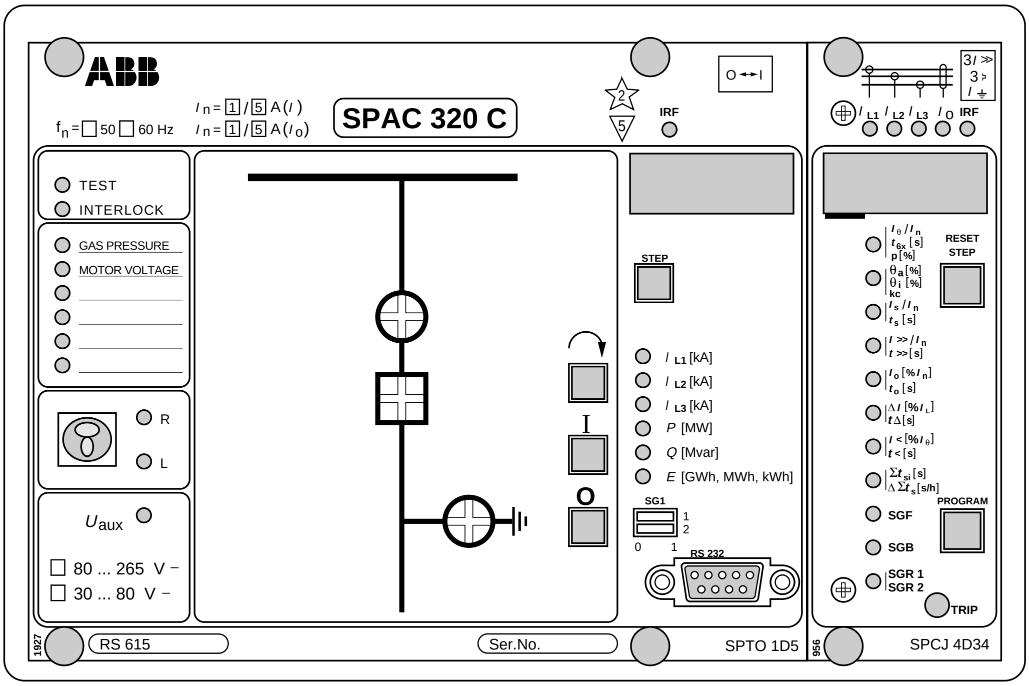
# SPAC 320 C
# Motor protection terminal

## User´s manual and Technical description



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# SPAC 320 C
# Motor protection terminal



## Contents



The complete user's manual for the motor protection terminal SPAC 320 C consists of the following partial manuals:

| | |
|---|---|
| Motor protection terminal, general description | 1MRS 750739-MUM EN |
| Control module SPTO 1D5 | 1MRS 750740-MUM EN |
| General characteristics of D type relay modules | 1MRS 750066-MUM EN |
| Motor protection relay module SPCJ 4D34 | 1MRS 750476-MUM EN |

## Features

Complete motor protection terminal for the protection of medium-sized contactor controlled motors and circuit breaker controlled asychronous motors

Local and remote status indication of three objects and local or remote control of one controllable object

User-configurable object level interlocking system for the prevention of unpermitted switching operations

Six user-configurable binary inputs with local and remote status indication

Phase current, energy, active and reactive power measurement and indication

Serial interface for remote control and data interchange

Continuous self-supervision of hardware and software for maximum reliability

Three-phase thermal overload unit with separately definable thermal trip level and thermal prewarning level

High-set phase overcurrent unit with definite time or instantaneous operation characteristic

Phase unbalance/single-phasing unit with inverse time characteristic

Sensitive earth-fault protection unit with definite time or instantaneous operation characteristic

Undercurrent protection unit with wide starting current and operation time setting ranges

## Area of application

The motor protection terminal SPAC 320 C is designed to be used as cubicle-based protection and remote control interface unit. In addition to protection, control and measurement functions the terminal features data communication properties needed for the control of the motor feeder cubicle. Connection to higher level substation control equipment is carried out via a fibre-optic serial bus.

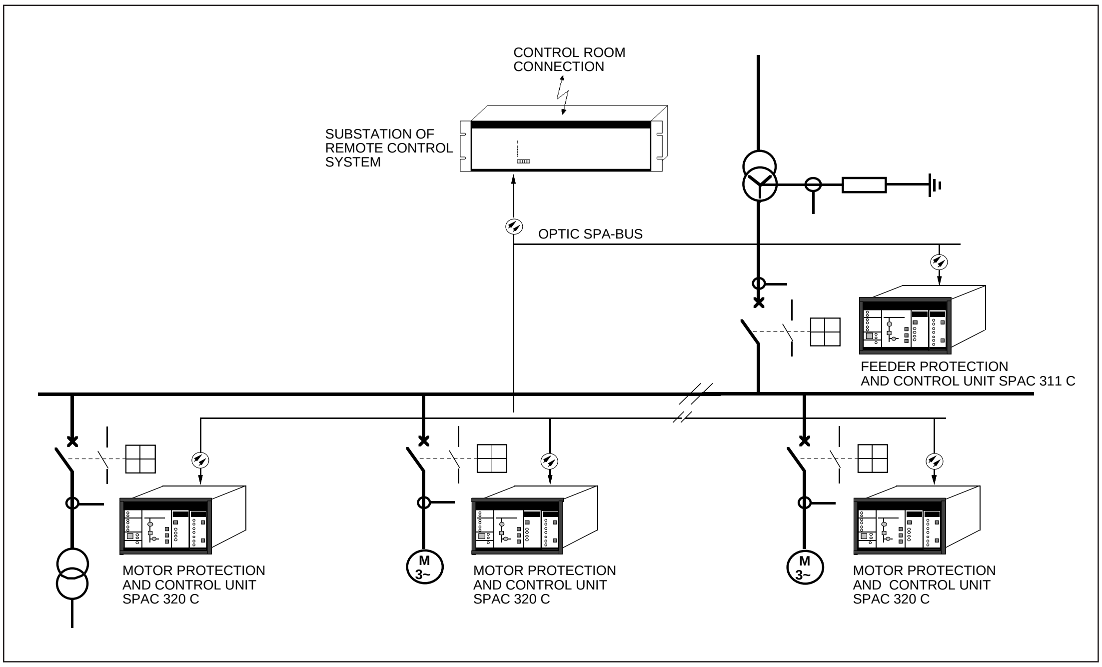



Fig.1. Distributed motor protection and control system based on terminals type SPAC 320 C.

The control module included in the motor protection terminal indicates locally by means of LED indicators the status of 1…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, for instance, a circuit breaker, to be opened and closed via the remote control system. The status information and the control signals are transmitted over the serial bus. Also local control of one object is possible by using the 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 by means of external measuring transducers. Energy can be calculated on the basis of the measured power values or by using one input as an energy pulse counter input. The measured values can be displayed locally and remotely as scaled values.

The motor protection module SPCJ 4D34 is an integrated design current measuring multifunction relay module for the complete protection of a.c. motors. The main area of application covers large or mediumsized three-phase motors in all types of conventional contactor or circuit breaker controlled motor drives.

The motor protection terminal can also be used in other applications reguiring a single-, two- or three-phase overcurrent and/or thermal overload protection and non-directional earth-fault protection.

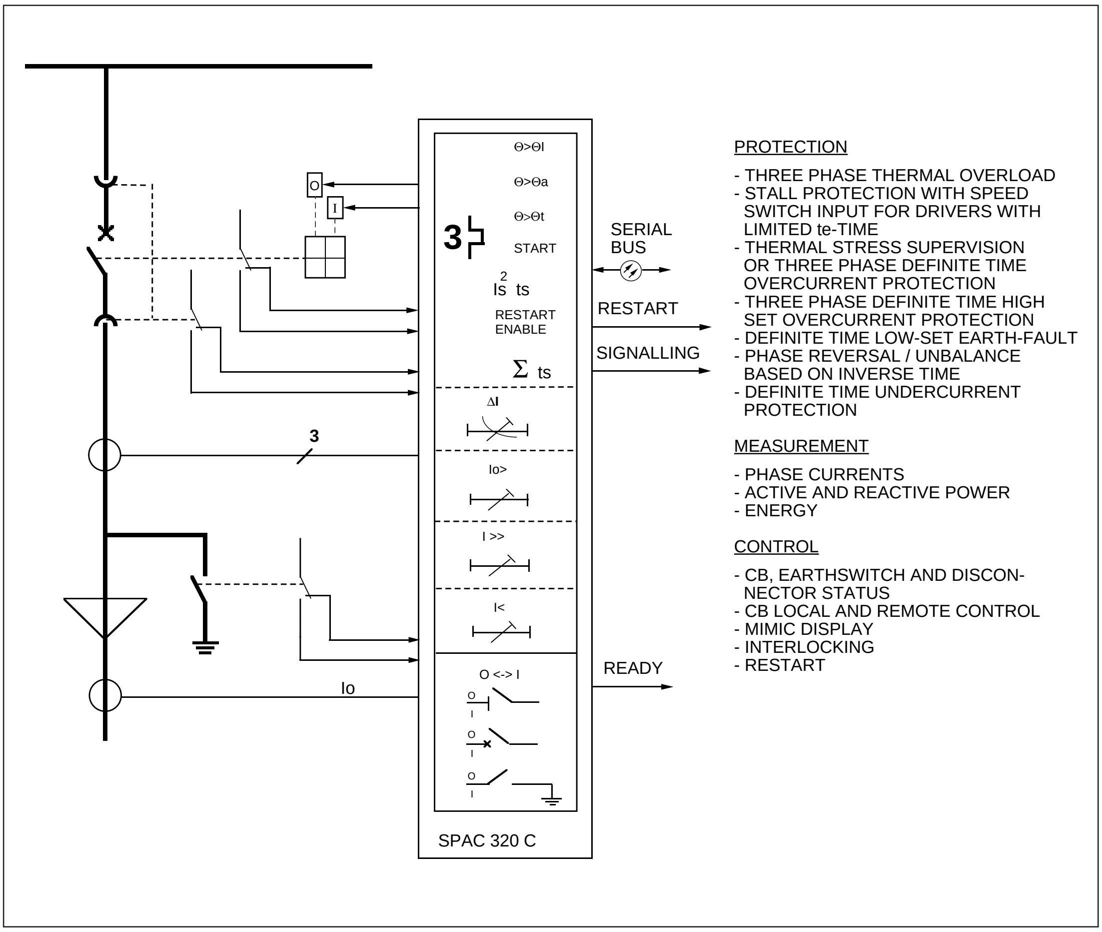



Fig. 2. Basic functions of the motor protection terminal SPAC 320 C.

## Description of function

### Design

The motor protection terminal includes five modules. Their functions are listed in the following table.

| Module | Function |
|---|---|
| Motor protection relay module SPCJ 4D34 | Thermal overload, low-set overcurrent, start-up supervision, high-set overcurrent, neutral overcurrent, phase unbalance, undercurrent and time-based start inhibit counter |
| Control module SPTO 1D5 | Reads and indicates locally and remotely status data of one to three disconnectors or circuit breakers<br>Reads and indicates locally and remotely maximum six external binary signals<br>Measures and displays locally and remotely three phase currents, active and reactive power and energy<br>Carries out local or remote open and close commands for one circuit breaker |
| I/O module SPTR 3B12 or SPTR 3B13 | Includes 12 opto-isolated binary inputs, trip and close output contacts and IRF alarm contact |
| Power supply module SPGU 240A1 or SPGU 48B2 | Forms the internal voltages required by the other modules |
| Energizing input module SPTE 4F3 | Includes matching transformers and calibration electronics for three phase currents and the neutral current.<br>Includes the motherboard with three signalling output contacts, a restart enable output contact and the electronics for the mA inputs |

The withdrawable control module SPTO 1D5 includes two PC boards; a CPU board and a front PC board which are joined together. The I/O board SPTR 3B12 or SPTR 3B13 is located behind the front PC board and it is attached to the front PC board by screws.

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

The motor protection relay module SPCJ 4D34 is attached to the case by means of two finger screws and the control module SPTO 1D5 by means of four finger screws. These modules are removed by unwinding the finger screws and withdrawing the modules of the subrack. 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 PC board have to be removed.

The energizing input module SPTE 4F3 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 withdrawable modules, the detachable multi-pole connector strips of the inputs and outputs, the calibration resistors of the energizing inputs and the electronics of the signal, restart enable and mA inputs.

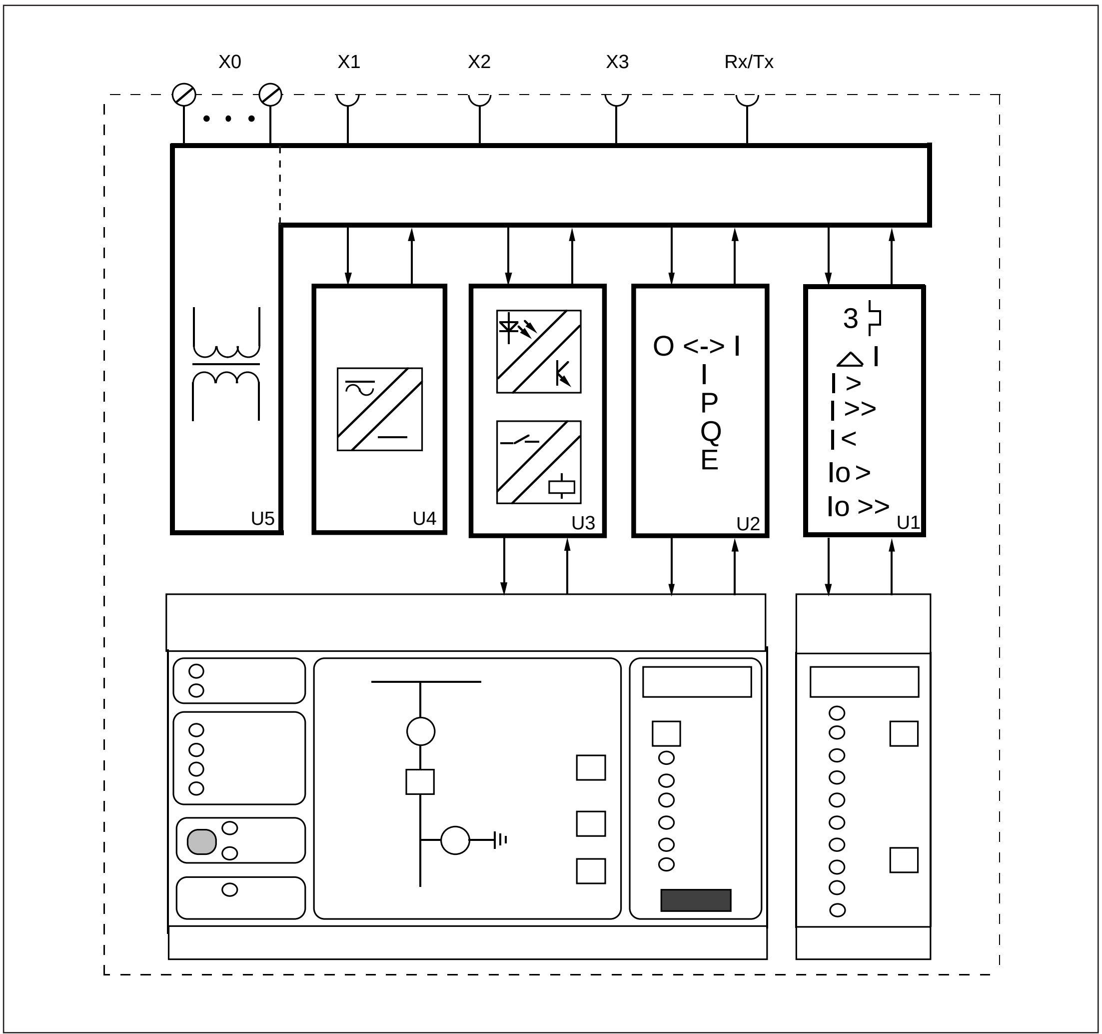



Fig. 3. Block diagram of the motor protection terminal SPAC 320 C

| | |
|---|---|
| U1 | Motor protection relay module SPCJ 4D34 |
| U2 | Control module SPTO 1D5 |
| U3 | I/O module SPTR 3B12 or SPTR 3B13 for digital inputs and contact outputs |
| U4 | Power supply module SPGU 240 A1 or SPGU 48 B2 |
| U5 | Energizing input module and motherPC board SPTE 4F3 |
| X0 | Screw terminals |
| X1…X3 | Multi-pole connectors |
| Rx/Tx | Serial communication port |

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

The cover of the relay case contains two push buttons which can be used for scanning through the displays of the motor protection terminal.

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

The cover is locked with two finger screws. A rubber gasket between the cover and the collar ensures that the cover, too, fulfills the IP54 requirements. The opening angle of the cover is 145°.

## Protection functions

### *Motor protection*

The motor protection relay module SPCJ 4D34 is a multifunction relay module which measures three phase currents and the neutral current of the protected motor feeder. On the basis of the values of three phase currents measured the thermal condition of the motor is calculated and the faults of the network are detected. In fault situations the different protection units of the relay module provide alarms or trip the circuit breaker.

By appropriate configuration of the output relay matrix, different start, prior alarm and restart inhibit signals are obtained as contact functions. The contact information is used, for instance, for blocking co-operating protection relays located upstreams in the power system, for connection to annunciator units etc.

The motor protection relay module contains one external logic control input, which is activated by a control signal on the auxiliary voltage level. The influence of the control input on the protection functions of the relay module is determined by the selector swithes of the motor protection relay module. The control input can be used as a blocking input for one or more protection stages, as an external trip command input, as a restart inhibit control input, as an output relay resetting input, when the the manual reset mode has been selected, or as a speed switch signal input for motors with a limited permitted stall time $t_e$.

### *Contact outputs of the protection*

The tripping signal of the motor protection terminal is wired to the OPEN output.The terminal has four signalling contacts, one of which is the common internal relay failure (IRF) output. Three signalling outputs, SIGNAL 1…3, can be used to indicate starting or tripping of the protection stages, see chapter "Signal diagram".

### *Restart enable output*

Output relay G, terminals 74-75, is a heavy duty output relay capable of directly controlling a circuit breaker, as is the main trip relay A. Relay G is used for controlling restart of the motor. If the thermal capacity used exceeds the set restart inhibit level of the thermal unit or if the allowed maximum cumulative start-up count is exceeded or if the external restart inhibit signal is active, the output relay G prevents a motor restart attempt by opening contact gap 74 - 75. This also applies to a condition where the motor protection terminal is out of auxiliary supply.

## Control functions

### *General*

The control module SPTO 1D5 is used for reading status information for circuit breakers and disconnectors.The module indicates status locally by means of LED indicators and transfers the information to higher level equipment via the SPA bus. The status of maximum three objects can be indicated.

The control module is also used for controlling one object, for instance a circuit breaker, locally by means of the push buttons on the front panelor by remote control with the control commands obtained over the SPA bus.

In addition to status information the control module can read other binary data, indicate the information locally and transfer it to higher system levels. At a maximum six external binary signals can be wired to the motor protection terminal.

### *Input channels 1…3*

The control module uses the inputs CHANNEL 1…3 to read the status information of circuit breakers and disconnectors. Each input CHANNEL 1…3 is formed by two binary inputs, one input member is used for reading the open status and the other for reading the closed status of an object. This means that the status information must be wired to the motor protection terminal as a 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 and disconnectors of the switchgear cubicle. At a time, three of these LEDs can be used for status indication. The circuit breaker/disconnector configuration can be configured by the user.

One of the objects, the status of which is read via inputs CHANNEL 1…3, is controlable via the OPEN and CLOSE outputs.

### *Input channels 4…9 and 10…13*

The control module can be used for reading six external and four internal binary signals. The external signals, CHANNEL4…9, are single contact signals wired from the switchgear cubicle and the internal signals, CHANNEL10, 12 and 13, are start and trip signals of the protection relay module. CHANNEL11 provides the restart enable signal.

The inputs CHANNEL4…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 status of the inputs CHANNEL 4…9 can be indicated with LEDs on the front panel. The LEDs can be made latching, in which case they are reset by pushing the STEP and SELECT push buttons simultaneously or by giving the parametre S5 the value 0 or 1.

The inputs CHANNEL 4…13 can be used to control the OPEN, CLOSE and SIGNAL 1…3 outputs. On activation of an input channel the configured OPEN or CLOSE output provides an output pulse, whereas the outputs SIGNAL 1…3 are continuously activated as long as the concerned inputs are activated.

### *Interlocking*

The control module includes a feeder-oriented interlocking which is freely configurable by the user. On writing an interlocking program the user defines under which circumstances the controlled object may be opened and closed. When an opening or closing command is given the interlocking program is run and after that the command is executed or canceled.

The interlocking system 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 start-up the motor protection terminal is provided with a number of preprogrammed default interlocking schemes. A certain default interlocking scheme is always related to a certain default circuit breaker/disconnector configuration.

### *Conditional direct output control*

Normally the OPEN and CLOSE outputs are controlled by giving an open or close command. In the conditional direct output control the outputs, i.e. OPEN, CLOSE and SIGNAL 1…3, can be controlled without the ordinary open and close commands. In this case the outputs are controlled by the direct output control program which checks the status of the inputs CHANNEL 1…3, CHANNEL4…13 and the R/L key switch.

## Measurement functions

Both the control module SPTO 1D5 and the motor protection relay module SPCJ 4D34 measure analog signals.

The motor protection relay module SPCJ 4D34 measures the three phase currents and the neutral current. The module desplays the current values locally and transmits the data via the SPA bus to higher system levels. The motor protection relay module displays the measured values as multiples of the rated current of the used energizing input.

The control module SPTO 1D5 measures five analog signals; three phase currents and active and reactive power. The transforming ratio of the primary current transformers can be keyed into the control module. In that way it is possible to display the measured phase currents as primary values.

The control module measures the active and reactive power via two mA inputs. External measuring transducers are required. The mA signals are scaled to actual MW and Mvar values and the data can be displayed locally and transmitted to the higher system levels.

Active energy is measured in two ways; either by calculating the value on the basis of the measured power or by using the input CHANNEL7 as a pulse counter input. In the latter case an external energy meter with a pulse output is needed. In both cases the value of the measured energy can be displayed locally and transmitted to higher system levels.

## Serial communication

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

The 9-pin RS 232 connection on the front panel is to be used for setting the motor protection terminal and for determining the circuit breaker/ disconnector configuration, the object-oriented interlocking and other parameters from a terminal or a portable computer.

The 9-pin RS 485 port on the rear panel is used for connecting the motor protection terminal to the SPA bus by means of a bus connection module type SPA-ZC 21 or SPA-ZC 17.

## Auxiliary power supply

The motor protection terminal requires a secured supply of auxiliary energy. The auxiliary power module SPGU_ forms the voltages required by the protection relay module, the control module and the input/output module.

The auxiliary power module is a transformer connected, galvanically isolating, pulse-width modulated, flyback type, dc/dc converter. The primary side of the power module is protected with a fuse, F1, located on the PC board of the module. The fuse size is 1 A (slow).

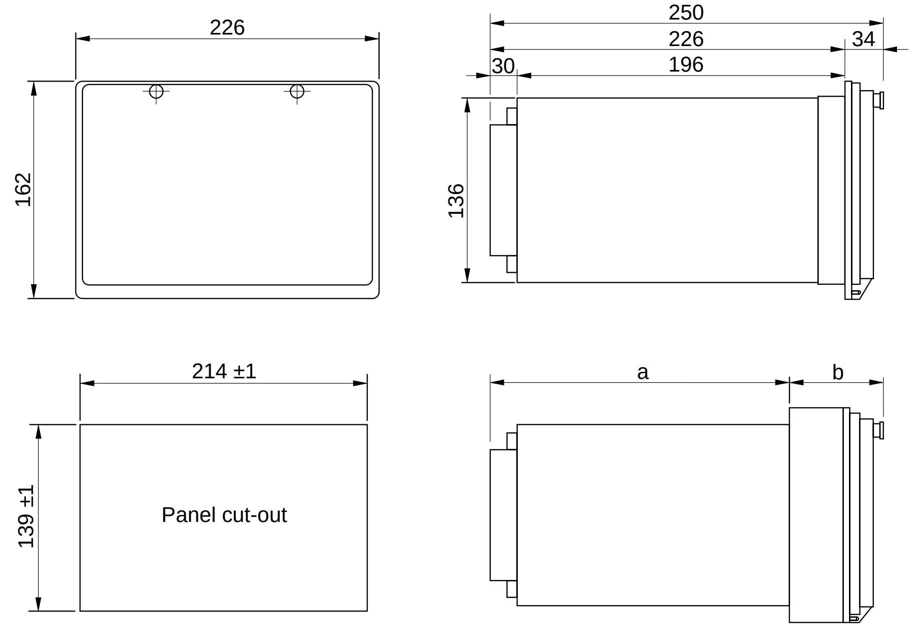
A green LED indicator $U_{aux}$ on the front panel is lit when the auxiliary power module is operating. There are two versions of auxiliary power modules available, with identical secondary sides but different input voltage specifications. The input voltage range is marked on the front panel of the control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

## Application

### Mounting and dimension drawings

The motor protection terminal SPAC 320 C is housed in a normally flush mounted case. The case of the motor protection terminal is fastened to the mounting panel by means of four galvanized sheet steel mounting brackets. A surface mounting case type SPA-ZX 316 is also available.

Flush mounting case




| Raising frame | a | b |
|---|---|---|
| SPA-ZX 301 | 186 | 74 |
| SPA-ZX 302 | 146 | 114 |
| SPA-ZX 303 | 106 | 154 |

Surface mounting case

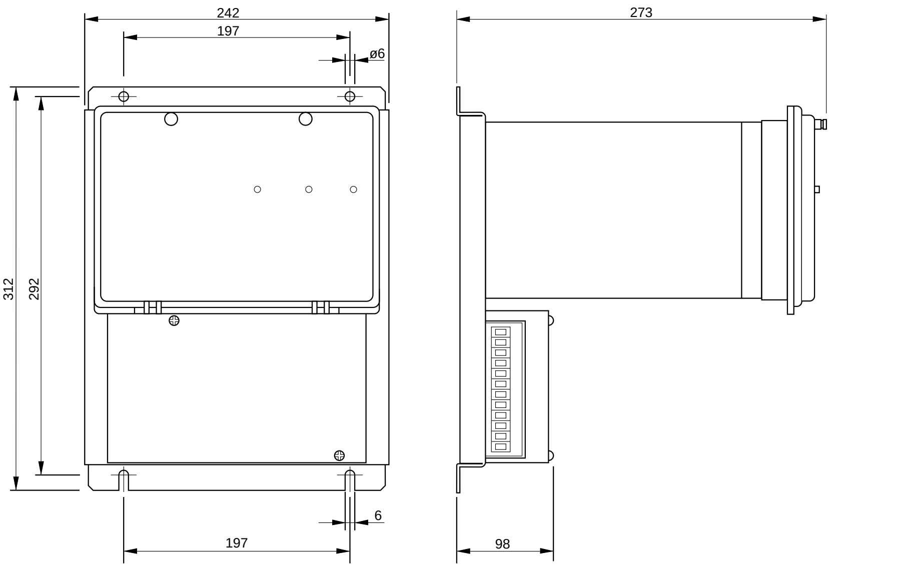



Fig. 4. Mounting and dimension drawings of the motor protection terminal SPAC 320 C

Connection
diagram

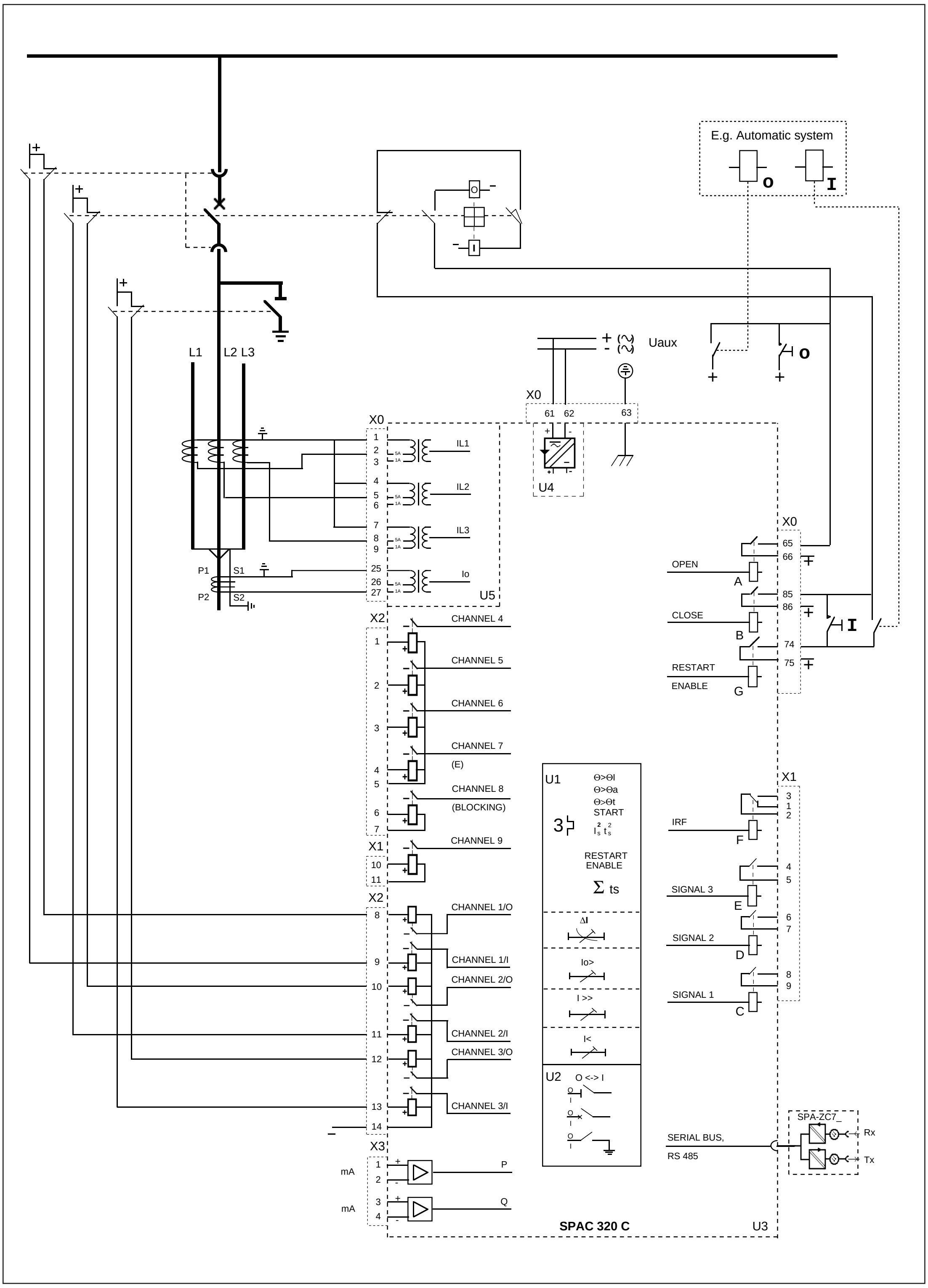



Fig. 5.1 Connection diagram for the motor protection terminal SPAC 320 C. The protected motor is controlled by a circuit breaker. The contact interval 74-75 of the restart inhibit output relay G is closed when motor restarting is allowed. The restart inhibit signal from the motor protection module is also routed to the input CHANNEL11, see Fig. 6. The restart inhibit signal can be included in the interlocking program for conditional restarting via the CLOSE output.

