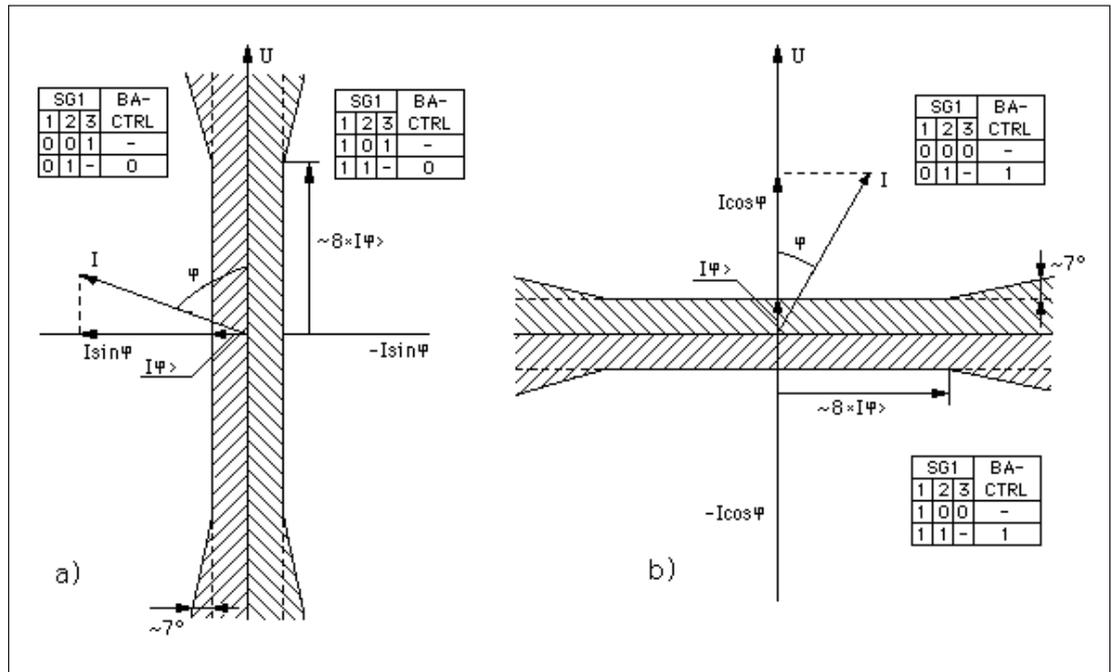


Fig. 4. Operation characteristic of the directional neutral overcurrent relay module SPCS 3C4. Fig. 4a shows the $I_0 \sin \varphi$ characteristic, Fig. 4b the $I_0 \cos \varphi$ characteristic.

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 manually reset.

Indication	Manual	Default
Starting, stage $I \varphi >$, yellow	1	0
Tripping, stage $I \varphi >$, red	2	2
Starting, stage $I \varphi >>$, yellow	4	0
Tripping, stage $I \varphi >>$, 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 STEP & RESET	x x	x	x
1	0	0	STEP RESET STEP & RESET	x x x	x	x
0	1	0	STEP RESET STEP & RESET	x x x	x	x
0	0	1	STEP RESET STEP & RESET	x x	x x	x
1	0	1	STEP RESET STEP & RESET	x x x	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.
$I\phi$	$I_0\sin\phi$ value or $I_0\cos\phi$ value measured by the module, expressed as a percentage of the rated current of the relay assembly. If $I\phi$ 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 $I\phi$ 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.

