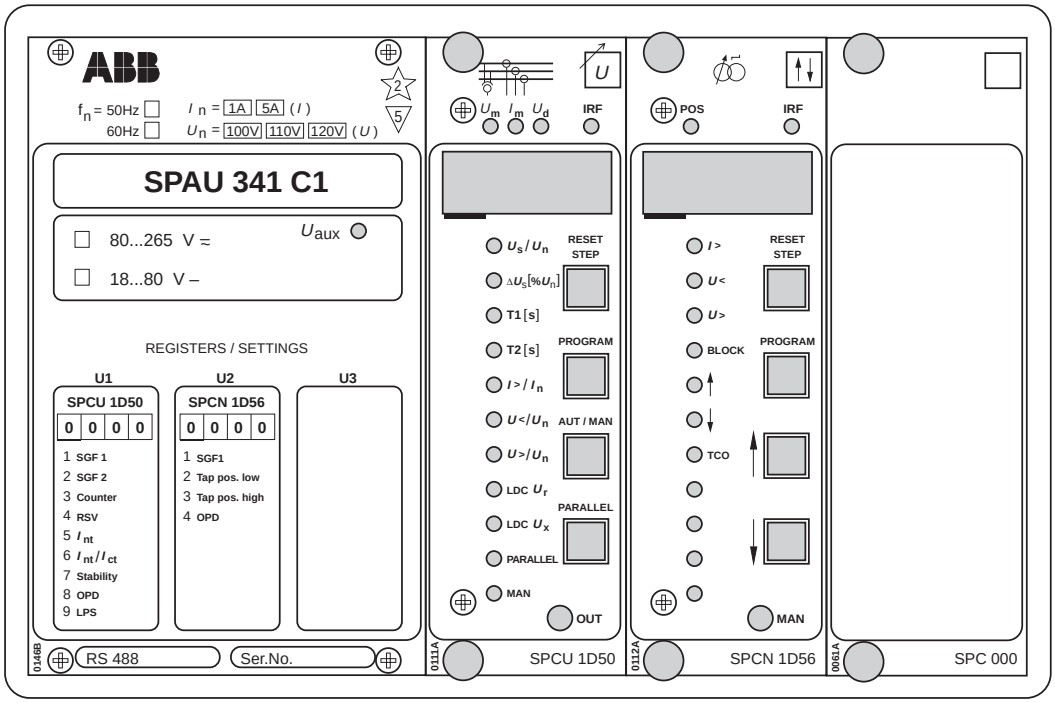
SPAU 341 C
Voltage regulator

User´s manual and Technical description



1MRS 750110-MUM EN

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SPAU 341 C
Voltage regulator

Contents

The complete manual for the voltage regulator SPAU 341 C includes the following submanuals:

Voltage regulator manual, general part	1MRS 750110-MUM EN
Automatic voltage regulating module, SPCU 1D50	1MRS 750111-MUM EN
Manual voltage regulating module, SPCN 1D56	1MRS 750112-MUM EN
General characteristics of D-type modules	1MRS 750066-MUM EN

Features

Automatic or manual voltage control of transformers using raise and lower signals.

Three-phase overcurrent blocking and undervoltage blocking.

Line drop compensation.

Parallel operation of transformers feeding the same busbar, by the master/slave, negative reactance or minimizing circulating current principle.

Tap-changer position measurement.

Numerical display of setting values, measured values, indications, etc.

Serial interface for bus connection module and fibre-optic substation bus.

Continuous self-supervision of relay hardware and software for enhanced system reliability and availability.

Powerful software support for parametrization and supervision of the regulator.

Area of application

The voltage regulator SPAU 341 C is intended to be used for regulating the voltage of power transformers with on-load tap-changers in distribution substations. The connections required for a simple voltage regulating function is the measured phase-to-phase voltage U_{12} and the raise and lower output contacts. If the line drop compensation, the minimizing circulating current or the overcurrent blocking feature is to be used, one or more phase currents have to be measured. If only one phase current is measured, it is always connected to the terminals of the phase current I L1, and the current to be measured is selected with the software switches SGF2/6 and SGF2/7 of the automatic voltage regulating module SPCU 1D50.

