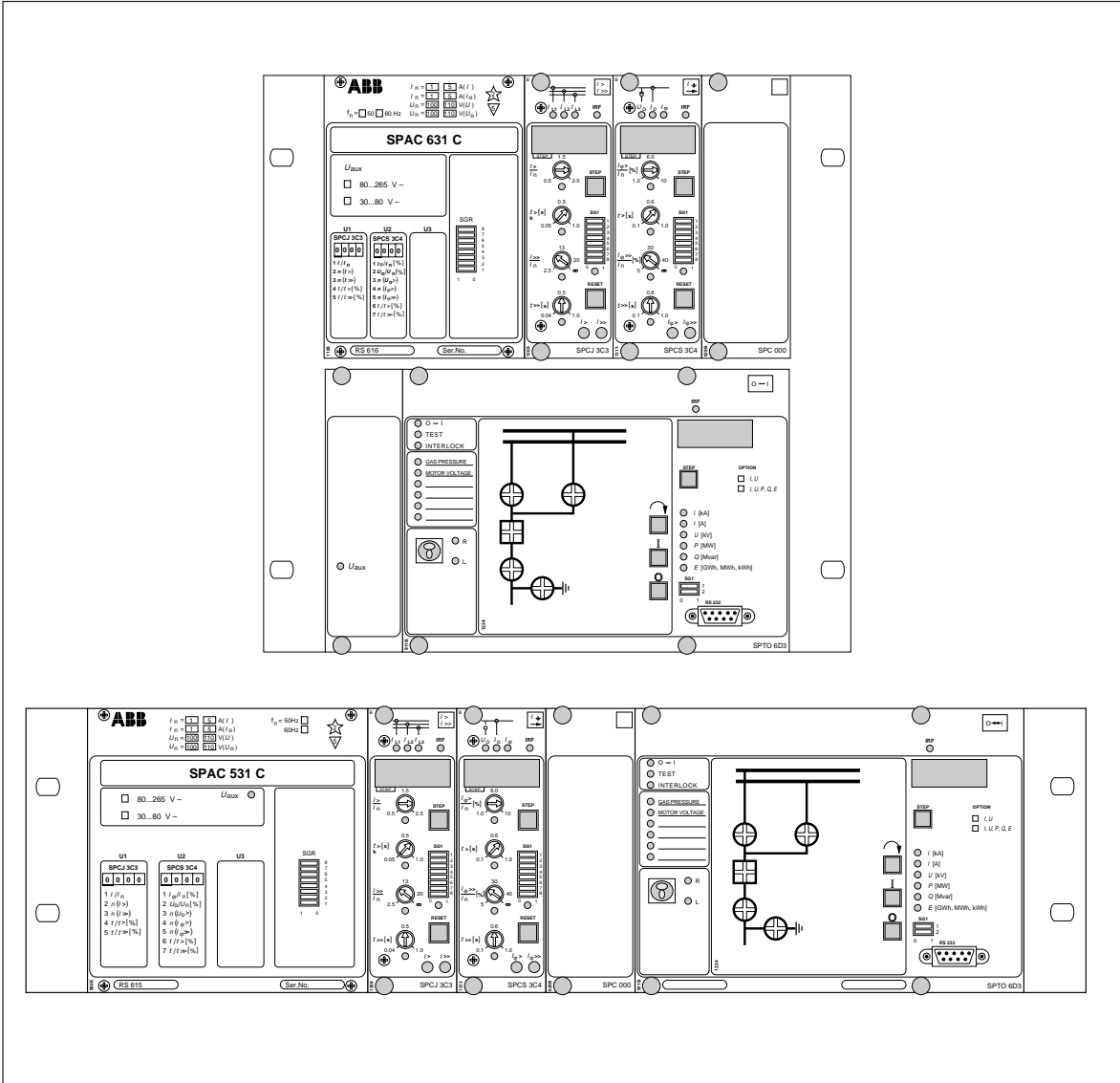


# SPAC 531 C and SPAC 631 C Feeder terminal

User's manual and Technical description



Data subject to change without notice

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### Contents

Features .....	3
Area of application .....	3
Description of function .....	5
Design .....	5
Protection functions .....	8
Auto-reclosing .....	9
Control functions .....	10
Measurement functions .....	11
Serial communication .....	11
Auxiliary power supply .....	11
Mounting and dimension drawings .....	12
Connection diagram .....	14
Intermodular control signal exchange ( <i>modified 2000-10</i> ) .....	17
Terminals and wiring .....	20
Start-up .....	22
Applications .....	23
Technical data ( <i>modified 2002-04</i> ) .....	40
Maintenance and repairs .....	44
Exchange and spare parts .....	44
Delivery alternatives .....	45
Order information .....	46

The user's manual for the feeder terminal SPAC 531 C/SPAC 631 C is composed of the following partial manuals:

General description	1MRS 750852-MUM EN
Control module SPTO 6D3	1MRS 750202-MUM EN
General characteristics of C-type relay modules	1MRS 750328-MUM EN
Overcurrent relay module SPCJ 3C3	1MRS 750602-MUM EN
Directional neutral current relay module SPCS 3C4	1MRS 750350-MUM EN

<b>Features</b>	Complete field unit with definite or inverse time overcurrent protection, directional earth-fault protection and auto-reclosing	Measurement and indication of phase currents, phase-to-phase voltages, energy, active and reactive power
	User-programmable status indication and feeder level interlocking logic	Serial interface for remote control and data interchange
	Local and remote status indication of seven objects and local or remote control of six objects	Continuous self-supervision for maximum reliability
	Seven user-programmable binary inputs with local and remote indication	

**Area of application**

The integrated feeder terminals SPAC 531 C and SPAC 631 C are designed to be used as a cubicle-based protection and remote control interface unit. In addition to protection, control and measurement functions the unit is provided with the data communication properties needed for the control of the feeder. Connection to higher level substation control equipment is carried out via a fibre-optic serial bus. The feeder terminals are available in two mechanical designs, in a 19 inch 3U subrack for SPAC 531 C and a half of a full width 19 inch 6U subrack for SPAC 631 C.

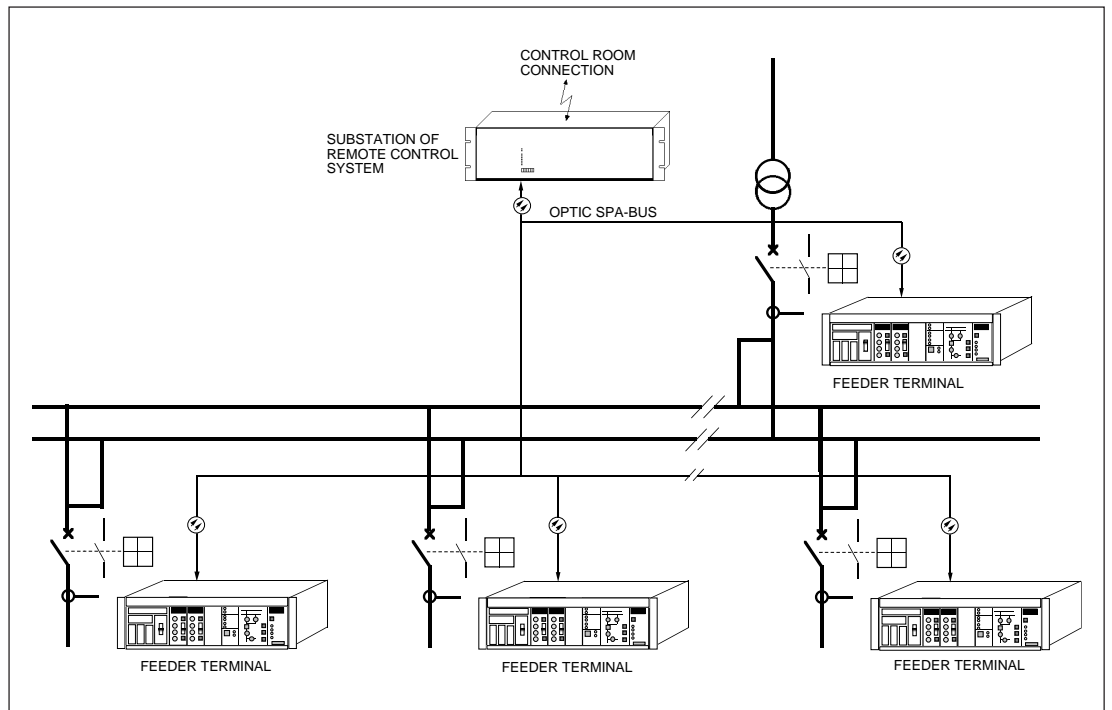


Fig. 1. Distributed protection and control system based on SPAC 531 C feeder terminals

The feeder terminal is designed to be used for the selective short-circuit and earth-fault protection of radial feeders in resonant earthed or isolated neutral power systems. The protection functions are based on an overcurrent module type SPCJ 3C3 and an earth-fault module type SPCS 3C4.

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

Auto-reclosing is integrated in the control module. Up to five high-speed or delayed auto-reclosures can be carried out.

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

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

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

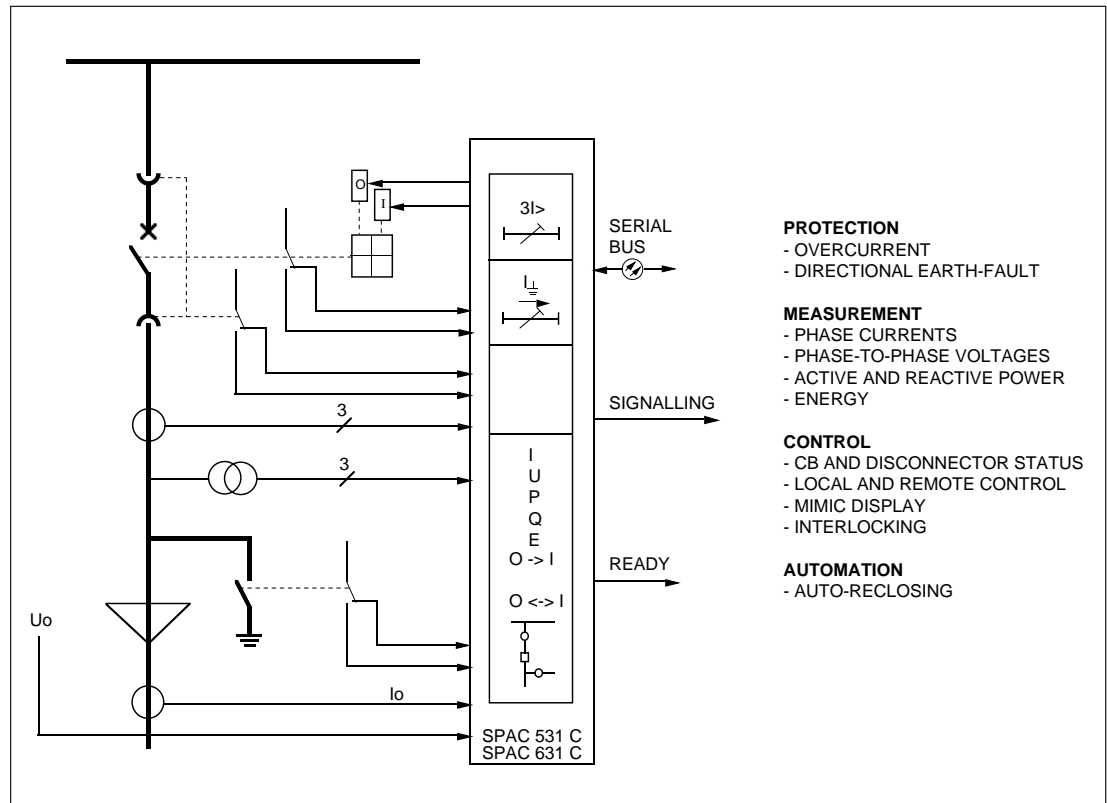


Fig. 2. Basic functions of the integrated feeder terminal SPAC 531 C or SPAC 631 C

**Description of function**

Design

The feeder terminal SPAC 531 C is housed in a 19 inch subrack of Europe size, height 3U (~133 mm) and the feeder terminal SPAC 631 C is housed in a half of a full width 19 inch subrack, height 6U (~266mm). The rear of the subrack is provided with an extension part of galvanized steel sheet.

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

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

Module	Function
Overcurrent relay module SPCJ 3C3	Three-phase, two-stage overcurrent protection. Measures, records and indicates the three phase currents locally and transmits the data to the remote control system.
Directional neutral current module SPCS 3C4	Directional two-stage earth-fault protection. Measures, records and indicates neutral current and residual voltage locally and transmits the data to the remote control system.
Control module SPTO 6D3	Reads and indicates the status data of seven disconnectors or circuit breakers locally and transmits the data to the remote control system. Reads seven external binary signals, indicates six of them locally, and transmits the data to the remote control system. Measures and indicates three phase currents, three phase-to-phase voltages, active and reactive power and energy locally and transmits the information to the remote control system. Executes local or remote open and close commands for a maximum of six circuit breakers or disconnectors. Performs up to five successive high-speed or delayed auto-reclosures.
I/O module SPTR 4D1 or SPTR 4D2 (3 pcs)	Includes 7 optically isolated binary inputs, two OPEN output contacts and two CLOSE output contacts controlled by the control module.
I/O module SPTR 6B11	Includes 3 optically isolated binary inputs and 5 output contacts controlled by the relay modules. Includes an IRF output contact which is common to the relay modules and the control module.
Power supply module SPGU 240A1 or SPGU 48B2	Forms the voltages required by the modules of the feeder terminal.
Energizing input module SPTTE 8C3 (SPAC 531 C) SPTTE 8C4 (SPAC 631 C)	Includes matching transformers and calibration electronics for three phase currents, three phase-to-phase voltages, neutral current and residual voltage.

To be able to measure analog signals the control module requires an optional module.

The functions of the three optional modules available are as follows:

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

The phase overcurrent relay module SPCJ 3C3 and the directional neutral overcurrent relay module SPCS 3C4 are withdrawable Euro-size (100 x 160 mm) modules.

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

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

In SPAC 531 C the power supply module SPGU 240A1 or SPGU 48B2 and the I/O module SPTR 6B11 are located behind the system front panel. The modules can be withdrawn after removal of the system panel.

In SPAC 631 C the power supply module SPGU 240A1 or SPGU 48B2 is located behind the leftmost front plate of the lower level of the subrack. The I/O module SPTR 6B11 is located behind the system front panel. The modules are withdrawable.

The relay modules SPCJ 3C3 and SPCS 3C4 are fastened to the case with two finger screws and the control module SPTO 6D3 with four finger screws. These modules can be pulled out of the subrack after the finger screws have been loosened.

Note !

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

The energizing input module SPTE 8C3 (SPAC 531 C) or SPTE 8C4 (SPAC 631 C) is located behind the system panel in the left part of the case. This module includes the calibration resistors of the secondary burden as well as the matching transformers. A screw terminal block is fitted on the rear plate of the energizing input module.

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

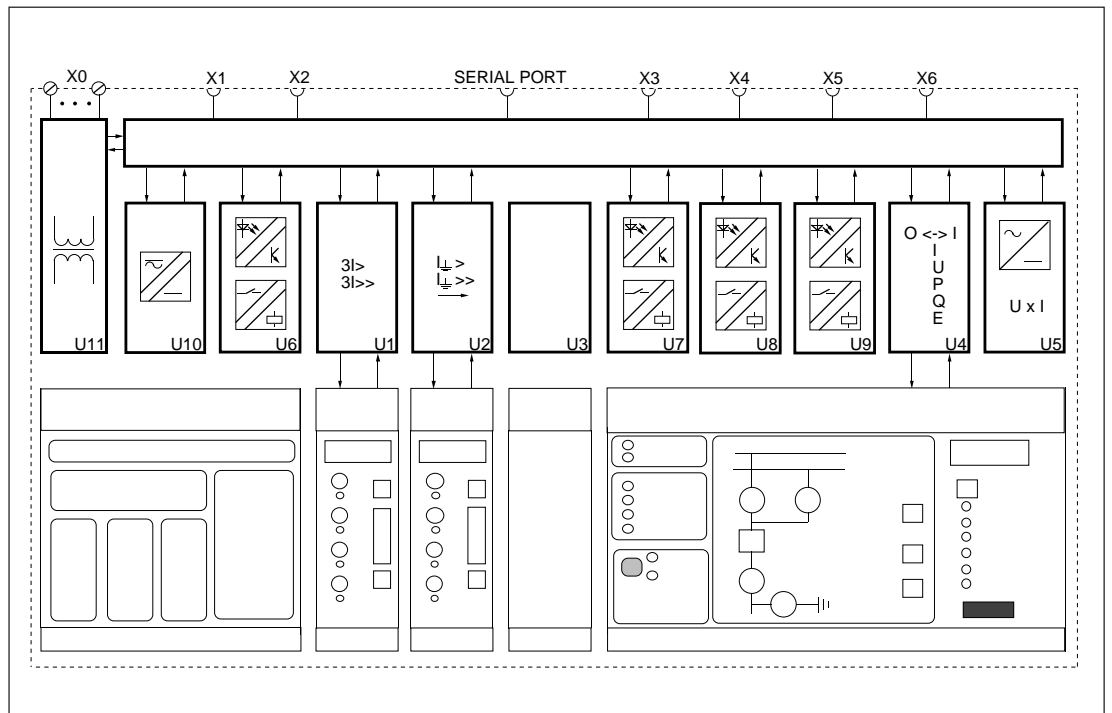


Fig. 3. Block diagram for feeder terminals SPAC 531 C and SPAC 631 C

U1	Overcurrent relay module SPCJ 3C3
U2	Directional neutral current relay module SPCS 3C4
U3	Empty module location
U4	Control module SPTO 6D3
U5	Optional measuring module SPTM 8A1, SPTM 6A2 or SPTM 6A3
U6	I/O module SPTR 6B11 for the protection
U7...U9	I/O modules SPTR 4D1 or SPTR 4D2 for the control module (3 pcs)
U10	Power supply module SPGU 240 A1 or SPGU 48 B2
U11	Energizing input module SPTE 8C3 (SPAC 531 C) or SPTE 8C4 (SPAC 631 C)
X0	Screw terminals
X1...X6	Multi-pole connectors
SERIAL PORT	Serial communication port

Protection functions

*Phase overcurrent protection*

The overcurrent protection of the protection module SPCJ 3C3 includes two operating stages, a low-set stage and a high-set stage. The low-set stage may be given a definite time or an inverse definite minimum time (IDMT) characteristic, whereas the high-set stage can operate with a definite time characteristic only.

The module measures the phase currents of the feeder to be protected. When a phase current exceeds the setting value of the low-set overcurrent stage  $I_{>}$ , the overcurrent stage starts, simultaneously starting its timing circuit. When the set operating time has elapsed, a tripping command is delivered. In the same way the high-set overcurrent stage starts when its setting value is exceeded. It starts its timing circuit and performs a tripping when the circuit has timed out.

*Directional neutral overcurrent protection*

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

when the residual voltage exceeds the set starting value and the neutral current and the phase angle between current and voltage are such that the set starting value  $I_{\phi>}$  is exceeded. When the selected operation time has elapsed the high-set stage delivers a tripping signal.

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

*I/O module SPTR 6B11 of protection modules*

The I/O module SPTR 6B11 of feeder terminal is located behind the system panel. The module can be withdrawn after removal of the system panel. The I/O module includes three optically separated binary inputs (BS1, BS2, BACTRL), five output contacts controlled by the protec-

tion relay modules (output relays A, B, C, D, E) and an IRF output contact (output relay F) that is common to the protection relay modules and the control module and indicates internal feeder terminal fault.

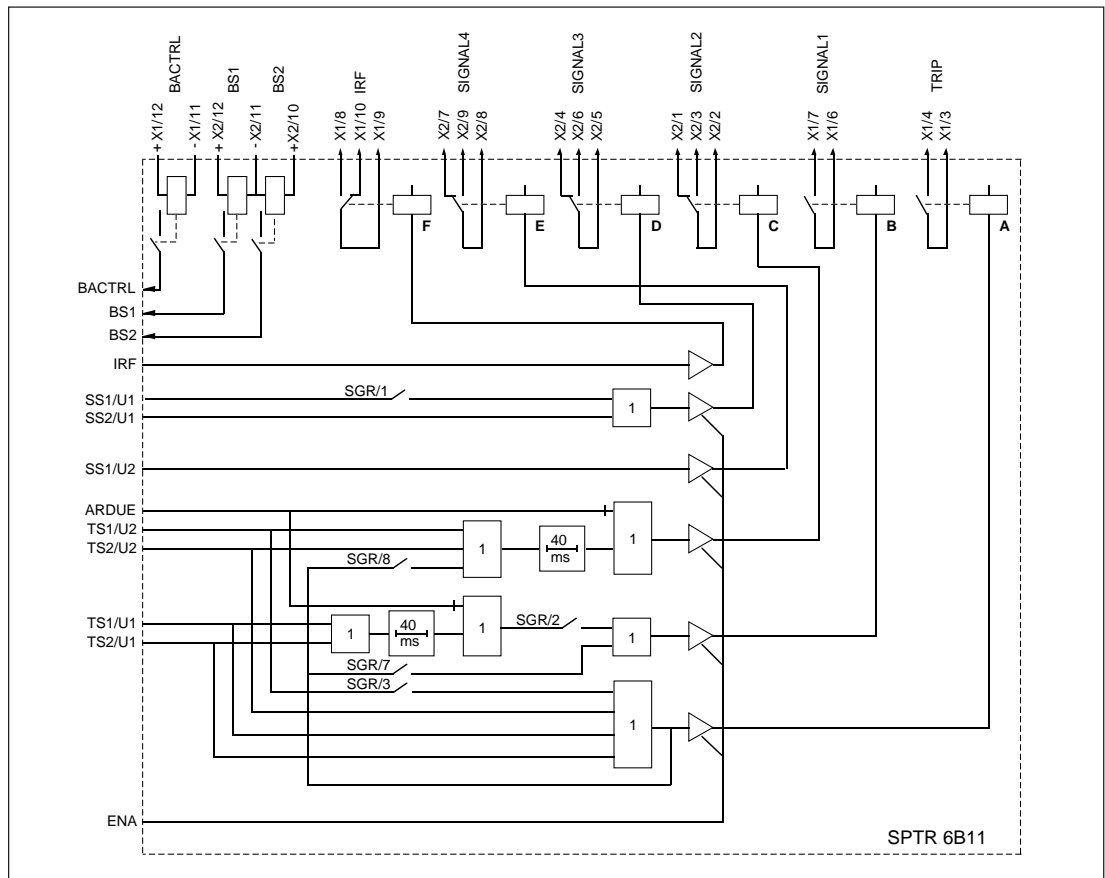


Fig. 4. Block diagram for I/O module SPTR 6B11.



SS1/U1	Start of overcurrent module, stage I>
SS2/U1	Start of overcurrent module, stage I>>
TS1/U1	Trip of overcurrent module, stage I>
TS2/U1	Trip of overcurrent module, stage I>>
SS1/U2	Start of earth-fault module, stage Iφ>
TS1/U2	Trip of earth-fault module, stage Iφ>
TS2/U2	Trip of earth-fault module, stage Iφ>>
ARDUE	"Auto-reclosure due" signal from control module
IRF	Self-supervision
ENA	Enable signal for output signals
A (TRIP)	Trip output 1 of protection relay modules ( I>, I>>, Iφ>, Iφ>>)
B (SIGNAL1)	Alarm output for final trip by overcurrent module or trip output 2 of protection relay modules
C (SIGNAL 2)	Alarm output for final trip by earth-fault module or common alarm output (I>, I>>, Iφ>, Iφ>>)
D (SIGNAL 3)	Output relay for starts of overcurrent module, stages I> and I>>
E (SIGNAL 4)	Output relay for start of earth-fault module, stage Iφ>
F (IRF)	Self-supervision alarm output
BACTRL	Selection of Isinφ/Icosφ operation for earth-fault module using an external control voltage
BS1	Blocking signal 1 for tripping of protection relay modules
BS2	Blocking signal 2 for tripping of protection relay modules

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

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

## Auto-reclosing

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

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

The three start initiating signals are either starting or tripping signals of the protection relay modules. In feeder terminals one of the signals has typically been reserved for starting or tripping signals of the high-set overcurrent stage, one signal has been reserved for starting or tripping signals from the low-set overcurrent stage and one for starting and tripping signals of the low-set earth-fault stage. For the configuration of the signals see chapter "Intermodular control signal exchange".

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

<p>Control functions</p> <p><i>General</i></p>	<p>The control module SPTO 6D3 is used to read the status information of circuit-breakers and disconnectors. The module indicates the status locally by means of LED indicators and transfers the information to station level equipment via the SPA bus. The status of seven objects can be indicated.</p> <p>The control module is also used to control up to</p>	<p>six objects, e.g. circuit breakers or disconnectors, either locally or through opening or closing commands received over the SPA bus.</p> <p>In addition to status information the control module can read other binary data, indicate it locally and transfer the information to station level equipment. A maximum of seven external binary signals can be wired to the feeder terminals.</p>
<p><i>Input channels 1...7</i></p>	<p>The control module uses input channels 1...7 to read status information from circuit breakers and disconnectors. Each of these channels consists of two binary inputs, one for reading open status and the other for reading closed status of an object. This means that the status information must be wired to the feeder terminal as four-pole information.</p> <p>The front panel of SPTO 6D3 has a 4x4 matrix</p>	<p>of status indication LEDs. At a time seven of these LEDs can be used for status indication. The circuit breaker/disconnector configuration indicated by these LEDs is freely selectable by the user.</p> <p>At the most six of the objects whose status is read via input channels 1...7 can be controlled. The outputs OPEN1...6 and CLOSE1...6 operate as the control outputs of the feeder terminal.</p>
<p><i>Input channels 8...14 and 15..17</i></p>	<p>Further, the control module can be used to read seven external and three internal binary signals. The external signals, channels 8...14, can be single contact data wired from the bay and the internal signals, channels 15...17, are starting and tripping signals of the protection relay modules. Compare the diagram "Intermodular control signal exchange" in this manual.</p> <p>The input signal type for 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. The indications of the activations of the external input channels 8...13 can individually be programmed to be memory controlled, which means that the LED corresponding to an input channel, which has been activated for more than 10 ms, remains lit until separately reset. Red light of a LED indicates that the concerned input channel is activated.</p>	<p>The active status of the separate input channels 8...13 can be programmed to remain memorized. Then the LED of the concerned input channel does not go out until the channels is reset by pressing push-buttons STEP and SELECT simultaneously or by giving parameter S5 the value of 0 or 1 via the remote control system.</p> <p>The input channels 8...17 can be used to control the OPEN1...6, CLOSE1...6 and SIGNAL 5 or 6 outputs. When an input channel is activated the OPEN or CLOSE output configured to the channel delivers a control pulse. The SIGNAL outputs are active as long as the input channels are active.</p> <p>Input channel 17 of the control module SPTO 6D3 is not used in feeder terminals SPAC 531 C and SPAC 631 C.</p>
<p><i>Interlocking</i></p>	<p>The control module includes a feeder oriented interlocking logic which can be freely programmed by the user. When writing an interlocking program the user defines when it is allowed to give an open or close signal to a specific object. When an open or close command is given, the interlocking system checks whether the operation is permitted. After that</p>	<p>the command is executed or cancelled.</p> <p>The interlocking can be selected to be depending on the status of the four-pole input channels 1...7 or the input channels 8...17. The tripping signals of the relay modules are not affected by the interlocking system.</p>
<p><i>Direct output control</i></p>	<p>Normally the outputs OPEN1...6 and CLOSE 1...6 are controlled by open or close commands, either given locally with push-buttons or over the serial bus. When Direct Output Control has been selected all outputs, i.e.</p>	<p>OPEN1...6, CLOSE1...6 and SIGNAL5 or 6, can be controlled without an open or close command. The outputs are controlled by a programmed logic and the status of input channels 1...7 and 8...17.</p>

<p>Measurement functions</p>	<p>The control module SPTO 6D3, the overcurrent module SPCJ 3C3 and the neutral current module SPCS 3C4 measure analog signals.</p> <p>The overcurrent module SPCJ 3C3 measures the three phase currents. The measured currents are indicated locally on the display of the overcurrent module and, if necessary, transmitted to higher-level systems over the SPA bus.</p> <p>The directional neutral current module SPCS 3C4 measures three analog signals: neutral current <math>I_0</math>, residual voltage <math>U_0</math>, and <math>I_\phi</math>, which is the resistive or capacitive component of the neutral current. The three analog signals are presented locally on the display of the module and, if necessary, transmitted to higher-level systems over the SPA bus.</p> <p>The relay modules also record the analog signals in a fault situation. The relay modules always indicate the measured values as multiples of the rated current and rated voltage of the feeder terminal.</p> <p>The standard control module is provided with a pulse counter input for the counting of the energy pulses. To be able to measure analog signals the control module SPTO 6D3 requires an optional measuring module: type SPTM 8A1, SPTM 6A2 or SPTM 6A3. When using the measuring module SPTM 8A1 the control module is able to measure three phase currents and three phase-to-phase voltages. Active and reactive power are measured via the mA inputs and external measuring transducers.</p>	<p>When using the measuring module SPTM 6A2 the control module can measure three phase currents and three phase-to-phase voltages. Active and reactive power are measured using an Aron connection and the internal current and voltage signals of the module.</p> <p>When using the measuring module SPTM 6A3 the control module can measure three phase currents and three phase-to-phase voltages. Active and reactive power are measured on the basis of the internal voltage of the module and two current signals. The voltage to be used and the corresponding currents are selected with switches.</p> <p>The ratio of the primary current and voltage transformers can be selected with the control module. Based on these values the control module is able to indicate the currents, voltages and power as primary values. If the mA inputs are used for power measurement, the mA signals can be scaled as actual MW and Mvar values. These primary values can be indicated locally and, when needed, be transmitted to the higher-level system over the SPA bus.</p> <p>Active energy can be measured in two ways; by calculating the value on the basis of the power measured via one of the optional measuring modules, SPTM 8A1, SPTM 6A2 or SPTM 6A3, or by employing input channel 11 as a pulse counter input. In the latter case an external energy meter with pulse output is needed. In both cases the amount of measured energy can be displayed locally and transmitted to the remote control system over the SPA bus.</p>
<p>Serial communication</p>	<p>The feeder terminal includes two serial communication ports, one on the front panel and the other on the rear panel.</p> <p>The 9-pole RS 232 connection on the front panel is intended for the connection of a PC to be used for setting the CB/disconnector con-</p>	<p>figuration, feeder oriented interlocking and other parameters of the control module with a PC.</p> <p>The 9-pole RS 485 connection on the rear panel is used to connect the feeder terminal to the SPA bus via an interface module type SPA-ZC17_ or SPA-ZC21_.</p>
<p>Auxiliary power supply</p>	<p>For its operation the feeder terminal requires a secured auxiliary voltage supply. The feeder terminal's internal power supply module SPGU 240A1 or SPGU 48B2 forms the voltages required by the measuring relay modules, the control module and the input / output modules.</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 with a fuse, F1, located on the PCB of the module. The fuse size is 1 A (slow).</p> <p>A green LED indicator <math>U_{aux}</math> on the front panel is lit when the power supply module is in operation. There are two versions of power supply modules available. The secondary sides of the modules are identical, but the input voltage range is different. The input voltage range is marked on the front panel of the control module.</p>

## Mounting and dimension drawings

### SPAC 531 C

The feeder terminal SPAC 531 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 feeder terminal is door-mounted, the door structure should be reinforced.

