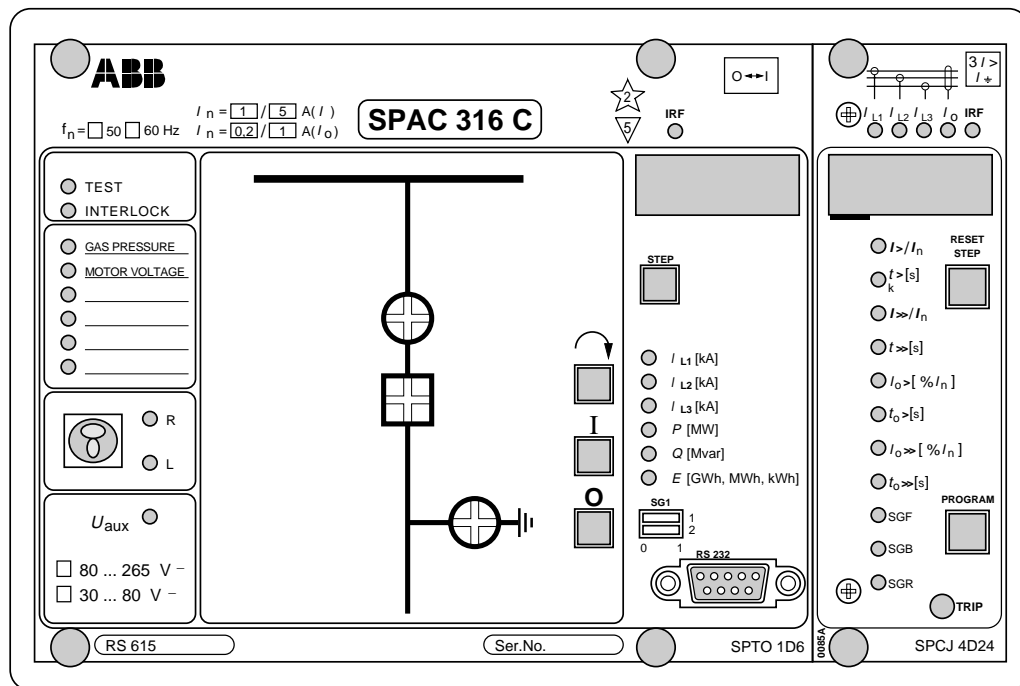


SPAC 316 C

Feeder terminal

User's manual and Technical description



Data subject to change without notice

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The user's manual for the feeder terminal SPAC 316 C is composed of the following separate manuals:

Feeder terminal SPAC 316 C, general part	1MRS 750120-MUM EN
Control module SPTO 1D6	1MRS 750118-MUM EN
General characteristics of D type relay modules	1MRS 750066-MUM EN
Combined overcurrent and earth-fault relay module SPCJ 4D24	1MRS 750121-MUM EN

Features

Complete feeder terminal with a three-phase two-stage overcurrent unit and a two-stage non-directional earth-fault unit	Local and remote status indication of three switching objects
Definite time or inverse definite minimum time (IDMT) operation characteristic for the low-set stage of the overcurrent unit	Complete control module for local/remote control of one switching object
Definite time operation characteristic for the low-set stage of the earth-fault unit	Double-pole circuit breaker control for additional operational safety
Instantaneous or definite time operation characteristic of the high-set stage of the overcurrent unit and the earth-fault unit	Large library of pre-designed mimic diagram plates for presentation of the selected circuit-breaker/disconnector configuration
Continuous monitoring of energizing input current circuits	Phase current, energy, active and reactive power measurement and indication
Continuous circuit breaker trip circuit supervision	Serial interface for connection of the feeder terminal to a substation level and network control level systems
Configurable feeder level interlocking system for preventing unpermitted switching operations	Continuous self-supervision for maximum system reliability and availability.

The feeder terminal type SPAC 316 C is designed to be used as cubicle-oriented protection and local/remote control interface unit. In addition to protection, control and measurement functions the feeder terminal is provided with

the data communication properties needed for the control of a feeder cubicle. Connection to higher level substation control equipment is carried out via an fibre-optical serial bus, the so called SPA bus.

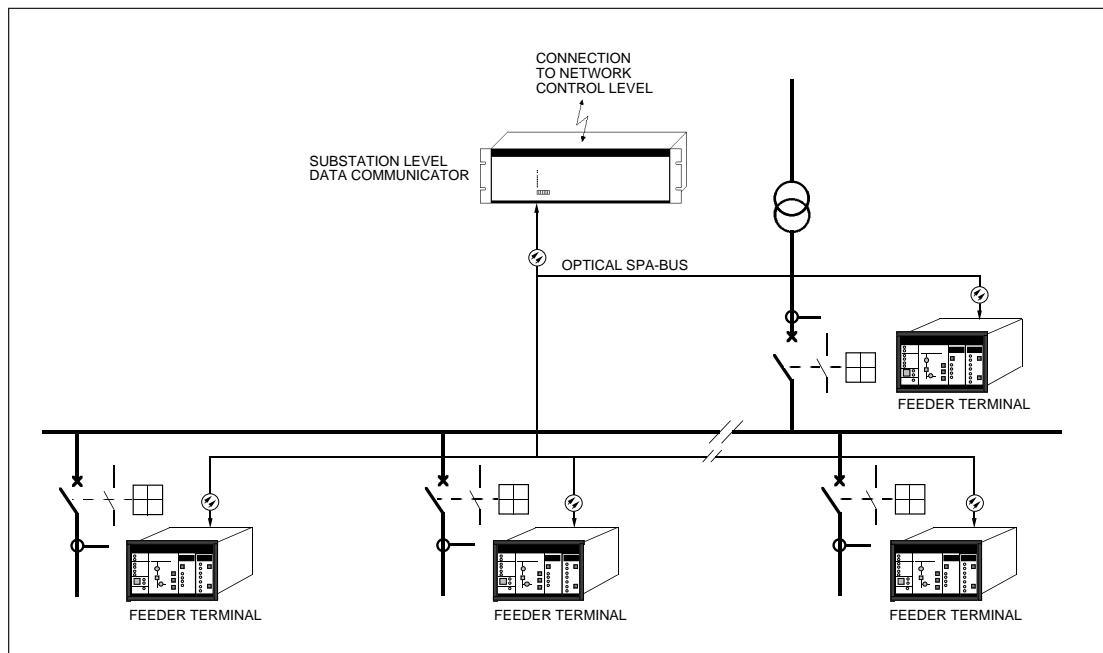


Fig. 1. Distributed protection and control system based on feeder terminals type SPAC 316 C.

The feeder terminal SPAC 316 C is intended for the selective short-circuit and earth-fault protection of radial feeders in solidly earthed, resistance earthed or impedance earthed power systems. The short-circuit and earth-fault protection is obtained by means of a combined overcurrent and earth-fault relay module.

The overcurrent unit is provided with 5 A and 1 A energizing current inputs and the earth-fault unit is provided with 1 A and 0.2 A inputs.

The control module included in the feeder terminal indicates locally by means of LED indicators the status of 1 to 3 disconnectors or circuit breakers. Further the module allows status information from the circuit breaker and the disconnectors to be transmitted to the remote control system, and one object, e.g. a circuit breaker, to be opened and closed via the remote control system. Single pole or double pole circuit

breaker control can be used. The status information and the control signals are transmitted over the serial bus. Local control of one object is possible via push buttons on the front panel of the control module.

The control module measures and displays the three phase currents. The active and reactive power are measured over two mA-inputs. External measuring transducers are needed. Energy calculations can be based on the measured power values or on using one binary input as an energy pulse counter input. The measured values can be displayed locally and remotely as scaled values.

The protection relay module also measures and records the three phase currents and the neutral current. All the measured and recorded values can be displayed locally and transmitted to the remote control system over the SPA bus.

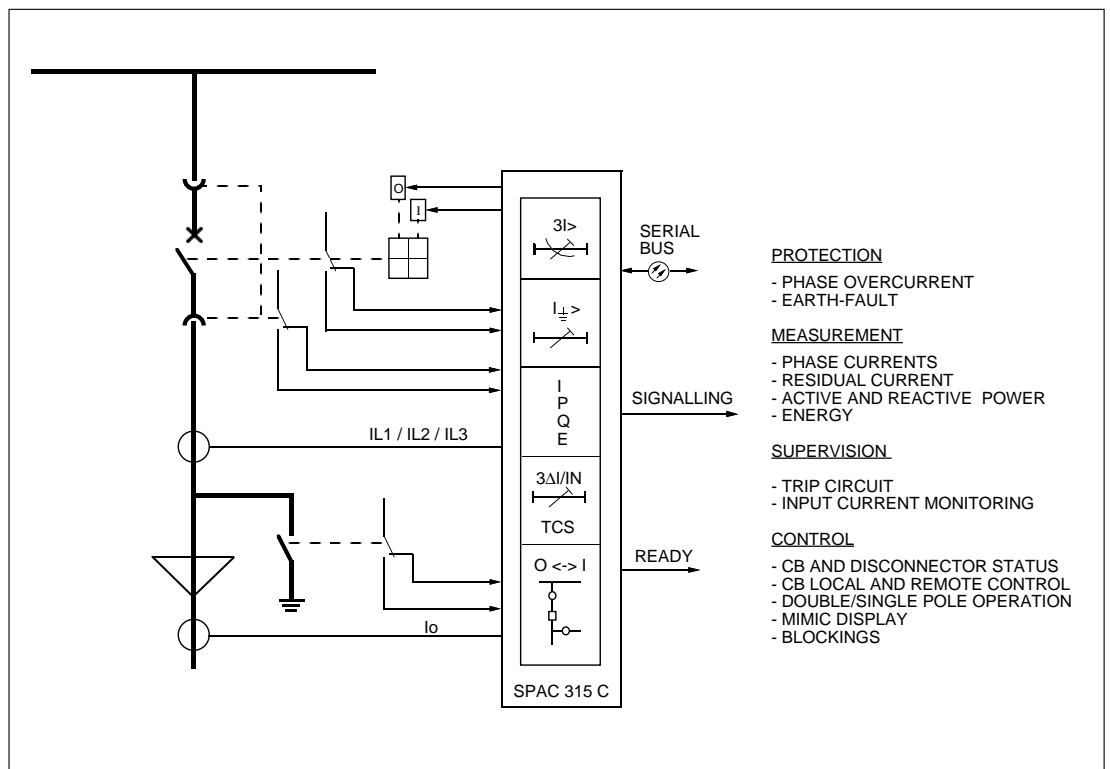


Fig. 2. Basic functions of the feeder terminals type SPAC 316 C.

Description of function

Design

The feeder terminal type SPAC 316 C include four withdrawable functional modules and one fixed functional module each. The main func-

tions of the modules are specified in the following table.

Module	Function
Protection relay module SPCJ 4D24	Phase overcurrent protection and earth-fault protection. Definite time or inverse time low-set overcurrent protection, definite time low-set earth-fault protection, instantaneous or definite time high-set overcurrent and earth-fault protection.
Control module SPTO 1D6	Reads and displays locally and remotely status data of maximum three disconnectors, CB trucks or CBs. Reads and displays locally and remotely max. six external binary signals. Three phase currents, active and reactive power and energy are measured and displayed locally and remotely. Transfers local or remote open and close commands for one circuit breaker.
I/O module SPTR 2B17 or SPTR 2B18	Includes 12 optically isolated binary inputs, trip and close output relays. Single-pole or double-pole circuit breaker control and trip circuit supervision electronics.
Power supply module SPGU 240A1 or SPGU 48B2	Forms the internal supply voltages required by the other function modules.
Energizing input module SPTE 4F9	Includes matching transformers and their tuning electronics for three phase currents and the neutral current. Includes the motherboard with four signalling output contacts and the electronics for the mA inputs. Includes the Internal Relay Fault alarm output relay.

The combined phase overcurrent and earth-fault relay module SPCJ 4D24 is a Euro-size (100 mm x 160 mm) withdrawable unit.

The control module type SPTO 1D6 is also withdrawable. The control module includes two PC boards; a CPU board and a front PCB which are joined together.

The I/O module SPTR 2B17 (or SPTR 2B18) is located behind the front PC board and is attached to the front PC board by screws.

The power supply module SPGU 240A1 or SPGU 48B2 is located behind the front PCB of the control module and can be withdrawn from the case after the control module has been removed.

The protection relay module SPCJ 4D24 is fastened to the relay case by means of two finger screws and the control module type SPTO 1D6 by means of four finger screws.

These modules are removed by undoing the finger screws and pulling the modules out of the aluminium case. Before the I/O module can be removed the control module has to be withdrawn from the case and the screws holding the I/O module attached to the front PCB have to be removed.

The energizing input module SPTE 4F9 is located behind the front PC board of the control module on the left side of the case. A screw terminal block, the rear plate and the mother PC board are connected to the energizing input module.

The mother PC board contains the card connectors for the plug-in modules, the detachable multi-pole connector strips of the inputs and outputs, the tuning resistors of the secondary burden of the matching transformers and the electronics of the signal outputs and mA inputs.

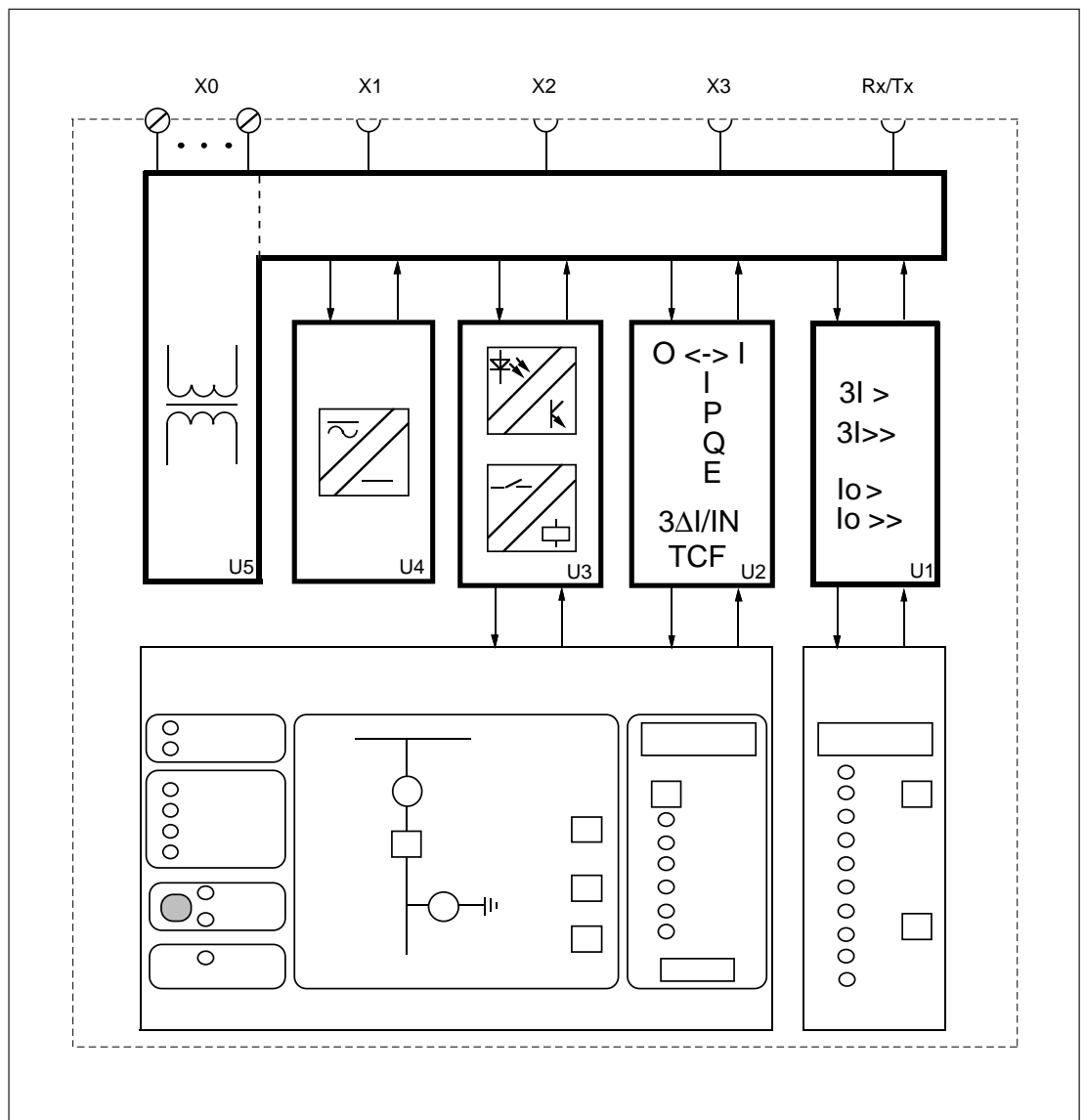


Fig. 3. Block diagram for the feeder terminal type SPAC 316 C

U1	Phase overcurrent and earth-fault relay module SPCJ 4D24
U2	Control module SPTO 1D6
U3	I/O module SPTR 2B17 or SPTR 2B18 for digital inputs and contact outputs
U4	Power supply module SPGU 240A1 or SPGU 48B2
U5	Energizing input module and motherboard SPTE 4F9
X0	Screw terminal strip
X1...X3	Multi-pole connector strips
Rx/Tx	Serial communication port

The relay case is made of an extruded aluminium section, the collar is of cast aluminium and the cover of clear UV-stabilized polycarbonate. The collar is fitted with a rubber gasket providing an IP54 degree of protection by enclosure between the relay case and the mounting panel.

The cover of the case contains two push-buttons which can be used for scanning through the displays of the feeder terminal. To reset the

operation indicators of the protection and to use the local control push buttons of the control module, the front cover has to be opened.

The cover is locked with two finger screws which can be sealed to prevent unauthorized access to the front panel. The rubber gasket between the cover and the collar ensures that the cover, too, complies with the IP54 requirements. The opening angle of the cover is 145°.

Protection functions	<p>The overcurrent unit of the combined overcurrent and earth-fault relay module SPCJ 4D24 has two protection stages, a low-set stage I> and a high-set stage I>>. The overcurrent unit measures the three phase currents of the protected system. The unit can also be used for two or single phase measurement.</p> <p>When a phase current exceeds the set start value of the low-set overcurrent stage, the overcurrent stage starts, simultaneously starting the corresponding timing circuit. When the set or calculated operate time has elapsed, a trip command is issued. Correspondingly the high-set overcurrent stage starts when its start value is exceeded. As the high-set stage starts it starts its timing circuit and trips when the set operate time has elapsed.</p> <p>The low-set stage of the overcurrent unit can be given definite time characteristic or inverse definite minimum time (IDMT) characteristic. The high-set stage of the overcurrent unit can be set to operate instantaneously or it can be given definite time characteristic.</p> <p>By appropriate configuration of the output relay matrix the start signals can be obtained as contact functions. The start signals can be used, for instance, as blocking signals for cooperating protection relays.</p> <p>The combined overcurrent and earth-fault relay module contains one external control input, which is activated by an external control voltage applied to the input CHANNEL 8. The effect of the external blocking signal on the relay module is determined by the selector switches of the relay module. The control input can be used for blocking one or more of the protection stages or for carrying out a trip command by means of an external control signal.</p>	
<i>Phase overcurrent protection</i>		
<i>Earth-fault protection</i>	<p>The combined overcurrent and earth-fault relay module SPCJ 4D24 also includes a non-directional two-stage earth-fault protection unit. The earth-fault unit measures the residual current or neutral current of the protected system.</p> <p>When the residual current exceeds the set start value of the low-set earth-fault stage, the earth-fault stage starts, simultaneously starting the corresponding timing circuit. When the set operate time has elapsed, a trip command is delivered. Correspondingly the high-set earth-fault stage starts when its start value is exceeded.</p> <p>As the high-set stage starts it starts its timing circuit and trips when the set operate time has elapsed.</p> <p>Both the low-set stage and the high-set stage of the earth-fault unit operate with definite time characteristic.</p> <p>The operation of the two earth-fault stages can be blocked by feeding a control voltage to one of the external control input CHANNEL 8 of the feeder terminal.</p>	
<i>Contact outputs of the protection</i>	<p>The tripping signal of the feeder terminal is wired to the OPEN output. Double-pole or single-pole circuit breaker control can be used for opening and closing of the circuit breaker. Single-pole circuit breaker control is used as standard. If double-pole circuit breaker control is to be used the links between terminals 96-97 of the OPEN circuit and terminals 98-99 of the CLOSE circuit should be removed, see Fig. 5.2.</p> <p>The trip OPEN circuit is continuously supervised by means of the constant current injection principle. The feeder terminal has five signalling contacts, one of which is the common internal relay failure (IRF) output. Four signalling outputs, SIGNAL 1...4, can be used to indicate starting or tripping of the protection, see chapter "Signal diagram".</p>	

Control functions	The control module SPTO 1D6 is used for reading status information from circuit breakers, CB trucks and disconnectors. The module indicates the status locally by means of LED indicators and transfers the information to the substation level via the fibre-optic SPA bus. The status of maximum three objects can be indicated.	of push buttons on the front panel or with the opening or closing commands received over the SPA bus. Normally the double-pole control principle is used for controlling the circuit breaker.
<i>General</i>	The control module is also used for controlling one object e.g. a circuit breaker, locally by means	In addition to status information the control module can read other binary data, indicate the information locally and transfer it to the substation level equipment. Six external binary signals can be wired to the feeder terminal.
<i>Inputs CHANNEL 1...3</i>	The control module uses input channels 1...3 to read status information from circuit breakers, CB trucks and disconnectors. Each input CHANNEL 1...3 is formed by two binary inputs, one input is used for reading the open status and the other for reading the close status of an object. This means that the status information must be wired to the feeder terminal as four-pole message.	The front panel of the control module holds a 4x4 LED matrix, which is used for status indication of the circuit breakers, CB trucks and disconnectors of the feeder cubicle. At a time, three of these LEDs can be used for status indication. The circuit breaker/CB truck/disconnector configuration indicated by the LEDs is freely configurable by the user.
		One of the objects, the status of which is read via inputs CHANNEL 1...3 can be controlled with the OPEN and CLOSE outputs.
<i>Inputs CHANNEL 4...9 and CHANNEL 10...13</i>	The control module can be used for reading six external and four internal binary signals. The external signals, CHANNEL 4...9, can be single contact data wired from the switchgear cubicle and the internal signals, CHANNEL 10...13, are start and trip signals of the protection relay module. The inputs CHANNEL 4...13 can be configured to be active at high state, i.e. input energized, or active at low state, i.e. input not energized.	The front panel has a local LED indication for the external inputs CHANNEL 4...9. The red LED is normally lit when the input is active. The inputs CHANNEL 4...13 can be used to control the outputs OPEN, CLOSE and SIGNAL 1...4. On activation of an input the configured OPEN or CLOSE output provides an output pulse, whereas the outputs SIGNAL 1...4 are continuously activated as long as the concerned inputs are activated.
<i>Interlocking</i>	The control module includes a cubicle-oriented interlocking which is freely programmable by the user. By writing an interlocking program the user defines under which circumstances the controlled object can be closed or opened. When an opening or closing command is given the interlocking program is checked and after that the command is executed or canceled.	The interlocking can be so programmed that it considers the status of the four-pole inputs CHANNEL 1...3 and the inputs CHANNEL 4...13. The trip signals of the protection relay module are not influenced by the interlocking. To simplify commissioning the feeder terminal is provided with default interlocking schemes. A certain default interlocking scheme is always related to a certain circuit breaker/disconnector configuration.
<i>Conditional direct output control</i>	Normally the OPEN and CLOSE outputs are controlled by an open or close command given by the operator. In the conditional direct output control outputs OPEN, CLOSE and SIGNAL 1...4, can be controlled without an open or	close command given by the operator. In this case the outputs are controlled by the direct output control program, which checks the status of the inputs CHANNEL 1...3, CHANNEL 4...13 and the R/L-key switch.

Measurement functions	<p>The control module SPTO 1D6 and the combined overcurrent and earth-fault relay module SPCJ 4D24 both measure analog signals.</p> <p>The combined overcurrent and earth-fault relay module measures three phase currents and the neutral current. The module displays the current values locally and transmits the information via the SPA bus to the remote control system. The protection relay module displays the measured values as multiples of the rated current of the used energizing input of the feeder terminal.</p> <p>The control module SPTO 1D6 measures five analog signals; three phase currents, active and reactive power. The transforming ratio of the primary current transformers can be keyed in to the control module. In that way it is possible to</p>	<p>display the measured phase currents as primary values.</p> <p>The control module measures the active and reactive power via two mA inputs. External measuring transducers are to be utilized. The mA signals are scaled to actual MW and Mvar values and the data is displayed locally and can be transmitted to the remote control system.</p> <p>Active energy is measured in two ways; either by calculating the value from the measured power values or by using input CHANNEL 7 as a pulse counter input. In the latter case an external energy meter with pulse output will be needed. In both cases the energy measurement value is displayed locally and can be transmitted to the remote control system.</p>
Supervision functions	<p>Energizing current circuit monitoring and trip circuit supervision are integrated into the control module SPTO 1D6. The trip circuit, i.e. the OPEN circuit, is supervised using the constant current injection principle. If the resistance of the trip circuit exceeds a preset level, because of loose contacts, oxidation or circuit discontinu-</p>	<p>ity, an alarms signal is provided via output SIGNAL 4.</p> <p>The energizing current circuit monitoring function monitors the input energizing currents and provides an alarm signal if one or two of the phase currents are interrupted.</p>
Serial communication	<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-pin RS 232 connection on the front panel is to be used for configuring the feeder terminal and determining the circuit breaker/CB truck/disconnector configuration, for loading the</p>	<p>feeder-oriented interlocking program and other data from a terminal or a PC.</p> <p>The 9-pin RS 485 connection on the rear panel connects the feeder terminal to the SPA bus. An optional bus connection module type SPA-ZC 17 or SPA-ZC 21 is required.</p>
Auxiliary power supply	<p>For the operation of the feeder terminal a secured auxiliary voltage supply is needed. The power supply module SPGU 240A1 or SPGU 48B2 forms the voltages required by the protection relay module, the control module and the input/ output module.</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 slow 1 A fuse, F1, located on the PC board of the control module.</p> <p>A green LED indicator U_{aux} on the front panel is lit when the power supply module is in operation. There are two versions of power supply modules available. The secondary sides are identical, only the input voltage range is different. The input voltage range is indicated on the front panel of the control module.</p>

Application

Mounting and dimension drawings

The feeder terminals are housed in a normally flush mounted relay case. The feeder terminals are fixed to the mounting panel by means of four galvanized sheet steel mounting brackets. The

feeder terminal can also be semi-flush mounted by means of optional raising frames. A surface mounting case type SPA-ZX 316 is also available.

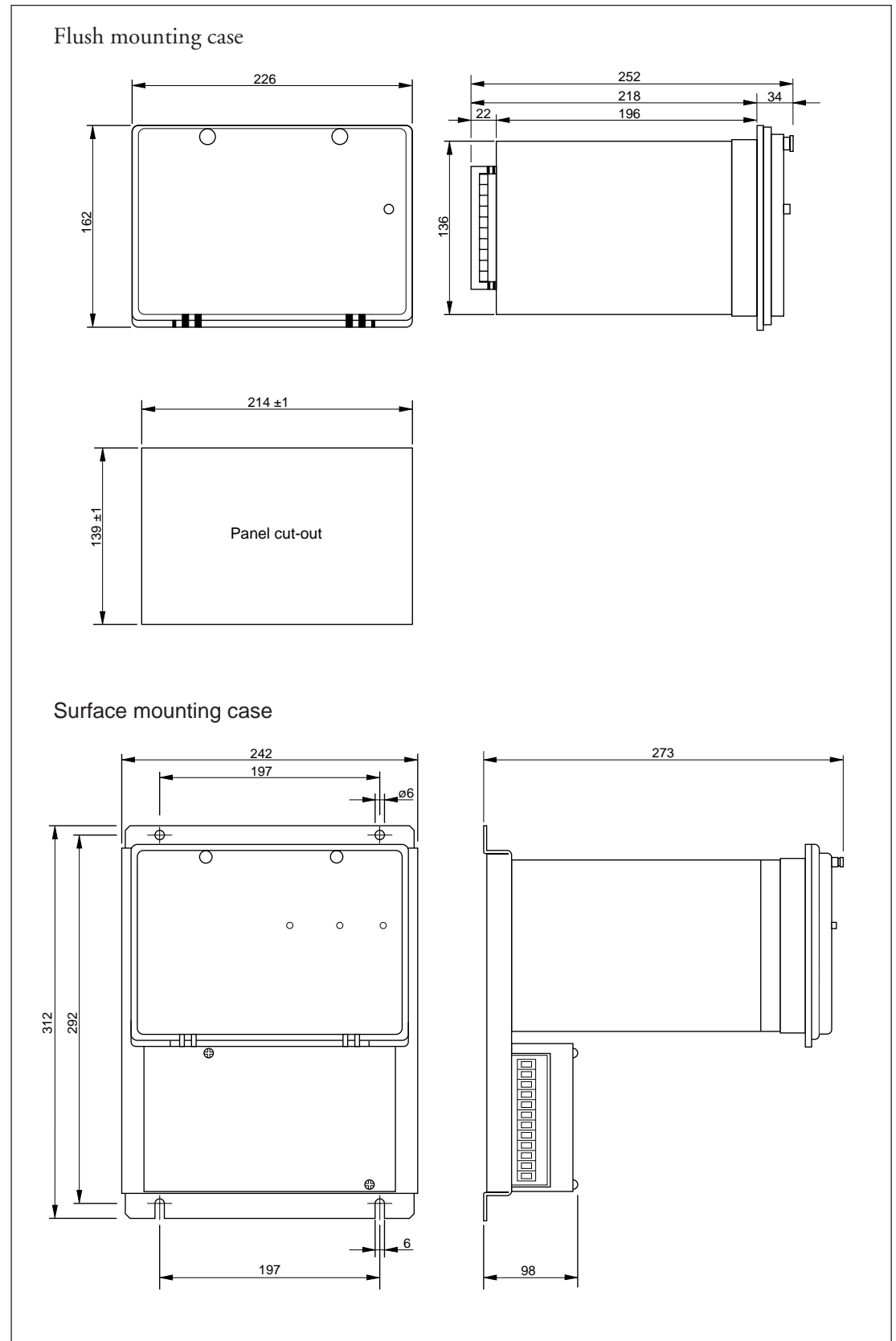


Fig. 4. Dimensional drawings for the feeder terminal type SPAC 316 C

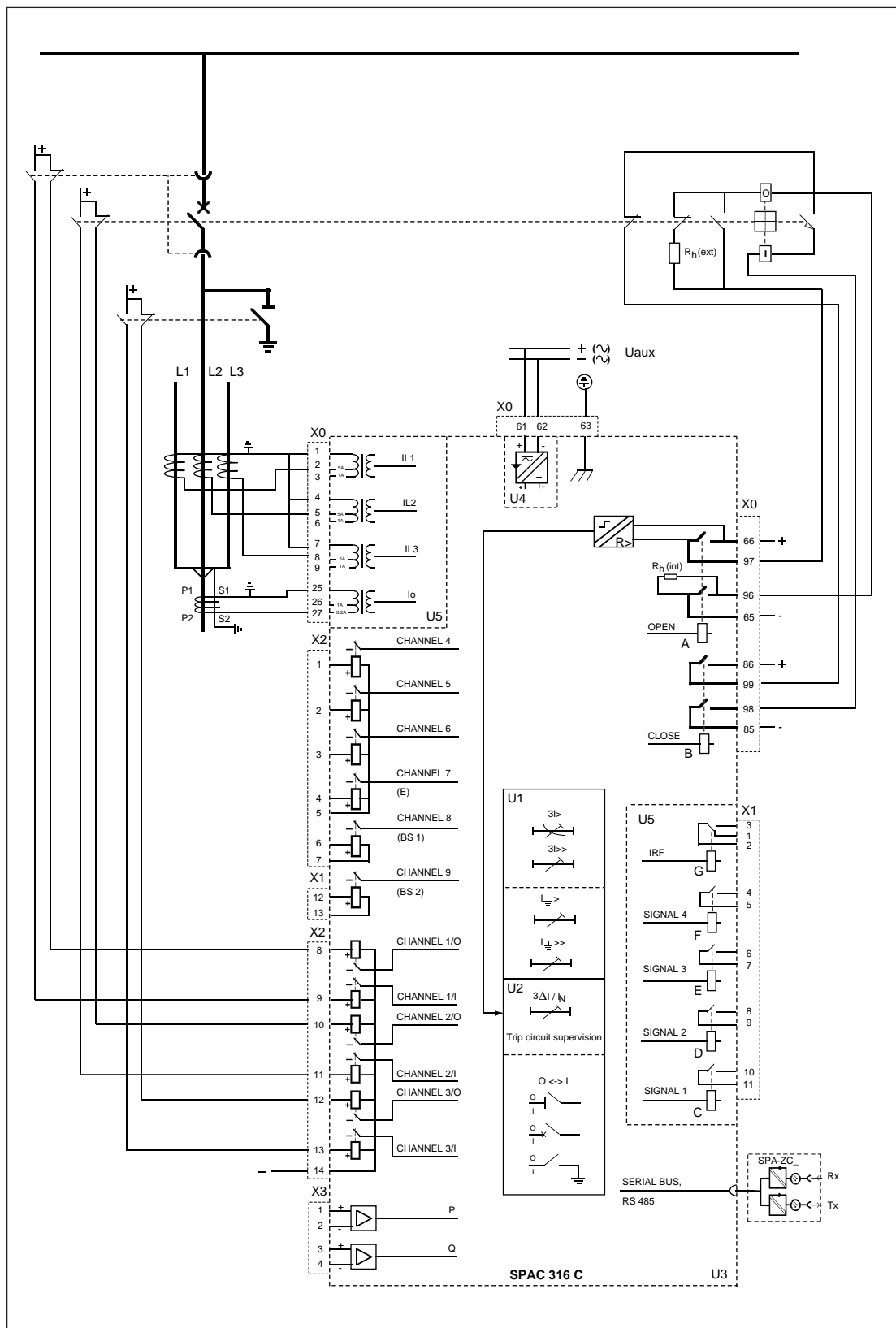


Fig. 5.1. Connection diagram for the feeder terminal type SPAC 316 C. The circuit-breaker is controlled using the double-pole control principle.