Description of operation

The purpose of the regulator is to maintain a stable secondary voltage of the power transformer. The basis for this operation is the reference voltage, which is set by the user. By adding or decreasing various compensation factors, the regulator calculates a control voltage from the reference voltage. Hence, the control voltage is the desired transformer secondary voltage to be maintained by the regulator. Then the control voltage is compared with the voltage measured and the difference between these two forms the regulating process error.

Since the tap-changer changes the voltage in steps, a certain error has to be allowed. This error, called bandwidth, is also set by the user. If the measured voltage fluctuates within the bandwidth, the regulator is inactive. Should, on the other hand, the measured voltage be outside these bandwidth limits, an adjustable delay T1 starts. This delay T1 remains active as long as the measured voltage is outside the hysteresis limits of the bandwidth. The factory setting of the hysteresis limits is 90%.

Should the measured voltage still be outside the hysteresis, when the delay counter T1 reaches its setting value, the raise or lower output relay is activated and the motor drive of the tap-changer is operated. If, on the other hand, the measured voltage falls within the hysteresis limits, the delay counter is reset.

Should one tap-changer operation not be enough to regulate the transformer voltage within the hysteresis limits, a second adjustable delay T2, usually with a shorter time setting than T1, starts.
The delays T1 and T2 can be selected either with definite or inverse time characteristic. Inverse time characteristic means, that the delay is inversely proportional to the regulator error, i.e the delay is inversely proportional to the difference between the control voltage and the measured voltage.

The voltage regulating function will be described more in detail in the document 1MRS 750111-MUM EN.