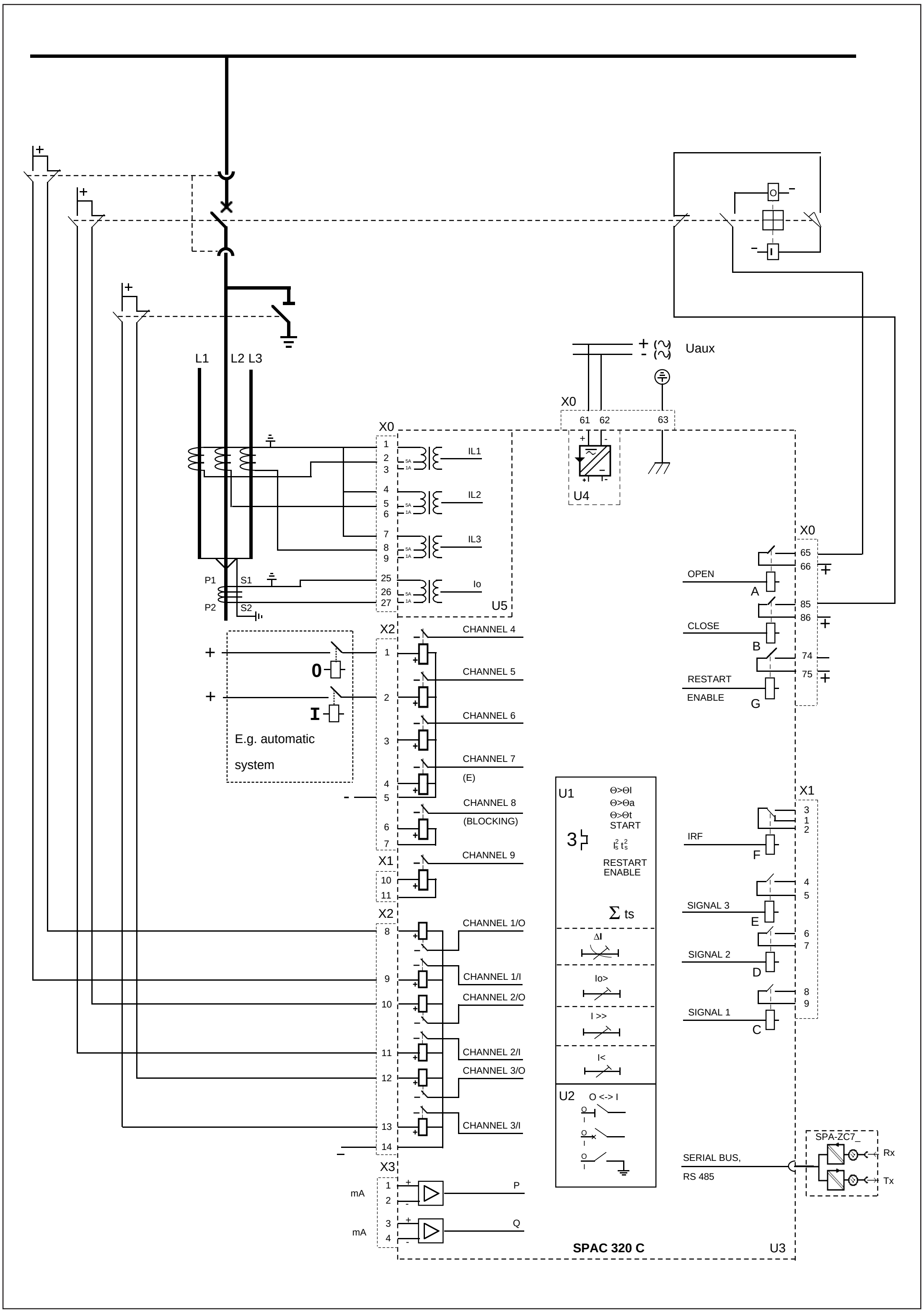



Fig. 5.2 Connection diagram for the motor protection terminal SPAC 320 C. The protected motor is controlled by a circuit breaker. The information wired to the inputs control starting of the motor in accordance with the determined interlocking program.

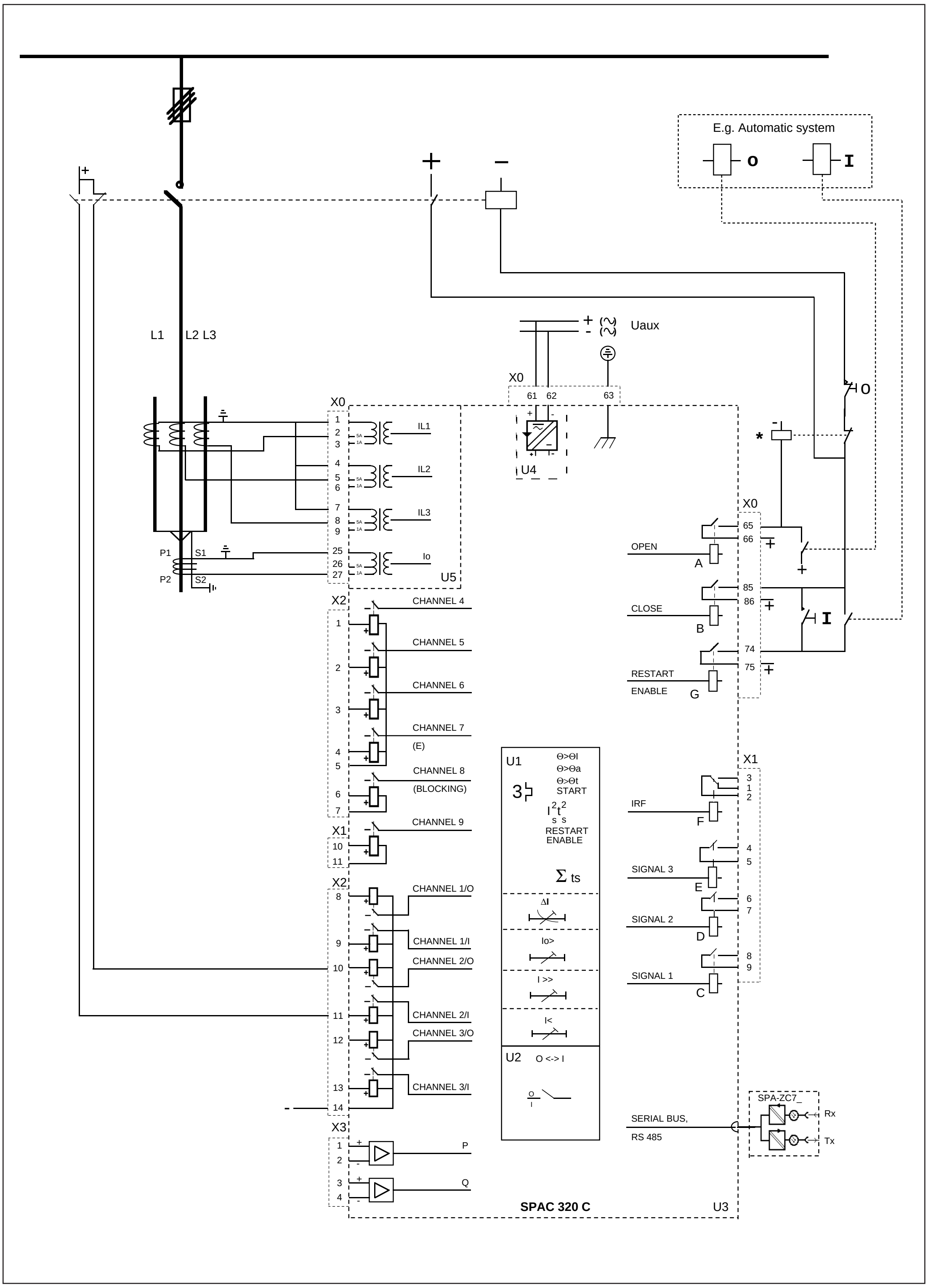



Fig. 5.3 Connection diagram for the motor protection terminal SPAC 320 C. The motor is controlled by a contactor. The contact interval 74-75 of the restart inhibit output relay G is closed when motor restarting is allowed. The restart inhibit signal from the motor protection module is also routed to the input CHANNEL11, see Fig. 6. The restart inhibit signal can be included in the interlocking program for conditional restarting via the CLOSE output.
* Note! The external auxiliary relay is not part of the delivery.

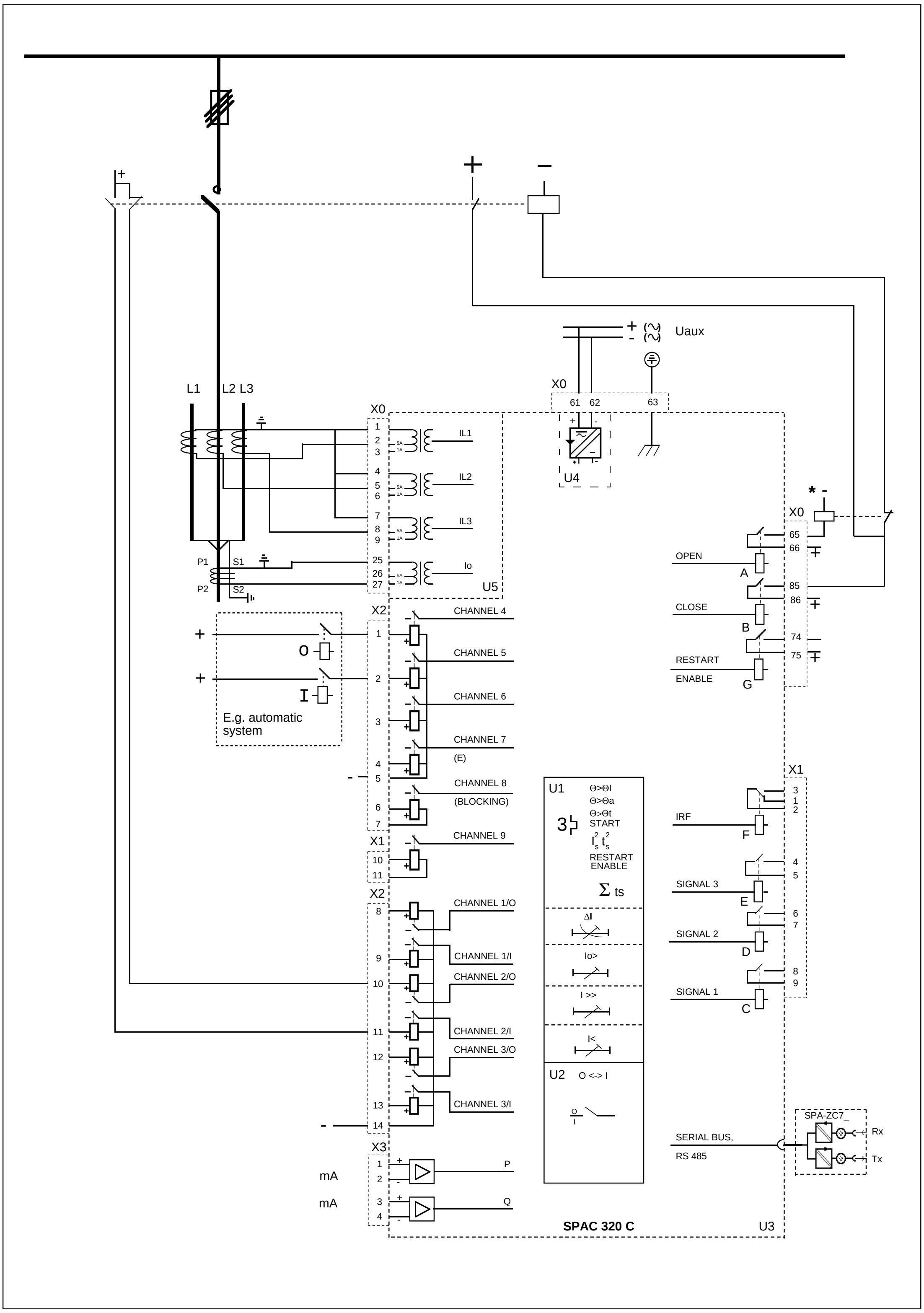



Fig. 5.4 Connection diagram for the motor protection terminal SPAC 320 C. The motor is controlled by a contacor. Starting of the motor is controlled by the information wired to the terminal and by the interlocking program.

* Note! The external auxiliary relay is not part of the delivery.

Terminal numbers:

| Terminal block | Terminal number | Function |
|---|---|---|
| X0 | 1-2 | Phase current $I_{L1}$, 5A |
| | 1-3 | Phase current $I_{L1}$, 1A |
| | 4-5 | Phase current $I_{L2}$, 5A |
| | 4-6 | Phase current $I_{L2}$, 1A |
| | 7-8 | Phase current $I_{L3}$, 5A |
| | 7-9 | Phase current $I_{L3}$, 1A |
| | 25-26 | Neutral current $I_0$, 5A |
| | 25-27 | Neutral current $I_0$, 1A |
| | 61-62 | Auxiliary power supply. Positive voltage should be connected to terminal 61 |
| | 63 | Protective earth |
| | 65-66 | Open output, as a default also thermal trip, I>(Is), I>>, ΔI, I< and $I_0$> tripping signals |
| | 74-75 | Restart enable output |
| | 85-86 | Close output |
| X1 | 1-2-3 | Self-supervision (IRF) signalling output. When auxiliary power is connected and the device is operating properly the contact 2-3 is closed |
| | 4-5 | Signal output 3. E.g. alarm for thermal trip, thermal prior alarm, I>(Is) alarm, I>> alarm, ΔI alarm, I< alarm or $I_0$> alarm (programmable), as a default thermal prior alarm |
| | 6-7 | Signal output 2. Can be controlled via control module |
| | 8-9 | Signal output 1. E.g. Start-up info, thermal prior alarm or I>> start, as a default start-up info |
| | 10-11 | Input CHANNEL9 |
| X2 | 1-5 | Input CHANNEL4 |
| | 2-5 | Input CHANNEL5 |
| | 3-5 | Input CHANNEL6 |
| | 4-5 | Input CHANNEL7 or energy pulse counter |
| | 6-7 | Input CHANNEL8 or blocking signal BS1 |
| | 8-14 | Input CHANNEL1, open status. E.g. when the circuit breaker is open the input should be energized. |
| | 9-14 | Input CHANNEL1, closed status. E.g. when a circuit breaker is closed there must be a voltage connected to this input. |
| | 10-14 | Input CHANNEL2, open status |
| | 11-14 | Input CHANNEL2, closed status |
| | 12-14 | Input CHANNEL3, open status |
| | 13-14 | Input CHANNEL3, 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 those used when the control module SPTO 1D5 is programmed. The following codes are used for the outputs when the control module is programmed:

| Output | Terminal numbers | Output code for interlocking | Output code for Conditional Direct Output Control |
|---|---|---|---|
| OPEN | X0/65-66 | 20 | 220 |
| CLOSE | X0/85-86 | 21 | 221 |
| SIGNAL 1 | X1/8-9 | 22 | 22 |
| SIGNAL 2 | X1/6-7 | 23 | 23 |
| SIGNAL 3 | X1/4-5 | 24 | 24 |

Intermodular control signal exchange

The default factory settings of the motor protection terminal may have to be changed in different applications. The diagram below shows how the input and output signals can be interconnected to obtain the required functions of the terminal.

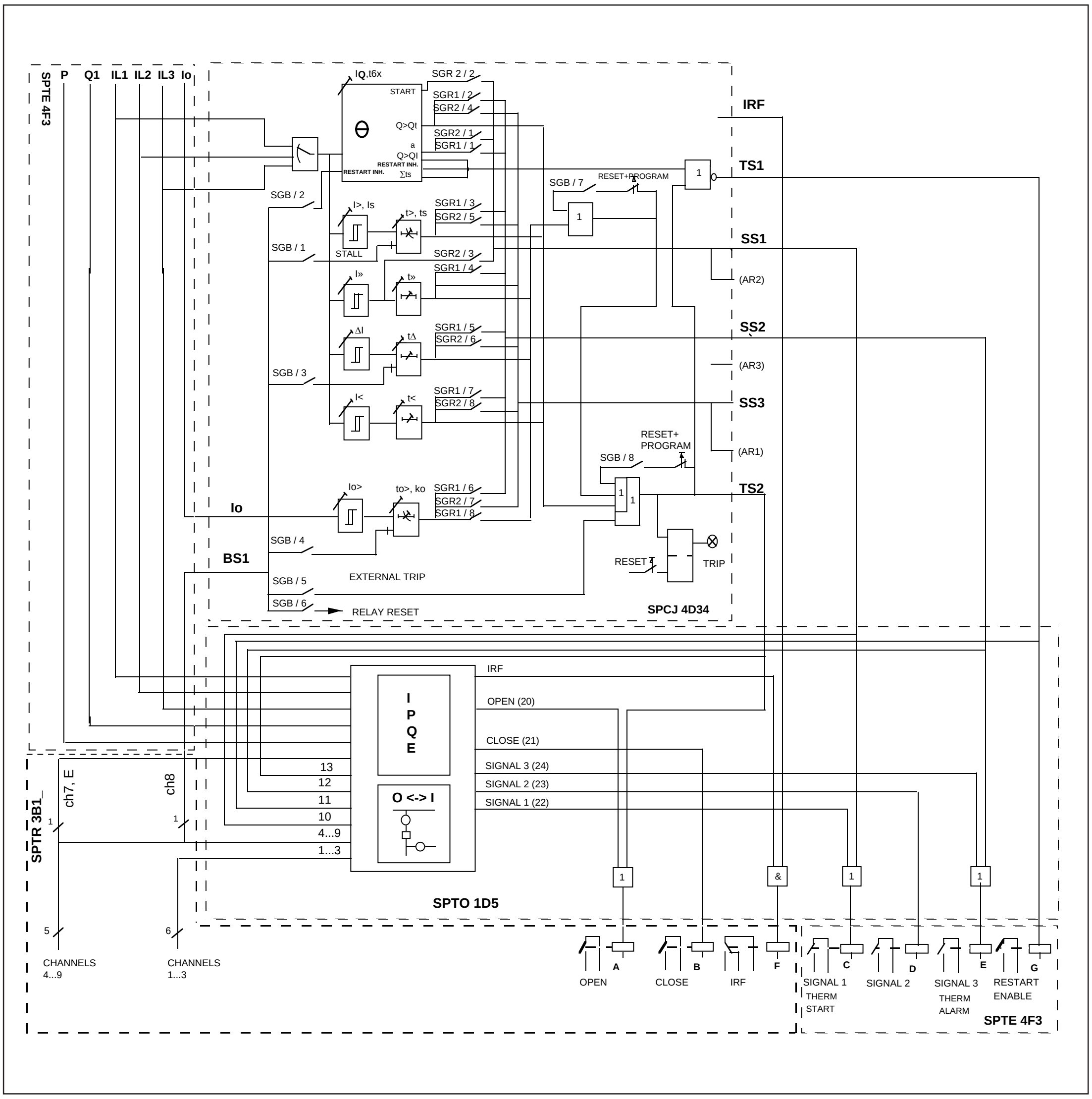



Fig. 6. Signal diagram for the motor protection terminal SPAC 320 C.

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

| Switch | Function | Default value |
|---|---|---|
| SGB/1 | Forms from a voltage connected to input 8 a stall information for the motor protection relay module | 0 |
| SGB/2 | Forms from a voltage connected to input 8 a restart inhibit signal for the motor protection relay module | 0 |
| SGB/3 | Forms from a voltage connected to input 8 a blocking signal for the unbalance stage of the motor protection relay module | 0 |
| SGB/4 | Forms from a voltage connected to input 8 a blocking signal fot the earth-fault stage of the motor protection relay module | 0 |
| SGB/5 | Forms from a voltage connected to input 8 a trip signal TS2 | 0 |
| SGB/6 | Forms from a voltage connected to input 8 a remote reset of latched outputs and memorized values | 0 |
| SGB/7 | Selects a latching feature for the trip signal TS2 on operation of the high-set stage I>>, the unbalance stage ΔI and the earth-fault stage $I_0$ | 0 |
| SGB/8 | Selects a latching feature for the trip signal TS2 for any tripping | 0 |
| SGR1/1 | Routes the thermal prior alarm signal to output SIGNAL3 | 1 |
| SGR1/2 | Routes the thermal trip signal to output SIGNAL 3 | 0 |
| SGR1/3 | Routes the trip signal of the stall protection stage to output SIGNAL 3 | 0 |
| SGR1/4 | Routes the trip signal of the high-set overcurrent stage to output SIGNAL3 | 0 |
| SGR1/5 | Routes the trip signal of the current unbalance stage to output SIGNAL3 | 0 |
| SGR1/6 | Routes the trip signal of the neutral overcurrent stage to output SIGNAL3 | 0 |
| SGR1/7 | Routes the trip signal of the undercurrent stage output SIGNAL 3 | 0 |
| SGR1/8 | Routes the trip signal of the neutral overcurrent stage to output OPEN | 1 |
| SGR2/1 | Routes the thermal prior alarm signal to output SIGNAL 1 | 0 |
| SGR2/2 | Routes the motor start-up signal to output SIGNAL 1 | 1 |
| SGR2/3 | Routes the start signal of the high-set overcurrent to output SIGNAL1 | 1 |
| SGR2/4 | No function in the motor protection terminal SPAC 320 C | 1 |
| SGR2/5 | No function in the motor protection terminal SPAC 320 C | 1 |
| SGR2/6 | No function in the motor protection terminal SPAC 320 C | 1 |
| SGR2/7 | No function in the motor protection terminal SPAC 320 C | 1 |
| SGR2/8 | No function in the motor protection terminal SPAC 320 C | 1 |

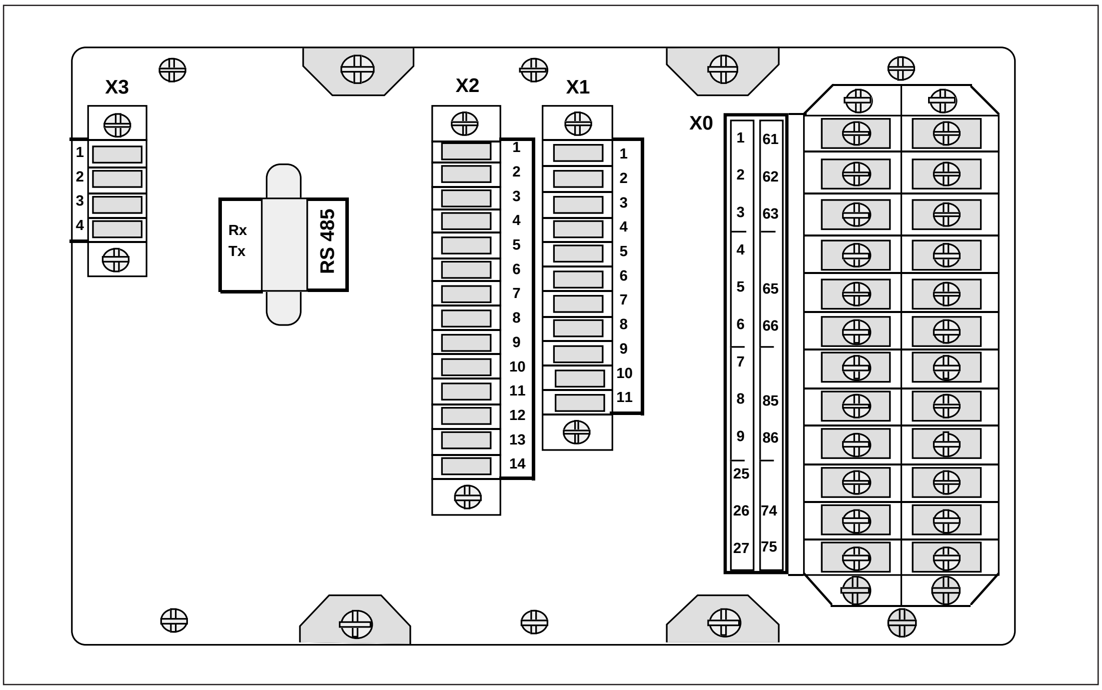



Fig. 7. Rear view of the motor protection terminal SPAC 320 C.

All external conductors are connected to the terminal blocks on the rear panel. Terminal block X0 consists of fixed screw terminals fastened to the energizing input module. The connectors X1…X3 are detachable multi-pole connector strips with screw terminals.

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

The measuring signals, the auxiliary supply voltage and the OPEN, CLOSE and restart inhibit contact outputs are connected to the terminal block X0. Each terminal is dimensioned for one 4 $mm^2$ or two max. 2.5 $mm^2$ wires. The 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 CHANNEL1…3 and CHANNEL4…8 are connected via connector X2. Input CHANNEL9 is wired via connector X1 and the two mA inputs via connector X3. One max. 1.5 $mm^2$ wire or two max. 0.75 $mm^2$ wires can be be connected to one screw terminal.

The rear panel of the motor protection terminal is provided with a serial port for the SPA bus (Rx/Tx). Two types of bus connection modules are available. The bus connection module type SPA-ZC 21 is attached directly to the rear panel of the terminal. The bus connection module type SPA-ZC 17 is provided with a connection cable, which is inserted into the D type subminiature connector on the rear panel of the terminal while the bus connection module is fastened on the wall of the switchgear cubicle.

## Start-up

The start-up of the motor protection terminal should be done according to the following instructions. Checks1 and 2 have to be performed before the auxiliary power supply is switched on.

1. Voltage ranges of the binary inputs

Before the inputs CHANNEL1…9 are energized, check the permitted control voltage range of the inputs. The control voltage range, $U_{aux}$, is marked on the front panel of the control module.

2. Auxiliary supply voltage

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

3. Programming of the control module SPTO 1D5

All the non-volatile EEPROM parameters have been given default values at the factory. The default configuration and interlocking scheme 3 has been selected. The default parameters are explained in the manual of the control module SPTO 1D5.

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

- Configuration; default or user-definable configuration
- Interlocking; default or user-definable interlocking
- OPEN and CLOSE outputs; pulse lengths
- Measurements; transforming 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 CHANNEL4…9; latching function of indicators
- Event reporting; event masks, event delay times

The programming can be done via the RS 232 port on the front panel or the RS 485 port on the rear panel by using the SPA protocol. Instructions are to be found in the manual of the control module SPTO 1D5.

4. Settings of the motor protection module SPCJ 4D34

The motor protection relay module has been given default settings at the factory. The start current and operate time settings have been set at their minimum values. The default checksum values of the switchgroups are as follows:

| Switchgroup | Checksum $\Sigma$ |
|---|---|
| SGB | 0 |
| SGR1 | 171 |
| SGR2 | 165 |

These values can be changed manually by means of the push buttons on the front panel of the protection relay module. Also the RS 232 port on the front panel of the control module or the RS 485 port on the rear panel of the motor protection terminal can be used for changing the settings of the protection module using commands of the SPA protocol.

The exact functions of the switchgroups are explained in the manual of the motor protection relay module SPCJ 4D34.

## Technical data

*(modified 2002-04)*

### Energizing inputs

| | | |
|---|---|---|
| Rated current $I_n$ | 1 A | 5 A |
| Thermal withstand capability | | |
| - continuously | 4 A | 20 A |
| - for 1s | 100 A | 500 A |
| Dynamic current withstand, | | |
| - half-wave value | 250 A | 1250 A |
| Input impedance | <100 mΩ | <20 mΩ |
| Rated frequency $f_n$ | 50 Hz | |
| Rated frequency on request | 60 Hz | |

### mA inputs

| | |
|---|---|
| Terminal numbers | |
| - active power | X3/1-2 |
| - reactive power | X3/3-4 |
| Input current range | -20…0…20 mA |

### Binary inputs

| | |
|---|---|
| Terminal numbers | |
| - CHANNEL1…3, i.e. four-pole inputs | X2/8-14, 9-14, 10-14, 11-14, 12-14 and 13-14 |
| - CHANNEL4…9, i.e. single-contact inputs | X2/1-5, 2-5, 3-5, 4-5, 6-7 and X1/10-11 |
| Input voltage range | |
| - input module type SPTR 3B12 | 80…265V dc |
| - input module type SPTR 3B13 | 30…80 V dc |
| Current drain | ~2 mA |

### Energy pulse counter input (input channel 7)

| | |
|---|---|
| Terminal numbers | X2/4-5 |
| Maximum frequency | 25 Hz |
| Input voltage range | |
| - input module type SPTR 3B12 | 80…265V dc |
| - input module type SPTR 3B13 | 30…80 V dc |
| Current drain | ~2 mA |

### External control input (input channel 8)

| | |
|---|---|
| Terminal numbers | X2/6-7 |
| Input voltage range | |
| - input module type SPTR 3B12 | 80…265V dc |
| - input module type SPTR 3B13 | 30…80 V dc |
| Current drain | ~2 mA |

### Contact outputs

| | |
|---|---|
| Control outputs | |
| Terminals | X0/65-66, 85-86 |
| - 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≤40 ms at the control voltage levels 48/110/220 V dc | 5 A/3 A/1 A |
| - contact surface | $AgCdO_2$ |
| - control output operating mode, when operated by the control module | pulse shaping |
| - control pulse length | 0.1…100 s |

| | |
|---|---|
| Restart inhibit output | |
| Terminals | X0/74-75 |
| - 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≤40 ms at the control voltage levels 48/110/220 V dc | 5 A/3 A/1 A |

| | |
|---|---|
| Signalling outputs | |
| Terminals | X1/1-2-3, 4-5, 6-7 and 8-9 |
| - 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≤40 ms at the control voltage levels 48/110/220 V dc | 1 A/0.25 A/0.15 A |

### Auxiliary supply voltage

| | |
|---|---|
| Type of built-in power supply module and supply voltage range | |
| - type SPGU 240A1 | 80...265 V ac or dc |
| - type SPGU 48B2 | 18...80 V dc |
| Burden of auxiliary supply under quiescent/ operating conditions | ~10 W / ~15 W |

## Combined phase and neutral overcurrent relay module SPCJ 4D34

| Thermal overload protection | |
|---|---|
| - full load current $I_\theta$, setting range | 0.5 ... 1.50 x $I_n$ |
| - resolution of current setting | 1 % |
| - stall time $t_{6x}$, setting range | 2.0 ... 120 s |
| - resolution of stall time setting handled by algorithm | 0.5 s |
| - cooling time-constant at zero current (standstill) constant | 1 ... 64 x heating time constant |
| - thermal prior alarm level $\theta_a$, if in use | 50 ... 100 % of set thermal trip level |
| - restart inhibit level $\theta_i$ | 20 ... 80 % of set thermal trip level |
| - thermal protection initialization after an auxiliary supply interruption *) | 70 % of set prior alarm level, i.e. hot motor condition |

| Low-set overcurrent stage I> | |
|---|---|
| - start current I>, setting range | 1.0 … 10.0 x $I_n$ |
| - operate time t> | 2 ... 60 s |

| Current based run-up supervision $I_s$ **) | |
|---|---|
| - run-up current $I_s$, setting range | 1.0 ... 10.0 x $I_n$ |
| - run-up time $t_s$, setting range | 2 ... 60 s |

| High-set overcurrent stage I>> | |
|---|---|
| - Start current I>>, setting range | 2.0…20 x $I_n$ and ∞, infinite |
| - operate time t>>, setting range | 0.04…30 s |

| Neutral overcurent stage $I_0$> | |
|---|---|
| - start current $I_0$>, setting range | 0.01…1.00 x $I_n$ |
| - operate time $t_0$> | 0.05…30 s |
| - suppression of third harmonic, typ. | -20 dB |

| Phase unbalance unit ΔI | |
|---|---|
| - basic sensitivity ΔI, stabilized to phase current levels below $I_n$ | 10 ... 40 % |
| - operate time at lowest settable start level, 10 % | 20 ... 120 s, inverse time |
| - operating time at full unbalance (single phasing) | 1 s |
| - operate time at incorrect phase sequence | 600 ms |

| Undercurrent unit I< | |
|---|---|
| - start current I< in per cent of the full load current setting | 30 ... 80 % $I_\theta$ |
| - operation inhibited below | 12 % $I_\theta$ |
| - operate time | 2 ... 60 s |

| Time-based restart inhibit counter | |
|---|---|
| - setting range $\Sigma_{ts}$ | 5 ... 500 s |
| - countdown rate of start time counter $\Delta_{ts}/\Delta_t$ | 2 ... 250 s/h |

*) Note!
If the thermal prior alarm is set below 70 %, the connection of the relay will cause a thermal prior alarm signal.

**)
Note! The operation can be defined either as a low-set definite time overcurrent function (SGF/7=0) or as acurrent based start-up supervision function (SGF/7=1). Both functions cannot be used at the same time. In either case, the time-counting can be stopped by a control signal to the speed switch input (SGB/1=1).