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

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

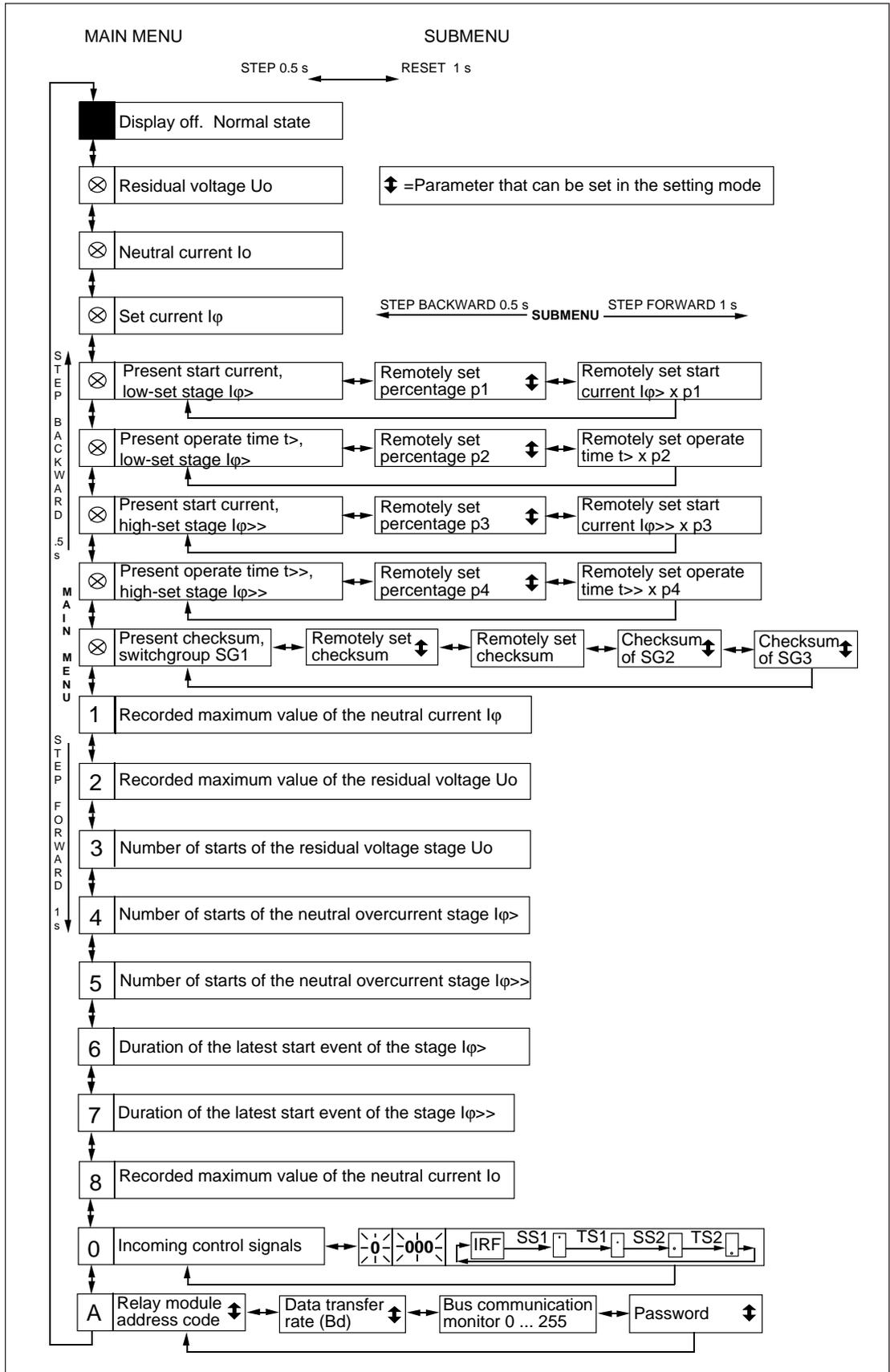
Register/ STEP	Recorded information
0	<p>Display of the state of the basic angle control signal BACTRL and other external control signals. The rightmost digit in the display shows the state of the blocking signals BTS1 and BTS2. The following states are indicated:</p> <p>0 = no active incoming blocking signal 1 = operation of stage Iϕ> blocked 2 = operation of stage Iϕ>> blocked 3 = operation of both stages blocked</p> <p>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:</p> <p>0 = BACTRL in the 0 state, i.e. the operation characteristic is $I_0 \sin \phi$, if the external control of the operation characteristic has been selected 1 = BACTRL in the 1 state, i.e. the operation characteristic is $I_0 \cos \phi$, if the external control of the operation characteristic has been selected</p> <p>The leftmost green digit indicates the state of the remote reset control input, if any. The following states are indicated:</p> <p>0 = remote reset control input not energized 1 = remote reset control input energized</p> <p>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".</p>
A	<p>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:</p> <ol style="list-style-type: none"> 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 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 I ϕ >

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
Resetting 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 I ϕ > + inaccuracy caused by ±1° phase displacement

High-set neutral overcurrent stage I ϕ >>

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
Resetting 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 I ϕ >> + 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 switch-group 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 $U_0 > 25\% \times U_n$
Measured neutral current value	I2	R	0...100% x I_n 999, if $I_0 > 100\% \times I_n$
Measured value $I_0 \cos \varphi$ or $I_0 \sin \varphi$ (sign +/-)	I3	R	$\pm 0...100\% \times I_n$ ± 999 , if $I\varphi > 100\% \times I_n$
Blocking of low-set stage $I\varphi >$	I4	R	0 = no blocking 1 = tripping $I\varphi >$ -stage blocked
Blocking of high-set stage $I\varphi >>$	I5	R	0 = no blocking 1 = tripping $I\varphi >>$ -stage blocked
Remote control of the operation characteristic $\sin \varphi / \cos \varphi$	I6	R	0 = $I_0 \sin \varphi$ 1 = $I_0 \cos \varphi$
Start of low-set stage $I\varphi >$	O1	R	0 = stage $I\varphi >$ not started 1 = stage $I\varphi >$ started
Tripping of low-set stage $I\varphi >$	O2	R	0 = stage $I\varphi >$ not tripped 1 = stage $I\varphi >$ tripped
Start of high-set stage $I\varphi >>$	O3	R	0 = stage $I\varphi >>$ not started 1 = stage $I\varphi >>$ started
Tripping of high-set stage $I\varphi >>$	O4	R	0 = stage $I\varphi >>$ not tripped 1 = stage $I\varphi >>$ tripped
Active start current $I\varphi$ of the low-set stage $I\varphi >$	S1	R	1...10% x I_n
Active operate time $t >$ of the low-set stage $I\varphi >$	S2	R	0.1...10 s
Active start current $I\varphi >>$ of the high-set stage (sign \pm)	S3	R	$\pm 1...40\% \times I_n$ $\pm 999 = \infty$
Active operate time $t >>$ of the high-set stage $I\varphi >>$	S4	R	0.1...1 s
Active checksum of selector switch-group SG1	S5	R	0...255
Start current $I\varphi$ of stage $I\varphi >$, set with the setting knob	S11	R	1...10% x I_n
Operate time $t >$ of stage $I\varphi >$, set with the setting knob	S12	R	0.1...10 s
Start current of stage $I\varphi >>$, set with the setting knob (sign \pm)	S13	R	$\pm 1...40\% \times I_n$ $\pm 999 = \infty$
Operate time of stage $I\varphi >>$, 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 de-

tected 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



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