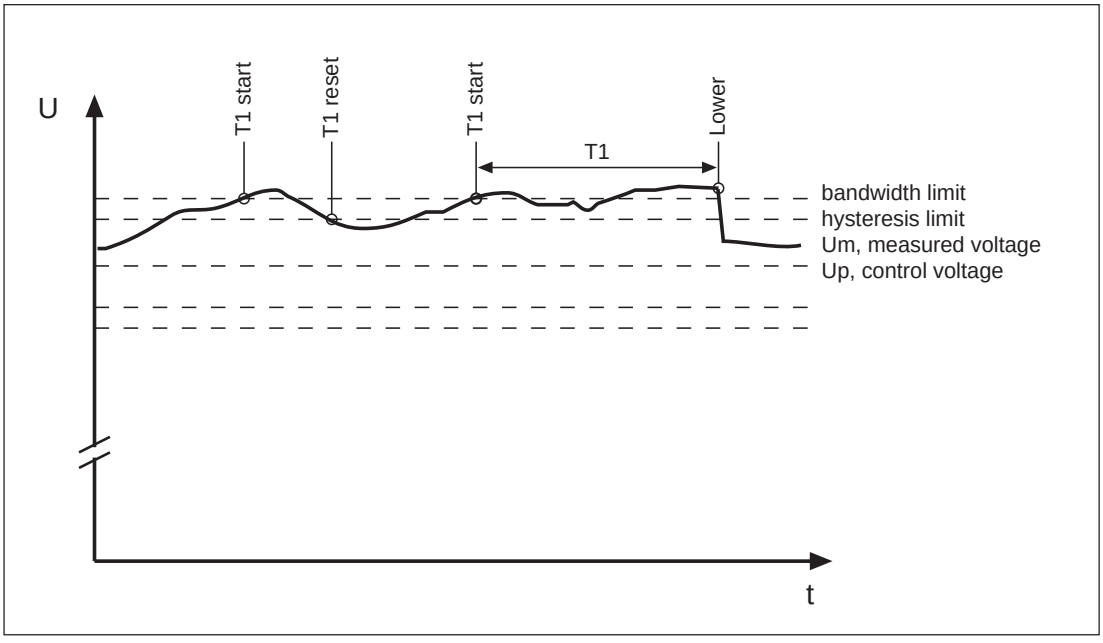


Fig.1. Voltage regulating function

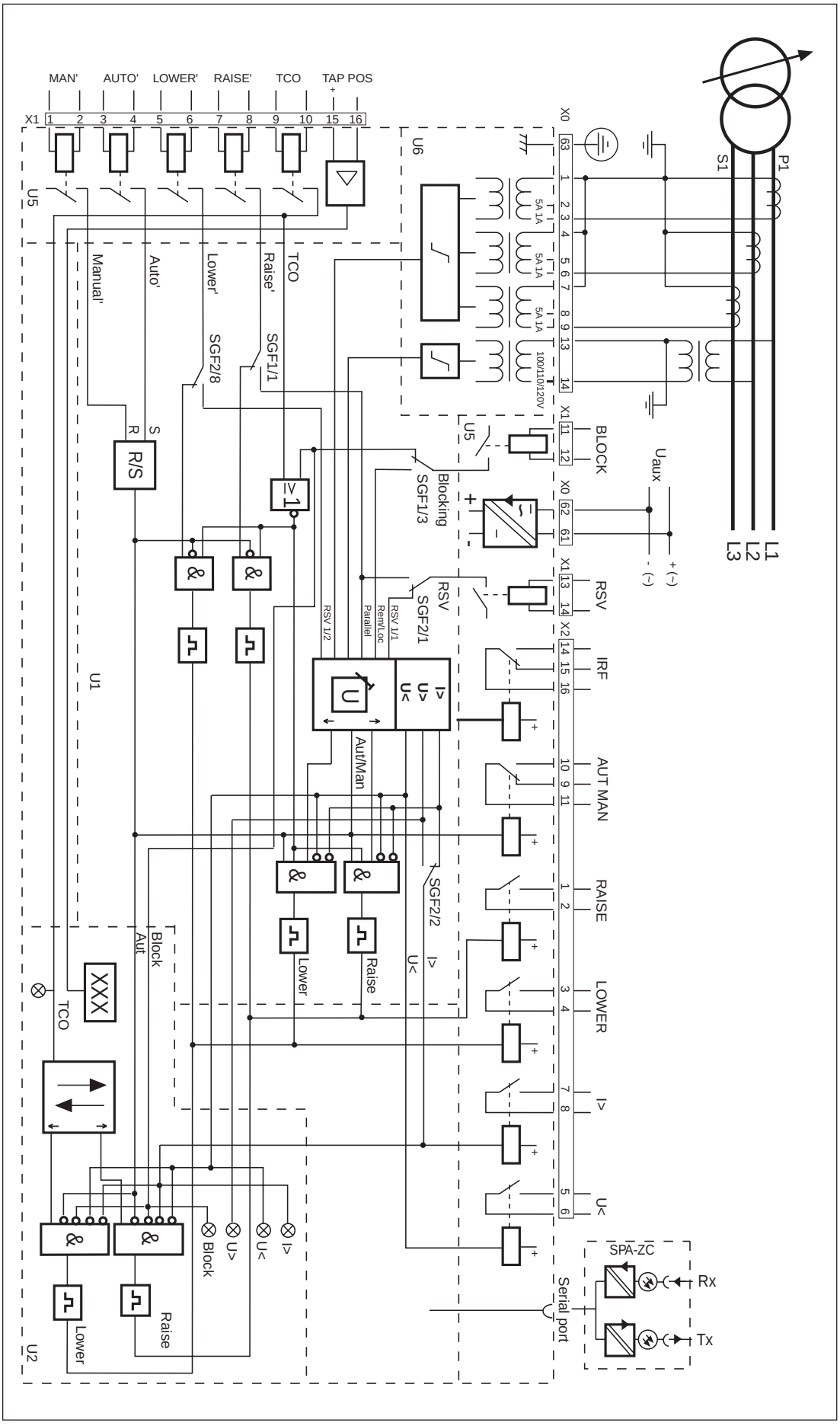


Fig. 2. Connection diagram for the voltage regulator SPAU 341 C

Block	Blocking of regulating function, input
U_{aux}	Auxiliary voltage, input
RSV	Reduce set voltage or parallel input
AUT/MAN	Automatic or manual mode, output
IRF	Self-supervision signal, output
RAISE	Raise signal, output
LOWER	Lower signal, output
I>	Overcurrent or overvoltage blocking, output
U<	Undervoltage blocking output
SERIAL PORT	Serial communication port
TAP POS	Tap-changer position input, mA signal
TCO	Tap-changer operating input
RAISE'	Raise command or parallel operation input
LOWER'	Lower command or reduce set voltage input
AUTO'	Automatic mode input
MAN'	Manual mode input
U1	Automatic voltage regulating module SPCU 1D50
U2	Manual voltage regulating module SPCN 1D56
U5	I/O module
U6	Energizing input module
SPA-ZC_	Bus connection module
Rx/Tx	Fibre-optic receiver (Rx) and transmitter (Tx) of the bus connection module