### Control module SPTO 1D5

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

Measurement functions
- phase currents, measuring range 0…2.5 x $I_n$
- phase current measuring accuracy better than ±1% of $I_n$
- active and reactive power measurement via mA inputs, external measuring transducers are needed
- mA inputs' measuring current range -20 mA…0…+20 mA
- power measuring accuracy better than ±1% of the maximum value of the measuring range
- energy measurement via pulse counter input or by calculating of measured power
- local and remote reading of measured data as scaled values

### Data communication

| | |
|---|---|
| Rear panel | |
| - port | RS485, 9-pin, female |
| - bus connection module for rear connection | |
| - for plastic core cables | SPA-ZC 21BB |
| - for glass fibre cables | SPA-ZC 21MM |
| - bus connection module for separate mounting | |
| - for plastic core cables | SPA-ZC 17 BB |
| - for glass fibre cables | SPA-ZC 17 MM |
| Front panel | |
| - connection | RS232, 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 µs, 0.5 J |
| Insulation resistance measurement IEC 60255-5 | >100 MΩ, 500 Vdc |

### Electromagnetic Compatibility Tests *)

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

### Environmental conditions

| | |
|---|---|
| Specified ambient service temperature | -10…+55 °C |
| Transport and storage temperature range | -40...+70 °C |
| Long term damp heat withstand according to IEC 60068-2-3 | <95%, at 40 °C for 56 d/a |
| Degree of protection by enclosure when panel mounted | IP54 |
| Mass of the motor protection terminal | ~5 kg |

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

## Exchange and spare parts

| | |
|---|---|
| Control module | SPTO 1D5 |
| Motor protection relay module | SPCJ 4D34 |
| I/O module, input voltage range 80…265 V dc | SPTR 3B12 |
| I/O module, input voltage range 30…80 V dc | SPTR 3B13 |
| Power supply module, 80…265 V ac or dc | SPGU 240A1 |
| Power supply module, 18…80 V dc | SPGU 48B2 |
| Case without plug-in modules, SPAC 320 C | SPTK 4F3 |

## Maintenance and repairs

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

If the environmental conditions at the mounting site differ from those specified, regarding temperature and humidity, or, if the atmosphere around the terminal contains chemically active gases or dust, the terminal should be visually inspected in association with the secondary test being performed. At the visual inspection the following things should be noted:

- Check for signs of mechanical damage on case or terminals
- Dust inside the plastic cover or the case; remove carefully by blowing instrument air
- Rust spots or signs of oxidation on terminals, connectors or relay case

If the motor protection terminal fails in operation or if the operation values differ from those of the technical specifications, the terminal should be given a proper overhaul. Minor measures can be taken by the operator but all major measures involving overhaul of the electronics and recalibration 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 terminal.

Note!
Motor protection terminals are measuring instruments and should be handled with care and protected against dust, damp and mechanical stress, especially during transport.

## Order information

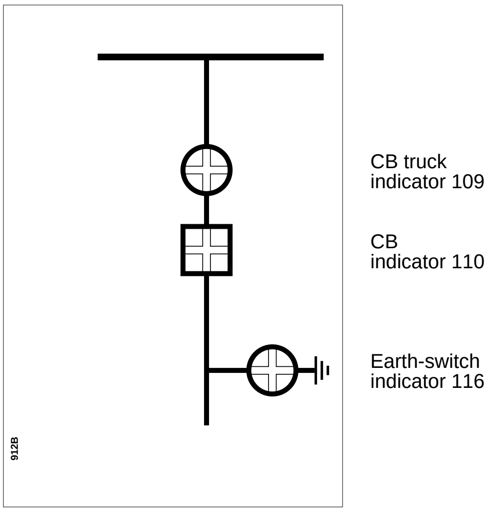
The following information should be given when motor protection terminals are ordered.

| | |
|---|---|
| 1. Quantity and type designation | 15 pces SPAC 320 C |
| 2. Rated frequency | $f_n$ = 50 Hz |
| 3. Auxiliary supply voltage | $U_{aux}$ =110 V dc |
| 4. Type designation of the configuration plate | SYKK 912 |
| 5. Accessories | 15 bus connection modules SPA-ZC 7CBB |

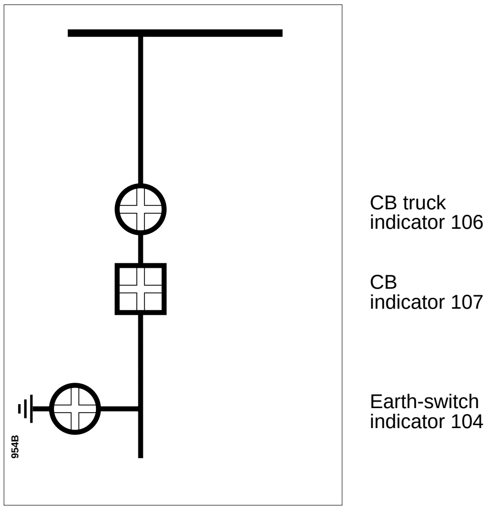
Four empty legend text films SYKU 997 for the inputs CHANNEL4…9 are included in the motor protection terminal delivery.

As different configuration plates are available for the motor protection terminal SPAC 320 C and the type designation of the configuration plate should be stated in the order.

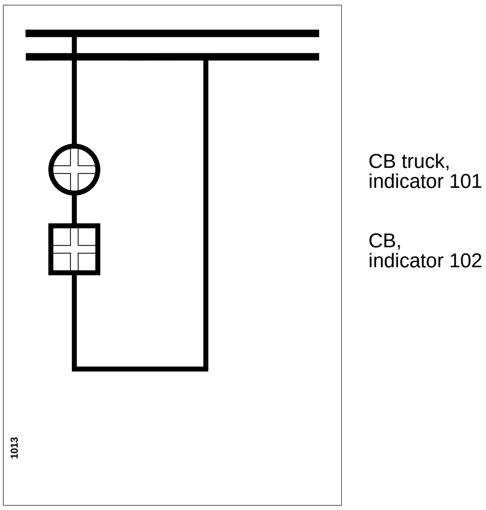
There are two parallel configuration plates for one circuit breaker/disconnector configuration; in the first type the closed status is indicated by red colour and the open status by green colour, in the second type the colours are reversed. In the following figures some standard configuration plates are illustrated.



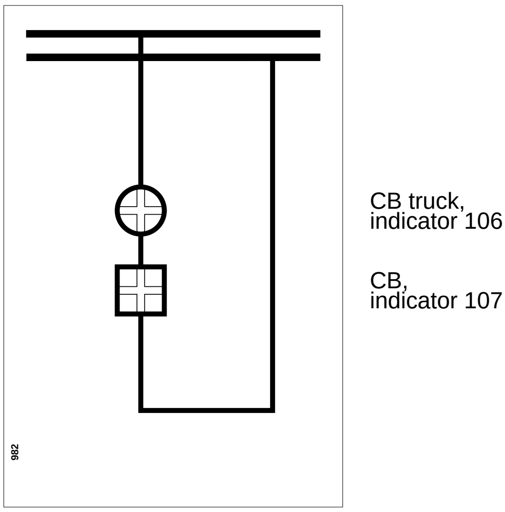

Configuration plate type SYKK 912
Open status = green colour
Closed status = red colour




Configuration plate type SYKK 954
Open status = red colour
Closed status = green colour




Configuration plate type SYKK 1013
Open status = green colour
Closed status = red colour




Configuration plate type SYKK 982
Open status = red colour
Closed status = green colour

Fig. 8. Standard configuration plates for the motor protection terminal SPAC 320 C.

Note! Regardless of the configuration plate the control module always has the default configuration and interlocking scheme 3 on delivery.

On special request other types of configuration plates can be delivered. Figure 9 shows the LED matrix of the control module. To help design customized configuration plates the customer is requested to sketch the single line diagram of the desired configuration and to draw the proposal for a configuration plate with the help of Fig. 9. The following instructions should be kept in mind:

- In columns 1 and 3 the red LEDs are vertical and the green LEDs horizontal
- In columns 2 and 4 the red LEDs are horizontal and the green LEDs vertical
- A circuit breaker is illustrated by a square
- A disconnector is illustrated by a circle
- When indicating closed status by red LEDs, the earth-switch should be on the right hand side, see SYKK 912
- When indicating closed status by green LEDs, the earth-switch should be on the left hand side, see SYKK 954
- When indicating closed status by red LEDs, the CB should refer to indicator No. 102 or 110
- When indicating closed status by green LEDs, the CB should refer to indicator No. 107 or 115

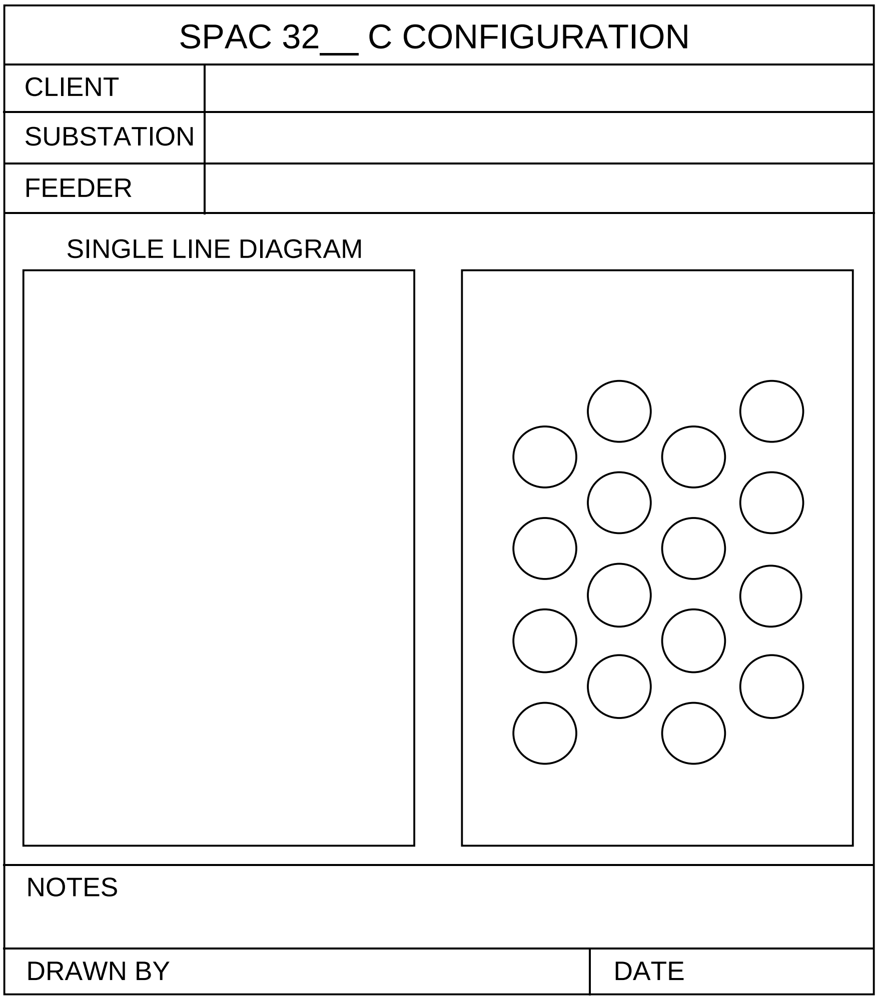
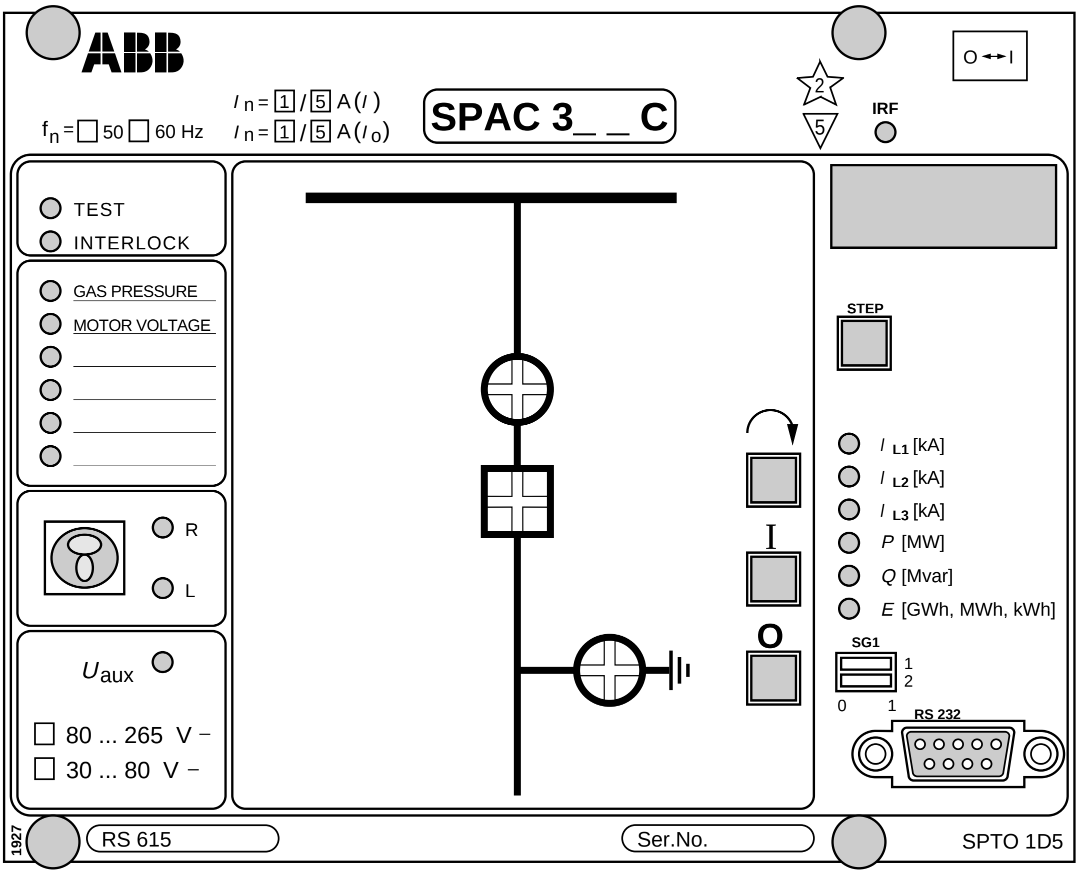



Fig. 9. Template for sketching customized configuration plate for the control module SPTO 1D5 of the motor protection terminal SPAC 320 C. The circles of the configuration plate illustrate the status indication LEDs.

# SPTO 1D5
# Control module

## User´s manual and Technical description




ABB

1MRS 750740-MUM EN

Issued 97-05-22
Version A (replaces 34 SPTO 7 EN1)
Checked TK
Approved TK

# SPTO 1D5
# Control module

Data subject to change without notice

## Contents

## Description of functions

### Control functions

The control module type SPTO 1D5 reads binary input signals and indicates the status of these signals locally and remotely. The control module also performs OPEN and CLOSE commands.

The input channels 1…3 are used for reading status information of circuit breakers and disconnectors (objects). Each of these channels includes two physical inputs, one for object open and one for object closed information. The module indicates the status information locally on the front panel by means of LED indicators and transfers the information to station level equipment via the SPA bus.

The control module is able to read the status information of maximum 3 objects. The front panel has a matrix of status indication LEDs. The configuration indicated by these LEDs is freely programmable by the user.

Input channels 4…13 consist of one physical binary input. These channels are used mainly to transfer binary signals other than circuit breaker and disconnector status information over the SPA bus to the remote control system. There is a local LED indication for the input channels 4…9 on the front panel.

The control module is able to give OPEN and CLOSE commands for one object. The commands may be given by means of the local push-buttons, via the SPA bus or the input channels 4…13. The output is a pulse with programmable pulse length.

An enable signal must be given by an interlocking program before the OPEN or CLOSE output pulse can be activated. The enable signal is given on the basis of the status of input channels 1…3 and 4…13 and the programmed logic.

The signalling outputs, SIGNAL 1…3, can be used to indicate the status of input channels 4…13. The selected output is active as long as the input channel is active.

The outputs OPEN, CLOSE or SIGNAL1…3 can be controlled by the conditional direct output control program. The program is similar to that of interlocking. The user can define when an output is to be activated. This is depending on the status of inputs 1…3 and 4…13 and the programmed logic. The output is active as long as the program gives the output signal.

### Measurement functions

The control module SPTO 1D5 is able to measure three phase currents and two mA signals. The mA inputs are used for measuring active and reactive power. External measuring transducers are needed.

Input channel 7 can be used as a pulse counter for energy pulses. Energy can also be calculated on the basis of the measured power.

The measured signals can be scaled and they are indicated locally and over the SPA bus as actual values.

Block diagram

Simplified block diagram of the control module SPTO 1D5 is shown in Fig. 1.

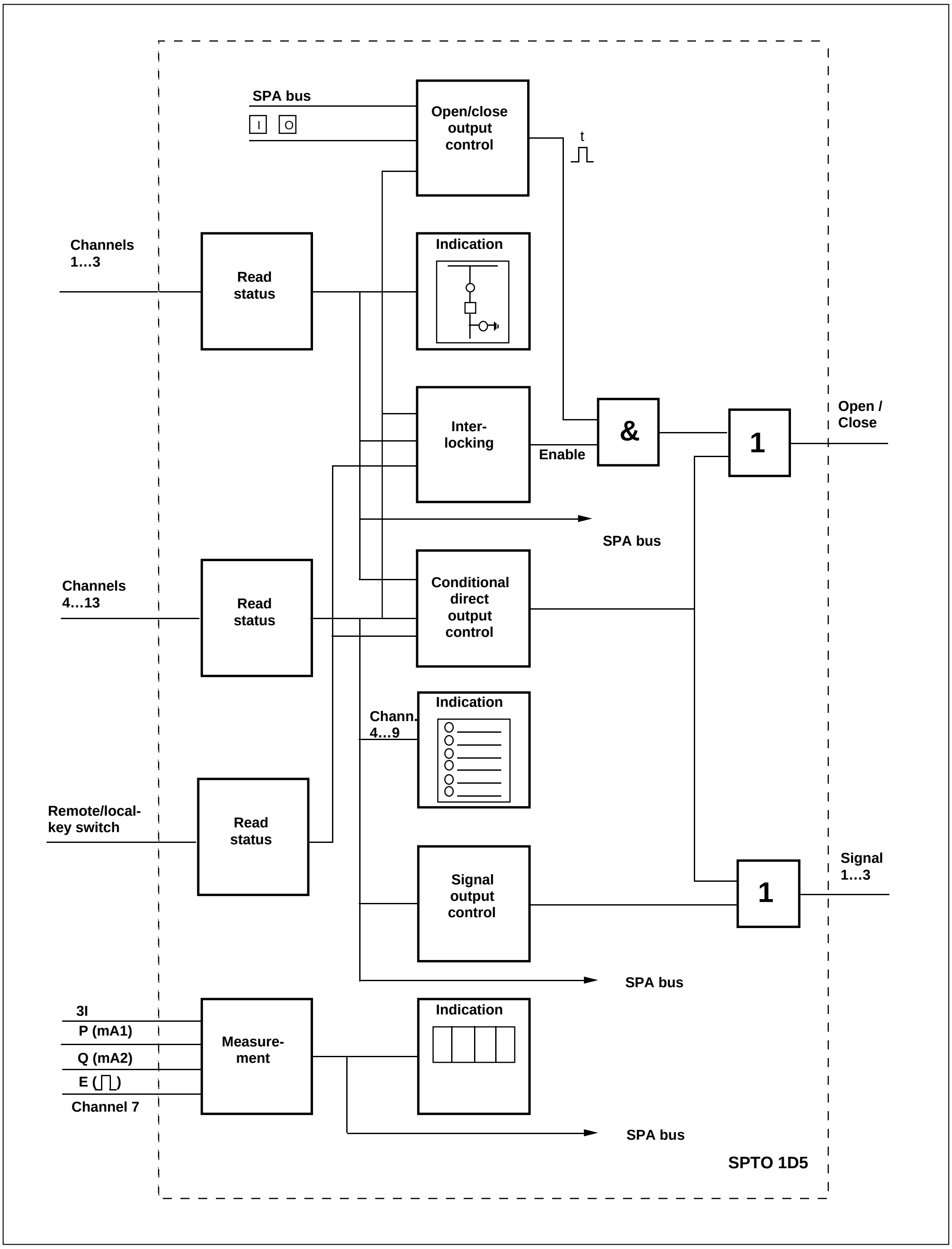



Fig. 1. Block diagram of the control module SPTO 1D5.

## Front panel

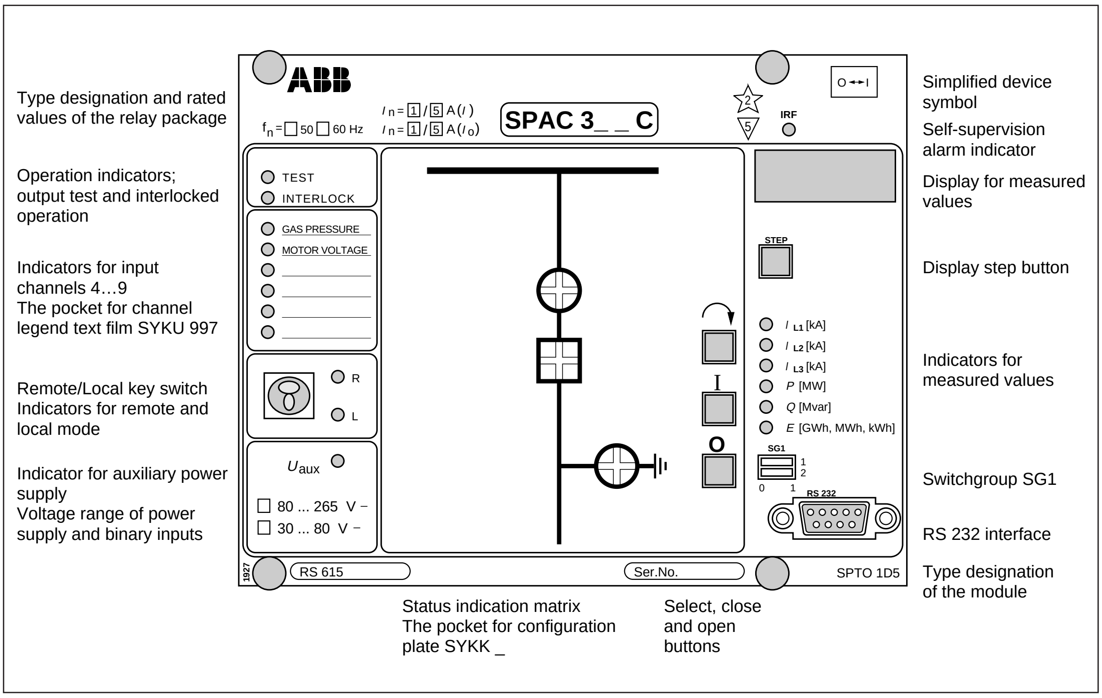



Fig. 2. Front panel of the control module SPTO 1D5 without the configuration plate SYKK _ _ and the channel legend text foil SYKU 997.

Object status indicators

The front panel has 16 LED indicators for local status indication. The indicators are arranged as a 4 x 4 matrix. Three of these indicators can be used simultaneously in the control module SPTO 1D5. The combination of indicators used is freely programmable by the user, see chapter "Configuration".

In front of the indicators there is a pocket for a separate plastic configuration plate type SYKK_ . The bottom of the pocket is open. By changing the configuration plate and programming a new indicator combination different kinds of bays can be described.

The circuit breakers and disconnectors of the bay are shown on the configuration plate. The configuration plate has a transparent window in front of the indicators that are in use. The unused indicators are hidden.

One object indicator is composed of four LEDs, two vertical and two horizontal. Two of the LEDs are red and two are green. The red LEDs are vertical and the green LEDs horizontal in columns 1 and 3, see Fig. 6. In the columns 2 and 4 the green LEDs are vertical and the red LEDs horizontal. Due to this system both colours can be used to indicate either open or closed status.

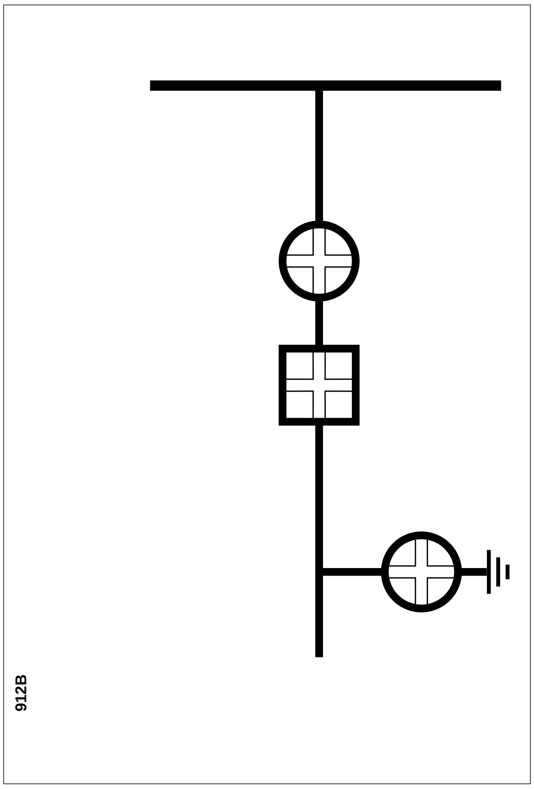



Fig. 3. Example of plastic configuration plate SYKK _. The size of the plate is 72 x 106.5 mm.

## Indicators for input channels 4…9

The status of the input channels 4...9 is indicated locally on the front panel. Channel 4 refers to the upmost red indicator and channel 9 to the lowest one.

An input can be defined to be active at high state (NO contact) or active at low state (NC contact). The LED is normally lit when the input is active.

The front panel has a pocket for a text legend foil, SYKU 997, on which the user can write the desired input legend text. The left side of the pocket is open. An empty text legend foil is delivered with the relay package.

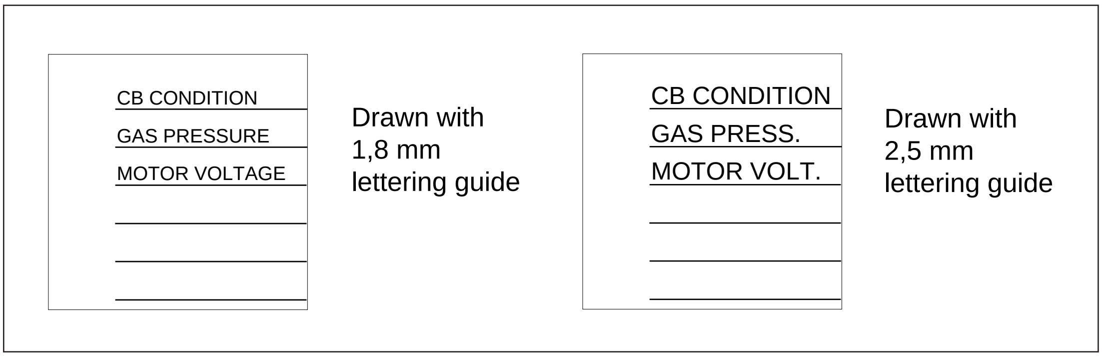



Fig. 4. Example of text legend foil SYKU 997. The foil is shown in actual size, width 33.5 mm and height 34 mm.

## Operation indicators

The control module includes two red operation indicators showing the status of the module itself. These LEDs are normally dark. The indicators have the following function:

| Indicator | Function |
|---|---|
| TEST | Is lit when the switch SG1/1=1. Then the interlockings are out of use |
| INTERLOCK | The LED is lit when a control command is given locally but the control of the object is prohibited by the interlocking program. The led indicator can be switched off by pushing the « button but it is also automatically switched off after about 30 s.<br>The indicator is also lit when the control module is in the programming mode and the interlockings are in use. It is switched off when the operation mode is entered or when the interlockings are set out of use. |

The green indicator $U_{aux}$ indicates that an external power supply voltage is connected and the power supply module of the unit is operating. The input voltage range of the digital inputs and the power supply module is marked below the $U_{aux}$ indicator.

## REMOTE/LOCAL key switch

To be able to use the local OPEN (O) and CLOSE (I) push-buttons, the key switch must be in the position LOCAL, indicated by the yellow LED L. All remote controls via the serial communication are inhibited, but control operations via input channels 4…13 or control operations by the conditional direct output control function are allowed.

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 R. When the key switch is in the REMOTE position, local push-button controls are inhibited. Control signals via input channels 4...13 or the direct output control programme are allowed both in the LOCAL and the REMOTE position. The position information can also be included in the Direct Output Control function.

The key can be removed both in local and in remote position.

∩ , I and O push-buttons

The 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 closed position starts flashing and if the object is open the indicator for open position starts flashing. The indicator remains flashing until a control command is given or a timeout of 10 s has elapsed.

The close and open command are given with the I (close) or O (open) push-button. Depending on the status of inputs 1…3 and 4…13 and the interlocking program logic the control module executes the selected command or turns on the INTERLOCK-LED indicating that the operation is interlocked.

The lenght of the the control output pulse can be programmed within the range 0.1…100 s.

Switchgroup SG1

| Switch | Function |
|---|---|
| SG1/1 | Switch SG1/1 is used to inhibit interlocking during testing<br><br>When SG1/1=0, the interlockings are in use<br><br>When SG1/1=1, the interlockings are not in use and the red TEST- LED is lit. All control operations are allowed.<br><br>NOTE! This switch position should be used for testing purposes only! |
| SG1/2 | Switch SG1/2 is not in use and should be in position 0. |

Display of measured values and serial communication parameters

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

| Indicator | Data to be displayed |
|---|---|
| $I_{L1}$ [kA] | The measured phase current IL1 in actual kiloamperes. The range is 0.000…999 kA, 0.000 is indicated as .000 |
| $I_{L2}$ [kA] | The measured phase current IL2 in actual kiloamperes. The range is 0.000…999 kA, 0.000 is indicated as .000 |
| $I_{L3}$ [kA] | The measured phase current IL3 in actual kiloamperes. The range is 0.000…999 kA, 0.000 is indicated as .000 |
| P [MW] | The measured active power in megawatts. Both positive and negative values are indicated.<br>The positive values have no sign but the negative sign is indicated by the red digit |
| Q [MVar] | The measured reactive power in megavars. Both positive and negative values are indicated.<br>The positive values have no sign but the negative sign is indicated by the red digit |
| E [GWh,MWh,kWh] | The measured active energy. The energy is displayed in three parts; in gigawatthours, in megawatthours and in kilowatthours |

The serial communication parameters are indicated by the four-digit display. The address of the data to be displayed is indicated by the red digit at the extreme left 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. May have values 4.8 or 9.6 kBd. The default value is 9.6 kBd. |
| C | Serial communication monitor. If the device is connected to a data communicator and the communication system is operating the monitor reading is 0, otherwise the numbers 0…255 are scrolling in the display. |

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

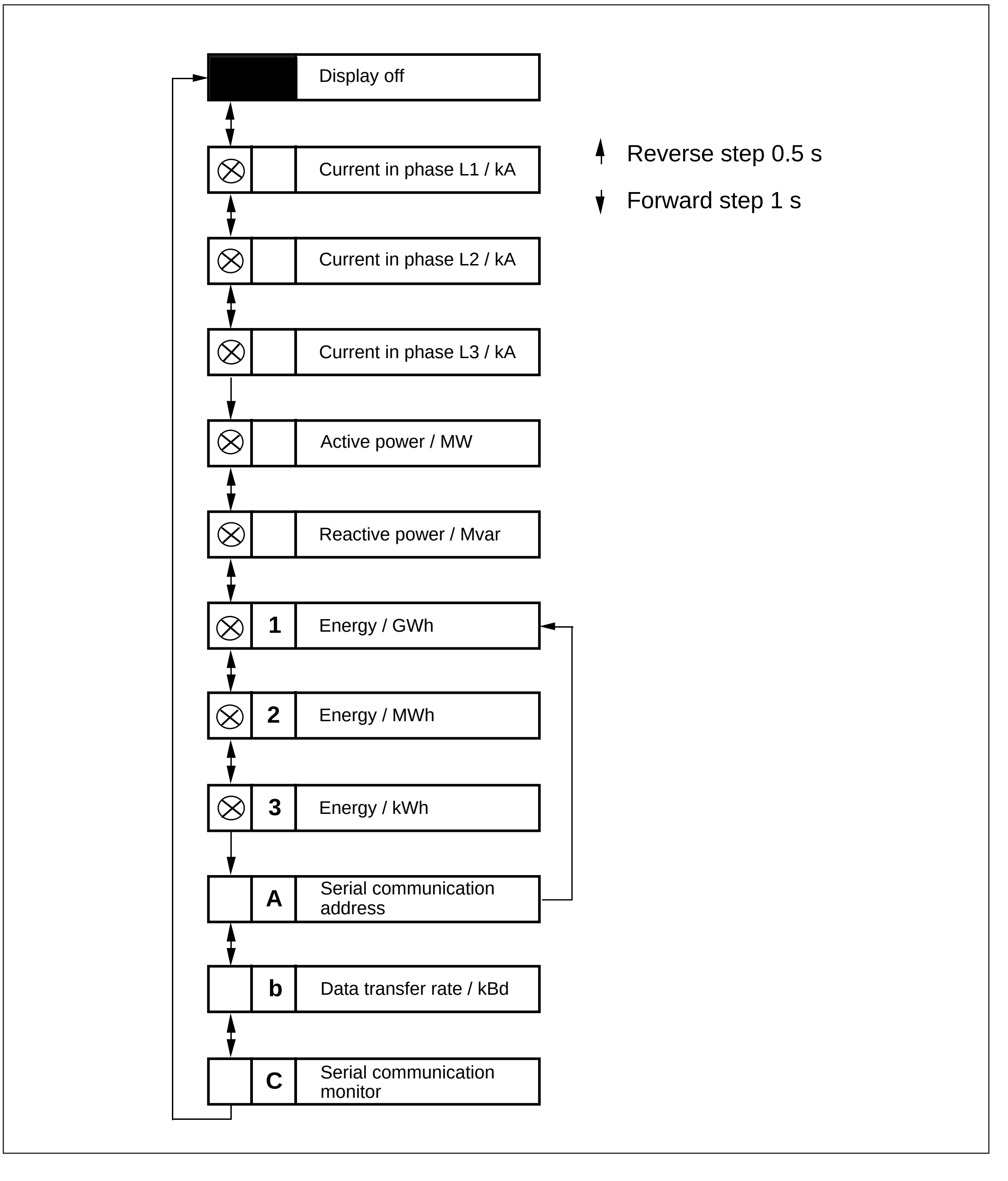



Fig. 5. Display menu of the control module SPTO 1D5.