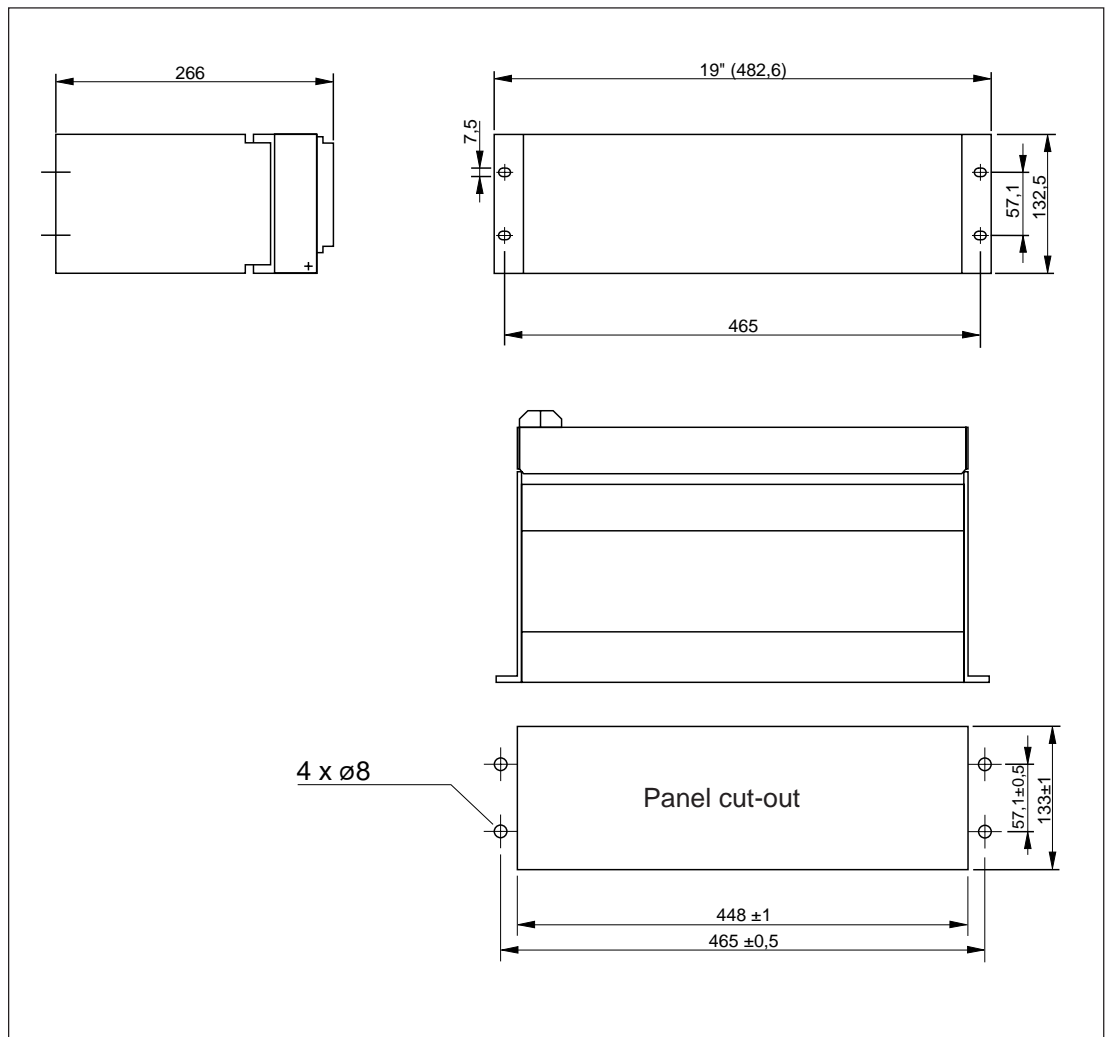


Fig. 5. Mounting and dimensional drawings of the feeder terminal SPAC 531 C

The feeder terminals SPAC 631 C can be used in switchgear cubicles with a limited width. Its mounting depth is also smaller than that of SPAC 531 C. The feeder terminal is fixed to the

frame by means of four screws. When the feeder terminal is door-mounted, the door structure should be reinforced.

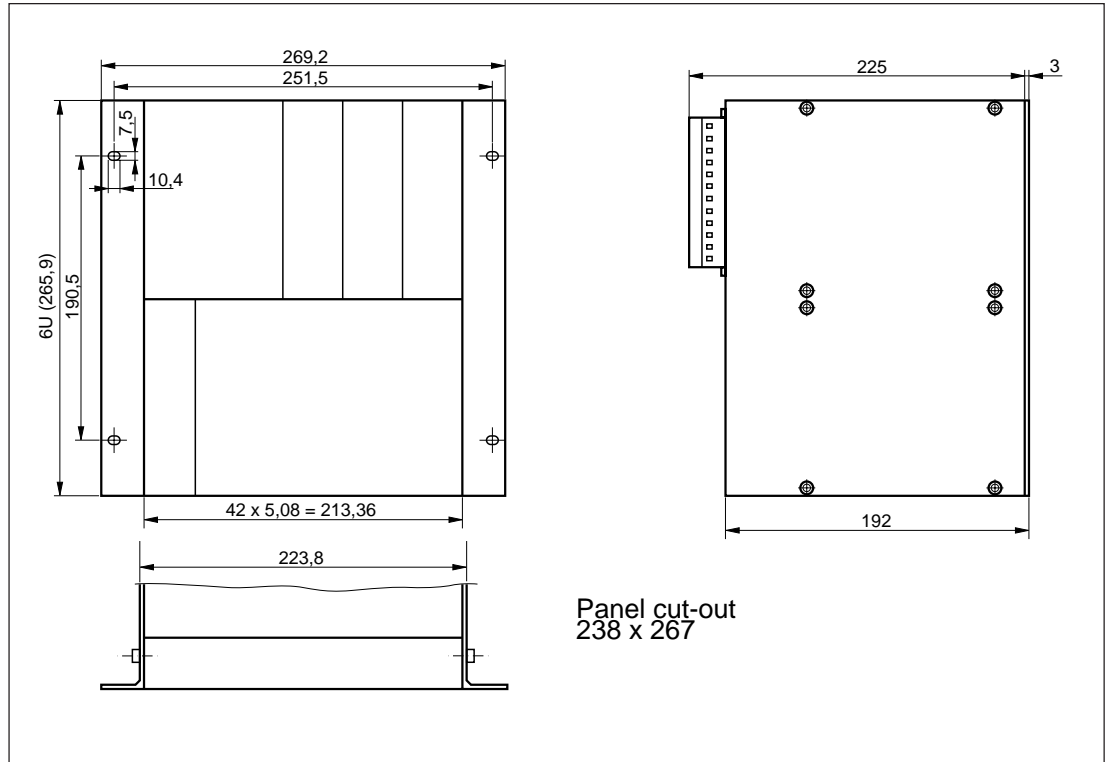


Fig. 6. Mounting and dimensional drawings of the feeder terminal SPAC 631 C

# Connection diagram

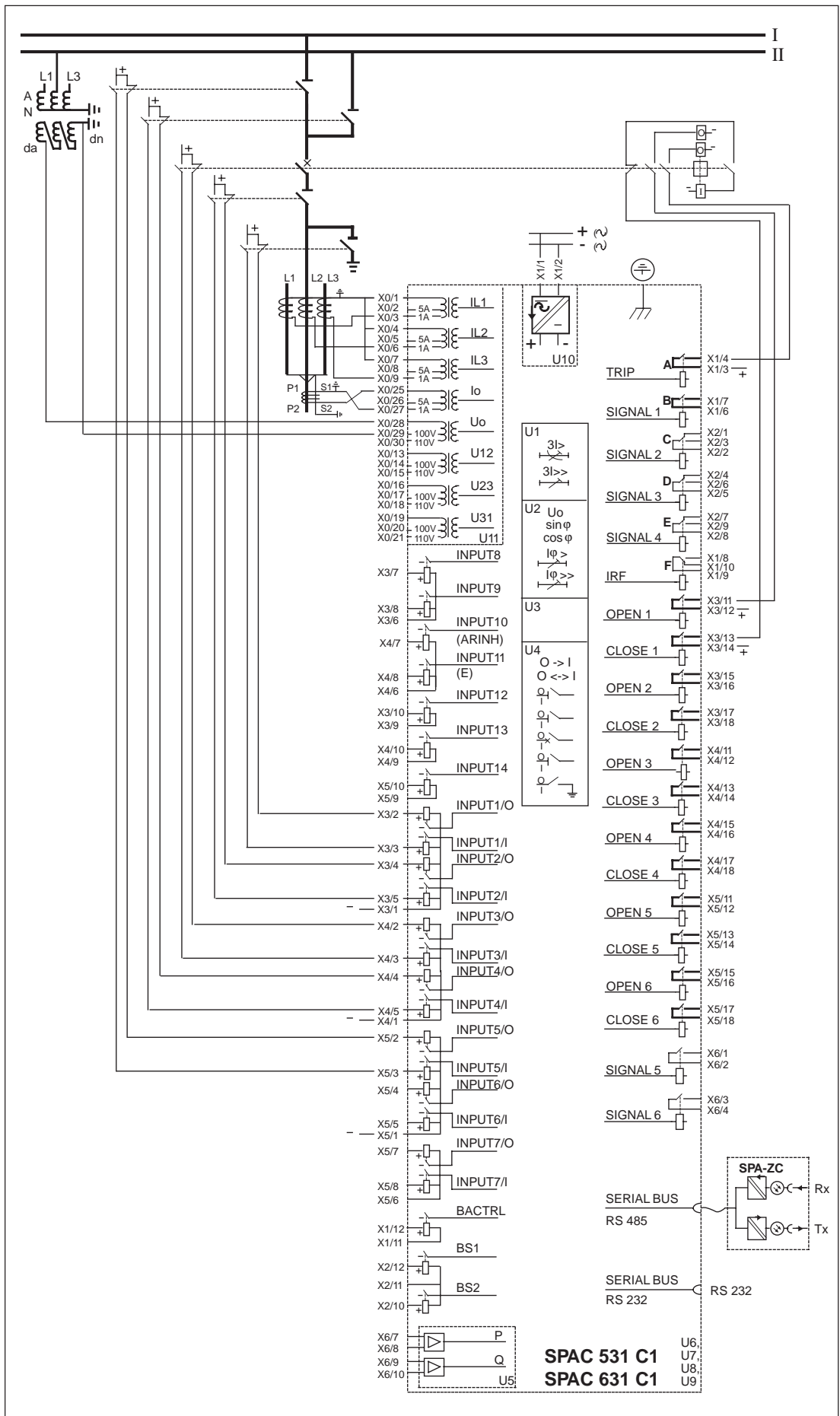


Fig. 7. Connection diagram for the feeder terminals SPAC 531 C and SPAC 631 C. Module U5 is optional

Numbering of 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). Measurement
	13-15	Voltage $U_{12}$ (110 V). Measurement
	16-17	Voltage $U_{23}$ (100 V). Measurement
	16-18	Voltage $U_{23}$ (110 V). Measurement
	19-20	Voltage $U_{31}$ (100 V). Measurement
	19-21	Voltage $U_{31}$ (110 V). Measurement
	25-26	Neutral current $I_0$ (5 A). Earth-fault protection
	25-27	Neutral 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	Tripping output (TRIP) of relay modules ( $I>$ , $I>>$ , $I\phi>$ , $I\phi>>$ )
	6-7	Signal "Final trip on overcurrent; $I>$ , $I>>$ " or tripping output 2 (SIGNAL 1)
	8-9-10	Self-supervision signalling contact (IRF). Operates on the closed circuit principle. In normal condition 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 operating characteristic $I_{sin\phi}/I_{cos\phi}$ for the directional earth-fault module U2 (BACTRL)
X2	1-2-3	Signal "Final trip on earth-fault; $I\phi>$ , $I\phi>>$ " output or "general protection trip; $I>$ , $I>>$ , $I\phi>$ , $I\phi>>$ "-signal output (SIGNAL 2)
	4-5-6	Starting signal ( $I>$ , $I>>$ ) from overcurrent relay module (SIGNAL 3)
	7-8-9	Starting signal ( $I\phi>$ ) from earth-fault relay module (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 e.g. the circuit-breaker is closed, voltage must be applied 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 control module (OPEN 2)
17-18		Close output 2 of 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 control module (OPEN 3)
	13-14	Close output 3 of control module (CLOSE 3)
	15-16	Open output 4 of control module (OPEN 4)
17-18	Close output 4 of control module (CLOSE 4)	
X5	1-2	Input channel 5 of control module, open status (INPUT5/O)
	1-3	Input channel 5 of control module, closed status (INPUT5/I)
	1-4	Input channel 6 of control module, open status (INPUT6/O)
	1-5	Input channel 6 of control module, closed status (INPUT6/I)
	6-7	Input channel 7 of control module, open status (INPUT7/O)
	6-8	Input channel 7 of control module, closed status (INPUT7/I)
	9-10	Input channel 14 of control module (INPUT 14) or input for external autoreclose starting signal, not indicated by LED
	11-12	Open output 5 of control module (OPEN 5)
	13-14	Close output 5 of control module (CLOSE 5)
	15-16	Open output 6 of control module (OPEN 6)
17-18	Close output 6 of control module (CLOSE 6)	
X6	1-2	Signal output 5 of control module (SIGNAL 5)
	3-4	Signal output 6 of control module (SIGNAL 6)
	5-6	Not used
	7-8	mA input 1 (used only with optional measuring module SPTM 8A1)
	9-10	mA input 2 (used only with optional measuring module SPTM 8A1)

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

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

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

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

used to open an object and CLOSE1 output is used to close the same object.



**Intermodular control signal exchange**  
(modified 2000-10)

The initial factory settings of the feeder terminal may have to be changed in different applications. Fig. 8 below illustrates schematically

how the input and output signals of the feeder terminal can be configured to obtain the required functions.

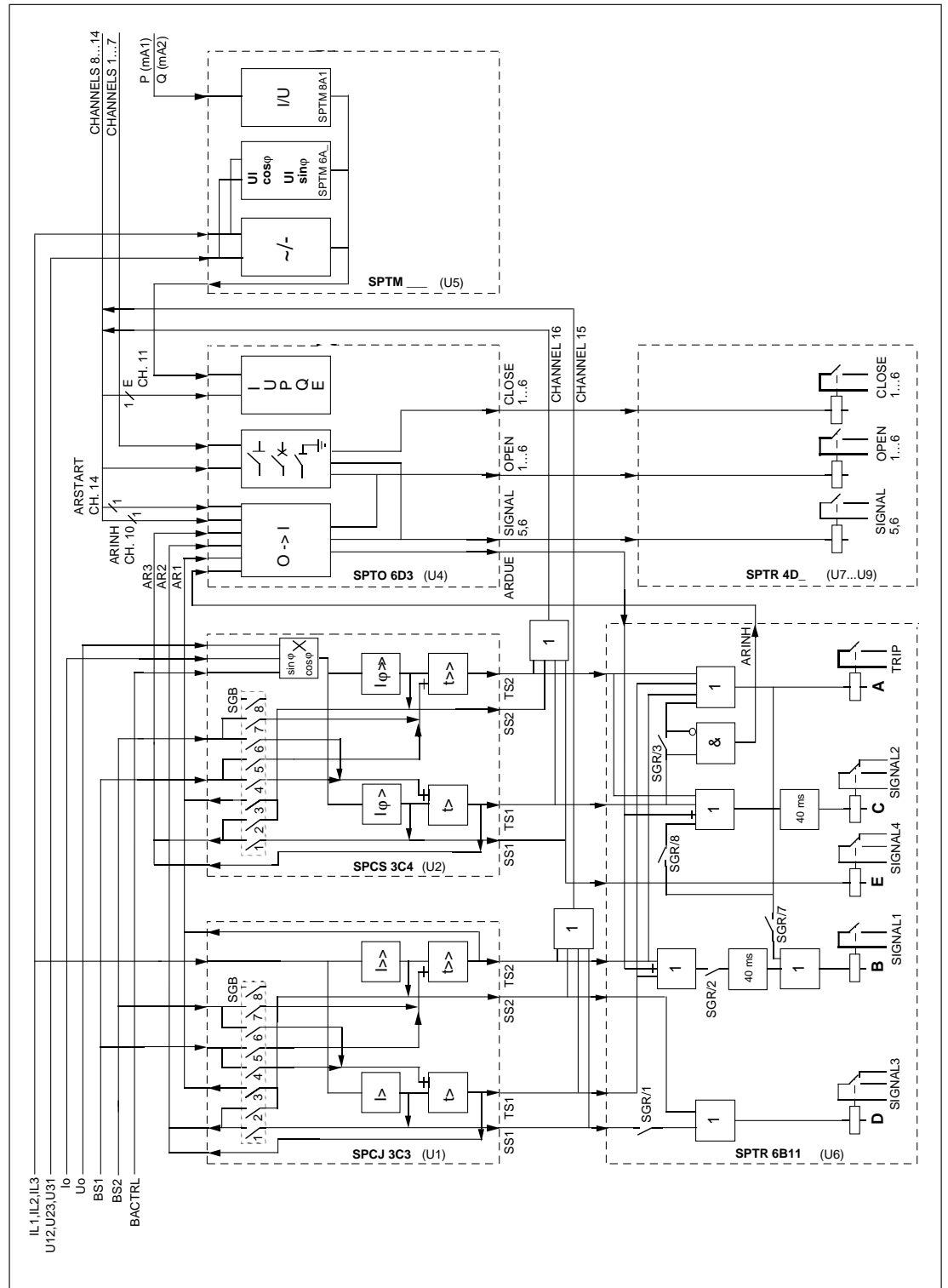


Fig. 8. Intermodular control signals of feeder terminals SPAC 531 C and SPAC 631 C. Input channel 17 is not used in the feeder terminals SPAC 531 C and SPAC 631 C

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

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

The following functions can be selected with the SGR switches:

Switch	Function	Default value
SGR/1	When SGR/1 = 1, the starting signal of stage I> is linked to output SIGNAL3	1
SGR/2	When SGR/2 = 1, the tripping signals of stages I> and I>> are linked to output SIGNAL1	1
SGR/3	When SGR/3 = 1, the tripping signal of stage Iφ> is linked to output TRIP	1
SGR/4	No function in SPAC 531/631 C. Has to be in position 0	0
SGR/5	No function in SPAC 531/631 C. Has to be in position 0	0
SGR/6	No function in SPAC 531/631 C. Has to be in position 0	0
SGR/7	When SGR/7 = 1, all the signals connected to output TRIP are linked to output SIGNAL1	0
SGR/8	When SGR/8 = 1, all the signals connected to output TRIP are linked to output SIGNAL2	0

Note!

Switch SGR/3:

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

Switch SGR/7:

When SGR/7 = 1 the output SIGNAL1 can be used as a second trip output, for instance, in applications with two circuit breakers.

Switch SGR/8:

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

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

The switches of the programming switchgroup SGB on the PC boards of the overcurrent and earth-fault modules are used for linking the starting signals of the relay modules to the starting inputs of the auto-reclose module. The SGB switches are also used for connecting the incoming blocking signals to the protection.

The SGB switches on the PC board of the overcurrent module SPCJ 3C3 have the following functions:

Switch	Function	Default value
SGB/1	Links the starting signal of stage I> to the starting input AR2 of the auto-reclose module. (generally the starting input of AR initiated by the low-set overcurrent stage)	1
SGB/2	Links the starting signal of stage I>> to the starting input AR2 of the auto-reclose module	0
SGB/3	Links the starting signal of stage I>> to the starting input AR1 of the auto-reclose function. (generally the starting input of AR initiated by the high-set overcurrent stage)	1
SGB/4	Forms from the blocking input signal BS1 a blocking signal for the tripping of stage I>	0
SGB/5	Forms from the blocking input signal BS1 a blocking signal for the tripping of stage I>>	0
SGB/6	Forms from the blocking input signal BS2 a blocking signal for the tripping of stage I>	0
SGB/7	Forms from the blocking input signal BS2 a blocking signal for the tripping of stage I>>	0
SGB/8	No function in SPAC 531/631 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.

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

Switch	Function	Default value
SGB/1	Links the starting signal of stage I $\phi$ > to the starting input AR3 of the auto-reclose module (generally the starting input of AR initiated by the low-set earth-fault stage)	1
SGB/2	Links the starting signal of stage I $\phi$ >> to the starting input AR3 of the auto-reclose module	0
SGB/3	Links the starting signal of stage I $\phi$ >> to the starting input AR1 of the auto-reclose module	0
SGB/4	Forms from the blocking input signal BS1 a blocking signal for the tripping of stage I $\phi$ >	0
SGB/5	Forms from the blocking input signal BS1 a blocking signal for the tripping of stage I $\phi$ >>	0
SGB/6	Forms from the blocking input signal BS2 a blocking signal for the tripping of stage I $\phi$ >	0
SGB/7	Forms from the blocking input signal BS2 a blocking signal for the tripping of stage I $\phi$ >>	0
SGB/8	No function in SPAC 531/631 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.

## Terminals and wiring

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

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

The measuring signal inputs are connected to terminal block X0. Each terminal is dimensioned for one max. 6 mm<sup>2</sup> or two max. 2.5 mm<sup>2</sup> 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 relay modules are connected to the multi-pole connectors X1 and X2. The auxiliary power supply is connected to the multi-pole connector X1. The binary inputs, mA inputs and contact outputs of the control module are connected to the multi-pole connectors X3...X6. One max. 1.5 mm<sup>2</sup> wire or two max. 0.75 mm<sup>2</sup> wires can be connected to one screw terminal.

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

17\_ is connected to the feeder terminal with the cable included in the delivery of the module and fastened to the wall of the switchgear cubicle with screws.

The 9-pole D-type subminiature connector INTERLOCK is reserved for future use.

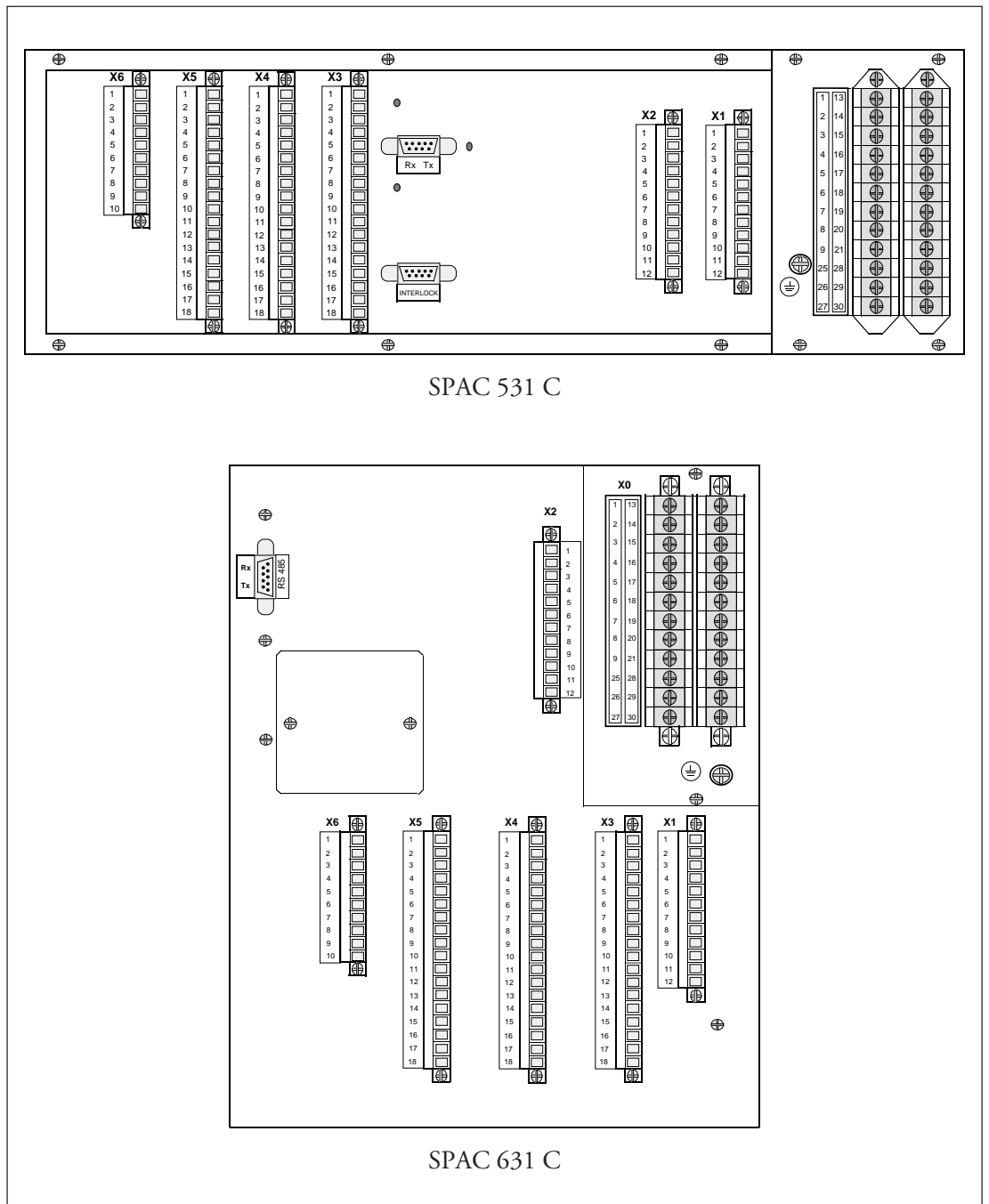


Fig. 9. Rear view of feeder terminal SPAC 531 C and SPAC 631 C

## Start-up

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

### 1. Voltage ranges of the binary inputs

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

### 2. Auxiliary supply voltage

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

### 3. Setting of the control module SPTO 6D3

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

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

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

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

### 4. Settings of overcurrent and earth-fault modules

At the factory the switches of the overcurrent and earth-fault modules have been given default values, see chapter "Intermodular control signal exchange". If auto-reclose functions or blockings are used for the relay modules, check the positions of the SGB switches on the PC boards of the modules SPCJ 3C3 and SPCS 3C4.

The front panel potentiometers of the protective relay modules are set in the middle position and all the front panel switches SG1 are turned off. The functions of the front panel switches of the overcurrent and earth-fault relay modules are explained in the manual of the overcurrent relay module SPCJ 3C3 and in the manual of the directional earth-fault relay module SPCS 3C4.

Fig. 10 shows a substation, in which the protection and control functions are based on feeder terminals type SPAC 531 C and SPAC 533 C.

For clarity reasons other protection relays have been omitted.

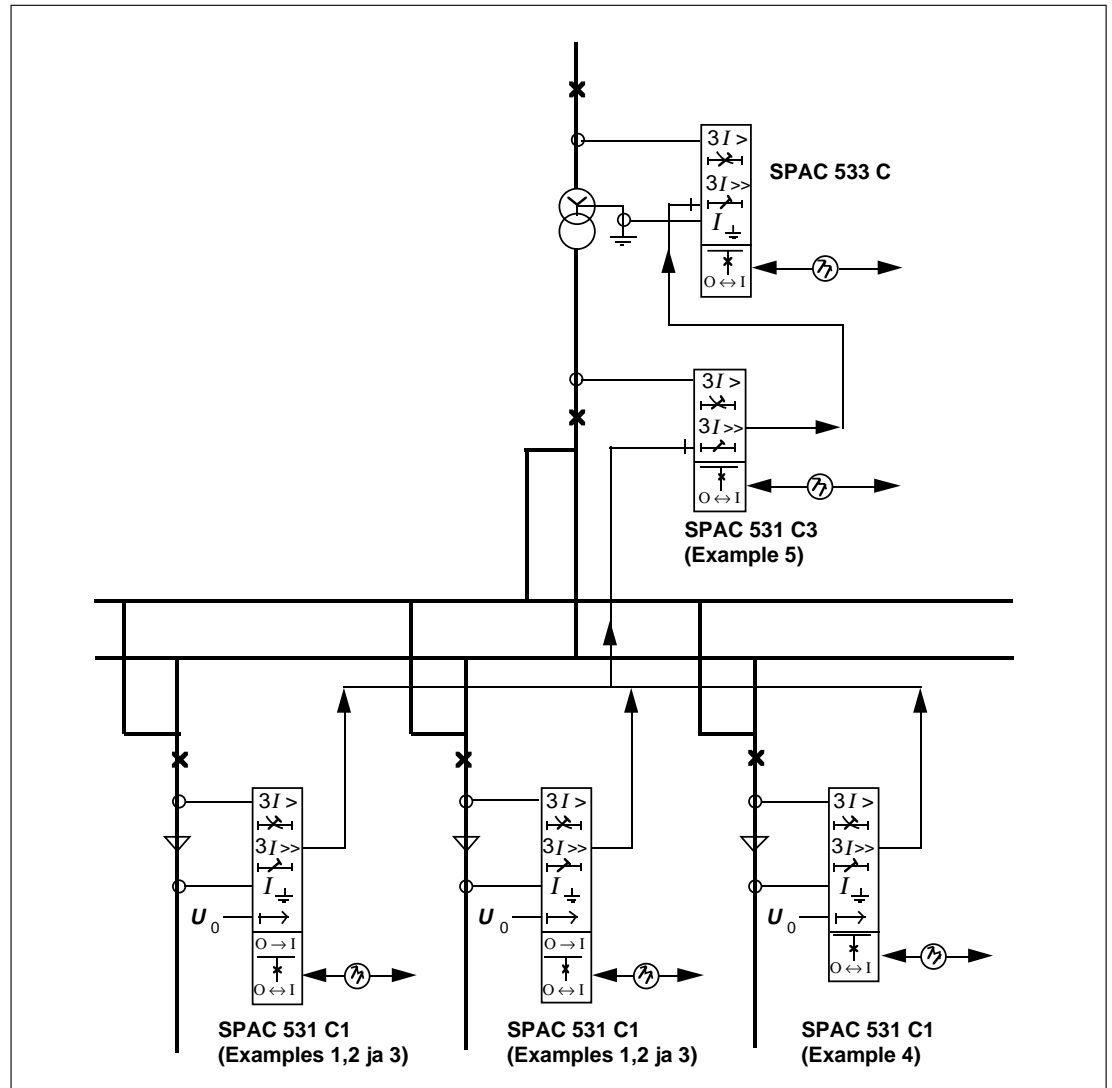


Fig. 10. Substation protection and control using SPAC 530 series feeder terminals. Other protection relays and the connection of the remote control system have been omitted.

In the example in Fig. 11 the protection of the outgoing feeders and the control of the circuit breakers are based on the feeder terminal SPAC 531 C1. This version is a fully equipped unit including overcurrent and short circuit protection, directional earth fault protection and a control module.

533 C feeder terminal which includes a dual-stage overcurrent and a dual-stage earth fault protection module, a harmonics measuring blocking module and a control module. When starting the overcurrent relay of the low voltage side blocks the high-set stage of the HV side overcurrent relay.

A feeder terminal type SPAC 531 C3 is used for protecting the incoming feeder cubicle and the busbar system and for controlling the circuit breakers. This version includes a three-phase overcurrent module and a control module. The operation of the busbar protection equipment is blocked by the starting signals of the overcurrent modules of the outgoing feeders.

The feeder terminals of the SPAC 530 series can be used both in one-breaker systems and in two-breaker systems. The examples 1 to 5 describe different protection methods and situations in one-breaker systems. Example 6 shows a basic two-breaker system.

The protection of the high voltage side of the power transformer and the control of the circuit breaker have been implemented using a SPAC

The operation of the feeder terminal SPAC 531 C1 used in a two-breaker system is the same as that of a SPAC 531 C1 used in a one-breaker system, except for certain contact functions.

Example 1.  
Feeder terminal  
SPAC 531 C1 for  
the protection of an  
outgoing feeder in a  
one-breaker system.

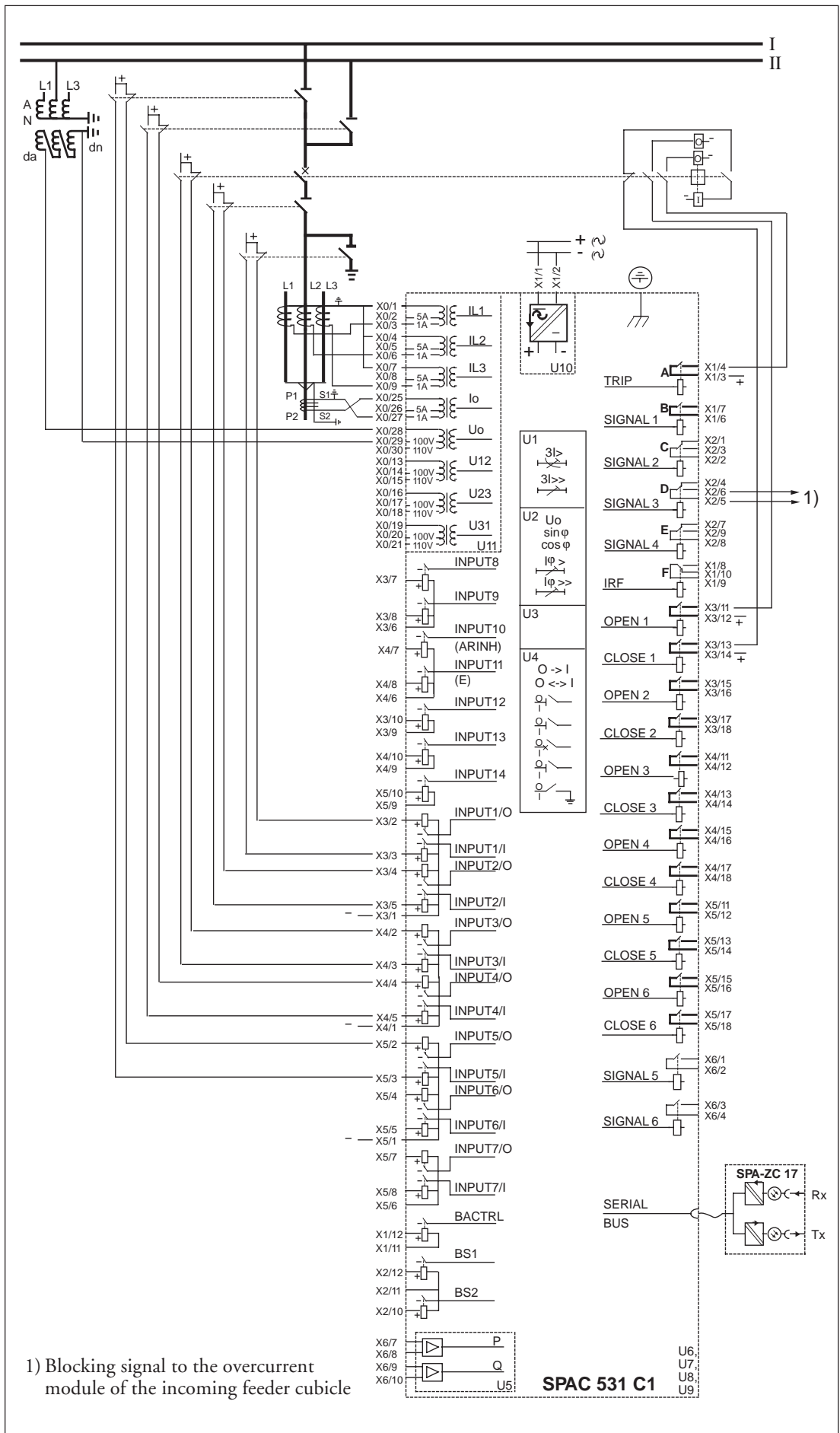


Fig. 11. Feeder terminal SPAC 531 C1 used for protecting an outgoing feeder. The earth-fault relay module has a tripping function.