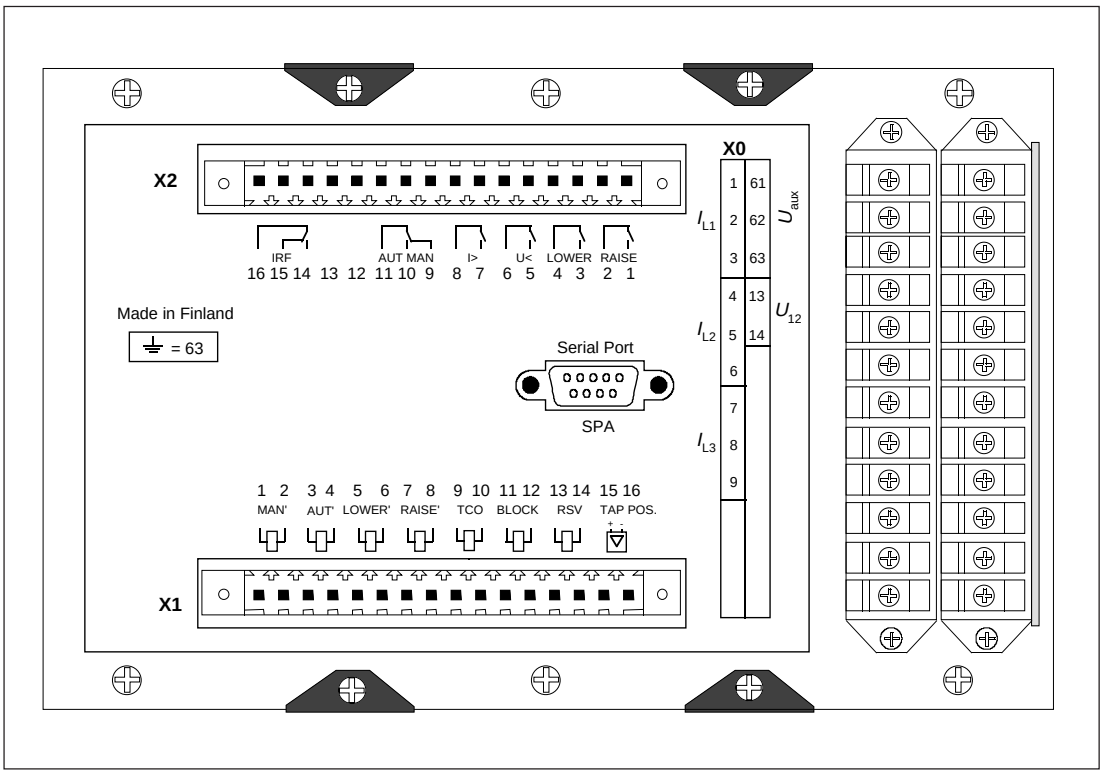


Fig. 3. Rear wiew of the voltage regulator SPAU 341 C

Specification of input and output terminals

Terminal group	Terminal	Function
X0	1-2	Phase current I_{L1}(5 A).
	1-3	Phase current I_{L1}(1 A).
	4-5	Phase current I_{L2}(5 A).
	4-6	Phase current I_{L2}(1 A).
	7-8	Phase current I_{L3}(5 A).
	7-9	Phase current I_{L3}(1 A).
		If only one phase current is available for measuring purposes, the terminals X0/1-2 or X0/1-3 for I_{L1} should be used. Then the software switches of the automatic voltage regulating module SPCU 1D50 are set accordingly.
	13-14	Phase-to-phase voltage U_{12} (100,110,120 V).
	61-62	Auxiliary voltage supply. Terminal 61 positive for DC supply voltage. Auxiliary voltage range marked on the front panel.
	63	Protection earth.
X1	1-2	Manual control signal, changes the regulator to manual mode. The manual control signal has priority over the automatic control signal.
	3-4	Automatic control signal, changes the regulator to automatic mode.
	5-6	Lower control signal, gives lower output signal if the unit is in manual mode. Can also be configured as reduce set voltage input.
	7-8	Raise control signal, gives a raise output signal if the unit is in manual mode. Can also be configured as parallel control input.
	9-10	Tap-changer operating input. To avoid regulating pulses when a tap change is in progress, this input can be connected to the corresponding tap-changer output.
	11-12	Blocking control signal. Can also be configured as remote/local control input.
	13-14	RSV control signal, reduces the voltage set value (U_s). Can also be configured as parallel control input.
	15-16	Tap-changer position input, mA signal. The positive pole of the signal is connected to terminal 15.
X2	1-2	Raise output relay
	3-4	Lower output relay
	5-6	Undervoltage blocking output relay
	7-8	Overcurrent blocking output relay. Can also be configured as overvoltage detection output relay.
	9-10-11	Automatic or manual mode output relay, energized in automatic mode
	14-15-16	Self-supervision output relay