RS 232 interface

The 9-pin RS 232 interface on the front panel is to be used for programming the control module from a terminal or a PC. The control module SPTO 1D5 supervises the serial communication of the feeder terminal. This enables protection modules of the same terminal to be set via the RS 232 interface.

If a terminal or a PC is connected to the RS 232 interface the SPA-bus interface on the rear panel of the feeder terminal is disconnected. When using the RS 232 interface, the SPA-bus protocol has to be used.

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 next table shows the signal names and pin numbers of the cable to be used between the RS 232 interface and a programming device.

| RS 232 interface of SPTO 1D5 | | Programming 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 | 2 | 3 | 2 | Data transmit |
| Data transmit | 3 | 2 | 3 | Data receive |
| Ground | 5 | 5 | 7 | Ground |
| DSR | 6 | 4 | 20 | DTR |
| DTR, +12V | 4 | - | - | - |

Pin 4 of the RS 232 interface of the control module SPTO 1D5 can be used for feeding supply voltage to an optic modem. An optic modem may be necessary between the control module and the programming device if the possible potential difference cannot be eliminated.

## Programming

### Configuration

The control module SPTO 1D5 is capable of indicating the status of 3 objects (circuit breakers or disconnectors) and to control (open or close) one object.

The control module can be used for different circuit breaker/disconnector/earth-switch configurations within the above mentioned limits. The configuration can be defined freely by using configuration commands explained below or by choosing a suitable default configuration. Each default configuration uses a fixed interlocking scheme.

The default configurations and interlockings are explained in the appendixes 1…3. If the configuration or the interlocking is not suitable for a certain application then both must be programmed by the user.

After factory testing the default configuration and interlocking 3 has been selected for the control module. Another default configuration is chosen by writing the configuration number for variable S100 via the SPA bus.

Normally the control module is in the run mode which means that the interlocking program is executed. When programming a configuration or selecting a new default setting the control module must be in the program mode (S198=0).

Example 1: Selection of the default configuration and interlocking 11 instead of default 3.

```
>99WS198:0:XX
   ; Change into program mode
>99WS100:11:XX
   ; Select the default 11
>99WS198:1:XX
   ; Change into run mode
>99WV151:1:XX
   ; Store the programmed parameters
```

If variable 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 can be used to read status data of circuit breaker and disconnectors. The input channel numbers are used when programming the feeder terminal configuration.

The front panel indicators are numbered from 101 to 116. These numbers are used when programming the feeder terminal configuration. The positions and the numbers of the indicators in the matrix are shown in Fig. 6.

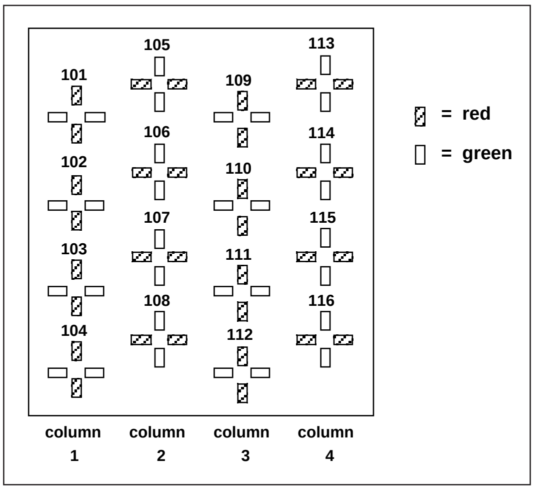



Fig. 6. Position, number and colour of the indicators on the front panel of SPTO 1D5.

The control module has two outputs, OPEN and CLOSE, for controlling one object. The control outputs have their own codes, 20 and 21, which have to be used when programming a configuration. The corresponding operation is given in the following table.

| Output code | Operation |
|---|---|
| 20 | OPEN |
| 21 | CLOSE |

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

When programming a configuration an indicator number, a four-pole input number and an output code are linked together using one SPA protocol command.

The setting parameters S101…S116 which refer to the indicator numbers 101…116 are reserved for the configuration commands. As an output number either the code of OPEN output or CLOSE output can be used. Also some other parameter, such as type of object and position of open and closed status indicators, are defined in the SPA protocol command.

Example 2: Indicator 109 (S109) indicates the status read via input channel 2. Output 20 is used for opening the object which means that output 21 must be used for closing the same object. The object is a circuit breaker and the closed status is indicated by vertical red LEDs.

The command has the formula:

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

- 1 → Type of object
  0 = not circuit breaker
  1 = circuit breaker
- 20 → Output code
  0 = object is not controlled
  20 = code of OPEN output
  21 = code of CLOSE output
  Note! Either 20 or 21 can be used if the object is to be controlled.
- 2 → Input channel number
  Channels 1…3
- 1 → Defines the vertical/horizontal position of open/closed indication
  0 = vertical LEDs indicate open status
  (horizontal LEDs indicate closed status)
  1 = vertical LEDs indicate closed status
  (horizontal LEDs indicate open status)
- 1 → Defines the use of object indicator
  0 = not used
  1 = used
- 109 → Number of object indicator
- WS → Write Setting
- 99 → Data communication address
  Default value is 99

Syntax rules for programming the configuration for SPTO 1D5:

1. The programming has to be done in the program mode.
2. Maximum three objects can be configured (three settings in the range of S101…S116).
3. Only input channel numbers 1…3 are accepted. Each number can be used only once.
4. If an object indicator is not used, no other values need to be given.
5. Output code 20 or 21 can be given only once. If the output code is 0, the definition of the object (CB/other object) need not be given.
6. Only one object can be defined to be a circuit breaker.

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

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

Example 3: To program a configuration similar to the default configuration 3 (indicator 109 CB truck, indicator 110 CB and indicator 116 earth-switch), the following commands are required:

```
>99WS198:0:XX
   ; Change into program mode
>99WS100:0:XX
   ; Change into freely programmable mode
>99WS109:1,1,1,0:XX
   ; CB truck : vertical red LEDs indicate
     closed status, input channel 1, not
   controlled
>99WS110:1,1,2,20,1:XX
   ; Circuit breaker : vertical red LEDs indi-
     cate closed status, input channel 2,
     controlled
>99WS116:1,1,3,0:XX
   ; Earth-switch : horizontal red LEDs
     indicate closed status, input channel 3,
     not controlled
>99WV151:1:XX
   ; Store the programmed parameters
```

After this also the interlocking program must be written before opening or closing of the circuit breaker is possible. See Chapter "Interlocking".

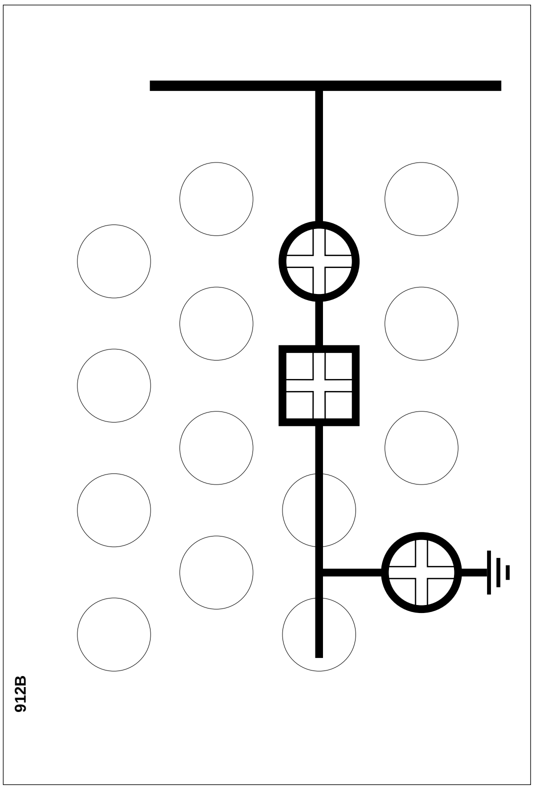



Fig. 7. Configuration programmed in the example number 3.

The programmed configuration can be read indicator by indicator or with a single command.

Example 4: To read the configuration of indicators 101…116 with one command only.

```
>99RS101/116:XX
```

This command will give all the setting values of every indicator (101 to 116 ), including those not configured into the system. The parameters of indicators not in use are zero.

Interlocking

An interlocking program is used to inhibit the closing or opening command for a controllable object in certain situations. In practice, in the control module SPTO 1D5, the interlocking 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 appendixes 1…3. If a default interlocking related to a default configuration is not suitable, both configuration and interlocking must be programmed by the user.

The interlocking system of the control module reads the status of input channels 1…3 and 4…13. The interlocking program enables the opening or closing of a controllable object but a separate open or close command must be given via the local push-buttons, the serial bus or the input channels 4…13.

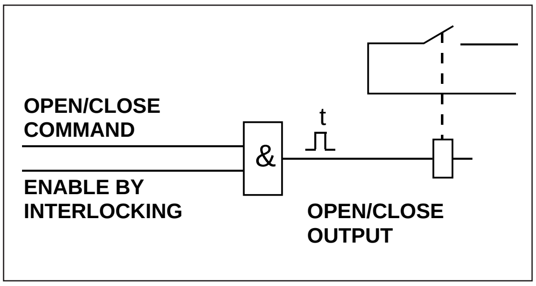



Fig. 8. Operation principle of OPEN and CLOSE outputs.

When the parameter S198 = 0, the module is in the program mode, and when the parameter S198 = 1, the module is in the run mode. In the run mode the interlocking program is executed and it cannot be changed by the operator. The operations enabled by the interlocking program can be carried out.

In the program mode the interlocking program is not executed and program changes can be done. In this mode the control of the objects is not allowed, except in the case that interlockings are completely out of use. The interlocking is programmed or a default interlocking is selected in the program mode.

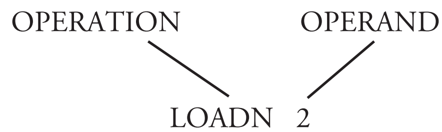
The interlocking logic, when used, is always operative both in local and remote control mode and if the control commands are given via input channels 4…13. The interlocking program is executed every 20 ms. With setting S199 the interlocking can be taken completely out of use.

Example 5: In example 3 a configuration was programmed. If the interlockings are not used the programming continues with the following commands:

```
>99WS199:0:XX
   ; Disable interlockings
>99WV151:1:XX
   ; Store the programmed parameters
```

In this case when the interlockings are not programmed, the value 1 cannot be given for the parameter S198. However, the status indication and object control operate as normal because the interlockings are disabled.

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




OPERATION is a logic command
OPERAND is a code of an input or an output or a 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 the program |

For inputs 1…3 a separate operand code is defined for each status, open, closed or undefined. The activated status of inputs 4…13 can be used as an operand in the logic.

In SPTO 1D5 the following operand values can be used with operations LOAD, LOADN, AND, ANDN, OR, ORN :

| | | |
|---|---|---|
| 1…3 | = input channel number | ; Code of an input, if the status "closed" should be used |
| 101…103 | = input channel number + 100 | ; Code of an input, if the status "undefined" should be used |
| 201…203 | = input channel number + 200 | ; Code of an input, if the status "open" should be used |
| 4…13 | = input channel number | ; Code of an input, if the status "active" should be used |
| 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 SPTO 1D5 the following operand values can be used with operation OUT:

| | |
|---|---|
| 20 or 21 | ; Code of an output |
| 70…89 | ; Number of a temporary register |

The input channel numbers and the output codes are those defined when programming the configuration.

The two special registers, 60 and 61, have constant values; register 60 is always zero and register 61 one. The registers 70...89 are used as temporary data storage 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 the input 1
>99WM201:AND 202:XX
   ; Read the open status of an object wired
     to the input 2
>99WM202:OUT 70:XX
   ; Write the result of the logic operation into
     register 70
```

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

Syntax rules for programming the interlocking for SPTO 1D5:

1. The interlockings have to be programmed in the program 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 row number of the interlocking program.
4. The program always begins at M200 and must not include empty lines.
5. The program always begins with the command LOAD or LOADN.
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 command, the OUT command should be used.
9. Before the END command an OUT command should be used.

Example 8: Programming of an interlocking logic. This example is related to 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 CB truck is in the isolating position or in the service position and the earth-switch is open.

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

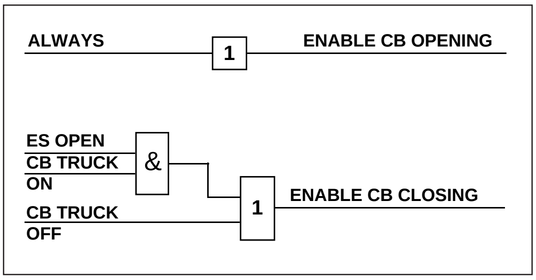



Fig. 9. Simple logic diagram for the interlocking logic for example 8

Below a detailed logic diagram is drawn.

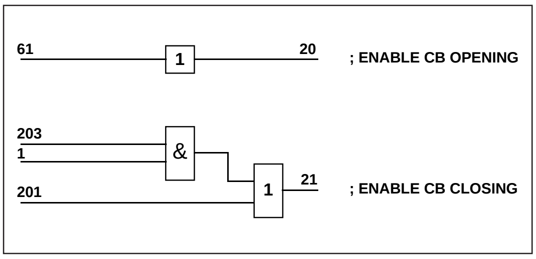



Fig. 10. Detailed logic diagram of the interlocking logic for example 8

The actual 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 interlocking commands given by the operator are written over these END commands.

A configuration was programmed in example 3. If the interlockings described above are taken into use the programming 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 the open command of
     the CB
>99WM202:LOAD 1:XX
   ; Read the in service status of the CB truck
>99WM203:AND 203:XX
   ; Read the open status of the earth-switch
>99WM204:OR 201:XX
   ; Read the isolated status of the CB truck
>99WM205:OUT 21:XX
   ; Enable the close command of the CB
>99WM206:END:XX
   ; End of interlocking program

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

The program is automatically compiled, when changing back into the run mode. If there are syntax errors in the program, the compiling will not be passed and the interlocking stays in the program mode. First the syntax errors must be corrected and then the interlocking system can be changed into the run 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 on. 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 , then variable S199 can be set to 0. Then the opening or closing of an object is always enabled.

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

## Conditional Direct Output Control

The Conditional Direct Output Control logic controls the outputs OPEN, CLOSE and SIGNAL1…3.

The outputs are activated on the basis of the programmed logic and the status of input channels 1…3 and 4…13. The controlled output remains active as long as the statuses of the inputs which caused the operation do not change.

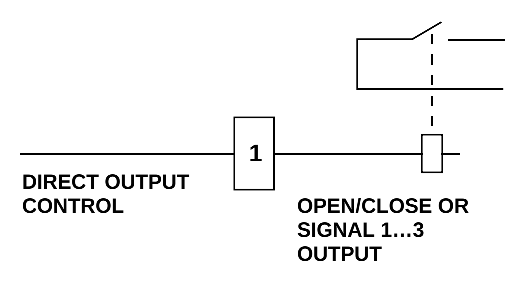



Fig. 11. Operation principle of Conditional Direct Output Control.

The programming principles and the program structure of the Conditional Direct Output Control are the same as those of the interlocking logic. The differences between these two logic programs are;

- The codes of OPEN and CLOSE outputs
- The outputs SIGNAL1…3 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 |

The 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 logic was programmed in example 8. In this example a Conditional Direct Output Control logic is added for SIGNAL 3 output.

The SIGNAL 3 output will be activated when:

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

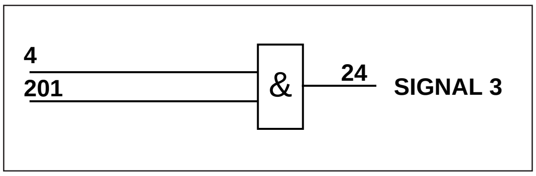



Fig. 12. Detailed logic diagram of the Conditional Direct Output Control logic for the example number 9.

The described Conditional Direct Output Control logic is effectuated with the following commands.

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

>99WS198:1:XX
   ;Change the program into run mode
>99WS199:1:XX
   ;Effectuate the 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 and disconnector status information. The binary signals can be external contact signals or internal binary signals, e.g. starting and tripping signals of protective relay modules. For the definition of internal and external signals see chapter "Intermodular control signal exchange" in the user´s manual of the feeder terminal.

The status of the binary inputs 4…13 can be read via the serial bus. The status of the input channels 4…9 is also indicated locally by LEDs on the front panel. A LED is lit when the corresponding input becomes active and the LED is switched off when the corresponding input becomes inactive. The indicators of the input channel 4...9 can individually be set to be memory controlled by parameter S5, which means that the indicator of the 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 defined to be active at high state or at low state by using parameter S2. The high state activity means that an input is considered to be active if there is a voltage connected to the corresponding external input or if a protective relay module has activated its output signal. Low state activity is the opposite to high state activity. As a default all the inputs are active at high state.

The following features are related to input channels 4…13:

- Events are formed by status changes
- The channels can be used to activate the OPEN or CLOSE output pulse
- The channels can be used to inhibit the OPEN or CLOSE output pulse
- The channels can be used to activate one of the outputs SIGNAL1…3
- The channels may be included in the interlocking program logic
- The channels may be included in the Conditional Direct Output Control logic
- Channel 7 can be used as an energy pulse counter, see chapter "Scaling of measurements".

When using an input channel one signal output (SIGNAL1…3) 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 defined by parameters S3 and S4.

The position of the R/L keyswitch is without significance when the control outputs (OPEN or CLOSE) are controlled via inputs 4…13, but a check with the interlocking logics is always made before a control action.

If an input channel is defined 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 run mode.

```
>99W8S2:1:XX
    ; Define input 8 to be active at high state
>99W8S3:22:XX
    ; Configure input 8 to activate the SIG-
      NAL1 output
>99W8S4:20:XX
    ; Configure input 8 to activate the OPEN
      output pulse
>99WV151:1:XX
    ; Store the programmed parameters
```

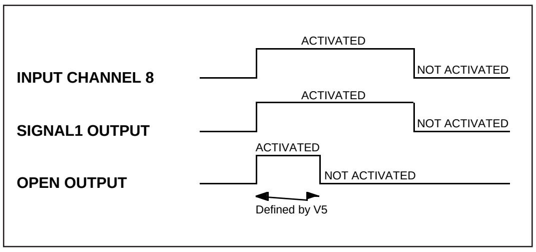



Fig. 13. Operation of outputs SIGNAL1 and OPEN when input channel 8 in example 10 is activated.

If an input channel is used for inhibiting a control command the opening or closing of an object is inhibited as long as the input is active. If the interlockings are out of use (S199=0), the input channels 4…13 cannot be used to inhibit the OPEN and CLOSE outputs.

If the input 7 is operating as an energy pulse counter, it cannot be used for other purposes. As a default the input channels 4…13 are operating in a general input mode, but are not activating or inhibiting any outputs.

## Outputs

The control module SPTO 1D5 has five outputs: three signal outputs (SIGNAL1…3) and two control outputs (OPEN and CLOSE). For programming 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 | |

The OPEN and CLOSE outputs can be controlled in four ways:

- Locally by using the OPEN and CLOSE push-buttons
- Remotely by commands over the serial bus
- Remotely via the binary inputs 4…13, see chapter "Input channels 4…13"
- By the Conditional Direct Output Control logic, see chapter "Conditional Direct Output Control"

To define the object to be controlled via the outputs OPEN and CLOSE, see chapter "Configuration".

When using the three first ways of operation the OPEN and CLOSE outputs give pulses. Before the output is activated the interlocking logic must enable the operation.

The pulse lengths for opening and closing outputs are defined with the SPA bus variables V5 and V6. The definitions have to be made only for the channel on which the object to be controlled is located. As a default the object to be controlled is located on channel 2.

The pulse length can be set in the range 0.1...100 s with a time resolution of 0.1 s. As a default the values for V5 and V6 of channel 2 are 0.1 s.

Example 11: The pulse lengths can be programmed in the run mode. In default configuration 3 the object to be controlled is defined to be a CB in channel 2. To change the open and close pulse lengths from 0.1 s the following SPA bus commands are used:

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

The open and close commands are given via the serial communication to the input channel on which the object is located. The OPEN and CLOSE outputs can be controlled via the serial communication by using two different procedures:

- Direct control: An output command is given by using the parameter O1. When the parameter has been given the value 0 (open) or 1 (close) the corresponding output pulse is delivered, if enabled by the interlocking.
- Secured control: First an output is set into a state of alert by using parameter V1 for opening and parameterV2 for closing. After that the corresponding output command is executed by using parameter V3. The output pulse is given if the interlocking enables it. The state of alert is cancelled after the execute command. The state of alert can also be cancelled by using parameter V4.

When the Conditional Direct Output Control logic is used for controlling the OPEN and CLOSE output, the output is activated as long as the statuses of the inputs which have caused the operation remain unchanged.

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

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

The outputs SIGNAL1…3 can be controlled in two ways:

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

The control module SPTO 1D5 includes a self-supervision system which has its own output, IRF. The output is active when auxiliary power is connected and the self-supervision system has not detected any fault. The output signal goes low if the auxiliary power supply is switched off or a permanent fault is detected. The self-supervision output is connected to the common IRF output of the feeder terminal.

Scaling of measurements

The control module is able to measure 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. For measuring active and reactive power the module includes two mA-inputs. The output signals of external measuring transducers are wired to these two inputs. Energy can be measured in two ways; by using input 7 as a pulse counter or integrating the measured power. If the pulse counter is used an external energy meter with a pulse output is needed.

Phase currents

The three phase currents are displayed locally and transferred in actual kiloamperes via the serial bus. To be able to do this the current measurement must be scaled. The scaling is based on the entered rated current of the primary side of the primary current transformer.

Example 12: Scaling of the phase current measurement.

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

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

The scaling factor can be programmed within the range 0.00…10000.00. The default value of variable S9 after factory testing is 200.00.

Active and reactive power

The value of the active power is displayed locally and transferred in actual megawatts via the serial bus. Correspondingly the value of the reactive power is displayed locally and transferred in actual megavars via the serial bus. Both negative and positive power values can be measured.

The power measurement is enabled or disabled by means of parameter S91. As a default power measurement is disabled (S91=0). The input signal range of the mA-inputs is -20…20 mA. The following setting parameters are used for scaling the inputs:

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

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

Example 13: The scale of the measured active power ranges from -50 to 135 MW and the corresponding mA range is -20…20 mA.

```
>99WS91:1:XX
   ;Enable power measurement
>99WS12:-20:XX
   ;Set low limit of the mA signal
>99WS13:+20:XX
   ;Set high limit of the mA signal
>99WS16:-50.00:XX
   ;Set value of power corresponding to
    the mA signal -20 mA
>99WS17:+135.00:XX
   ;Set value of power corresponding to
    the mA signal 20 mA
>WV151:1:XX
   ;Store the programmed parameters
```

Example 14: The scale of the measured reactive power ranges from 0 to 2.2 Mvar and the corresponding mA range is 4...20 mA.

```
>99WS91:1:XX
   ;Enable power measurement
>99WS14:+4:XX
   ;Set the low limit of the mA signal
>99WS15:+20:XX
   ;Set the high limit of the mA signal
>99WS18:+0.00:XX
   ;Set the value of power corresponding
    to the mA signal 4 mA
>99WS19:+2.20:XX
   ; Set the value of the power corresponding
    to the mA-signal 20 mA
>99WV151:1:XX
   ;Store the programmed parameters
```

The scaled active and reactive power can be transmitted to the remote control system as SPA-bus variables V3 and V4 for the active power and reactive power respectively.

Energy

Input channel 7 can be used for counting energy pulses. The measured energy is displayed locally by three digits in three parts; in kilowatthours, in megawatthours and in gigawatthours. Correspondingly, the energy value can be read via the serial bus in three parts with maximum three digits (parameters V8…V10) but also in one part in kilowatthours with maximum nine digits (parameter V5). Before the pulse counter can be used the energy measurement must be enabled by variable S92. As a default energy is not measured (S92=0).

The following parameters must be defined for channel 7:

S1 = definition of channel 7
- 0 = general ON/OFF input (default)
- 1 = pulse counter without local indication with front panel LED
- 2 = pulse counter with local indication with front panel LED

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, range 0.01…1000 kWh per pulse. Default value is 1.

Example 15: Measurement of energy via the pulse counter.

```
>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
```

The energy can also be integrated by using the measured active and reactive power. In this case the measured active energy in one direction is displayed locally whereas the measured active and reactive energy can be read in both directions via the serial bus.

The integration is used automatically if the energy measurement is enabled by parameter S92 but input channel 7 is not defined as a pulse counter.

Example 16: Measurement of energy by integrating the measured power. Initially the measurement of power must be enabled and scaled, see examples 13 and 14.

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

Event codes

Over the SPA bus substation level data communicator can read the event data, change in status, produced by the control module SPTO 1D2. The events are represented by the event codes e.g. 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 second)
channel number = 0...13
event code = E1...E54, depending on the channel

Example 17: Calculation of the event mask.

Most of the event codes and the events represented by these may be included in or excluded from the event reporting by writing an event mask (V155) to the module. The event mask is a binary number coded to a decimal number. Each channel (0...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 event is included in the reporting, or by 0, which means that event is not included in the reporting, and finally adding up the results of multiplications.

| 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 | Output activation fault | 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 channels 4…13 may have a value within the range 0…15 and the event mask of channels 1…3 within the range 0…2047. The default values are shown in the next table.

Channels 1...13 have a setting S20, which enables or inhibits the event reporting of the corresponding channel. The default value is 0, which means that event reporting is allowed according to event mask.

The settings S10...S13 for channels 1...3 and settings S10 and S11 for channels 4…13 define the event delays. The event 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 event is the actual event time added with the delay time.

The control module has the following event codes:

| Channel | Code | Event | Number representing the event | Default value |
|---|---|---|---|---|
| 0 | E1 | Key switch to LOCAL position | 1 | 1 |
| 0 | E2 | Key switch to REMOTE position | 2 | 1 |
| 0 | E3 | Output test switch SG1/1 ON | 4 | 0 |
| 0 | E4 | Output test switch SG1/1 OFF | 8 | 0 |

V155 = 3

| | | | | |
|---|---|---|---|---|
| 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 | Output activation fault 2) | 512 | 1 |
| 1…3 | E11 | Trying to activate an output without open/close selection 3) | 1024 | 1 |

V155 =1875

| | | | | |
|---|---|---|---|---|
| 4…13 | E1 | Input channel activated | 1 | 1 |
| 4…13 | E2 | Input channel reset | 2 | 1 |
| 4…13 | E3 | SIGNAL1…3 output activated | 4 | 0 |
| 4…13 | E4 | SIGNAL1…3 output reset | 8 | 0 |

V155 = 3

| | | | | |
|---|---|---|---|---|
| 0 | E50 | Restarting | * | - |
| 0 | E51 | Overflow of event register | * | - |
| 0 | E52 | Temporary disturbance in data communication | * | - |
| 0 | E53 | No response from the module over the data communication | * | - |
| 0 | E54 | The module responds again over the data communication | * | - |

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

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

1) Event E9, output activation inhibited, is given when 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.

Programming quick reference

If all the parameters are programmed at the same time the following instructions should be used when changing between program and run mode and when storing the parameters.

As a default the parameters related to interlocking and configuration have the following values:

S100 = 3
    Default configuration and interlocking 3
S198 = 1
    The interlocking program is in run mode
S199 = 1
    Interlockings are in use

The following examples illustrate the programming.

Example 18: Select another configuration and interlocking than default 3.

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

Example 19: Select a user defined configuration and interlocking.