The SG1 switchgroups on the front plates of the measuring relay modules and the control module shown in the example in Fig. 11, can be set in accordance with the following table.

Switch	SG1/SPCJ 3C3	SG1/SPCS 3C4	SG1/SPTO 6D3
1	0 } $t_{>} = 0.05...1.00$ s	0 $I_{\phi>>}$ forward dir.	0 blockings operative
2		0 } $I_{\sin\phi}$ , manual select.	0 AR in use
3	0 definite time oper.	1 } no self-holding	
4	0 no self-holding	0 no self-holding	
5	0 no $I_{>>}$ doubling	1 $t_{>} = 1...10$ s	
6	0 $I_{>>} = 2.5...20 \times I_n$	0 $I_{\phi>>} = 5...40\% \times I_n$	
7	0 } $t_{>>} = 0.04...1.00$ s	0 } $U_0 = 10\% \times U_n$	
8			1 } $U_0 = 10\% \times U_n$
	Checksum = 0	Checksum = 148	

The SGB switches on the PC boards of the measuring relay modules and the SGR switches at the front edge of the I/O module SPTR 6B11 are to be set as follows:

Switch	SGB/SPCJ 3C3	SGB/SPCS 3C4	SGR
1	1 $I_{>}$ start to AR2	1 $I_{\phi>}$ start to AR3	0 no $I_{>}$ start to SIGNAL 3
2	0 no $I_{>>}$ start to AR2	0 no $I_{\phi>>}$ start to AR3	1 $I_{>}$ and $I_{>>}$ trip to SIGNAL 1
3	1 $I_{>>}$ start to AR1	0 no $I_{\phi>>}$ start to AR1	1 $I_{\phi>}$ trip to TRIP output
4	0 no block. BS 1 to $t_{>}$	0 no block. BS 1 to $t_{>}$	0 not in use
5	0 no block. BS 1 to $t_{>>}$	0 no block. BS 1 to $t_{>>}$	0 not in use
6	0 no block. BS 2 to $t_{>}$	0 no block. BS 2 to $t_{>}$	0 not in use
7	0 no block. BS 2 to $t_{>>}$	0 no block. BS 2 to $t_{>>}$	0 no TRIP sign. to SIGNAL 1
8	0 not in use	0 not in use	0 no TRIP sign. to SIGNAL 2

With above SGB and SGR settings the output contacts of feeder terminal SPAC 531 C1 have the following functions:

Contact	Function
X1/3-4	Opening 1 of CB ( $I_{>}$ , $I_{>>}$ , $I_{\phi>}$ , $I_{\phi>>}$ )
X1/6-7	Signal for final trip ( $I_{>}$ and $I_{>>}$ )
X2/1-2-3	Signal for final trip ( $I_{\phi>}$ and $I_{\phi>>}$ )
X2/4-5-6	$I_{>>}$ start and blocking to overcurrent module of incoming feeder cubicle
X2/7-8-9	$I_{\phi>}$ start
X1/8-9-10	Self-supervision alarm (IRF)
X3/11-12	Opening 2 of CB (local control, remote control, AR)
X3/13-14	CB closing

The function of the contacts for CB opening 2 and closing 2 is determined by the configuration of the control module.

In the example illustrated in Fig. 11 the overcurrent module U1 (SPCJ 3C3) operates as the overcurrent and short circuit protection of the outgoing feeder. The setting of the low-set current stage extends to the range of the high-set stage. The high-set overcurrent stage operates

for short circuits occurring near the substation. If the feeder is provided with branch circuit breakers near the substation, it may be necessary to delay the high-set stage, too, in order to obtain time grading. Current asymmetry, if any, may be disregarded when the current setting is determined, because due to the peak-to-peak measurement method employed, asymmetry will not increase the sensitivity of the protection.

When a short circuit occurs in the protected feeder, the overcurrent module records the current value at the moment of tripping and indicates the faulty phases. The current level shows how distant the fault is and the type of fault, that is, whether it is a two-phase or three-phase fault.

The recorded values can also be used to verify the correctness of the setting values. In a fault situation the correspondence between the relay settings and the actual currents can be verified. In the same way a comparison of the setting values and the values during normal operation is allowed. The length of the starting signal of the relay indicates the duration of a connection inrush current.

The neutral overcurrent relay module U2 (SPCS 3C4) operates as a directional dual-stage earth-fault protection of the outgoing feeder. In the application illustrated in Fig 11, where the earth-fault relay module has a tripping function, the SGR/3 switch of the I/O module has to be in position 1.

The low-set stage of the earth-fault relay module is set low enough to fulfil the sensitivity requirements of the safety regulations. The requirements concerning operate times are basically fulfilled by the operate time of the high-set stage.

The neutral overcurrent module can be used in networks with resonant earthed, resistively earthed and isolated neutrals.

When an earth fault occurs on the protected feeder, the level of the neutral current is recorded by the earth-fault relay module. The residual voltage is recorded by the relay module monitoring the residual voltage of the measuring cubicle. The degree of development of the earth fault can be determined on the basis of these values.

The control module U4 (SPTO 6D3) includes an auto-reclose function carrying out the auto-reclose functions required on the feeder. In this example the AR starts are initiated by starting of the neutral overcurrent or the phase overcurrent module. The scheme in Fig. 12 shows the signals and their time interdependence.

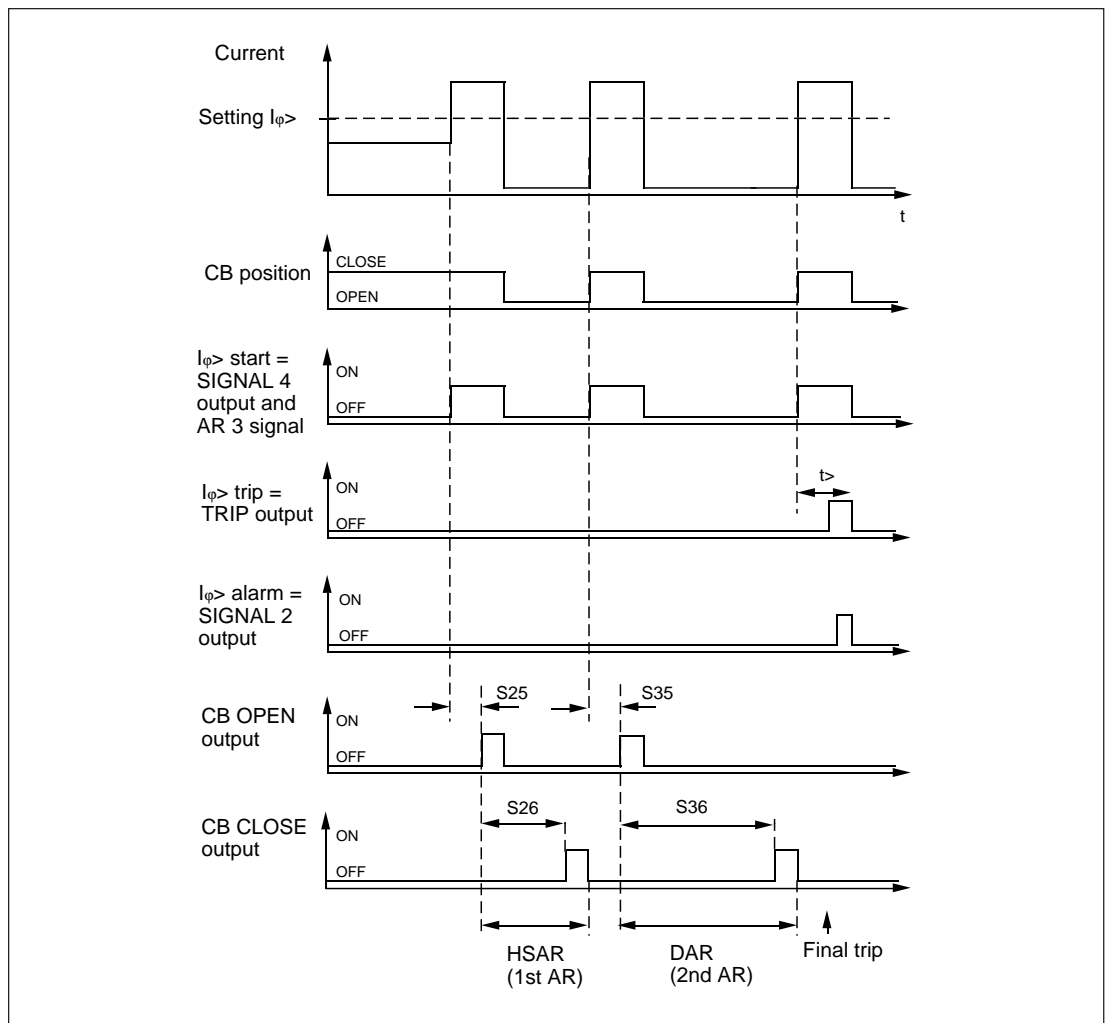


Fig. 12. Signal diagram for an auto-reclose sequence initiated by starting of the  $I_{\phi}>$  stage.

In this example the trips are initiated by the auto-reclose unit. The start signals are routed via the SGB switches to the auto-reclose module that performs a preprogrammed auto-reclose sequence. AR start times are determined by the parameters S24, S25 and S35, dead times by the parameters S26 and S36. When the AR sequence has been completed, the relay module delivers a final trip signal to the output TRIP (contact X1/3-4). When the overcurrent module has performed final tripping an alarm signal is received from the output SIGNAL 1 (contact X1/6-7), whereas final tripping initiated by the earth-fault relay module produces an alarm signal via output SIGNAL 2 (contact X2/1-2-3).

The AR unit is programmed either from a PC connected via the RS 232 serial port on the front panel or over the remote control system via the SPA bus interface on the rear panel. The parameters to be used have been explained in the manual for the control module SPTO 6D3.

AR functions initiated by overcurrent or earth fault can be separately delayed. Unwanted auto-reclose functions due to load inrush currents or transient earth faults can be averted by delaying the start of a high-speed auto-reclose (HSAR) sequence. In the same way, the delay of a delayed auto-reclose (DAR) sequence prevents an unwanted DAR cycle caused by switching inrush currents following a HSAR cycle. Both HSAR and DAR functions can be initiated by the high-set phase overcurrent stage. Then the auto-reclose functions start without a preceding start delay.

With the setting shown in example 1 only HSAR functions are started by the phase overcurrent module and both HSAR and DAR functions by the neutral overcurrent module. No auto-reclose functions are started by the high-set phase overcurrent stage.

In the example HSAR has been defined as AR1 and DAR as AR 2.

Parameter	Value	Function
S78	1	Alerts the auto-reclose functions
S21	0	Prevents AR1 from starting by tripping of the high-set phase overcurrent stage
S22	1	Starts AR1 initiated by phase overcurrent
S23	1	Starts AR1 initiated by neutral overcurrent
S24	0.10	Sets AR1 starting time at 0.1 s, AR initiated by phase overcurrent
S25	0.50	Sets AR1 starting time at 0.5 s, AR initiated by neutral overcurrent
S26	0.30	Sets AR1 dead time at 0.3 s
S31	0	Prevents AR2 from starting initiated by tripping of the high-set phase overcurrent stage
S32	0	Does not start AR2 initiated by phase overcurrent
S33	1	Starts AR2 initiated by neutral overcurrent
S35	0.50	Sets AR2 starting time at 0.5 s, AR initiated by neutral overcurrent
S36	120	Sets AR2 dead time at 120 s
S77	5.0	Sets the reclaim time at 5.0 s
V151	1	Stores the input parameters

The setting of the AR parameters is described in detail in the manual for the control module SPTO 6D3.

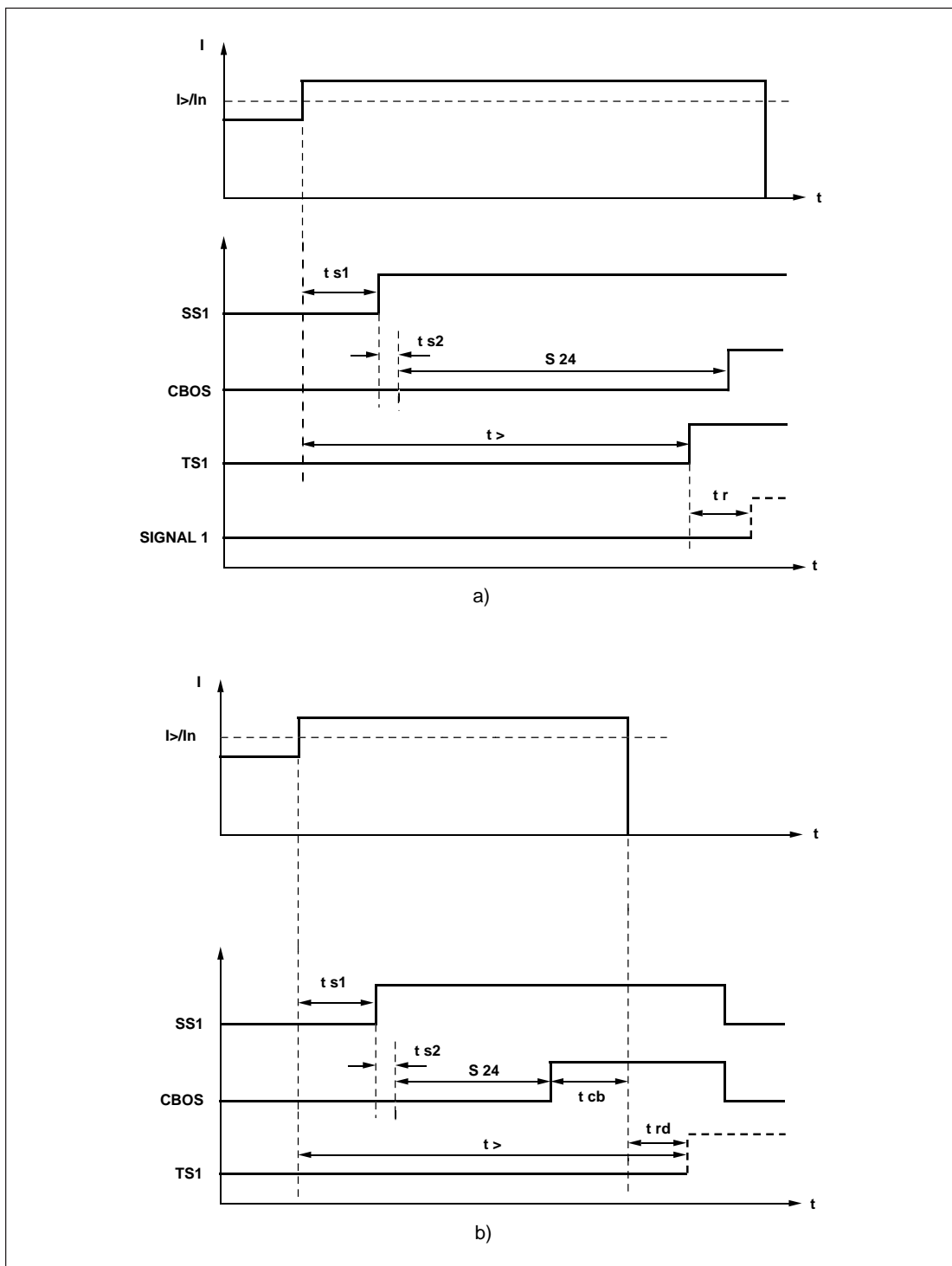


Fig. 13. Setting of auto-reclose starting times

$I$	Current
$I > I_n$	Starting current level
SS1	Starting signal of phase overcurrent module
TS1	Tripping signal of phase overcurrent module
OPEN	CB opening signal at AR
SIGNAL1	Contact X1/6-7
$t_{s1}$	Starting time of phase overcurrent module
$t_{>}$	Operate time of phase overcurrent module
$t_{s2}$	Starting time of auto-reclose unit
S24	Operate time of auto-reclose unit
$t_{cb}$	CB operate time
$t_{rd}$	Retardation time
$t_r$	Delay of contact X1/6-7

The final CB trip signal delivered by the overcurrent and earth-fault relay module (contacts X1/6-7 or X2/1-2-3) is delayed about 40 ms by the electronics of the relay. When the AR functions are initiated by starting of the phase overcurrent module, the starting time setting of the auto-reclose unit must be 50 ms shorter than the operate time  $t_{>}$  of the phase overcurrent module to prevent the signal contact X1/6-7 from providing an unwanted signal when an auto-reclose sequence starts. After that the operation of the signalling relay is blocked when an auto-reclose sequence starts. This situation is illustrated in Fig 13 a.

When the neutral overcurrent module starts an auto-reclose sequence, the starting time setting of the auto-reclose unit should be about 150 ms shorter than the operate time  $t_{>}$  of the neutral overcurrent module.

In the situation above there is enough time for the red operation indicator of the phase overcurrent and neutral overcurrent module to go on and information about tripping is received over the SPA bus, although no contact alarm signal is received. To prevent the red operation indicator from going on and the trip message from being transmitted over the serial bus, the starting time setting of the auto-reclose unit should be about  $100 \text{ ms} + \text{CB operate time } t_{\text{cb}}$  shorter than the operate time  $t_{>}$  of the phase overcurrent module. Fig. 13 b illustrates this situation.

In the same way the starting time setting of the auto-reclose unit has to be about  $200 \text{ ms} + \text{CB operating time } t_{\text{cb}}$  shorter than the operate time of the earth-fault relay module.

The starting times of the auto-reclose unit can also be used for time grading functions when the feeder includes line branch circuit breakers. Starting of the auto-reclose functions regarding the entire feeder can be delayed so much that the branch circuit breaker relay has time to operate and open the circuit breaker of the faulty branch. By grading the operate times of the relays of the branch circuit breakers it is possible to locate a faulty branch on the basis of the durations of the starting signals recorded by the substation relays.

The auto-reclose function of the control module allows five successive HSAR and/or DAR cycles. The dead time of each auto-reclose cycle can be set in the range 0.2...300 s, at 0.1 s steps. When voltage controlled line sectionalizers are used, this feature can be used for locating a fault. The first isolator opens during the first AR cycle, the second during the second AR cycle and so on. Should the fault persist after the last DAR, final CB tripping will follow.

The AR counters of the control module provide specific information about the cause of an auto-reclose function. The information of these counters, data recorded by the measuring modules and statistical information indicate what measures are to be taken, that is, if it is necessary to clear a line road or to remove snow from the line or if there is a normal earth fault or short circuit caused by atmospheric overvoltages. The counter data also show whether a connection inrush current has caused unwanted DAR functions.

When the circuit breaker is closed manually over the control module, either locally or remotely, the reclaim time starts and the auto-reclose functions are blocked. Before the auto-reclose program opens or closes the circuit breaker, it checks the blocking program, to find out whether the control operation is permitted or not.

When the circuit breaker is closed manually, but not via the push-buttons of the control module or via the remote control system, the connection inrush current may lead to an unwanted auto-reclose function. This can be avoided by applying a blocking signal to the auto-reclose unit when the CB is closed and by giving the input the function of blocking and interrupting auto-reclose functions. The blocking signal is routed to terminals X4/6-7 of the feeder terminal. When the circuit breaker is closed against a fault this blocking signal provides final CB tripping without auto-reclosures. The blocking signal can also be used for interrupting an auto-reclose sequence going on.

The auto-reclose functions can be tested by means of the Trip test function of the relay modules. This test includes the entire auto-reclose sequence plus the circuit breaker.

Example 2.

Feeder terminal SPAC 531 C1 used for the protection of an outgoing feeder in a one-breaker system. The auto-reclose unit is started by the tripping signals of the phase overcurrent and neutral overcurrent modules.

In the application illustrated in Fig. 11 auto-reclosing can be started by the tripping signal of the high-set and low-set phase overcurrent stage and the low-set stage of the earth-fault module. The operate time of the stage starting the auto-reclose unit must not be longer than the reclaim time selected for the auto-reclose unit. Should the operate time be longer than the reclaim time, the auto-reclose unit resets before a new start signal is received and the sequence will not be completed.

In the application presented in example 2 the starting times of the auto-reclose unit have to be set at zero, because otherwise there will not be enough time for the auto-reclose unit to be started by the tripping signal. To prevent the auto-reclose module from being started by the starting signal of the low-set phase overcurrent and low-set neutral overcurrent stage ( $I>$  or  $I\phi>$ ) the SGB/1 switches on the PC boards of the concerned modules have to be in position 0. Since the start of the  $I>>$  stage is used for blocking the auto-reclose unit, the starting signal is routed to the auto-reclose unit via the SGB/3 switch.

The SGB switches on the PC boards of the relay modules and the SGR switches at the front edge of the I/O module SPTR 6B11 should be set as follows:

Switch	SGB/SPCJ 3C3	SGB/SPCS 3C4	SGR
1	0 no $I>$ start to AR2	0 no $I\phi>$ start to AR3	0 no $I>$ start to SIGNAL 3
2	0 no $I>>$ start to AR2	0 no $I\phi>>$ start to AR3	1 $I>$ and $I>>$ trip to SIGNAL 1
3	1 $I>>$ start to AR1	0 no $I\phi>>$ start to AR1	1 $I\phi>$ trip to TRIP output
4	0 no block. BS 1 to $t>$	0 no block. BS 1 to $t>$	0 not in use
5	0 no block. BS 1 to $t>>$	0 no block. BS 1 to $t>>$	0 not in use
6	0 no block. BS 2 to $t>$	0 no block. BS 2 to $t>$	0 not in use
7	0 no block. BS 2 to $t>>$	0 no block. BS 2 to $t>>$	0 no TRIP sign. to SIGNAL 1
8	0 not in use	0 not in use	0 no TRIP sign. to SIGNAL 2

The contact functions are the same as those in example 1. Also the SG1 switches on the front plate can be set as in example 1. When the SGB switches on the PC boards and the SGR switches of the I/O module are set as above and the parameters of the control module SPTO 6D3 in accordance with the table below, all auto-reclose

functions will be blocked by the high-set stage. The tripping signal from the low-set stage of the phase overcurrent module will start a HSAR sequence and the tripping signal from the neutral overcurrent module both a HSAR and a DAR sequence.

Parameter	Value	Function
S78	1	Alerts the auto-reclose functions
S21	0	Prevents AR1 from starting initiated by the high-set phase overcurrent stage
S22	1	Starts AR1 initiated by tripping of the overcurrent module
S23	1	Starts AR1 initiated by tripping of the earth-fault module
S24	0.0	Sets AR1 starting time at 0.0 s, AR initiated by tripping of the overcurrent module
S25	0.0	Sets AR1 starting time at 0.0 s, AR initiated by tripping of the earth-fault module
S26	0.3	Sets AR1 dead time at 0.3 s
S31	0	Prevents starting of AR2 initiated by tripping of the high-set stage of the overcurrent module
S32	0	Does not start AR2 initiated by tripping of the overcurrent module
S33	1	Starts AR2 initiated by tripping of the earth-fault module
S35	0.0	Sets AR2 starting time at 0.0 s, AR initiated by earth-fault module
S36	120	Sets AR2 dead time at 120 s
S77	5.0	Sets the reclaim time at 5.0 s
V151	1	Stores the input parameters

The setting of the AR parameters is described in detail in the manual for the control module SPTO 6D3.

An auto-reclose sequence started by a tripping signal from the earth-fault module will cause no unwanted alarm signal over the contacts X2/1-2-3, as the operation of this contact has been delayed in the output relay module. The signalling contact X1/6-7 of the phase overcurrent module operates in the same way. However, the red operation indicator of the relay module that

starts an auto-reclose sequence is lit and trip event data is received over the SPA bus.

Fig. 14 shows the signals and their time relations, when the start of the auto-reclose unit is initiated by the tripping signal of the neutral overcurrent module.

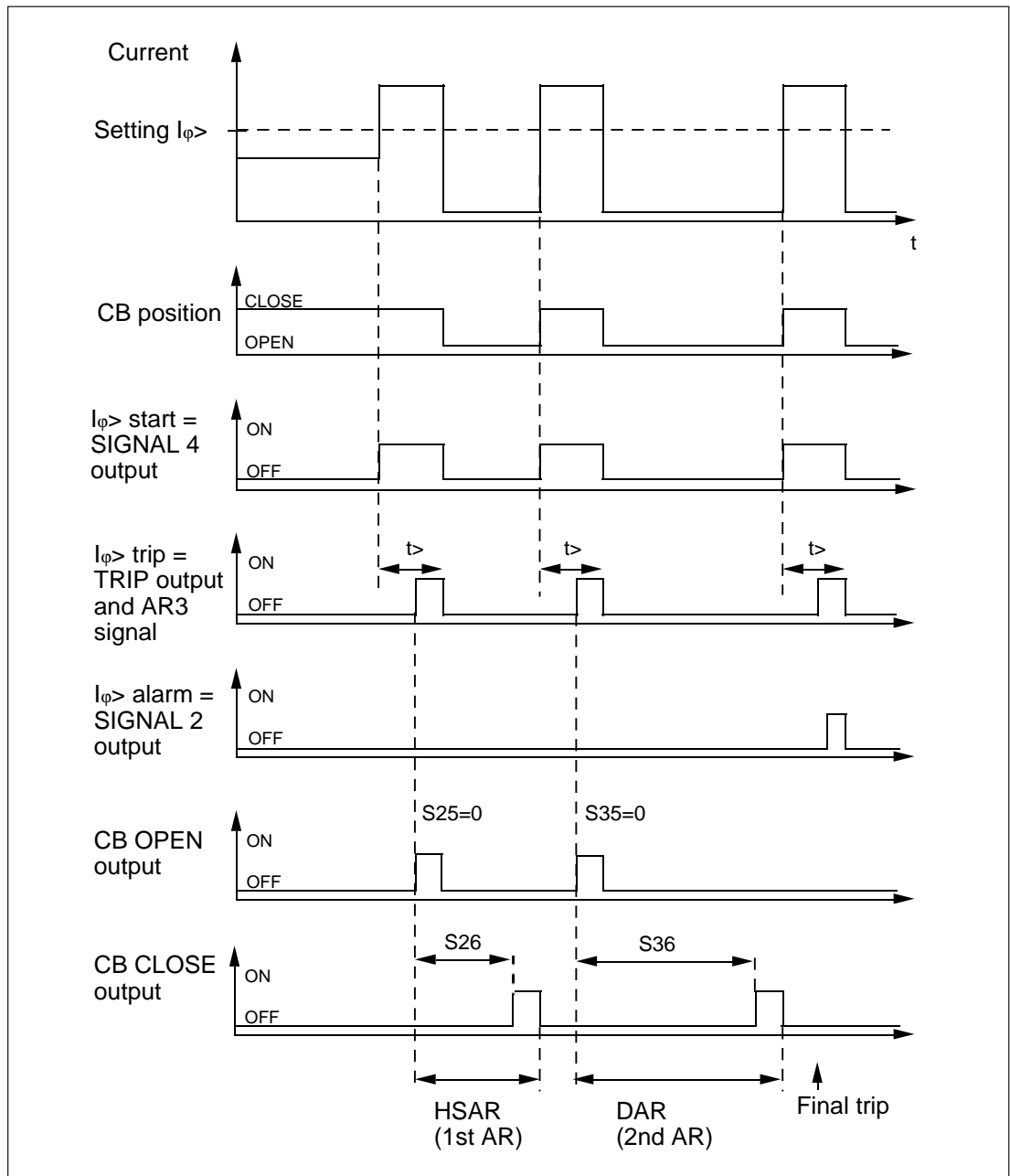


Fig. 14. Signal diagram for an auto-reclose sequence initiated by tripping of stage  $I\phi>$ .

The tripping signals are received directly via the trip output TRIP (contact X1/3-4). The auto-reclose functions are started by the tripping signal. As the starting time (parameters S24, S25 and S35) of the auto-reclose unit is zero, the auto-reclose unit performs tripping practically at the same moment via the OPEN 1 output (contact X3/11-12). Parameters S26 and S36 are used for setting the time delay before the auto-reclose unit is allowed to close the circuit

breaker. When the auto-reclose sequence has been completed, the relay module performs final CB tripping and the circuit breaker remains open. An alarm signal is received from the output SIGNAL 2 (contact X2/1-2-3) when the earth-fault relay module has given a signal for final CB tripping and via the output SIGNAL 1 (contact X1/6-7), when the signal for final tripping is received from the phase overcurrent module.



Example 3.

Feeder terminal SPAC 531 C1 used for the protection of an outgoing feeder in a one-breaker system. The earth-fault protection has a signalling function only.

In this application (Fig. 11) the earth-fault protection has a signalling function only. In such a case the auto-reclose functions can be started in the normal way also by the directional earth-fault relay module. The starting time (e.g. parameters S25 and S35) of the auto-reclose unit should be 200 ms + CB operate time  $t_{cb}$  shorter than the time delay preceding final tripping. At the end of the auto-reclose sequence a signal for earth fault is received and the start of another auto-reclose sequence is prevented.

The start of low-set stage of the directional earth-fault relay module produces a signal over the contact X2/7-8-9. After the operate time  $t>$  an alarm signal is received over the contact X2/1-2-3. In such a case the SGR/3 switch of the I/O module must be in position 0. Selection of the starting value  $\infty$ , infinite, sets the high-set stage of the directional earth-fault relay module totally out of operation.

The switches on the PC boards of the relay modules have to be set as follows:

Switch	SGB/SPCJ 3C3	SGB/SPCS 3C4	SGR
1	1 I> start to AR2	1 I $\phi$ > start to AR3	0 no I> start to SIGNAL 3
2	0 no I>> start to AR2	0 no I $\phi$ >> start to AR3	1 I> and I>> trip to SIGNAL 1
3	1 I>> start to AR1	0 no I $\phi$ >> start to AR1	0 no I $\phi$ > trip to TRIP output
4	0 no block. BS 1 to t>	0 no block. BS 1 to t>	0 not in use
5	0 no block. BS 1 to t>>	0 no block. BS 1 to t>>	0 not in use
6	0 no block. BS 2 to t>	0 no block. BS 2 to t>	0 not in use
7	0 no block. BS 2 to t>>	0 no block. BS 2 to t>>	0 no TRIP sign. to SIGNAL 1
8	0 not in use	0 not in use	0 no TRIP sign. to SIGNAL 2

With the I $\phi$ >> setting  $\infty$ , infinite, and above SGB and SGR switch settings the output con-

tacts of feeder terminal SPAC 531 C1 have the following functions:

Contact	Function
X1/3-4	Opening 1 of CB (I>, I>>)
X1/6-7	Signal for final trip (I> or I>>)
X2/1-2-3	I $\phi$ > alarm signal
X2/4-5-6	I>> start and blocking signal to phase overcurrent modules of incoming feeder cubicle
X2/7-8-9	I $\phi$ > start
X1/8-9-10	Self-supervision alarm (IRF)
X3/11-12	Opening 2 of CB (local control, remote control, AR)
X3/13-14	CB closing

The AR parameters can be set as shown in example 1.

Example 4.

Feeder terminal SPAC 531 C1 used for the protection of an outgoing feeder in a one-breaker system. No auto-reclosures.

Automatic shifting of the characteristic angle of the directional neutral overcurrent module (SPCS 3C4) is selected by turning switch SG1/2 on the front panel of the module into position 1.

The selection of the current component to be measured by the neutral current protection in the application illustrated in Fig. 15 is automatically controlled by the auxiliary contacts of the arc suppression coil (Petersen coil), the circuit breaker and the truck.