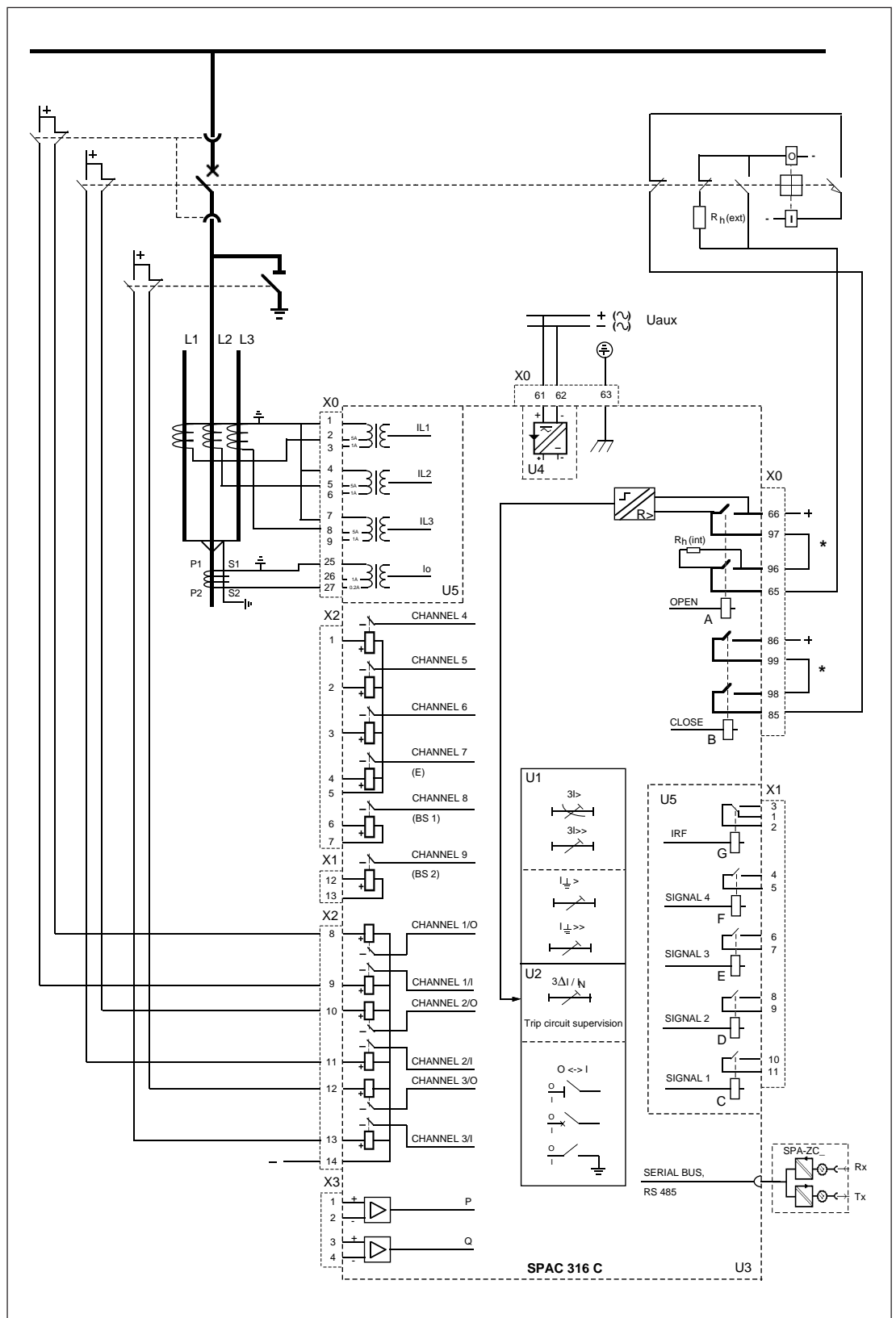


Fig. 5.2. Connection diagram for the feeder terminal type SPAC 316 C. The circuit-breaker is controlled using the single-pole control principle.

* Note!

The single-pole circuit breaker control principle requires external linking of the terminals to be done, i.e. terminal 96 should be linked to terminal 97 and terminal 98 to terminal 99. These

links are furnished at the factory. For trip circuit supervision the proper polarity of the OPEN contact is important.

Terminal numbers:

Terminal block	Terminal number	Function
X0	1-2	Phase current I_{L1} , 5 A
	1-3	Phase current I_{L1} , 1 A
	4-5	Phase current I_{L2} , 5 A
	4-6	Phase current I_{L2} , 1 A
	7-8	Phase current I_{L3} , 5 A
	7-9	Phase current I_{L3} , 1 A
	25-26	Neutral current I_0 , 1 A
	25-27	Neutral current I_0 , 0.2 A
	61-62	Auxiliary power supply. When dc supply voltage is used the positive pole is to be connected to terminal 61
	63	Equipment earth terminal
	65	OPEN output Single-pole control: terminal 65 connects to CB OPEN coil Double-pole control: terminal 65 connects to negative control voltage pole
	66	OPEN output Double/Single-pole control: terminal 66 connects to positive control voltage pole
	96	OPEN output Single-pole control: terminal 96 connects to terminal 97 Double-pole control: terminal 96 connects to CB OPEN coil
	97	OPEN output Single-pole control: terminal 97 connects to terminal 96 Double-pole control: terminal 97 connects to CB OPEN coil
	85	CLOSE output Single-pole control: terminal 85 connects to CB CLOSE coil Double-pole control: terminal 85 connects to negative control voltage pole
	86	CLOSE output Double/Single-pole control: terminal 86 connects to positive control voltage pole
	98	CLOSE output Single-pole control: terminal 98 connects to terminal 99 Double-pole control: terminal 98 connects to CB CLOSE coil
	99	CLOSE output Single-pole control: term. 99 connects to terminal 98 Double-pole control: term. 99 connects to CB CLOSE coil
X1	1-2-3	Self-supervision (IRF) signalling output. When auxiliary power is connected and the device is operating properly the interval 2-3 is closed
	4-5	Signal output 4. E.g.alarm from energizing current monitoring and trip circuit supervision or $3I>$ alarm or $3I>>$ alarm or $I_0>$ alarm or $I_0>>$ alarm, configured by user
	6-7	Signal output 3, configured by user
	8-9	Signal output 2, configured by user
	10-11	Signal output 1, configured by user
	12-13	Input CHANNEL 9

Terminal numbers:

Terminal block	Terminal number	Function
X2	1-5	Input CHANNEL 4
	2-5	Input CHANNEL 5
	3-5	Input CHANNEL 6
	4-5	Input CHANNEL 7 or energy pulse counter input
	6-7	Input CHANNEL 8 or blocking input for the protection module
	8-14	Input CHANNEL 1, open status. E.g. when a circuit breaker is open the input must be energized
	9-14	Input CHANNEL 1, closed status. E.g. when a circuit breaker is closed the input must be energized
	10-14	Input CHANNEL 2, open status
	11-14	Input CHANNEL 2, closed status
	12-14	Input CHANNEL 3, open status
	13-14	Input CHANNEL 3, closed status
X3	1-2	mA input for the measurement of active power
	3-4	mA input for the measurement of reactive power

The channel numbers mentioned above are used when the control module SPTO 1D6 is to be configured. When the control module is configured the following codes are used for the outputs:

Output	Terminal numbers	Output code for interlocking	Output code for Conditional Output Control
OPEN	X0/66-97	20	220
OPEN	X0/65-96	20	220
CLOSE	X0/86-99	21	221
CLOSE	X0/85-98	21	221
SIGNAL 1	X1/10-11	22	22
SIGNAL 2	X1/8-9	23	23
SIGNAL 3	X1/6-7	24	24
SIGNAL 4	X1/4-5	25	25

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

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

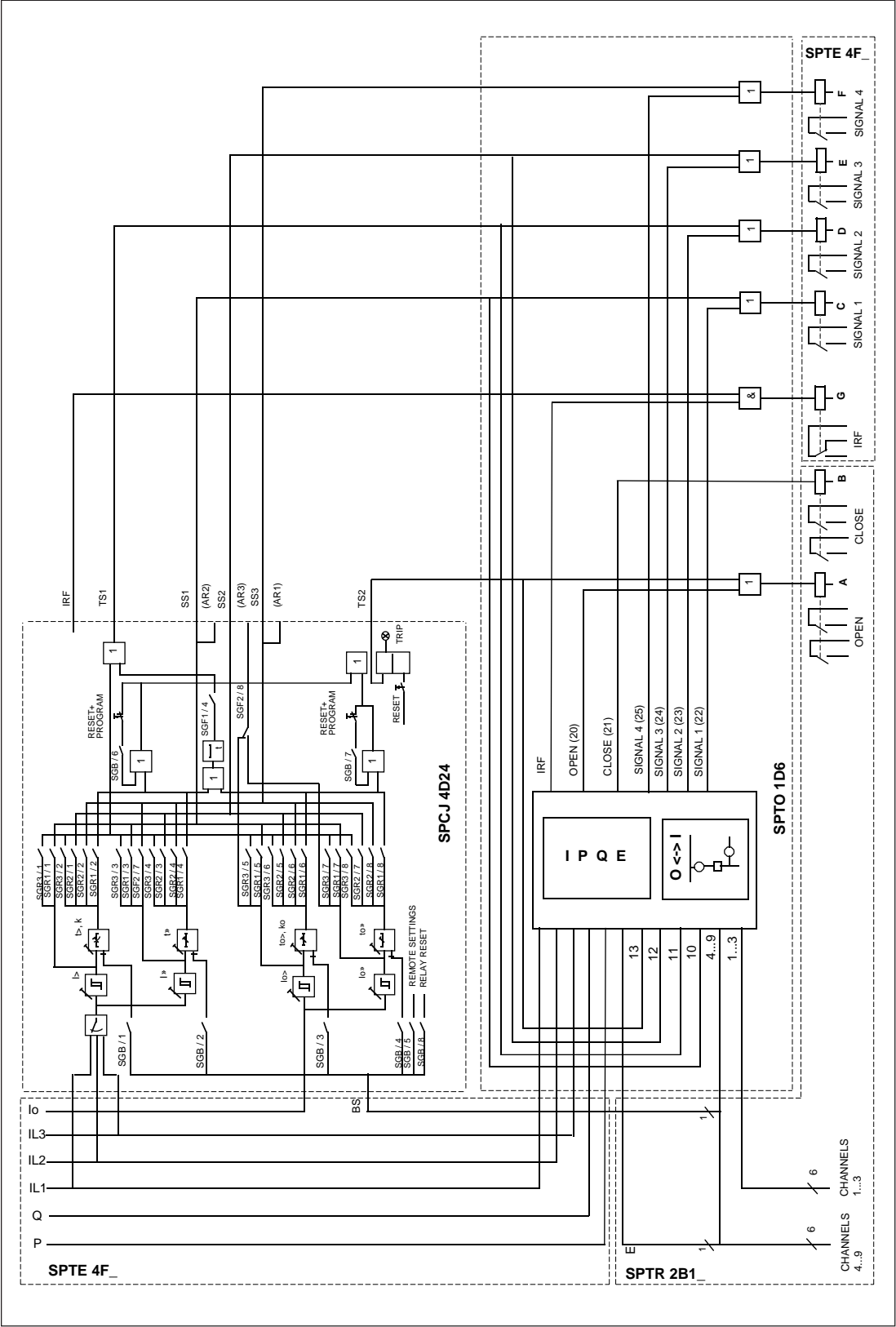


Fig. 6. Control signals between the modules of the feeder terminal type SPAC 316 C

The following table gives the default values of the switches shown in Fig. 6.

Switch	Function	Default value
SGB1/1	Forms from a control voltage applied to input 8 a blocking signal for the tripping of the I> stage	0
SGB1/2	Forms from a control voltage applied to input 8 a blocking signal for the tripping of the I>> stage	0
SGB1/3	Forms from a control voltage applied to input 8 a blocking signal for the tripping of the I ₀ > stage	0
SGB1/4	Forms from a control voltage applied to input 8 a blocking signal for the tripping of the I ₀ >> stage	0
SGB1/5	Enables switching from protection main settings to second settings by applying an external control voltage to input 8	0
SGB1/6	Selects a latching function for the trip signal TS2 at overcurrent faults	0
SGB1/7	Selects a latching function for the trip signal TS2 at earth-faults	0
SGB1/8	Enables remote resetting of latched output relays and recorded values by an external control voltage on input 8	0
SGR1/1	Routes the start signal of stage I> to the SIGNAL 1 output	1
SGR1/2	Routes the trip signal of stage I> to the OPEN output	1
SGR1/3	Routes the start signal of stage I>> to the SIGNAL 1 output	0
SGR1/4	Routes the trip signal of stage I>> to the OPEN output	1
SGR1/5	Routes the start signal of stage I ₀ > to the SIGNAL 1 output	0
SGR1/6	Routes the trip signal of stage I ₀ > to the OPEN output	1
SGR1/7	Routes the start signal of stage I ₀ >> to the SIGNAL 1 output	0
SGR1/8	Routes the trip signal of stage I ₀ >> to the OPEN output	1
SGR2/1	Routes the trip signal of stage I> to the SIGNAL 3 output	1
SGR2/2	Routes the trip signal of stage I> to the SIGNAL 4 output	0
SGR2/3	Routes the trip signal of stage I>> to the SIGNAL 3 output	1
SGR2/4	Routes the trip signal of stage I>> to the SIGNAL 4 output	0
SGR2/5	Routes the trip signal of stage I ₀ > to the SIGNAL 3 output	0
SGR2/6	Routes the trip signal of stage I ₀ > to the SIGNAL 4 output	1
SGR2/7	Routes the trip signal of stage I ₀ >> to the SIGNAL 3 output	0
SGR2/8	Routes the trip signal of stage I ₀ >> to the SIGNAL 4 output	1
SGR3/1	Routes the start signal of stage I> to the SIGNAL 2 output	0
SGR3/2	Routes the trip signal of stage I> to the SIGNAL 2 output	0
SGR3/3	Routes the start signal of stage I>> to the SIGNAL 2 output	0
SGR3/4	Routes the trip signal of stage I>> to the SIGNAL 2 output	0
SGR3/5	Routes the start signal of stage I ₀ > to the SIGNAL 2 output	0
SGR3/6	Routes the trip signal of stage I ₀ > to the SIGNAL 2 output	0
SGR3/7	Routes the start signal of stage I ₀ >> to the SIGNAL 2 output	0
SGR3/8	Routes the trip signal of stage I ₀ >> to the SIGNAL 2 output	0
SGF1/1	Switches SGF1/1...3 are used for selecting the required operation characteristic of the low-set overcurrent stage I>, i.e. definite time or inverse time (IDMT) characteristic. Further selection at inverse time characteristic: standard inverse, very inverse, extremely inverse or long-time inverse.	0
SGF1/2		0
SGF1/3		0
SGF1/4	Selection of circuit breaker failure protection function	0
SGF1/5	Selection of automatic doubling of the set start value of stage I>> at energization of the protected object	0
SGF1/6	Inhibition of the operation of the earth-fault unit high-set stage on starting of the low-set stage of the overcurrent unit	0
SGF1/7	Reserved	
SGF1/8	Reserved	

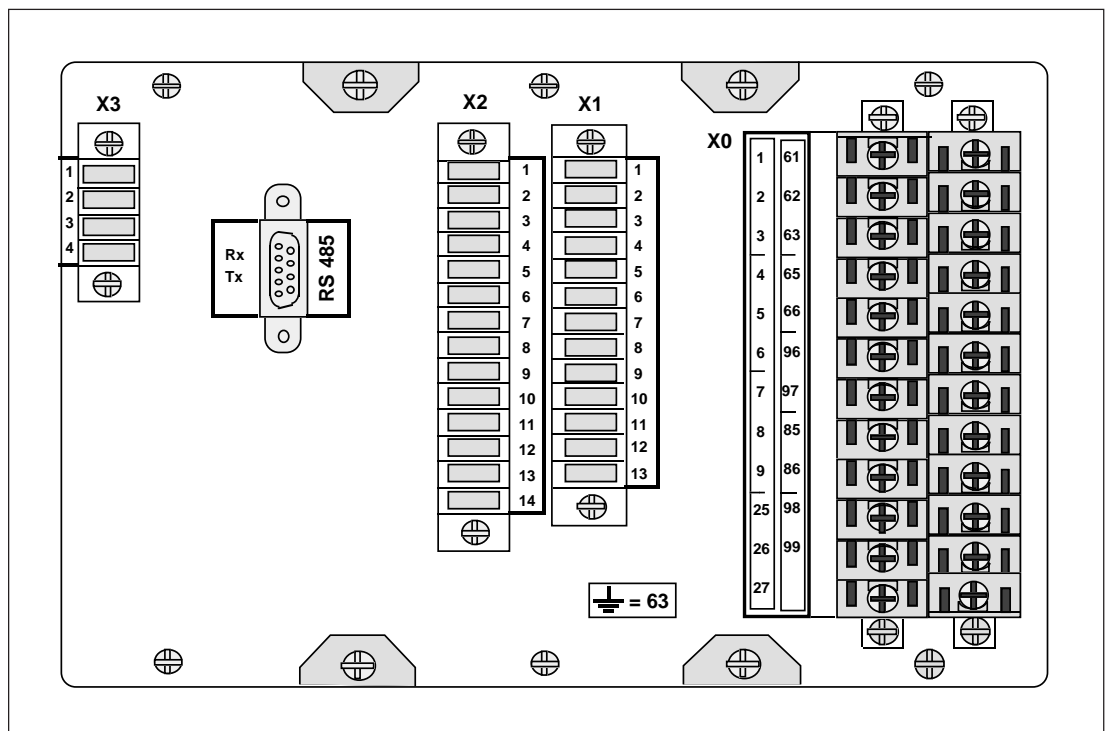


Fig. 7. Rear view of the feeder terminal type SPAC 316 C

All external conductors are connected to the terminal blocks on the rear panel. Terminal block X0 is a fix-mounted screw terminal block fastened to the energizing input module. The connectors X1...X3 are detachable-type multi-pole connector strips equally with screw terminals.

The male part of the multi-pole connector strips are attached to the mother PC board. The female parts of the detachable connector strips are delivered as loose parts together with the feeder terminal. The position of the female connector strips can be secured by means of fixing accessories and screws at the ends of the connector.

The measuring signal inputs, auxiliary voltage supply and OPEN and CLOSE contact outputs are connected to the terminal block X0. Each terminal is dimensioned for one 4 mm² or two 2.5 mm² wires. The pilot wires are fastened with M 3.5 Phillips cross-slotted screws, recess type H.

The signalling contact outputs are connected to the multi-pole connector X1. The inputs CHANNEL 1...3 and CHANNEL 4...8 are connected via connector X2. Input CHANNEL 9 is wired via connector X1 and the two mA inputs via connector X3. One max. 1.5 mm² wire or two max. 0.75 mm² wires can be connected to one screw terminal.

The rear panel of the feeder terminal is provided with a serial interface for the SPA bus (RS 485). Two types of bus connection modules are available. The bus connection module type SPA-ZC21 is fitted directly to the 9-pin D-type subminiature connector. The bus connection module SPA-ZC17 includes a connection cable with a D-type connector. Thus the connection module can be installed at a suitable place in the switchgear cubicle within the reach of the connection cable.

Commissioning

Commissioning of the feeder terminal should be done in accordance with the following instructions. Checks 1 and 2 have to be performed before the auxiliary power supply is switched on.

1. Control voltage ranges of the binary inputs

Before connecting a voltage to inputs CHANNEL 1...9, check the permitted control voltage range of the inputs. The voltage range, U_{aux} , is marked up on the front panel of the control module.

2. Auxiliary supply voltage

Before switching on the auxiliary supply voltage check the permitted input voltage range of the power supply module. The voltage range, U_{aux} , is marked up on the front panel of the control module.

3. Configuration of the control module SPTO 1D6

All parameters of the non-volatile EEPROMs have been given default values after factory testing. "Configuration and interlocking scheme No. 1" has been selected. The default parameter values are shown in the manual of the control module SPTO 1D6.

If the default parameters have to be changed, the following parameters can be altered:

- Configuration; default configuration or user-definable configuration
- Interlocking; default interlocking or user-definable interlocking
- OPEN and CLOSE outputs; pulse lengths
- Measurements; ratio of primary current transformers, settings for active and reactive power measurement, settings for energy measurement
- Inputs CHANNEL 4...13; specification of activation conditions and configuration of outputs
- Inputs CHANNEL 4...9; latching function of indicators
- Event reporting; event masks, event delay times
- Supervision; settings for energizing input monitoring and trip circuit supervision

The programming can be done via the front panel RS 232 port or the rear panel RS 485 port by using the SPA protocol. Detailed instructions are given in the manual of the control module SPTO 1D6.

4. Settings of the overcurrent and earth-fault relay module SPCJ 4D24

The overcurrent and earth-fault relay module has been given default setting values at the factory. The start current and operate time parameters are set at their minimum values. The default checksum values for the switchgroups are:

Switchgroups	Σ (checksums)
SGB	0
SGF1	0
SGR1	171
SGR2	165
SGR3	0

The values can be changed manually from the push-buttons on the front panel of the protection module. Also the RS 232 interface on the front panel of the control module or the RS 485 interface on the rear panel of the feeder terminal can be used for changing the settings of the overcurrent and earth-fault relay module using command according to the SPA protocol.

The exact meaning of the switchgroups is explained in the manual of the combined phase overcurrent and earth-fault protection relay module SPCJ 4D24.

Technical data
(modified 2002-04)

Energizing inputs

Rated currents I_n			
Overcurrent unit			
Phase current inputs		X0/1-3, 4-6, 7-9	X0/1-2, 4-5, 7-8
Rated current I_n		1 A	5 A
Earth-fault unit			
Neutral current inputs	X0/25-27	X0/25-26	
Rated current I_n	0.2 A	1 A	
Thermal withstand capability			
- continuous	1.5 A	4 A	20 A
- for 1s	20 A	100 A	500 A
Dynamic current withstand,			
- half-wave value	50 A	250 A	1250 A
Input impedance	<750 m Ω	<100 m Ω	<20 m Ω
Rated frequency f_n , acc. to order	50 Hz or 60 Hz		

mA inputs

Terminal numbers	
Active power	X3/1-2
Reactive power	X3/3-4
Input current range	-20 mA...0...20 mA

Binary inputs

Terminal numbers	
CHANNEL 1...3, four-pole inputs	X2/8-14, 9-14, 10-14, 11-14, 12-14 and 13-14
CHANNEL 4...9, single-contact inputs	X2/1-5, 2-5, 3-5, 4-5, 6-7 and X1/10-11
Control input voltage range	
- input module type SPTR 2B17	80...265 V dc
- input module type SPTR 2B18	30...80 V dc
Current consumption at activation	<2 mA

Energy pulse counter input, CHANNEL 7

Terminal numbers	X2/4-5
Maximum control frequency	25 Hz
Input voltage range	
- input module type SPTR 2B17	80...265 V dc
- input module type SPTR 2B18	30...80 V dc
Current consumption at activation	<2 mA

Blocking input, CHANNEL 8

Terminal numbers	X2/6-7
Input voltage range	
- input module type SPTR 2B17	80...265 V dc
- input module type SPTR 2B18	30...80 V dc
Current consumption at activation	<2 mA

Output contacts

CB control output terminals	X0/66-97, 65-96 and 86-99, 85-98
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
Control output operating mode, when operated by the control module	pulse shaping
- control pulse length	0.1...100 s
Signalling output terminals	X1/1-2-3, 4-5, 6-7, 8-9 and 10-11
Rated voltage	250 V ac or dc
Continuous carry	5 A
Make and carry for 0.5 s	10 A
Make and carry for 3 s	8 A
Breaking capacity for dc, when the control circuit time constant $L/R \leq 40$ ms at the control voltage levels 48/110/220 V dc	1 A/0.25 A/0.15 A

Auxiliary supply voltage

Type of power supply module and corresponding supply voltage range	
- type SPGU 240A1	80...265 V ac or dc
- type SPGU 48B2	18...80 V dc
operating conditions	~10 W / ~15 W

Combined overcurrent and earth-fault module SPCJ 4D24

Phase overcurrent unit

Low-set overcurrent stage I> *

Start current **

- at definite time characteristic $0.5...5.0 \times I_n$
- at inverse time characteristic *** $0.5...2.5 \times I_n$

Time/current characteristic

- definite time characteristic
 - operate time $t_{>}$ $0.05...300 \text{ s}$
- inverse definite minimum time (IDMT) characteristic as per IEC 60255-3 and BS 142
 - Extremely inverse
 - Very inverse
 - Normal inverse
 - Long-time inverse
- special type inverse characteristic
 - RI-type inverse
 - RXIDG-type inverse
- time multiplier k $0.05...1.0$

High-set overcurrent stage I>> *

Start current

$0.5...40 \times I_n$ and ∞ , infinite

Operate time $t_{>>}$

$0.04...300 \text{ s}$

Earth-fault unit

Low-set earth-fault stage I₀> ****

Start current

$0.1...0.8 \times I_n$

Time/current characteristic

- definite time characteristic
 - operate time $t_{0>}$ $0.05...300 \text{ s}$

High-set earth-fault stage I₀>> ****

Start current

$0.1...10.0 \times I_n$ and ∞ , infinite

Operate time $t_{0>>}$

$0.05...300 \text{ s}$

* Note!

When the high-set overcurrent stage I>> starts the operation of the low-set overcurrent stage I> is inhibited. Consequently, the operate time of the relay equals the set operate time $t_{>>}$ at any fault current level over the set start current I>>. In order to obtain a trip signal, the high-set overcurrent stage I>> must be routed to a trip output relay.

** Note!

If the set start current exceeds $2.5 \times I_n$, the maximum continuous carry of the energizing inputs ($4 \times I_n$) must be noted.

*** CAUTION!

Never use start current settings above $2.5 \times I_n$ at inverse time operation although allowed by the relay.

**** Note!

When the high-set earth-fault stage I₀>> starts the operation of the low-set earth-fault stage I₀> is inhibited. Consequently, the operate time of the relay equals the set operate time $t_{0>>}$ at any fault current level over the set start current I₀>>. In order to obtain a trip signal, the high-set earth-fault stage I₀>> must be routed to a trip output relay.

Control module SPTO 1D6

Control functions

- status indication for maximum three objects
(e.g. circuit breakers, CB trucks, disconnectors, earth switches)
- user configurable configuration
- remote or local control (open and close) for one object
- user-configurable cubicle-related interlocking scheme

Measurement functions

- phase currents, measuring range $0 \dots 2.5 \times I_n$
- phase current measuring accuracy better than $\pm 1\%$ of I_n
- active and reactive power measurement via mA-inputs, external measuring transducers are needed
- mA measuring input current range $-20 \text{ mA} \dots 0 \dots 20 \text{ mA}$
- power measuring accuracy better than $\pm 1\%$ of maximum value of measuring range
- energy measurement via pulse counter input or by calculating of measured power
- local and remote reading of measured data as scaled values

Supervision functions

- energizing current input supervision
- trip circuit supervision
- internal self-supervision

Data communication

Rear panel

Connection

RS 485, 9-pin, female

Bus connection module for rear connection

- for plastic-core optical fibres
- for glass-fibre optical fibres

SPA-ZC21C BB
SPA-ZC21C MM

Bus connection module for separate mounting

- for plastic-core optical fibres
- for glass-fibre optical fibres

SPA-ZC17C BB
SPA-ZC17C MM

Front panel

Connection

RS 232, 9-pin, female

Data code

ASCII

Selectable data transfer rates

4800 or 9600 Bd

Insulation Tests *)

Dielectric test IEC 60255-5

2 kV, 50 Hz, 1 min

Impulse voltage test IEC 60255-5

5 kV, 1.2/50 μ s, 0.5 J

Insulation resistance measurement IEC 60255-5

>100 M Ω , 500 Vdc

Electromagnetic Compatibility Tests *)

High-frequency (1 MHz) burst disturbance test

IEC 60255-22-1

- common mode
- differential mode

2.5 kV
1.0 kV

Electrostatic discharge test IEC 60255-22-2 and

IEC 61000-4-2

- contact discharge
- air discharge

6 kV
8 kV

Fast transient disturbance test IEC 60255-22-4

and IEC 61000-4-4

- power supply
- I/O ports

4 kV
2 kV

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

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 IEC 60068-2-3	<95%, at 40°C for 56 d
Degree of protection by enclosure when panel mounted	IP 54
Mass of the unit	~5 kg

Exchange and spare parts

Control module	SPTO 1D6
Combined overcurrent and earth-fault relay module	SPCJ 4D24
I/O module, input voltage range 80...265 V dc	SPTR 2B17
I/O module, input voltage range 30...80 V dc	SPTR 2B18
Power supply module, 80...265 V ac or dc	SPGU 240A1
Power supply module, 18...80 V dc	SPGU 48B2
Housing without plug in modules	SPTK 4F9

Maintenance and repairs

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

If the environmental conditions at the relay operation 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 test being performed. At the visual inspection the following things should be noted:

- Check for signs of mechanical damage on relay case or terminals
- Check for dust inside the relay case or the cover of the relay case; remove by blowing pressurized air carefully
- Check for rust spots or signs of erugo on terminals, relay case or inside the relay.

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

Note!

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

Order information The following information should be given when ordering feeder terminals.

1. Quantity and type designation	15 units, feeder terminal SPAC 316 C
2. Rated frequency	$f_n = 50 \text{ Hz}$
3. Auxiliary supply voltage	$U_{aux} = 110 \text{ V dc}$
4. Type designation of the configuration plate	SYKK 912
5. Accessories	15 units, connection module SPA-ZC21BB

Four empty legend text films SYKU 997 for channel 4...9 indication are included in the feeder terminal delivery.