The voltage regulator SPAU 341 C is connected to the fibre-optic communication bus via a bus connection module type SPA-ZC 17 or type SPA-ZC 21. If the regulator operates in parallel with other regulators, according to the minimizing circulating current principle, the bus connection module SPA-ZC 100 is used. The bus connection modules SPA-ZC 17 and SPA-ZC 21 connect directly to the D-type connector (SERIAL PORT) on the rear panel of the regulator, whereas the module SPA-ZC 100 is connected via a cable type SPA-ZP 25A05.

The opto-connectors of the optical fibres are plugged into the counter connectors Rx and Tx of the bus connection module. The communication mode selector switches of the bus connection module are to be set in position "SPA".

Power supply module

The power supply module is located behind the system front panel of the regulator and can be withdrawn after removal of the system front panel. The power supply module produces the voltages required by the regulating modules from the auxiliary voltage.

There are two types of power supply modules, differing only in input voltage:

SPGU 240 A1:
Rated voltage U_n = 110/120/230/240 V ac
U_n = 110/125/220 V dc
Operative range U = 80…265 V ac/dc

SPGU 48 B2:
Rated voltage U_n = 24/48/60 V dc
Operative range U = 18…80 V dc

Which power supply the regulator contains, is marked on the system panel.

The power supply module is a transformer-connected, i. e. galvanically separated primary and secondary circuits, flyback type rectifier. The primary circuit is protected by a 1 A fuse, F1 (slow), in SPGU 240 A1, and a 4 A fuse (fast) in SPGU 48 B2. The fuses are located on the circuit board of the module.

When the power supply module is operating, the green LED indicator Uaux on the system panel is lit. The supervision of the supply voltages for the electronics is incorporated into the regulating modules. A self-supervision alarm is given if one of the secondary voltages differs by more than 25% from the rated value. An alarm signal is also obtained, if the power supply module is missing, or if the auxiliary voltage to the regulator has been interrupted.

I/O module

The I/O module SPTR 6B32 is located on the rear panel of the regulator, in the same direction as the mother board. It can be removed by undoing the fixing screws, the protection earth cable, and the bus connection to the mother board.

To be noted! If the I/O module for some reason has to be changed, and the regulator contains the manual regulating module SPCN 1D56 with the position measuring option, the mA input has to be recalibrated. The I/O module includes all the output relays, the relay control circuits, the external control inputs, and the circuits needed for the serial bus.

Mother board

Signals received from and transmitted to the I/O module are linked to the mother board, which distributes them to the proper regulating module. Furthermore, the mother board contains secondary supply voltage lines to the regulating modules. The regulating modules have their fixed positions on the mother board: the automatic voltage regulating module SPCU 1D50 in location U1 (the leftmost module location) and the manual voltage regulating module SPCN 1D56 in location U2 (the middle location). The rightmost module location is empty.

Technical data

(modified 2002-04)

Voltage input

Rated voltage U_n, selectable	100 V (110 V, 120 V)
Terminal numbers	X0/13-14
Continuous voltage withstand	$2*U_n$
Rated burden of voltage input at U_n	<0.5 VA
Rated frequency according to order	50 Hz or 60 Hz

Current inputs

Nominal current I_n	1 A	5 A
Terminal numbers	X0/1-3, 4-6, 7-9	X0/1-2, 4-5, 7-8
Thermal current withstand		
- continuously	4 A	20 A
- for 10 s	25 A	100 A
- for 1 s	100 A	500 A
Dynamic withstand		
- half-wave value	250 A	1250 A
Input impedance	<100 mΩ	<20 mΩ