The switches on the PC boards of the relay modules have been set as follows:

Switch	SGB/SPCJ 3C3	SGB/SPCS 3C4	SGR
1	0 no I> start to AR2	0 no Iφ> start to AR3	0 no I> start to SIGNAL 3
2	0 no I>> start to AR2	0 no Iφ>> start to AR3	1 I> and I>> trip to SIGNAL 1
3	0 no I>> start to AR1	0 no Iφ>> start to AR1	1 Iφ> trip to TRIP output
4	0 no block. BS 1 to t>	0 no block. BS 1 to t>	0 not in use
5	0 no block. BS 1 to t>>	0 no block. BS 1 to t>>	0 not in use
6	0 no block. BS 2 to t>	0 no block. BS 2 to t>	0 not in use
7	0 no block. BS 2 to t>>	0 no block. BS 2 to t>>	0 no TRIP sign. to SIGNAL 1
8	0 not in use	0 not in use	0 no TRIP sign. to SIGNAL 2

With above SGB and SGR switch settings the output contacts of feeder terminal SPAC 531 C1 have the following functions:

Contact	Function
X1/3-4	Opening 1 of CB (I>, I>>, Iφ>, Iφ>>)
X1/6-7	
X2/1-2-3	
X2/4-5-6	
X2/7-8-9	
X1/8-9-10	
X3/11-12	
X3/13-14	

In example 4 the AR parameters can be set as in example 1. The function of the contacts for CB

closing and opening 2 is determined by the configuration of the control module.

Parameter	Value	Function
S78	0	Inhibits AR functions
V151	1	Stores the set parameter

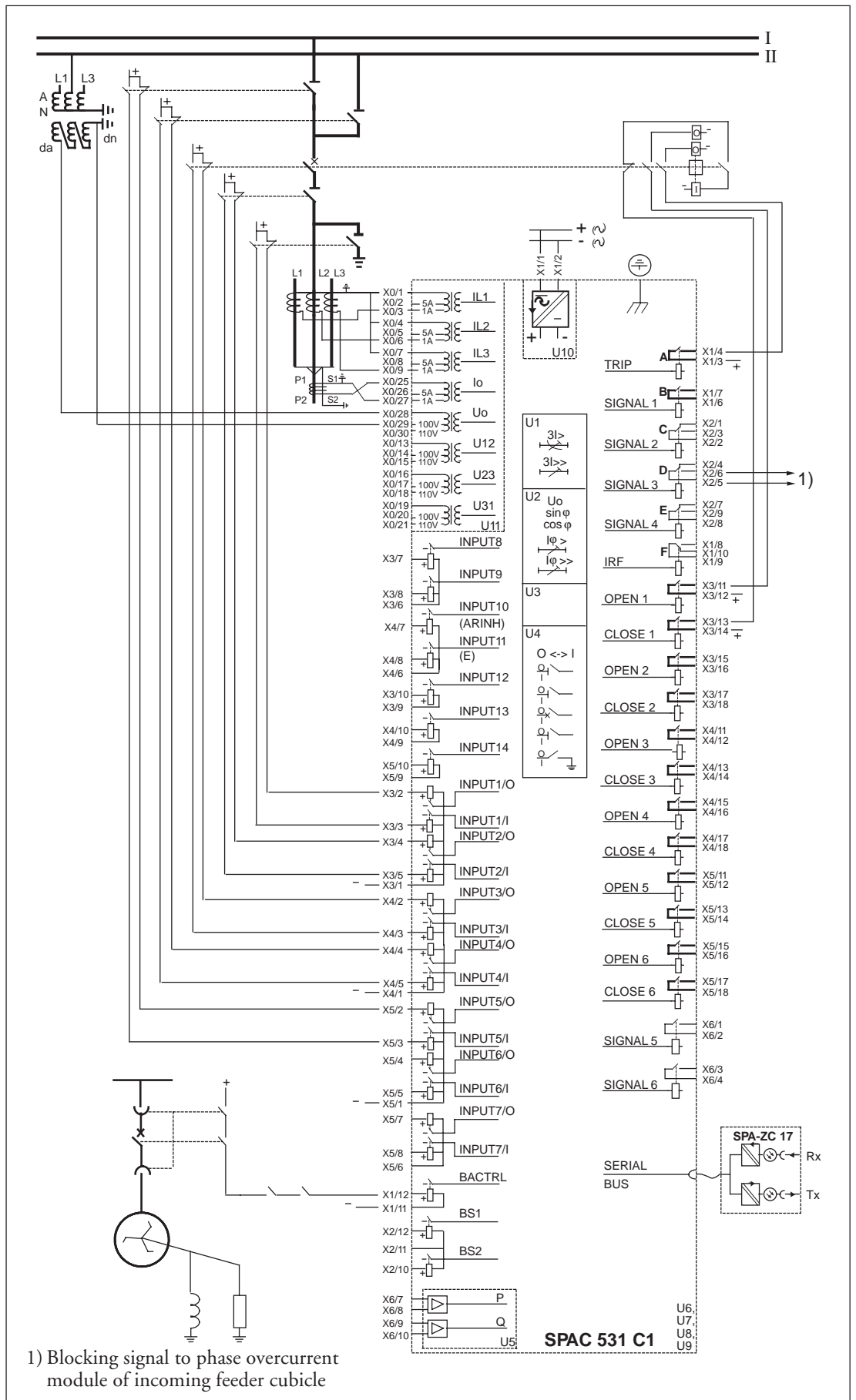


Fig. 15. Feeder terminal SPAC 531 C1 protecting an outgoing feeder, no auto-reclosures. Automatic shifting of the characteristic angle of the directional earth-fault relay module is obtained by means of an auxiliary contact of the CB of the Petersen coil and an auxiliary contact of the CB truck of the switchgear.

Example 5.  
Feeder terminal  
531 C3 protecting  
the incoming feeder  
cubicle and the  
busbar system.

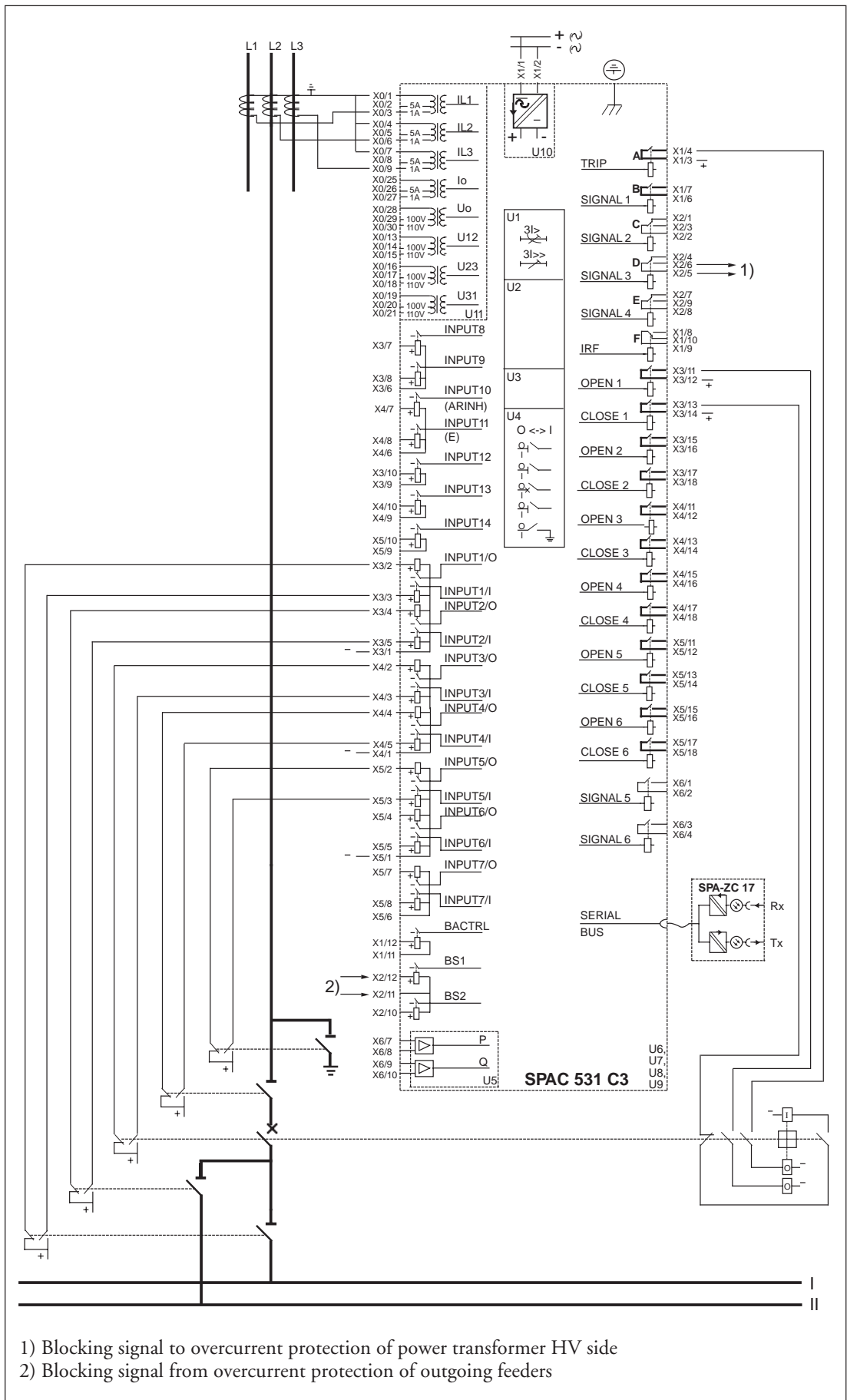


Fig. 16. Feeder terminal SPAC 531 C3 protecting the incoming feeder cubicle and the busbar system.

The incoming feeder cubicle and the busbar system are protected by one single feeder terminal type SPAC 531 C3, which incorporates a phase overcurrent relay module SPCJ 3C3 and a control module SPTO 6D3, but no neutral overcurrent module.

In the example illustrated in Fig. 16 the low-set stage of the phase overcurrent module U1 (SPCJ 3C3) operates as back-up protection for the outgoing feeders, whereas the high-set stage is used for the protection of the busbar system.

The operation of the busbar protection has been speeded up by means of blocking signals from the phase overcurrent relays of the feeders. If there is a fault on an outgoing feeder, the overcurrent module of the feeder delivers a blocking signal to the overcurrent relay module of the incoming feeder cubicle. If the fault is in the busbar system, no blocking signal is received and the overcurrent relay module of the incoming feeder cubicle delivers a tripping signal to

the circuit breaker. Thus a relay time of about 100 ms is obtained in the event of short circuit in the busbar. Due to its wide setting range the high-set phase overcurrent stage is well suited for starting the busbar protection.

Busbar protection based on blockings can also be used when the outgoing feeder has a reverse current infeed, provided the level of the reverse current is below the setting of the high-set phase overcurrent stage. Then the blocking signal from the overcurrent relay module of the outgoing feeder is taken from the high-set stage of the protection.

The blocking signals to the contacts X2/11-12 of the busbar protection are routed to the high-set stage of the phase overcurrent module by setting the SGB/5 switch on the PC board of the overcurrent module in position one (ON). The other internal switches of the modules can be set as shown in the following table.

Switch	SGB/SPCJ 3C3	SGR
1	0 no I> start to AR2	0 no I> start to SIGNAL 3
2	0 no I>> start to AR2	1 I> and I>> trip to SIGNAL 1
3	0 no I>> start to AR1	0 no Iφ> trip to TRIP output
4	0 no block. BS 1 to t>	0 not in use
5	1 blocking BS 1 to t>>	0 not in use
6	0 no block. BS 2 to t>	0 not in use
7	0 no block. BS 2 to t>>	0 no TRIP sign. to SIGNAL 1
8	0 not in use	0 no TRIP sign. to SIGNAL 2

With above SGB and SGR switch settings the output contacts of feeder terminal SPAC 531 C3 have the following functions:

Contact	Function
X1/3-4	Opening 1 of CB (I>, I>>)
X1/6-7	Signal for final tripping (I> or I>>)
X2/1-2-3	Not in use
X2/4-5-6	I>> start and blocking signal to the phase overcurrent module of power transformer high voltage side
X2/7-8-9	Not in use
X1/8-9-10	Self-supervision alarm (IRF)
X3/11-12	Opening 2 of CB (local control, remote control)
X3/13-14	CB closing

Since no auto-reclose functions are used in example 5, the AR parameters can be set as follows:

Parameter	Value	Function
S78	0	Inhibits AR functions
V151	1	Stores the set parameter

Example 6

Feeder terminal SPAC 531 C1 used for the protection of an outgoing feeder in a two-breaker system.

changed, compare one-breaker system shown in example1.

Fig. 17 illustrates a situation in which the feeder terminal SPAC 531 C1 protects the outgoing feeder in a two-breaker system. When SPAC 531 C1 is used in a two-breaker system the function of certain output contacts have to be

The SG1 switchgroups on the front panels of the relay modules and the SGB switchgroups on the PC boards are set in the same way as in a one-breaker system. The SGR switchgroup at the front edge of the I/O module SPTR 6B11 is set as follows.

Switch	SGR
1	0 no I> start to SIGNAL 3
2	0 no I> and I>> trip to SIGNAL 1
3	1 Iφ> trip to TRIP output
4	0 not in use
5	0 not in use
6	0 not in use
7	1 TRIP signals to SIGNAL 1
8	1 TRIP signals to SIGNAL 2

In the two-breaker systems presented in this example the output SIGNAL 1 is used as a second trip output. Then SGR/7 has to be in position 1 and SGR/2 in position 0. In two-breaker systems the I> and I>> alarm signals, as the alarm signals Iφ> and Iφ>>, are routed to the output SIGNAL 2. The SGR/8 switch has to be in position 1. The neutral overcurrent protec-

tion has a tripping function, since the SGR/3 switch is closed. The switches SGR/4, SGR/5 and SGR/6 have no function in SPAC 531 C and should be in position 0.

With above switch settings the output contacts of feeder terminal SPAC 531 C1 have the following functions:

Contact	Function
X1/3-4	Opening 1 of CB 1 (I>, I>>, Iφ>, Iφ>>)
X1/6-7	Opening 1 of CB 2 (I>, I>>, Iφ>, Iφ>>)
X2/1-2-3	Signal for final tripping (I>, I>>, Iφ>, Iφ>>) N.B. All trip signals are routed to the same contact.
X2/4-5-6	I>> start
X2/7-8-9	Iφ> start
X1/8-9-10	Self-supervision alarm (IRF)
X3/11-12	Opening 2 of CB 1 (local control, remote control, AR)
X3/13-14	Closing of CB 1
X3/15-16	Opening 2 of CB 2 (local control, remote control, AR)
X3/17-18	Closing of CB 2

The contacts for CB closing and opening 2 depend on the configuration of the control module.

directional earth fault module both high-speed and low-speed auto-reclosing.

The AR parameters can be set as shown in example 1. Then the overcurrent module will cause only high-speed auto-reclosing and the

If two separate feeder terminals are used for the protection of the busbar, the blocking signal is routed in parallel to the terminals.

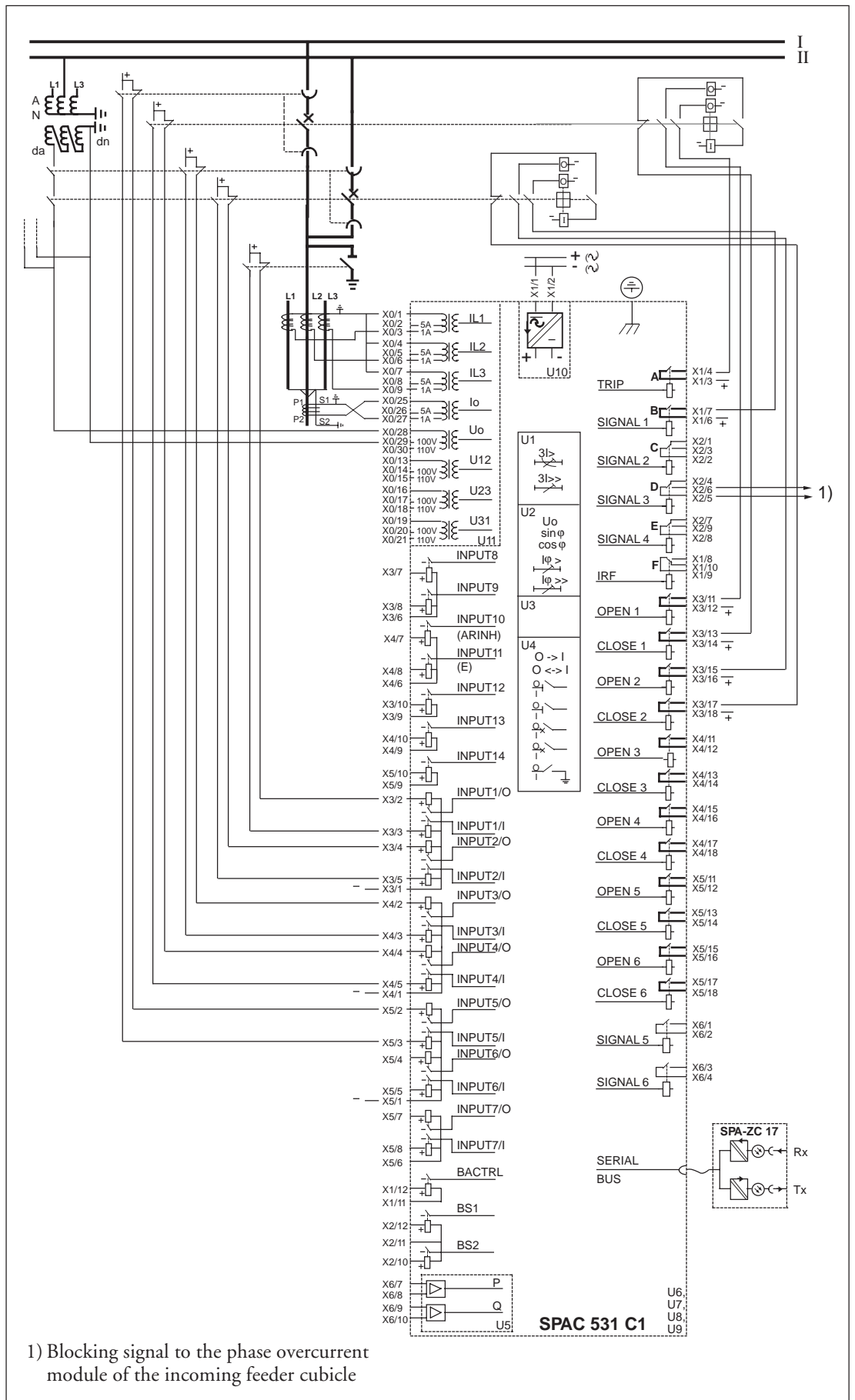


Fig. 17. SPAC 531 C1 used for the protection of an outgoing feeder in a two-breaker system.

**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 $\Omega$	<20 m $\Omega$
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 with measuring module SPTM 8A1))**

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

**Binary inputs of control module**

Terminal numbers	
- channels 1...7, four-pole inputs	X3/1-2, 1-3, 1-4, 1-5, X4/1-2, 1-3, 1-4, 1-5, X5/1-2, 1-3, 1-4, 1-5, 6-7, 6-8
- channels 8...14, single contact inputs	X3/6-7, 6-8, 9-10, X4/6-7, 6-8, 9-10, X5/9-10
Control voltage range	
- I/O module type SPTR 4D1	80...265 V dc
- I/O module type SPTR 4D2	30...80 V dc
Current drain	~2 mA

**Binary inputs of relay modules**

Terminal numbers	
- blocking inputs	X2/10-11, 11-12
- control input for operation mode $I_{sin\phi}$ or $I_{cos\phi}$ of earth-fault protection	X1/11-12
Control voltage range	18...265 Vdc or 80...265 Vac
Current drain	~2 mA

**Energy pulse counter input (input channel 11)**

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

**External auto-reclose inhibit input (input channel 10)**

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



## External auto-reclose start input (input channel 14)

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

## Contact outputs

Control outputs	X1/3-4, 6-7, X3/11-12, 13-14, 15-16, 17-18, X4/11-12, 13-14, 15-16, 17-18, X5/11-12, 13-14, 15-16, 17-18
- rated voltage	250 V ac or dc
- 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 controlled by the control module	pulse, pulse length 0.1...100 s

## Signal outputs

	X1/8-9-10, X2/1-2-3, 4-5-6, 7-8-9, X6/1-2, 3-4
- rated voltage	250 V ac or dc
- 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

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

## Overcurrent module SPCJ 3C3

Low-set overcurrent stage I>	
- starting current $I_{>}$ , setting range	$0.5 \dots 2.5 \times I_n$
- operation modes to be selected	
- definite time operation	
- operate time $t_{>}$	0.05...100 s
- inverse definite minimum time (IDMT) mode acc. to IEC 60255-3 and BS 142	Extremely inverse Very inverse Normal inverse Long-time inverse
- time multiplier k	0.05...1.00
High-set overcurrent stage I>>	
- starting current $I_{>>}$ , setting range	$0.5 \dots 20 \times I_n$ and $\infty$
- operate time $t_{>>}$	0.04...100 s

## Directional earth-fault module SPCS 3C4

Low-set earth-fault stage $I_{\phi}>$	
- current setting range	$1.0 \dots 10.0\% \times I_n$
- operation modes to be selected	$I_0 \sin \phi$ or $I_0 \cos \phi$
- operating time $t>$	$0.10 \dots 10.0$ s
High-set earth-fault stage $I_{\phi}>>$	
- current setting range	$1.0 \dots 40.0\% \times I_n$ and $\infty$
- operation modes to be selected	$\pm I_0 \sin \phi$ or $\pm I_0 \cos \phi$
- operating time $t>>$	$0.10 \dots 1.00$ s
Starting level of the neutral displacement voltage $U_0$	
- selectable values	2, 5, 10 or $20\% \times U_n$

## Control module SPTO 6D3

### Control functions

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

### Measurement functions

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

### Measurement functions, with optional measuring module SPTM 8A1 (option 1)

- measurement of three phase currents and three phase-to-phase voltages
- measurement range for current  $0 \dots 1,5 \times I_n$ , for voltage  $0 \dots 1,5 \times U_n$
- accuracy of current and voltage measurement  $\geq \pm 1\%$  of rated value
- mA inputs for measurement of active and reactive power via external measuring transducers
- accuracy of power measurement  $\geq \pm 1\%$  of maximum value of measurement range
- the energy value can be integrated on the basis of the measured power, alternative to energy pulse counter

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

- measurement of three phase currents and three phase-to-phase voltages
- measurement ranges, current  $0 \dots 1,5 \times I_n$ , voltage  $0 \dots 1,5 \times U_n$
- accuracy of current and voltage measurement  $\geq \pm 1\%$  of rated value
- measurement of active and reactive power using internal current and voltage signals, the measurement is based on the Aron connection
- power measurement range  $0 \dots 1,1 \times P_n$  and  $0 \dots 1,1 \times Q_n$
- accuracy of positive power measurement  $\geq \pm 2\%$  of rated value
- accuracy of negative power measurement  $\geq \pm 3\%$  of rated value
- the energy value can be integrated using the measured power, alternative to energy pulse counter

### Measurement functions, with optional measuring module SPTM 6A3 (option 3)

- measurement of three phase currents and three phase-to-phase voltages
- measurement ranges, current  $0 \dots 1,5 \times I_n$ , voltage  $0 \dots 1,5 \times U_n$
- accuracy of current and voltage measurement  $\geq \pm 1\%$  of rated value
- measurement of active and reactive power using one internal voltage signal and two current signals, the currents and voltage used are selected with switches
- power measurement range  $0 \dots 1,1 \times P_n$  and  $0 \dots 1,1 \times Q_n$
- the energy value can be integrated by using the measured power, alternative to energy pulse counter

### Auto-reclosing

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

## Data communication

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

## Insulation Tests \*)

Dielectric test IEC 60255-5	2 kV, 50 Hz, 1 min
Impulse voltage test IEC 60255-5	5 kV, 1.2/50 $\mu$ s, 0.5 J
Insulation resistance measurement IEC 60255-5	>100 M $\Omega$ , 500 Vdc

## Electromagnetic Compatibility Tests \*)

High-frequency (1 MHz) burst disturbance test IEC 60255-22-1	
- common mode	2.5 kV
- differential mode	1.0 kV
Electrostatic discharge test IEC 60255-22-2 and IEC 61000-4-2	
- contact discharge	6 kV
- air discharge	8 kV
Fast transient disturbance test IEC 60255-22-4 and IEC 61000-4-4	
- power supply	4 kV
- I/O ports	2 kV

## Environmental conditions

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

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

## Maintenance and repairs

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

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

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

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

### Note!

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

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## 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
Three-phase phase overcurrent relay module	SPCJ 3C3
Directional neutral current relay module	SPCS 3C4
I/O module for control signals, input voltage range 80...265 V dc	SPTR 4D1
I/O module for control signals, input voltage range 30...80 V dc	SPTR 4D2
I/O module for protection functions	SPTR 6B11
Power supply module, 80...265 V ac or dc	SPGU 240A1
Power supply module, 18...80 V dc	SPGU 48B2
Rack without plug-in modules (SPAC 531 C)	SPTK 8C3
Rack without plug-in modules (SPAC 631 C)	SPTK 8C4
Counter contacts for multi-pole connectors X1...X6 including accessories (included in relay delivery)	SPA-ZT6

Delivery alternatives

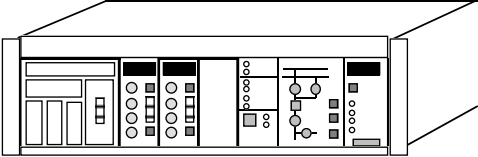
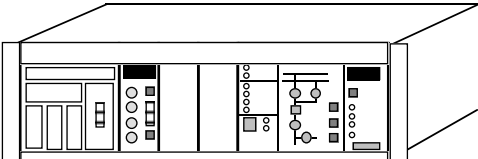
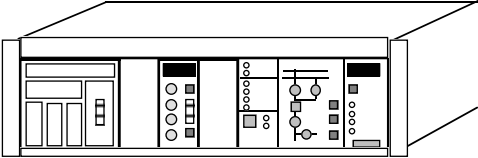
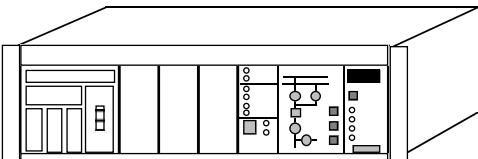
Illustration	Modules	Type
	<p>Complete feeder terminal including an overcurrent module, a directional earth-fault and a control module</p>	<p>SPAC 531 C1</p>
	<p>Partially equipped feeder terminal including an overcurrent module and a control module</p>	<p>SPAC 531 C3</p>
	<p>Partially equipped feeder terminal including an earth-fault module and a control module</p>	<p>SPAC 531 C5</p>
	<p>Partially equipped feeder terminal including a control module alone</p>	<p>SPAC 531 C7</p>

Fig. 18. Delivery alternatives of feeder terminal SPAC 531 C

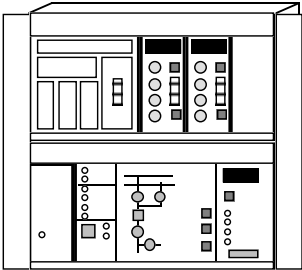
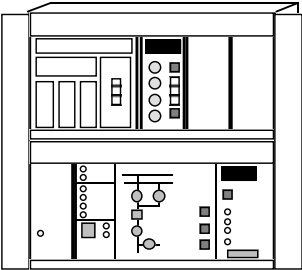
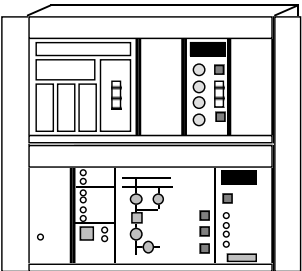
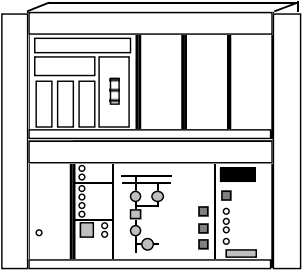
Illustration	Modules	Type
	Complete feeder terminal including an overcurrent module, an earth-fault module and a control module	SPAC 631 C1
	Partially equipped feeder terminal including an overcurrent module and a control module	SPAC 631 C3
	Partially equipped feeder terminal including an earth-fault module and a control module	SPAC 631 C5
	Partially equipped feeder terminal including a control module alone	SPAC 631 C7

Fig. 19. Delivery alternatives of feeder terminal SPAC 631 C

**Order information** Please state the following information when ordering feeder terminals.

1. Quantity and type designation	15 units, SPAC 531 C1
2. Rated frequency	$f_n = 50 \text{ Hz}$
3. Auxiliary supply voltage	$U_{aux} = 110 \text{ V dc}$
4. Type designation of configuration plate	15 pcs, SYKK 973
5. Options	15 pcs, Measuring module SPTM 8A1
6. Accessories	15 pcs, Bus connection module SPA-ZC17 MM2A

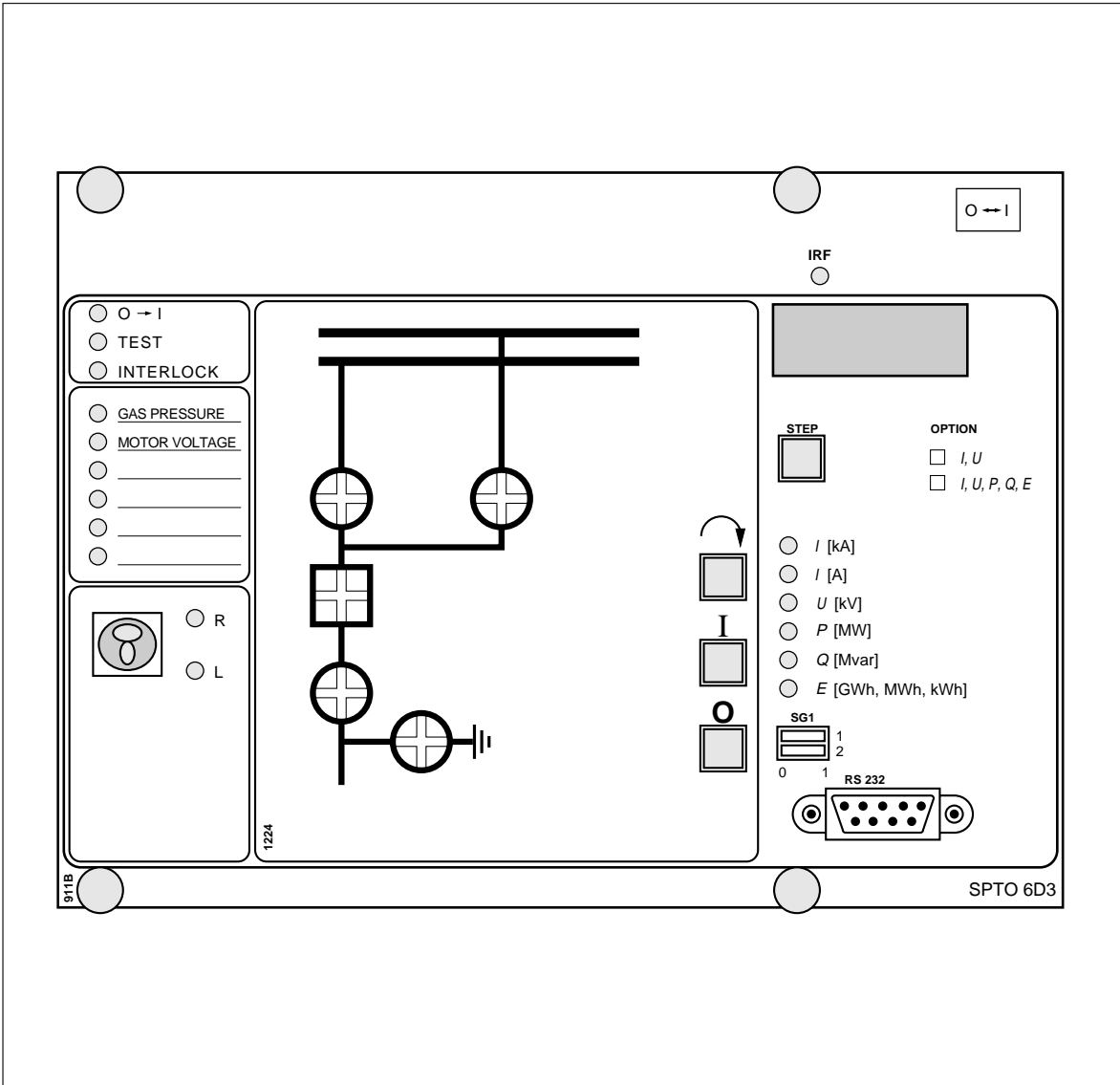
The delivery includes 3 empty legend text films SYKU 997 for channels 8...13.