As different configuration plates are available for the feeder terminal SPAC 316 C the type designation of the configuration plate should be stated in the order.

There are two parallel configuration plates for one circuit breaker/disconnector configuration; in the first type the closed status is indicated by red colour and open status by green colour, in the second type the colours are the opposite.

The following some standard configuration plates are illustrated.

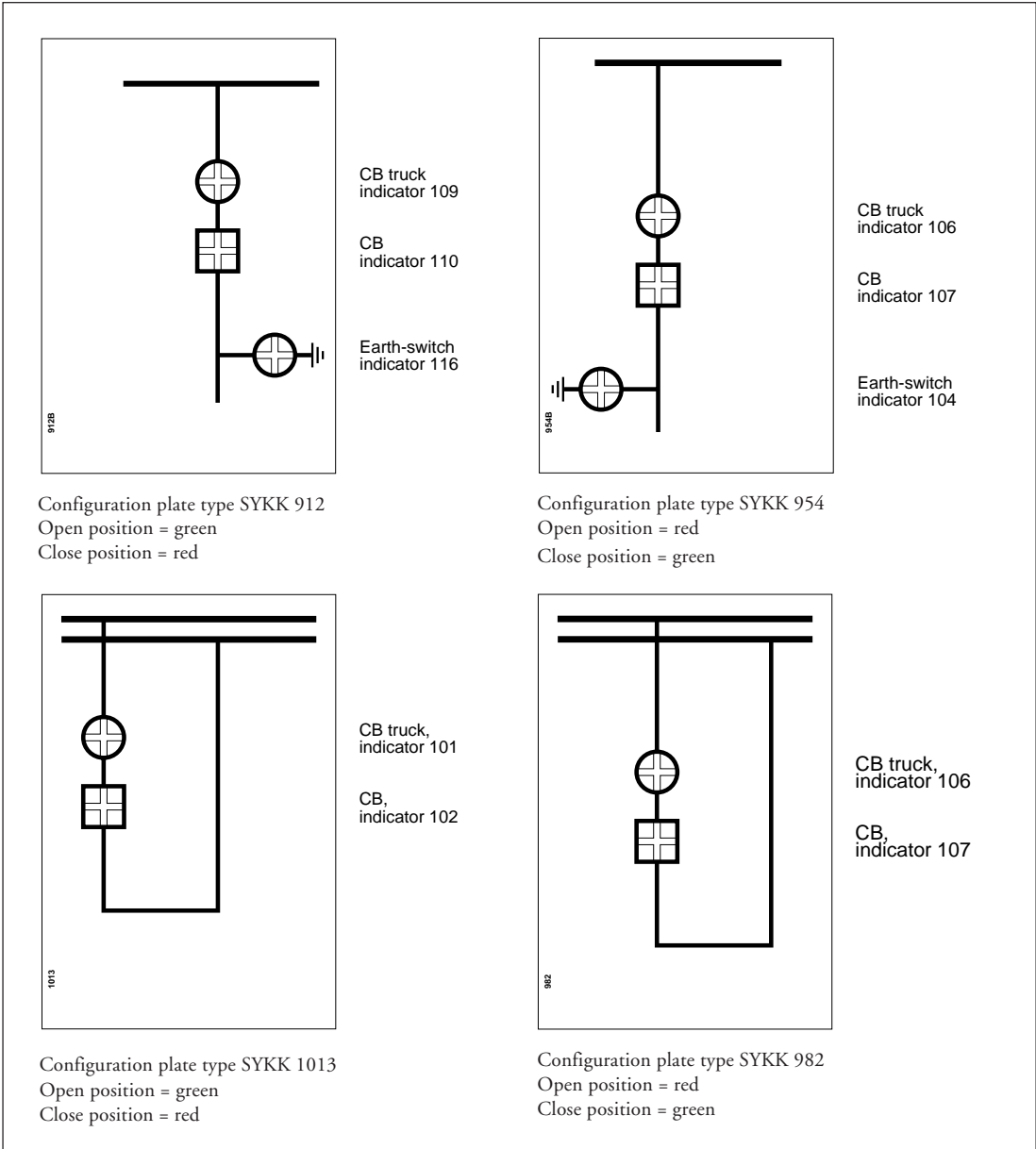


Fig. 8. Standard configuration plates for the feeder terminal SPAC 316 C

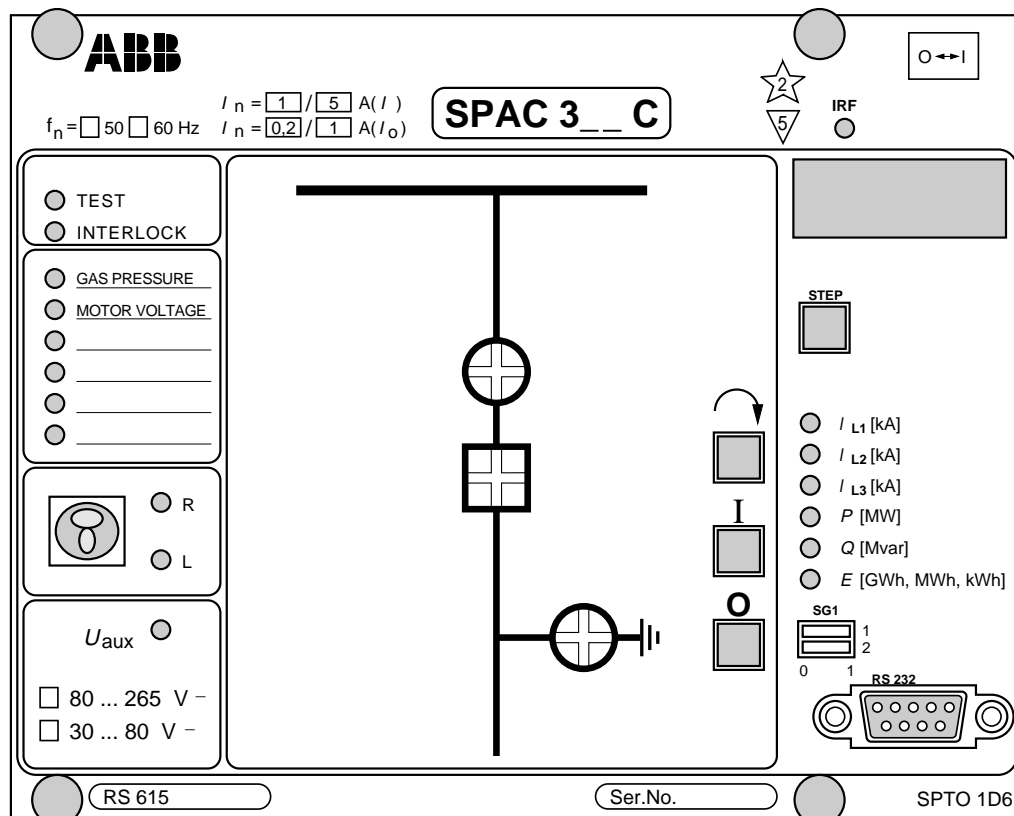
Note! On delivery the control module is given the "Configuration and interlocking scheme

No. 1", regardless of the type of configuration plate delivered with the control module.

SPTO 1D6

Control module

User's manual and Technical description



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Description of functions

Control functions

The control module type SPTO 1D6 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.

The input channels 1...3 are used for reading status information of the switching devices, i.e. circuit breakers and disconnectors here after called objects. Each of these channels includes 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. 3 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 4...13 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 4...9

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 one switching object. The commands may be given via the local push-buttons on the front panel, the SPA serial bus or the input channels 4...13. 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...3 and 4...13 and the interlocking program written by the user.

The signal outputs, signal 1...4, can be used for indicating the status of the input channels 4...13. The selected output is active as long as the input channel is in an active state.

The open, close or signal 1...4 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 input channels 1...3 and 4...13, the position of the local/remote key switch and the Direct Output Control program written by the user.

Measurement functions

The control module SPTO 1D6 measures three phase currents and two mA signals. The mA inputs are used for measuring active and reactive power. External measuring transducers are needed. The input channel 7 can be used as a pulse counter for energy pulses. Energy can also

be calculated by integrating the measured power values over time.

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

Supervision functions

The trip circuit supervision function and the energizing current monitoring function can be locally disabled by turning switch SG1/2 on the front panel in position 1. The locally

performed selection in the control module overrides the selection made over the SPA bus, using parameters S200 and S202.

Trip circuit supervision (modified 96-02)

The trip circuit supervision unit in the control module consists of three functional units; a constant current generator, a measuring and time delay circuit and an output circuit for signaling. The input/output circuits are galvanically isolated from each other. The constant current generator forces a 1.5 mA measuring current to flow through the circuit breaker trip circuit. The constant current generator is connected over the OPEN contact of the feeder terminal circuit. Under no-fault conditions the voltage over the OPEN contact or the constant current generator must exceed 30 V dc, when the voltage drop caused by the 1.5 mA measuring current in other parts of the supervised circuit are observed.

Mathematically the operation condition can be expressed as:

$$U_c - (R_h(\text{ext.}) + R_h(\text{int.}) + R_s) \times I_c \geq 30 \text{ V dc}$$

(Formula 1)

- where
- U_c = operating voltage over the supervised trip circuit
 - I_c = measuring current through the trip circuit, approximately 1.5 mA
 - $R_h(\text{ext.})$ = external shunt resistor value
 - $R_h(\text{int.})$ = internal shunt resistor value, 1 kΩ
 - R_s = trip coil resistance value

The resistor $R_h(\text{ext.})$ must be so calculated that the trip circuit supervision current through the resistor is low enough to leave the trip coil of the circuit breaker unaffected. On the other hand the voltage drop over the resistor $R_h(\text{ext.})$ must not be too high to jeopardize the operating condition presented in Formula 1 above.

The following values are recommended for resistor $R_h(\text{ext.})$ in figure 1:

Operating voltage U_c	Shunt resistor $R_h(\text{ext.})$
48 V dc	1.2 kΩ, 5 W
60 V dc	5.6 kΩ, 5 W
110 V dc	22 kΩ, 5 W
220 V dc	33 kΩ, 5 W

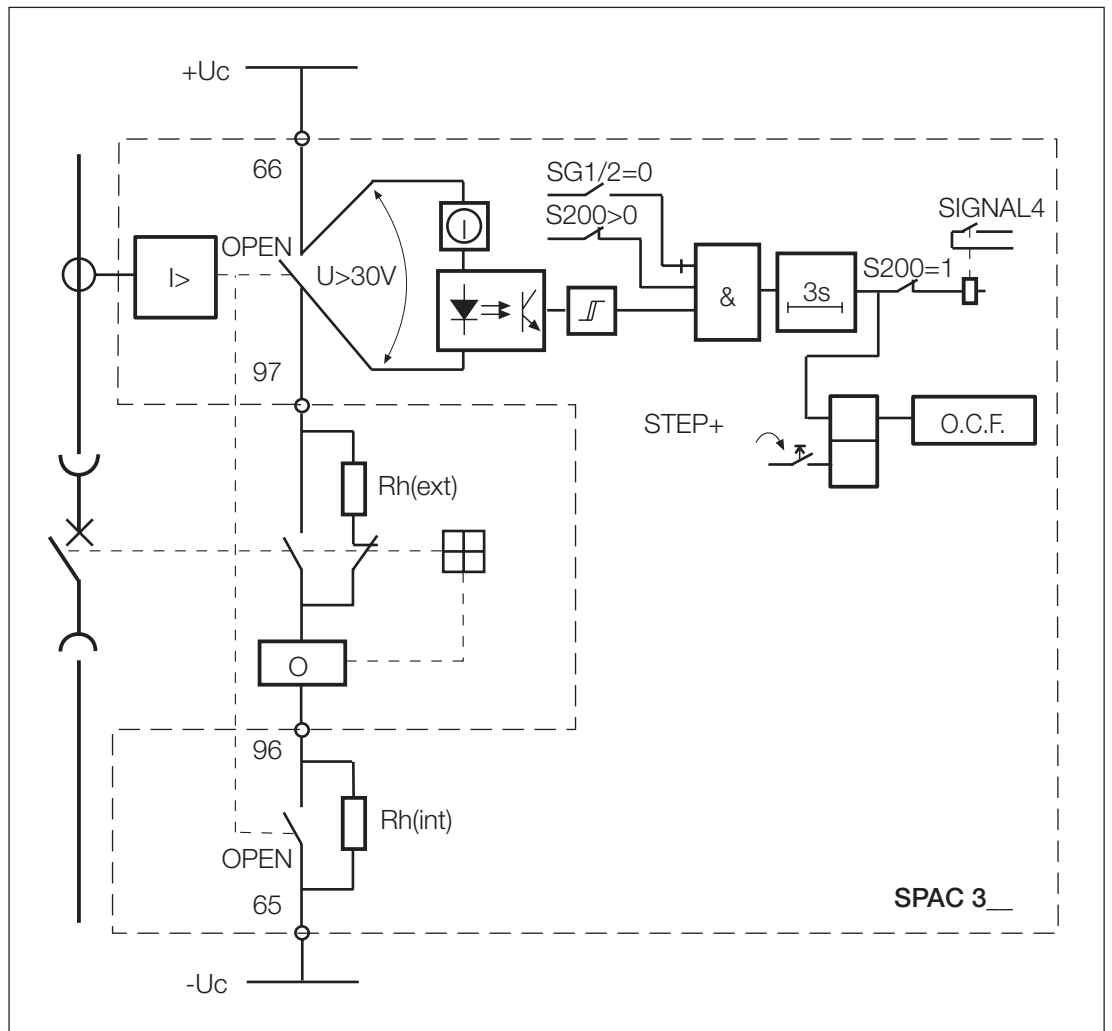


Fig. 1. Operating principle of the supervision function of the trip circuit

The supervision of the trip circuit is based on the constant current injection principle. If the resistance of the trip circuit, e.g. because of loose contacts or oxidation, exceeds a certain limit or if the OPEN contact has welded, the voltage over the OPEN contact goes below 30 V dc and the supervision function of the trip circuit is activated. If the fault persists, a trip circuit supervision alarm signal in the form of a flashing "O.C.F." message (Open Circuit Fault) on the display is obtained after the preset 3 s delay time. By default the alarm signal is connected to the alarm output contact SIGNAL 4. If this output contact is already used as an alarm output of e.g. earth fault protection, by setting parameter S200= 2, the trip circuit supervision alarm can be configured so that only display alarm and event is generated.

The fault message can be locally acknowledged by pressing the push-buttons STEP and SELECT \cap simultaneously for about 1 s.

Note!

Only the display indication needs acknowledging, not the alarm signal output. The alarm output will reset automatically when the fault disappears.

As a default and to avoid unnecessary alarms, the function of the trip circuit supervision is blocked when the trip signal TS2 initiated by the protection module is activated, that is when the OPEN contact is closed. The trip circuit supervision is also automatically disabled when the circuit breaker is withdrawn, i.e. when the four-pole status of both CB and CB truck indicate "undefined" status (no voltage at binary status inputs). The CB truck is defined by value "11" for object type on the configuration command line. Further, in case of removed CB, the flashing position indicators of CB and CB truck showing undefined status, can be set to be switched off after 10 min timeout. This can be done with parameter S7.

The supervision function of the energizing current input circuit detects interruptions of the energizing circuit. The supervision unit can be given a two-phase or three-phase function with parameter S203. The supervision is based on comparison between the measured phase currents. If one or two phase currents exceed 12% of the rated value I_n , while in one or two phases the measured phase current is below 6% of the rated current I_n , an alarm is given in the form of a flashing "C.I.F" message (Current Input Fault) on the display after a set operate time delay. By default the alarm signal is connected to the alarm output contact SIGNAL 4. If this output contact is already used as an alarm output of e.g. earth fault protection, by setting parameter S202 = 2, the energizing current input supervision alarm can be configured so that only display alarm and event is generated.

The operate time delay can be set with parameter S204 in the range of 3...60 s. The default value is 15 s. The monitoring function is disabled if all input currents are under 6% of I_n . The fault message can be locally acknowledged by pressing the push-buttons STEP and SELECT simultaneously.

Note!
Only the display indication needs acknowledging, not the alarm signal output. The alarm output will reset automatically when the fault disappears.

The phase current values can be called up on the display by means of the STEP push-button.

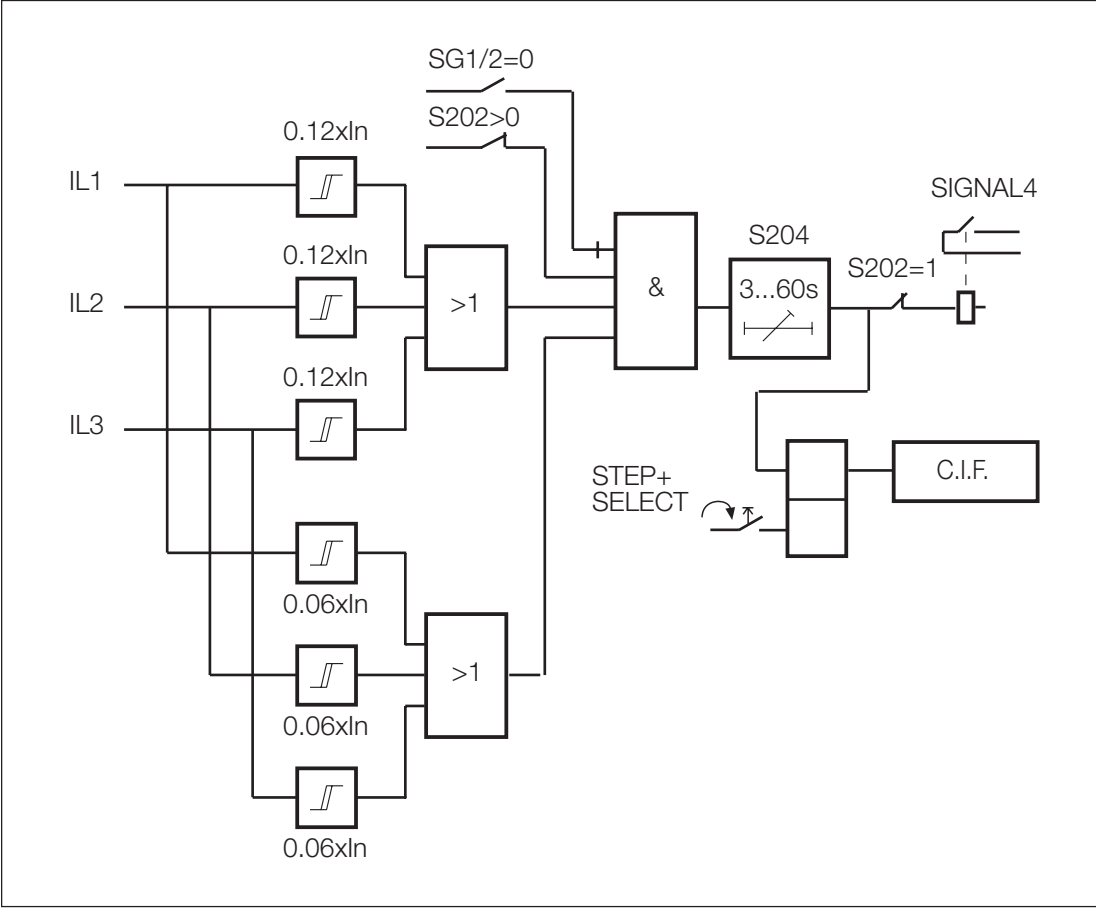


Fig. 2. Principle of the supervision function of the energizing current input circuit.

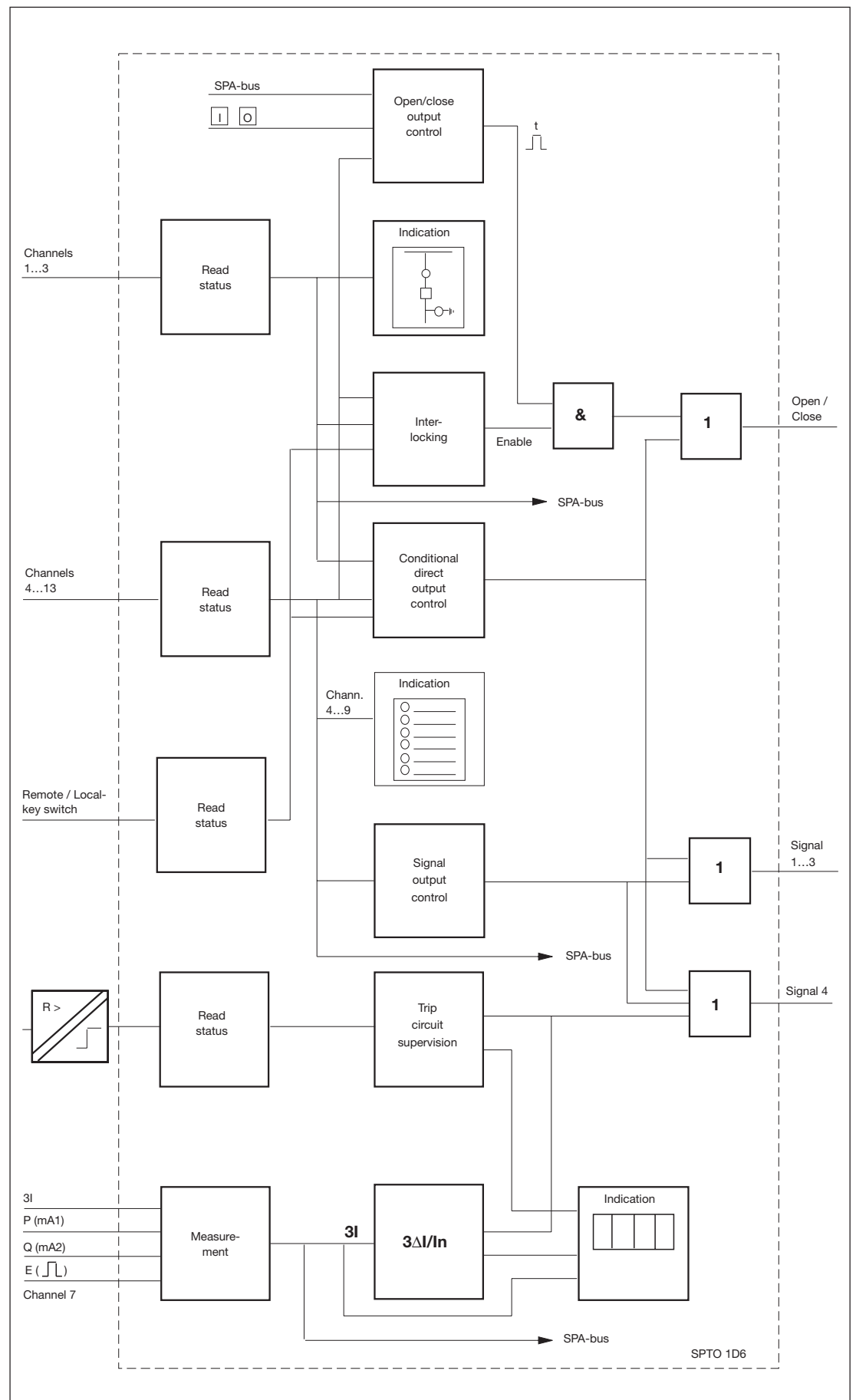


Fig. 3. Block schematic diagram of the control module SPTO 1D6.

Front panel

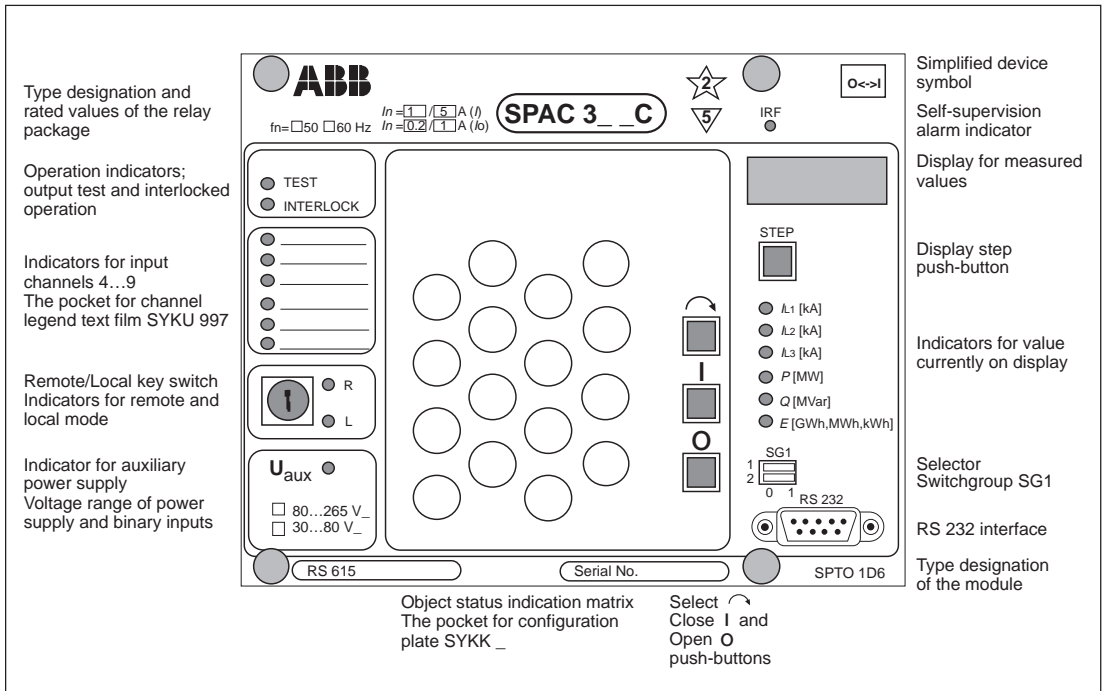


Fig. 4. Front panel of the control module SPTO 1D6 without the configuration plate SYKK _ and the channel legend text foil SYKU 997.

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 1D6 three 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. 5. 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.

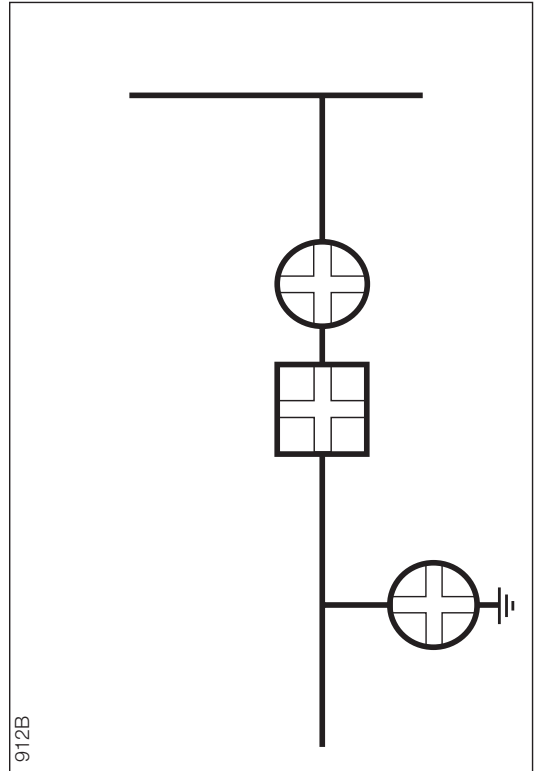


Fig. 5. Example of a plastic configuration plate SYKK_. The actual size of the configuration plate is 72mm x 106.5 mm.

Indicators for input channels 4...9

The status of the input channels 4...9 is indicated locally by LEDs on the front panel. Channel 4 is indicated by the topmost LED and channel 9 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 4...9 can 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. A clear text foil is delivered with the feeder terminal.

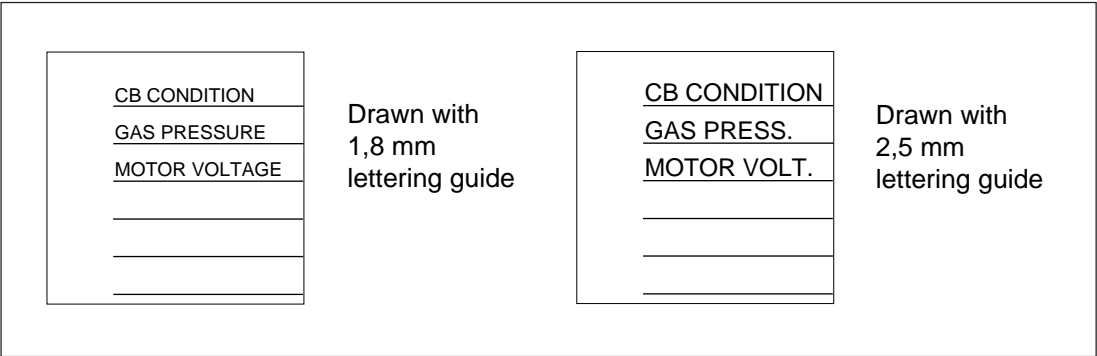


Fig. 6. Example of a text foil type SYKU 997. The foil is shown in its natural size, width 33.5 mm and height 34 mm.

Operation indicators

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

Indicator	Function
TEST	The LED is lit when the switch SG1/1=1. In this position the interlocking functions are out of use.
INTERLOCK	<p>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 SELECT \cap button but it is also automatically switched off after about 30 s.</p> <p>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.</p>

Local/Remote key switch

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

Accordingly, to be able to control an object via the serial communication, the key switch must be in the REMOTE position, indicated by the yellow LED marked R. When the key switch is

in the REMOTE position, local push-button control is inhibited. Control signals via input channels 4...13 or the Direct Output Control program are allowed both in the LOCAL and the REMOTE position. The position information can also be included in the Direct Output Control function.

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

Push-buttons ∩, I and O

A local control sequence is started by pressing the push-button SELECT ∩. After that the LED indicator of the object which has been defined controllable starts flashing.

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

The close and open commands are given with the I (CLOSE) or O (OPEN) push-buttons. Depending on the status of input channels 1...3 and 4..13 and the interlocking function, the control module either executes the selected command or switches on the INTERLOCK-LED to indicate that the operation is inhibited.

The length of the 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 interlockings during testin.</p> <p>When SG1/1 = 0, the interlocking function is in use. When SG1/1 = 1, the interlocking function is out of use and the red TEST LED is lit. All control operations are allowed.</p> <p>NOTE! Switch SG1/1 should be used only for test purposes.</p>
SG1/2	<p>Switch SG1/2 is used to inhibit trip circuit and energizing current supervision.</p> <p>When SG1/2 = 0 the trip circuit and energizing current supervisions are alerted. When SG1/2 = 1 the trip circuit and energizing current supervisions are out of use.</p>

Display of measured values and serial data communicator 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 _{L1} [kA]	Measured phase current I _{L1} in kiloamperes. The measuring range is 0.000...999 kA. NOTE! 0.000 is indicated as .000
I _{L2} [kA]	Measured phase current I _{L2} in kiloamperes. The measuring range is 0.000...999 kA.
I _{L3} [kA]	Measured phase current I _{L3} in kiloamperes. The measuring range is 0.000...999 kA.
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 leftmost red minus sign on the display.
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 leftmost red minus sign on the display.
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. May have a value within the range 0...254. The default value is 99.
B	Serial communication baudrate. Selectable transmission rate 4.8 or 9.6 kBd. The default value is 9.6 kBd.
C	Serial communication monitor. If the device is connected to a higher level data communication equipment and the communication system is operating, the monitor reading is 0, otherwise the numbers 0...255 are continuously scrolling on the display.