Regulating contacts

Terminal numbers	X2/1-2, 3-4
- Rated voltage	250 V ac/dc
- Continuous current carrying capacity	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 48/110/220 V dc control circuit voltage.	5 A/3 A/1 A

Signalling contacts

Terminal numbers	X2/5-6,7-8,9-10-11,14-15-16
- Rated voltage	250 V ac/dc
- Continuous current carrying capacity	5 A
- Make and carry for 0.5 s	10
- Make and carry for 3 s	8 A
- Breaking capacity for dc, when the control circuit time-constant L/R <40 ms, at 48/110/220 V dc control circuit voltage	1A/0.25A/0.15A

External control inputs

Terminal numbers	X1/1-2,3-4,5-6,7-8,9-10,11-12,13-14
- External control voltage	18…250 V dc or 80…250 V ac
- Current drain of activated control input	2…20 mA

External mA input

Terminal numbers	X1/15-16
- External control current	0…20 mA
- Input resistance	300 Ω

Supply voltage

Power supply module voltage range:	
- SPGU 240 A1	
Rated voltage	U_n = 110/120/230/240 V ac
	U_n = 110/125/220 V dc
Operative range	U = 80…265 V ac/dc
- SPGU 48 B2	
Rated voltage	U_n = 24/48/60 V dc
Operative range	U = 18…80 V dc
Power consumption, regulator under quiescent/operation conditions	10 W/15 W

SPCU 1D50

See the specific regulating module manual chapter "Technical data"

SPCN 1D56

See the specific regulating module manual chapter "Technical data"

Data communication

Transmission mode	Fibre-optic serial bus
Coding	ASCII
Data transfer rate, selectable	4800 or 9600 Bd
Optical bus connection module	
- for plastic cables	SPA-ZC 21 BB
- for glass fibre cables	SPA-ZC 21 MM
Optical bus connection module powered from the internal power supply	
- for plastic cables	SPA-ZC 17 BB
- for glass fibre cables	SPA-ZC 17 MM
Optical bus connection module for parallel operation	
- for plastic cables	SPA-ZC 100 BB
- for glass fibre cables	SPA-ZC 100 MM

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

Service temperature range	-10…+55°C
Transport and storage temperature range according to IEC 60068-2-8	-40…+70°C
Temperature influence	
- Voltage measurement	< 0.025%/°C
- Tap-changer position measurement	< 0.025%/°C
- Current measurements	< 0.1%/°C
Damp heat test according to IEC 60068-2-30	93…95%, 55°C, 6 cycles
Degree of protection by enclosure of flush mounting regulator case according to IEC 60529	IP 54
Weight of fully equipped regulator	5.5 kg

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

Line drop compensation

The line drop compensation feature is used for compensating the voltage drop along a line or network fed by the transformer. The compensation setting parameters can be calculated theoretically, if the resistance and reactance of the line are known, or practically by measuring the line drop. If the transformer is feeding two or more lines, the regulator can be given an average of the line parameters, thus providing a more stable voltage supply in the line ends, than would be possible without compensation.

The line drop compensation also operates in "reverse direction". At reversed power flow, the compensation reduces the secondary voltage of the transformer according to the line drop, instead of raising it.

Line drop compensation is possible in single transformer applications and in applications with parallel transformers. Please refer to the manual of module SPCU 1D50 for further information.

Blockings

The operation of the voltage regulator may be blocked for several reasons. Undervoltage and overcurrent blockings are caused internally in the regulator if the values measured exceed the user settable limits. External blocking is activated by the external control input. Furthermore, there is an overvoltage detection feature, which blocks operation of the regulator except for the "fast lower control". Selector switches in the module SPCU 1D50 are used for enabling or disabling the internal blockings and the overvoltage detection feature. If the manual voltage regulating module SPCN 1D56 is included in the regulator, the blocking situations and overvoltage detection are indicated by red alarm LEDs. Manual voltage regulation is enabled in undervoltage and overvoltage situations. In overcurrent and external blocking situations, however, manual voltage regulation is disabled.

Exceptions to the operation explained above if SGF2/2 is in position 1:
- an overvoltage situation U> will activate the I> output relay, disable manual voltage regulation and lit both I> and U> alarm LEDs.
- an overcurrent blocking I> will disable automatic voltage regulation and not block manual voltage regulation.