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

# SPTO 6D3

## Control module

User's manual and Technical description



Data subject to change without notice

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<b>Contents</b>	Description of functions .....	3
	Control functions .....	3
	Measurement functions .....	3
	Auto-reclosing .....	4
	Block schematic diagram ( <i>modified 96-12</i> ) .....	4
	Front panel .....	5
	Object status indicators .....	5
	Indicators for input channels 8...13 .....	6
	Operation indicators .....	6
	LOCAL/REMOTE key switch .....	7
	Push-buttons $\cap$ , I and O .....	7
	Switchgroup SG1 .....	7
	Display of measured values and serial communication parameters .....	8
	RS 232 interface .....	10
	Setting .....	11
	Configuration .....	11
	Interlocking .....	14
	Direct Output Control .....	17
	Input channels 8...17 ( <i>modified 96-12</i> ) .....	18
	Outputs .....	19
	Scaling of measured values .....	21
	Auto-reclosing ( <i>modified 96-12</i> ) .....	25
	Event codes .....	30
	Quick reference for setting .....	33
	Serial communication parameters ( <i>modified 96-12</i> ) .....	34
	Default values of parameters ( <i>modified 96-12</i> ) .....	42
	Technical data .....	45



## 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)

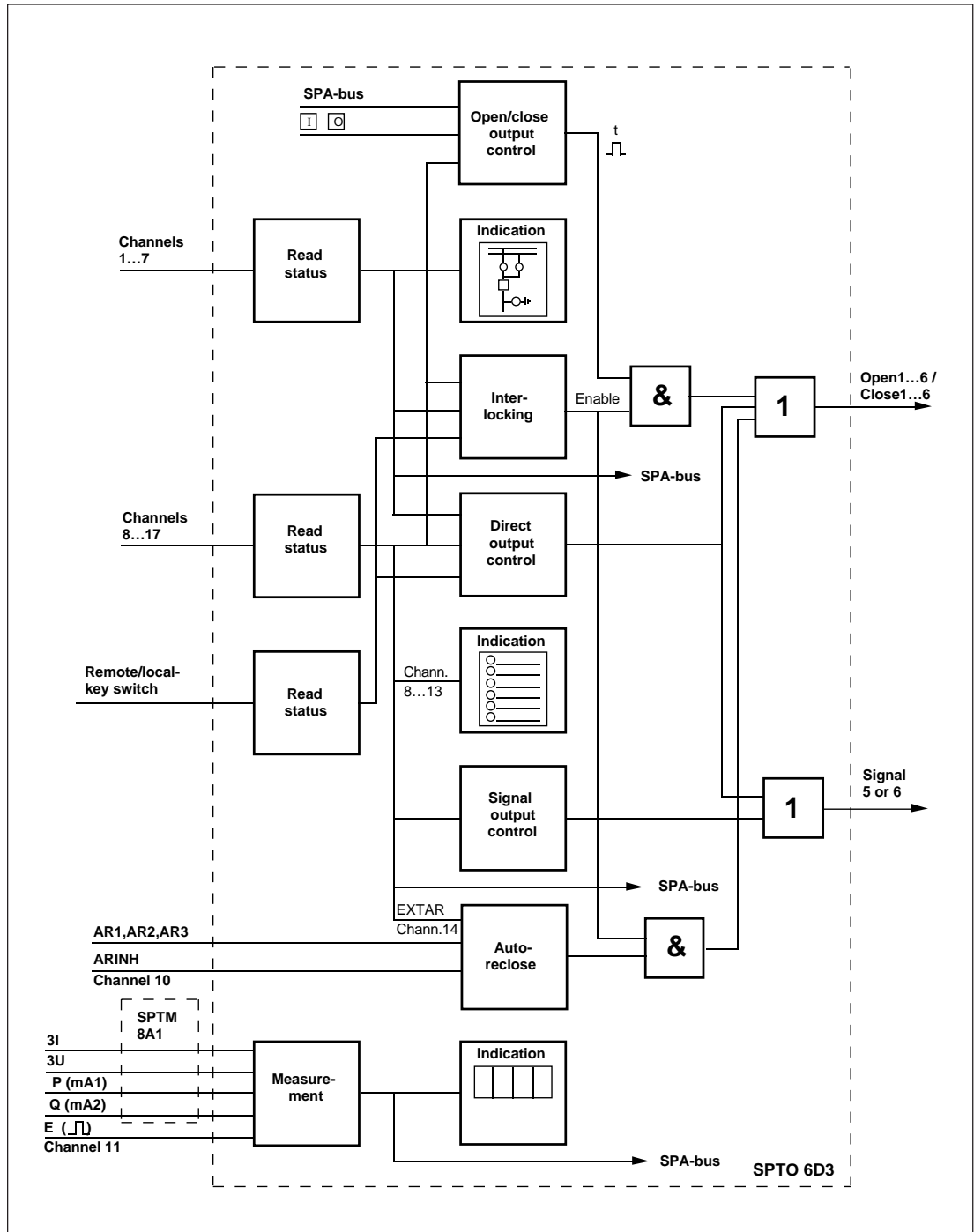


Fig. 1. Block schematic diagram for the control module SPTO 6D3 including an optional measuring module SPTM 8A1.

## Front panel

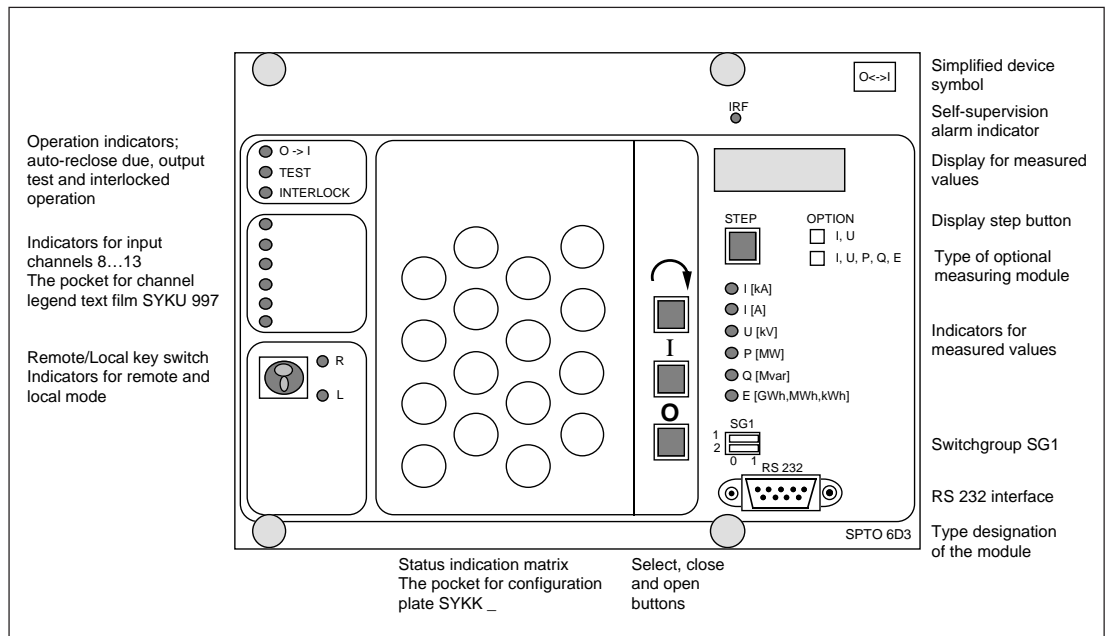


Fig. 2. Front panel of the control module SPTO 6D3 without the configuration plate SYKK\_ and the channel legend text foil SYKU 997.

## 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.

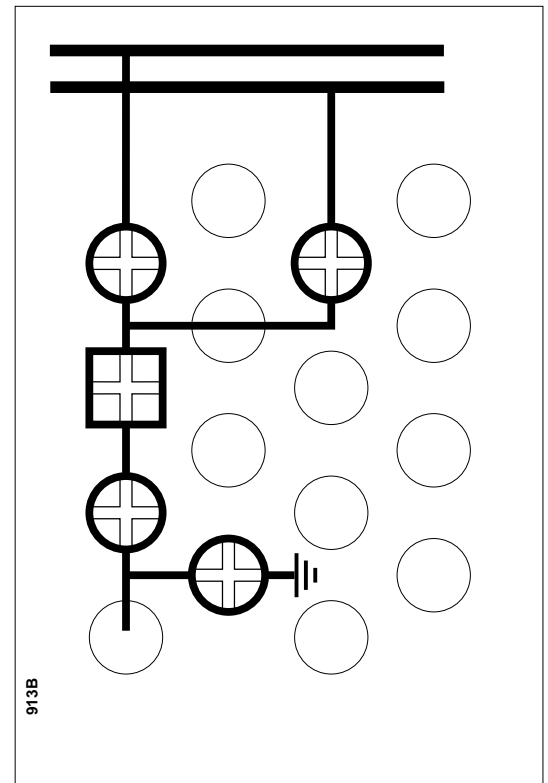


Fig. 3. Example of a plastic configuration plate SYKK\_. The actual size of the configuration plate is 72mm x 106.5 mm.

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.

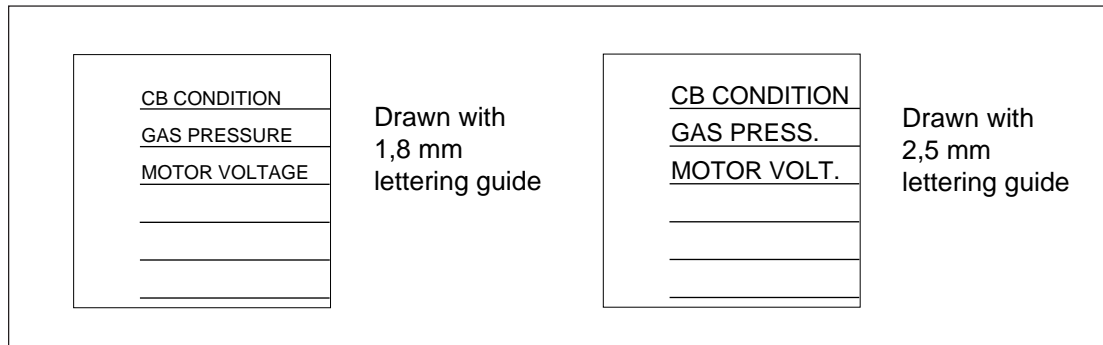


Fig. 4. Example of a text foil type SYKU 997. The foil is shown in its natural size, width 33.5 mm and height 34 mm.

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  
∩, I and O

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

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 ∩ 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.

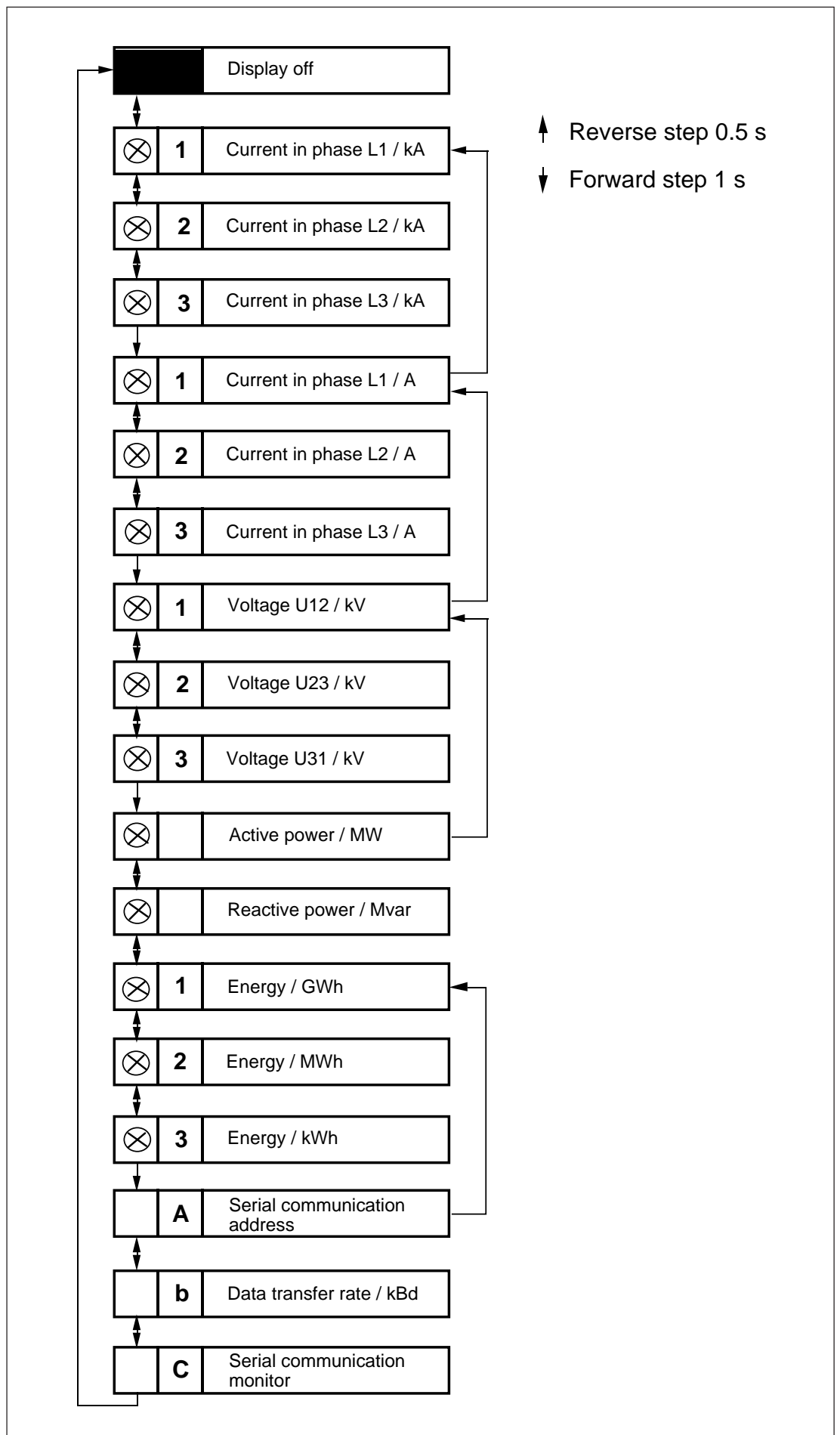


Fig. 5. Display menu of the control module SPTO 6D3.

## 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.

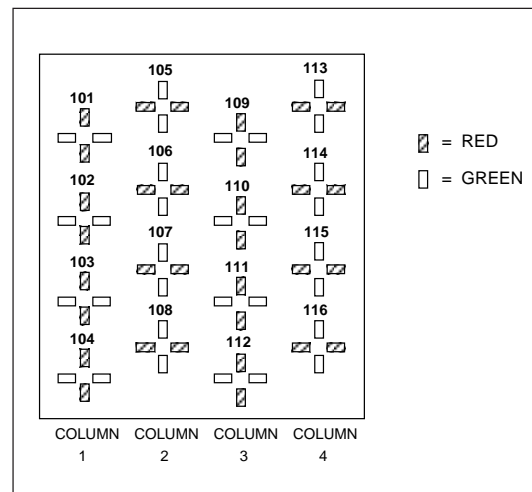


Fig. 6. Position, code number and colour of the indicator units on the front panel of the control module.

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.

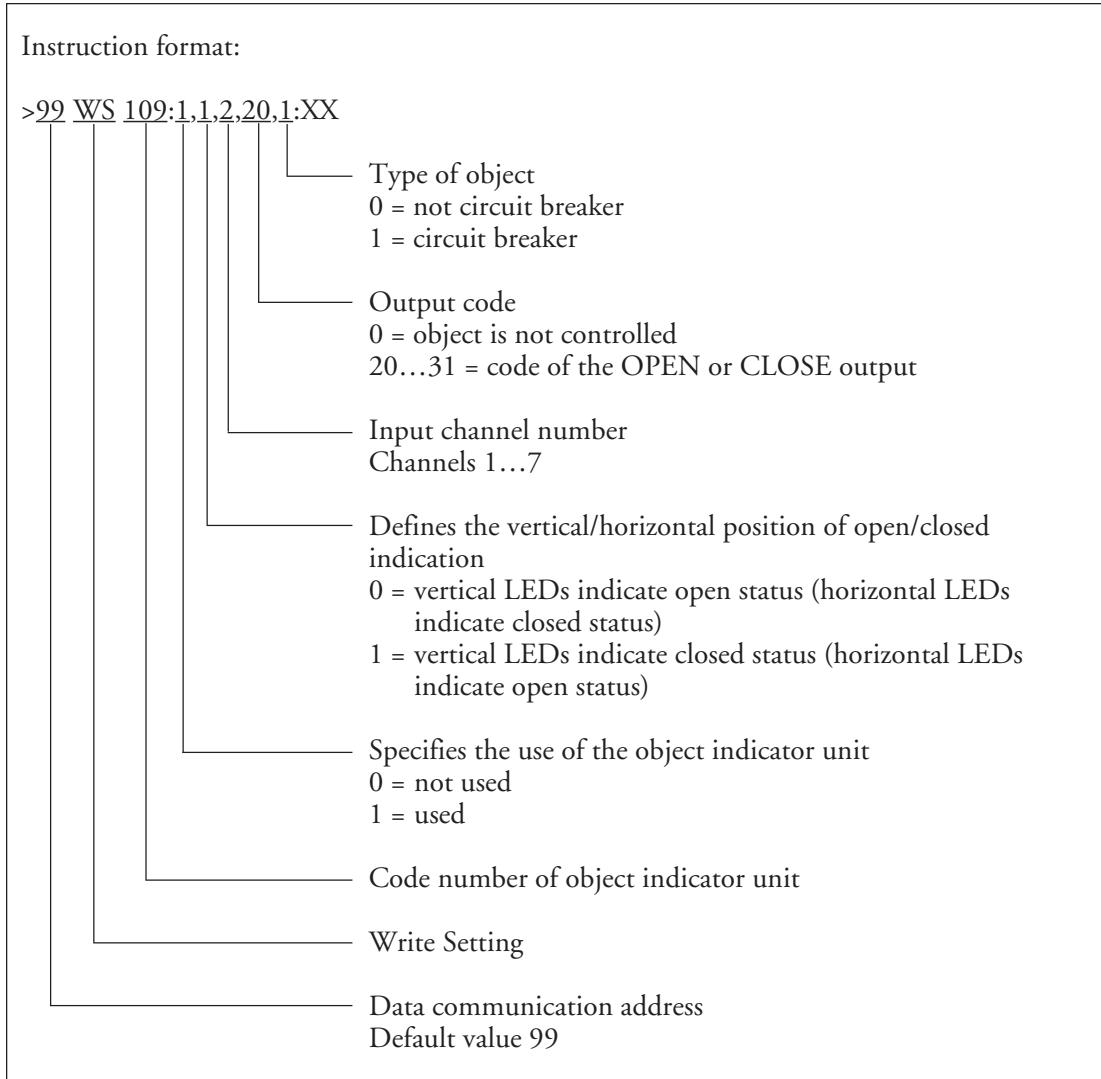
*A configuration is set by linking the indicator number, the four-pole input number and the output code number by using an SPA protocol command.*

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.

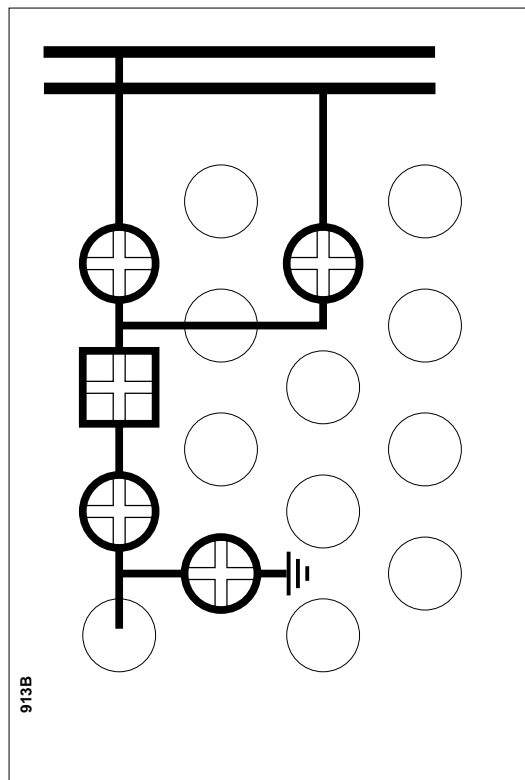


Fig. 7. Object configuration set in example 2.

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.

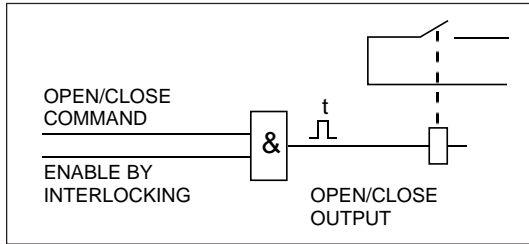


Fig. 8. Operation principle of the control functions.

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:

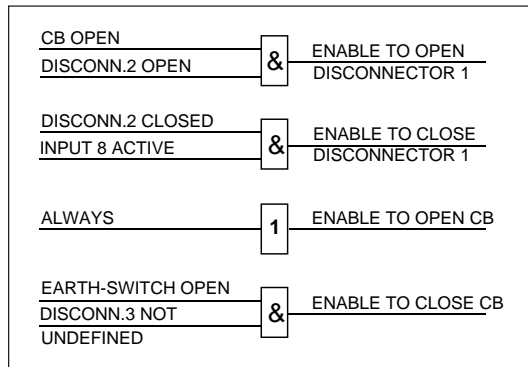


Fig. 9. Simplified logic diagram for the interlocking logic in example 7.

Below a detailed logic diagram is shown.

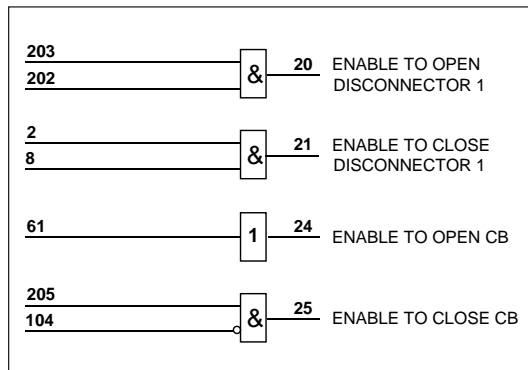


Fig. 10. Detailed logic diagram for the interlocking logic in example 7.

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.

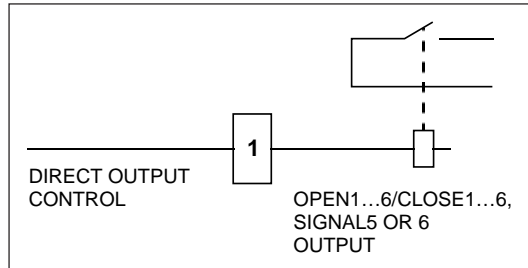


Fig. 11. Operation principle of the Direct Output Control.

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

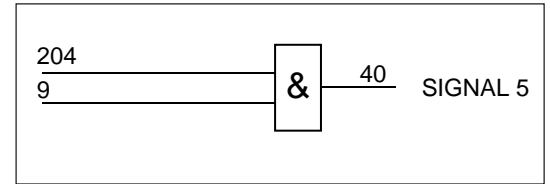


Fig. 12. Logic diagram for the Direct Output Control in example 8.