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

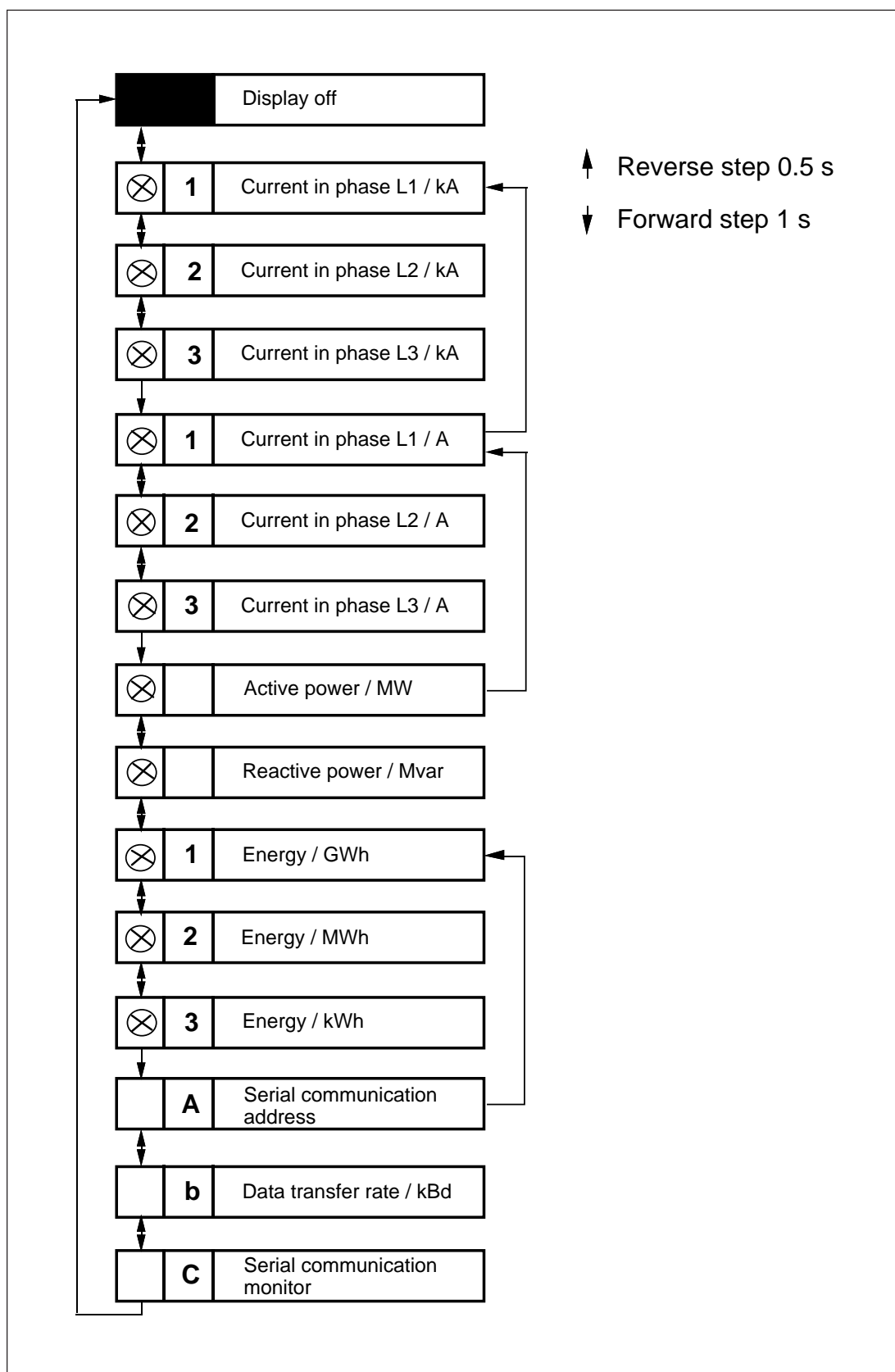


Fig. 7. Display menu of the control module SPTO 1D6.

Alarm indications of supervision functions

Energizing current monitoring

The energizing current monitoring alarm is locally indicated with a flashing "C.I.F." (Current Input Fault) message on the display. The "C.I.F." message is acknowledged by pressing the STEP and SELECT \cap push-buttons simultaneously. The measured phase current value can be called

up for display by means of the STEP push-button, although the monitor is in the alarm state, but no other display menu items.

The energizing current monitoring function can be disabled with switch SG1/2.

Trip circuit supervision

The trip circuit supervision alarm is locally indicated with a flashing "O.C.F." (Open Circuit Fault) message on the display. The "O.C.F." message is acknowledged by pressing the STEP and SELECT \cap push-buttons simultaneously.

After acknowledge the display will reset, if the

fault has disappeared. If the fault still exists, the steady "O.C.F." message remains on until the fault is cleared. The alarm contact output is automatically reset when the fault disappears.

The trip circuit supervision function can be disabled with switch SG1/2.

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 terminal goes over the control module SPTO 1D6. This enables protection modules of the same feeder terminal to be 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 1D6		Setting device		
Signal name	Pin number 9-pin male conn.	Pin number 9-pin female 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, +12V	4	-	-	-

Pin 4 of the RS 232 interface of the control module SPTO 1D6 can be used for feeding supply voltage to an optic modem. An optic mo-

dem 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 1D6 is capable of indicating status of 3 objects, i.e. circuit breaker, CB truck or disconnectors and controlling (opening or closing) one object.

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 or by choosing a suitable default configuration. Each default configuration uses a fixed interlocking scheme.

The default configurations and corresponding interlocking programs are explained in the appendices 1...3. If the configuration or the interlocking program is not suitable for a certain application, then both must be selected by the user.

After factory testing the default configuration and interlocking 1 has been selected for the control module. Another default configuration is chosen by writing the configuration number for the setting parameter S100 via the SPA bus.

Normally the control module is in the operation mode which means that the interlocking program is executed. When setting a configuration or selecting a new default configuration the control module must be in the program mode, i.e. the setting parameter S198=0.

Example 1
Selection of the default configuration and interlocking 10 instead of default 1.

```
>99WS198:0:XX  
; Enter into setting mode  
>99WS100:10:XX  
; Select the default 10  
>99WS198:1:XX  
; Change into run mode  
>99WV151:1:XX  
; Store the set parameters
```

If the setting parameter S100 is 0, the configuration is freely programmable. In this case all indicators are initially set out of use. In a freely programmable configuration, only the objects to be used must be programmed.

The three input channels 1...3 are used to read status data of circuit breaker 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. 8.

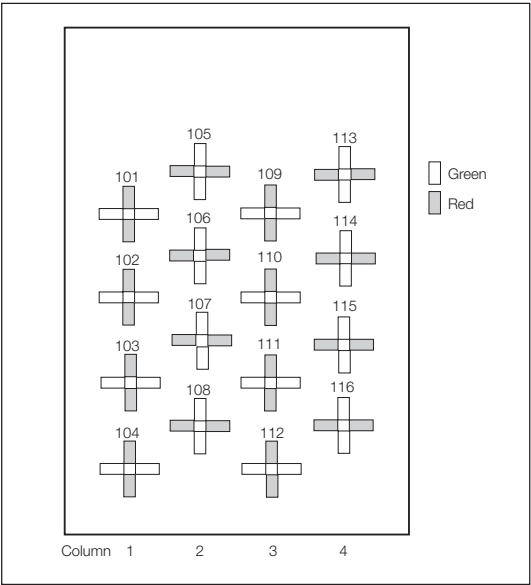


Fig. 8. Position, code number and colour of the indicator units on the front panel of the control module SPTO 1D6.

The control module has two outputs, OPEN and CLOSE, for the control of one object. The control outputs have their own code numbers, 20 and 21, 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	OPEN
21	CLOSE

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.

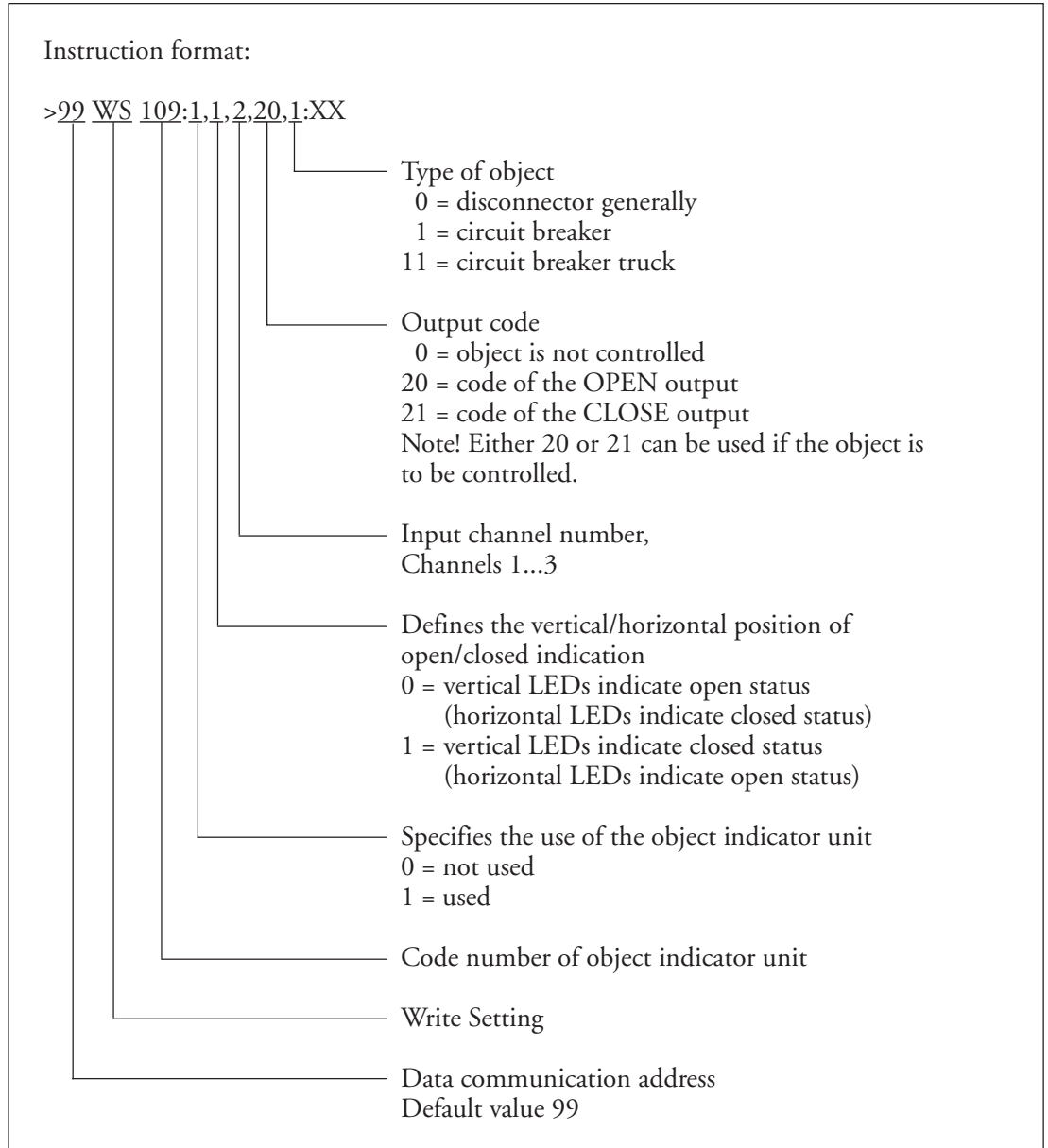
A configuration is set by linking the indicator number, the four-pole input number and the output code number by using a SPA protocol command.

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 2

Indicator 109 (setting 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 the closed status is indicated by vertical red LEDs.



Syntax rules for configuring the control module SPTO 1D6.

1. The configuration work has to be done in the setting mode.
2. Up to three objects can be configured (three settings in the range of S101...S116).
3. Only the input channel numbers 1...3 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 or 21 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 one object can be defined as a circuit breaker and also only one object can be defined as a circuit breaker truck.

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 (setting parameter 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 3

To set a configuration similar to the default configuration 1 (indicator 109 for circuit breaker truck, indicator 110 for circuit breaker and indicator 116 for an earthing switch), the following commands are required:

```
>99WS198:0:XX  
; Enter into setting mode  
>99WS100:0:XX  
; Enter into mode for free configuration  
>99WS109:1,1,1,0,11:XX  
; Circuit breaker truck : vertical red LEDs  
indicate closed status for input channel 1.  
No control  
>99WS110:1,1,2,20,1:XX  
; Circuit breaker : vertical red LEDs indi-  
cate closed status for input channel 2.  
Control outputs OPEN and CLOSE  
>99WS116:1,0,3,0,0:XX  
; Earthing switch : horizontal red LEDs in-  
dicate closed status for input channel 3.  
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. See Chapter "Interlocking".

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

Example 4

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.

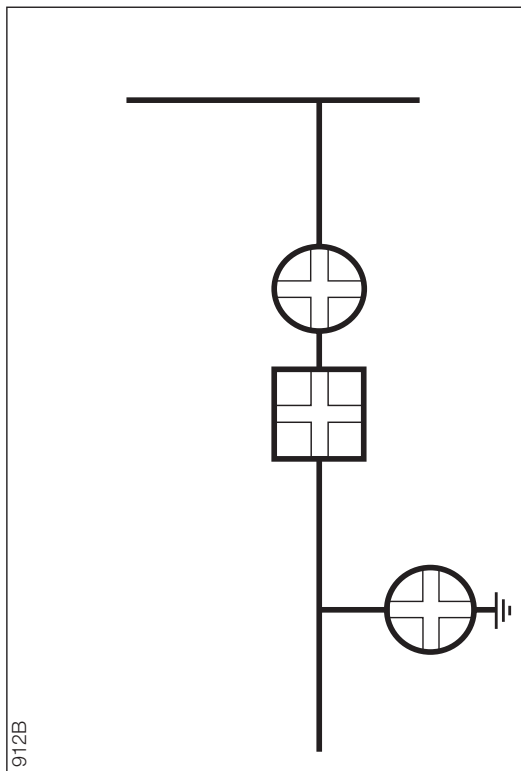


Fig. 9. Object configuration set in example 3.

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 1D6, enables the control operations, i.e. everything that is not enabled by the interlocking program is inhibited.

The default configurations have their own default interlocking programs, see appendices 1...3. If a default interlocking related to a default configuration is not suitable, both configuration and interlocking must be set by the user.

The interlocking program of the control module reads the status of input channels 1...3 and 4...13 and enables the opening or closing of a controllable object when the actual open or close command is given with the local push-buttons, the serial bus or the input channels 4...13.

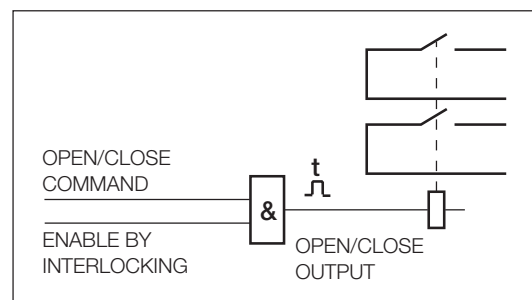


Fig. 10. Operation principle of the control functions.

When parameter S198 = 0, the control module is in the setting mode, and when parameter S198 = 1, the module is in the operation mode. In the operation mode the interlocking program is executed and it cannot be changed by the operator. 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 done. In the setting mode the control of the objects is not allowed, except for the case that interlockings are completely out of use. The interlocking is set or a default interlocking is selected in the setting mode.

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 4...13. The interlocking program is executed every 20 ms. The interlocking program can be taken completely out of use with parameter setting S199.

Example 5

In example 3 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 because the interlockings are set out of use.

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 input channels 1...3 a separate operand code is defined for each status, open, closed or undefined. The active status of input channels 4...13 can be used as operands in the logic.

In SPTO 1D6 the following operand values can be used with the operations LOAD, LOADN, AND, ANDN, OR, ORN:

1...3 = input channel number
 ; input code, if the status "closed" is used in the logic
101...103 = input channel number + 100
 ; input code, if the status "undefined" is used in the logic
201...203 = input channel number + 200
 ; input code, if the status "open" is used in the logic
4...13 = 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

In control module SPTO 1D6 the following operand values can be used with operation OUT:

20 or 21 ; 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 (0) and register 61 is one (1). Register 62 is used for position information of the L/R key switch; register 62 is one (1) when the L/R key switch is in REMOTE position and zero (0) when the key switch is in LOCAL position. The registers 70...89 are used as temporary data storages during the interlocking program execution.

Example 6

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 7

How to use input channels 4...13 in the logic.

```
>99WM200:LOAD 1:XX
; Read the closed status of an object wired to input 1
>99WM201:AND 4:XX
; Read the active status of input channel 4
>99WM202:OUT 20:XX
; Enable output 20
```

After these commands the output OPEN (code 20) is enabled if object 1 is closed and input channel 4 is active.

Syntax rules for setting the interlocking logic for the control module SPTO 1D6:

1. The setting has to be done in the setting mode.
2. With the interlocking program the operator defines when the opening and closing of an object is allowed.
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 8

Setting of the interlocking logic. The configuration is the same as in example 3. The circuit breaker is to be controlled.

The following rules are given for the interlocking:

- Opening of the circuit breaker is always allowed.
- Closing of the circuit breaker is allowed when the circuit breaker truck is in the isolating position or in the service position and the earth switch is open.

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

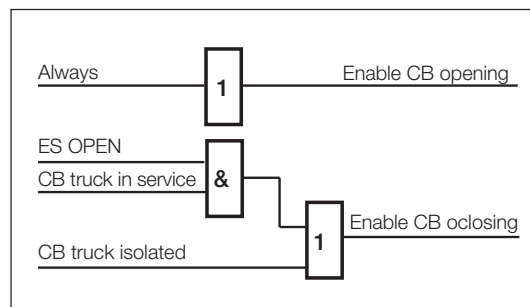


Fig. 11. Simplified logic diagram for the interlocking logic in example 8.

Below a detailed logic diagram is drawn.

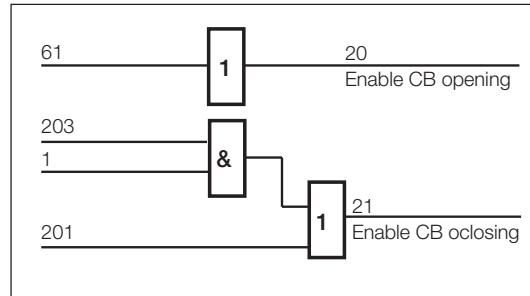


Fig. 12. Detailed logic diagram of the interlocking logic in example 8.

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 operator overwrites these END commands with the actual interlocking program.

A configuration was set in example 3. If the interlockings described above are to be used the setting continues with the following commands.

```
>99WM200:LOAD 61:XX
; Read the value of special register 61
; (the value is always 1)
>99WM201:OUT 20:XX
; Always enable open command of CB
>99WM202:LOAD 1:XX
; Read the service status of CB truck
>99WM203:AND 203:XX
; Read the open status of earth switch
>99WM204:OR 201:XX
; Read the isolated status of CB truck
>99WM205:OUT 21:XX
; Enable the close command of CB
>99WM206: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 compiling will not be performed and 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 switch SG1/1 on the front panel can be turned into position 1. Then the interlocking program is interrupted and opening/closing of an 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 an object is always enabled.

The interlocking program does not affect the tripping signal of the protection module.

The Conditional Direct Output Control logic controls the outputs OPEN, CLOSE and SIGNAL 1...4.

The outputs are activated on the basis of the selected logic diagram and the status of input channels 1...3 and 4...13. 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.

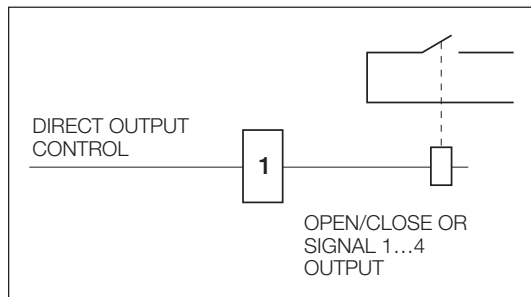


Fig. 13. Operation principle of the Conditional Direct Output Control.

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

- The codes of outputs OPEN and CLOSE
- The outputs SIGNAL1...4 can be controlled by the Conditional Direct Output Control program.

The output codes are:

Output code	Definition
220	OPEN
221	CLOSE
22	SIGNAL 1
23	SIGNAL 2
24	SIGNAL 3
25	SIGNAL 4

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

Example 9

An interlocking program is set in example 8. In the example below a Conditional Direct Output Control logic program is added for the output SIGNAL 3.

Output SIGNAL 3 output is to be activated if:

- CB truck is in the isolated position and input channel 4 is activated.

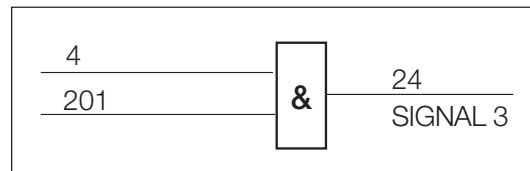


Fig. 14. Detailed logic diagram of the Conditional Direct Output Control logic in example 9.

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

```

...
; Interlocking logic command lines
M200...M205
>99WM206:LOAD 201:XX
; Read isolated status of CB truck
>99WM207:AND 4:XX
; Read active status of input 4
>99WM208:OUT 24:XX
; Activate SIGNAL3 output
>99WM209: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 4...13

The input channels 4...13 are used to read other binary signals than circuit breaker 4...13 and disconnector status information. The binary signals can be external contact signals or internal binary signals, e.g. start and tripping signals of protection relay modules. For the definition of internal and external signals see chapter "Inter-modular control signal exchange" in the User's manual of the feeder terminal.

The status of the binary inputs 4...13 can be read via the SPA-bus. The status of the input channels 4...9 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 4...9 can individually be set to be memory controlled by parameter S5, which means that the indicator of a channel activated once for at least 10 ms is not switched off until it has been reset. As a default the indicators are set not to be memory controlled.

Each input channel can be selected to be active at high input signal state (1) or at low input signal state (0) by using parameter S2. 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.

Activation and deactivation of the input channels 4...13 can be delayed by using parameters S10 or S11 in steps of 20 ms in the range from 0.00 s to 60 s. As a default changes in the input channel status are not delayed.

Characteristics of input channels 4...13:

- An event is formed by status changes
- The channels can be used to activate the outputs OPEN or CLOSE
- The channels can be used to inhibit the outputs OPEN or CLOSE
- The channels can be used to activate one of the outputs SIGNAL1 to 4
- The channels can be included in the interlocking logic
- The channels can be included in the Conditional Direct Output Control logic
- Channel 7 can be used as an energy pulse counter input, see chapter "Scaling of measured values".

Via one input channel one signal output (SIGNAL1...4) and one control output (OPEN or CLOSE) can be activated simultaneously. 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 position of the R/L keyswitch is without significance when the control outputs (OPEN or CLOSE) are activated via input channels 4...13, but a comparison with the interlocking logic is always made before a control action.

If an input channel has been selected to control a signal output, the output is activated as long as the input is active whereas the length of the opening and closing pulse is defined by the SPA bus variables V5 and V6 respectively and they are not depending on the input pulse length.

Example 10

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)
>99W8S3:22:XX
; Configure input 8 to activate output
  SIGNAL1
>99W8S4:20:XX
; Configure input 8 to activate output
  OPEN
>99WV151:1:XX
; Store the programmed parameters
```

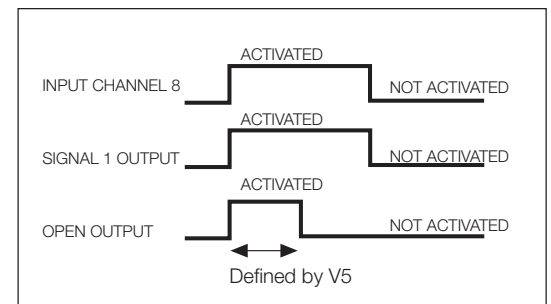


Fig. 15. Operation of outputs SIGNAL1 and OPEN when input channel 8 in example 10 is activated.

If an input channel is used for inhibiting 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 4...13 cannot be used to inhibit the control of the OPEN and CLOSE outputs.

If input channel 7 operates as an energy pulse counter input, this input cannot be used for other purposes. As a default input channels 4...13 operate as ordinary input channels and are not linked to any outputs.

The control module SPTO 1D6 has six (6) outputs: four signal outputs (SIGNAL1...4) and two control outputs (OPEN and CLOSE). For the purpose of setting the outputs are coded in the following way:

Output	Output code	Remarks
OPEN	20	For configuration and interlocking
OPEN	220	For Conditional Direct Output Control
CLOSE	21	For configuration and interlocking
CLOSE	221	For Conditional Direct Output Control
SIGNAL1	22	
SIGNAL2	23	
SIGNAL3	24	
SIGNAL4	25	

The outputs OPEN and CLOSE 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 by commands over the SPA bus
- Remotely via the binary input channels 4...13, see chapter "Input channels 4...13"
- By the Conditional Direct Output Control logic, see chapter "Conditional Direct Output Control"

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 only for the input channel to which the object to be controlled is connected. As a default the object to be controlled is connected to input channel 2.

The pulse length can be set within the range 0.1...100 s with a time resolution of 0.1 s. As a default the value for SPA bus variables V5 and V6 in input channel 2 is 0.1 s.

Example 11

The pulse lengths can be set in the operation mode. In default configuration 3 the object to be controlled is configured to input channel 2 and defined to be a CB. The following SPA bus commands are used to set the open and close pulse lengths.

```
>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 OPEN and CLOSE 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 corresponding 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.

When the Conditional Direct Output Control logic is used to control the outputs OPEN and CLOSE, the output is activated as long as the status of the input control signal remains unchanged.

The operation of the outputs OPEN and CLOSE can be inhibited in two ways:

- By the interlocking program, see chapter "Interlocking"
- By input channels 4...13, see chapter "Input channels 4...13"

The outputs SIGNAL1...4 can be controlled in two ways:

- By input channels 4...13, see chapter "Input channels 4...13"
- By the Conditional Direct Output Control logic program, see chapter "Conditional Direct Output Control"

Note!

Output SIGNAL4 is also controlled by the supervision functions if in use.

The control module SPTO 1D6 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 supply 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, active and reactive power and energy. The phase currents are measured via the 1 A or 5 A current inputs of the feeder terminal. The module includes two mA-inputs for measuring active and reactive power via external measuring transducers. Energy can be measured in two ways, either by using input 7 as a pulse counter or by integrating the measured power. If the pulse counter input is used an external energy meter with a pulse output is needed.

Phase currents

The three phase currents are displayed locally as kA values and transferred via the SPA bus as kiloampere values. However, to be able to do this the measured values must be scaled, using the information about the rated current of the primary side of the current transformers.

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. The default value of variable S9 after factory testing is 200.00.

Active and reactive power

Active power is displayed locally and transferred via the SPA 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 measurement can be enabled or disabled with parameter S91. As a default power measurement is disabled (S91=0).

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 13

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

```
>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 set high mA signal limit
>WV151:1:XX
; Store set parameters
```

Example 14

Reactive power is to be measured in the range 0...2.2 Mvar and the corresponding mA signal range is 4...20 mA.

```
>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
```

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

Energy

Input channel 7 can be used as an energy pulse counter. The measured energy is displayed locally by three digits in three parts; in kilowatt-hours, in megawatthours and in gigawatthours. Correspondingly, the energy value can be read via the serial bus in three parts with maximum three digits (parameters V8...V10) but also as one part in kilowatthours with maximum nine digits (parameter V5). Before the energy pulse counter can be used the energy measurement must be enabled by variable S92. The default setting of variable S92 is 0, which means that energy measurement is disabled.

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 7 has not been defined as a pulse counter input.

The following parameters must be defined for input channel 7:

- S1 = definition of input channel 7
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 = pulse direction
0 = negative pulse
1 = positive pulse (default)

The following parameters must be defined for channel 0:

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

Example 15

Energy measurement via input channel 7 defined as pulse counter input.

```
>99WS92:1:XX
; Enable energy measurement
>99WS3:5:XX
; Set energy value 5 kWh per pulse
>99W7S1:1:XX
; Set input 7 as a pulse counter without
  local indication
>99W7S2:1:XX
; Set a positive polarity of pulses
>99WV151:1:XX
; Store the programmed parameters
```

Example 16

Energy measurement by integrating the measured power value over time. Initially the power measurement must be enabled and the power values scaled, see examples 13 and 14.

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

Over the SPA bus a substation level data communicator can read the event data, such as status change, transmitted by the control module SPTO 1D6. 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...13

event code = E1...E54, depending on the channel

Most of the event codes and the corresponding events may be included in or excluded from the event reporting by writing an event mask (V155) to the control module. The event mask is a binary number coded to a decimal number. Each input channel 1...13 has its own event mask.

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

Example 17

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 without open/close selection	1024	x 0	= 0
Event mask V155 for channel 2					347

The event mask V155 of channel 0 and input channels 4...13 may have a value within the range 0...15 and the event mask of input channels 1...3 within the range 0...2047. The default values are shown in the next table.

Input channels 1...13 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 input channels 1...3 and settings S10 and S11 for input channels 4...13 define the activation/deactivation delays. The set delays are used for filtering 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 delay time, 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 and vice versa. The time marking of a delayed activation/deactivation event is the actual event time added with the delay time.

The control module has the following event codes:

Channel	Code	Event	Weighting factor	Default value
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	Supervision functions disabled SG1/2 ON	16	0
0	E6	Supervision functions enabled SG1/2 OFF	32	0
0	E7	Trip circuit fault	64	1
0	E8	Trip circuit fault reset	128	0
0	E9	Energizing current input fault	256	1
0	E10	Energizing current input fault reset	512	0
0			V155 = 323	

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

4...13	E1	Input channel activated	1	1
4...13	E2	Input channel reset	2	1
4...13	E3	SIGNAL1...4 output activated	4	0
4...13	E4	SIGNAL1...4 output reset	8	0
4...13			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) Event E9, output activation inhibited, is obtained if the operation is inhibited by the interlocking program or by an input channel 4...13.

2) Event E10, output activation fault, is given if the status of the controlled object does not change during the time of the output pulse.

3) Event E11, attempt to activate an output without an open/close selection, is given 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, the following instructions should be used when changing between setting and run mode and when storing the parameters.

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

S100 = 1
Default configuration and interlocking 1
S198 = 1
The interlocking program is in run mode
S199 = 1
Interlockings are in use

The following example shows the setting procedure.

Example 18

To select another configuration and interlocking than default 1.