```
>99WS198:0:XX
   ;Change into program mode
>99WS100:0:XX
   ;Change into freely programmable mode
>99WS101:...
   ;Configuration commands
.
.
.
>99WM200:...
   ;Interlocking program
.
.
.
>99WS198:1:XX
   ;Change into run mode
.
   ;Change other parameters
.
.
>99WV151:1:XX
    ;Store the programmed parameters
```

Serial communication parameters

A part 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 in phase L1 (x $I_n$) | 0 | I1 | R | 0.00…2.50 x $I_n$ |
| Current in phase L2 (x $I_n$) | 0 | I2 | R | 0.00…2.50 x $I_n$ |
| Current in phase L3 (x $I_n$) | 0 | I3 | R | 0.00…2.50 x $I_n$ |
| Active power (bits) | 0 | I4 | R | -1023…1023 bits |
| Reactive power (bits) | 0 | I5 | R | -1023…1023 bits |
| Current in phase L1 (A) | 0 | I6 | R | 0…9999 A |
| Current in phase L2 (A) | 0 | I7 | R | 0…9999 A |
| Current in phase L3 (A) | 0 | I8 | R | 0…9999 A |
| Status of an object | 1…3 | I1 | R | 0 = undefined (inputs 00)<br>1 = closed<br>2 = open<br>3 = undefined (inputs 11) |
| Closed status of an object | 1…3 | I2 | R | 0 = not closed<br>1 = closed |
| Open status of an object | 1…3 | I3 | R | 0 = not open |
| Status of inputs 4…13 | 4…13 | I1 | R | 0 = not active<br>1 = active |
| Direct output write | 1…3 | O1 | W | 0 = open<br>1 = close |
| Open select (secured operation) | 1…3 | V1 | RW | 0 = non select<br>1 = select |
| Close select (secured operation) | 1…3 | V2 | RW | 0 = non select<br>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 addr. 900) | 0 | V251 | W | 1 = execute all selected operations |
| Cancel selected open/close operations (common addr. 900) | 0 | V252 | W | 1 = cancel all selected operations |
| kWh value per pulse | 0 | S3 | RW(e) | 0.01…1000 kWh per pulse |
| Position of switch SG1/1 | 0 | S6 | R | 0 = operation position (SG1/1=0)<br>1 = interlockings off (SG1/1=1) |
| Object indication mode | 0 | S7 | RW(e) | 0 = continuous display<br>1 = automatic switch-off after 10 min. |
| Display indication mode | 0 | S8 | RW(e) | 0 = continuous display<br>1 = automatic switch-off after 5 min. |
| Scaling of current measurement | 0 | S9 | RW(e) | 0.00…10000.00 |

| Data | Channel | Code | Data direction | Values |
|---|---|---|---|---|
| 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 react. power | 0 | S14 | RW(e) | -20…+20 mA |
| High limit for mA signal of react. 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<br>1 = power is measured |
| Energy measurement | 0 | S92 | RW(e) | 0 = no energy measurement<br>1 = energy is measured |
| Configuration and interlocking | 0 | S100 | RW(e) | 0 = freely programmable configuration and interlocking program<br>2 = default 2<br>3 = default 3<br>11 = default 11 |
| Configuration of objects (format; value 1, value 2, input No, output No, value 3) | 0 | S101<br>:<br>S116 | RW(e) | - value 1;<br>0 = indicator not used<br>1 = indicator used<br>- value 2;<br>0 = vertical LEDs indicate open status<br>1 = vertical LEDs indicate closed status<br>- input number;<br>1…3 = input number 1…3<br>- output number;<br>0 = not controlled object<br>20 or 21 = outputs 20 and 21 used<br>- value 3;<br>0 =object other than a CB<br>1 = object is a CB |
| Program/run mode selection | 0 | S198 | RW(e) | 0 = program mode<br>1 = run mode |
| Interlocking selection | 0 | S199 | RW(e) | 0 = no interlockings<br>1 = interlockings in use |

| Data | Channel | Code | Data direction | Values |
|---|---|---|---|---|
| Interlocking and Conditional Direct Output Control program (format; operation, operand) | 0 | M200 : M300 | RW(e) | operation = LOAD, LOADN AND, ANDN OR, ORN OUT END operands for inter-locking = status closed (1…3) or active (4…13) status undefined (101…103) status open (201…203) No. of output (20 or 21) Special register (60, 61) position of L/R key (62) No. of memory (70…89) operands for Conditional Direct Output Control = status closed (1…3) or active (4…13) status undefined (101…103) status open (201…203) No of output (22…24, 220 or 221) Special register (60, 61) position of L/R key (62) No. of memory (70…89) |
| Event delay; —>10 (open) | 1…3 | S10 | RW(e) | 0.0, or 0.1…60.0 s |
| Event delay; —>01 (close) | 1…3 | S11 | RW(e) | 0.0, or 0.1…60.0 s |
| Event delay; —>11 (undefined) | 1…3 | S12 | RW(e) | 0.0, or 0.1…60.0 s |
| Event delay; —>00 (undefined) | 1…3 | S13 | RW(e) | 0.0, or 0.1…60.0 s |
| Use of input 7 | 7 | S1 | RW(e) | 0 = general mode 1 = pulse counter without indication 2 = pulse counter with indication |
| Operation direction of inputs 4…13 | 4…13 | S2 | RW(e) | 0 = active at low state 1 = active at high state |
| Signal output activation by inputs 4…13 | 4…13 | S3 | RW(e) | 0 = no SIGNAL output 22 = SIGNAL1 output is activated 23 = SIGNAL2 output is activated 24 = SIGNAL3 output is activated |

| Data | Channel | Code | Data direction | Values |
|---|---|---|---|---|
| Operation of OPEN and CLOSE outputs by inputs 4…13 | 4…13 | S4 | RW(e) | 0 = no activation or inhibit<br>20 = activate OPEN output<br>21 = activate CLOSE output<br>120 = inhibit OPEN output<br>121 = inhibit CLOSE output |
| Memory controlled function of the indicators of the binary inputs | 4 ... 9 | S5 | RW(e) | 0=not memory controlled<br>1=memory controlled |
| Event delay; —>activated | 4…13 | S10 | RW(e) | 0.0, or 0.1…60.0 s |
| Event delay; —>reset | 4…13 | S11 | RW(e) | 0.0, or 0.1…60.0 s |
| Event reporting | 1…13 | S20 | RW(e) | 0 = event reporting enabled<br>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 |
| Status of the local/remote key switch | 0 | V6 | R | 0 = local<br>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 |
| Data store into EEPROM | 0 | V151 | W | 1 = store, takes ~10 s |
| Load default values after EEPROM failure | 0 | V152 | RW(e) | 0 = enable to load default values<br>1 = inhibit to load default values |
| Event mask | 0 | V155 | RW(e) | 0…15 |
| Event mask | 1…3 | V155 | RW(e) | 0…2047 |
| Event mask | 4…13 | V155 | RW(e) | 0…15 |
| Activation of self-supervision output | 0 | V165 | W | 0 = reset<br>1 = activate |
| 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, 9600 |
| Program version symbol | 0 | V205 | R | E.g. 084 B |

| Data | Channel | Code | Data direction | Values |
|---|---|---|---|---|
| Type designation of the module | 0 | F | R | SPTO 1D5 |
| 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<br>1 = module been subject to automatic reset<br>2 = overflow of event register<br>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 unit
W = Data which can be written to the unit
(e) = Data which has to be stored into EEPROM (V151) after having been changed

The data transfer codes L, B, C and T have been reserved for the event data transfer between the 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 transmission, it is possible, by using the B command, to re-read the contents of the event register once read by means of the L command. When required, the B command can be repeated.

Default values of the parameters

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

The following table lists the default values of the parameters

| Parameter | Channel | Code | Default value |
|---|---|---|---|
| Length of open pulse | 2 | V5 | 0.1 s |
| Length of close pulse | 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 react. power | 0 | S14 | +4 mA |
| High limit of mA-signal of react. power | 0 | S15 | +20 mA |
| Active power corresponding to the mA-signal at low limit | 0 | S16 | +0.00 |
| Active power corresponding to the mA-signal at high limit | 0 | S17 | +999.99 |

| Parameter | Channel | Code | Default value |
|---|---|---|---|
| Reactive power corresponding to the mA-signal at low limit | 0 | S18 | +0.00 |
| Reactive power corresponding to the mA-signal at low 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 | 3 = default configuration and interlocking 3 |
| Configuration of objects | 0 | S101<br>:<br>S116 | default configuration 3, see appendix 2 |
| | | | |
| Program/run mode selection | 0 | S198 | 1 = run mode |
| Interlocking selection | 0 | S199 | 1 = interlockings in use |
| | | | |
| Interlocking program | 0 | M200<br>:<br>M300 | default interlocking 3, see appendix 2 |
| | | | |
| Event delay; —>10 (open) | 1…3 | S10 | 0.0 s |
| Event delay; —>01 (close) | 1…3 | S11 | 0.0 s |
| Event delay; —>00, —>11 | 1 and 3 | S12 | 10.0 s |
| Event delay; —>00, —>11 | 2 | S12 | 0.2 s |
| | | | |
| Use of input 7 | 7 | S1 | 0 = general mode |
| Operation direction of inputs 4…13 | 4…13 | S2 | 1 = active at high state |
| Signal output activation by inputs 4…13 | 4…13 | S3 | 0 = no signal output |
| Operation of OPEN and CLOSE outputs by inputs 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 |
| | | | |
| Event delay; —>activated | 4…13 | S10 | 0.0 s |
| Event delay; —>reset | 4…13 | S11 | 0.0 s |
| | | | |
| Event reporting | 1…13 | S20 | 0 = event reporting enabled |
| | | | |
| Load default values after EEPROM failure | 0 | V152 | 1 = inhibited |
| | | | |
| Event mask | 0 | V155 | 3 |
| 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, earth switches
- configuration freely programmable by the user
- remote or local control (open and close) for one object
- output pulse length programmable, 0.1…100.0 s
- 10 other binary inputs to read contact data other than status information
- feeder oriented interlocking freely programmable, the 3 status inputs, 10 other binary inputs and the L/R key switch states may be included
- the 10 binary inputs may be used to operate the OPEN and CLOSE outputs
- three signal outputs, can be controlled by the 10 binary inputs

### Measurements

- measurement of three phase currents
- phase current measuring range 0…2.5 x $I_n$
- phase current measuring accuracy better than ±1 % of $I_n$
- two mA inputs for measuring active and reactive power
- mA input range -20…20 mA, can be limited by programming
- power measuring accuracy better than ±1 % of maximum value of measuring range
- one pulse counter input for energy pulse counting, maximum frequency 25 Hz
- energy can also be calculated on the basis of measured power
- all measured values can be scaled to actual primary values
- local display or remote reading of measured values

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

The configuration commands are:

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

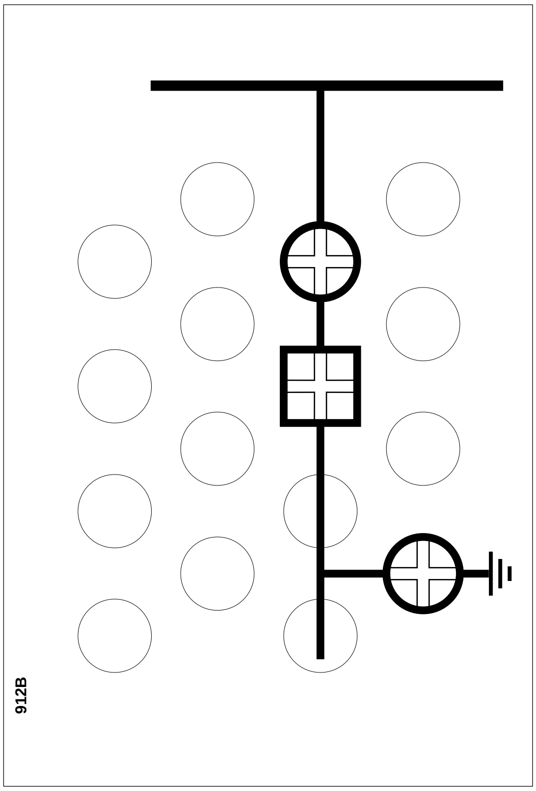



Fig. 14. Default configuration 2.

Interlocking

The following rules apply for interlocking:

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

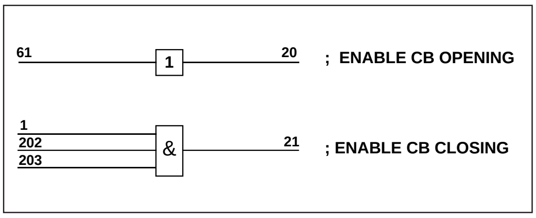



Fig. 15. Logic diagram for the default interlocking 2.

The interlocking program has the following formula:

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

## Appendix 2:

Default configuration and interlocking 3

Default configuration and interlocking 3 is selected by giving variable S100 the value 3. The other parameters have the values given in the chapter “Default values of the parameters”

Configuration

The configuration 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 OPEN (20) and CLOSE (21) output
- Circuit breaker truck;
  input channel 1, indicator 109, not controlled
- Earth-switch;
  input channel 3, indicator 116, not controlled

The configuration commands are:

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

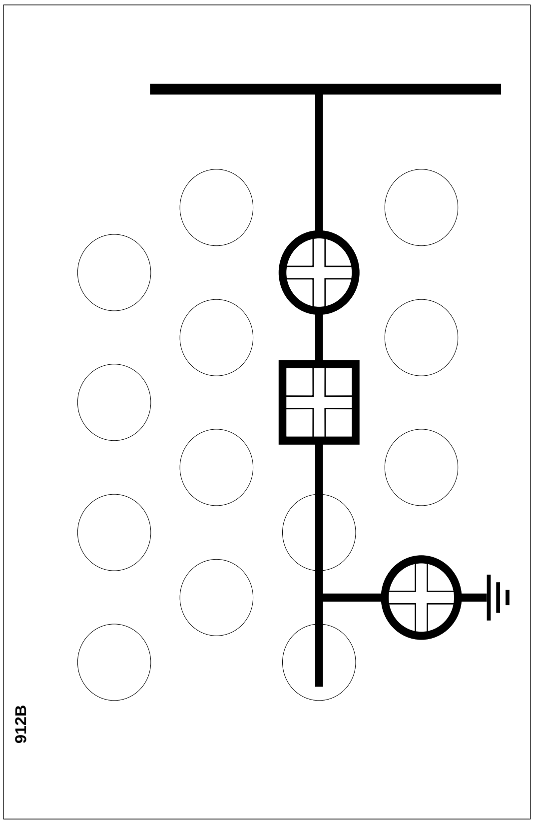



Fig. 16. Default configuration 3

nterlocking

The following rules apply for interlocking:

- The CB can always be opened.
- The CB can be closed if the CB truck is in the isolated position or if the CB truck is in the service position and the earth-switch is open and motor restarting is enabled (channel 11)

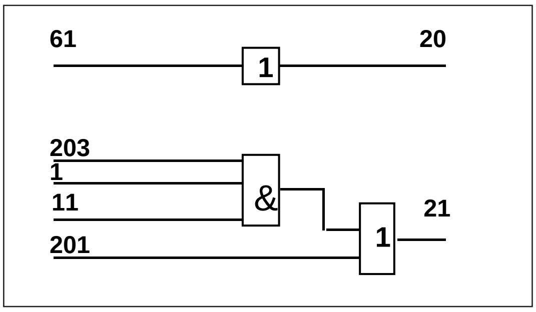



Fig. 17. Logic diagram for the default interlocking 3.

The interlocking program has the following formula:

M200:LOAD 61
M201:OUT 20
M202:LOAD 1
M203:AND11
M204:AND 203
M205:OR 201
M206:OUT 21
M207:END

**Appendix 3:**

Default configuration and interlocking 11

Default configuration and interlocking 11 is selected by giving variable S100 the value 11. The other parameters have the values given in the chapter "Default values of the parameters".

Configuration

The configuration has three objects, a circuit breaker, a circuit breaker truck and an earth-switch. The close state is indicated with green colour and the open state with red colour. This default is the same as default 1, but the colours of the object indicators are reversed. The following inputs, indicators and outputs are used:

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

The configuration commands are:

S106:1,1,1,0,0
S107:1,1,2,20,1
S 104:1,0,3,0,0

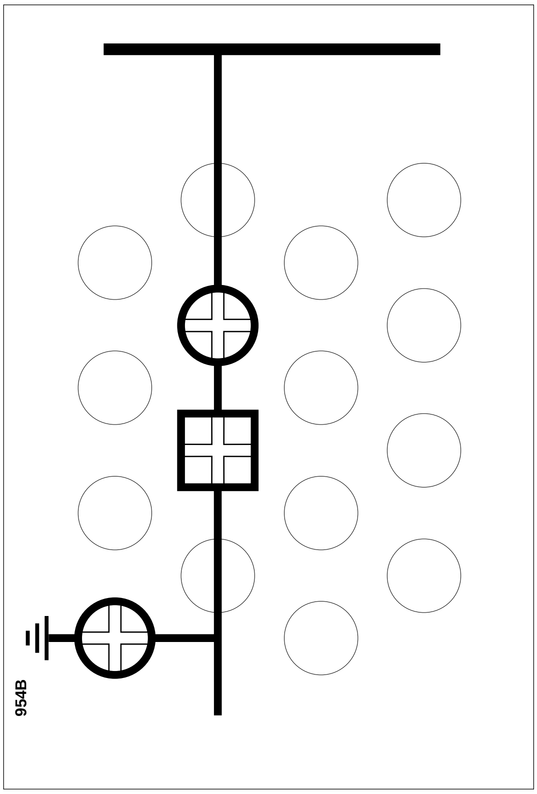



Fig. 18. Default configuration 11.

Interlocking

The interlocking is defined with the following rules:

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

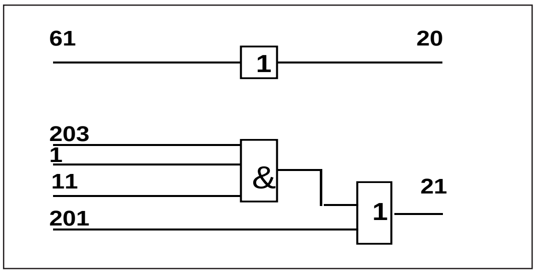



Fig. 19. Logic diagram for the default interlocking 11.

The interlocking program has the following formula:

M200:LOAD 61
M201:OUT 20
M202:LOAD 1
M203:AND 203
M204:AND 11
M205:OR 201
M206:OUT 21
M207:END

# General characteristics of D-type relay modules

## User´s manual and Technical description

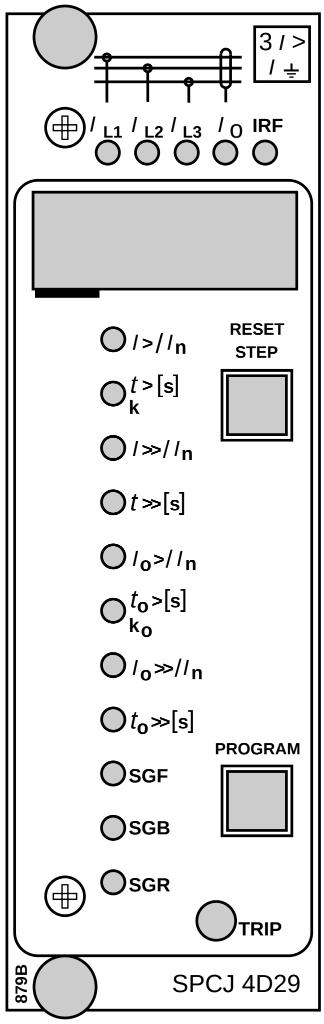
Fastening screw

Indicators for measured quantities

Indicators for setting parameters

Indicators for switchgroups SGF, SGB and SGR

Fastening screw




Relay symbol

Self-supervision alarm indicator (Internal Relay Fault)

Display, 1 + 3 digits

Reset / Step push-button

Programming push-button

Trip indicator

Module type designation

**1MRS 750066-MUM EN**

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

Data subject to change without notice

# General characteristics of D type relay modules

## Contents

## Control push-buttons

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

## Display

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

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

### Display main menu

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

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

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

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

### Display submenus

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

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

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

## Selector switchgroups SGF, SGB and SGR

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

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

| Switch No | Pos. | | Weigth | | Value |
|---|---|---|---|---|---|
| 1 | 1 | x | 1 | = | 1 |
| 2 | 0 | x | 2 | = | 0 |
| 3 | 1 | x | 4 | = | 4 |
| 4 | 1 | x | 8 | = | 8 |
| 5 | 1 | x | 16 | = | 16 |
| 6 | 0 | x | 32 | = | 0 |
| 7 | 1 | x | 64 | = | 64 |
| 8 | 0 | x | 128 | = | 0 |
| | Checksum | | $\Sigma$ | = | 93 |

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

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

## Settings

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

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

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

### Setting mode

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

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

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

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

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

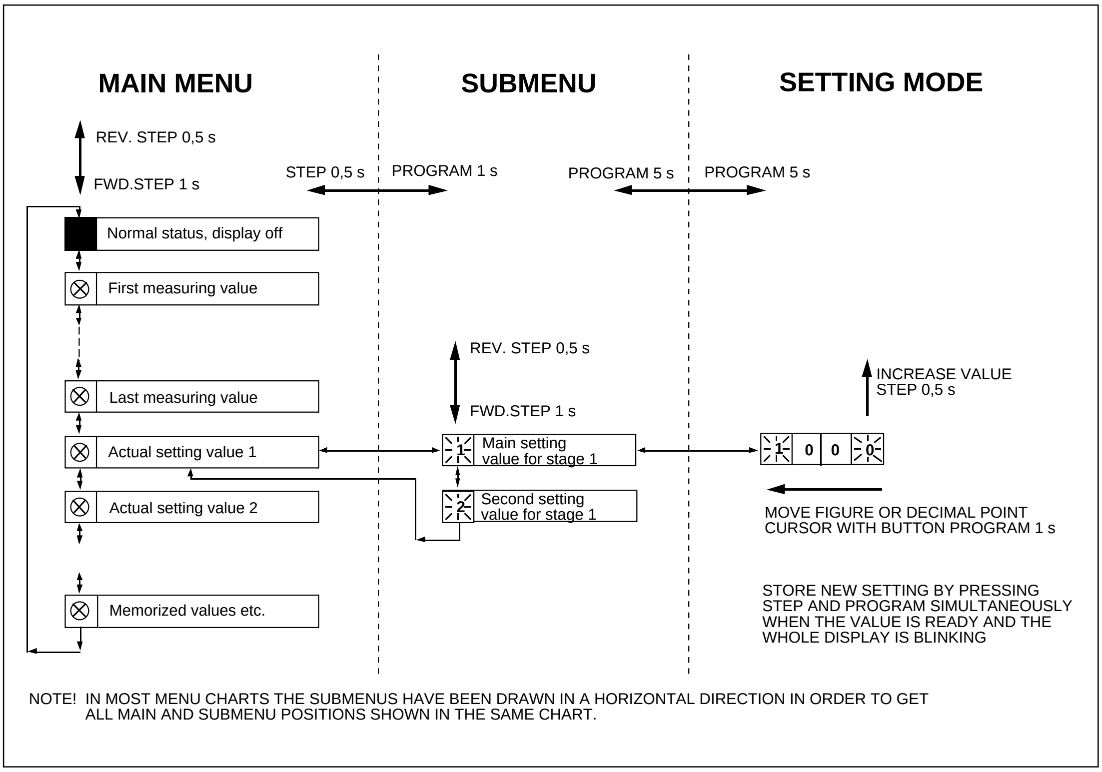



Fig.3. Basic principles of entering the main menus and submenus of a relay module.

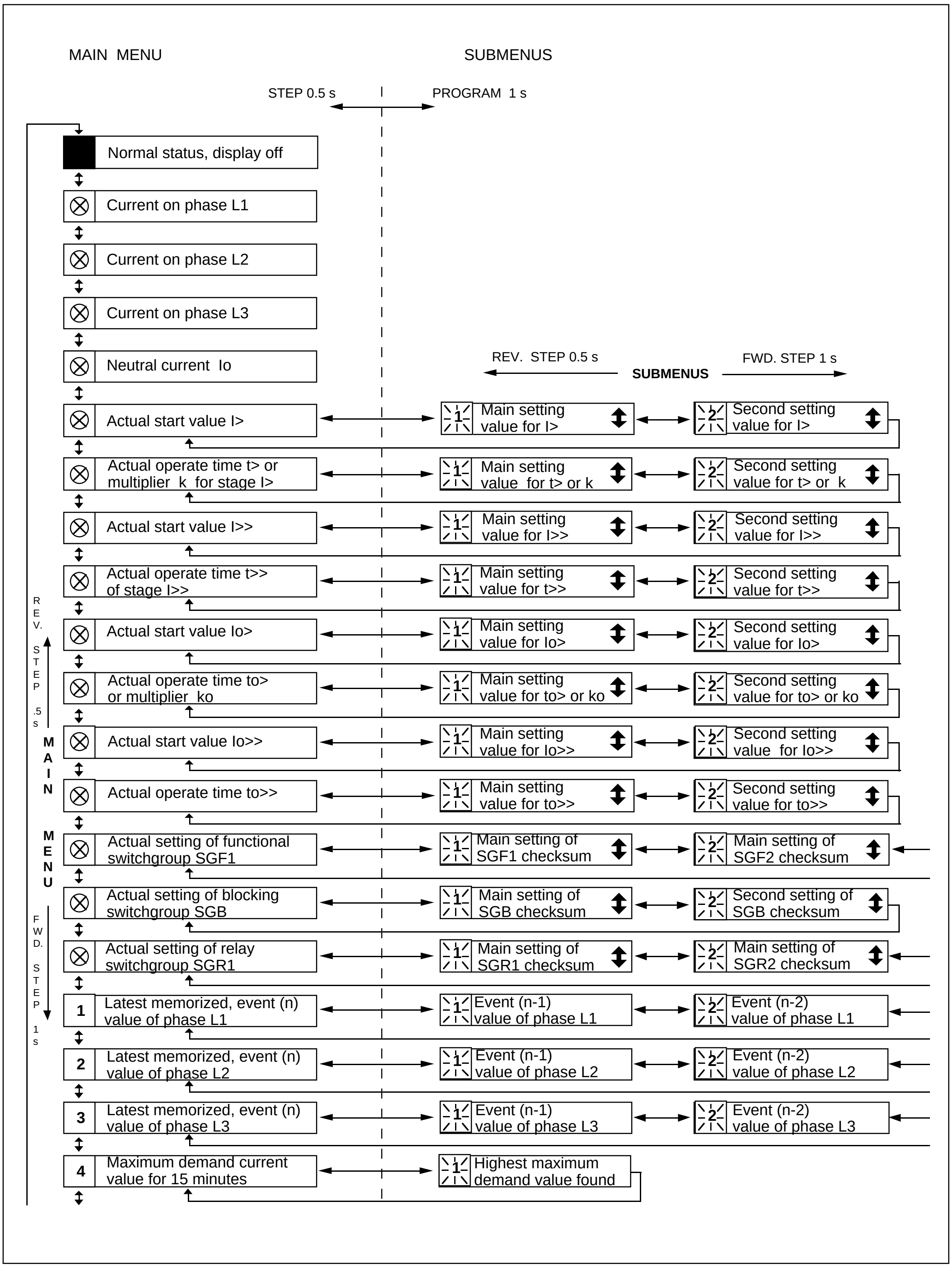
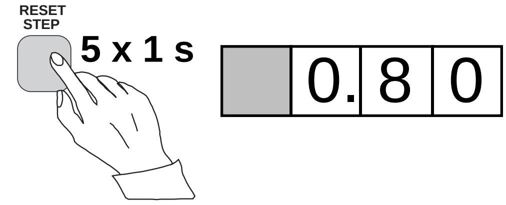



Fig. 4. Example of part of the main and submenus for the settings of the overcurrent and earth-fault relay module SPCJ 4D29. The settings currently in use are in the main manu and they are displayed by pressing the STEP push button. The main menu also includes the measured current values, the registers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

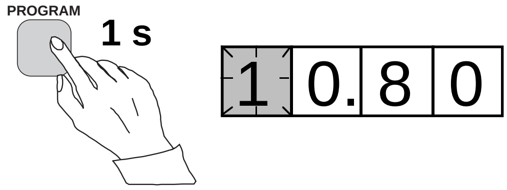
Example 1

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

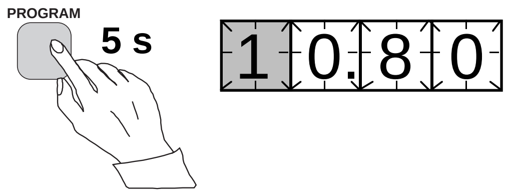
a)
Press push button STEP repeatedly until the LED close to the I> symbol is lit and the current start value appears on the display.



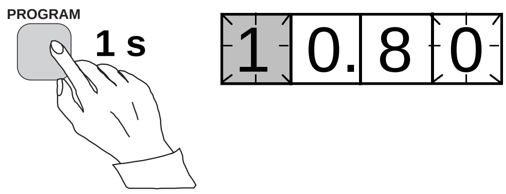

b)
Enter the submenu to get the main setting value by pressing the PROGRAM push button more than one second and then releasing it. The red display digit now shows a flashing number 1, indicating the first submenu position and the green digits show the set value.



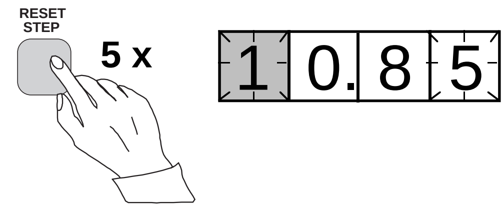

c)
Enter the setting mode by pressing the PROGRAM push button for five seconds until the display starts flashing.



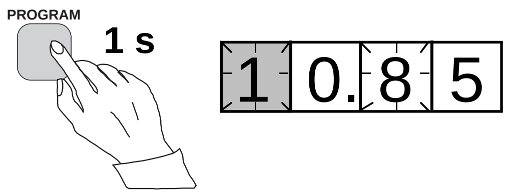

d)
Press the PROGRAM push button once again for one second to get the rightmost digit flashing.



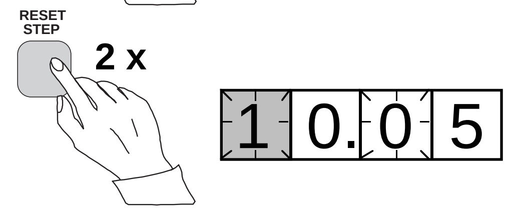

e)
Now the flashing digit can be altered. Use the STEP push button to set the digit to the desired value.



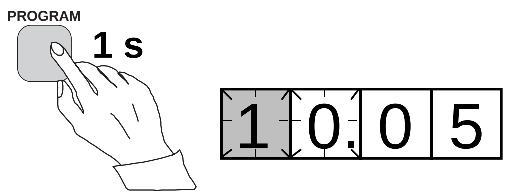

f)
Press the PROGRAM push button to make the middle one of the green digits flash.



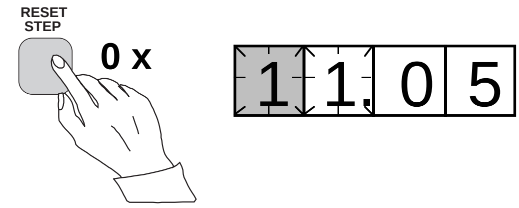

g)
Set the middle digit with of the STEP push button.



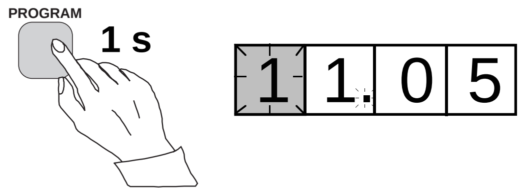

h)
Press the PROGRAM push button to make the leftmost green digit flash.



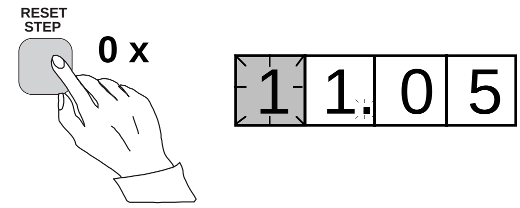
i)
Set the digit with the STEP push button.



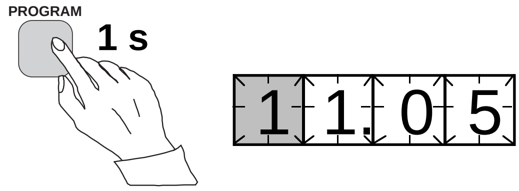

j)
Press the PROGRAM push button to make the decimal point flash.



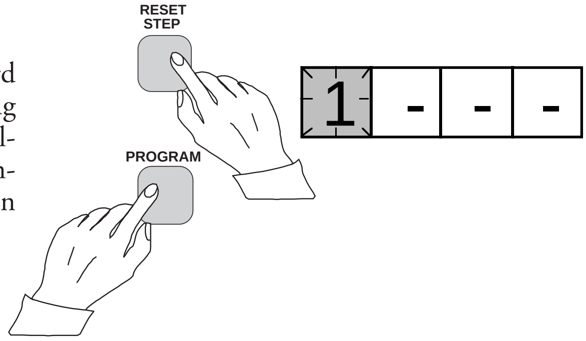

k)
If needed, move the decimal point with the STEP push button.



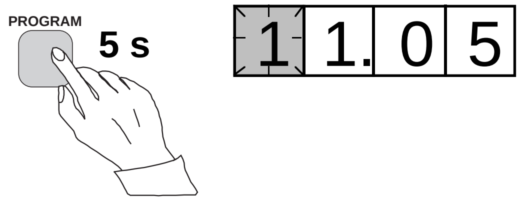

l)
Press the PROGRAM push button to make the whole display flash. In this position, corresponding to position c) above, one can see the new value before it is recorded. If the value needs changing, use the PROGRAM push button to alter the value.



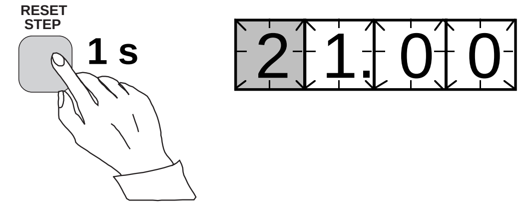

m)
When the new value has been corrected, record it in the memory of the relay module by pressing the PROGRAM and STEP push buttons simultaneously. At the moment the information enters the memory, the green dashes flash once in the display, i.e. 1 - - -.




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




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

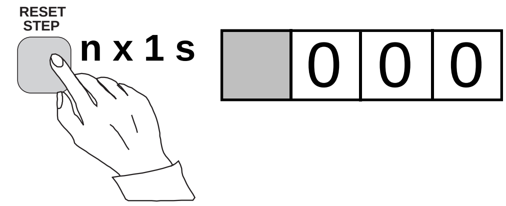



Enter the setting mode as in step c) and proceed in the same way. After recording of the requested values return to the main menu is obtained by pressing the STEP push button until the first digit is switched off. The LED still shows that one is in the I> position and the display shows the new setting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

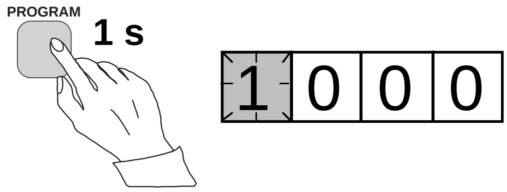
Example 2

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

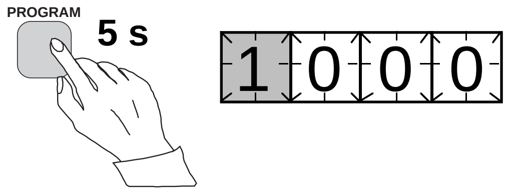
a)
Press push button STEP until the LED close to the SGF symbol is lit and the checksum appears on the display.



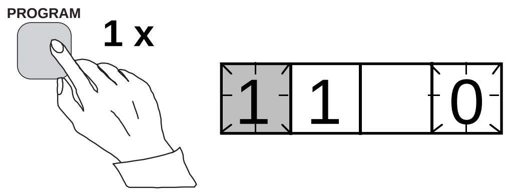

b)
Enter the submenu to get the main checksum of SGF1 by pressing the PROGRAM push button for more than one second and then releasing it. The red display now shows a flashing number 1 indicating the first submenu position and the green digits show the checksum.



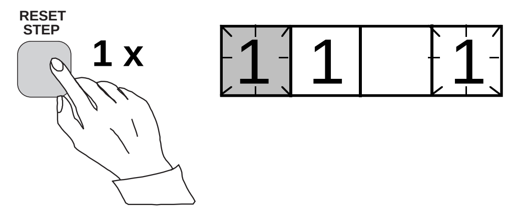

c)
Enter the setting mode by pressing the PROGRAM push button for five seconds until the display starts flashing.



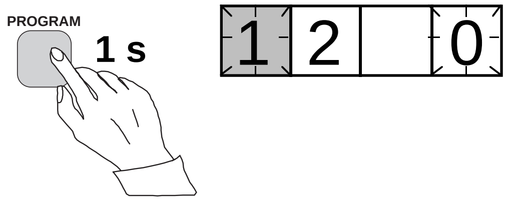

d)
Press the PROGRAM push button once again to get the first switch position. The first digit of the display now shows the switch number. The position of the switch is shown by the rightmost digit.



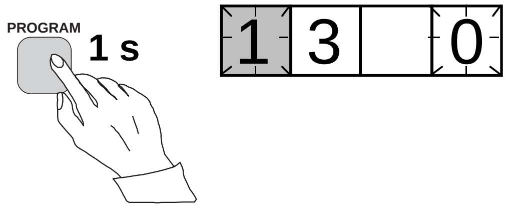

e)
The switch position can now be toggled between 1 and 0 by means of the STEP push button and it is left in the requested position 1.



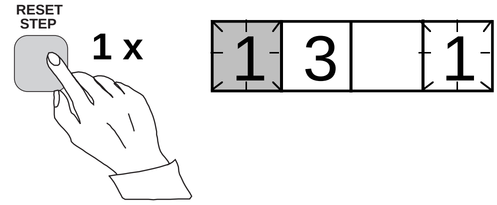

f)
When switch number 1 is in the requested position, switch number 2 is called up by pressing the PROGRAM push button for one second. As in step e), the switch position can be altered by using the STEP push button. As the desired setting for SGF1/2 is 0 the switch is left in the 0 position.



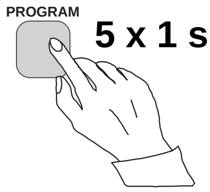

g)
Switch SGF1/3 is called up as in step f) by pressing the PROGRAM push button for about one second.



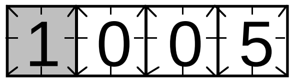
h)
The switch position is altered to the desired position 1 by pressing the STEP push button once.



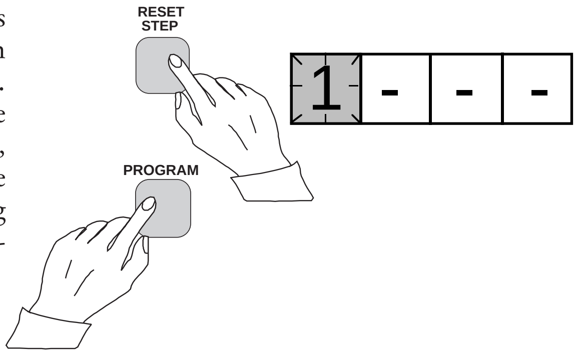

i)
Using the same procedure the switches SGF 1/ 4...8 are called up and, according to the example, left in position 0.



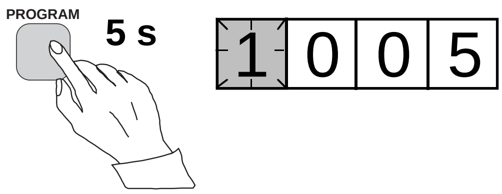

j)
In the final setting mode position, corresponding to step c), the checksum based on the set switch positions is shown.



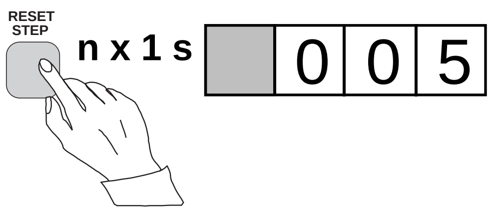

k)
If the correct checksum has been obtained, it is recorded in the memory by pressing the push buttons PROGRAM and STEP simultaneously. At the moment the information enters the memory, the green dashes flash in the display, i.e.1 - - -. If the checksum is incorrect, the setting of the separate switches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




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




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



## Recorded information

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

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

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

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

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

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

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

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

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

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

## Trip test function

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

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

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

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

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

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

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

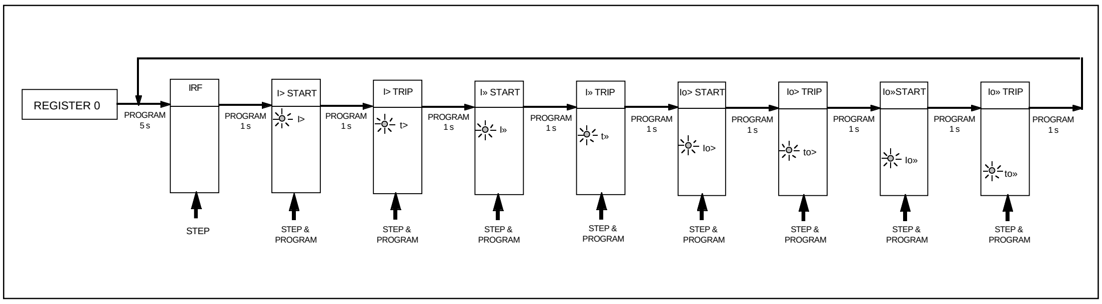



Fig. 5. Sequence order for the selection of output signals in the Trip test mode

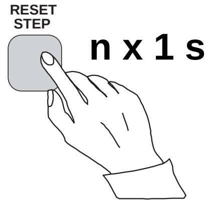