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
```

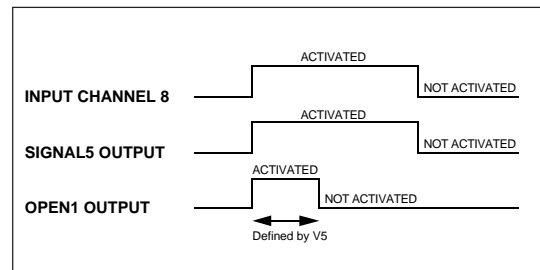


Fig. 13. Operation of outputs SIGNAL5 and OPEN1 when input channel 8 in example 9 is activated.

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.

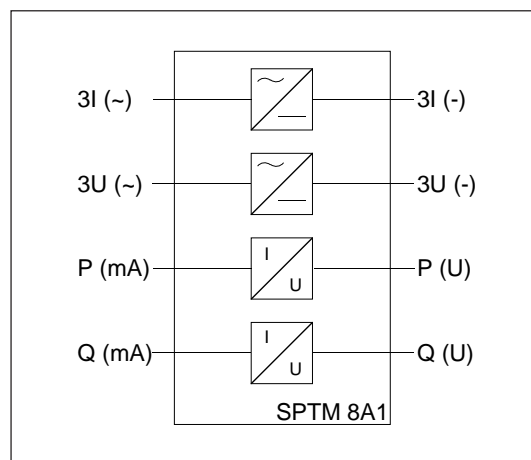


Fig. 14. Block diagram of measuring module SPTM 8A1.

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.

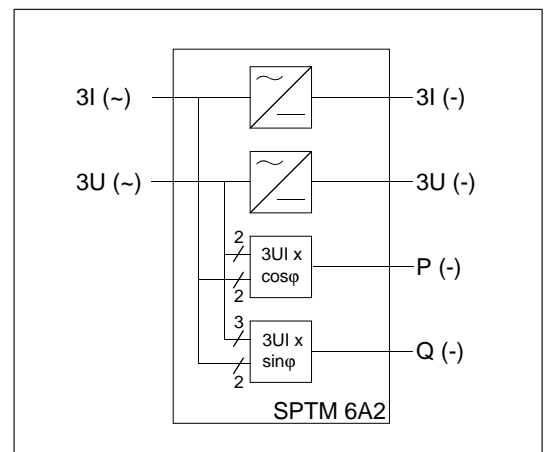


Fig. 15. Block diagram of measuring module SPTM 6A2.

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.

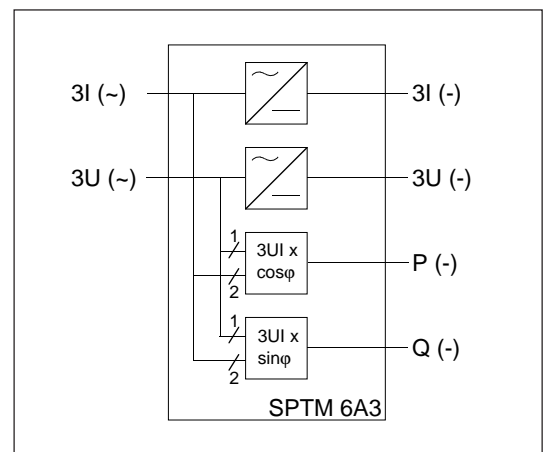


Fig. 16. Block diagram of measuring module SPTM 6A3.

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.



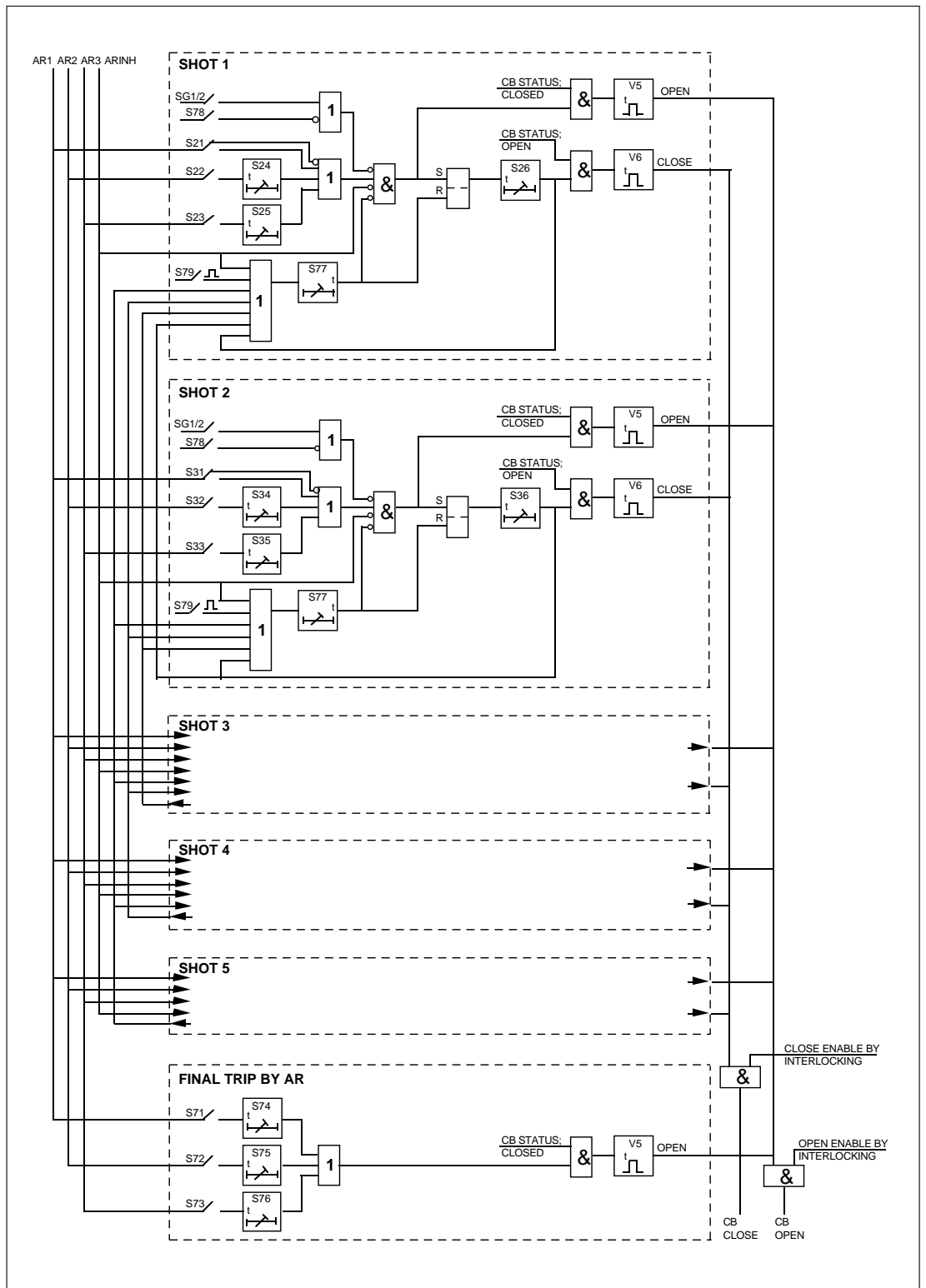


Fig. 17. Simplified block diagram for the auto-re-close functions in the control module SPTO 6D3.

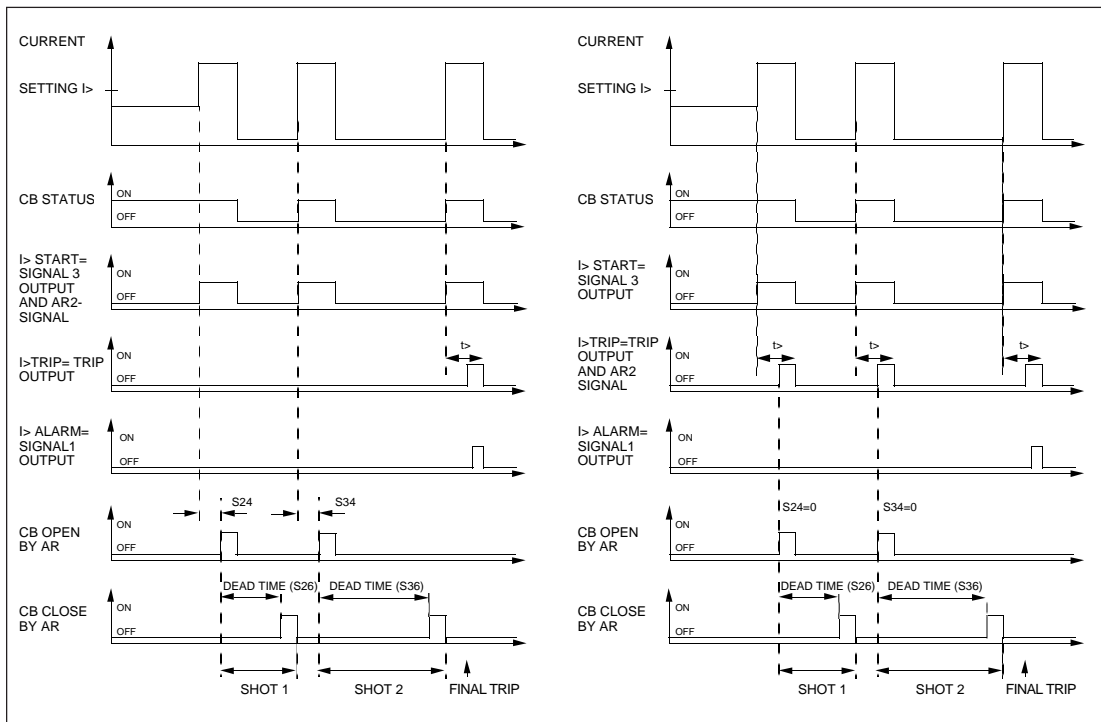


Fig. 18. a) Signal flow diagram for an AR cycle started by the start signal of the I> stage  
 b) Signal flow diagram for an AR cycle started by the trip signal of the I> stage

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 <sup>1)</sup>	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 <sup>2)</sup>	256	1
1...7	E10	Failed to open or close <sup>3)</sup>	512	1
1...7	E11	Attempt to activate an output without open/close selection <sup>4)</sup>	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 <sub>1</sub> (x I <sub>n</sub> )	0	I1	R	0.00...1.50 x I <sub>n</sub> (opt. 1, 2 or 3)
Current on phase L <sub>2</sub> (x I <sub>n</sub> )	0	I2	R	0.00...1.50 x I <sub>n</sub> (opt. 1, 2 or 3)
Current on phase L <sub>3</sub> (x I <sub>n</sub> )	0	I3	R	0.00...1.50 x I <sub>n</sub> (opt. 1, 2 or 3)
Voltage U <sub>12</sub> (x U <sub>n</sub> )	0	I4	R	0.00...1.50 x U <sub>n</sub> (opt. 1, 2 or 3)
Voltage U <sub>23</sub> (x U <sub>n</sub> )	0	I5	R	0.00...1.50 x U <sub>n</sub> (opt. 1, 2 or 3)
Voltage U <sub>31</sub> (x U <sub>n</sub> )	0	I6	R	0.00...1.50 x U <sub>n</sub> (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 <sub>1</sub> (A)	0	I11	R	0...9999 A (opt. 1, 2 or 3)
Current on phase L <sub>2</sub> (A)	0	I12	R	0...9999 A (opt. 1, 2 or 3)
Current on phase L <sub>3</sub> (A)	0	I13	R	0...9999 A (opt. 1, 2 or 3)
Voltage U <sub>12</sub> (kV)	0	I14	R	0.00...999.99 kV (opt. 1, 2 or 3)
Voltage U <sub>23</sub> (kV)	0	I15	R	0.00...999.99 kV (opt. 1, 2 or 3)
Voltage U <sub>31</sub> (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  $\pm 1$  % of rated value
- two mA inputs for measurement of active and reactive power
- accuracy of power measurement better than  $\pm 1$  % 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  $\pm 1$  % 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  $\pm 2$  % of the rated value
- accuracy of the negative power measurement better than  $\pm 3$  % 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  $\pm 1$  % 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  $0...1,1 \times Q_n$

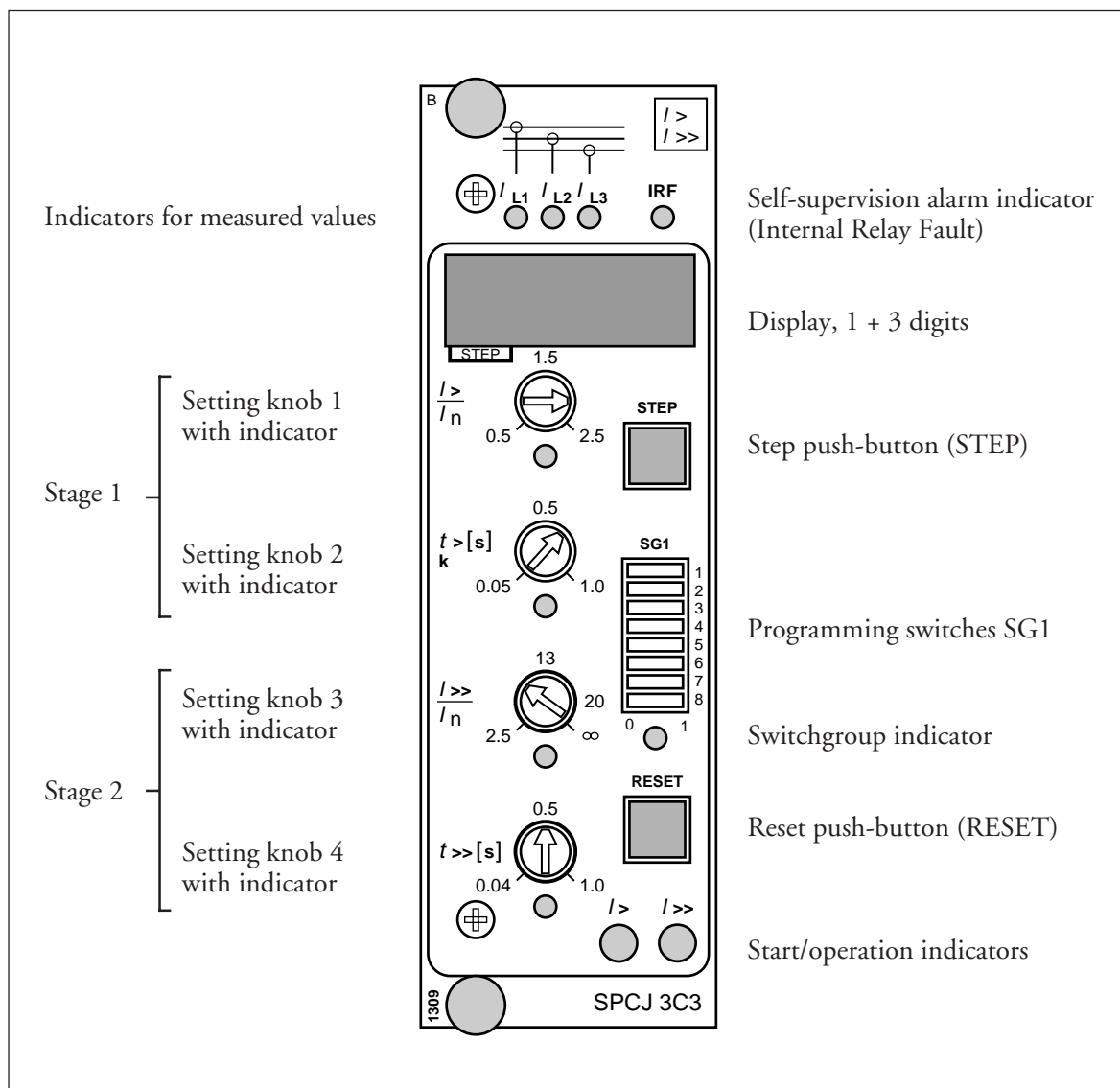
### Auto-reclosing

- 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 C-type relay modules

## User's manual and Technical description



Data subject to change without notice

<b>Contents</b>	Push-buttons .....	2
	Programming switches SG1 .....	2
	Setting knobs .....	3
	Display .....	3
	Display main menu .....	3
	Display submenu .....	4
	Setting mode .....	4
	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.

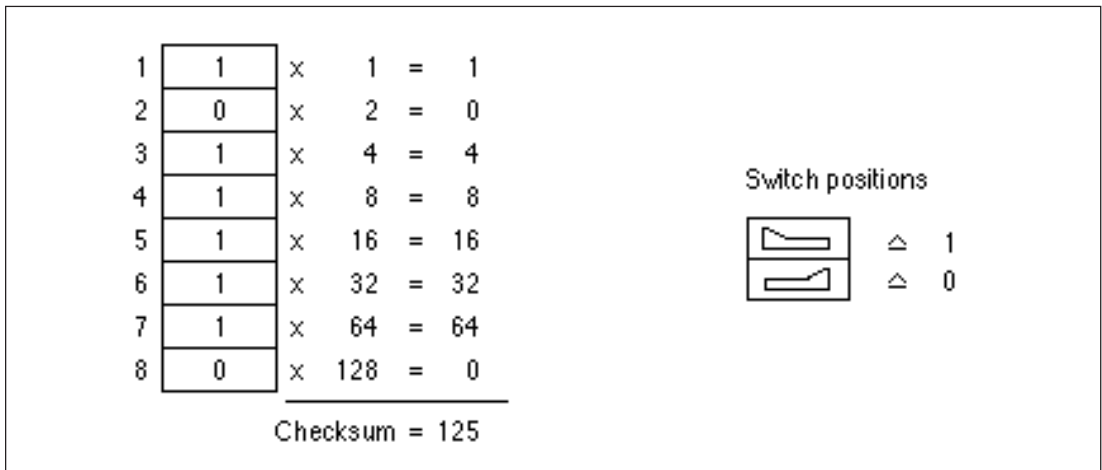


Fig. 2. Example of calculating the checksum of programming switchgroup SG1.

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.

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## 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.

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## 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.

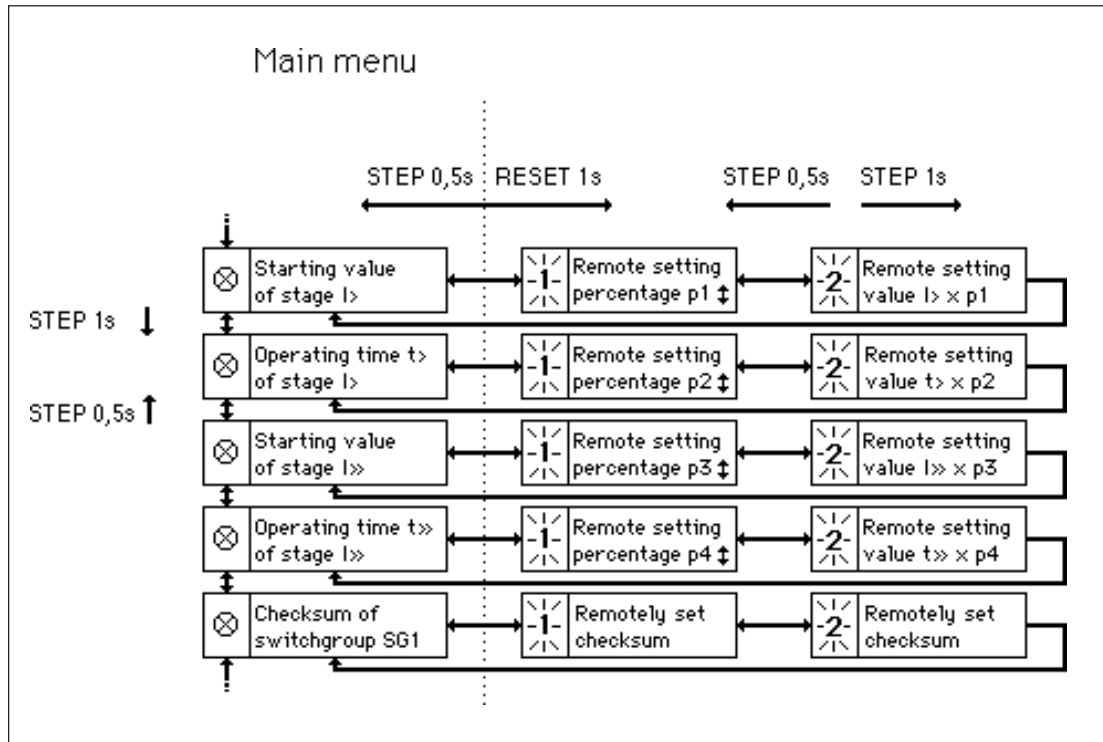


Fig. 3. Example of the main and submenus for the settings of the overcurrent relay module SPCJ 3C3. The settings made with the setting knobs are in the main menu and they are displayed by pressing the STEP button. In addition to the setting knob settings the main menu contains the measured current values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

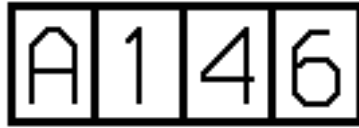
The values to be set in the setting mode are for instance the address code of the relay module and the data transfer rate for the serial communication. Further the percentage values for the remote settings can be changed.



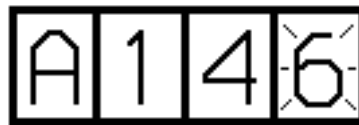
Example 1:

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.

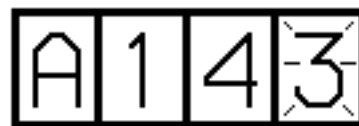
a) Press push-button STEP until register address A appears on the display.



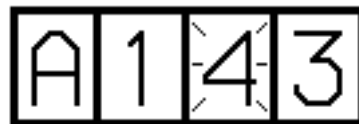
b) Press the RESET button for about 10 s until the right most digit starts flashing.



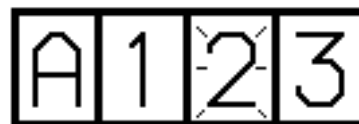
c) Press the STEP button repeatedly to set the digit to the value desired.



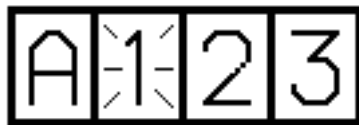
d) Press the RESET button to make the middle of the green digits flash.



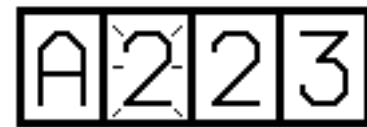
e) Set the middle address digit by means of the STEP button.



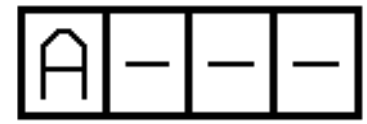
f) Press the RESET button to make the left most green digit flash.



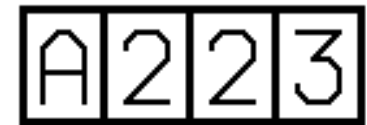
g) Set the digit by means of the STEP button.



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.

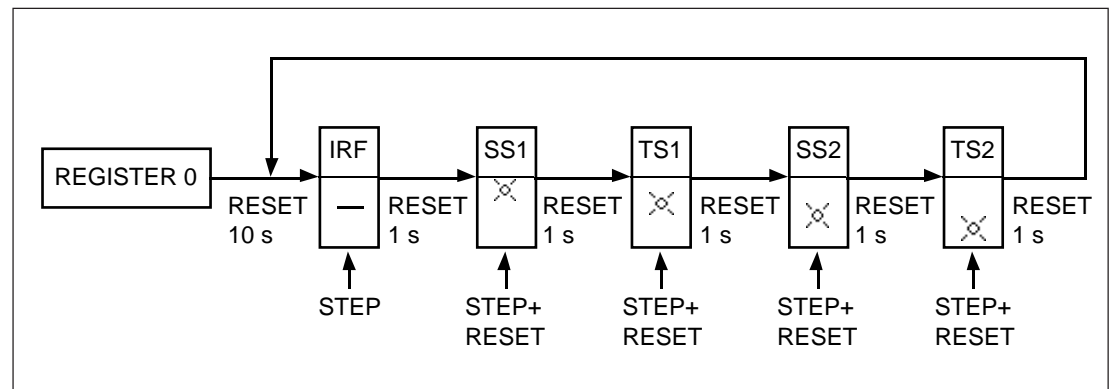


Fig. 4. Sequence order for selecting the output signals in the Trip-test mode.

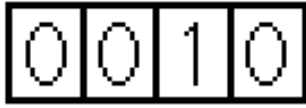
If e.g. the indicator of the setting knob 2 (second from the top) is flashing, and the push-buttons STEP and RESET are being pressed, the signal TS1 (tripping of stage 1) is activated. Return to the main menu is possible at any stage of the

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.

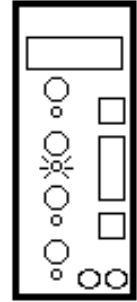
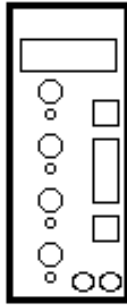
Example 2:

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

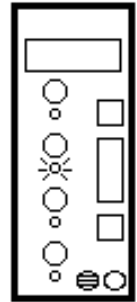
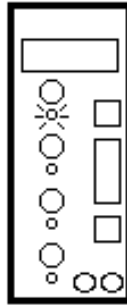
a) Step forward on the display to register 0.



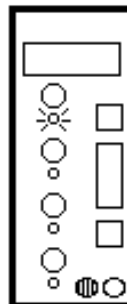
- Indicator switched off
- Yellow indication
- Red indication



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.

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## 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.

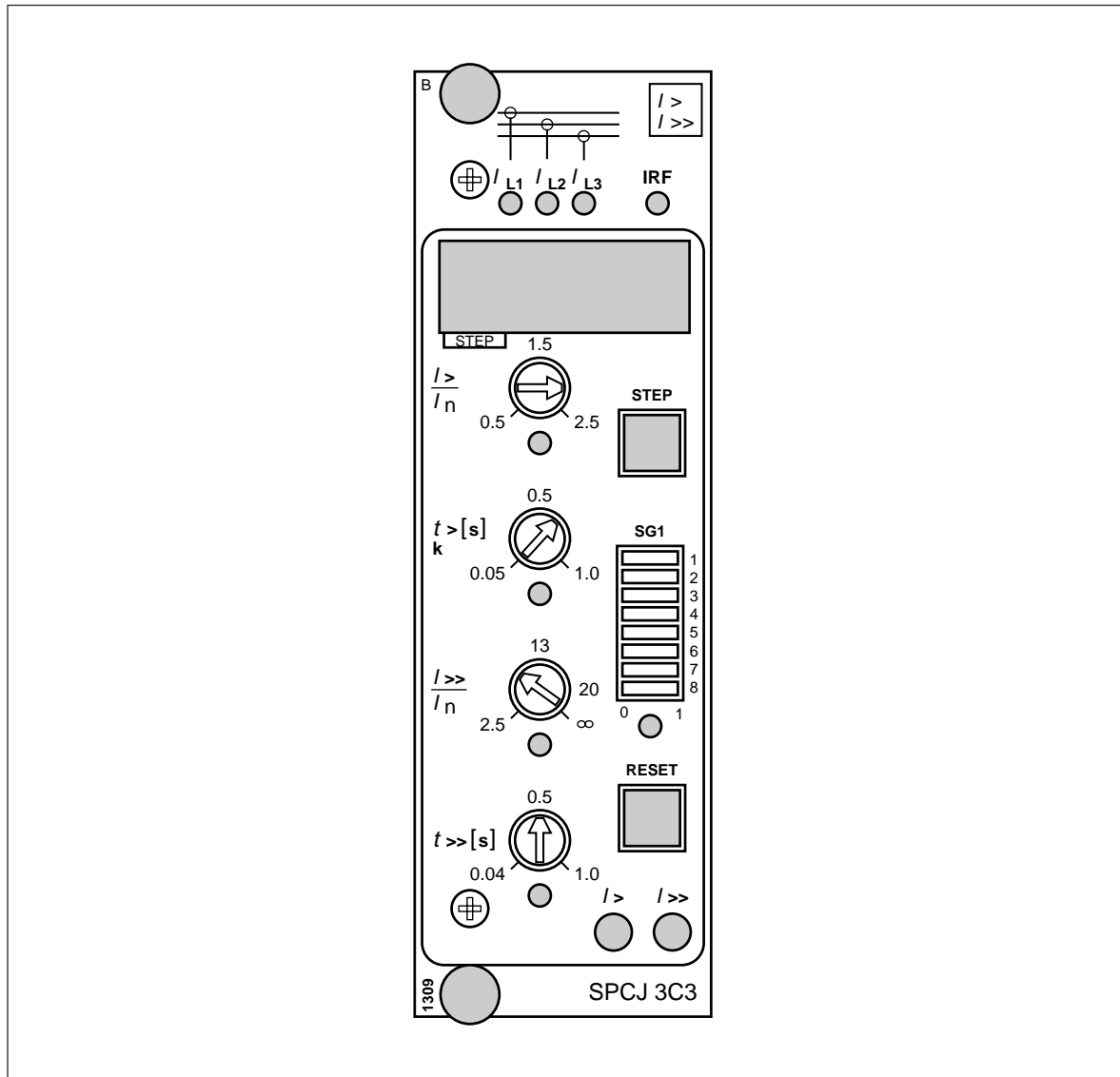
In most fault situations a fault code, indicating the nature of the fault, appears on the display of the module. The fault code, which consists of a red digit (1) and a three digit green code number, cannot be removed from the display by resetting. When a fault occurs, the fault code should be recorded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



# SPCJ 3C3

## Overcurrent relay module

User's manual and Technical description



Data subject to change without notice

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<b>Contents</b>	Features .....	2
	Description of operation .....	3
	Block diagram .....	4
	Front panel .....	5
	Operation indicators .....	5
	Settings .....	6
	Selector switches .....	7
	Measured data .....	9
	Recorded information .....	10
	Main menus and submenus of settings and registers .....	12
	Time/current characteristics ( <i>modified 2002-05</i> ) .....	13
	Technical data .....	18
	Event codes .....	19
	Remote transfer data .....	20
	Fault codes .....	23

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<b>Features</b>	Low-set overcurrent stage I> with selectable definite time or inverse definite minimum time (IDMT) operation characteristic	Digital display of measured and set values, recorded fault values, operation indications and fault messages
	High-set current stage I>> with instantaneous operation or definite time operation characteristic	Comprehensive serial communication capability
	Both overcurrent stages can be blocked by means of an external control signals from cooperating protection relays	Continuous self-supervision of the electronics and the software including autodiagnosics



## Description of operation

The overcurrent relay module SPCJ 3C3 can be used in single-phase, two-phase or three-phase protection relays and it contains two overcurrent stages, i.e. a low-set overcurrent stage  $I>$  and a high-set overcurrent stage  $I>>$ .

The low-set or high-set overcurrent stage starts if the current on one of the protected phases exceeds the set start value of the concerned stage. On starting, the concerned stage provides a starting signal SS1 or SS2 and simultaneously the operation indicator of the stage is lit with yellow light. If the overcurrent situation lasts long enough to exceed the set operation delay, the stage that started provides a tripping signal, TS1 or TS2. At the same time the operation indicator of the concerned stage is lit with red light. The red operation indicator remains lit although the protection stage resets. The yellow start indications and the red operation indications can be given self-reset or latching mode of operation. When the latching mode is selected the indicators are reset with the RESET push-button on the module's front panel or by the command V101 or V102 over the serial interface.

The operation of the low-set overcurrent stage  $I>$  can be blocked by routing a blocking signal BTS1 to the stage. Similarly, the operation of the high-set overcurrent stage  $I>>$  can be blocked by a blocking signal BTS2. The blockings are selected by means of switchgroup SGB on the PC board of the relay module.

If the protection relay incorporates an auto-reclose relay module, switchgroup SGB is additionally used for the purpose of selecting the start signals for the auto-reclose module. The instructions for selector switchgroup SGB are given in the general description of the protection relay unit, in association with the diagram illustrating the signals between the relay modules.

The operation of the low-set overcurrent stage  $I>$  can be based on definite time or inverse definite minimum time (IDMT) characteristic. The required operation characteristic is selected

with switch SG1/3. At definite time characteristic the operation time  $t>$  can be selected within one of the three available setting ranges of the stage. The operation time setting range is selected with switches SG1/1 and SG1/2. When inverse time characteristic (IDMT) is used four time/current curve groups with different slopes of inversivity are available. The required characteristic is selected with switches SG1/1 and SG1/2.

The operation time  $t>>$  of the high-set overcurrent stage is set separately. The setting range, one of three available, is selected by means of switches SG1/7 and SG1/8.

Normally both overcurrent stages are self-reset. With the selector switch SG1/4 both stages can be given a so called latching function, which means that the tripping output is kept energized after an operation though the fault has disappeared, until separately reset. The outputs are reset by pressing the push-buttons STEP and RESET simultaneously or by the commands V101 or V102 over the serial interface. See also table (switchgroup SG3) on page 9 in chapter "Selector switches".

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

The setting range of the high-set overcurrent stage is selected with switch SG1/6. Two alternatives setting ranges are available,  $2.5 \dots 20 \times I_n$  and  $0.5 \dots 4.0 \times I_n$ . When the lower range is chosen the relay module will contain two almost identical operation stages. In this case the overcurrent module SPCJ 3C3 may be used e.g. as a two-stage load shedding module. The operation of the high-set overcurrent stage may be blocked by choosing the setting value  $\infty$ , infinite.

Block diagram

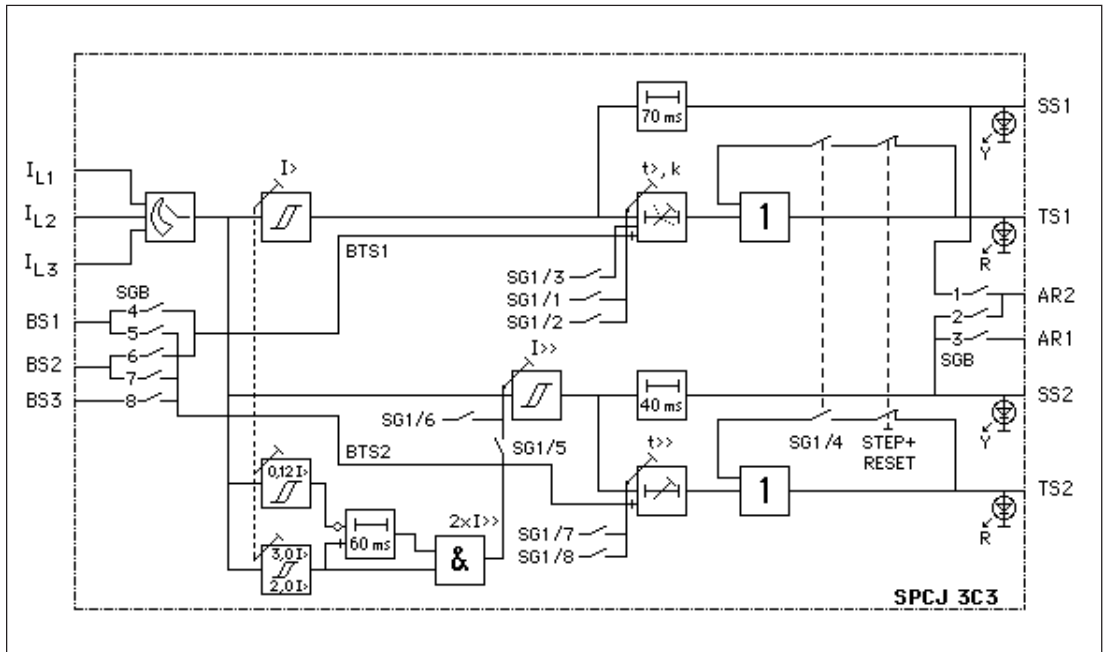


Fig. 1. Block diagram for the overcurrent relay module SPCJ 3C3.

$I_{L1}, I_{L2}, I_{L3}$	Measured phase currents
BS1, BS2, BS3	External blocking signals
BTS1	Blocking signal for the tripping of stage I>
BTS2	Blocking signal for the tripping of stage I>>
SG1	Selector switchgroup on the front panel
SG2	Function selector switchgroup for the operation indicators
SGB	Blocking signal selector switchgroup on the PC board and starting signal selector switchgroup for the auto-reclose functions
SS1	Start signal of stage I>
TS1	Trip signal of stage I>
SS2	Start signal of stage I>>
TS2	Trip signal of stage I>>
AR1, AR2	Start signals for auto-reclose functions
Y	Yellow indicator, starting
R	Red indicator, tripping

NOTE!

All input and output signals of the relay module are not necessarily wired to the terminals of any protection relay incorporating this module. The signals wired to the terminals are shown in the

diagram illustrating the interchange of signals between the various modules of the protection relay.

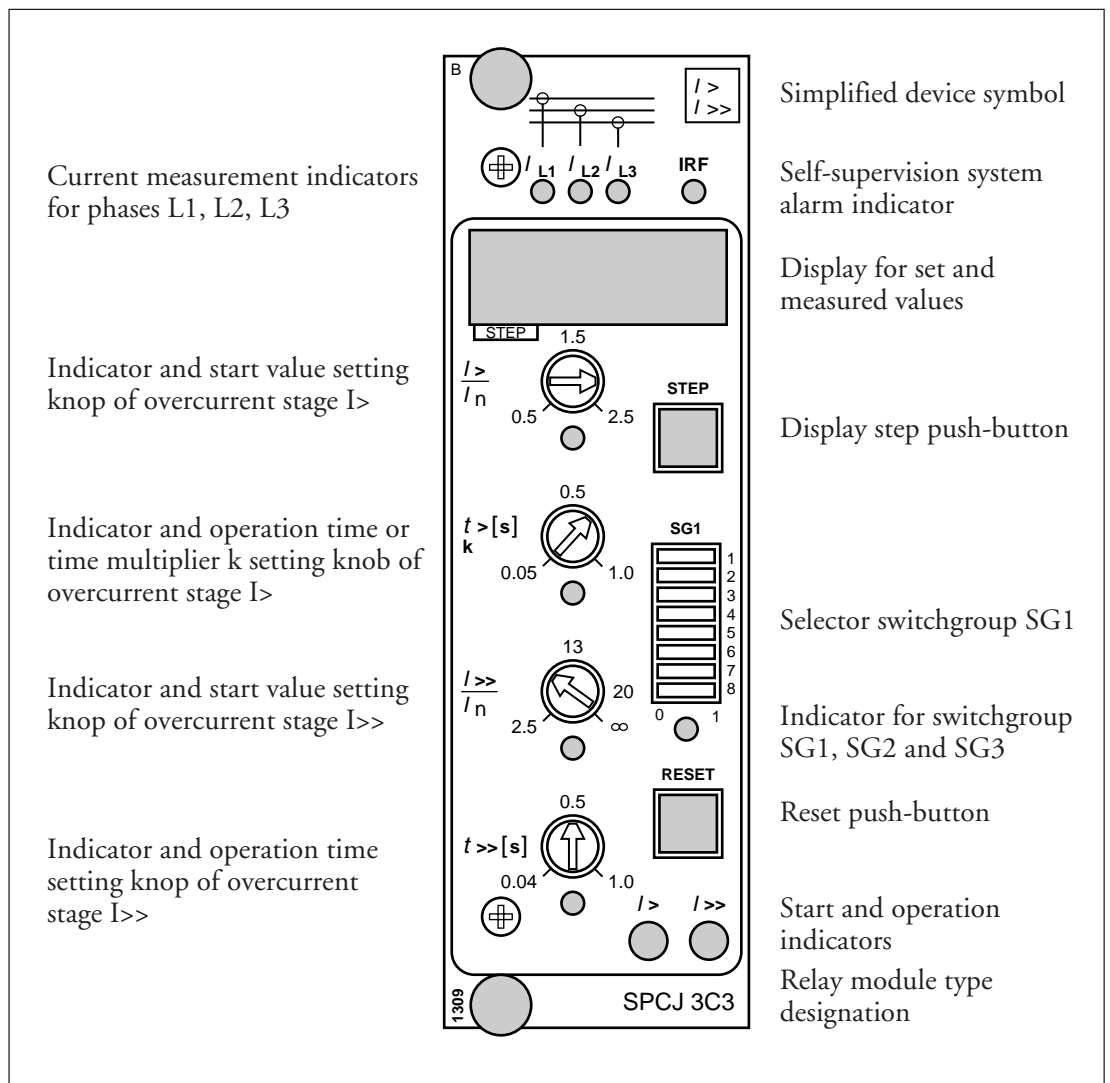


Fig. 2. Front panel of the overcurrent relay module SPCJ 3C3.

**Operation indicators**

Both 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 a self-reset mode of operation or manual reset mode. If, for instance, the yellow start indicator of the low-set overcurrent stage I> has been given the manual reset mode, the indicator is lit with yellow colour when the overcurrent stage starts and turning red when the stage operates. When the protection stage returns to normal the yellow indication remains lit. The indicators that have been given the manual reset mode 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.

When the display of the relay module is dark and one of the protection stages operates, the

indicators for the measured values of the module indicate the faulty phase, i.e. in which phase(s) the current has exceeded the setting value of the stage (so called phase fault indication). If, for instance, the operation indicator of stage I> is lit with red light and the indicators  $I_{L1}$  and  $I_{L2}$  also are lit, the relay operation was caused by overcurrent on phases L1 and L2. The phase fault indications are reset by pushing the STEP push-button or the RESET push-button. See also table (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 digits of the display. When lit, the indicator below a setting knob shows that the concerned setting value is being displayed.

$I_{>}/I_n$	Set start current of stage I> as a multiple of the rated current $I_n$ of the energizing input used. Setting range 0.5...2.5 x $I_n$ .
$t_{>}$ [s] k	The set start time of stage I>, expressed in seconds, when the definite time characteristic is used (SG1/3 = 0). The setting range is determined by the position of switches SG1/1 and SG1/2. Selectable setting ranges 0.05...1.00 s, 0.5...10.0 s and 5...100 s.  At inverse definite minimum time characteristic (SG1/3 = 1) the setting range of time multiplier k is 0.05...1.00.
$I_{>>}/I_n$	Set starting current of stage I>> as a multiple of the rated current $I_n$ of the energizing input used. Setting range 2.5...20.0 x $I_n$ , when SG1/6 = 0, and 0.5...4.0 x $I_n$ , when SG1/6 = 1. Additionally, the setting infinite (displayed as - - -) can be selected, rendering the high-set stage I>> inoperative.
$t_{>>}$ [s]	The set operation time of stage I>>, expressed in seconds. The setting ranges, 0.04...1.00 s, 0.4...10.0 s and 4...100 s, are determined by the position of switches SG1/7 and SG1/8, see below.

Further, the checksum of the selector switch-group SG1 is indicated on the display when the indicator under the switchgroup is glowing. In this way a checked can be carried out to prove that the switches have been set and that the

switches themselves work properly. An example of calculating the checksum is given in the description "General characteristics of C-type relay modules".

## Selector switches

Additional functions required by individual applications are selected by means of the selector switches of switchgroup SG1 located on the

front panel. The numbering of the switches 1...8, as well as the switch positions 0 and 1 are marked on the front panel.

Switch	Function																																													