```
>99WS198:0:XX
; Change into setting mode
>99WS100:2:XX
; Select the default 2
>99WS198:1:XX
; Change into run mode
:
; Change other parameters
:
>99WV151:1:XX
; Store set parameters
```

Example 19

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
:
; Change 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 L1 ($\times I_n$)	0	I1	R	0.00...2.50 $\times I_n$
Current on phase L2 ($\times I_n$)	0	I2	R	0.00...2.50 $\times I_n$
Current on phase L3 ($\times I_n$)	0	I3	R	0.00...2.50 $\times I_n$
Active power (bits)	0	I4	R	-1023...1023 bits
Reactive power (bits)	0	I5	R	-1023...1023 bits
Current on phase L1 (A)	0	I6	R	0...9999 A
Current on phase L2 (A)	0	I7	R	0...9999 A
Current on phase L3 (A)	0	I8	R	0...9999 A
Undelayed status of trip circuit supervision input	0	I9	R	0 = deactivated 1 = activated
Undelayed status of the energizing current monitoring	0	I10	R	0 = input states normal 1 = current input(s) faulty
Object status	1...3	I1	R	0 = undefined (inputs 00) 1 = closed 2 = open 3 = undefined (inputs 11)
Closed status of an object	1...3	I2	R	0 = not closed 1 = closed
Open status of an object	1...3	I3	R	0 = not open 1 = open
Status of input channels 4...13	4...13	I1	R	0 = not active 1 = active
Direct output control	1...3	O1	W	0 = open 1 = close
Trip circuit supervision alarm	0	O9	R	0 = alarm reset 1 = alarm active
Energizing input monitoring alarm	0	O10	R	0 = alarm reset 1 = alarm active
Open select (secured operation)	1...3	V1	RW	0 = no selection 1 = select
Close select (secured operation)	1...3	V2	RW	0 = no selection 1 = select
Execute selected open/close operation	1...3	V3	W	1 = execute selected operation
Cancel selected open/close operation	1...3	V4	W	1 = cancel selected operation
Open pulse length	1...3	V5	RW(e)	0.1...100.0 s
Close pulse length	1...3	V6	RW(e)	0.1...100.0 s
Execute selected open/close operation (common address 900)	0	V251	W	1 = execute all selected operations
Cancel selected open/close operation (common address 900)	0	V252	W	1 = cancel all selected operations

Data	Channel	Code	Data direction	Values
kWh value per pulse	0	S3	RW(e)	0.01...1000 kWh per pulse
Energizing input and trip circuit supervision function	0	S5	R	0 = function enabled (SG1/2=0) 1 = function disabled (SG1/2=1)
Interlockings	0	S6	R	0 = interlocking enabled (SG1/1=0) 1 = interlocking disabled (SG1/1=1)
Object indicator mode	0	S7	RW(e)	0 = continuous display (default setting) 1 = automatic switch-off after 10 min. (re-display from \cap push-button) 2 = automatic switch-off of CB and truck indicators after 10 min. if showing undefined status, i.e. CB removed. (re-display from \cap push-button or status change)
Display indicator 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
Low limit for mA signal of active power	0	S12	RW(e)	-20...+20 mA
High limit for mA signal of active power	0	S13	RW(e)	-20...+20 mA
Low limit for mA signal of reactive power	0	S14	RW(e)	-20...+20 mA
High limit for mA signal of reactive power	0	S15	RW(e)	-20...+20 mA
Active power corresponding to the mA signal at low limit	0	S16	RW(e)	- 999.99...+999.99
Active power corresponding to the mA signal at high limit	0	S17	RW(e)	- 999.99...+999.99
Reactive power corresponding to the mA signal at low limit	0	S18	RW(e)	- 999.99...+999.99
Reactive power corresponding to the mA signal at high limit	0	S19	RW(e)	- 999.99...+999.99
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 = default 1 2 = default 2 10 = default 10

Data	Channel	Code	Data direction	Values
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 number; 1...3 = input number 1...3 - output code; 0 = not controlled object 20 or 21 = outputs 20 or 21 used - value 3; 0 = object other than CB or CB truck 1 = object is a CB 11 = object is a CB truck
Selection of setting/run mode	0	S198	RW(e)	0 = program mode 1 = run mode
Interlocking selection	0	S199	RW(e)	0 = no interlockings 1 = interlockings in use
Trip circuit supervision (TCS)	0	S200	RW(e)	0 = no TCS 1 = TCS in use alarm via SIGNAL 4 2 = TCS in use, but no contact alarm
Supervision mode	0	S201	RW(e)	0 = continuous supervision 1 = no TCS when TS2 activated (binary input channel 13) (default setting) 2 = no TCS when OPEN signal activated 3 = no TCS when TS2 or OPEN signal activated
Energizing current monitoring	0	S202	RW(e)	0 = no monitoring 1 = monitoring in use alarm via SIGNAL 4 2 = monitoring in use, but no contact alarm
Monitored phase currents	0	S203	RW(e)	1 = L1+L2+L3 (default) 2 = L1+L2 3 = L1+L3 4 = L2+L3
Operation delay for energizing current monitoring alarm	0	S204	RW(e)	3...60 s in 1 s steps (default 15 s)

Data	Channel	Code	Data direction	Values
Interlocking and Conditional 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...3) or active (4...13) status undefined (101...103) status open (201...203) Output code (20, 21) Special register (60, 61) L/R key switch position information (62) Memory No. (70...89) Variables for Conditional Direct Output Control = status closed (1...3) or active (4...13) status undefined (101...103) status open (201...203) Output code (22...25, 220 or 221) Special register (60, 61) L/R key switch position (62) Memory No. (70...89)
Event delay; —>10 (open)	1...3	S10	RW(e)	0.00, or 0.02...60.00 s
Event delay; —>01 (close)	1...3	S11	RW(e)	0.00, or 0.02...60.00 s
Event delay; —>11 (undefined)	1...3	S12	RW(e)	0.00, or 0.02...60.00 s
Event delay; —>00 (undefined)	1...3	S13	RW(e)	0.00, or 0.02...60.00 s
Use of input 7	7	S1	RW(e)	0 = general mode 1 = pulse counter without indication 2 = pulse counter with indication
Operation principle of input channels 4...13	4...13	S2	RW(e)	0 = active at low state 1 = active at high state
Signal output activation via input channels 4...13	4...13	S3	RW(e)	0 = no SIGNAL output activated 22 = SIGNAL1 output activated 23 = SIGNAL2 output activated 24 = SIGNAL3 output activated 25 = SIGNAL4 output activated

Data	Channel	Code	Data direction	Values
Operation of OPEN and CLOSE outputs via input channels 4...13	4...13	S4	RW(e)	0 = no activation or inhibit 20 = activate OPEN output 21 = activate CLOSE output 120 = inhibit OPEN output 121 = inhibit CLOSE output
Memory controlled function of the indicators of the binary inputs	4...9	S5	RW(e)	0 = not memory controlled 1 = memory controlled
Channel 4...13 activation delay	4...13	S10	RW(e)	0.00 s or 0.02...60.00 s (default setting 0.00 s)
Channel 4...13 reset delay	4...13	S11	RW(e)	0.00 s or 0.02...60.00 s (default setting 0.00 s)
Event reporting	1...13	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
Store data into EEPROM	0	V151	W	1 = storing, takes about 10 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, default 323 (R/L-key switch positions and supervision events reported)
Event mask	1...3	V155	RW(e)	0...2047
Event mask	4...13	V155	RW(e)	0...15

Data	Channel	Code	Data direction	Values
Activation of self-supervision output	0	V165	W	0 = reset 1 = activate
Start display test	0	V167	W	1 = start display test sequence; overrides O.C.F. and/or C.I.F. display messages if active
Internal fault code	0	V169	R	Fault code
Data communication address	0	V200	RW(e)	1...255
Data transfer rate	0	V201	RW(e)	4800 Bd or 9600 Bd
Program version symbol	0	V205	R	E.g. 092 A
Type designation of the module	0	F	R	SPTO 1D6
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 parameters

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 SELECT \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 parameters are stored into the EEPROM by using parameter V151.

The following table lists the default values of the parameters:

Parameter	Channel	Code	Default value
Open pulse length	2	V5	0.1 s
Close pulse length	2	V6	0.1 s
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
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 reactive power	0	S14	+4 mA
High limit of mA signal of reactive 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
Power measurement	0	S91	0 = no power measurement
Energy measurement	0	S92	0 = no energy measurement
Configuration and interlocking	0	S100	1 = default configuration and interlocking program 1
Configuration of objects	0	S101 : S116	default configuration 1, see appendix 1
Setting/run mode selection	0	S198	0 = setting mode
Interlocking selection	0	S199	0 = interlockings out of use
Trip circuit supervision (TCS)	0	S200	1 = TCS in use
Supervision mode	0	S201	1 = no TCS when TS2 activated
Energizing current monitoring	0	S202	1 = monitoring in use
Monitored phase currents	0	S203	1 = L1+L2+L3
Operation delay for energizing current monitoring alarm	0	S204	15 s
Interlocking program	0	M200 : M300	default interlocking 1, see appendix 1
Event delay; —>10 (open)	1...3	S10	0.00 s
Event delay; —>01 (close)	1...3	S11	0.00 s
Event delay; —>11	1 and 3	S12	10.00 s
Event delay; —>00	2	S13	0.20 s

Parameter	Channel	Code	Default value
Use of input 7	7	S1	0 = general mode
Operation principle of input channels 4...13	4...13	S2	1 = active at high state
Signal output activation by input channels 4...13	4...13	S3	0 = no signal output
Operation of OPEN and CLOSE outputs by input channels 4...13	4...13	S4	0 = no activation or inhibit
Memory controlled function of the indicators of the binary inputs	4 ...13	S5	0 = not memory controlled
Activation delay	4...13	S10	0.00 s
Deactivation delay	4...13	S11	0.00 s
Event reporting	1...13	S20	0 = event reporting enabled
Load default values after EEPROM failure	0	V152	1 = inhibited
Event mask	0	V155	323
Event mask	1...3	V155	1875
Event mask	4...13	V155	3
Data communication address	0	V200	99
Data transfer rate	0	V201	9600 Bd

Technical data

Control functions

- status indication for maximum 3 objects, e.g. circuit breakers, disconnectors, earthing switches
- configuration freely selectable by the user
- remote or local control (open and close) for one object
- output pulse length selectable, 0.1...100.0 s
- 10 binary inputs for reading contact data other than status information
- freely selectable feeder oriented interlocking system, the 3 status inputs plus 10 other binary input channels and the L/R key switch state can be included
- the 10 binary input channels can be used to control the OPEN and CLOSE outputs
- four signal outputs which can be controlled by the 10 binary input channels

Measurements

- measurement of three phase currents, measurement range $0...2.5 \times I_n$
- accuracy of phase current measurement better than $\pm 1\%$ of I_n
- two mA inputs for measurement of active and reactive power
- mA input range -20...+20 mA, can be limited by setting
- accuracy of power measuring better than $\pm 1\%$ of maximum value of measurement range
- one pulse counter input for energy pulse counting, maximum input signal frequency 25 Hz
- energy can also be calculated by integrating the measured active and reactive power value over time
- all measured values can be scaled as actual primary values
- local display or remote reading of measured values

Supervision functions

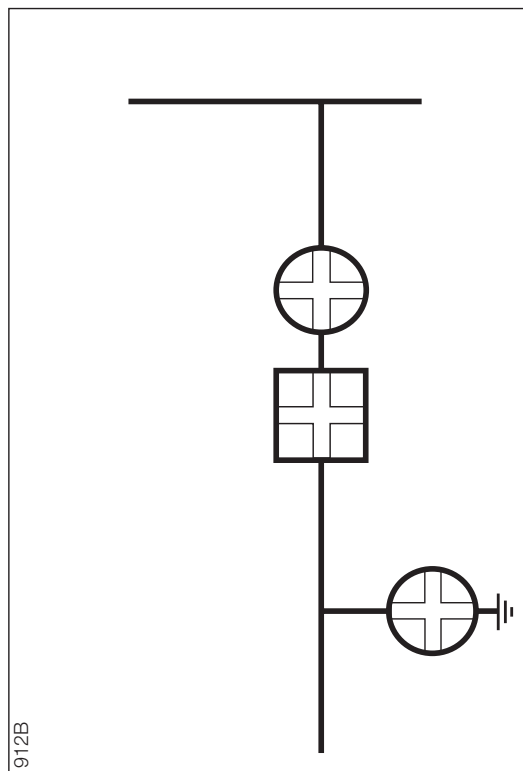
- energizing current circuit monitoring
- trip circuit supervision
- internal self-supervision of hardware and software in the control module

Default configuration and interlocking 1

Configuration

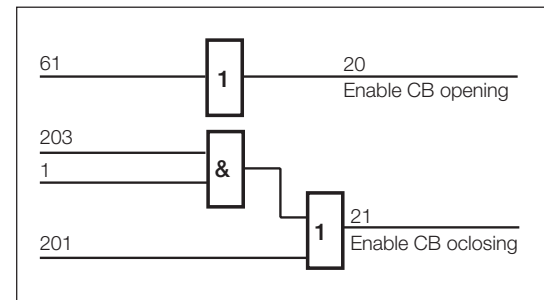
- Circuit breaker;
input channel 2, indicator 110, controlled by
outputs OPEN (20) and CLOSE (21)
- Circuit breaker truck;
input channel 1, indicator 109, not controlled
- Earth-switch;
input channel 3, indicator 116, not controlled

S109:1,1,0,11
S110:1,1,2,20,1
S116:1,0,3,0,0



Interlocking

- The CB can always be opened.
- The CB can be closed if the CB truck is in the service position and the earth-switch is open or the CB truck is in the isolated position.



The interlocking program has the following form:

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Appendix 2

Default configuration and interlocking 2

Default configuration and interlocking 2 is selected by giving variable S100 the value 2. The other parameters have the values given in the chapter "Default values of the parameters".

Configuration

The configuration unit has three objects, a circuit breaker, a circuit breaker truck and an earth-switch. The close state is indicated with red colour and the open state with green colour. The following inputs, indicators and outputs are used:

- Circuit breaker;
input channel 2, indicator 110, controlled by outputs OPEN (20) and CLOSE (21)
- Circuit breaker truck;
input channel 1, indicator 109, not controlled
- Earth-switch;
input channel 3, indicator 116, not controlled

The configuration commands are as follows:

S109:1,1,1,0,11
S110:1,1,2,20,1
S116:1,0,3,0,0

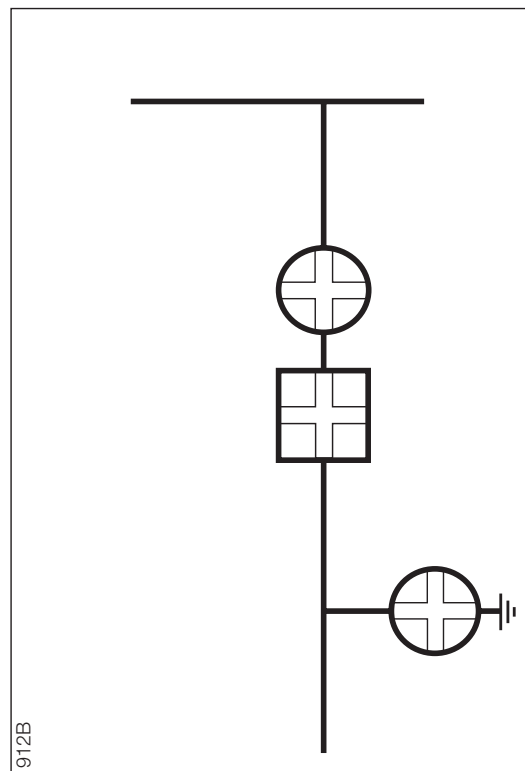


Fig 18. Default configuration 2.

Interlocking

The following rules apply for interlocking:

- The CB can always be opened.
- The CB can be closed if the CB truck is in isolated position or if the CB truck is in the service position and the earth-switch is open.

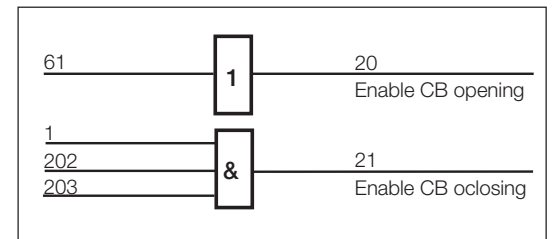


Fig. 19. Logic diagram for the default interlocking 2.

The interlocking program has the following form:

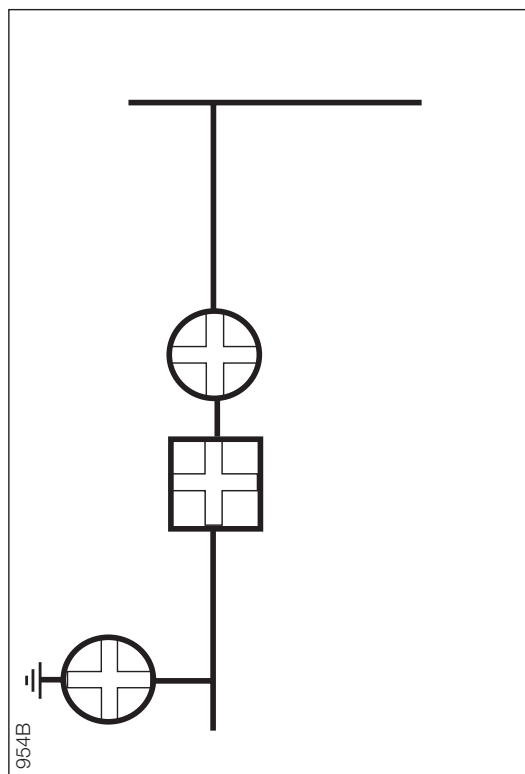
```
M200:LOAD 61
M201:OUT 20
M202:LOAD 1
M203:AND 202
M204:AND 203
M205:OUT 21
M206:END
```

Default configuration and interlocking 10

Configuration

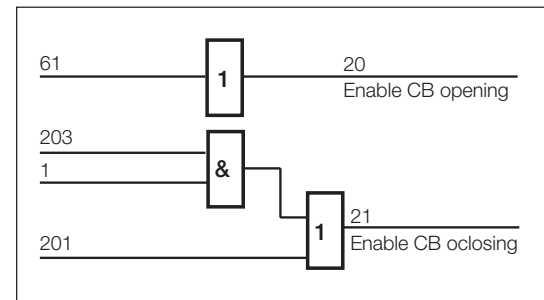
- Circuit breaker;
input channel 2, indicator 107, controlled by
outputs OPEN (20) and CLOSE (21)
- Circuit breaker truck;
input channel 1, indicator 106, not controlled
- Earth-switch;
input channel 3, indicator 104, not controlled

S106:1,1,0,11
S107:1,1,2,20,1
S104:1,0,3,0,0



Interlocking

- The CB can always be opened.
- The CB can be closed if the CB truck is in the service position and the earth-switch is open or if the CB truck is in isolated position.

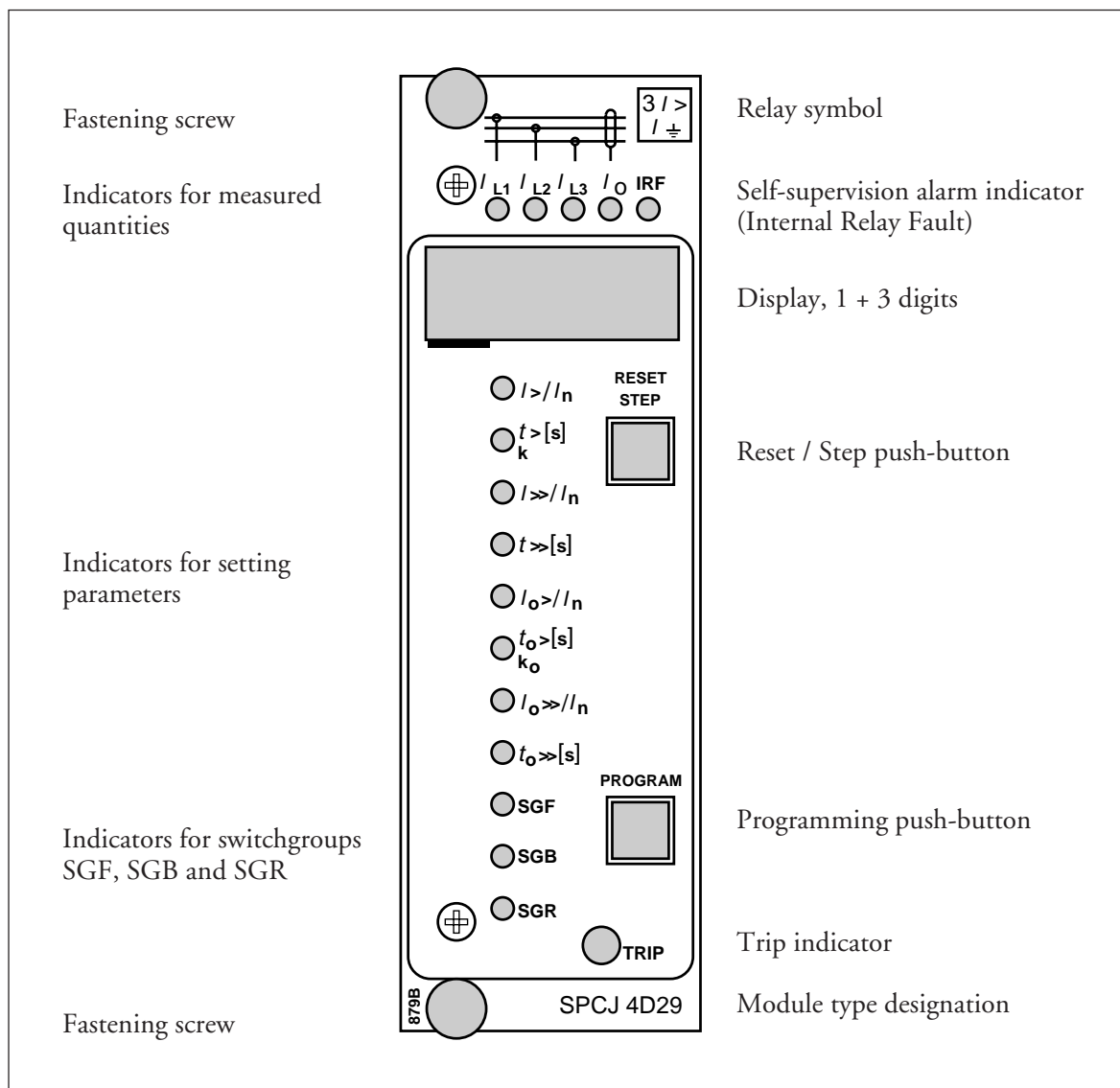


The interlocking program has the following form:

```
M200:LOAD 61
M201:OUT 20
M202:LOAD 1
M203:AND 203
M204:OR 201
M205:OUT 21
M206:END
```


General characteristics of D-type relay modules

User's manual and Technical description



General characteristics of D type relay modules

Data subject to change without notice

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Control push-buttons	<p>The front panel of the relay module contains two push buttons. The RESET / STEP push button is used for resetting operation indicators and for stepping forward or backward in the display main menu or submenus. The PROGRAM push button is used for moving from a</p>	<p>certain position in the main menu to the corresponding submenu, for entering the setting mode of a certain parameter and together with the STEP push button for storing the set values. The different operations are described in the subsequent paragraphs in this manual.</p>
Display	<p>The measured and set values and the recorded data are shown on the display of the protection relay module. The display consists of four digits. The three green digits to the right show the measured, set or recorded value and the leftmost red digit shows the code number of the register. The measured or set value displayed is indicated by the adjacent yellow LED indicator on the front panel. When a recorded fault value is being displayed the red digit shows the number of the corresponding register. When the display functions as an operation indicator the red digit alone is shown.</p>	<p>When the auxiliary voltage of a protection relay module is switched on the module initially tests the display by stepping through all the segments of the display for about 15 seconds. At first the corresponding segments of all digits are lit one by one clockwise, including the decimal points. Then the center segment of each digit is lit one by one. The complete sequence is carried out twice. When the test is finished the display turns dark. The testing can be interrupted by pressing the STEP push button. The protection functions of the relay module are alerted throughout the testing.</p>
Display main menu	<p>Any data required during normal operation are accessible in the main menu i.e. present measured values, present setting values and recorded parameter values.</p> <p>The data to be shown in the main menu are sequentially called up for display by means of the STEP push button. When the STEP push button is pressed for about one second, the display moves forward in the display sequence. When the push button is pressed for about 0.5 seconds, the display moves backward in the display sequence.</p>	<p>From a dark display only forward movement is possible. When the STEP push button is pushed constantly, the display continuously moves forward stopping for a while in the dark position.</p> <p>Unless the display is switched off by stepping to the dark point, it remains lit for about 5 minutes from the moment the STEP push button was last pushed. After the 5 minutes' time-out the display is switched off.</p>
Display submenus	<p>Less important values and values not very often set are displayed in the submenus. The number of submenus varies with different relay module types. The submenus are presented in the description of the concerned protection relay module.</p> <p>A submenu is entered from the main menu by pressing the PROGRAM push button for about one second. When the push button is released, the red digit of the display starts flashing, indicating that a submenu has been entered. Going from one submenu to another or back to the main menu follows the same principle as when moving from the main menu display to another;</p>	<p>the display moves forward when the STEP push button is pushed for one second and backward when it is pushed for 0.5 seconds. The main menu has been re-entered when the red display turns dark.</p> <p>When a submenu is entered from a main menu of a measured or set value indicated by a LED indicator, the indicator remains lit and the address window of the display starts flashing. A submenu position is indicated by a flashing red address number alone on the display without any lit set value LED indicator on the front panel.</p>

Selector switch-groups SGF, SGB and SGR

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

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

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

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

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

Settings

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

In addition to the main stack of setting values most D type relay modules allow a second stack of settings. Switching between the main settings

and the second settings can be done in three different ways:

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

Setting mode

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

The registers of the main menu and the submenus contain all parameters that can be set. The settings are made in the so called setting mode, which is accessible from the main menu or a submenu by pressing the PROGRAM push button, until the whole display starts flashing. This position indicates the value of the parameter before it has been altered. By pressing the PROGRAM push button the programming sequence moves forward one step. First the rightmost digit starts flashing while the rest of the display is steady. The flashing digit is set by means of the STEP push button. The flashing

cursor is moved on from digit to digit by pressing the PROGRAM push button and in each stop the setting is performed with the STEP push button. After the parameter values have been set, the decimal point is put in place. At the end the position with the whole display flashing is reached again and the data is ready to be stored.

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

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

Before a relay module is inserted into the relay case, one must assure that the module has been given the correct settings. If there however is

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

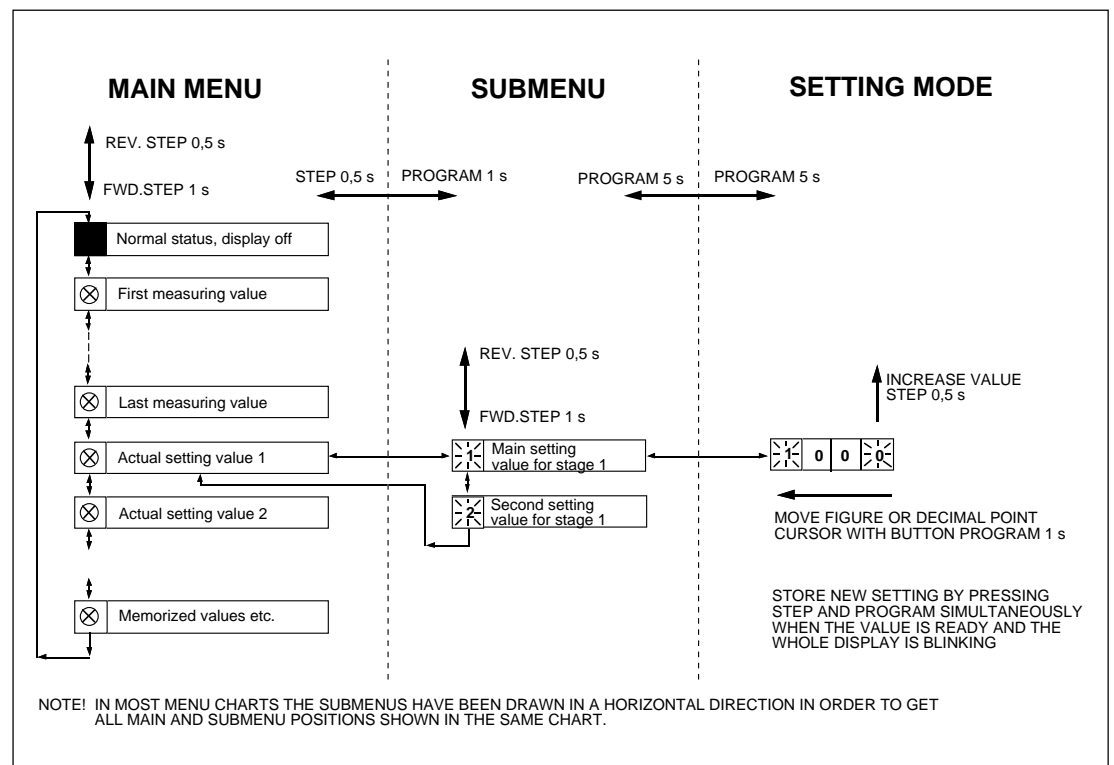


Fig.3. Basic principles of entering the main menus and submenus of a relay module.

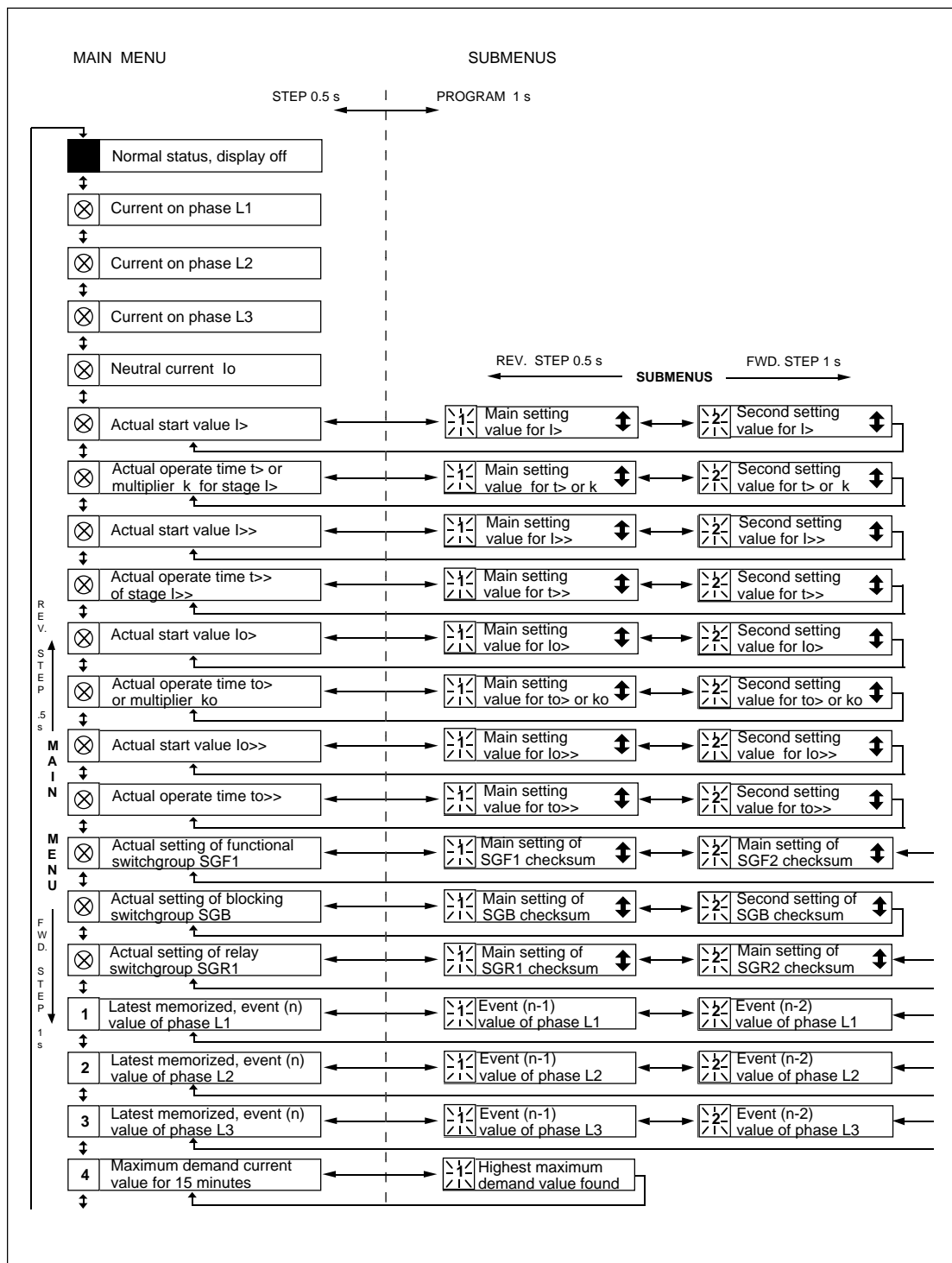


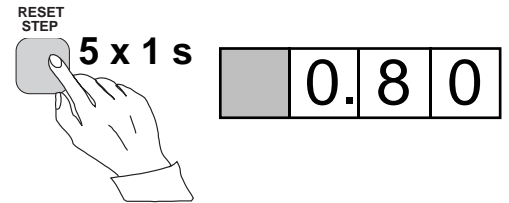
Fig. 4. Example of part of the main and submenus for the settings of the overcurrent and earth-fault relay module SPCJ 4D29. The settings currently in use are in the main menu and they are displayed by pressing the STEP push button. The main menu also includes the measured current values, the registers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

Example 1

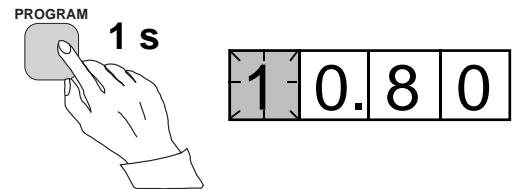
Operation in the setting mode. Manual setting of the main setting of the start current value $I>$ of an overcurrent relay module. The initial value

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

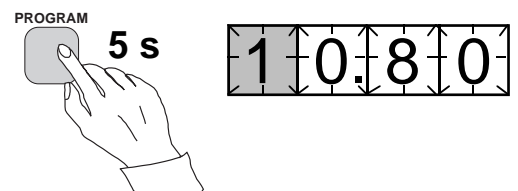
a)
Press push button STEP repeatedly until the LED close to the $I>$ symbol is lit and the current start value appears on the display.



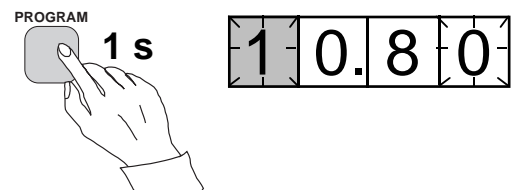
b)
Enter the submenu to get the main setting value by pressing the PROGRAM push button more than one second and then releasing it. The red display digit now shows a flashing number 1, indicating the first submenu position and the green digits show the set value.



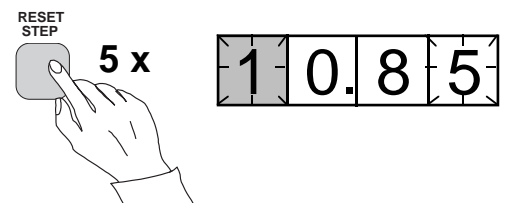
c)
Enter the setting mode by pressing the PROGRAM push button for five seconds until the display starts flashing.



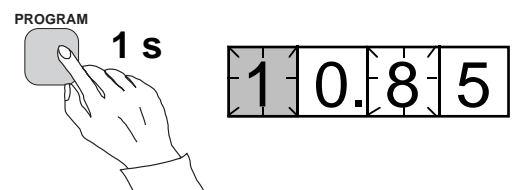
d)
Press the PROGRAM push button once again for one second to get the rightmost digit flashing.



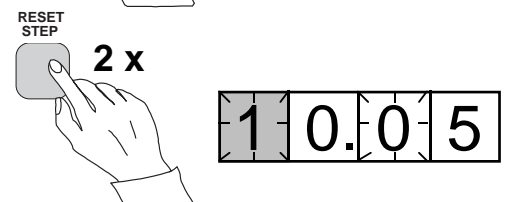
e)
Now the flashing digit can be altered. Use the STEP push button to set the digit to the desired value.



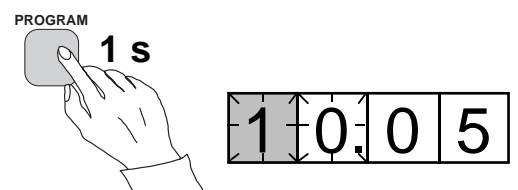
f)
Press the PROGRAM push button to make the middle one of the green digits flash.



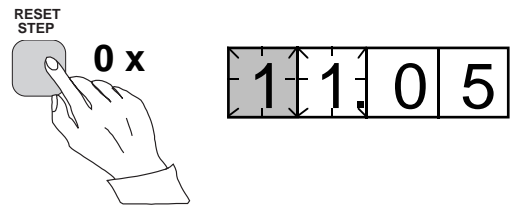
g)
Set the middle digit with the STEP push button.



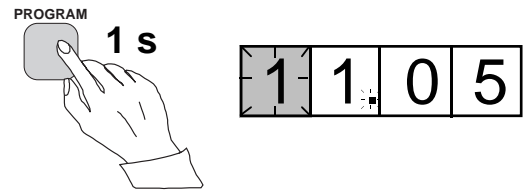
h)
Press the PROGRAM push button to make the leftmost green digit flash.



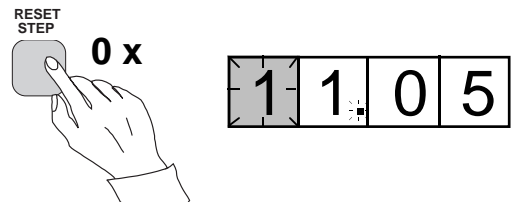
- i)
Set the digit with the STEP push button.



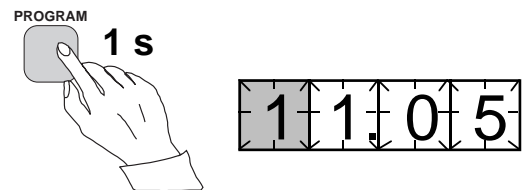
- j)
Press the PROGRAM push button to make the decimal point flash.



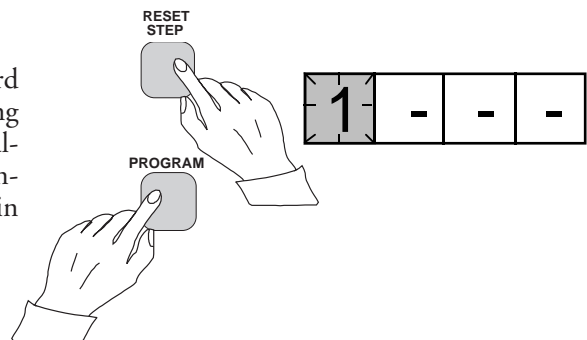
- k)
If needed, move the decimal point with the STEP push button.



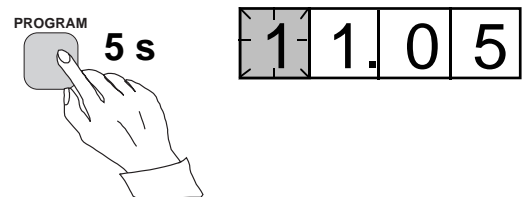
- l)
Press the PROGRAM push button to make the whole display flash. In this position, corresponding to position c) above, one can see the new value before it is recorded. If the value needs changing, use the PROGRAM push button to alter the value.



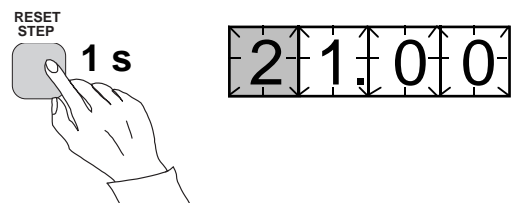
- m)
When the new value has been corrected, record it in the memory of the relay module by pressing the PROGRAM and STEP push buttons simultaneously. At the moment the information enters the memory, the green dashes flash once in the display, i.e. 1 - - -.



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



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



Enter the setting mode as in step c) and proceed in the same way. After recording of the requested values return to the main menu is obtained by pressing the STEP push button

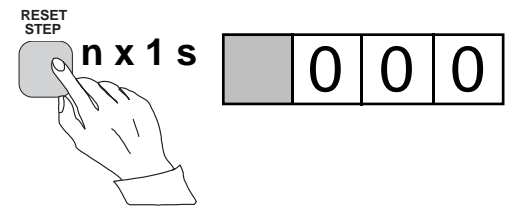
until the first digit is switched off. The LED still shows that one is in the I> position and the display shows the new setting value currently in use by the relay module.

Example 2

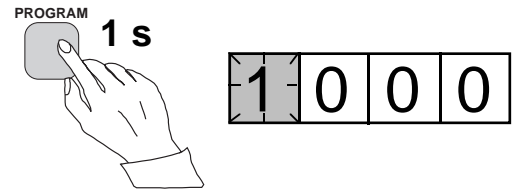
Operation in the setting mode. Manual setting of the main setting of the checksum for the switchgroup SGF1 of a relay module. The initial value for the checksum is 000 and the switches

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

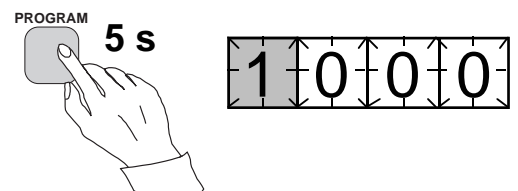
a)
Press push button STEP until the LED close to the SGF symbol is lit and the checksum appears on the display.



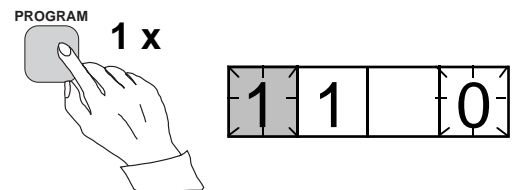
b)
Enter the submenu to get the main checksum of SGF1 by pressing the PROGRAM push button for more than one second and then releasing it. The red display now shows a flashing number 1 indicating the first submenu position and the green digits show the checksum.



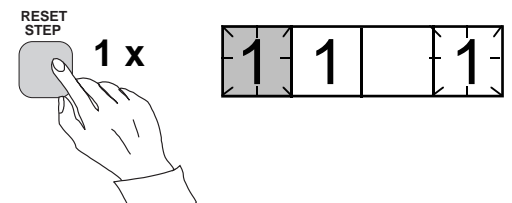
c)
Enter the setting mode by pressing the PROGRAM push button for five seconds until the display starts flashing.



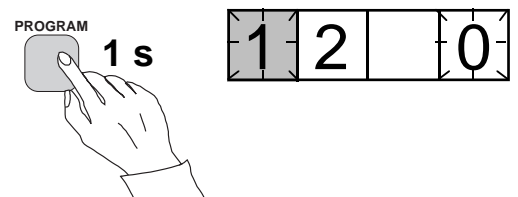
d)
Press the PROGRAM push button once again to get the first switch position. The first digit of the display now shows the switch number. The position of the switch is shown by the rightmost digit.



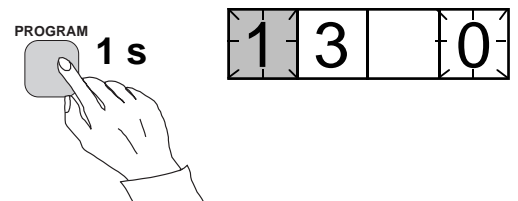
e)
The switch position can now be toggled between 1 and 0 by means of the STEP push button and it is left in the requested position 1.



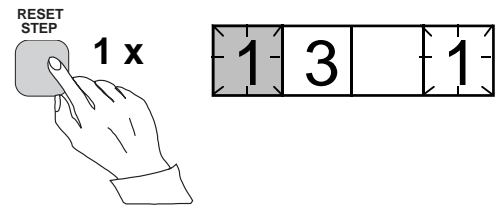
f)
When switch number 1 is in the requested position, switch number 2 is called up by pressing the PROGRAM push button for one second. As in step e), the switch position can be altered by using the STEP push button. As the desired setting for SGF1/2 is 0 the switch is left in the 0 position.



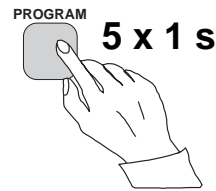
g)
Switch SGF1/3 is called up as in step f) by pressing the PROGRAM push button for about one second.



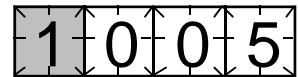
h)
The switch position is altered to the desired position 1 by pressing the STEP push button once.



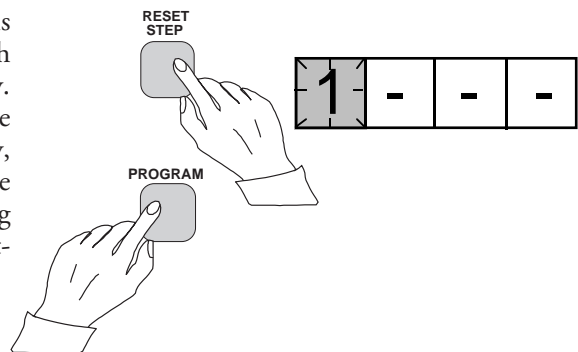
i)
Using the same procedure the switches SGF 1/4...8 are called up and, according to the example, left in position 0.



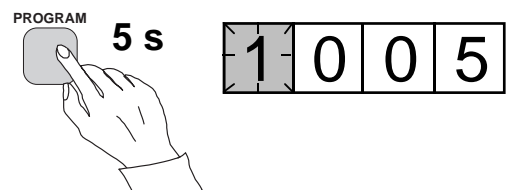
j)
In the final setting mode position, corresponding to step c), the checksum based on the set switch positions is shown.



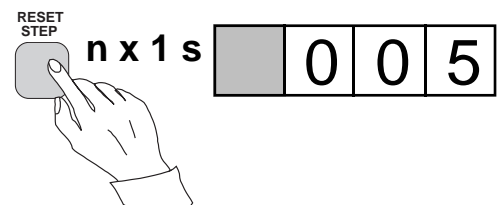
k)
If the correct checksum has been obtained, it is recorded in the memory by pressing the push buttons PROGRAM and STEP simultaneously. At the moment the information enters the memory, the green dashes flash in the display, i.e. 1 - - -. If the checksum is incorrect, the setting of the separate switches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



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



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



Recorded information

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

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

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

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

Register A contains the address code of the relay module which is required by the serial communication system.

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

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

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

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

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

Trip test function

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

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

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

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

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

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

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

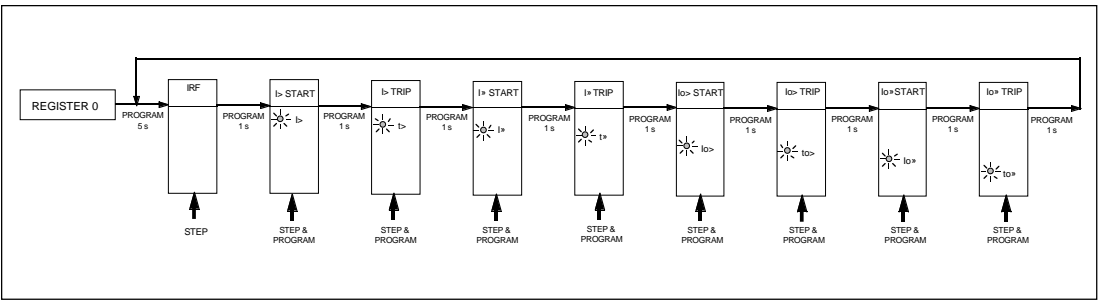


Fig. 5. Sequence order for the selection of output signals in the Trip test mode

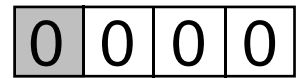
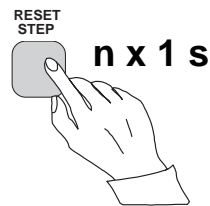
If, for instance, the indicator of the setting t> is flashing, and the push buttons STEP and PROGRAM are being pressed, the trip signal from the low-set overcurrent stage is activated. Return to the main menu is possible at any stage of the trip test sequence scheme, by pressing the PROGRAM push button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

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

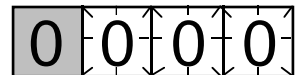
Example 3

Trip test function. Forced activation of the outputs.

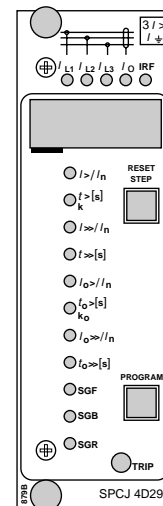
- a)
Step forward on the display to register 0.



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

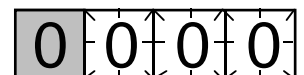
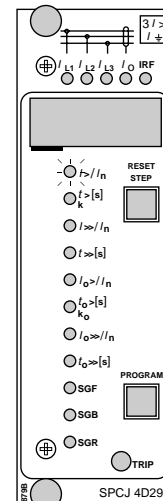
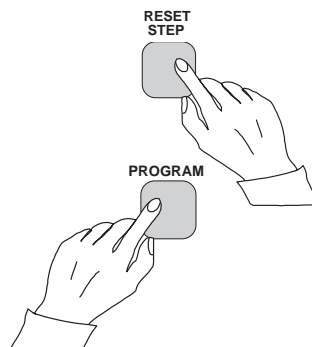


- c)
Hold down the STEP push button. After one second the red IRF indicator is lit and the IRF output is activated. When the step push button is released the IRF indicator is switched off and the IRF output resets.

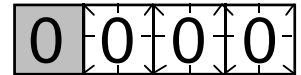
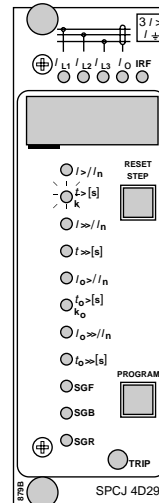


- d)
Press the PROGRAM push button for one second and the indicator of the topmost setting start flashing.

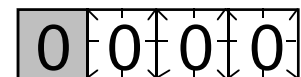
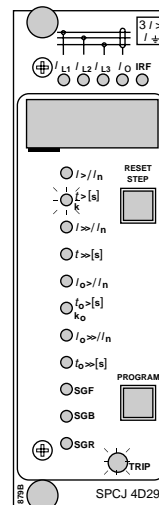
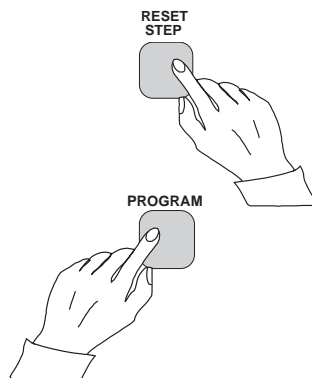
- e)
If a start of the first stage is required, now press the push-buttons PROGRAM and STEP simultaneously. The stage output will be activated and the output relays will operate according to the actual programming of the relay output switchgroups SGR.



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



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



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

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

Operation indication

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

The starting of a relay stage is indicated with one number which changes to another number when the stage operates. The indicator remains glowing although the operation stage resets. The

indicator is reset by means of the RESET push button of the relay module. An unreset operation indicator does not affect the function of the protection relay module.

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

Fault codes

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

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

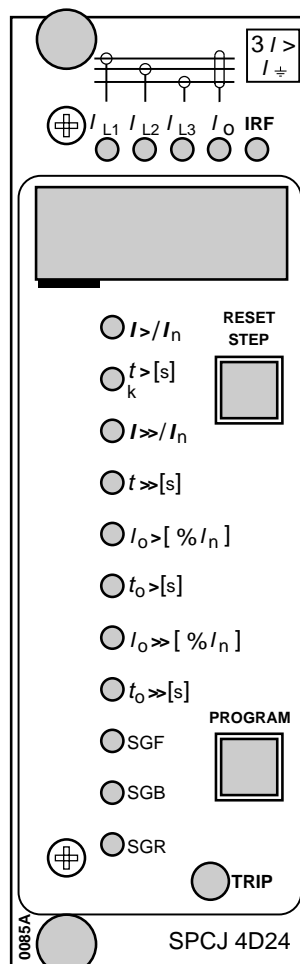
In most fault situations a fault code, indicating the nature of the fault, appears on the display of

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

SPCJ 4D24

Combined overcurrent and earth-fault relay module

User's manual and Technical description



SPCJ 4D24

Combined overcurrent
and earth-fault relay
module

Data subject to change without notice

Contents	Features	2
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Features

- A low-set overcurrent stage $I_{>}$ with a definite time and six inverse time modes of operation

A high-set overcurrent stage $I_{>>}$ with a setting range of $0.5...40 \times I_n$. The operation of the high-set overcurrent stage can be set out of function

A low-set neutral overcurrent stage $I_{0>}$ with a setting range of $1.0...25.0 \% I_n$ and definite time mode of operation

A high-set neutral overcurrent stage $I_{0>>}$ with a setting range of $2.0...200 \% I_n$. The operation of the high-set neutral over current stage can be set out of function
- Digital display of measured and set values and sets of data recorded at the moment when faults occur

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

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

Description of function

Overcurrent unit

The overcurrent unit of the combined overcurrent and earth-fault module SPCJ 4D24 is designed for single-phase, two-phase or three-phase operation. 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 current stage starts if the current on one of the phases exceeds the setting value of the stage concerned. When starting, the concerned stage provides a starting signal SS1 or TS1 and simultaneously the digital display on the front panel indicates starting. If the overcurrent situation lasts long enough to exceed the set operating time, the stage that started calls for a C.B. tripping by providing a tripping signal TS2. At the same time the operation indicator goes on with red light. The red operation indicator remains on although the stage resets. The indicator is reset with the RESET push-button. By proper configuration of the output relay switchgroups an additional auxiliary trip signal TS1 can be generated.

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

The operation of the low-set overcurrent stage $I_{>}$ or the high-set overcurrent stage $I_{>>}$ can be blocked by bringing a blocking signal BS to the unit. The blocking configuration is set by means of switchgroup SGB.

The operation of the low-set overcurrent stage can be based on a definite time or an inverse time characteristic. The mode of operation is programmed with SGF1/1...3. At definite time mode of operation the operating time $t_{>}$ is directly set in seconds within the setting range, 0.05...300 s. When using inverse time mode of operation (I.D.M.T.) four internationally standardized and two special type time/current characteristics are available. The programming switches SGF1/1...3 are also used for selecting the desired operation characteristic.

The operating time $t_{>>}$ of the high-set overcurrent stage is set separately within the range 0.04...300 s.

The operation of the two overcurrent stages is provided with a latching facility (switch SGB/6) keeping the tripping output energized, although the signal which caused the operation disappears. The stages are reset by simultaneous pressing of the push-buttons RESET and PROGRAM, see section "Programming switches".

The setting value $I_{>>}/I_n$ of the high-set overcurrent stage may be subject to automatic doubling when connecting the protected object to the network, i.e. in a starting situation. Thus the setting value of the high-set overcurrent stage may be lower than the connection inrush current. The automatic doubling function is selected with switch SGF1/5. The starting situation is defined as a situation where the phase currents rise from a value below $0.12 \times I_{>}$ to a value exceeding $1.5 \times I_{>}$ in less than 60 ms. The starting situation comes to an end when the currents fall below $1.25 \times I_{>}$.

The setting range of the high-set overcurrent stage is $0.5...40 \times I_n$. When selecting a setting in the lower end of the range, the module will contain two almost identical operation stages. In this case the overcurrent unit of the SPCJ 4D24 module may be used for e.g. two-stage load shedding purposes.

The operation of the high-set overcurrent stage may be set out of operation by means of switch SGF2/5. When the high-set unit is set out of operation the display shows a "- - -" readout, indicating that the operating value is infinite.

Note!

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

Note!

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