If, for instance, the indicator of the setting t> is flashing, and the push buttons STEP and PROGRAM are being pressed, the trip signal from the low-set overcurrent stage is activated. Return to the main menu is possible at any stage of the trip test sequence scheme, by pressing the PROGRAM push button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

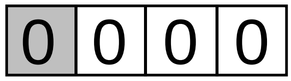
Note!
The effect on the output relays then depends on the configuration of the output relay matrix switchgroups SGR 1...3.

Example 3

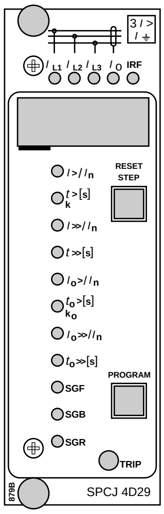
Trip test function. Forced activation of the outputs.

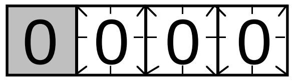
a)
Step forward on the display to register 0.

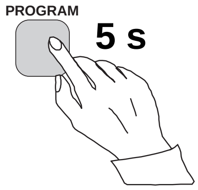



b)
Press the PROGRAM push button for about five seconds until the three green digits to the right.

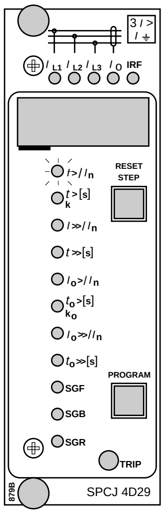


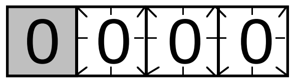



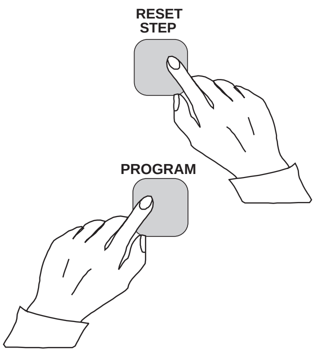

c)
Hold down the STEP push button. After one second the red IRF indicator is lit and the IRF output is activated. When the step push button is released the IRF indicator is switched off and the IRF output resets.

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

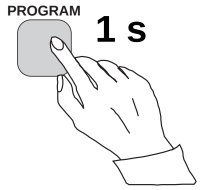


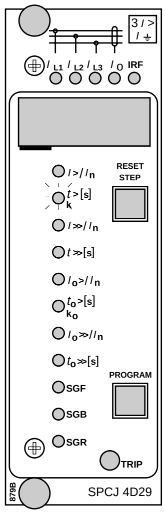



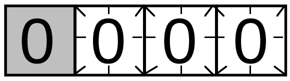

e)
If a start of the first stage is required, now press the push-buttons PROGRAM and STEP simultaneously. The stage output will be activated and the output relays will operate according to the actual programming of the relay output switchgroups SGR.



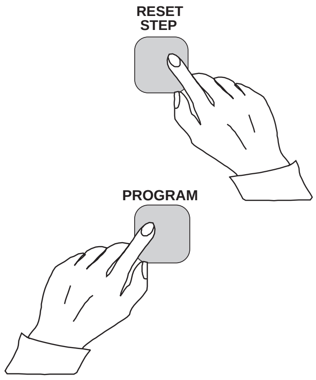
f)
To proceed to the next position press the PROGRAM push button for about 1 second until the indicator of the second setting starts flashing.

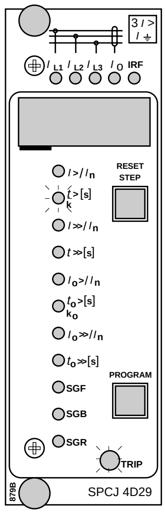


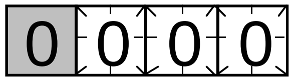




g)
Press the push buttons PROGRAM and STEP simultaneously to activate tripping of stage 1 (e.g. the I> stage of the overcurrent module SPCJ 4D29). The output relays will operate according to the actual programming of the relay switchgroups SGR. If the main trip relay is operated the trip indicator of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




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

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

## Operation indication

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

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

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

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## Fault codes

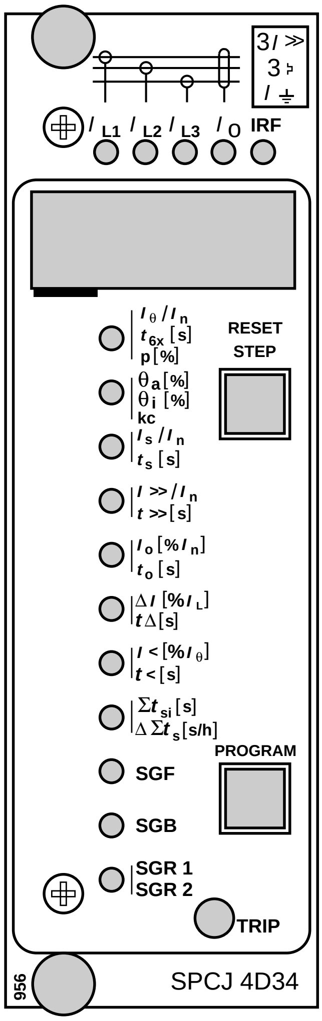
In addition to the protection functions the relay module is provided with a self-supervision system which continuously supervises the function of the microprocessor, its program execution and the electronics.

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 4D34
# Motor protection relay module

## User´s manual and Technical description



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Version B (replaces 34 SPCJ 10 EN1)
Checked GL
Approved JS

# SPCJ 4D34
# Motor protection relay module



## Contents

## Characteristics

Thermal overload protection with the motor full load current setting range 0.5...1.50 x $I_n$ and with the safe stall time setting range 2...120 s. Features also prior alarm and restart inhibition, reduced cooling at standstill etc.

High-set overcurrent stage I>> with the setting range 0.5...20 x $I_n$ with a definite time operation 0.04...30 s. The operation of the high-set overcurrent stage can be set out of function with a switch

Sensitive low-set non-directional neutral overcurrent stage $I_0$> with the setting range 1.0... 100% $I_n$, based on definite time characteristic, with a setting range 0.05...30 s

Unbalance protection with setting range 10... 40% $I_L$, fully stabilized to the load current, based on inverse time characteristic and with a basic time setting range 20...120 s

Separate incorrect phase sequence protection with a operate time of 600 ms

Start-up supervision unit, operating on definite time overcurrent or thermal stress counting with a control input for a motor speed switch signal Undercurrent protection e.g. for protection of conveyors or submersible pump drives

Cumulative start-up time counter protecting against too frequent start-up attempts

Digital display of measured and set values and sets of data recorded at the moment of tripping All settings can be keyed in using the push-buttons on the front panel, can be set by using a personal computer or via the serial communication

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

## Description of units

### Thermal overload unit

The thermal overload unit constitutes an adequate thermal protection for the motor under varying load conditions. The heating-up of a motor follows an exponential curve, the level-out value of which is determined by the squared value of the load current. The operating values of the thermal unit are defined by means of two relay settings. The full load current (FLC) setting $I_\theta$ defines the thermal operating level of the unit and the time setting $t_{6x}$ defines the operate time. The setting $t_{6x}$ is the operate time of the thermal unit at six times FLC, starting from a cold motor condition.

The thermal unit comprises two different thermal curves, one describing short and long time overloads, carrying out the tripping and an other curve keeping track of the thermal background. A weighting factor p which determines the ratio of thermal increase of the two curves is settable between 20% and 100%. For direct online started motors having a characteristic hotspot behaviour p is typically set at 50%. For the protection of objects without hot-spot characteristics, e.g. cables or motors started with soft starters, a setting p =100% is used.

A multiplexer continuously monitors the energizing input signals and selects the highest phase value. As long as the motor current stays below the set full load current $I_\theta$, the relay will not cause a tripping. It only monitors the thermal condition of the motor, in order to take the prior thermal history into account under a heavy load condition. If the current continuously exceeds the set full load current value $I_\theta$ by more than five per cent, all of the thermal capacity of the motor will be used after a time, which depends on the set FLC, the set stall time and the prior load of the motor. When the thermal level exceeds the set prior alarm level $\theta_a$, a prior alarm signal is given, if routed to an output relay with switch SGR1/1 or SGR2/1. The prior alarm is indicated by a figure 1 on the display. Tripping due to overload is indicated by a figure 2 and carried out when the thermal level exceeds 100%. Whenever the thermal capacity has reached a level above the set thermal restart inhibit level $\theta_i$, the restart enable output relay is disengaged. In this way, unnecessary motor start-up attempts are prevented. During the restart inhibit time a figure 3 is presented on the display, after that the other thermal function indications have been acknowledged.

An estimate of the waiting time left, before a successful restart can be made, is found in register 9. For thermal operate times, see the thermal trip diagrams on page 4 and 5. The restart inhibit function can be set out of operation by turning switch SG4/2 in position 1.

For varying currents, the thermal unit behaves in different ways depending on the value of the weighting factor p:

- When e.g. p = 50% the thermal unit takes into account the hot spot behaviour of the motor and distinguishes between short time thermal stress and a long time thermal history background. After a short period of thermal stress, e.g. a start-up, the thermal level quite rapidly decreases, thus simulating the levelling out of the motor hot spots. This means that the availability of the motor is higher for successive start-ups. This can be seen by comparing the hot and cold curves on page 4 and 5.
- When p = 100%, the thermal level after a heavy load condition only slowly decreases according to the new lower load level. This makes the unit suitable for applications, where no hot spot behaviour is to be expected, e.g. motors started with soft starters or cables or similar objects, where no hot spots exist.

A standstill of the motor is determined by the motor current being less than 12 per cent of $I_\theta$. During a standstill condition, the reduced cooling properties of the motor are taken into account by making the cooling time constant longer than the heating time constant determined by the $t_{6x}$ setting. The multiplier $k_c$ of the heating time constant to obtain the cooling time constant can be adjusted within the integer range 1…64.

A start-up condition of the motor is defined by a sequence, where the initial current is less than 12% of $I_\theta$, i.e. the motor is at standstill, and where the current within about 60 ms rises to a value higher than 1.5 times $I_\theta$. When the current falls below 1.25 times $I_\theta$ for a time of about 100 ms, the start-up condition is defined to be over. The start-up counter is incremented for every start and can indicate up to 999 starts, after which it starts counting from zero again. The start-up time refers to the time the current value is between the two current levels mentioned above. It should be noted that a start-up clears all front panel indications and writes a new set of memorized operational values. The start-up information can be routed to output SS1.

After a loss of auxiliary supply or whenever powered up, the relay assumes the motor to be heated up to a level corresponding to about 70 per cent of the full thermal capacity of the motor. This ensures that under heavy load conditions, tripping is carried out in a safe time. Under a low-load condition, the thermal replica of the relay slowly decays to the actual level determined by the motor currents.

Note!
At low prior alarm settings the connection of the auxiliary supply to the relay will cause a thermal prior alarm because of the initialization to 70%. A cold 0% thermal reference level for testing can be established by keeping both buttons depressed on powering-up.

## Time/current characteristics

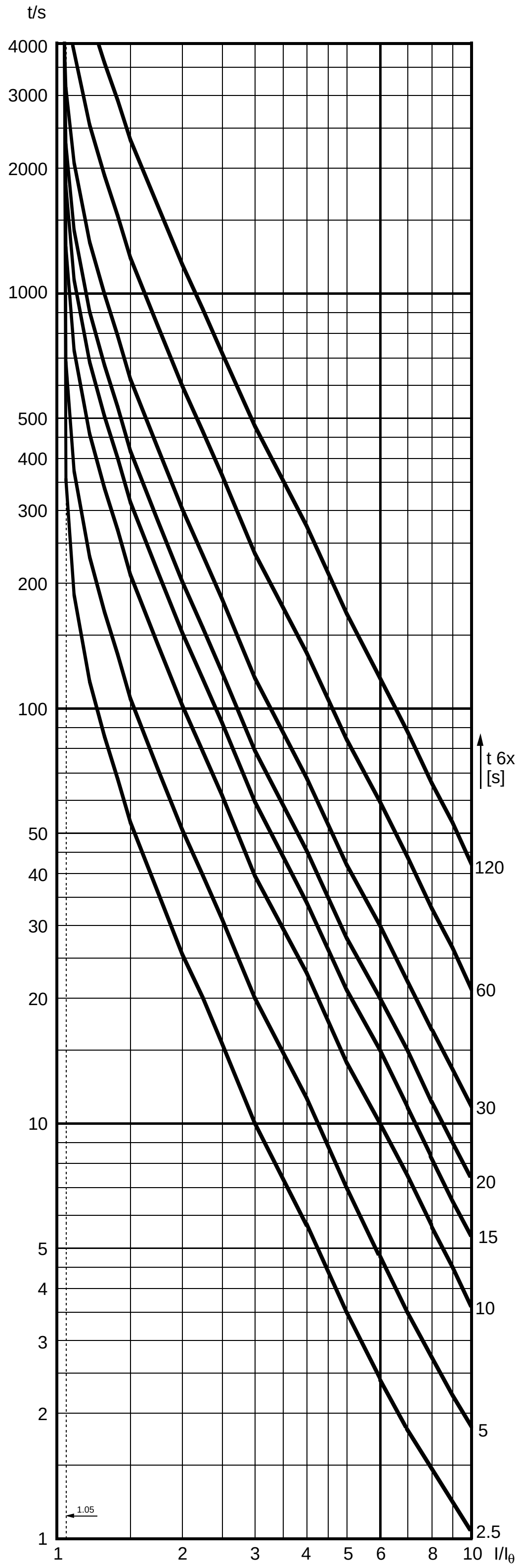


Fig. 1. Trip curves for the thermal unit with no prior load ("cold curve"); p = 20 ...100 %

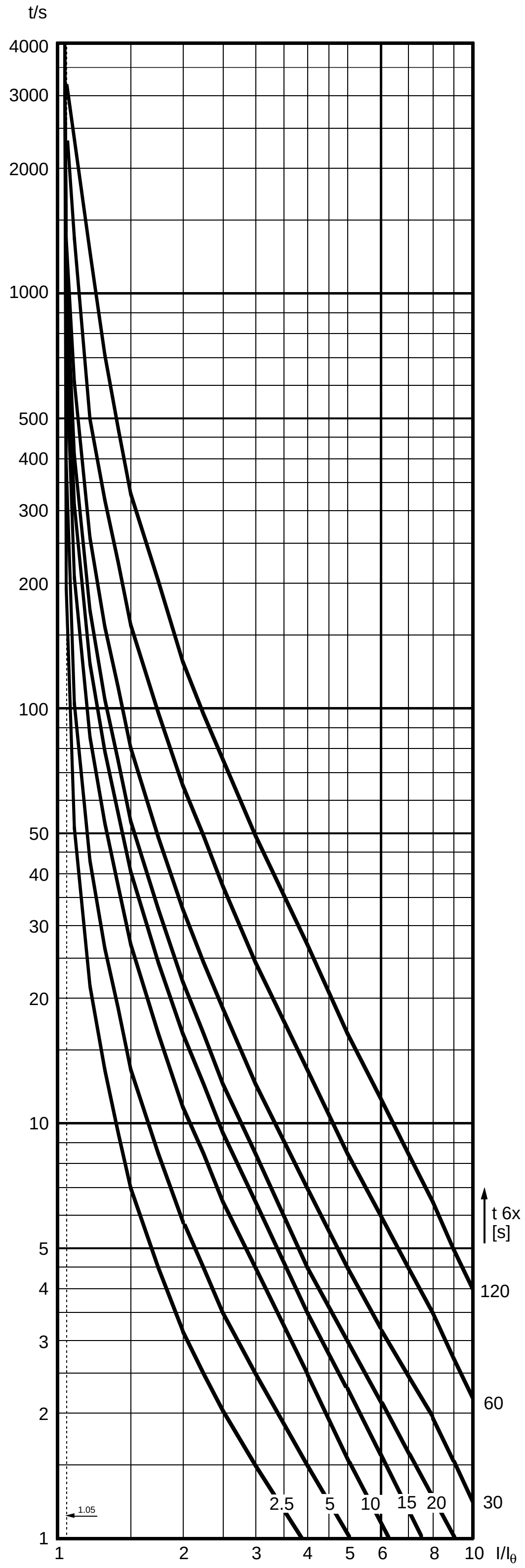


Fig. 2. Trip curves for the thermal unit with prior load 1.0 x $I_\theta$ ("hot curve") at p = 100 %.

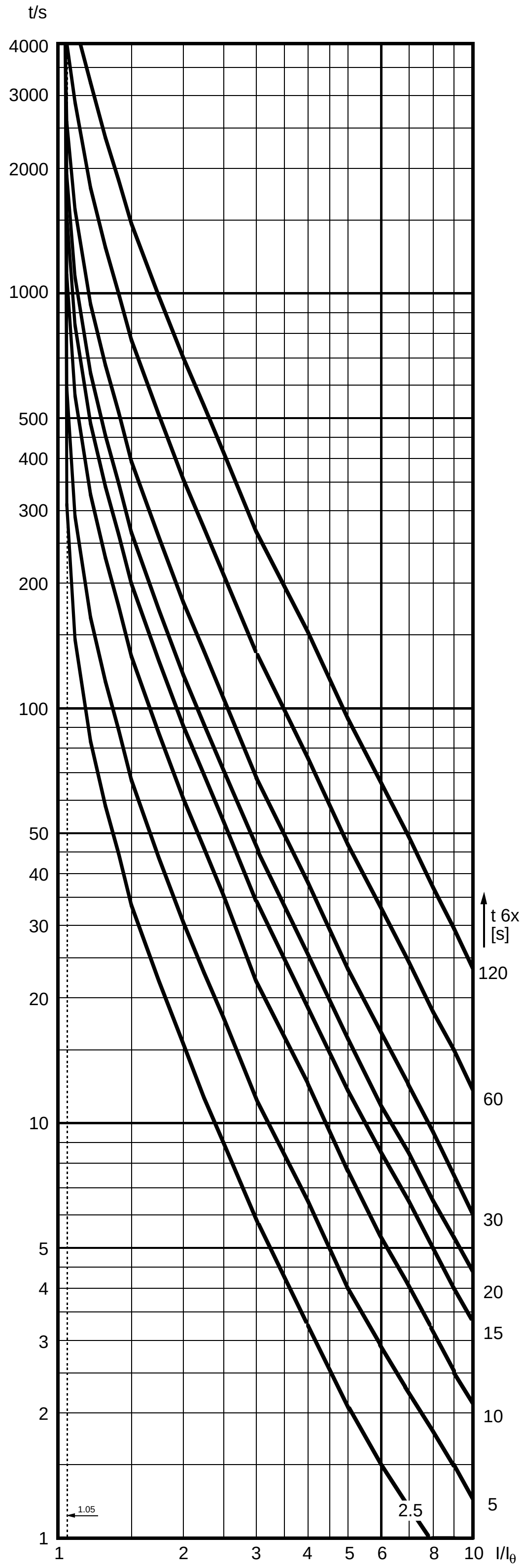


Fig. 3. Trip curves for the thermal unit with prior load 1.0 x $I_\theta$ ("hot curve") at p = 50 %.

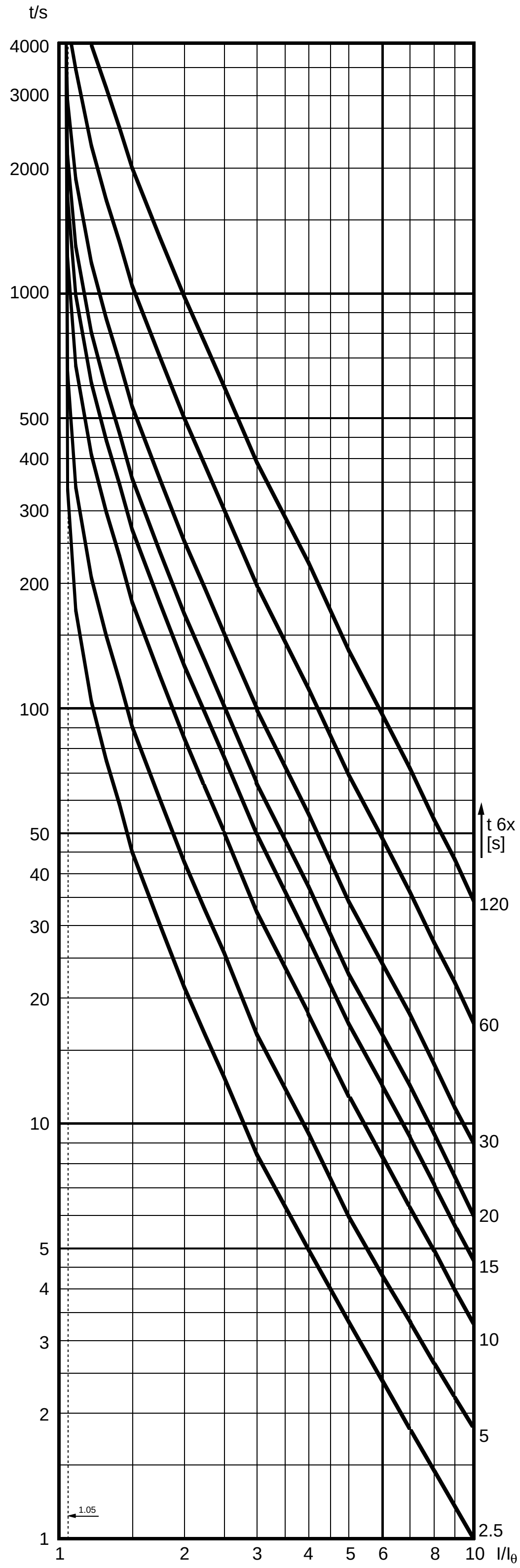


Fig. 4. Trip curves for the thermal unit with prior load 1.0 x $I_\theta$ ("hot curve") at p = 20 %.

Start-up supervision unit

The start-up stall protection can be carried out in two ways as selected with switch SGF/7:

1. Start-up supervision based on definite time overcurrent protection

The most straightforward way is to monitor the start-up time using a definite time overcurrent function. The start condition is detected by the fact that the setting $I_s$ is exceeded and the allowed start-up time is set as $t_s$. The dis-advantage with this configuration is that the maximum allowed start-up time is fixed and does not allow for a growing start-up time during a low voltage condition.

The overcurrent stage starts if the current on one or several phases exceeds the setting value. If the overcurrent situation lasts long enough to exceed the set operating time, the unit calls for a C.B. tripping by issuing a tripping signal. At the same time the operation indicator is lit with red light and the display shows a red figure 6. The red operation indicators remain on although the protection stage resets. The indicators are reset with the RESET push-button. By proper configuration of the output relay switchgroups a trip signal can be generated from the signal SS2 or SS3. The start signal can be routed directly to the output SS1via switch SG4/3.

The current I> setting range of the stage is 1.0...10 x $I_n$. The operate time $t_s$ of the overcurrent stage is set within the range 0.3...80 s.

The operation of the low-set overcurrent unit is provided with a latching feature (switch SGB/8), which keeps the trip output energized, although the fault that caused the operation has disappeared. The output relay may be reset in five different ways; a) by pressing the PROGRAM push-button, b) by pressing the STEP and PROGRAM push-buttons simul-taneously, by remote control over the SPA bus using c) the command V101 or d) the command V102 and further e) by remote control over the external control input. When resetting according to a) or c) no stored data are erased, but when resetting according to b), d) or e) the recorded data are erased.

2. Start-up supervision based on thermal stress calculation

The settings $I_s$ and $t_s$ can also be used in another way by selecting the function mode $I_s^2$ x $t_s$ with selector switch SGF/7. In this case the current $I_s$ is set equal to the actual start-up current of the motor and the time $t_s$ is set to the normal start-up time of the motor. The relay now calculates the product $I_s^2$ x $t_s$, which is equal to the amount of thermal stress built up during a normal start-up of the motor. During the motor start-up the relay then continuously measures the start current, raises the value into the second power and multiplies it with the running time.

If the software switch SG4/1 has been set in position 1, the unit starts counting the $I_s^2$ x $t_s$ value as soon as the start current value $I_s$ is exceeded. When the counted value exceeds the set $I_s^2$ x $t_s$ value the unit operates. The START signal can be routed directly to the output SS1 via switch SG4/3.

At operation the indicator is lit with red light and the display shows a red figure 6. The red operation indicators remain lit although the protection stage resets. The indicators are reset with the RESET push-button. By proper configuration of the output relay switchgroups a trip signal can be generated from the signal SS2 or SS3. This type of start-up monitoring also ensures that the low voltage conditions are catered for by allowing the start-up time to grow until the set maximum thermal stress is exceeded.

The start current setting range of the stage is 1.0...10 x $I_n$. The operate time $t_s$ of the overcurrent stage is set within the range 0.3...80 s.

The operation of the low-set overcurrent unit is provided with a latching feature (switch SGB/8), which keeps the tripping output energized, although the fault that caused the operation has disappeared. The output relay may be reset in five different ways; a) by pressing the PROGRAM push-button, b) by pressing the STEP and PROGRAM push-buttons simultaneously, by remote control over the SPA bus using c) the command V101 or d) the command V102 and further e) by remote control over the external control input. When resetting according to a) or c) no stored data are erased, but when resetting according to b), d) or e) the recorded data are erased.

3. Start-up supervision with a motor speed switch

For some ExE-type motors the safe stall time is shorter than the normal start-up time of the motor. In this case a speed switch on the motor shaft is needed to give information about whether the motor is beginning to run up or not when started. The information from the speed switch is routed to the control input terminals 10 and 11 on the relay. On activation of the control input the counting of the definite time or the building-up of thermal stress in the start-up supervision unit is inhibited.

High-set overcurrent unit

The high-set overcurrent stage starts if the current on one or several phases exceeds the setting value. When starting, the stage issues a starting signal. If the overcurrent situation lasts long enough to exceed the set operate time, the unit calls for a C.B. tripping by providing a tripping signal. At the same time the operation indicator is lit with red light. The red operation indicator remains on although the stage resets. The indicator is reset with the RESET push-button. The trip signal is always routed to output SS3 and can also, by programming, be routed to output SS2.

The start current setting range of the high-set overcurrent stage is 0.5...20 x $I_n$. The operate time t>> of the high-set overcurrent stage is set within the range 0.04...30 s.

The operation of the high-set overcurrent unit is provided with a latching feature (switch SGB/7 or SGB/8), which keeps the tripping output energized, although the fault that caused the operation has disappeared. The output relay may be reset in five different ways; a) by pressing the PROGRAM push-button, b) by pressing the STEP and PROGRAM push-buttons simultaneously, by remote control over the SPA bus using c) the command V101 or d) the command V102 and further e) by remote control over the external control input. When resetting according to a) or c) no stored data are erased, but when resetting according to b), d) or e) the recorded data are erased.

The setting value $I>>/I_n$ of the high-set overcurrent stage may be given an automatic doubling function when the protected object is connected to the network, i.e. in a starting situation. Hence 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 SGF/2. The starting situation is defined as a situation where the phase currents rise from a value below 0.12 x $I_\theta$ to a value exceeding 1.5 x $I_\theta$ in less than 60 ms. The starting situation ends when the currents fall below 1.25 x $I_\theta$.

The high-set overcurrent stage may be set out of operation by means of switch SGF/1. When the high-set unit is set out of operation the display shows a "- - -" readout, indicating that the operation value is infinite.

Earth-fault unit

The sensitive, non-directional earth-fault unit of the module SPCJ 4D34 is a single-pole neutral overcurrent unit. It contains a low-set overcurrent stage $I_0$> with the setting range 1.0... 100% $I_n$. The operate time can be set within the range 0.05...30 s.

The stage starts and provides a starting signal if the measured current exceeds the setting value. If the current lasts long enough to exceed the set operate time, the unit calls for a C.B. tripping by providing a tripping signal. The operation of the earth-fault unit is indicated with a figure 7 on the display on the relay front panel. At the same time the red operation indicator of the tripping stage is lit. The operation indicators remain on although the stage resets. The indicators are reset with the RESET push-button. If the unit is programmed to be signalling only, i.e. the route through SGR1/8 to the trip relay is left open, the trip indicator will reappear as long as the unit is activated. By proper configuration of the output relay switchgroups a trip signal can be generated from the signal SS2 or SS3.

The operation of the stage $I_0$> can be blocked by applying a blocking signal BS on the stage. The blocking is programmed by means of switch SGB/4 on the front panel of the module.

The operation of the high-set stage of the earth-fault unit is provided with a latching feature (switch SGB/7 or SGB/8), which keeps the tripping output energized, although the fault that caused the operation has disappeared. The output relay may be reset in five different ways; a) by pressing the PROGRAM push-button, b) by pressing the STEP and PROGRAM push-buttons simultaneously, by remote control over the SPA bus using c) the command V101 or d) the command V102 and further e) by remote control over the external control input. When resetting according to a) or c) no stored data are erased, but when resetting according to b), d) or e) the recorded data are erased.

To prohibit operation of the contactor in a contactor controlled drive at too high phase currents, the earth-fault unit can be inhibited during a high-current condition by selecting switch SGF/3 and SGF/4. In this case, the operation of the earth-fault unit is inhibited as soon as the phase currents exceed four, six or eight times the full load current $I_\theta$, as selected with the two switches.

With isolated neutral networks it is in some cases possible to use the earth-fault unit in a non-tripping mode and only use the output for signalling. This function can be obtained by opening switch SGR1/8 which links the earth-fault unit to the trip output TS2. If the unit is selected to be tripping, both the trip output TS2 and the selected signal output relays are operated. If the unit is set to be signalling only, the trip output TS2 is not operated.

## Phase unbalance unit

The phase current unbalance unit constitutes a single-phasing protection and an inverse time current unbalance protection.

The unbalance of the power system is detected by monitoring the highest and the lowest phase current values, i.e. the unbalance $\Delta I$ = 100% x $(I_{Lmax}-I_{Lmin})/I_{Lmax}$. At full unbalance the display shows 100 % which equals a negative phase sequence current $I_2$ = 57.8%. If the unbalance exceeds the set operating level $\Delta I$, the unit starts and a timer is started. The operate time depends on the degree of unbalance and the basic operate time setting $t_\Delta$ according to the diagram below. At the lowest selectable starting level, the operate time is equal to the set value $t_\Delta$ and for a full single-phasing condition, the operate time is about 1 second.

Unnecessary trippings at low current levels are avoided by the fact that for currents less than the full load current, the current value $I_{Lmax}$ in the denominator part of the $\Delta I$ formula, is assumed to be equal to the full load current $I_\theta$.

If the unbalance situation lasts long enough to exceed the set operate time, the unit requests C.B. tripping by providing a tripping signal. At the same time the operation indicator is lit with red light and the display shows a figure 5. The red operation indicators remain on although the stage resets. The indicators are reset with the RESET push-button. By proper configuration of the output relay switchgroups a trip signal can be generated from the signals SS2 or SS3.

The operation of the phase unbalance protection can be blocked by bringing a blocking signal BS to the unit. The blocking configuration is set by means of switchgroup SGB/3. With switch SGF/5 the unbalance unit can be made operative or set out of function.