SG1/1 SG1/2 SG1/3	<p>Switch SG1/3 is used for choosing the operation characteristic of the low-set current stage I&gt;, i.e. definite time or inverse definite minimum time (IDMT) characteristic. At definite time mode characteristic the setting range of the operation time <math>t_{&gt;}</math> is selected by means of switches SG1/1 and SG1/2, whereas, at inverse definite minimum time characteristic the switches are used for choosing the current/time characteristic of the overcurrent stage.</p> <table border="1"> <thead> <tr> <th>SG1/1</th> <th>SG1/2</th> <th>SG1/3</th> <th>Characteristic</th> <th>Operation time <math>t_{&gt;}</math> or type of characteristic</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>0</td> <td>Definite time</td> <td>0.05...1.00 s</td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> <td>"</td> <td>0.5...10.0 s</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> <td>"</td> <td>0.5...10.0 s</td> </tr> <tr> <td>1</td> <td>1</td> <td>0</td> <td>"</td> <td>5...100 s</td> </tr> <tr> <td>0</td> <td>0</td> <td>1</td> <td>IDMT</td> <td>Extremely inverse</td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> <td>"</td> <td>Very inverse</td> </tr> <tr> <td>0</td> <td>1</td> <td>1</td> <td>"</td> <td>Normal inverse</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> <td>"</td> <td>Long-time inverse</td> </tr> </tbody> </table>	SG1/1	SG1/2	SG1/3	Characteristic	Operation time $t_{>}$ or type of characteristic	0	0	0	Definite time	0.05...1.00 s	1	0	0	"	0.5...10.0 s	0	1	0	"	0.5...10.0 s	1	1	0	"	5...100 s	0	0	1	IDMT	Extremely inverse	1	0	1	"	Very inverse	0	1	1	"	Normal inverse	1	1	1	"	Long-time inverse
SG1/1	SG1/2	SG1/3	Characteristic	Operation time $t_{>}$ or type of characteristic																																										
0	0	0	Definite time	0.05...1.00 s																																										
1	0	0	"	0.5...10.0 s																																										
0	1	0	"	0.5...10.0 s																																										
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0	1	1	"	Normal inverse																																										
1	1	1	"	Long-time inverse																																										
SG1/4	<p>Selection of the latching function for the tripping signals TS1 and TS2.</p> <p>When SG1/4 = 0, the tripping signals return to normal (= the output relay resets, when the energizing input signal causing the operation falls below the start level. When SG1/4 = 1, the tripping signals remain on (= output relay energized), although the energizing input signal falls below the starting level. The latched tripping signals are reset by pressing the push-buttons STEP and RESET simultaneously or with the command V101. When the STEP and RESET push-buttons are pushed the recorded values are erased as well. *)</p>																																													
SG1/5	<p>Selection of automatic doubling of the setting value of the high-set overcurrent stage when the protected object is connected to the network.</p> <p>When SG1/5 = 0, no doubling of the set start value of stage I&gt;&gt; is obtained. When SG1/5 = 1, the set start value of stage I&gt;&gt; doubles automatically. The doubling feature makes it possible to give the high-set current stage a setting value, which is lower than the connection inrush current of the protected object.</p>																																													
SG1/6	<p>Selection of the start current setting range of the high-set overcurrent stage I&gt;&gt;.</p> <p>When SG1/6 = 0, the setting range is 2.5...20 x <math>I_n</math> and <math>\infty</math>, infinite. When SG1/6 = 1, the setting range is 0.5...4 x <math>I_n</math> and <math>\infty</math>, infinite. When SG1/6 = 1, the module comprises two almost identical overcurrent stages and may in this case be used for load shedding purposes. The setting <math>\infty</math>, infinite, is indicated by - - - on the display.</p>																																													

\*) From the program version 052 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.

Switch	Function															
SG1/7 SG1/8	Selection of the setting range of the operation time $t_{>>}$ of the high-set overcurrent stage $I_{>>}$ . <table border="1" style="margin-left: 20px;"> <thead> <tr> <th>SG1/7</th> <th>SG1/8</th> <th>Operation time <math>t_{&gt;&gt;}</math></th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>0.04...1.00 s</td> </tr> <tr> <td>1</td> <td>0</td> <td>0.4...10.0 s</td> </tr> <tr> <td>0</td> <td>1</td> <td>0.4...10.0 s</td> </tr> <tr> <td>1</td> <td>1</td> <td>4...100 s</td> </tr> </tbody> </table>	SG1/7	SG1/8	Operation time $t_{>>}$	0	0	0.04...1.00 s	1	0	0.4...10.0 s	0	1	0.4...10.0 s	1	1	4...100 s
SG1/7	SG1/8	Operation time $t_{>>}$														
0	0	0.04...1.00 s														
1	0	0.4...10.0 s														
0	1	0.4...10.0 s														
1	1	4...100 s														

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 and the high-set overcurrent stage can be given self-reset mode of operation or latching 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 latching.

If the checksum of switchgroup SG2 = 0 no LED indications are obtained after a fault, i.e. no start or operation indications  $I_{>}$  or  $I_{>>}$  nor phase indications  $I_{L1}$ ,  $I_{L2}$  or  $I_{L3}$ .

Indication	Latching	Default
Starting, stage $I_{>}$ , yellow	1	0
Tripping, stage $I_{>}$ , red	2	2
Starting, stage $I_{>>}$ , yellow	4	0
Tripping, stage $I_{>>}$ , red	8	8
Checksum	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 holds a switchgroup SGB including switches 1...8. Switches 1...3 are used for selecting the starting signals for a possible auto-reclose module, whereas switches 4...8 are used for routing

blocking signals to the overcurrent module in various protection relays. The functions of the selector switchgroup SGB is described in the general part of the manual of the concerned protection relay.

### Measured data

The measured values are displayed by the rightmost three digits on the display. The rele-

vant measured data are indicated by a lit indicator on the front panel.

Indicator	Measured data
I <sub>L1</sub>	Line current on phase L1 as a multiple of the rated current I <sub>n</sub> .
I <sub>L2</sub>	Line current on phase L2 as a multiple of the rated current I <sub>n</sub> .
I <sub>L3</sub>	Line current on phase L3 as a multiple of the rated current I <sub>n</sub> .

NOTE! The rated current I<sub>n</sub> is the rated current of the energizing input taken in use in the concerned protection relay.

## Recorded information

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

Register/ STEP	Recorded information
1	<p>Maximum phase current measured as a multiple of the rated current of the protection relay. If the module operates, the current value at the moment of operation is stored in the memory. A new tripping erases the old value and updates the register with the new value. The same thing happens if the current exceeds a previously registered maximum value.</p> <p>In the 1.st submenu the current value measured at the last operation is recorded.</p>
2	Number of startings of the low-set overcurrent stage $I_{>}$ , $n(I_{>}) = 0...255$ .
3	Number of startings of the high-set overcurrent stage $I_{>>}$ , $n(I_{>>}) = 0...255$ .
4	Duration of the latest starting situation of stage $I_{>}$ as a percentage of the set operation time $t_{>}$ or at IDMT mode of operation the calculated operation time. A new starting resets the counter which thus always contains the value from the latest starting. When the stage has operated, the counter reading is 100.
5	Duration of the latest starting situation of stage $I_{>>}$ as a percentage of the set operating time $t_{>>}$ . A new starting resets the counter which thus always contains the value from the latest starting. When the stage has operated, the counter reading is 100.
0	<p>Display of blocking signals and other external control signals. The leftmost digit indicates the state of the blocking inputs of the module. The following states may be indicated:</p> <ul style="list-style-type: none"> <li>0 = no incoming blockings</li> <li>1 = operation of stage <math>I_{&gt;}</math> blocked</li> <li>2 = operation of stage <math>I_{&gt;&gt;}</math> blocked</li> <li>3 = operation of both stages blocked</li> </ul> <p>In this register the middle green digit of the display is always zero. The leftmost green digit indicates the state of the remote reset input, if any. The following states may be indicated:</p> <ul style="list-style-type: none"> <li>0 = remote reset control input not energized</li> <li>1 = remote reset control input energized</li> </ul> <p>From this register it is possible to move on to the TEST mode, where the start and operation signals of the module can be activated one by one. For further details see the description "General characteristics of C-type relay modules".</p>



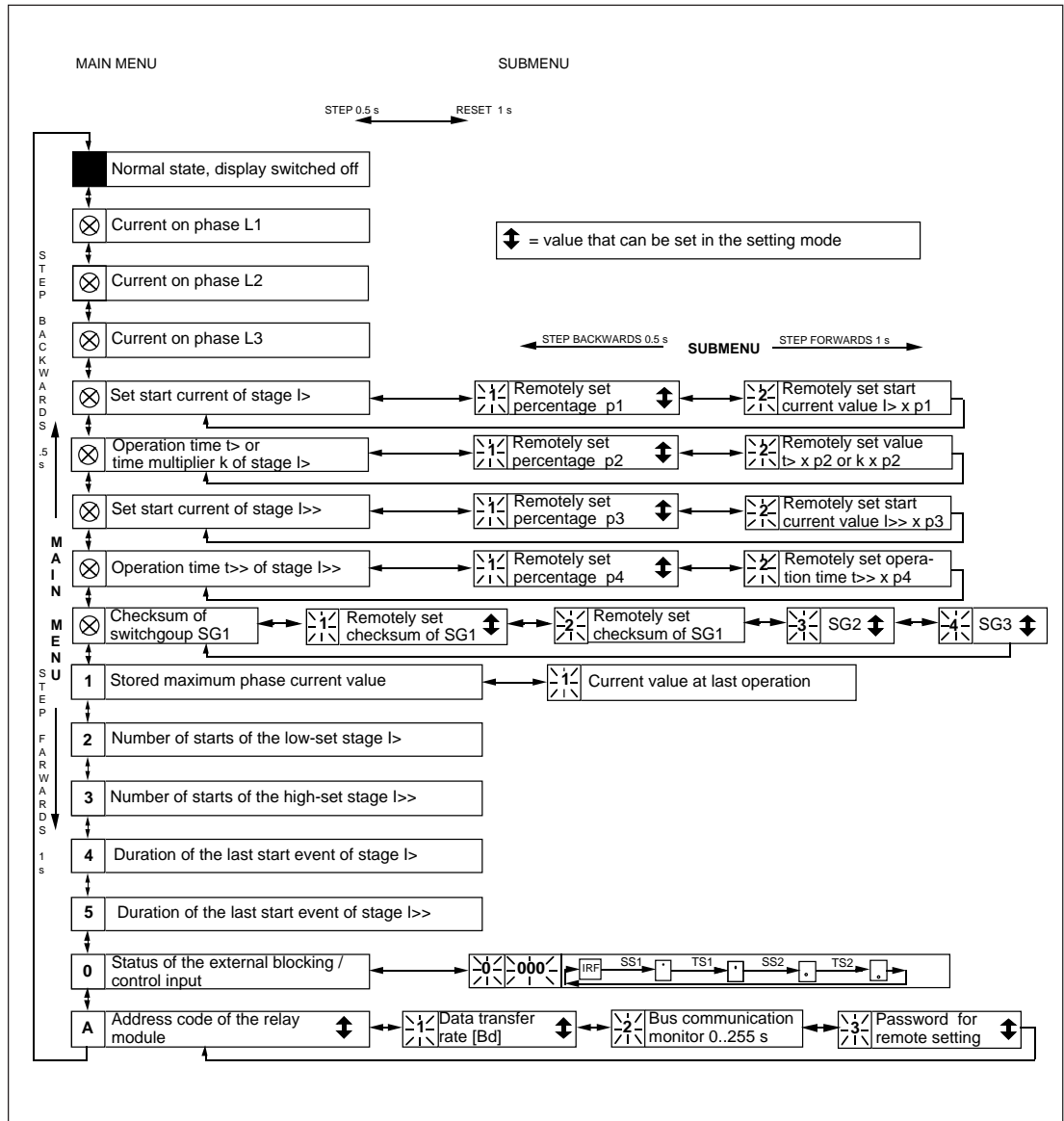
Register/ STEP	Recorded information
A	<p>The address code of the protection relay module, required by the serial communication system. If the address code is set at zero the serial communication is out of use. The submenus in this register are:</p> <ol style="list-style-type: none"> <li>1) Selection of data transfer rate for the serial communication. Selectable values: 300, 1200, 2400, 4800 or 9600 Bd. Default value 9600 Bd.</li> <li>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. If the communication is interrupted the numbers 0...255 is scrolling in the display.</li> <li>3) Password required for the remote control of relay settings</li> </ol>
-	<p>Display dark. By pressing the STEP push-button the starting point of the display menu obtained.</p>

The values of the registers 1...5 are erased by pressing the push-buttons STEP and RESET simultaneously or with the command V102. The register values are also erased if the auxiliary power supply of the module is interrupted. The address code of the relay module, the value of

the data transfer rate of the serial communication and the password are not erased by an auxiliary voltage interruption. The instructions for setting the address and the data transfer rate are given in the description "General characteristics of C-type relay modules".

## Main menus and submenus of settings and registers

The diagram below shows the available main menus and submenus of the overcurrent relay module SPCJ 3C3.



Instructions for entering a submenu or the setting mode, procedures for doing the settings and for handling the TEST mode are given in

the manual "General characteristics of C-type relay modules".

**Time/current characteristics**  
(modified 2002-05)

The operation of the low-set current stage I> of the overcurrent module is based on either definite time or inverse time characteristic. The operation characteristic is selected with switch 3 of switchgroup SG1, see page 7.

When an I.D.M.T. characteristic is chosen, the operation time of the low-set overcurrent stage I> will be a function of the current; the higher the current, the shorter the operation time. The relationship between current and time comply with the standards BS 142 of 1966 and IEC 60255-3 and may generally be expressed as:

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

where t = operation time in seconds  
k = time multiplier  
I = measuring current  
I> = set start current

The module includes four characteristics with different slopes. The characteristic to be used is chosen with switches 1 and 2 of switchgroup SG1, see page 7.

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

Over the normal current ranges, the inverse-time stage of the overcurrent module SPCJ 3C3 complies with the tolerances of class 5 for all four characteristics.

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

The slope of the time/current curves is determined by the values of the constants α and β:

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

According to the standard BS 142 of 1966 a normal current range is defined as 2...20 times the setting. Additionally the relay must start at the latest when the measured current exceeds 1.3 times the set start current, when the time/current characteristic is normal inverse, very inverse or extremely inverse. At long-time inverse characteristic, the normal range according to the standard is 2...7 times the set start current and the relay is to start when the current exceeds 1.1 times the set start current.

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

Note.

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

Inverse-time characteristics of overcurrent relay module SPCJ 3C3.

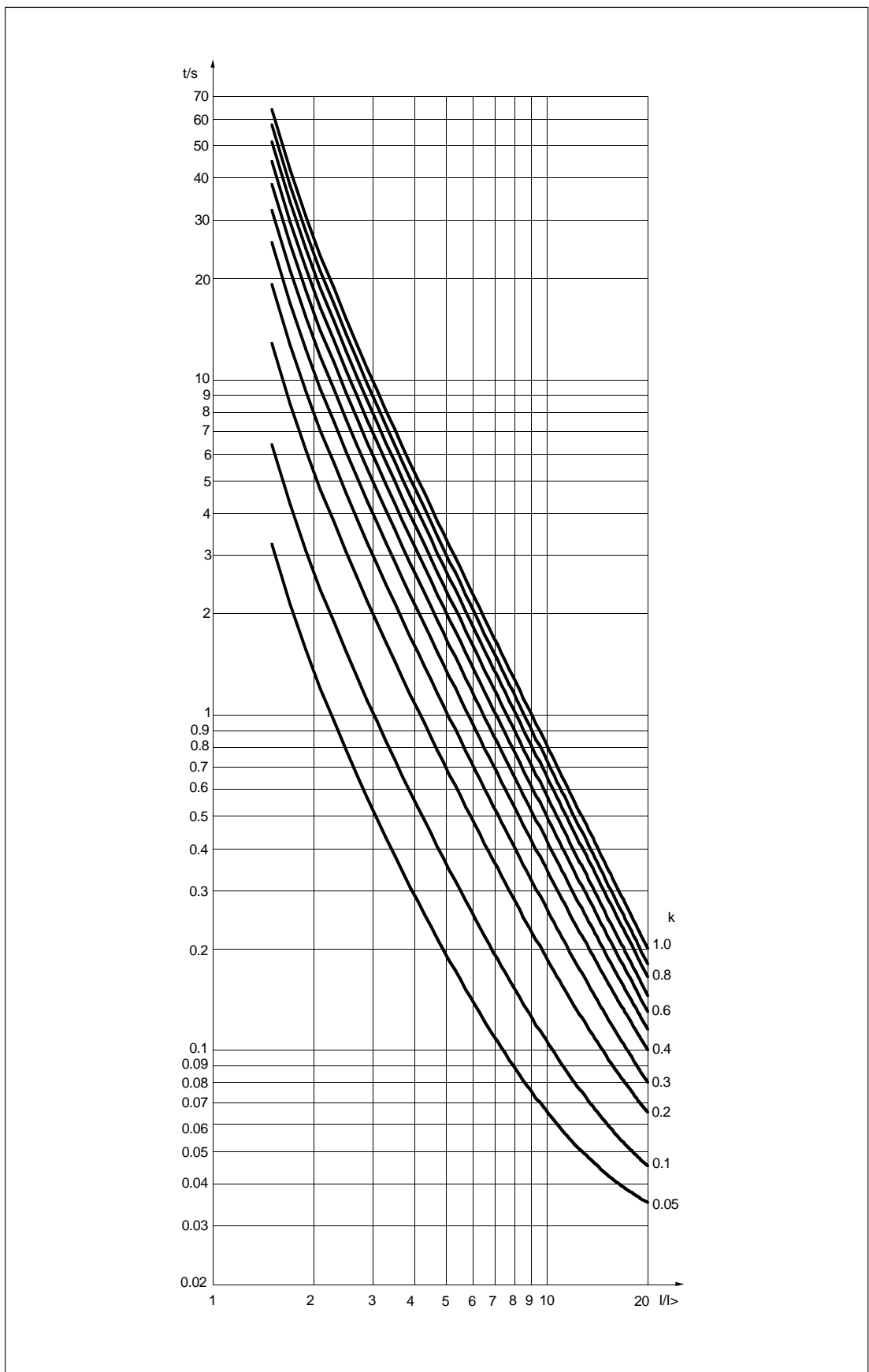


Fig. 3. Extremely inverse characteristic.

- $I$  = measured current
- $I>$  = set start current
- $t$  = operation time
- $k$  = time multiplier

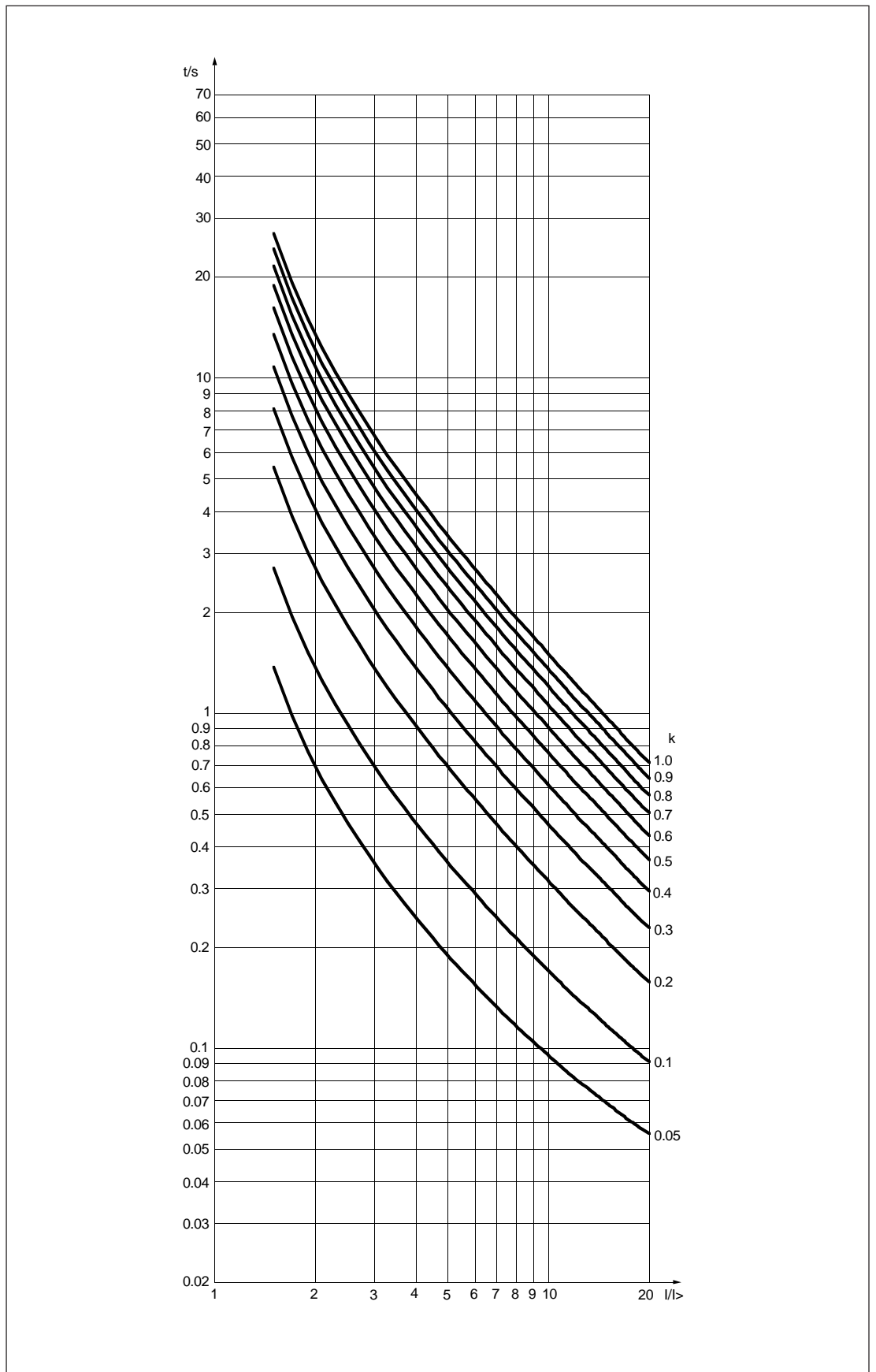


Fig. 4. Very inverse characteristic.

$I$  = measured current  
 $I>$  = set start current  
 $t$  = operation time  
 $k$  = time multiplier

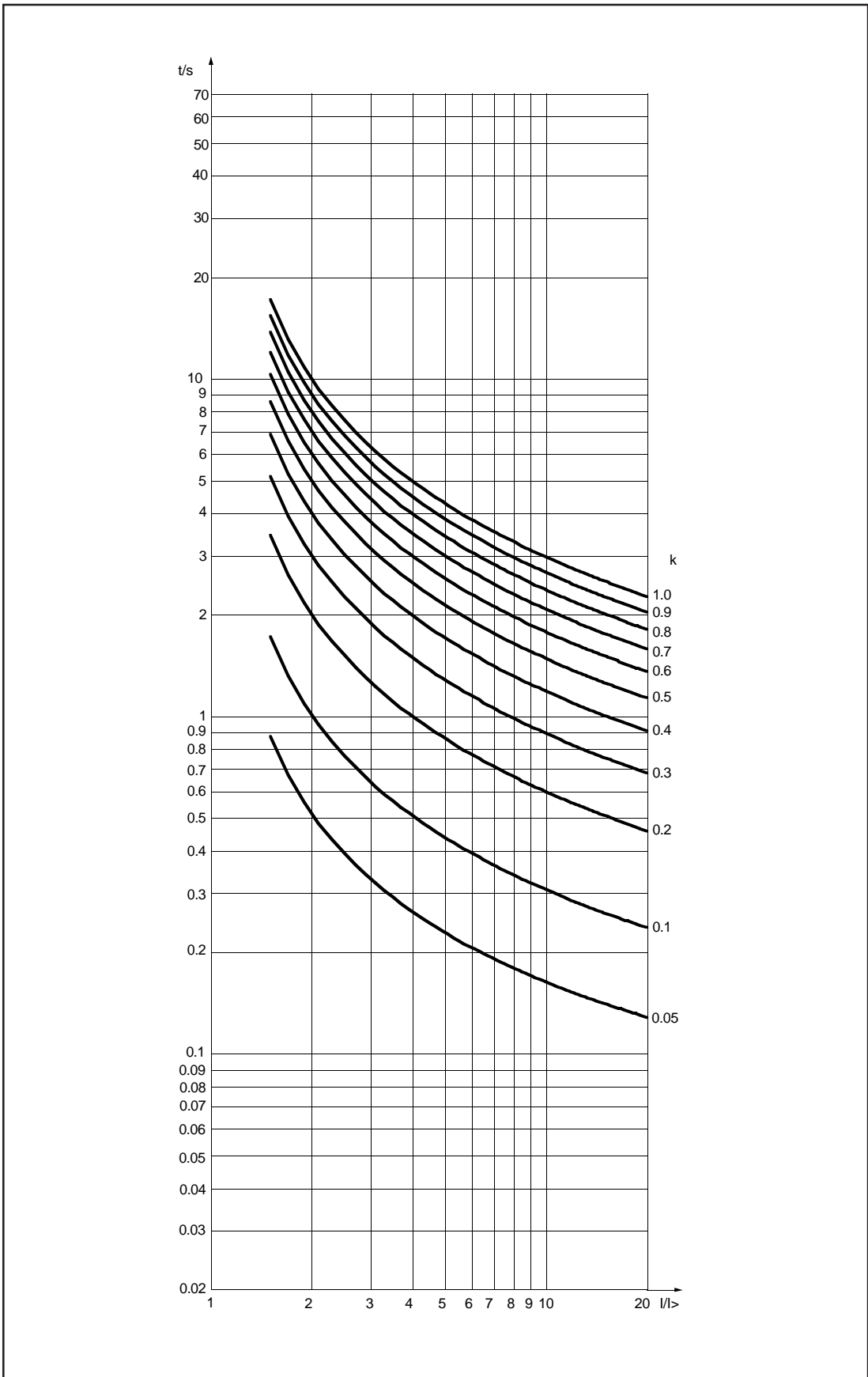


Fig. 5. Normal inverse characteristic.

- I = measured current
- I> = set current
- t = operation time
- k = time multiplier

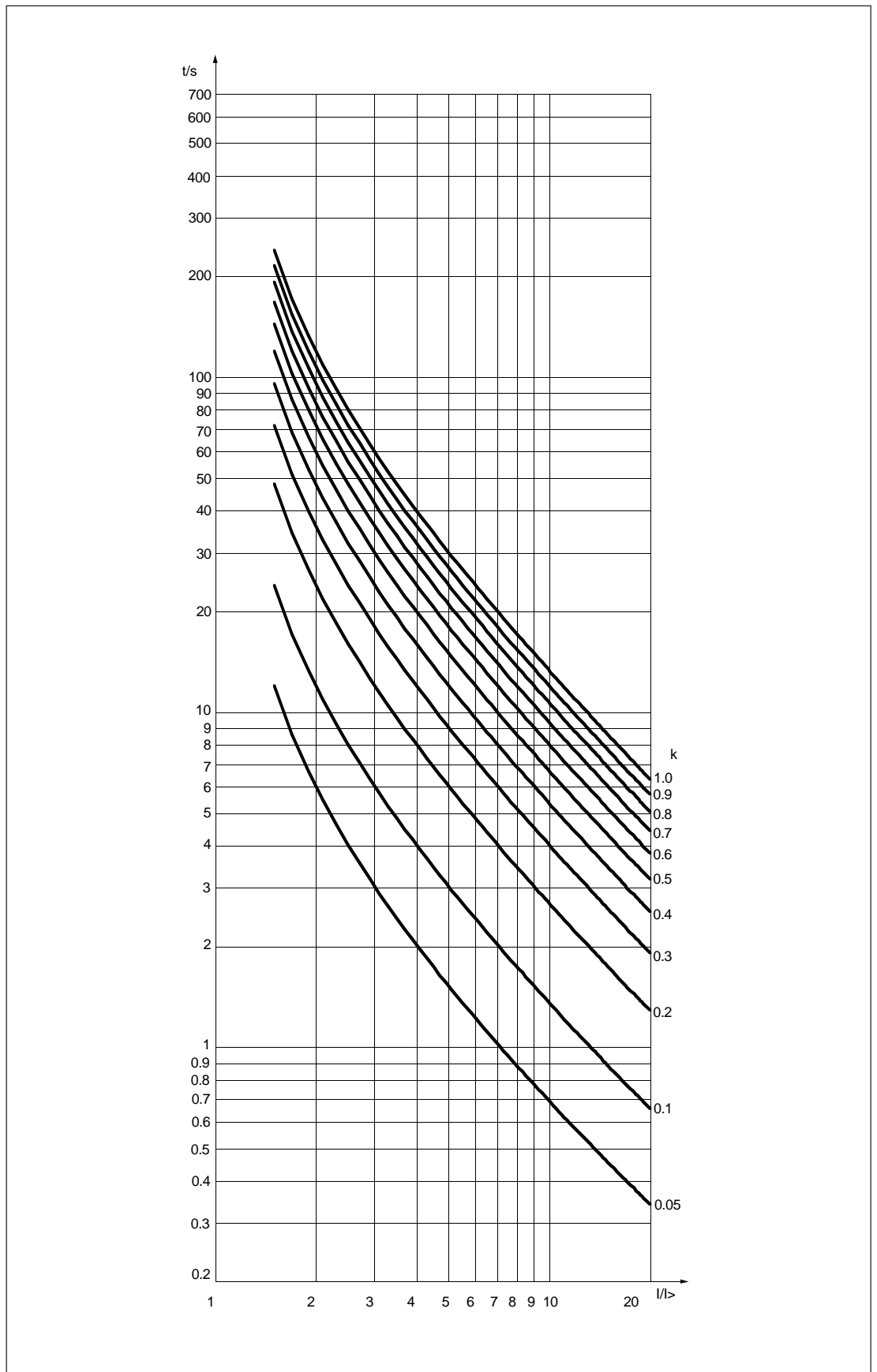


Fig. 6. Long-time inverse characteristic.

$I$  = measured current  
 $I_{>}$  = set start current  
 $t$  = operation time  
 $k$  = time multiplier

## Technical data

### Low-set overcurrent stage I>

Start current I>	0.5...2.5 x I <sub>n</sub>
Start time, typically	55 ms
Operate time t> at definite time characteristic	0.05...1.00 s, 0.5...10.0 s or 5...100 s
Time/current curves at inverse time characteristic (IDMT)	Extremely inverse Very inverse Normal inverse Long-time inverse
Time multiplier k	0.05...1.00
Reset time, typically	60 ms
Retardation time	<30 ms
Drop-off/pick-up ratio, typically	0.96
Operation time accuracy at definite time operation characteristic	±2% of set value or ±25 ms
Operation time accuracy class E at inverse time mode of operation	5
Operation accuracy	±3% of set value

### High-set overcurrent stage I>>

Start current I>>	2.5...20.0 x I <sub>n</sub> & ∞, infinite or 0.5...4.0 x I <sub>n</sub> & ∞, infinite
Start time, typically	40 ms
Operation time t>>	0.04...1.00 s, 0.4...10.0 s or 4...100 s
Reset time, typically	60 ms
Retardation time	<30 ms
Drop-off/pick-up ratio, typically	0.96
Operation time accuracy	±2% of set value or ±25 ms
Operation accuracy	±3% of set value



## Event codes

The substation level control data communicator is able to read, over the SPA serial bus, the event data of the protection module of the relay, e.g. start and trip information. Event information that have been read are printed out in the format: time (ss.sss) and event code. The event codes of the relay module SPCJ 3C3 are denoted E1...E8, E50 and E51. Additional event codes, i.e. E52...E54, are generated by the control data communicator. These event codes are, for instance, related to the data communication.

The event 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, an event mask (V155) to the relay module. The event mask is a binary number coded to a decimal number. The event codes

E1...E8 are represented by the numbers 1, 2, 4...128. The event mask is formed by multiplying, one by one, the above numbers either with 0 (event not included in the reporting) or 1 (event included in the reporting) and adding the products, check for the procedure for calculating the checksum.

The event mask may take a value within the range 0...255. The default value of the relay module SPCJ 3C3 is 85, which means that all start and trip signals are included in the reporting, but not the resetting. The event codes E50...E54 and the events represented by these cannot be excluded from the reporting.

Event codes for the overcurrent relay module SPCJ 3C3:

Code	Event	Number representing the event	Factory set default value
E1	Starting of stage I>	1	1
E2	Reset of starting of stage I>	2	0
E3	Tripping of stage I>	4	1
E4	Reset of tripping of stage I>	8	0
E5	Starting of stage I>>	16	1
E6	Reset of starting of stage I>>	32	0
E7	Tripping of stage I>>	64	1
E8	Reset of tripping of stage I>>	128	0
E50	Restarting	*	-
E51	Overflow of event register	*	-
E52	Temporary disturbance of the data communication	*	-
E53	No response from the relaymodule over the data communication	*	-
E54	The relay module responds again over the data communication	*	-

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

## Remote transfer data

Apart from the event codes the control data communicator is able to read, over the SPA bus, all input data (I data) of the relay module, set values (S values), output status data (O 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. Any information is located on channel 0, which needs not to be written in the data communication instructions.

Data	Code	Data direct.	Values
Current on phase L1 as a multiple of the rated current	I1	R	0...63 x I <sub>n</sub>
Current on phase L2 as a multiple of the rated current	I2	R	0...63 x I <sub>n</sub>
Current on phase L3 as a multiple of the rated current	I3	R	0...63 x I <sub>n</sub>
Blocking of tripping of stage I>	I4	R	0 = no blocking 1 = tripping of stage I> blocked
Blocking of tripping of stage I>>	I5	R	0 = no blocking 1 = tripping of stage I>> blocked
Starting of stage I>	O1	R	0 = stage I> has not started 1 = stage I> started
Tripping of stage I>	O2	R	0 = stage I> not tripped 1 = stage I> tripped
Starting of stage I>>	O3	R	0 = stage I>> not started 1 = stage I>> started
Tripping of stage I>>	O4	R	0 = stage I>> not tripped 1 = stage I>> tripped
Alerted start value for stage I>	S1	R	0.5...2.5 x I <sub>n</sub>