Earth-fault unit	<p>The non-directional earth-fault unit of the module SPCJ 4D24 is a single-pole neutral current or residual current overcurrent unit. It contains two neutral overcurrent stages, i.e. a low-set overcurrent stage $I_{0>}$ and a high-set overcurrent stage $I_{0>>}$.</p> <p>The low-set or high-set overcurrent stage starts if the current to be measured exceeds the setting value of the stage concerned. When starting, the stage provides a starting signal SS1 or TS1 and simultaneously the operation indicator on the front panel indicates starting. If the earth-fault situation lasts long enough to exceed the set operating time, the stage that started calls for a C.B. tripping by providing a tripping signal TS2. At the same time the red operation indicator of the tripping stage goes on. The operation indicator remains on although the stage resets. The indicator is reset with the RESET push-button.</p> <p>The neutral current measured by the earth-fault unit is filtered in a low-pass filter which effectively reduces the amount of harmonics in the measured signal. For example the third harmonics is reduced to about ten percent of its original value by the filter. Higher order harmonics are reduced even more.</p> <p>The operation of the low-set overcurrent stage $I_{0>}$ or the high-set stage $I_{0>>}$ can be blocked by applying a blocking signal BS onto the stage. The blockings are programmed by means of switchgroup SGB on the front of the plug-in module.</p>	<p>The operation of the low-set neutral current stage $I_{0>}$ is based on a definite time characteristic. The operating time $t_{0>}$ can be set within the setting range 0.05...300 s.</p> <p>The operating time $t_{0>>}$ of the high-set current stage is set separately within the range 0.05...300 s.</p> <p>The operation of the two neutral overcurrent stages is provided with a latching facility (switch SGB/7) keeping the tripping output energized, although the signal which caused the operation disappears. The stages are reset by simultaneous pressing of the push-buttons RESET and PROGRAM, see section "Programming switches".</p> <p>The operation of the high-set earth-fault stage may be inhibited when connecting the protected object to the network, i.e. when the low-set stage of the overcurrent unit is started. Thus it is possible to avoid malfunction due to virtual earth-fault currents caused by current transformer anomalies in connection with the connection inrush current. The automatic inhibiting function is selected with switch SGF1/6.</p> <p>The operation of the high-set earth-fault stage $I_{0>>}$ may be totally blocked by means of switch SGF2/6. When the high-set stage is set out of operation, the display shows a "- - -" readout, indicating that the setting value is infinite.</p>
Circuit breaker failure protection	<p>The unit is also provided with a circuit breaker failure protection (CBFP), which gives a trip signal via TS1 within a set time 0.1...1 s after the normal trip signal TS2, if the fault has not been cleared within that time. The output contact of the circuit breaker failure protection is normally used for tripping an upstream circuit breaker. The CBFP can also be used to estab-</p>	<p>lish a redundant trip system by using dual trip coils on the circuit breaker and wiring one of them to TS2 and the other one to TS1. The circuit breaker failure protection is selected by means of switch SGF1/4. The setting of the time delay can be made using submenu position five in register A.</p>
Remote settings	<p>All the main setting values may be provided with alternative setting values that can be called up by remote control. The switching between main and remote settings is normally made by utilizing the serial communication link. If the serial</p>	<p>communication is not used, the control input signal BS can be programmed to perform the switching too. Finally manual switching between setting banks can be made using submenu position four in register A.</p>

Block diagram

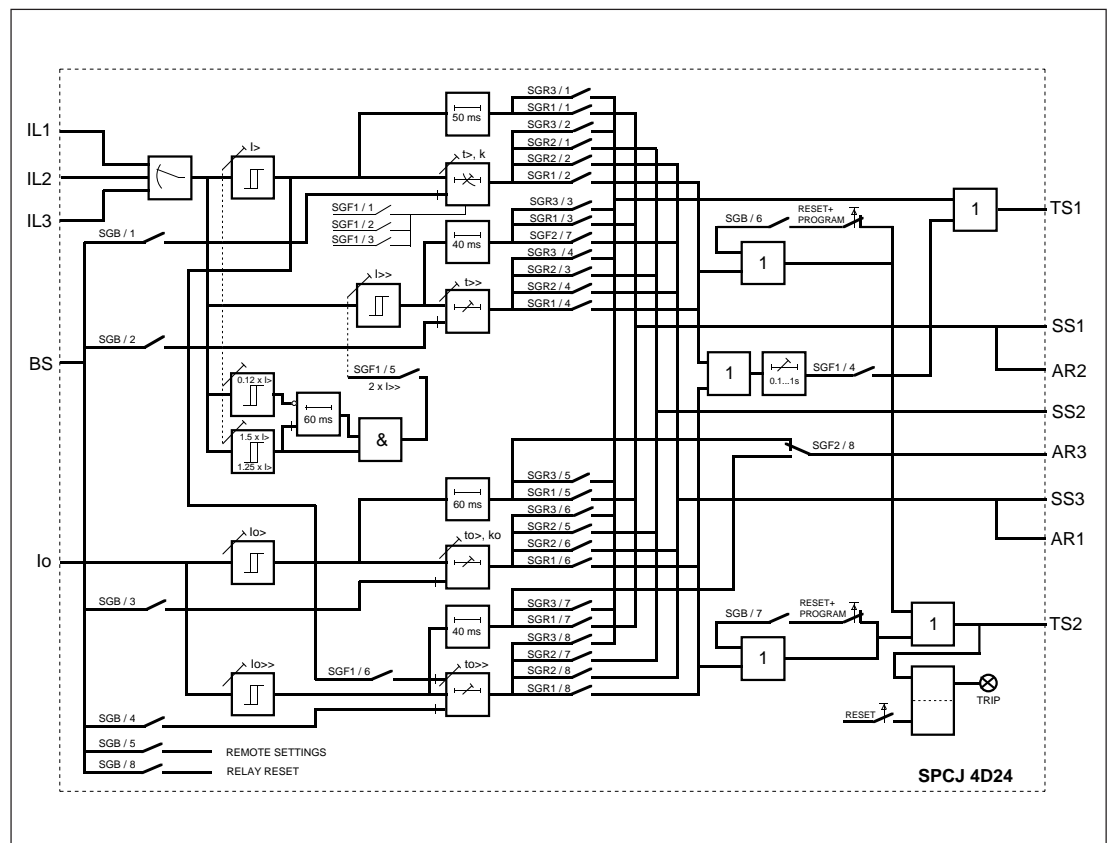


Fig. 1. Block diagram for overcurrent and earth-fault module SPCJ 4D24

I_{L1}, I_{L2}, I_{L3}	Measured phase currents
I_0	Measured neutral current
BS1	External blocking or resetting signal
SGF	Programming switchgroup SGF on the front panel
SGB	Programming switchgroup SGB on the front panel
SGR1...3	Programming switchgroups SGR on the front panel
TS1	Starting signal1 or auxiliary tripping signal depending on programming of switchgroup SGR3
SS1	Start signal for stages selected with switchgroup SGR1
SS2	Trip signal 1 for stages selected with switchgroup SGR2
SS3	Trip signal 2 for stages selected with switchgroup SGR2
TS2	Tripping signal from stages selected with switchgroup SGR1
AR1, AR2, AR3	Starting signals to autoreclose unit
TRIP	Red indicator for tripping

Note!

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

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

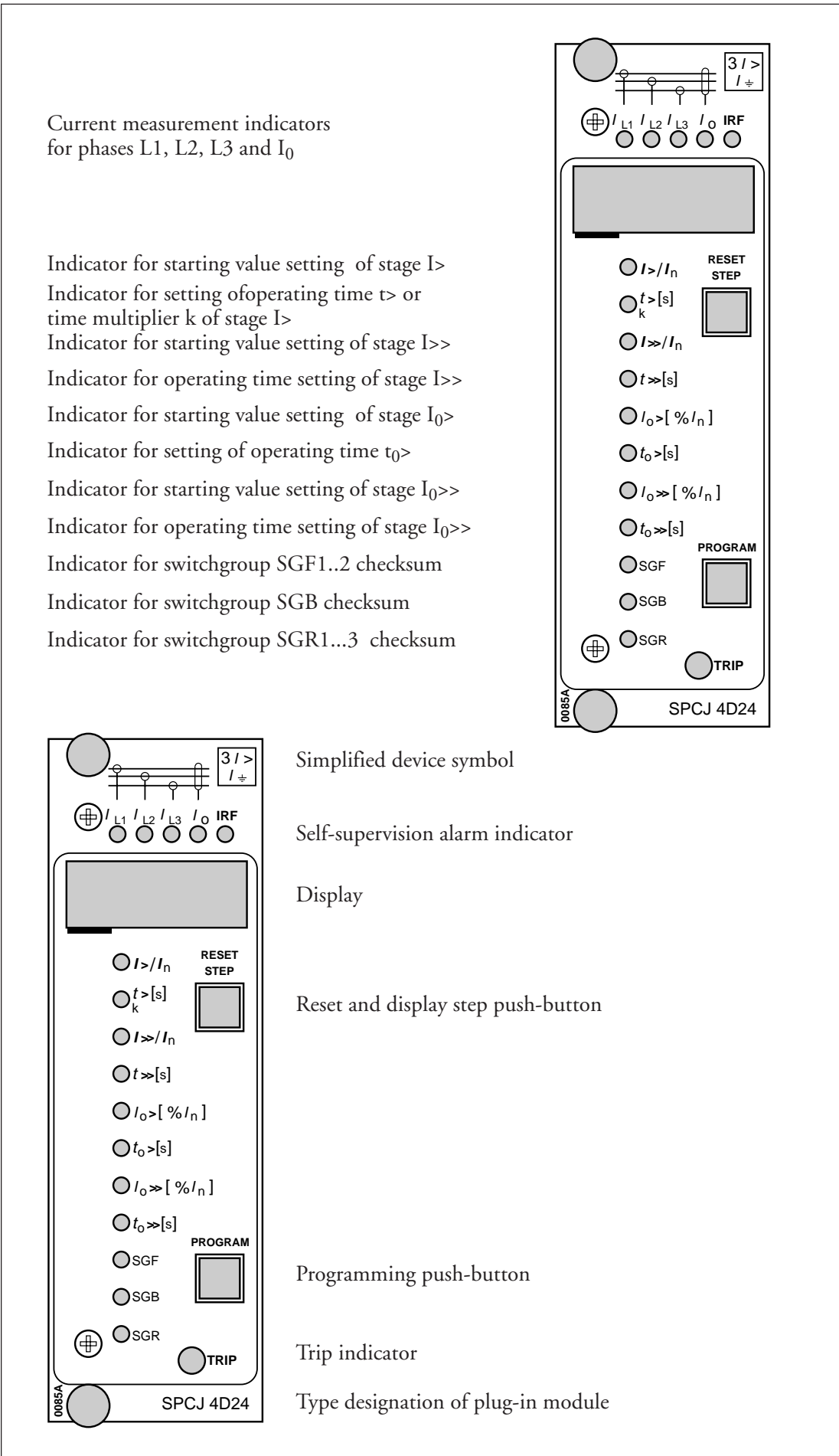


Fig. 2. Front panel of the combined overcurrent and earth-fault module SPCJ 4D24

Operation indications

Each overcurrent stage has its own starting indicator and operation indicator shown as a figure in the digital display. Further all stages share a common red LED indicator named "TRIP", which indicates that the module has delivered a tripping signal.

The operation indicator in the display remains illuminated when the current stage resets, thus indicating which protection stage was operating. The operation indicator is reset with the

RESET push-button. The function of the plug-in module is not affected by an activated operation indicator. If a starting of a stage is short enough not to cause a trip, the starting indication is normally self-reset when the stage is reset. By means of switches SGF2/1...4 if needed, the starting indicators can be programmed for manual resetting. The following table shows the starting and tripping indicators and their meanings.

Indication	Explanation
1	I> START = The low-set stage I> of the overcurrent unit has started
2	I> TRIP = The low-set stage I> of the overcurrent unit has tripped
3	I>> START = The high-set stage I>> of the overcurrent unit has started
4	I>> TRIP = The high-set stage I>> of the overcurrent unit has tripped
5	I ₀ > START = The low-set stage I ₀ > of the earth-fault unit has started
6	I ₀ > TRIP = The low-set stage I ₀ > of the earth-fault unit has tripped
7	I ₀ >> START = The high-set stage I ₀ >> of the earth-fault unit has started
8	I ₀ >> TRIP = The high-set stage I ₀ >> of the earth-fault unit has started
9	CBFP = The circuit breaker failure protection has operated

When one of the protection stages of the module performs a tripping, 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 the I> stage is switched goes on and the indicators I_{L1} and I_{L2} are illuminated, the operation was caused by overcurrent in phases L1 and L2. When pressing the push-button RESET, the phase fault indication disappears.

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 the fault has been detected. At the same time the plug-in module delivers a signal to the self-supervision system output relay of the protection assembly. Additionally, in most fault cases, a fault code showing the nature of the fault appears on the display of the module. The fault code, consisting of a red figure one and a green code number, persists until the STEP/RESET button is pressed. When a fault occurs, the fault code should be recorded and stated when ordering service.

Settings

The setting values are shown by the right-most three digits of the display. An indicator close to the setting value symbol shows when illumi-

nated which setting value is indicated on the display.

$I_{>}/I_n$	The operating current of the $I_{>}$ stage as a multiple of the rated current of the protection. Setting range $0.5...5.0 \times I_n$ at definite time characteristic and $0.5...2.5 \times I_n$ at inverse time characteristic.
$t_{>}$ k	The operating time of the $I_{>}$ stage, expressed in seconds, when in the definite time mode of operation (SGF1/1-2-3 = 0-0-0). The setting range is 0.05...300 s. At inverse definite minimum time mode of operation the time multiplier k setting range is 0.05...1.00.
$I_{>>}/I_n$	The starting current of the $I_{>>}$ stage as a multiple of the rated current of the protection. Setting range $0.5...40.0 \times I_n$. Additionally, the setting "infinite" (displayed as n - - -) can be selected, with switch SGF2/5, which makes the stage $I_{>>}$ inoperative.
$t_{>>}$	The operating time of the $I_{>>}$ stage, expressed in seconds. The setting range is 0.04...300 s
$I_{0>}/I_n$	The starting current of the $I_{0>}$ stage as a per cent of the rated current of the protection. Setting range 1.0...25.0 % I_n .
$t_{0>}$	The operating time of the $I_{0>}$ stage, expressed in seconds. The setting range is 0.05...300 s
$I_{0>>}/I_n$	The starting current of the $I_{0>>}$ stage as a percent of the rated current of the protection. Setting range 2.0...200% I_n . Additionally, the setting "infinite" set by switch SGF2/6 (displayed as n - - -) can be selected with switch SGF2/6 which makes the stage $I_{0>>}$ inoperative.
$t_{0>>}$	The operating time of the $I_{0>>}$ stage, expressed in seconds. The setting range is 0.05...300 s

Further, the checksums of the programming switchgroups SGF1, SGB and SGR1 are indicated on the display when the indicators adjacent to the switchgroup symbols on the front panel are illuminated. The checksums for groups SGF2, SGR2 and SGR3 are found in

the submenus of the corresponding first switchgroup. See further clause "Main menus and submenus of settings and registers". An example of calculating the checksum is given in the general description of the D-type SPC relay modules.

Programming switches

Additional functions required by individual applications are selected by means of the switchgroups SGF, SGB and SGR indicated on the front panel. The numbering of the switches, 1...8, and the switch positions 0 and 1 are indicated

when setting the switchgroups. In normal service only the checksums are shown. The switchgroups SGF2, SGR2 and SGR3 are found in the submenus of the switchgroups SGF and SGR.

Functional switch-group SGF1

Switch	Function																																													
SGF1/1 SGF1/2 SGF1/3	<p>Switches SGF1/1...3 are used for selecting the operation characteristic of the low-set overcurrent stage I>, i.e. definite time mode of operation or inverse definite minimum time (I.D.M.T.) mode of operation. At inverse definite minimum time mode of operation the switches are, further, used for selecting the current/time characteristic of the module.</p> <table><tr><th>SGF1/1</th><th>SGF1/2</th><th>SGF1/3</th><th>Mode of operation</th><th>Characteristics</th></tr><tr><td>0</td><td>0</td><td>0</td><td>Definite time</td><td>0.05...300 s</td></tr><tr><td>1</td><td>0</td><td>0</td><td>I.D.M.T</td><td>Extremely inverse</td></tr><tr><td>0</td><td>1</td><td>0</td><td>"</td><td>Very inverse</td></tr><tr><td>1</td><td>1</td><td>0</td><td>"</td><td>Normal inverse</td></tr><tr><td>0</td><td>0</td><td>1</td><td>"</td><td>Long-time inverse</td></tr><tr><td>1</td><td>0</td><td>1</td><td>"</td><td>RI-characteristic</td></tr><tr><td>0</td><td>1</td><td>1</td><td>"</td><td>RXIDG-characteristic</td></tr><tr><td>1</td><td>1</td><td>1</td><td>"</td><td>Not in use (long-time inverse)</td></tr></table>	SGF1/1	SGF1/2	SGF1/3	Mode of operation	Characteristics	0	0	0	Definite time	0.05...300 s	1	0	0	I.D.M.T	Extremely inverse	0	1	0	"	Very inverse	1	1	0	"	Normal inverse	0	0	1	"	Long-time inverse	1	0	1	"	RI-characteristic	0	1	1	"	RXIDG-characteristic	1	1	1	"	Not in use (long-time inverse)
SGF1/1	SGF1/2	SGF1/3	Mode of operation	Characteristics																																										
0	0	0	Definite time	0.05...300 s																																										
1	0	0	I.D.M.T	Extremely inverse																																										
0	1	0	"	Very inverse																																										
1	1	0	"	Normal inverse																																										
0	0	1	"	Long-time inverse																																										
1	0	1	"	RI-characteristic																																										
0	1	1	"	RXIDG-characteristic																																										
1	1	1	"	Not in use (long-time inverse)																																										
SGF1/4	<p>Selection of the circuit breaker failure protection.</p> <p>When SGF1/4 = 1 the trip signal TS2 will start a timer which will produce a 0.1...1 s delayed trip signal via TS1, if the fault has not been cleared before. With switch SGF1/4 = 0 only the normal trip signal TS2 is activated.</p>																																													
SGF1/5	<p>Selection of automatic doubling of the setting value of the high-set overcurrent stage when the protected object is energized.</p> <p>When SGF1/5 = 0, no doubling of the setting value I>> is obtained. When SGF1/5 = 1, the setting value of the I>> stage doubles automatically. This makes it possible to give the high-set current stage a setting value below the connection inrush current level.</p>																																													
SGF1/6	<p>High-set stage of the earth-fault protection inhibited by starting of the low-set stage of the overcurrent unit</p> <p>When SGF1/6 = 0, the operation of the high-set earth-fault protection is operating under all phase current conditions When SGF1/6 = 1, the earth-fault protection is inhibited if the low-set stage of the overcurrent unit has started</p>																																													
SGF1/7	Reserved for future use																																													
SGF1/8	Reserved for future use																																													

Switch	Function
SGF2/1 SGF2/2 SGF2/3 SGF2/4	<p>Switches SGF2/1...4 are used for selecting the mode of operation of the starting indicators of the different stages. When the switches are in position 0 the starting signals are all automatically reset when the fault is cleared. In order to get a hand reset starting indication for a stage, the corresponding switch is brought into position 1:</p> <p>SGF2/1 = 1 equals manual resetting of the starting indication of stage I> SGF2/2 = 1 equals manual resetting of the starting indication of stage I>> SGF2/3 = 1 equals manual resetting of the starting indication of stage I₀> SGF2/4 = 1 equals manual resetting of the starting indication of stage I₀>></p>
SGF2/5	<p>The high-set instantaneous operation of the stage I>> can be set out of operation by means of this switch.</p> <p>When SGF2/5 = 0 the high-set stage I>> is operative When SGF2/5 = 1 the high-set stage I>> is blocked and the display shows "- - -"</p>
SGF2/6	<p>The high-set instantaneous operation of the stage I₀>> can be completely set out of operation by means of this switch.</p> <p>When SGF2/6 = 0 the high-set stage I₀>> is operative When SGF2/6 = 1 the high-set stage I₀>> is blocked and the display shows "- - -"</p>
SGF2/7	<p>The starting signal of the high-set overcurrent stage I>> brought to the auto-reclose signal output AR1</p> <p>When SGF2/7 = 1, the starting signal of I>> is controlling AR1. Note! The output is equal to SS3, which means that in this case an other signal must not be connected to same output! When SGF2/7 = 0, the starting output of I>> is not affecting the output AR1 or SS3. Thus the signal output SS3 is available for other purposes.</p>
SGF2/8	<p>The starting signal from stage I₀>- or stage I₀>>- brought to auto-reclose signal output AR3</p> <p>When SGF2/8 = 0 the starting signal from stage I₀> is controlling AR3 When SGF2/8 = 1 the starting signal from stage I₀>> is controlling AR3</p>

Switch	Function
SGB/1...4	<p>Switches SGB/1...4 are used when the external control signal BS is to be used for blocking one or more of the current stages of the module. When all the switches are in position 0 no stage is blocked.</p> <p>When SGB/1 = 1, the stage I> is blocked by the input signal BS When SGB/2 = 1, the stage I>> is blocked by the input signal BS When SGB/3 = 1, the stage I₀> is blocked by the input signal BS When SGB/4 = 1, the stage I₀>> is blocked by the input signal BS</p>
SGB/5	<p>This switch enables switching over from the main settings to the second settings and vice versa even without serial communication, using the external control input signal BS.</p> <p>When SGB/5 = 0, the settings are not to be remotely controlled or they are controlled via the serial communication only When SGB/5 = 1, the settings are remotely controlled or via the external input. Main values of the settings are used when there is no control voltage on the input and the second settings are enforced when a control voltage is connected to the control input.</p> <p>Note! Whenever main and second settings are used, care should be taken that the switch SGB/5 has the same position both in the main and second setting bank. Otherwise a conflict situation might occur when switching setting banks by contact or via serial communication.</p>
SGB/6	<p>Selection of a latching feature for the tripping signal TS2 for overcurrent faults.</p> <p>When SGB/6 = 0, the tripping signal returns to its initial state (= the output relay drops off), when the measuring signal causing the operation falls below the starting level. When SGB/6 = 1, the tripping signal remains on (= the output relay operated), although the measuring signal falls below the starting level. Then the starting signals have to be reset by pressing the push-buttons RESET and PROGRAM simultaneously.¹⁾</p>
SGB/7	<p>Selection of a latching feature for the trip signal TS2 for earth faults.</p> <p>When SGB/7 = 0, the tripping signal returns to its initial state (= the output relay drops off), when the measuring signal causing the operation falls below the starting level. When SGB/7 = 1, the tripping signal remains on (= the output relay operated), although the measuring signal falls below the starting level. Then the starting signals have to be reset by pressing the push-buttons RESET and PROGRAM simultaneously.¹⁾</p>
SGB/8	<p>Remote resetting of a latched output relay.</p> <p>When the output relay with SGB/6 or SGB/7 has been selected to be latching, a remote relay reset can be performed using the control input signal BS when SGB/8 = 1. When delivered from factor all switches SGB are set at zero, i.e. the checksum SGB is 0.</p>

¹⁾ From the program version 042D and later versions an additional feature has been incorporated into the relay module SPCJ 4D24.

When the latching function is used the latched output can be reset by pushing the PROGRAM button alone, in which case the stored information of the module is not erased.

Output relay matrix
switchgroups SGR1,
SGR2 and SGR3

SGR1	The switches of switchgroup SGR1 are used to select the protective stages to be brought to the starting signal output SS1 and the tripping signal output TS2.
SGR2	The switches of switchgroup SGR2 are used for configuring the tripping signals of the different protective stages. There are two outputs, SS2 and SS3, to which the signals can be linked.
SGR3	The switches of switchgroup SGR3 are used for configuring the starting and tripping signals to the starting or auxiliary tripping output TS1. Note! If the circuit breaker failure protection has been selected in with switch SGF1/4, it will also utilize the TS1 output.

Switch	Function	Factory setting	Checksum value
SGR1/1	When SGR1/1 = 1, the starting signal of stage I> is linked to SS1	1	1
SGR1/2	When SGR1/2 = 1, the tripping signal of stage I> is linked to TS2	1	2
SGR1/3	When SGR1/3 = 1, the starting signal of stage I>> is linked to SS1	0	4
SGR1/4	When SGR1/4 = 1, the tripping signal of stage I>> is linked to TS2	1	8
SGR1/5	When SGR1/5 = 1, the starting signal of stage I ₀ > is linked to SS1	0	16
SGR1/6	When SGR1/6 = 1, the tripping signal of stage I ₀ > is linked to TS2	1	32
SGR1/7	When SGR1/7 = 1, the starting signal of stage I ₀ >> is linked to SS1	0	64
SGR1/8	When SGR1/8 = 1, the tripping signal of stage I ₀ >> is linked to TS2	1	128
Checksum for factory setting of SGR1			171

SGR2/1	When SGR2/1 = 1, the tripping signal from stage I> is linked to SS2	1	1
SGR2/2	When SGR2/2 = 1, the tripping signal from stage I> is linked to SS3	0	2
SGR2/3	When SGR2/3 = 1, the tripping signal from stage I>> is linked to SS2	1	4
SGR2/4	When SGR2/4 = 1, the tripping signal from stage I>> is linked to SS3	0	8
SGR2/5	When SGR2/5 = 1, the tripping signal from stage I ₀ > is linked to SS2	0	16
SGR2/6	When SGR2/6 = 1, the tripping signal from stage I ₀ > is linked to SS3	1	32
SGR2/7	When SGR2/7 = 1, the tripping signal from stage I ₀ >> is linked to SS2	0	64
SGR2/8	When SGR2/8 = 1, the tripping signal from stage I ₀ >> is linked to SS3	1	128
Checksum for factory setting of SGR2			165

Switch	Function	Factory setting	Checksum value
SGR3/1	When SGR3/1 = 1, the starting signal of stage I> is linked to TS1	0	1
SGR3/2	When SGR3/2 = 1, the tripping signal of stage I> is linked to TS1	0	2
SGR3/3	When SGR3/3 = 1, the starting signal of stage I>> is linked to TS1	0	4
SGR3/4	When SGR3/4 = 1, the tripping signal of stage I>> is linked to TS1	0	8
SGR3/5	When SGR3/5 = 1, the starting signal of stage I ₀ > is linked to TS1	0	16
SGR3/6	When SGR3/6 = 1, the tripping signal of stage I ₀ > is linked to TS1	0	32
SGR3/7	When SGR3/7 = 1, the starting signal of stage I ₀ >> is linked to TS1	0	64
SGR3/8	When SGR3/8 = 1, the tripping signal of stage I ₀ >> is linked to TS1	0	128
Checksum for factory setting of SGR3			0

Measured data

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

Indicator	Measured data
I _{L1}	Line current on phase L1 as a multiple of the rated current I _n (0...63 x I _n)
I _{L2}	Line current on phase L2 as a multiple of the rated current I _n (0...63 x I _n)
I _{L3}	Line current on phase L3 as a multiple of the rated current I _n (0...63 x I _n)
I ₀	Neutral current as a per cent of the rated current I _n (0...210% I _n)

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

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

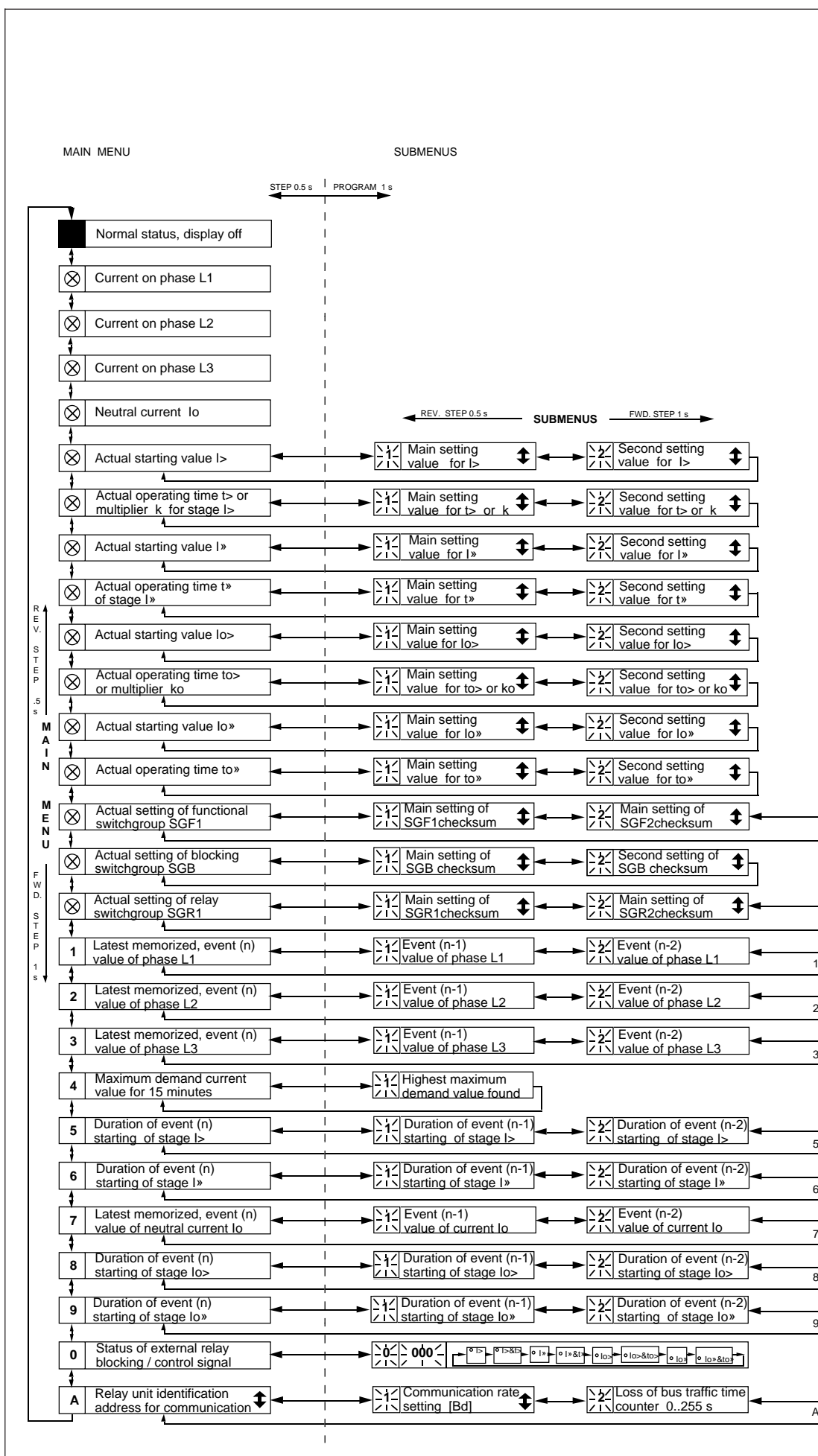
Register/ STEP	Recorded information
1	Phase current I_{L1} measured as a multiple of the rated current of the overcurrent protection. If the overcurrent stage starts or performs a tripping, the current value at the moment of tripping is stored in a memory stack. A new tripping moves the old value up one place in the stack and adds a new value to the stack. At a maximum five values are memorized - if a sixth starting occurs, the oldest value will be lost.
2	Phase current I_{L2} measured as a multiple of the rated current of the overcurrent protection. If the overcurrent stage starts or performs a tripping, the current value at the moment of tripping is stored in a memory stack. A new tripping moves the old value up one place in the stack and adds a new value to the stack. At a maximum five values are memorized - if a sixth starting occurs, the oldest value will be lost.
3	Phase current I_{L3} measured as a multiple of the rated current of the overcurrent protection. If the overcurrent stage starts or performs a tripping, the current value at the moment of tripping is stored in a memory stack. A new tripping moves the old value up one place in the stack and adds a new value to the stack. At a maximum five values are memorized - if a sixth starting occurs, the oldest value will be lost.
4	Maximum demand current value for a period of 15 minutes expressed in multiples of the relay rated current I_n and based on the highest phase current. // Highest maximum demand value found since latest full relay reset.