The setting range of the start current is 10... 40 % $I_L$ or ∞ (Indicated by "- - -"). The basic operate time $t_\Delta$ of the unbalance unit is set within the range 20...120 s.

The operation of the unbalance unit is provided with a latching feature (switch SGB/8), which keeps the tripping output energized, although the fault that caused the operation has disappeared. The output relay may be reset in five different ways; a) by pressing the PROGRAM push-button, b) by pressing the STEP and PROGRAM push-buttons simul-taneously, by remote control over the SPA bus using c) the command V101 or d) the command V102 and further e) by remote control over the external control input. When resetting according to a) or c) no stored data are erased, but when resetting according to b), d) or e) the recorded data are erased.

Note!
For a proper operation of the phase unbalance unit in a two-phase application, the two phase currents should be summed up in the third phase current transformer, i.e. a virtual third phase is established.

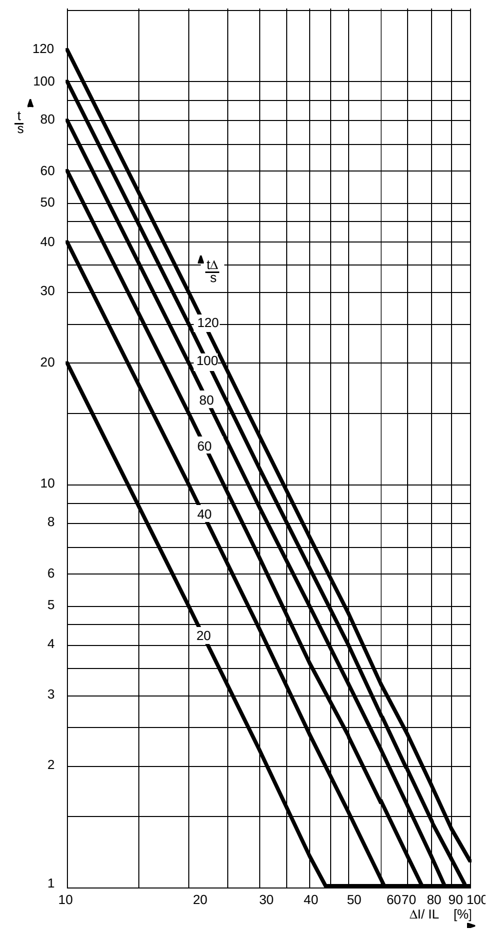


Fig. 5. The operate time of the unbalance protection as a function of the degree of unbalance

## Incorrect phase sequence unit

The incorrect phase sequence protection is based on the order of appearance for the positive half-waves of the phase currents. If the phase currents rise in an incorrect order, the unit starts and calls for a C.B. operation within less than one second. The incorrect phase sequence protection can be selected or inhibited by the switch SGF/6. After an ope-ration, the operation indicators and output relays are the same as for the previously described unbalance unit.

## Undercurrent unit

The undercurrent unit constitutes a protection for the drive and the motor upon sudden loss of load. The undercurrent protection can be used in applications where the loss of load indicates a fault condition, e.g. with pumps or conveyors.

The starting level of the unit is determined by the full load current setting $I_\theta$. If the load is lost, the three phase currents fall below the set level and the unit starts. If the undercurrent condition persists for a time longer than the set operate time t<, the unit calls for a C.B. tripping by providing a tripping signal. At the same time the operation indicator is lit with red light and the display shows a red figure 8. The red operation indicators remain lit although the stage resets. The indicators are reset with the RESET push-button. By proper configuration of the output relay switchgroups a trip signal can be generated from the signals SS2 or SS3.

The start current setting range of the stage is 30...80% $I_\theta$. The operate time t< is set within the range 2.0 ... 600 s.

In order not to trip a de-energized motor, the unit is inhibited at current levels below 12 per cent of the full load current.

If the undercurrent protection is not required, the unit can be set out of operation with switch SGF/8. The setting is in this case displayed as "- - -".

The operation of the undercurrent unit is provided with a latching feature (switch SGB/8), which keeps the tripping output energized, although the fault that caused the operation has disappeared. The output relay may be reset in five different ways; a) by pressing the PROGRAM push-button, b) by pressing the STEP and PROGRAM push-buttons simultaneously, by remote control over the SPA bus using c) the command V101 or d) the command V102 and further e) by remote control over the external control input. When resetting according to a) or c) no stored data are erased, but when resetting according to b), d) or e) the recorded data are erased.

## Cumulative start-up time counter

Any time the motor is started, the start-up time is added to a register $\sum t_s$. If the contents of the register exceeds a preset level $\sum t_{si}$, any attempt to restart the motor will be inhibited, because the restart enable relay will be reset. Besides the maximum amount of accumulated start-up time, a resetting speed is also set, defining how rapidly the contents of the start-up time register should be decreased. If the motor manufacturer e.g. states that a maximum of three 60 s starts may be made with a motor within four hours, the setting $\sum t_{si}$ should be 3 x 60 = 180 s and the setting $\Delta\sum t_s$ = 180 s / 4h = 45 s/h.

## Self-supervision

The microprocessor technology used enables a self-supervision feature to be implemented in the relay. The supervision unit continuously monitors the condition of most of the important components in the relay as well as the co-operation of the microprocessor and the analog-to-digital converter hardware. The operation of the processor software is also monitored. If an incorrect operation is detected, the signalling output relay is operated. This provides a means of avoiding conditions where the system could be operated without a proper protection. The output relay is normally energized, ensuring that an alarm is given also at a total loss of auxiliary power. If the fault condition permits it, the internal relay fault is indicated with a separate LED labelled "IRF" on the front panel.

## Block diagram

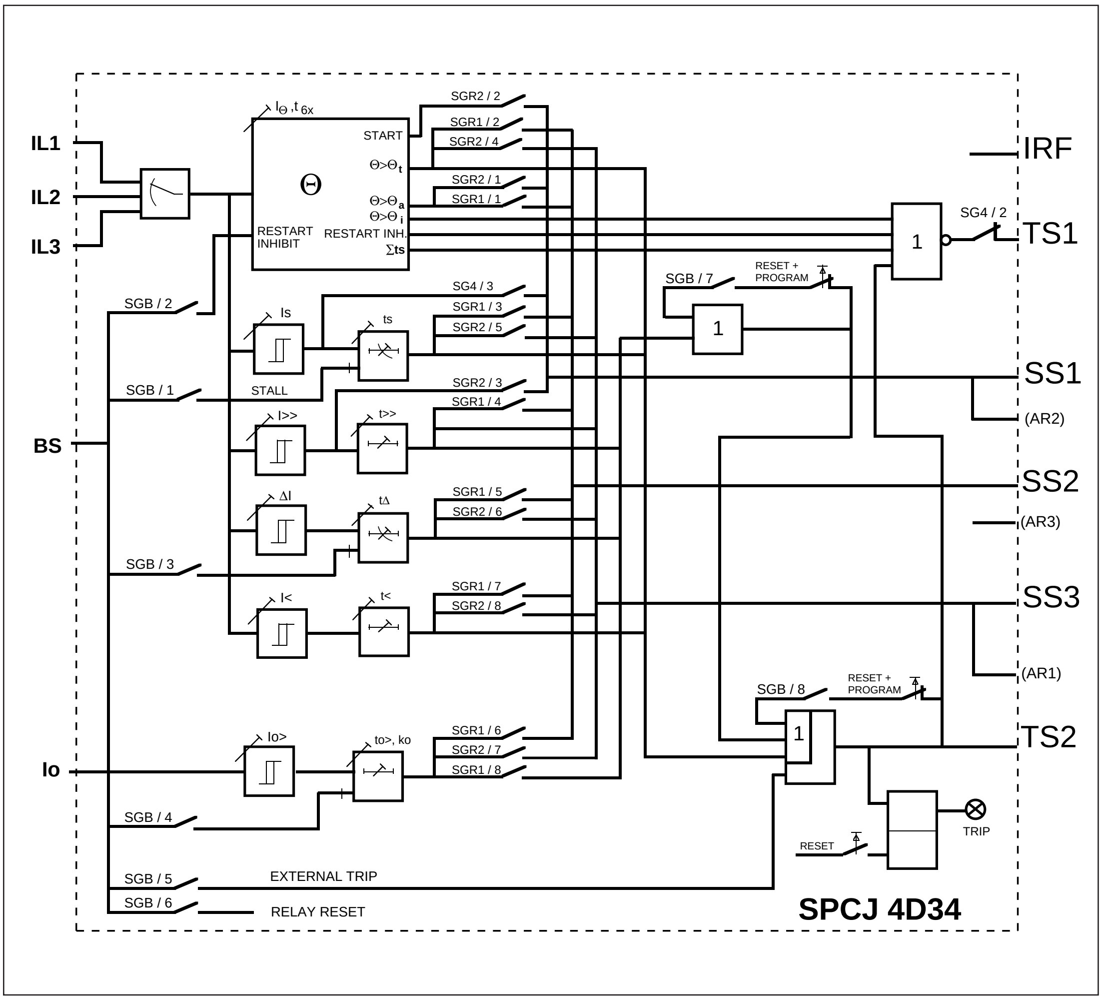


Fig. 6. Block diagram of the motor protection module SPCJ 4D34

| | |
|---|---|
| $I_{L1}$, $I_{L2}$, $I_{L3}$ | Phase currents |
| $I_0$ | Neutral current |
| BS | External control,blocking or resetting signal |
| SGF | Selector switchgroup SGF |
| SGB | Selector switchgroup SGB |
| SGR1...2 | Selector switchgroups SGR |
| TS1 | Restart enable signal |
| SS1 | Starting or prior alarm signal selected with switchgroup SGR2 |
| SS2 | Prior alarm or trip signal 2 selected with switchgroup SGR1 |
| SS3 | Trip signal 2 for stages selected with switchgroup SGR2 |
| TS2 | Tripping signal selected with switchgroup SGR2 |
| AR1, AR2, AR3 | Starting signals for external autoreclose unit (not used with motors!) |
| TRIP | Red indicator for tripping |

Note!
All input and output signals of the module are not necessarily wired to the terminals of every relay unit using a particular module. The signals wired to the terminals are shown in the diagram illustrating the flow of signals between the protection modules of the relay unit.

## Front panel

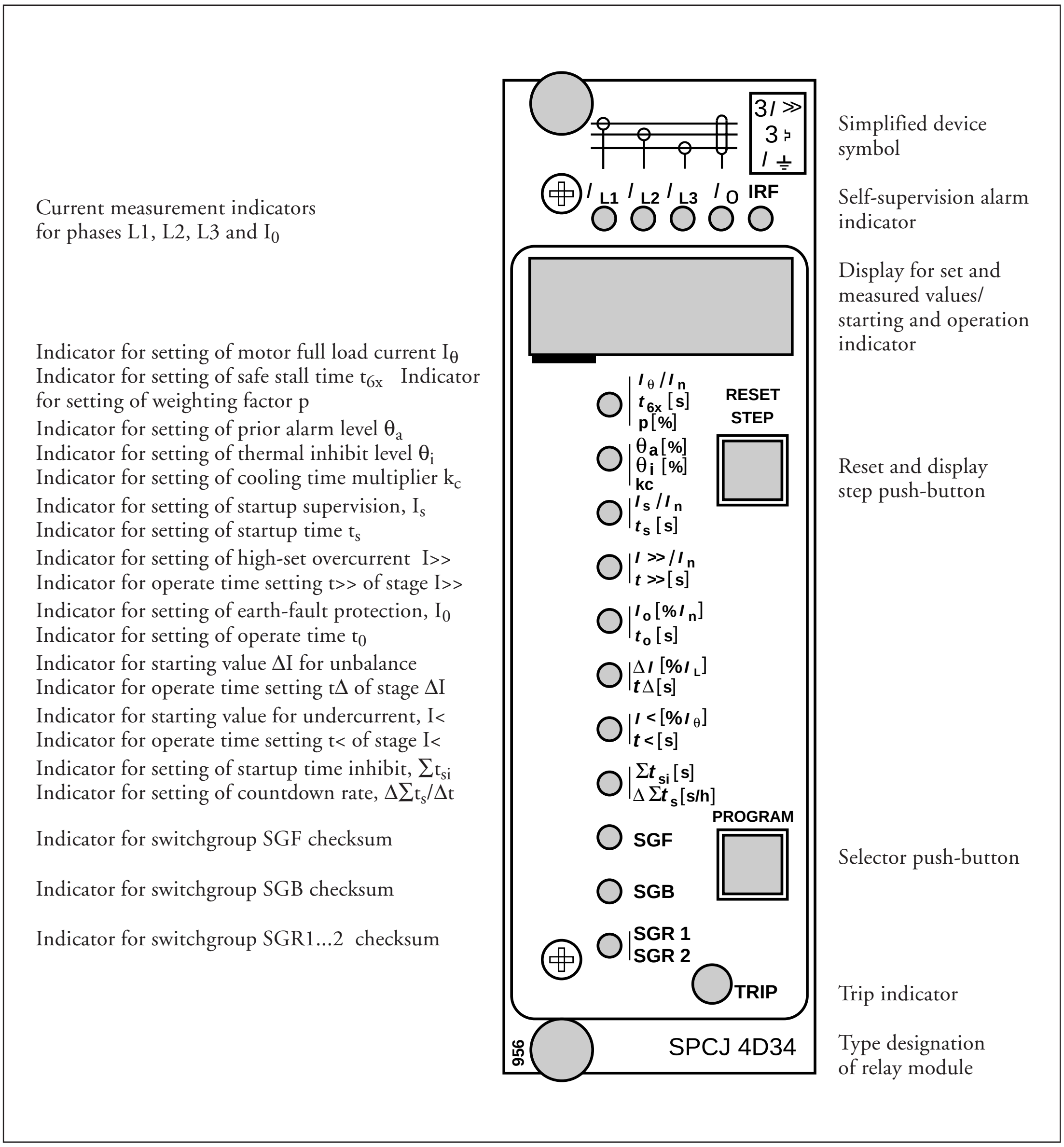


Fig. 7. Front panel of the motor protection relay module SPCJ 4D34

## Operation indications

Each protective unit has its own operation indicator shown as a figure in the digital display. Further all stages share a common operation indicator named "TRIP", which indicates with red light that the module has delivered a tripping signal.

The operation indication in the display persists when the current stage resets, thus indicating which protection stage was operating. The operation indication is reset with the RESET push-button. The function of the protection module is not affected by an unreset operation indicator.

The following table shows the starting and tripping indications and their meanings.

| Indication | Explanation | |
|---|---|---|
| 1 | $\theta > \theta_a$ | = A prior alarm signal for a thermal overload has been given |
| 2 | $\theta > \theta_t$ | = The thermal protection unit has tripped |
| 3 | $\theta > \theta_i$, $\Sigma t_{si}$, EINH | = The thermal restart inhibit level is exceeded, the startup time counter is full or the external inhibit signal is active |
| 4 | I>> | = The high-set stage I>> of the overcurrent unit has tripped |
| 5 | ΔI | = The unbalance/incorrect phase sequence protection unit has tripped |
| 6 | $I_s^2 \times t_s$ | = The start-up supervision unit has tripped |
| 7 | $I_0$ | = The earth-fault unit has tripped |
| 8 | I< | = The undercurrent unit has tripped |
| 9 | EXT.TRIP | = A trip from an external relay has been carried out via the relay |

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

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

## Relay settings

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

| Setting | Parameter | Setting range (Factory settings) |
|---|---|---|
| $I_\theta$ | Motor full load current $I_\theta$ as a multiple of the relay rated current $I_n$. Tripping will be carried out if the current exceeds the set value by more than 5% for an extended amount of time. | 0.50...1.50 x $I_n$ |
| $t_{6x}$ | Maximum safe stall time, i.e. operate time in seconds for a cold motor at six times the full load current $I_\theta$. | 2.0...120 s |
| p | Weighting factor for thermal unit curves | 20...100% (50%) |
| $\theta_a$ | Prior alarm level for an approaching thermal overload in per cent of the trip level | 50...100% of trip level |
| $\theta_i$ | Restart inhibit level for a thermal overload condition in per cent of the trip level | 20...80% of trip level |
| $k_c$ | Cooling reduction factor for a motor at standstill compared to the heating time constant | 1...64 x heating t.c. |
| $I_s$ | Motor start current setting as a multiple of the relay rated current $I_n$ | 1.0...10.0 x $I_n$ |
| $t_s$ | Motor start time setting in seconds *) | 0.3...80 s (2 s) |
| I>> | High-set overcurrent unit setting as multiples of relay rated current $I_n$ | 0.5...20 x $I_n$ and ∞ |
| t>> | High-set stage operate time in seconds | 0.04...30 s |
| $I_0$ | Start current setting $I_0$ for the earth-fault unit in per cent of the relay rated current $I_n$ | 1.0...100% $I_n$ |
| $t_0$ | Operate time of the earth-fault unit to in seconds | 0.05...30 s |
| ΔI | Setting ΔI for the unbalance protection in per cent of the highest phase current | 10...40% $I_L$ and ∞ |
| $t_\Delta$ | Operate time at the starting level in seconds, inverse time<br>Operate time for the incorrect phase sequence current protection | 20...120 s<br>< 1s |
| I< | Starting value for the undercurrent unit in per cent of the motor full load current | 30...80% $I_\theta$ and off |
| t< | Operate time of the undercurrent unit in seconds | 2…600 s |
| $\Sigma t_{si}$ | Time-based start inhibit counter setting in seconds*) | 5...500 s |
| $\Delta\Sigma t_s$ | Countdown rate of the start time counter in seconds per hour | 2...250 s/h |
| SGF<br>SGB<br>SGR | The checksums of the selector switchgroups SGF, SGB, SGR1 and SGR2 are indicated on the display when the indicators adjacent to the switchgroup symbols on the front panel are illuminated. The incluence of the position of the different switches on the operation of the relay is described in separate paragraphs. | |

*) Start-up is defined as a condition when the phase currents within less than 60 ms exceed a level 1.5 $I_\theta$ from a standstill state $I<0.12\ I_\theta$. The start-up condition ends when the phase currents again go lower than 1.25 $I_\theta$. For the start-up stall protection unit, time counting is stopped when the speed switch changes its state, if the facility is in use. In this case the setting $t_s$ should preferrably be equal to the $t_e$ time of the motor.

## Programming switches

The additional functions required in various applications are selected by means of switchgroups SGF, SGB, SGR1 and SGR2 indicated on the front panel. Further, the motor protection relay module contains a software switchgroup SG4, which is located in submenu four of register A. 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.

---

Functional programming switchgroup SGF

The selector switches of the switchgroup SGF are used to define certain functions of the relay and are identified as SGF/1 to SGF/8.

| Switch | Function | Factory default | User settings | Weight value |
|---|---|---|---|---|
| SGF/1 | High-set overcurrent unit inhibited or in use<br>0 = high-set stage inhibited (setting displayed "- - -")<br>1 = high-set stage in use | 1 | | 1 |
| SGF/2 | Setting of high-set overcurrent stage doubled during a motor start-up<br>0 = no doubling<br>1 = doubling feature active | 1 | | 2 |
| SGF/3<br>SGF/4 | Earth-fault trip inhibited on overcurrents higher than a selected multiple of the motor full load current FLC as follows: | 0<br>0 | | 4<br>8 |
| SGF/5 | Selection or deselection of phase unbalance protection<br>0 = not in use (setting displayed "- - -")<br>1 = operative | 1 | | 16 |
| SGF/6 | Incorrect phase sequence protection inhibited or in use<br>0 = not in use<br>1 = operative | 1 | | 32 |
| SGF/7 | Stall protection based on the thermal stress supervision, $I_s^2 \times t_s$ or a definite time overcurrent function, $I_s$ & $t_s$.<br>0 = definite time overcurrent;<br>1 = thermal stress monitoring | 1 | | 64 |
| SGF/8 | Selection or deselection of the undercurrent protection<br>0 = not in use (setting displayed "- - -")<br>1 = operative | 0 | | 128 |
| | Checksum for factory setting of SGF | | | 115 |

| | SGF/3 = 0 | SGF/3 =1 |
|---|---|---|
| SGF/4 = 0 | no inhibit | inhibit at four times FLC |
| SGF/4 = 1 | inhibit at six times FLC | inhibit at eight times FLC |

Blocking and control input selector switchgroup SGB

The selector switches of the switchgroup SGB are used to define certain functions of the external control input of the relay and are identified as SGB/1 to SGB/8.

| Switch | Function | Factory setting | Check-sum value |
|---|---|---|---|
| SGB /1 | Stall information to relay from speed switch on motor (1). This feature is mainly used for ExE-type motor drives where the motor must not be stalled for a time exceeding the motor start-up time. | 0 | 1 |
| SGB /2 | Restart of the motor inhibited by external command (1). Can be used to tie the motor restart to an external automation equipment. | 0 | 2 |
| SGB /3 | When SGB/3 = 1, the phase unbalance unit is blocked by the input signal BS. On deblocking, the unit operates with its normal operate time. Can be used e.g. to inhibit the operation during a start-up when the motor is connected to a soft-starter. | 0 | 4 |
| SGB /4 | When SGB/4 = 1, the earth-fault unit is blocked by the input signal BS. On deblocking, the unit operates with its normal operating time. Can be used e.g. to avoid possible nuisance trippings during start-up due to a soft-starter or saturated C.T.s. | 0 | 8 |
| SGB/5 | External trip command carried out to output relay A (1). External protective relays can be connected to the trip path using this feature.<br>Note! The trip signalling is not handled by the SPCJ-module and must be arranged using a contact on the external protective relay. | 0 | 16 |
| SGB/6 | External relay reset (1) makes it possible to have a manual master reset button outside the relay. The same button can serve all relays on a station. Another possibility is to link the reset to some automation. | 0 | 32 |
| SGB/7 | Latching of output relay for short-circuit, earth-fault or unbalance trip.<br><br>When SGB/7 = 0, the tripping signal returns to its initial state, i.e. the output relay drops off, when the measuring signal causing the operation falls below the starting level.<br>When SGB/7 = 1, the tripping signal remains on, i.e. the output relay operated although the measuring signal falls below the starting level. Then the tripping signals have to be reset by pressing the PROGRAM push-button, by pressing the PROGRAM and RESET push-buttons simultaneously or by remote control over the SPA bus or the external control input. | 0 | 64 |
| SGB /8 | Latching (1) of output relay for any tripping, independent of the cause.<br><br>When SGB/8 = 0, the tripping signal returns to its initial state, i.e. the output relay drops off, when the measuring signal causing the operation falls below the starting level.<br>When SGB/8 = 1, the tripping signal remains on, i.e. the output relay is energized, although the measuring signal falls below the starting level. The tripping signals have to be reset by pressing the PROGRAM push-button, by pressing the PROGRAM and RESET push-buttons simultaneously or by remote control over the SPA bus or the external control input. | 0 | 128 |
| | Checksum for factory setting of SGB | | 0 |

**Relay output programming switchgroups SGR1 and SGR2**

The selector switches of the switchgroups SGR1 and SGR2 are used to route desired output signals to the corresponding output relays. The switches are identified as SGR1/1 ...SGR1/8 and SGR2/1...SGR2/8.

Selector switchgroup SGR 1

| Switch | Function | Factory setting | Check-sum value |
|---|---|---|---|
| 1 | When SGR1/1 = 1, the thermal prior alarm linked to SS2 | 1 | 1 |
| 2 | When SGR1/2 = 1, the thermal trip signal linked to SS2 | 0 | 2 |
| 3 | When SGR1/3 = 1, the signal from stall protection linked to SS2 | 0 | 4 |
| 4 | When SGR1/4 = 1, the signal for high-set overcurrent linked to SS2 | 0 | 8 |
| 5 | When SGR1/5 = 1, the signal for current unbalance linked to SS2 | 0 | 16 |
| 6 | When SGR1/6 = 1, the signal for earth-fault linked to SS2 | 0 | 32 |
| 7 | When SGR1/7 = 1, the signal for undercurrent linked to SS2 | 0 | 64 |
| 8 | When SGR1/8 = 1, the earth-fault unit trip linked to TS2 | 1 | 128 |
| | Checksum for factory settings for SGR1 | | 129 |

Selector switchgroup SGR 2

| | | | |
|---|---|---|---|
| 1 | When SGR2/1 = 1, the thermal prior alarm linked to SS1 | 0 | 1 |
| 2 | When SGR2/2 = 1, the motor start-up info output linked to SS1 | 1 | 2 |
| 3 | When SGR2/3 = 1, the starting of the high-set overcurrent unit linked to SS1 | 0 | 4 |
| 4 | When SGR2/4 = 1, the thermal trip signal linked to SS3 | 1 | 8 |
| 5 | When SGR2/5 = 1, the signal from stall protection linked to SS3 | 1 | 16 |
| 6 | When SGR2/6 = 1, the signal for current unbalance linked to SS3 | 1 | 32 |
| 7 | When SGR2/7 = 1, the signal for earth-fault linked to SS3 | 1 | 64 |
| 8 | When SGR2/8 = 1, the signal for undercurrent linked to SS3 | 1 | 128 |
| | Checksum for factory settings for SGR2 | | 250 |

Switchgroup SG4

The software switchgroup SG4 contains three selector switches in the fourth submeny of register A.

| Switch | Function | Factory setting | Check-sum value |
|---|---|---|---|
| 1 | Switch SG4/1 is used, when the $I_s^2$ x $t_s$ principle has been selected for start-up supervision. (SGF/7 = 1)<br><br>When SG4/1 = 0, the relay calculates the $I_s^2$ x $t_s$ value in a starting situation. A starting situation is defined as a situation, where the phase currents increase from a value less than 0.12 $I_\theta$ to a value exceeding 1.5 x $I_\theta$ within less than 60 ms. The starting situation ceases when the phase currents fall below 1.25 x $I_\theta$ for more than 100 ms.<br><br>When SG4/1 = 1, the relay starts calculating the $I_s^2$ x $t_s$ value when the start current $I_s$ is exceeded. | 0 | 1 |
| 2 | When SG4/2 = 1, the restart enable message TS1 is disabled. | 0 | 2 |
| 3 | When SG4/3 = 1, the start signal of the $I_s$ stage is directly routed to output SS1. | 0 | 4 |
| | Factory set default checksum of switchgroup SG4 | | 0 |

## Example of checksum calculation

The example below illustrates how the checksum of switchgroup SGF can be calculated manually:

| Switch | Factor | | Switch position | | Value |
|---|---|---|---|---|---|
| SGF/1 | 1 | x | 1 | = | 1 |
| SGF/2 | 2 | x | 0 | = | 0 |
| SGF/3 | 4 | x | 1 | = | 4 |
| SGF/4 | 8 | x | 0 | = | 0 |
| SGF/5 | 16 | x | 0 | = | 0 |
| SGF/6 | 32 | x | 0 | = | 0 |
| SGF/7 | 64 | x | 1 | = | 64 |
| SGF/8 | 128 | x | 0 | = | + 0 |
| Switchgroup SGF checksum | | | | | 69 |

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

## 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 relay rated current $I_n$. |
| $I_{L2}$ | Line current on phase L2 as a multiple of the relay rated current $I_n$. |
| $I_{L3}$ | Line current on phase L3 as a multiple of the relay rated current $I_n$. |
| $I_0$ | Neutral current expressed in per cent of the relay rated current $I_n$. |

## Recorded information

Any time the relay starts or performs a tripping, the current values at the moment of tripping, the duration of the starting for different units and other parameters are stored in a two place memory stack. A new operation moves the old values up to the second place and adds a new value to the first place of the stack consisting of registers 1...7. Two value pairs are memorized - if a third starting occurs, the oldest set of values will be lost. A master reset of the relay erases all the contents of both of the register blocks.

The leftmost 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 unit. // The duration of the starting of the I> unit in per cent of the operate time. |
| 2 | Phase current $I_{L2}$ measured as a multiple of the rated current of the overcurrent unit. // The duration of the starting of the I>> unit in per cent of the operate time. |
| 3 | Phase current $I_{L3}$ measured as a multiple of the rated current of the overcurrent unit. // The duration of the starting of the I< unit in per cent of the operate time. |
| 4 | Neutral current Io measured as a per cent of the rated current of the earth-fault unit. // The duration of the starting of the $I_0$ unit in per cent of the operate time. |
| 5 | Phase unbalance ΔI in percent of highest phase current. // The duration of the starting of the ΔI unit in per cent of the trip time. |
| 6 | Start-up thermal stress product $I_s^2$ x $t_s$. // Motor start-up count. Cleared only by a power supply interrupt. |
| 7 | The thermal level $I_\theta$ at the end of the event, given in per cent of the trip level. // The thermal level $I_\theta$ at the beginning of the event, given in per cent of the trip level. |
| 8 | The actual value of the thermal capacity used. // The actual value of the phase unbalance. |
| 9 | The approximate time in minutes to a restart enabling of the motor if the motor is stopped. // The actual value of the cumulative start-up time counter, which is continuously decreased with a rate determined by the setting $\Delta\sum t/\Delta t$. // The motor start-up time memorized during the latest start-up. // Counter for the total amount of motor running hours expressed in hours x 100. |

| Register/ STEP | Recorded information |
|---|---|