Alerted operation time for stage I> or time multiplier k	S2	R	0.05...100 s 0.05...1.00
Alerted start value for stage I>>	S3	R	0.5...20 x I <sub>n</sub> 999 = ∞, infinite
Alerted operation time for stage I>>	S4	R	0.04...100 s
Alerted checksum of switchgroup SG1	S5	R	0...255
Start value of stage I>, set with the setting knob	S11	R	0.5...2.5 x I <sub>n</sub>
Operation time or time multiplier of stage I>, set with the setting knob	S12	R	0.05...100 s 0.05...1.00
Start value of stage I>>, set with the setting knob	S13	R	0.5...20 x I <sub>n</sub> 999 = ∞, infinite
Operation time of stage I>>, set with the setting knob	S14	R	0.04...100 s
Checksum of switchgroup SG1, set with the switches	S15	R	0...255
Remote setting percentage of the start value of stage I>	S21	R, W	0...999%
Remote setting percentage of the operation time or time multiplier of stage I>	S22	R, W	0...999%
Remote setting percentage of the start value of stage I>>	S23	R, W	0...999%
Remote setting percentage of the operation time of stage I>>	S24	R, W	0...999%
Remotely set checksum for the switchgroup SG1	S25	R, W	0...255

Data	Code	Data direct.	Values
Remotely set start value of stage I>	S31	R	0.5...2.5 x I <sub>n</sub>
Remotely set operation time value or time multiplier of stage I>	S32	R	0.05...100 s 0.05...1.00
Remotely set start value of stage I>>	S33	R	0.5...20 x I <sub>n</sub> 999 = ∞, infinite
Remotely set operation time value of stage I>>	S34	R	0.04...100 s
Remotely set checksum of switch-group SG1	S35	R	0...255
Max. measured current or current value at relay operation	V1	R	0...63 x I <sub>n</sub>
Number of starts of stage I>	V2	R	0...255
Number of starts of stage I>>	V3	R	0...255
Duration of the latest start situation of stage I>	V4	R	0...100%
Duration of the latest start situation of stage I>>	V5	R	0...100%
Phase data recorded at the latest tripping occasion	V6	R	1 = I <sub>L3&gt;</sub> , 2 = I <sub>L2&gt;</sub> , 4 = I <sub>L1&gt;</sub> , 16 = I <sub>L3&gt;&gt;</sub> , 32 = I <sub>L2&gt;&gt;</sub> , 64 = I <sub>L1&gt;&gt;</sub> + combinations
Current value at relay operation	V7	R	0...63 x I <sub>n</sub>
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...V7) are erased
Remote control of settings	V150	R, W	0 = setting with knobs S11...S15 alerted 1 = remote settings S31...S35 alerted
Event mask word	V155	R, W	0...255, see paragraph "Event codes"
Manual or automatic resetting of LED indicators (SG2)	V156	R, W	0...15, see paragraph "Selector switches"
Programming push-buttons (SG3)	V157	R, W	0...7, see paragraph "Selector switches"
Opening of password for remote setting of module parameters	V160	W	1...999
Renaming or closing of password for remote setting of parameters	V161	W	0...999
Activation of the self-supervision system output	V165	W	1 = self-supervision output is activated and IRF indicator turns on in about 5 seconds, whereafter the self-supervision system and the IRF indicator reset.
Fault code number	V169	R	0...255

Data	Code	Data direct.	Values
Data communication address of the relay module	V200	R, W	1...254
Program version number	V205	R	e.g. 052 B
Relay module type designation	F	R	SPCJ 3C3
Reading of event register	L	R	Time, channel number and event code
Re-reading of event register	B	R	Time, channel number and event code
Reading of relay module state data	C	R	0 = normal state 1 = module been subject to automatic reset 2 = overflow of event register 3 = events 1 and 2 together
Resetting of module state data	C	W	0 = resetting
Time reading and setting	T	R, W	00.000...59.999 s

R = data to be read from the unit  
W = data to be written to the unit

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

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

The set values S1...S5 are the alerted set values currently used by the relay. These values can be set either by means of the setting knobs and selector switches or by remote control. The values S11...S15 are set with the setting knobs and the switches of the relay module. The values S21...S25 are percentage factors to be multiplied by the set values given with the setting

knobs. The set values S21...S25 can be both read and written. A condition for writing is that the password, V160, for remote setting has been opened and the potentiometer settings must be valid, V150=0. The variables S31...S35 contain the actual remotely set values.

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

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

After an operation the relay module indicates by means of variable V6 the phases (phase indication) which have exceeded the setting value of the low-set stage or the high-set stage at the moment of operation. The same data are indicated by the LED indicators of the module, see section "Operation indicators". The data are

binary numbers coded to decimal numbers, so that, for the low-set overcurrent stage as well as for the high-set overcurrent stage, each phase is represented by a specific number. The final code is obtained by adding the separate phase code numbers.

Coding of phase fault data:

Fault	Code number
Low-set stage I> set value exceeded on phase L3	1
Low-set stage I> set value exceeded on phase L2	2
Low-set stage I> set value exceeded on phase L1	4
High-set stage I>> set value exceeded on phase L3	16
High-set stage I>> set value exceeded on phase L2	32
High-set stage I>> set value exceeded on phase L1	64

For instance when  $V6 = 7 (1 + 2 + 4)$ , the low-set current stage has operated (tripped) and the current on each phase has exceeded the set start value of the low-set stage I>.

4 only. If the high-set overcurrent stage operates, only the codes 16, 32 and 64 are updated. A new value always erases the old recorded value.

Register data V6 includes two separate parts, one for the low-set overcurrent stage and one for the high-set overcurrent stage. If the low-set overcurrent stage operates, the value of register V6 is updated with regard to the codes 1, 2 and

Register V6 can be set to zero either by pushing the buttons STEP and RESET simultaneously or by giving the variable V102 the value 1 via the SPA bus.

## Fault codes

Shortly after the self-supervision system has detected a permanent internal fault the red fault indicator IRF on the relay module front panel is lit. At the same time the self-supervision system puts forward a control signal to the output relay of the self-supervision system. Further, in most fault situations a self-diagnostic fault code is shown on the display of the relay module. The fault code is composed of a red number one (1)

and a green, one or two digit code number. It is recommended that the fault code number is noted down and passed forward to the service shop when overhaul and repair of the faulty relay module is ordered.

The three-phase overcurrent relay module SPCJ 3C3 may display the following fault codes:

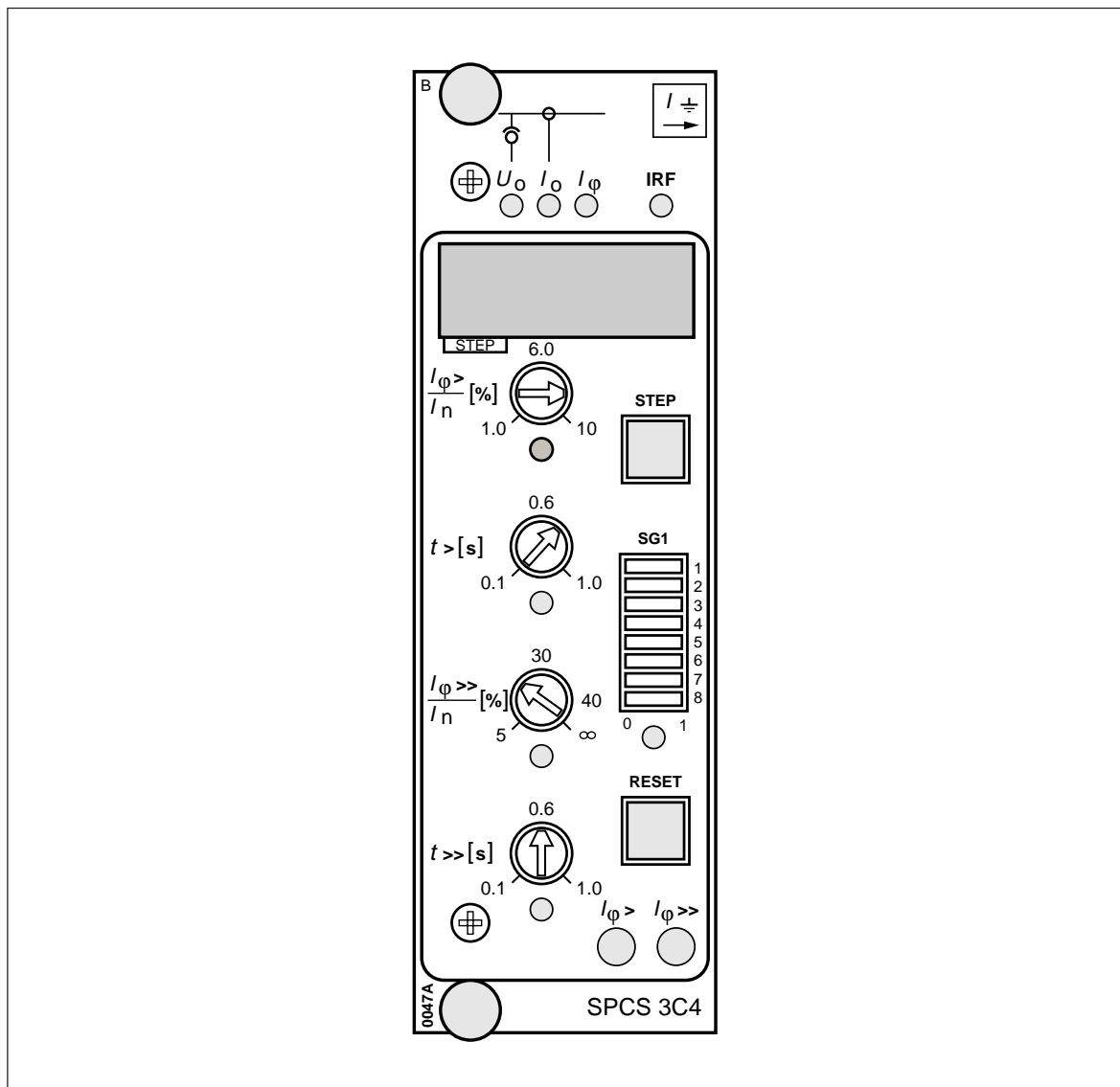
Fault code	Type of fault
4	Trip signal path broken or output relay module missing
30	Faulty program memory (ROM)
50	Faulty random access memory (RAM)
195	Too low a value on the reference channel with multiplier 1
131	Too low a value on the reference channel with multiplier 5
67	Too low a value on the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



# 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

<b>Contents</b>	Features .....	2
	Description of operation .....	3
	Block schematic diagram .....	4
	Front panel .....	5
	Operation indicators .....	5
	Settings .....	6
	Selector switches .....	7
	Measured data .....	9
	Recorded information ( <i>modified 2000-02</i> ) .....	10
	Main menus and submenus of settings and registers .....	12
	Technical data ( <i>modified 2000-02</i> ) .....	13
	Event codes .....	14
	Remote transfer data ( <i>modified 2000-02</i> ) .....	15
	Fault codes .....	18

<b>Features</b>	Directional neutral overcurrent relay module with definite time characteristic for earth fault protection	Four selectable start values for the residual voltage
	Two neutral overcurrent stages, a low-set stage $I_{\phi>}$ and a high-set stage $I_{\phi>>}$	Digital display of measured values, set values and recorded fault values
	The high-set stage can be given the same or the opposite direction of operation as compared with the low-set stage	Continuous self-supervision with autodiagnos- tics including both hardware and software
	$I_0\sin\phi$ or $I_0\cos\phi$ operation characteristic selected locally by switches or by remote control over the external control input	Serial communication capability for extensive data exchange between the relay module and the substation level communication or control system



## Description of operation

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

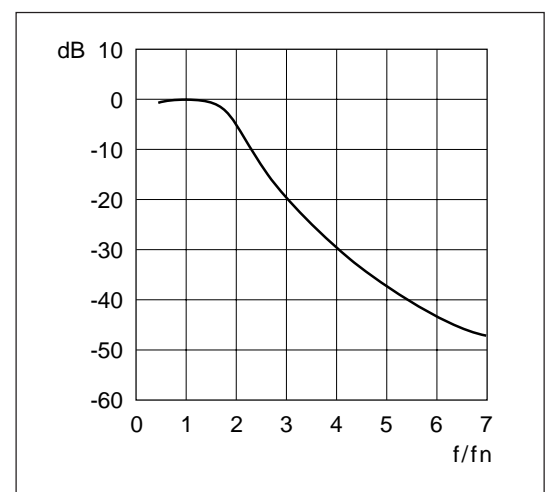


Fig. 1. Filter characteristics of the energizing inputs of the relay module SPCS 3C4.

Block schematic diagram

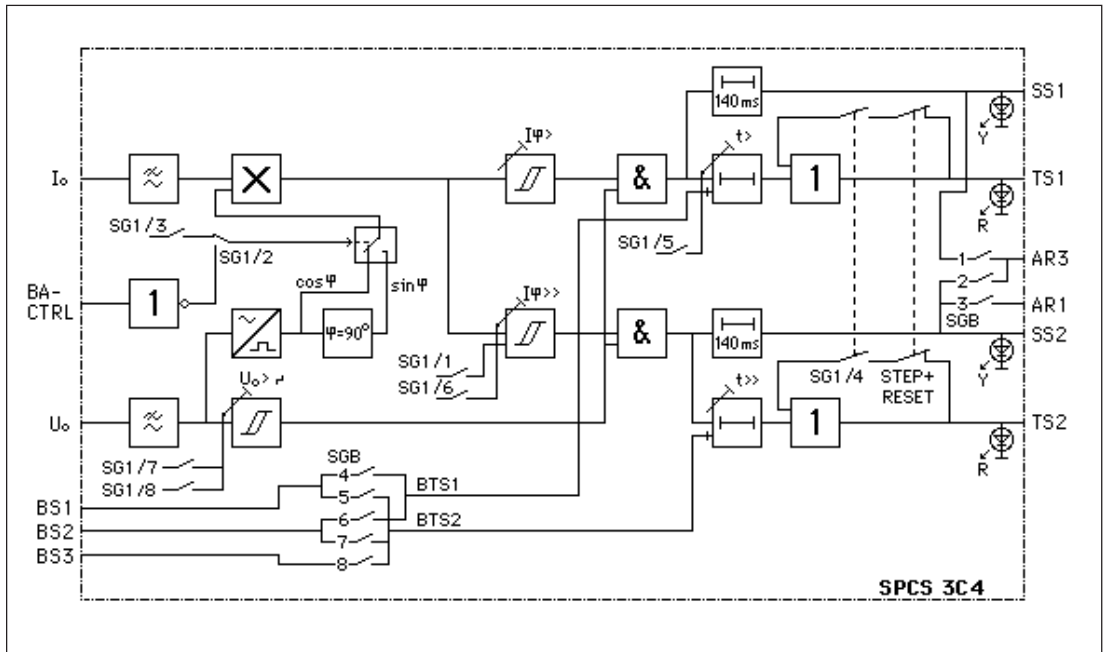


Fig. 2. Block diagram for the directional neutral current relay module SPCS 3C4.

$U_0$	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.

## Front panel

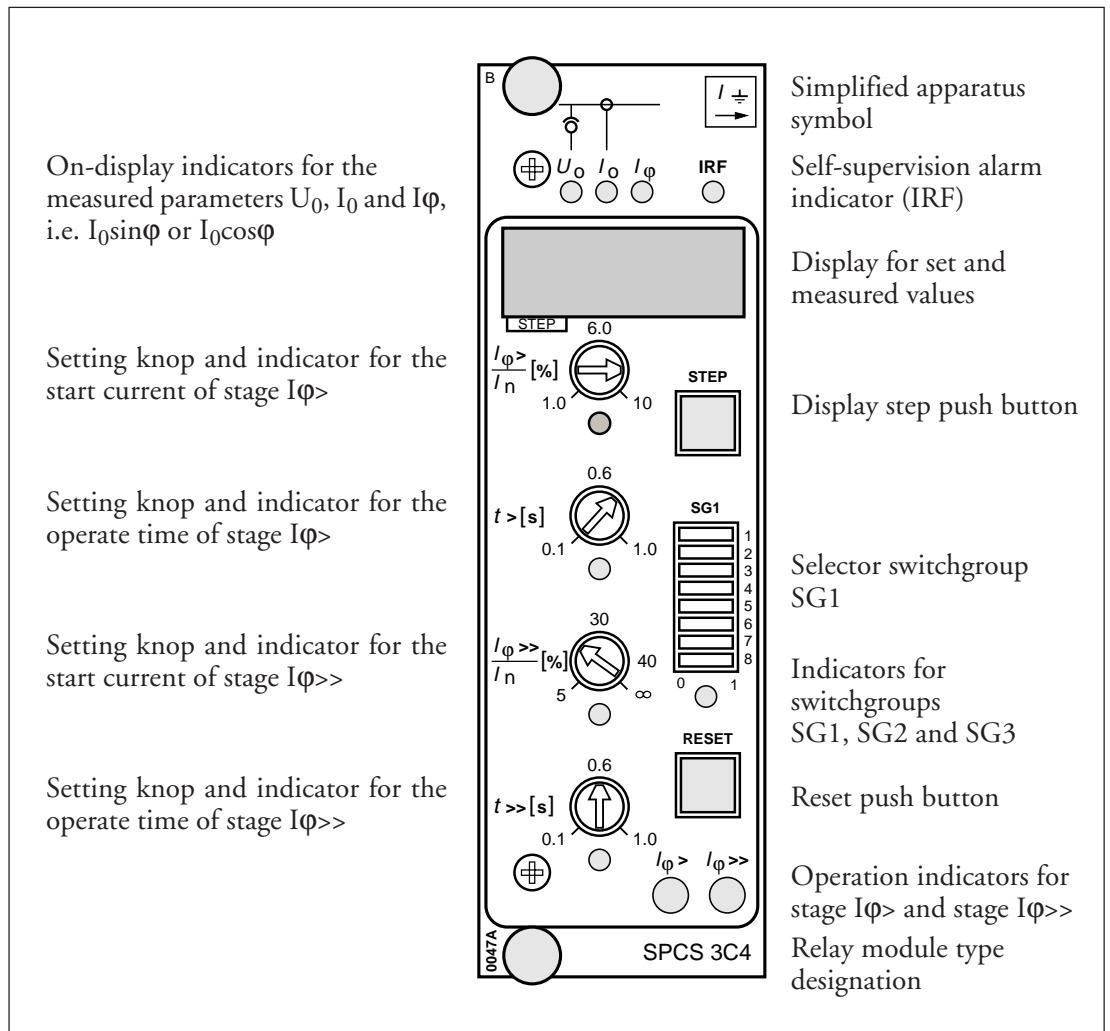


Fig. 3. Front panel of the directional neutral overcurrent relay module SPCS 3C4.

## Operation indicators

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

The four indications, two starts and two trippings, can be given with switches in SG2 a self-reset mode of operation or a manual mode. If, for instance, the yellow start indication (but not the red operation indication) of a protection stage is given the manual mode, the yellow indication is lit when the protection stage starts and turned red when the stage operates. When the protection stage returns to normal the yellow indication remains lit. Manual reset indications are reset 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% x $I_n$ .
$t> [s]$	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% x $I_n$ when $SG1/6 = 0$ , and 1...8% x $I_n$ when $SG1/6 = 1$ . Additionally, the setting $\infty$ , 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 switchgroup SG1 is presented on the display when the LED indicator under the switchgroup is lit. In this way the proper operation of the selector switches can be verified. An example illustrating the manual procedure for calculating the checksum is given in the manual "General characteristics of C type relay modules".

## Selector switches

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

Switch	Function																				
SG1/1	<p>Selection of operation direction for the high-set stage <math>I\phi&gt;&gt;</math>.</p> <p>Switch SG1/1 = 0 corresponds to the forward operation direction, i.e. the same direction as that of the low-set stage <math>I\phi&gt;</math>.</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. <math>I_0\sin\phi</math> or <math>I_0\cos\phi</math>.</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><math>I_0\cos\phi</math></td> </tr> <tr> <td>0</td> <td>1</td> <td>Manual selection</td> <td><math>I_0\sin\phi</math></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 <math>t&gt;</math> of the low-set stage <math>I\phi&gt;</math>.</p> <p>When SG1/5 = 0, the setting range of the operate time <math>t&gt;</math> is 0.1...1.0 s. When SG1/5 = 1, the setting range of the operate time <math>t&gt;</math> is 1...10 s.</p>																				
SG1/6	<p>Selection of setting range of the start value of the high-set stage <math>I\phi&gt;&gt;</math>.</p> <p>When SG1/6 = 0, the setting range of stage <math>I\phi&gt;&gt;</math> is 5...40% <math>\times I_n</math> or <math>\infty</math>, infinite. When SG1/6 = 1, the setting range of stage <math>I\phi&gt;&gt;</math> is 1...8% <math>\times I_n</math> or <math>\infty</math>, 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 <math>U_0</math></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.

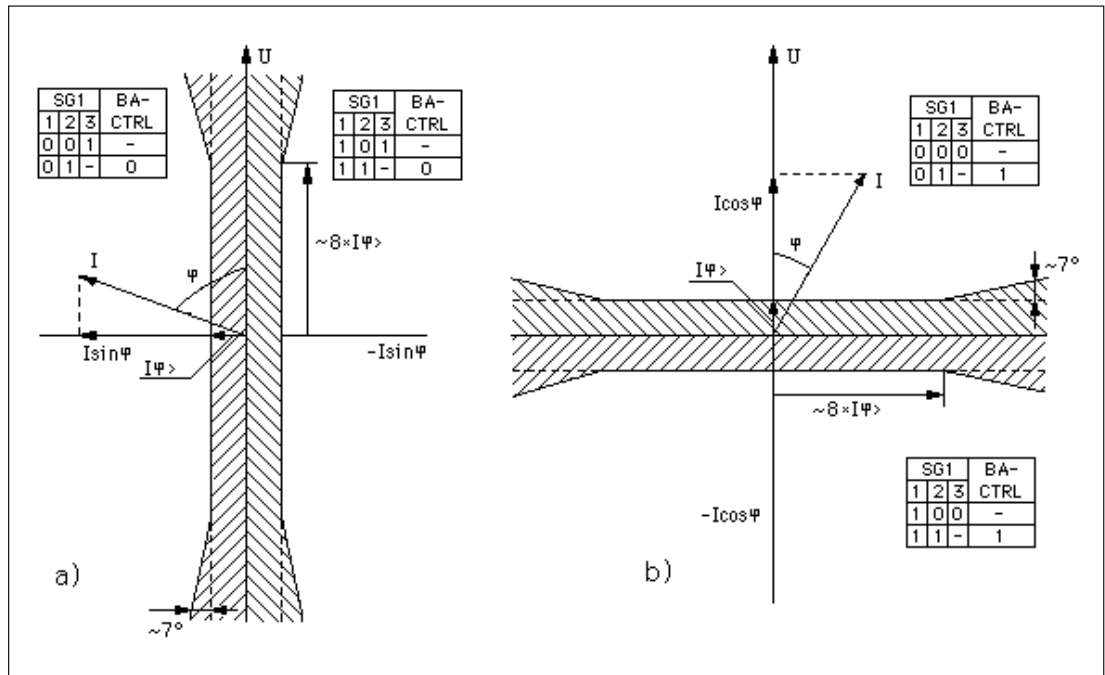


Fig. 4. Operation characteristic of the directional neutral overcurrent relay module SPCS 3C4. Fig. 4a shows the  $I_0 \sin \phi$  characteristic, Fig. 4b the  $I_0 \cos \phi$  characteristic.

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 $I \phi >$ , yellow	1	0
Tripping, stage $I \phi >$ , red	2	2
Starting, stage $I \phi >>$ , yellow	4	0
Tripping, stage $I \phi >>$ , red	8	8
Checksum $\Sigma$	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 <math>I_0 \sin \varphi</math> or <math>I_0 \cos \varphi</math> value as a percentage of the rated current. If <math>I\varphi</math> has a negative sign, a red minus sign appears in the leftmost position in the display. If the measured value exceed <math>100\% \times I_n</math>, the recorded value is expressed as 1 - - - or - - - -.</p> <p>The register is updated when one of <math>I\varphi&gt;</math> or <math>I\varphi&gt;&gt;</math> protection stages starts or operates. When the relay starts but does not operate, the relay module memorizes the maximum <math>I\varphi</math> during the start situation. A second exceeding of <math>I\varphi&gt;</math> or <math>I\varphi&gt;&gt;</math> protection stage will erase previously recorded value and starts to record a new maximum <math>U_0</math> value. When a stage operates, the value of <math>I\varphi</math> measured at the moment of operation is recorded.</p>
2	<p>Measured residual voltage <math>U_0</math> value as a percentage of the rated voltage <math>U_n</math>. 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 <math>I\varphi&gt;</math> or <math>I\varphi&gt;&gt;</math> protection stages starts or operates. When the relay starts but does not operate, the relay module memorizes the maximum <math>U_0</math> during the start situation. A second exceeding of <math>I\varphi&gt;</math> or <math>I\varphi&gt;&gt;</math> protection stage will erase previously recorded value and starts to record a new maximum <math>U_0</math> value. When a stage operates, the value of <math>U_0</math> 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, <math>n(U_0) = 0...255</math>.</p>
4	<p>Number of starts of the low-set stage <math>I\varphi&gt;</math>, <math>n(I\varphi&gt;) = 0...255</math>.</p>
5	<p>Number of starts of the high-set stage <math>I\varphi&gt;&gt;</math>, <math>n(I\varphi&gt;&gt;) = 0...255</math>.</p>
6	<p>Duration of the latest start event of stage <math>I\varphi&gt;</math>, expressed as a percentage of the set operate time <math>t&gt;</math>.</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 <math>I\varphi&gt;&gt;</math>, expressed as a percentage of the set operate time <math>t&gt;&gt;</math>.</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 <math>I_0</math> value as a percentage of the rated current <math>I_n</math>. 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>



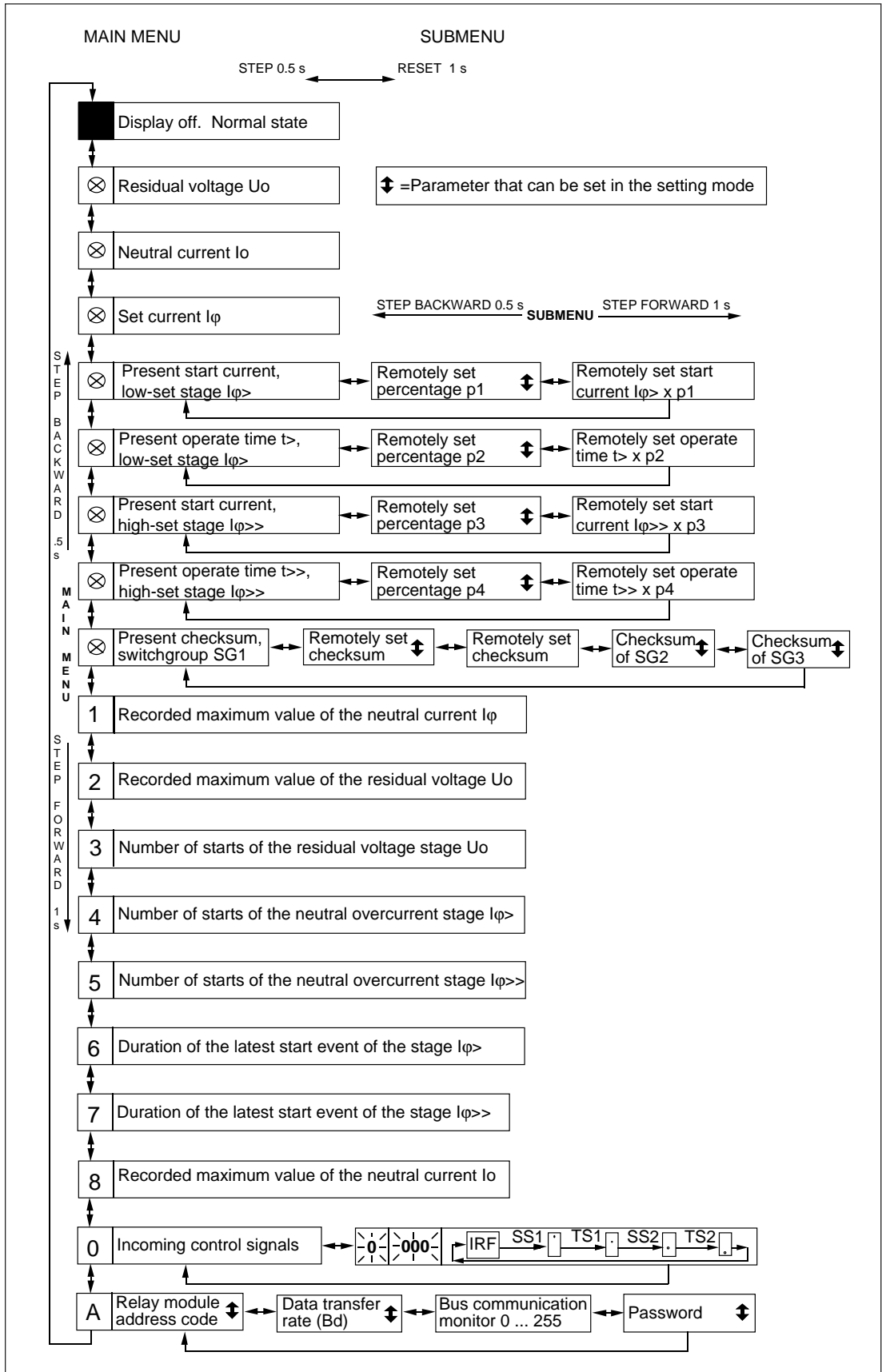
Register/ STEP	Recorded information
0	<p>Display of the state of the basic angle control signal BACTRL and other external control signals. The rightmost digit in the display shows the state of the blocking signals BTS1 and BTS2. The following states are indicated:</p> <p>0 = no active incoming blocking signal  1 = operation of stage I<math>\phi</math>&gt; blocked  2 = operation of stage I<math>\phi</math>&gt;&gt; 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 <math>I_0 \sin \phi</math>, if the external control of the operation characteristic has been selected  1 = BACTRL in the 1 state, i.e. the operation characteristic is <math>I_0 \cos \phi</math>, 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"> <li>1) Selection of data transfer rate for the serial communication. Selectable values: 300, 1200, 2400, 4800 and 9600 Bd. Default value 9600 Bd.</li> <li>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.</li> <li>3) Password required for the remote control of the relay settings</li> </ol>

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 $\phi$ >**

Start current	1...10% x I <sub>n</sub>
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 $\phi$ > + inaccuracy caused by ±1° phase displacement

**High-set neutral overcurrent stage I $\phi$ >>**

Start current	5...40% x I <sub>n</sub> and ∞, infinite, or 1...8% x I <sub>n</sub> 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 $\phi$ >> + 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	$\pm 0...100\% \times I_n$ $\pm 999$ , 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 <sub>n</sub>
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 <sub>n</sub> ±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 <sub>n</sub> ±999, if Iφ > 100% x I <sub>n</sub>
Maximum recorded value of the residual voltage U <sub>0</sub>	V2	R	0...25% x U <sub>n</sub> 999, if U <sub>0</sub> > 25% x U <sub>n</sub>
Number of starts of stage U <sub>0</sub>	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 <sub>0</sub>	V8	R	0...100% x I <sub>n</sub> , 999, if I <sub>0</sub> > 100% x I <sub>n</sub>
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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