5	Duration of the latest starting situation of stage $I>$ as a percentage of the set operating time $t>$ or at I.D.M.T. mode of operation the calculated operation time. A new starting resets the counter, which then starts counting from zero and moves the old value up in the memory stack. At a maximum five values are memorized - if a sixth starting occurs the oldest value will be lost. When the concerned stage has tripped, the counter reading is 100. // Number of startings of the low-set overcurrent stage $I>$, $n(I>) = 0...255$.
6	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 then starts counting from zero and moves the old value up in the memory stack. At a maximum five values are memorized - if a sixth starting occurs, the oldest value will be lost. When the concerned stage has tripped, the counter reading is 100. // Number of startings of the high-set overcurrent stage $I>>$, $n(I>>) = 0...255$.
7	Neutral overcurrent I_0 measured as a per cent of the rated current of the earth-fault protection. If the earth-fault stage starts or performs a tripping, the current value at the moment of tripping is stored in a memory stack. A new tripping moves the old value up one place in the stack and adds a new value to the stack. At a maximum five values are memorized - if a sixth starting occurs, the oldest value will be lost.

Register/ STEP	Recorded information
8	Duration of the latest starting situation of stage $I_{0>}$ as a percentage of the set operating time $t_{0>}$. A new starting resets the counter, which then starts counting from zero and moves the old value up in the memory stack. At a maximum five values are memorized - if a sixth starting occurs the oldest value will be lost. When the concerned stage has tripped, the counter reading is 100. // Number of startings of the low-set neutral overcurrent stage $I_{0>}$, $n(I_{0>}) = 0...255$.
9	Duration of the latest starting situation of stage $I_{0>>}$ as a percentage of the set operating time $t_{0>>}$. A new starting resets the counter, which then starts counting from zero and moves the old value up in the memory stack. At a maximum five values are memorized - if a sixth starting occurs, the oldest value will be lost. When the concerned stage has tripped, the counter reading is 100. // Number of startings of the high-set neutral overcurrent stage $I_{0>>}$, $n(I_{0>>}) = 0...255$.
0	<p>Display of blocking signals and other external control signals.</p> <p>The right-most digit indicates the state of the blocking input of the unit. The following states may be indicated: 0 = no blocking signal 1 = the blocking or control signal BS is active.</p> <p>The effect of the signal on the unit is determined by the setting of switchgroup SGB</p> <p>From this register "0" it is possible to move on to the TEST mode, where the starting and tripping signals of the module are activated one by one. For further details see the description "General characteristics of D-type SPC relay units".</p>
A	<p>The address code of the measuring relay module, required by the serial communication system. The address code is set at zero unless the serial communication system is used.</p> <p>The submenus of this register comprise the selection of the data transfer rate of the serial communication, a bus traffic monitor indicating the operating state of the serial communication system, a password required for the remote control of the settings and a status information for the main/second setting bank, and finally the setting of time delay for the circuit breaker failure protection.</p> <p>If the module is connected to a system including a control data communicator and if the communication system is operating, the counter reading of the bus traffic monitor will be zero. Otherwise the numbers 0...255 are continuously rolling in the counter. The password given in the setting mode of the next submenu step must always be entered via the serial communication before settings can be remotely altered. With the setting selector status in the fourth submenu either the main setting bank or the second setting bank can be made active.</p>
-	Display dark. By pressing the STEP push-button the beginning of the display sequence is re-entered.

The registers 1...9 are set to zero by pressing the push-buttons RESET and PROGRAM simultaneously. The registers are also cleared if the auxiliary power supply of the module is interrupted. The address code of the plug-in module, the data transfer rate of the serial commu-

nication, the password and the status of the main/second setting bank switch are not erased by a voltage failure. The instructions for setting the address and the data transfer rate are described in the "General characteristics of D-type SPC relay units".

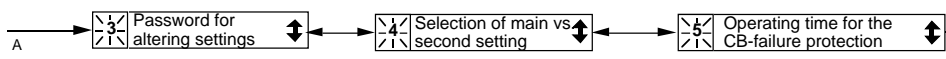
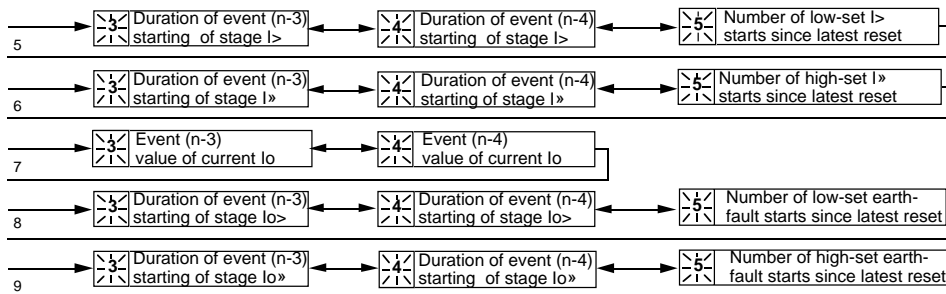
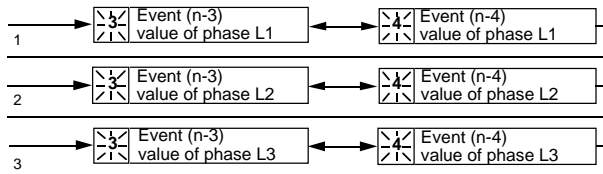
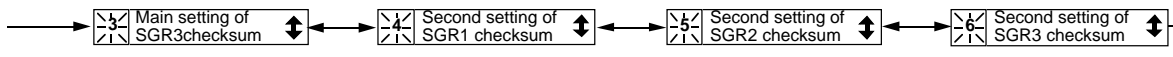
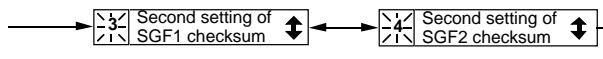
Main menus and submenus of settings and registers



The measures required for entering a submenu or a setting mode and how to perform the setting and use the TEST mode are described in

detail in the manual "General characteristics of the D-type relay modules". A short form guide to the operations is shown below.

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



Time/current characteristics
(modified 2002-05)

The operation of the low-set overcurrent stage I> of the module is based on either definite time or inverse time characteristics. The mode of operation is selected with switches 1...3 of switchgroup SGF1 (see page 9).

When selecting an IDMT mode of operation,

the operating time of the stage will be a function of the current; the higher the current, the shorter the operating time. The unit comprises of six different time/current characteristics - four according to the BS 142 standard and two special types called the RI and RXIDG characteristic..

BS-type characteristics

There are four standard curves, extremely, very, normal and long- time inverse. The relationship between current and time complies with the standards BS 142.1966 and IEC 60255-3 and may generally be expressed as:

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

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

The unit includes four BS 142-specified characteristics with different degrees of inversivity.

The degree of inversivity is determined by the values of the constants α and β

Degree of inversivity of the characteristic	α	β
Normal inverse	0.02	0.14
Very inverse	1.0	13.5
Extremely inverse	2.0	80.0
Long-time inverse	1.0	120.0

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

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

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

In the defined normal current ranges, the inverse-time stage of the overcurrent and earth-fault unit SPCJ 4D24 complies with the tolerances of class 5 at all degrees of inversivity.

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

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

RI-type characteristic

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

$$t [s] = k / (0.339 - 0.236 \times I_{>} / I)$$

where t = operating time in seconds
 k = time multiplier
 I = phase current
 $I_{>}$ = set starting current

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

RXIDG-type characteristic

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

The time / current characteristic can be expressed as:

$$t [s] = 5.8 - 1.35 \times \log_e (I / (k \times I_{>}))$$

where t = operating in seconds
 k = time multiplier
 I = phase current
 $I_{>}$ = set starting current

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

Note!

If the setting is higher than $2.5 \times I_n$, the maximum continuous carry ($3 \times I_n$) and the levelling out of the IDMT-curves at high current levels must be noted.

Note!

The high-current end of any inverse time characteristic is determined by the high-set stage which, when started, inhibits the low-set stage operation. The trip time is thus equal to the set $t_{>>}$ for any current higher than $I_{>>}$. In order to get a trip signal, the stage $I_{>>}$ must of course be linked to a trip output relay.

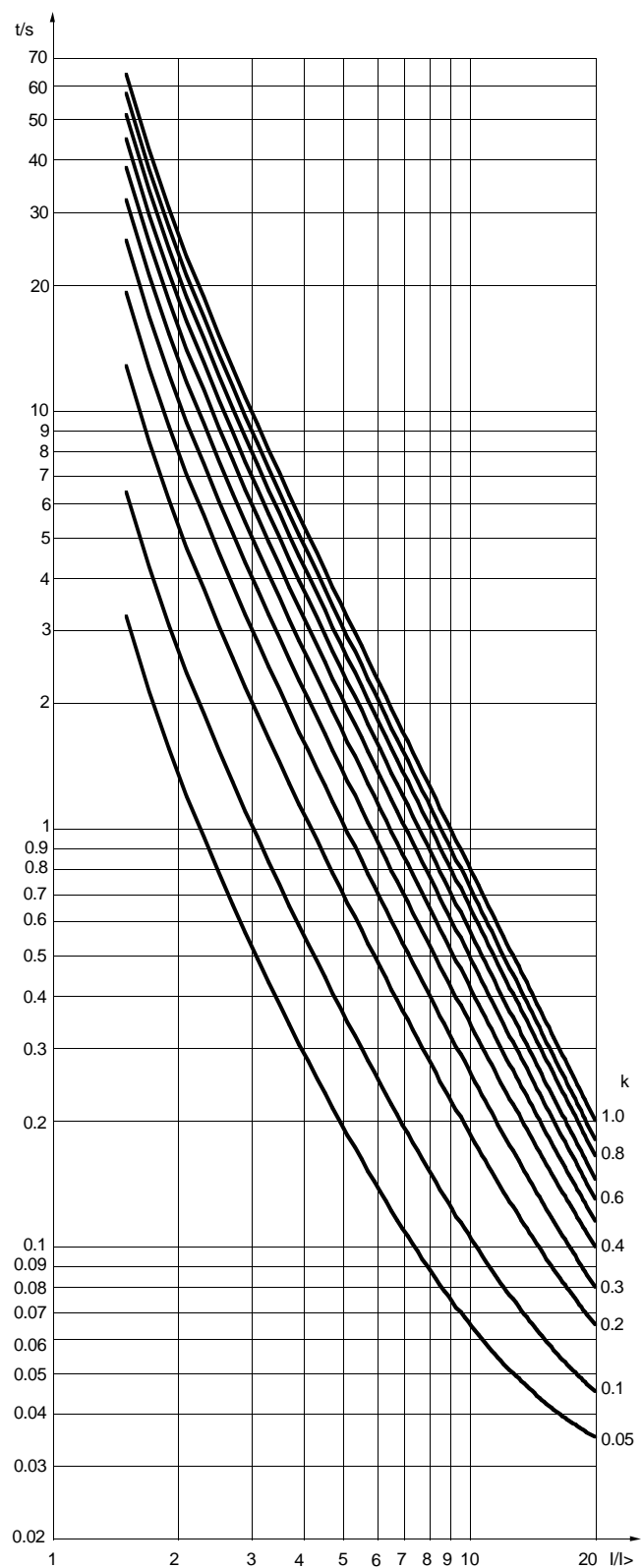


Fig. 3. Extremely inverse-time characteristics of the low-set overcurrent unit in relay module SPCJ 4D24

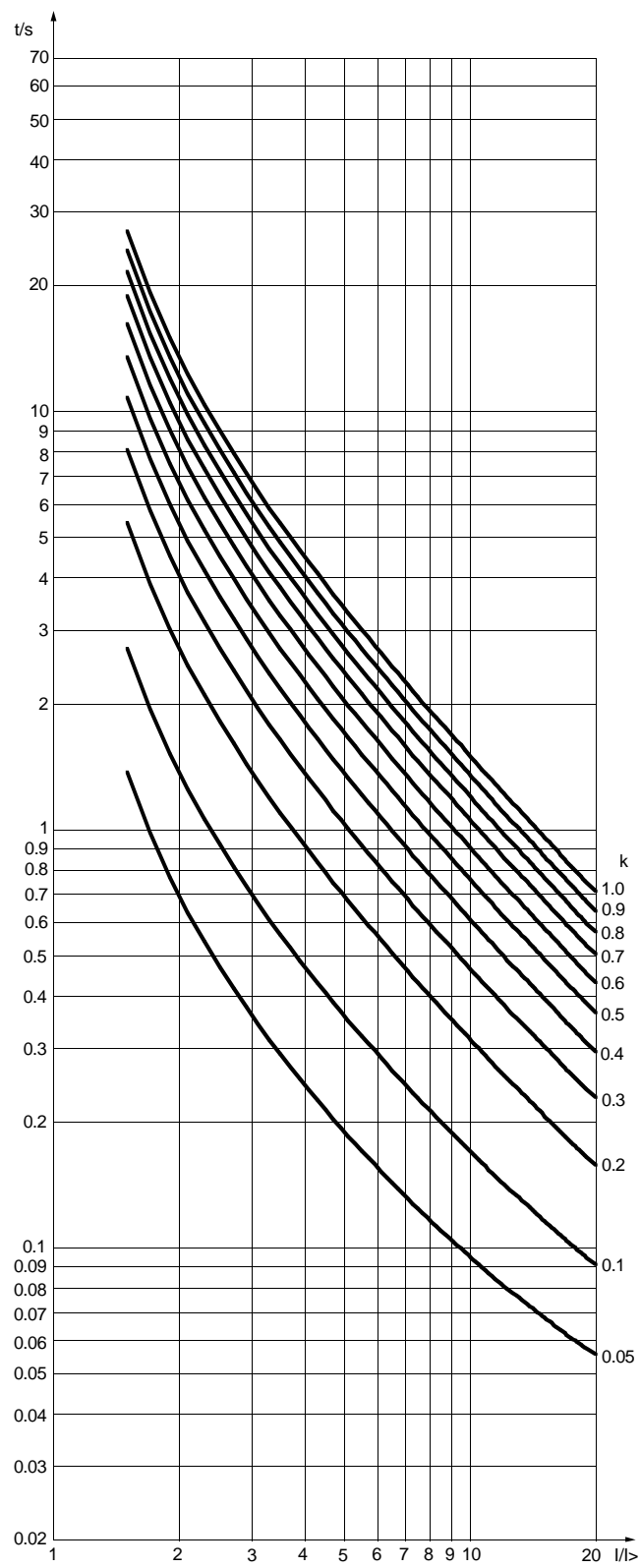


Fig. 4. Very inverse-time characteristics of the low-set overcurrent unit in relay module SPCJ 4D24

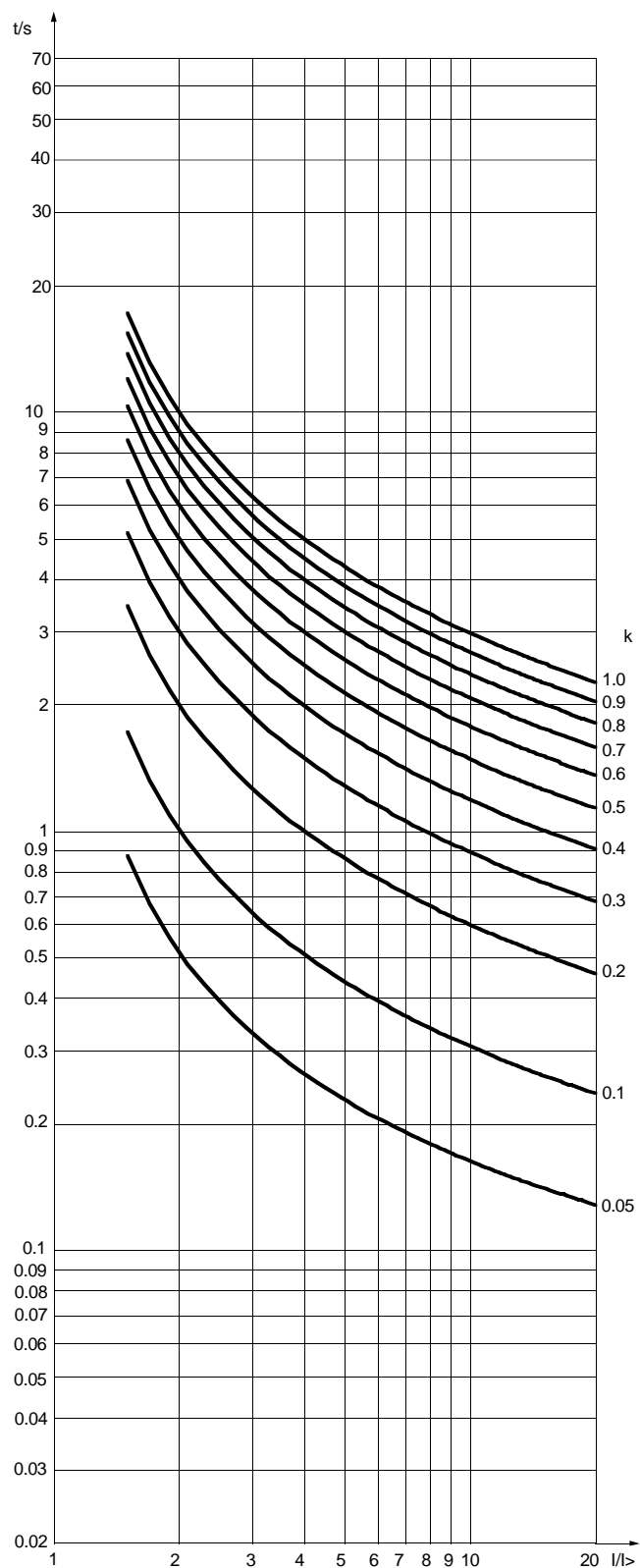


Fig. 5. Normal inverse-time characteristics of the low-set overcurrent unit in relay module SPCJ 4D24

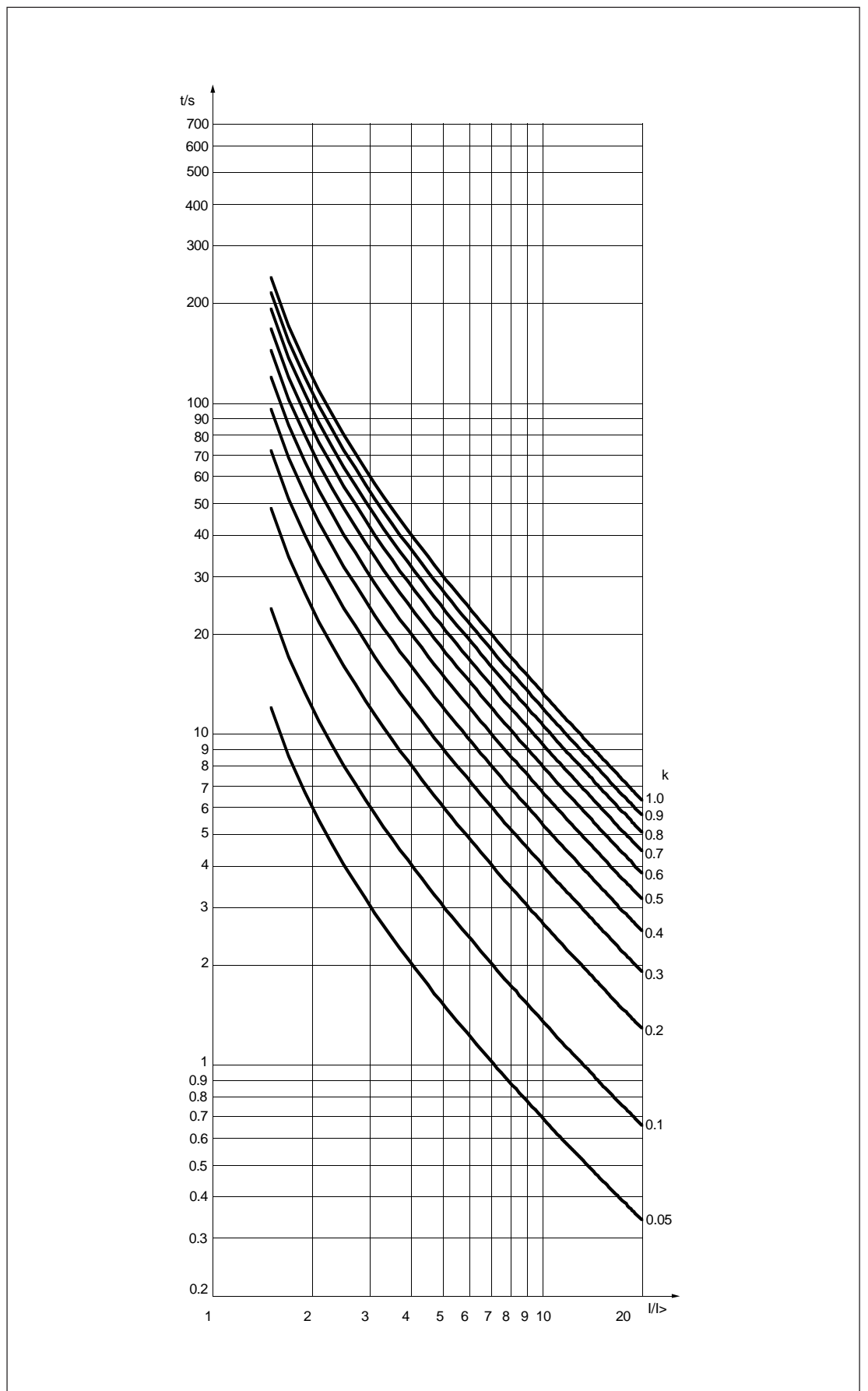


Fig. 6. Long-time inverse-time characteristics of the low-set overcurrent unit in relay module SPCJ 4D24

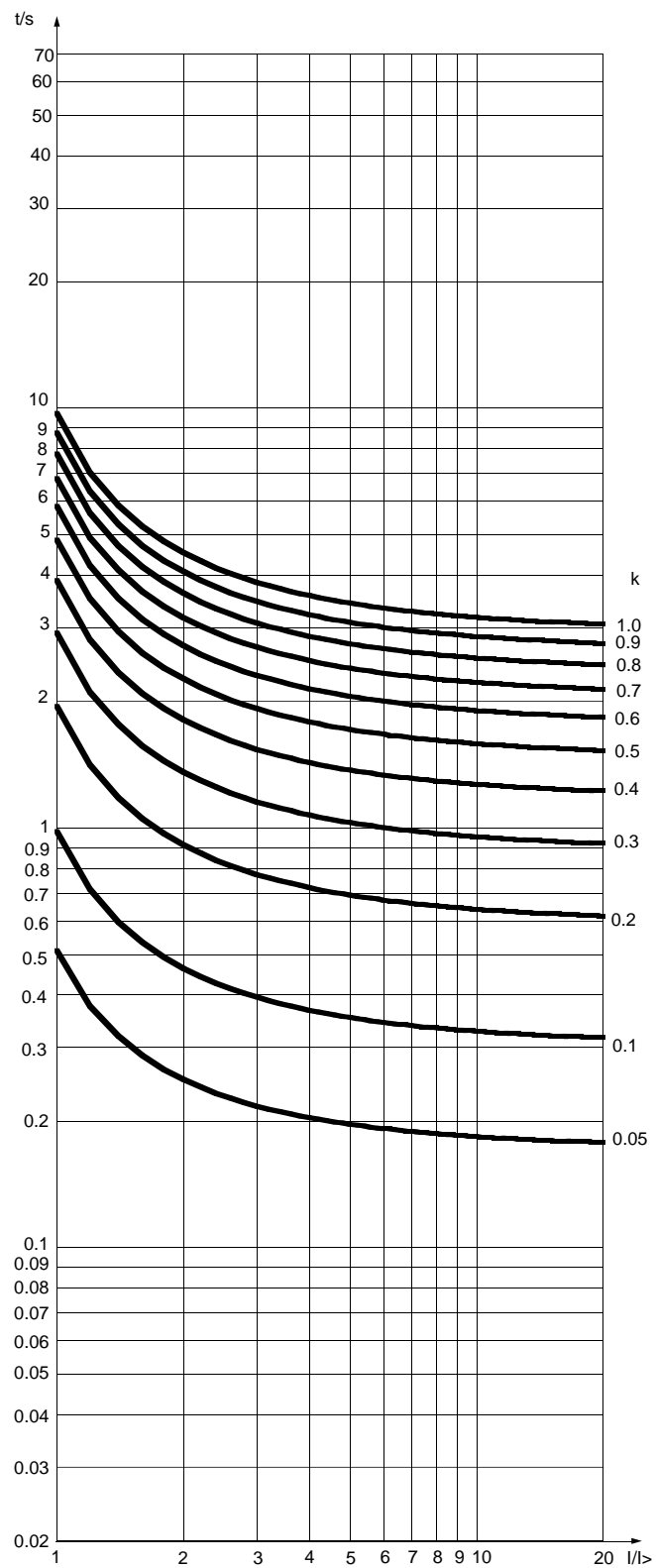


Fig. 7. RI-type inverse-time characteristics of the low-set overcurrent unit in relay module SPCJ 4D24

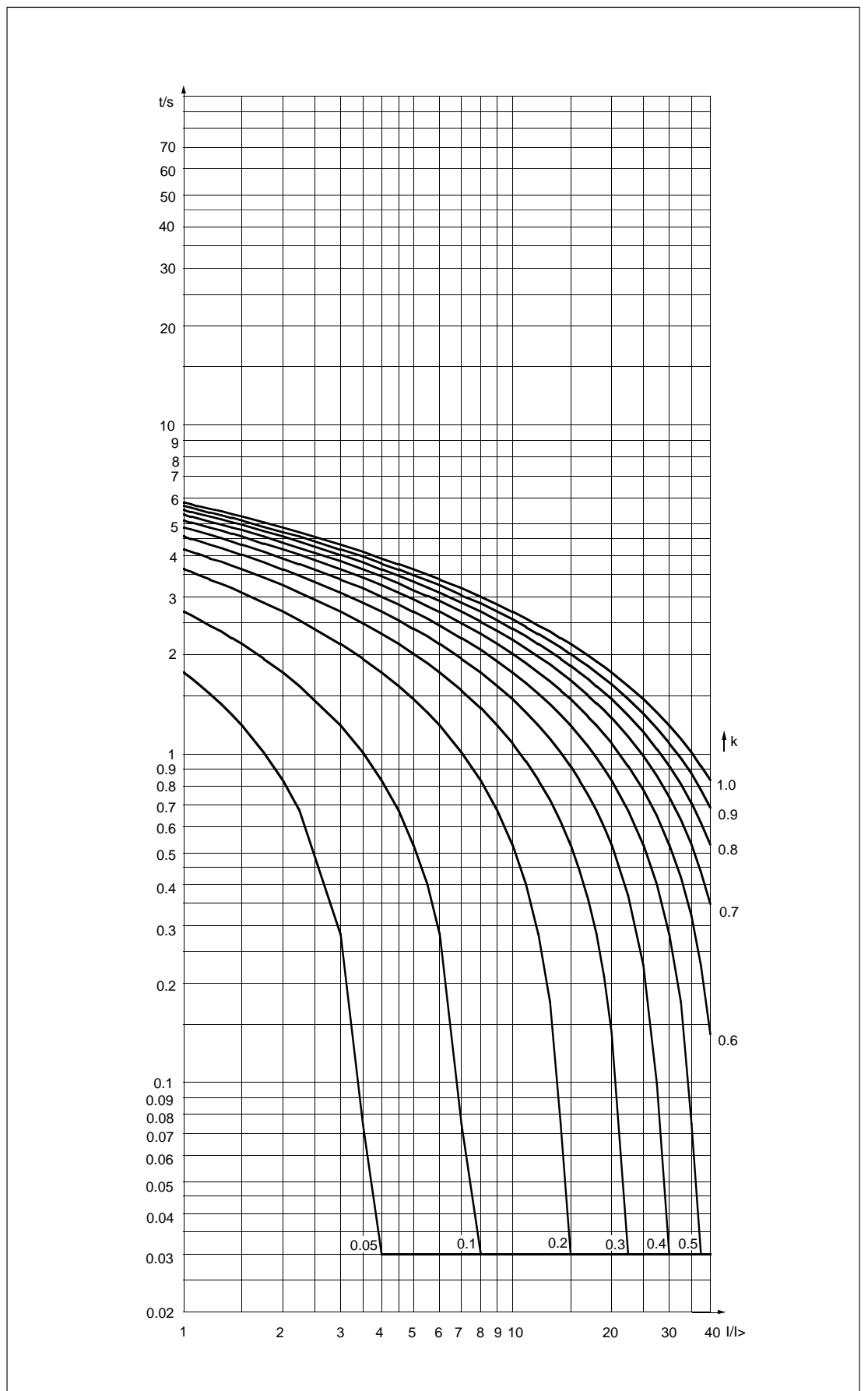


Fig. 8. RXIDG-type inverse-time characteristics of the low-set overcurrent unit in module SPCJ 4D24

Technical data

Low-set overcurrent stage I>

Setting range	0.5...5.0 x I_n
- at definite time	0.5...2.5 x I_n
- at inverse time	< 70 ms
Starting time	0.05...300 s
Operating time at definite time mode of operation	
Operating characteristics at IDMT mode of operation	Extremely inverse Very inverse Normal inverse Long-time inverse RI-type inverse RXIDG-type inverse
Time multiplier k	0.05...1.00
Resetting time	< 80 ms
Retardation time	30 ms
Drop-off/pick-up ratio, typically	0.96
Operation time accuracy at definite time mode of operation	± 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>>

Setting range	0.5...40.0 x I_n or ∞ , infinite
Starting time, typically	40 ms
Operating time	0.04...300 s
Resetting time	< 80 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

Low-set neutral overcurrent stage I₀>

Setting range	1.0...25.0 % I_n
Starting time	< 70 ms
Operation time	0.05...300 s
Resetting time	< 80 ms
Drop-off/pick-up ratio, typically	0.96
Operation time accuracy	± 2 % of set value or ± 25 ms
Operation accuracy	± 4 % of set value

High-set neutral overcurrent stage I₀>>

Setting range	2.0...200 % I_n or ∞ , infinite
Starting time, typically	50 ms
Operation time	0.05...300 s
Resetting time	< 80 ms
Drop-off/pick-up ratio, typically	0.96
Operation time accuracy	± 2 % of set value or ± 25 ms
Operation accuracy	± 4 % of set value

Serial communication parameters

Event codes

When the overcurrent and earth-fault relay module SPCJ 4D24 is linked to the control data communicator SACO 148 D4 over a SPA bus, the module will provide spontaneous event markings e.g. to a printer. The events are printed out in the format: time, text which the user may have programmed into SACO 148 D4 and event code.

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

The event masks V155 and V156 may have a value within range 0...255. The default value of the overcurrent and earth-fault relay module SPCJ 4D24 is 85 both for overcurrent and earth-fault events, which means that all startings and trippings are included in the reporting, but not the resetting.

The output signals are monitored by codes E17...E26 and the events represented by these can be included in or excluded from the event reporting by writing an event mask V157 to the

module. The event mask is a binary number coded to a decimal number. The event codes E17...E26 are represented by the numbers 1, 2, 4...512. An event mask is formed by multiplying the above numbers either by 0, event not included in reporting or 1, event included in reporting and adding up the numbers received, compare the procedure used in calculation of a checksum.

The event mask V157 may have a value within the range 0...1024. The default value of the overcurrent and earth-fault relay module SPCJ 4D24 is 768 which means that only the operations of the trip relay are included in the reporting.

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

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

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

Event codes of the combined overcurrent and earth-fault relay module SPCJ 4D24:

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

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

E17	Output signal TS1 activated	1	0
E18	Output signal TS1 reset	2	0
E19	Output signal SS1 activated	4	0
E20	Output signal SS1 reset	8	0
E21	Output signal SS2 activated	16	0
E22	Output signal SS2 reset	32	0
E23	Output signal SS3 activated	64	0
E24	Output signal SS3 reset	128	0
E25	Output signal TS2 activated	256	1
E26	Output signal TS2 reset	512	1
Default checksum for mask V157			768

E50	Restarting	*	-
E51	Overflow of event register	*	-
E52	Temporary interruption in data communication	*	-
E53	No response from the module over the data communication	*	-
E54	The module responds again over the data communication	*	-

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

Note !

The event codes E52...E54 are only generated by the data communicator unit (SACO 100M, SRI0 1000M, etc.)

Data to be transferred over the serial bus

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

All the data are available in channel 0.

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

Data	Code	Data direction	Values
INPUTS			
Measured current on phase L1	I1	R	0...63 x I _n
Measured current on phase L2	I2	R	0...63 x I _n
Measured current on phase L3	I3	R	0...63 x I _n
Measured neutral current	I4	R	0...210 % I _n
Blocking or control signal	I5	R	0 = no blocking 1 = external blocking or control signal active
OUTPUTS			
Starting of stage I>	O1	R	0 = I> stage not started 1 = I> stage started
Tripping of stage I>	O2	R	0 = I> stage not tripped 1 = I> stage tripped
Starting of stage I>>	O3	R	0 = I>> stage not started 1 = I>> stage started
Tripping of stage I>>	O4	R	0 = I>> stage not tripped 1 = I>> stage tripped
Starting of stage I ₀ >	O5	R	0 = I ₀ > stage not started 1 = I ₀ > stage started
Tripping of stage I ₀ >	O6	R	0 = I ₀ > stage not tripped 1 = I ₀ > stage tripped
Starting of stage I ₀ >> started	O7	R	0 = I ₀ >> stage not started 1 = I ₀ >> stage started
Tripping of stage I ₀ >> tripped	O8	R	0 = I ₀ >> stage not tripped 1 = I ₀ >> stage tripped
Signal START1 TS1	O9	R, W (P)	0 = signal not active 1 = signal active
Signal START2 SS1	O10	R, W (P)	0 = signal not active 1 = signal active
Signal ALARM1 SS2	O11	R, W (P)	0 = signal not active 1 = signal active
Signal ALARM2 SS3	O12	R, W (P)	0 = signal not active 1 = signal active
Signal TRIP TS2	O13	R, W (P)	0 = signal not active 1 = signal active
Operate output relays	O41	R, W (P)	0 = not operated 1 = operated

Data	Code	Data direction	Values
Memorized I> start	O21	R	0 = signal not active 1 = signal active
Memorized I> trip	O22	R	0 = signal not active 1 = signal active
Memorized I>> start	O23	R	0 = signal not active 1 = signal active
Memorized I>> trip	O24	R	0 = signal not active 1 = signal active
Memorized I ₀ > start	O25	R	0 = signal not active 1 = signal active
Memorized I ₀ > trip	O26	R	0 = signal not active 1 = signal active
Memorized I ₀ >> start	O27	R	0 = signal not active 1 = signal active
Memorized I ₀ >> trip	O28	R	0 = signal not active 1 = signal active
Memorized output signal TS1	O29	R	0 = signal not active 1 = signal active
Memorized output signal SS1	O30	R	0 = signal not active 1 = signal active
Memorized output signal SS2	O31	R	0 = signal not active 1 = signal active
Memorized output signal SS3	O32	R	0 = signal not active 1 = signal active
Memorized output signal TS2	O33	R	0 = signal not active 1 = signal active

PRESENT SETTING VALUES

Present starting value for stage I>	S1	R	0.5...5.0 x I _n
Present operating time for stage I>	S2	R	0.05...300 s
Present starting value for stage I>>	S3	R	0.5...40 x I _n 999 = not in use (∞)
Present operating time for stage I>>	S4	R	0.04...300 s
Present starting value for stage I ₀ >	S5	R	1.0...25.0 % I _n
Present operating time for stage I ₀ >	S6	R	0.05...300 s
Present starting value for stage I ₀ >>	S7	R	2...200 % I _n 999 = not in use (∞)
Present operating time for stage I ₀ >>	S8	R	0.05...300 s
Present checksum of switchgroup SGF1	S9	R	0...255
Present checksum of switchgroup SGF2	S10	R	0...255
Present checksum of switchgroup SGB	S11	R	0...255
Present checksum of switchgroup SGR1	S12	R	0...255
Present checksum of switchgroup SGR2	S13	R	0...255
Present checksum of switchgroup SGR3	S14	R	0...255

Data	Code	Data direction	Values
MAIN SETTING VALUES			
Starting value for I> stage, main setting	S21	R, W (P)	0.5...5.0 x I _n
Operating time for I> stage, main setting	S22	R, W (P)	0.05...300 s
Starting value for I>> stage, main setting	S23	R, W (P)	0.5...40.0 x I _n
Operating time for I>> stage, main setting	S24	R, W (P)	0.04...300 s
Starting value for I ₀ > stage, main setting	S25	R, W (P)	1.0...25.0 % I _n
Operating time for I ₀ > stage, main setting	S26	R, W (P)	0.05...300 s
Starting value for I ₀ >> stage, main setting	S27	R, W (P)	2...200 % I _n
Operating time for I ₀ >> stage, main setting	S28	R, W (P)	0.05...300 s
Checksum of group SGF1, main setting	S29	R, W (P)	0...255
Checksum of group SGF2, main setting	S30	R, W (P)	0...255
Checksum of group SGB, main setting	S31	R, W (P)	0...255
Checksum of group SGR1, main setting	S32	R, W (P)	0...255
Checksum of group SGR2, main setting	S33	R, W (P)	0...255
Checksum of group SGR3, main setting	S34	R, W (P)	0...255
SECOND SETTING VALUES			
Starting value for I> stage, second setting	S41	R, W (P)	0.5...5.0 x I _n
Operating time for I> stage, second setting	S42	R, W (P)	0.05...300 s
Starting value for I>> stage, second setting	S43	R, W (P)	0.5...40.0 x I _n
Operating time for I>> stage, second setting	S44	R, W (P)	0.04...300 s
Starting value for I ₀ > stage, second setting	S45	R, W (P)	1.0...25.0 % I _n
Operating time for I ₀ > stage, second setting	S46	R, W (P)	0.05...300 s
Starting value for I ₀ >> stage, second setting	S47	R, W (P)	2...200 % I _n
Operating time for I ₀ >> stage, second setting	S48	R, W (P)	0.05...300 s
Checksum of group SGF1, second setting	S49	R, W (P)	0...255
Checksum of group SGF2, second setting	S50	R, W (P)	0...255
Checksum of group SGB, second setting	S51	R, W (P)	0...255
Checksum of group SGR1, second setting	S52	R, W (P)	0...255
Checksum of group SGR2, second setting	S53	R, W (P)	0...255
Checksum of group SGR3, second setting	S54	R, W (P)	0...255
Operation time for circuit breaker failure prot.	S61	R, W (P)	0.1...1.0 s

Data	Code	Data direction	Values
RECORDED AND MEMORIZED PARAMETERS			
Current in phase L1 at starting or tripping	V11...V51	R	0...63 x I_n
Current in phase L2 at starting or tripping	V12...V52	R	0...63 x I_n
Current in phase L3 at starting or tripping	V13...V53	R	0...63 x I_n
Netral current I_0 at starting or tripping	V14...V54	R	0...210 % I_n
Duration of the latest starting situation of stage I>	V15...V55	R	0...100%
Duration of the latest starting situation of stage I>>	V16...V56	R	0...100%
Duration of the latest starting situation of stage I_0 >	V17...V57	R	0...100%
Duration of the latest starting situation of stage I_0 >>	V18...V58	R	0...100%
Maximum demand current for 15 min.	V1	R	0...2.5 x I_n
Number of startings of stage I>	V2	R	0...255
Number of startings of stage I>>	V3	R	0...255
Number of startings of stage I_0 >	V4	R	0...255
Number of startings of stage I_0 >>	V5	R	0...255
Phase conditions during trip	V6	R	1 = I_{L3} >, 2 = I_{L2} >, 4 = I_{L1} >, 8 = I_0 > 16 = I_{L3} >>, 32 = I_{L2} >> 64 = I_{L1} >>, 128 = I_0 >>
Operation indicator	V7	R	0...9
Highest maximum demand current 15 minute value	V8	R	0...2.55 x I_n
CONTROL PARAMETERS			
Resetting of output relays at self-holding	V101	W	1 = output relays and all information from the display are reset
Resetting of output relays and recorded data	V102	W	1 = output relays and registers are reset
Remote control of settings	V150	R, W	0 = main settings activated 1 = second settings activated, see section "Description of function"
Event mask word for overcurrent events	V155	R, W	0...255, see section "Event codes"
Event mask word for earth-fault events	V156	R, W	0...255, see section "Event codes"
Event mask word for output signal events	V157	R, W	0...1023, see section "Event codes"
Opening of password for remote settings	V160	W	1...999
Changing or closing of password for remote settings	V161	W (P)	0...999

Data	Code	Data direction	Values
Activating of self-supervision output	V165	W	1 = self-supervision output is activated and IRF LED turned on 0 = normal mode
EEPROM formatting	V167	W (P)	2 = formatted with a power reset for a fault code [53]
Internal error code	V 169	R	0...255
Data comm. address of the module	V200	R, W	1...254
Data transfer rate	V201	R, W	4,8 or 9,6 kBd (W) 4800 or 9600 Bd (R)
Programme version symbol	V205	R	042 _
Event register reading	L	R	time, channel number and event code
Re-reading of event register	B	R	time, channel number and event code
Type designation of the module	F	R	SPCJ 4D24
Reading of module status data	C	R	0 = normal state 1 = module been subject to automatic reset 2 = overflow of event regist. 3 = events 1 and 2 together
Resetting of module state data	C	W	0 = resetting
Time reading and setting	T	R, W	00.000...59.999 s

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

The setting values S1...S14 are the setting values used by the protection functions. These values are set either as the main settings and switch-group checksums S21...S34 or as the corresponding second settings S41...S54. All the settings can be read or written. A condition for writing is that remote set password has been opened.

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

Fault codes

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

number which indicates the fault type. When a fault code appears on the display, the code number should be recorded and given to the authorized repair shop when overhaul is ordered. In the table below some fault codes that might appear on the display of the SPCJ 4D24 module are listed:

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



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