| 0 | Display of blocking signals and other external control signals.<br><br>The rightmost digit indicates the state of the external control input of the unit. The following states may be indicated:<br>0 = no control / blocking signal<br>1 = the control or blocking signal BS is alert.<br><br>The effect of the signal on the unit is determined by the setting of switchgroup SGB<br><br>From the register "0" it is possible to move on to the TEST mode, where the alarm and tripping signals of the module are activated one by one in thefollowing order and indicated by the flashing setting indication LED:<br><br>● $I_\theta$ / In, t6x [s], p [%] — Tripping caused by the thermal unit<br>● $\theta_a$ [%], $\theta_i$ [%], kc — Thermal unit prior alarm carried out<br>● Is / In, ts [s] — Trip from start-up supervision unit and start condition signal<br>● I» / In, t» [s] — Trip from high-set overcurrent unit<br>● Io [%In], to [s] — Trip from earth-fault unit<br>● ΔI [%IL], tΔ [s] — Trip from unbalance unit<br>● I< [%$I_\theta$], t< [s] — Trip from undercurrent unit<br>● Σtsi [s], ΔΣts [s/h] — Restart inhibit from start-up time counter<br><br>The LED positions adjacent to SGF, SGB and SGR are not tied to any test function.<br><br>For further details, see the description "General characteristics of D-type SPC relay modules". |
| A | The address code of the protection relay module, required by the serial communication system. // Data transfer rate of the serial communication. // The bus traffic monitor indicating the operation state of the serial communication system. If the module is connected to a system including the control data communicator type SACO 148D4 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 scrolling in the counter. // The password required for the remote control of settings. 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. // Checksum of switchgroup SG4 |
| - | Display dark. By pressing the STEP push-button the beginning of the display sequence is re-entered. |

The memorized values in registers 1...7 are erased by pressing the push-buttons RESET and PROGRAM simultaneously. The registers are also erased if the auxiliary power supply of the module is interrupted. The address code of the relay module, the data transfer rate of the serial communication and the passwords 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 modules".

## Main menus and submenus of settings and registers

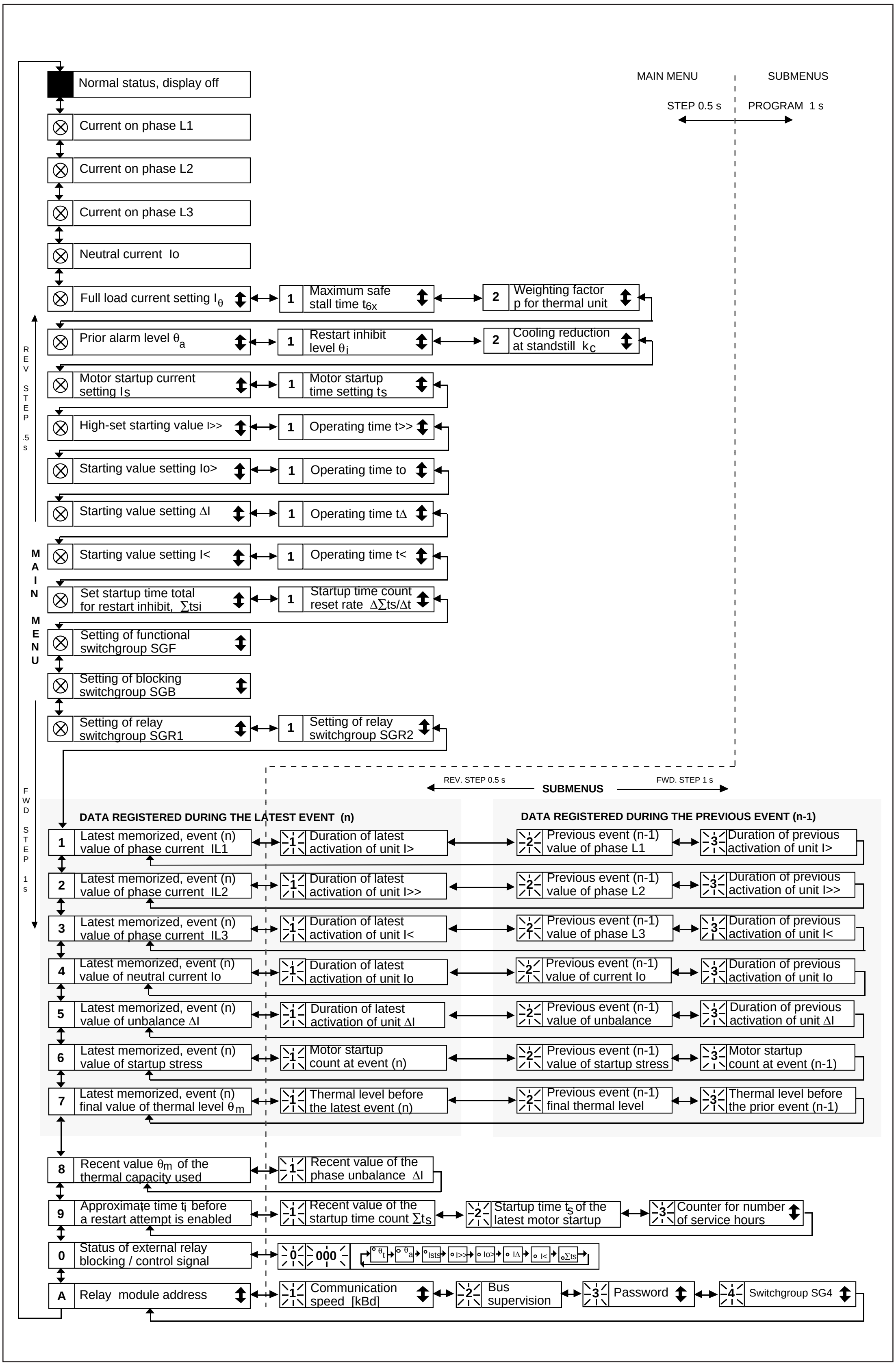


Fig. 8. Man-machine communication menu for the motor protection relay module SPCJ 4D34

The measures required for entering a submenu or a setting mode and how to perform the setting and use the TEST mode are described in detail on Data Sheet "General characteristics of the D-type SPC 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 forward scan in main menu | STEP | Keep depressed |
| Reverse step in main or submenu | STEP | Press less than about 0.5 s |
| Entering 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 | STEP&PROGRAM | Note! Operative outside setting mode |
| Resetting of latched output relays | PROGRAM | Press once, display must be off |
| Note! All parameters which can be set in a setting mode are indicated with the symbol ⇕. | | |

Acknowledge and reset functions:

RESET clears the operation indications on the display.

PROGRAM clears the operation indications on the display and unlatches a latched output relay (corresponds to the command V101 over the SPA bus).

RESET & PROGRAM clears the operation indications on the display, unlatches a latched output relay and erases the recorded fault values from the memory (corresponds to the command V 102 over the SPA bus).

## Technical data

### Thermal overload unit

| | |
|---|---|
| Motor full load current setting $I_\theta$ | |
| Setting range | 0.50...1.50 x $I_n$ |
| Setting resolution | 0.01 x $I_n$ |
| Accuracy of current measurement | ±2% |
| | |
| Safe stall time setting $t_{6x}$, operate time from cold state at 6 x $I_\theta$, | |
| Setting range | 2.0...120 s |
| Setting resolution as handled by algorithm | 0.5 s |
| Time count increments for the thermal unit | 0.5 s |
| Accuracy of timing functions | ±2% or ±0.5 s |
| | |
| Cooling time multiplier $k_c$ for motor at standstill, setting range | 1...64 times heating time constant |
| | |
| Thermal prior alarm level $\theta_a$, setting range | 50...100% of thermal trip level $\theta_t$ |
| | |
| Restart inhibit level $\theta_i$ for thermal overload, setting range | 20...80% of thermal trip level $\theta_t$ |
| | |
| Initialization of the thermal unit on connection of auxiliary supply, equal to motor hot state | 70% x $\theta_t$ *) |

### Start-up supervision unit

| | |
|---|---|
| Start-up current $I_s$, setting range | 1.0...10.0 x $I_n$ |
| Start-up time $t_s$, setting range | 0.3...80 s |
| | |
| When operating as definite time overcurrent relay: **) | |
| Reset time, typ. | 50 ms |
| Drop-off / pick-up ratio, typ. | 0.96 |
| Operate time accuracy | ±2% of set value or ± 25 ms |
| Operation accuracy | ±3% of set value |
| | |
| When operating as start-up thermal stress relay: **) | |
| Reset time, typ. | 200 ms |
| Operation accuracy | ±10% of set value $I_s^2$ x $t_s$ |
| Shortest possible operate time | about 300 ms |

### High-set overcurrent unit

| | |
|---|---|
| Start current I>>, setting range | 0.5...20.0 x $I_n$ or ∞, infinite |
| Start time, typically | 50 ms |
| Operate time setting range | 0.04...30 s |
| Reset time, typ. | 50 ms |
| Drop-off / pick-up ratio, typ. | 0.96 |
| Operate time accuracy | ±2% of set value or ± 25 ms |
| Operation accuracy | ±3% of set value |

*) Note!
Due to this feature, low settings of the prior alarm level will always render a thermal prior alarm signal when the auxiliary supply is connected.

**) Note!
Both protection functions cannot be selected at the same time. The selection is carried out with switch SGF/7. In both cases the operation of the timing circuit can be interrupted with an external control signal fed to the relay's control input (SGB/1 = 1).

### Earth-fault unit

| | |
|---|---|
| Start current $I_0$, setting range | 1.0...100 % $I_n$ |
| Start time, typ. | 50 ms |
| Operate time setting range | 0.05...30 s |
| Reset time, typ. | 50 ms |
| Drop-off / pick-up ratio, typ. | 0.96 |
| Operate time accuracy | ±2% of set value or ± 25 ms |
| Operation accuracy | ±3% of set value +0.0005 x $I_n$ |

### Unbalance / phase reversal unit

| | |
|---|---|
| Start current $\Delta I$, setting range | 10...40% $I_L$ or ∞, infinite |
| Operation time at lowest possible setting, 10 % | 20...120 s, inverse time |
| Reset time, typ. | 200 ms |
| Operate time accuracy | ± 20% of theoretical value for U/B > 20%, see Fig. 5 |
| Operate time for a single phasing condition | 1 s |
| Operate time at incorrect phase sequence | 600 ms |

### Undercurrent unit

| | |
|---|---|
| Starting value I<, setting range | 30...80% $I_q$ or off |
| Operate time t<, setting range | 2…600 s |
| Reset time, typ. | 200 ms |
| Drop-off / pick-up ratio, typ. | 1.1 |

### Start-up time counter unit

| | |
|---|---|
| Restart inhibiting start count setting $\Sigma t_{si}$ | 5...500 s |
| Countdown rate of start-up time counter $\Delta\Sigma t_s/\Delta t$ | 2...250 s/h |

## Serial communication

### Event codes

When the motor protection relay module SPCJ 4D34 is linked to the control data communicator SACO 148 D4 over the 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 SACO148D4 and event code.

The codes E1...E32 and the events represented by these can be included in or excluded from the event reporting by writing event masks V155, V156, V157 and V158 to the module over the SPA bus. The event masks are binary numbers coded to decimal numbers. The event codes, e.g. 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...V158 may have a value within range 0...255. The default values for the masks in the module SPCJ 4D34 are V155=80, V156=68, V157=68 and V158=20. The events selected by the default settings can be found in the list of events below.

The output signals are monitored by codes E33...E42 and the events represented by these can be included in or excluded from the event reporting by writing an event mask V159 to the module. The event mask is a binary number coded to a decimal number. The event codes E33...E42 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 V159 may have a value within the range 0...1023. The default value of the motor protection relay module SPCJ 4D34 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.

More information about the serial communication over the SPA-bus can be found in the description "SPA bus communication protocol", 34 SPACOM 2 EN1.

Event codes of the motor protection relay module SPCJ 4D34:

| Code | Event | Number representing the event | Default settings in the masks |
|---|---|---|---|
| E1 | Beginning of motor start-up condition | 1 | 0 |
| E2 | End of motor start-up condition | 2 | 0 |
| E3 * | Beginning of thermal overload condition | 4 | 0 |
| E4 * | End of thermal overload condition | 8 | 0 |
| E5 | Start of thermal prior alarm | 16 | 1 |
| E6 | Thermal prior alarm reset | 32 | 0 |
| E7 | Tripping of thermal unit starting | 64 | 1 |
| E8 | Tripping of thermal unit reset | 128 | 0 |
| | Default checksum for mask V155 | 80 | |
| E9 * | Starting of stage $I_s$> | 1 | 0 |
| E10 * | Starting of stage $I_s$> reset | 2 | 0 |
| E11 | Tripping of stage $I_s$> or $I_s^2 \times t_s$ | 4 | 1 |
| E12 | Tripping of stage $I_s$> or $I_s^2 \times t_s$ reset | 8 | 0 |
| E13 * | Starting of I>> stage | 16 | 0 |
| E14 * | Starting of I>> stage reset | 32 | 0 |
| E15 | Tripping of stage I>> | 64 | 1 |
| E16 | Tripping of stage I>> reset | 128 | 0 |
| | Default checksum for mask V156 | 68 | |

| Code | Event | Number representing the event | Default settings in the masks |
|---|---|---|---|
| E17 * | Starting of stage $I_0$> | 1 | 0 |
| E18 * | Starting of stage $I_0$> reset | 2 | 0 |
| E19 | Tripping of stage $I_0$> | 4 | 1 |
| E20 | Tripping of stage $I_0$> reset | 8 | 0 |
| E21 * | Starting of ΔI stage | 16 | 0 |
| E22 * | Starting of ΔI stage reset | 32 | 0 |
| E23 | Tripping of stage ΔI | 64 | 1 |
| E24 | Tripping of stage ΔI reset | 128 | 0 |
| | Default checksum for mask V157 | 68 | |
| E25 * | Starting of stage I< | 1 | 0 |
| E26 * | Starting of stage I< reset | 2 | 0 |
| E27 | Tripping of stage I< | 4 | 1 |
| E28 | Tripping of stage I< reset | 8 | 0 |
| E29 | Beginning of external trip signal | 16 | 1 |
| E30 | External trip signal reset | 32 | 0 |
| E31 | Beginning of motor restart inhibit | 64 | 0 |
| E32 | End of motor restart inhibit | 128 | 0 |
| | Default checksum for mask V158 | 20 | |
| E33 | Output signal TS1 activated | 1 | 0 |
| E34 | Output signal TS1 reset | 2 | 0 |
| E35 | Output signal SS1 activated | 4 | 0 |
| E36 | Output signal SS1 reset | 8 | 0 |
| E37 | Output signal SS2 activated | 16 | 0 |
| E38 | Output signal SS2 reset | 32 | 0 |
| E39 | Output signal SS3 activated | 64 | 0 |
| E40 | Output signal SS3 reset | 128 | 0 |
| E41 | Output signal TS2 activated | 256 | 1 |
| E42 | Output signal TS2 reset | 512 | 1 |
| | Default checksum for mask V159 | 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

E52…E54 are generated by SACO 100M or SRIO 500M/1000M

* Note!
During a motor start-up (E1-E2) the event codes for starting of protective units, marked with an asterisk in the table, are not transmitted.

Remote transfer data

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.

| Data | Code | Data flow direction | Value range |
|---|---|---|---|
| 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<br>1 = external blocking or control signal active |
| OUTPUTS | | | |
| Starting of stage $I_\theta$ | O1 | R | 0 = $I_\theta$ stage not started<br>1 = $I_\theta$ stage started |
| Thermal prior alarm | O2 | R | 0 = $I_\theta$ alarm active<br>1 = $I_\theta$ alarm reset |
| Tripping of stage $I_\theta$ | O3 | R | 0 = $I_\theta$ stage not tripped<br>1 = $I_\theta$ stage tripped |
| Starting of stage $I_s>$ or $I_s^2 \times t_s$ | O4 | R | 0 = $I_s>$ or $I_s^2 \times t_s$ stage not started<br>1 = $I_s>$ or $I_s^2 \times t_s$ stage started |
| Tripping of stage $I_s>$ or $I_s^2 \times t_s$ | O5 | R | 0 = $I_s>$ or $I_s^2 \times t_s$ stage not tripped<br>1 = $I_s>$ or $I_s^2 \times t_s$ stage tripped |
| Starting of stage I>> | O6 | R | 0 = I>> stage not started<br>1 = I>> stage started |
| Tripping of stage I>> | O7 | R | 0 = I>> stage not tripped<br>1 = I>> stage tripped |
| Starting of stage $I_0>$ | O8 | R | 0 = $I_0>$ stage not started<br>1 = $I_0>$ stage started |
| Tripping of stage $I_0>$ | O9 | R | 0 = $I_0>$ stage not tripped<br>1 = $I_0>$ stage tripped |
| Starting of stage ΔI | O10 | R | 0 = ΔI stage not started<br>1 = ΔI stage started |
| Tripping of stage ΔI | O11 | R | 0 = ΔI stage not tripped<br>1 = ΔI stage tripped |
| Starting of stage I< | O12 | R | 0 = I< stage not started<br>1 = I< stage started |
| Tripping of stage I< | O13 | R | 0 = I< stage not tripped<br>1 = I< stage tripped |
| External trip signal | O14 | R | 0 = signal not active<br>1 = signal active |
| External restart inhibit signal | O15 | R | 0 = inhibit not active<br>1 = inhibit active |
| RESTART ENABLE output TS1 | O16 | R | 0 = signal not active<br>1 = signal active |
| START output SS1 | O17 | R, W (P) | 0 = signal not active<br>1 = signal active |
| SIGNAL 2 output SS2 | O18 | R, W (P) | 0 = signal not active<br>1 = signal active |
| SIGNAL1 output SS3 | O19 | R, W (P) | 0 = signal not active<br>1 = signal active |
| TRIP output TS2 | O20 | R, W (P) | 0 = signal not active<br>1 = signal active |

| Data | Code | Data flow direction | Value range |
|---|---|---|---|
| Operating of output relays | O21 | R, W (P) | 0 = not operated<br>1 = operated |
| Restart enable output control | O22 | W(P) | 0 = not affecting restart enable<br>1 = restart remotely inhibited |
| Memorized starting of stage $I_\theta$ | O31 | R | 0 = $I_\theta$ stage not started<br>1 = $I_\theta$ stage started |
| Memorized thermal prior alarm | O32 | R | 0 = $I_\theta$ alarm active<br>1 = $I_\theta$ alarm reset |
| Memorized tripping of stage $I_\theta$ | O33 | R | 0 = $I_\theta$ stage not tripped<br>1 = $I_\theta$ stage tripped |
| Memorized starting of stage $I_s$> or $I_s^2$ x $t_s$ | O34 | R | 0 = $I_s$> or $I_s^2$ x $t_s$ stage not started<br>1 = $I_s$> or $I_s^2$ x $t_s$ stage started |
| Memorized tripping of stage $I_s$> or $I_s^2$ x $t_s$ | O35 | R | 0 = $I_s$> or $I_s^2$ x $t_s$ stage not tripped<br>1 = $I_s$> or $I_s^2$ x $t_s$ stage tripped |
| Memorized starting of stage I>> | O36 | R | 0 = I>> stage not started<br>1 = I>> stage started |
| Memorized tripping of stage I>> | O37 | R | 0 = I>> stage not tripped<br>1 = I>> stage tripped |
| Memorized starting of stage $I_0$> | O38 | R | 0 = $I_0$> stage not started<br>1 = $I_0$> stage started |
| Memorized tripping of stage $I_0$> | O39 | R | 0 = $I_0$> stage not tripped<br>1 = $I_0$> stage tripped |
| Memorized starting of stage ΔI | O40 | R | 0 = ΔI stage not started<br>1 = ΔI stage started |
| Memorized tripping of stage ΔI | O41 | R | 0 = ΔI stage not tripped<br>1 = ΔI stage tripped |
| Memorized starting of stage I< | O42 | R | 0 = I< stage not started<br>1 = I< stage started |
| Memorized tripping of stage I< | O43 | R | 0 = I< stage not tripped<br>1 = I< stage tripped |
| Memorized external trip signal | O44 | R | 0 = signal not active<br>1 = signal active |
| Memorized external restart inhibit signal | O45 | R | 0 = inhibit not active<br>1 = inhibit active |
| Memorized output signal TS1 | O46 | R | 0 = signal not active<br>1 = signal active |
| Memorized output signal SS1 | O47 | R | 0 = signal not active<br>1 = signal active |
| Memorized output signal SS2 | O48 | R | 0 = signal not active<br>1 = signal active |
| Memorized output signal SS3 | O49 | R | 0 = signal not active<br>1 = signal active |
| Memorized output signal TS2 | O50 | R | 0 = signal not active<br>1 = signal active |
| Memorized output ENA-signal | O51 | R | 0 = signal not active<br>1 = signal active |

| Data | Code | Data flow direction | Value range |
|---|---|---|---|
| SETTING VALUES | | | |
| Thermal trip current setting $I_\theta$ | S1 | R, W (P) | 0.5...1.50 x $I_n$ |
| Thermal unit stall time setting $t_{6x}$ | S2 | R, W (P) | 2.0...120 s |
| Weighting factor p of the thermal unit | S3 | R, W (P) | 20...100 % |
| Thermal prior alarm level setting $\theta_a$ | S4 | R, W (P) | 50...100 % of trip level |
| Restart inhibit level setting $\theta_i$ | S5 | R, W (P) | 20...80 % of trip level |
| Cooling time multiplier setting $k_c$ | S6 | R, W (P) | 1...64 |
| Starting value of the $I_s$ or $I_s^2$ x $t_s$ unit | S7 | R, W (P) | 1.0...10.0 x $I_n$ |
| Operate time $t_s$ of the $I_s$ or $I_s^2$ x $t_s$ unit | S8 | R, W (P) | 0.3...80 s |
| Starting value of stage I>> | S9 | R, W (P) | 0.5...20.0 x $I_n$<br>999 = not in use (∞) |
| Operate time of stage I>> | S10 | R, W (P) | 0.04...30 s |
| Starting value of stage $I_0$> | S11 | R, W (P) | 1.0...100 % $I_n$ |
| Operate time of stage $I_0$> | S12 | R, W (P) | 0.05...30 s |
| Starting value of stage ΔI | S13 | R, W (P) | 10...40 % $I_L$<br>999 = not in use (∞) |
| Basic operate time of stage ΔI | S14 | R, W (P) | 20...120 s |
| Starting value of stage I< | S15 | R, W (P) | 30...80 % $I_\theta$<br>999 = not in use (∞) |
| Operate time of stage I< | S16 | R, W (P) | 2.0…600 s |
| Setting of time-based start inhibit | S17 | R, W (P) | 5...500 s |
| Setting of count-down rate | S18 | R, W (P) | 2...250 s/h |
| Checksum of switchgroup SGF | S19 | R, W (P) | 0...255 |
| Checksum of switchgroup SGB | S20 | R, W (P) | 0...255 |
| Checksum of switchgroup SGR1 | S21 | R, W (P) | 0...255 |
| Checksum of switchgroup SGR2 | S22 | R, W (P) | 0...255 |
| Checksum of switchgroup SG4 | S23 | R, W (P) | 0...7 |
| RECORDED AND MEMORIZED PARAMETERS | | | |
| Current in phase L1 at starting or tripping | V21 & V41 | R | 0...63 x $I_n$ |
| Current in phase L2 at starting or tripping | V22 & V42 | R | 0...63 x $I_n$ |
| Current in phase L3 at starting or tripping | V23 & V43 | R | 0...63 x $I_n$ |
| Neutral current $I_0$ at starting or tripping | V24 & V44 | R | 0...210 % $I_n$ |
| Phase unbalance ΔI at starting or tripping | V25 & V45 | R | 0...100 % |
| Calculated value from start-up supervision | V26 & V46 | R | 0...100 % |
| Thermal level at trip instant | V27 & V47 | R | 0...100 % |
| Duration of activation of unit $I_s$> | V28 & V48 | R | 0...100 % |
| Duration of starting of unit I>> | V29 & V49 | R | 0...100 % |
| Duration of starting of unit I< | V30 & V50 | R | 0...100 % |
| Duration of starting of unit $I_0$ | V31 & V51 | R | 0...100 % |
| Duration of starting of unit ΔI | V32 & V52 | R | 0...100 % |
| Motor start-up counter value n | V33 & V53 | R | 0...999 |
| Thermal level at beginning of event | V34 & V54 | R | 0...100 % |

| Data | Code | Data flow direction | Value range |
|---|---|---|---|
| Actual thermal level | V1 | R,W(P) | 0...106 % |
| Actual unbalance level | V2 | R | 0...100 % |
| Estimated time to enabling of motor restart | V3 | R | 0...999 min |
| Actual reading of the cumulative start-up time counter | V4 | R | 0...999 s |
| Start-up time for latest motor start-up | V5 | R | 0...100 s |
| Phase conditions during trip *) | V6 | R | 1 = $I_{sL3}$, 2 = $I_{sL2}$, 4 = $I_{sL1}$, 8 = $I_0$>, 16 = $I_{L3}$>>, 32 = $I_{L2}$>>, 64 = $I_{L1}$>> 128 = not used |
| Operation indicator | V7 | R | 0...9 |
| Motor running hour counter | V8 | R, W(P) | 0...999 x100 h |

*) Code numbers 1, 2 and 4 are not in use, when the relay calculates the $I_s^2 \times t_s$ value only during the start-up situation (SGF/7 = 1 and SG4/1 = 0).

CONTROL PARAMETERS

| | | | |
|---|---|---|---|
| Resetting of output relays at self-holding | V101 | W | 1 = output relays are reset |
| Resetting of output relays and recorded data | V102 | W | 1 = output relays and registers are reset |
| Event mask word for motor start-up or thermal overload events | V155 | R, W | 0...255, see section event codes |
| Event mask word for overcurrent / start-up supervision or short-circuit events | V156 | R, W | 0...255, see section event codes |
| Event mask word for earth-fault or unbalance events | V157 | R, W | 0...255, see section event codes |
| Event mask word for underload or externally controlled events | V158 | R, W | 0...255, see section event codes |
| Event mask word for output signal events | V159 | 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 |
| Activating of self-supervision input | V165 | W | 1 = self-supervision input is activated and IRF LED turned on |
| Factory final test | V167 | W (P) | 2 = format EEPROM and switch power on and off |
| Internal error code | V169 | R | 1...255 |
| Data communication address of the module | V200 | R, W | 1...254 |
| Data transfer rate | V201 | R, W | 4800 or 9600 Bd (R) 4.8 or 9.6 kBd (W) |
| Programme version symbol | V205 | R | 043 _ |

| Data | Code | Data flow direction | Value range |
|---|---|---|---|
| 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 4D34 |
| Reading of module status data | C | R | 0 = normal state<br>1 = module been subject to automatic reset<br>2 = overflow of event regist.<br>3 = events 1 and 2 together |
| Resetting of module state data | C | W | 0 = resetting |
| Time reading and setting | T | R, W | 00.000...59.999 s |

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

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 SACO 100M resets abnormal status data, so this data is normally zero.

The setting values S1...S23 are the setting values used by the protection programs. 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 variables are not given out of range values as specified in the technical data of the module. If an out of range value is given to the module, either manually or by remote setting, the module 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 switched on and the output relay of the self-supervision system operates. Further, in most fault situations an autodiagnostic fault code is shown in the display. The fault code is composed of a red figure 1 and a green code number which indicates what may be the fault type. When a fault code appears on the display, the code number should be recorded on a piece of paper and given to the authorized repair shop when overhaul is ordered. Below is a list of some of the fault codes that might appear with the unit SPCJ 4D34:

| Fault code | Type of error in module |
|---|---|
| 4 | Trip relay path broken or output relay card missing |
| 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) blocks 1 and 2 faulty |
| 54 | Parameter memory (EEPROM) blocks 1 and 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 hardware filter on E/F channel |
| 253 | No interruptions from the A/D-converter |

**ABB Oy**
Substation Automation
P.O.Box 699
FIN-65101  VAASA
Finland
Tel. +358 (0)10 22 11
Fax.+358 (0)10 22 41094
www.abb.com/substationautomation

1MRS 750739-MUM EN