Undervoltage blocking:
The undervoltage blocking feature blocks the regulator if, for some reason, the measured voltage, is too low to be corrected by operating the tap-changer. Such a situation may be due to a faulty measuring circuit, an earth-fault or and overcurrent situation.

Overcurrent blocking:
Overcurrent blocking is mainly used for preventing the tap-changer from operating in an overcurrent situation, for example, if the current is not high enough to activate the protective relay of the substation but still fatal for the diverter switch of the tap-changer.

External blocking:
The operation of the voltage regulator can be entirely blocked via the external blocking control input. This input can also be configured as remote/local control input using the software switch SGF1/3 in the module SPCU 1D50.

Overvoltage detection:
If the voltage measured exceeds the setting value for "overvoltage detection" and this feature is enabled, the regulator will provide fast lower control until the voltage falls below the specified limit. Fast lower control means that the tap-changer is operated faster than normal by lower control pulses.

Parallel operation

The voltage regulator SPAU 341 C is able to operate parallel transformers in three ways: according to the master/slave, the negative reactance or the minimizing circulating current principle. The master/slave principle needs direct wiring between the regulators. The negative reactance principle does not require any connection between the regulators at all, whereas the minimizing circulating current principle is achieved by using the serial communication devices SPA-ZC 100. A maximum of three transformers can be operated in parallel when the minimizing circulating current principle is used. The other principles can be used with an unlimited number of transfomers in parallel.

Master/slave principle

The master/slave parallel operation is suitable for power transformers with identical ratings and step voltages.

One voltage regulator (master) measures and controls and the other regulators (slaves) follow the master i.e. all tap-changers connected in parallel are synchronized. The init situation is, that the tap-changers are manually operated into the same step, and then the master takes command. This parallel operation is obtained by connecting the master's outputs raise and lower to the corresponding inputs of the slave. If several regulators shall act as masters (one at a time), their outputs also have to be routed to the other regulators' inputs. To start parallel operation, the master regulator is set to automatic mode, and the slaves remain in manual mode.

Negative reactance principle

The negative reactance principle implemented in SPAU 341 C is modified from previous regulator designs. The expected phase-shift of the load supplied by the transformers operating in parallel is entered as a setting value. The regulators correct their control voltage according to the difference between the expected load phase-shift and the phase-shift measured. This parallel control scheme is suitable for power transformers with different ratings and step voltages. Since no connection between the regulators is required, transformers in separate substations can also be operated in parallel. To start parallel operation, parallel status has to be set for all the regulators included in the connection. Parallel status can be set via serial communication, a binary input, or the push-button on the front panel.

Minimizing circulating current

The minimizing circulating current principle is the optimal solution for controlling parallel transformers of different ratings or step voltages in substations with varying reactive loads. Since this control scheme allows exchange of data between the regulators, the circulating current can be calculated more exactly than with other schemes. However, a maximum of three regulators can be connected in parallel. To start parallel operation, parallel status has to be set for all the regulators of the connection. The serial communication, a binary input, or the push-button on the front panel is used for setting parallel status.

Address codes

When two or more SPAU 341 C regulators are operated in parallel, using the bus connection modules SPA-ZC 100 as communication devices, certain slave numbers have to be selected for the regulating modules. The bus connection modules SPA-ZC 100 can be ordered with factory configurations, adapted for these specific regulator applications. The factory configuration can be used when the parallel connected regulators are working independently, without being connected to a substation bus system. The factory configuration of the bus connection modules assumes that the address codes of the regulating modules are as follows:

Regulator	SPCU 1D50, address codes	SPCN 1D56, address codes	SPA-ZC 100 _ 1MRS 090704-xx	
			Plast fiber, xx=	Glass fiber, xx=
Regulator 1	10	11	AB	DB
Regulator 2	20	21	AC	DC
Regulator 3	30	31	AD	DD

If the regulators are to be connected to a substation bus system, and the slave address codes of the factory configuration interferes with the previously selected codes, the bus connection modules have to be reconfigured. During configuration phase the monitor registers in submenus 1…7 under register 3 of the SPCU 1D50 module, might be useful. The settings for parallel operation are described in detail in the manual of the automatic voltage regulating module, SPCU 1D50.

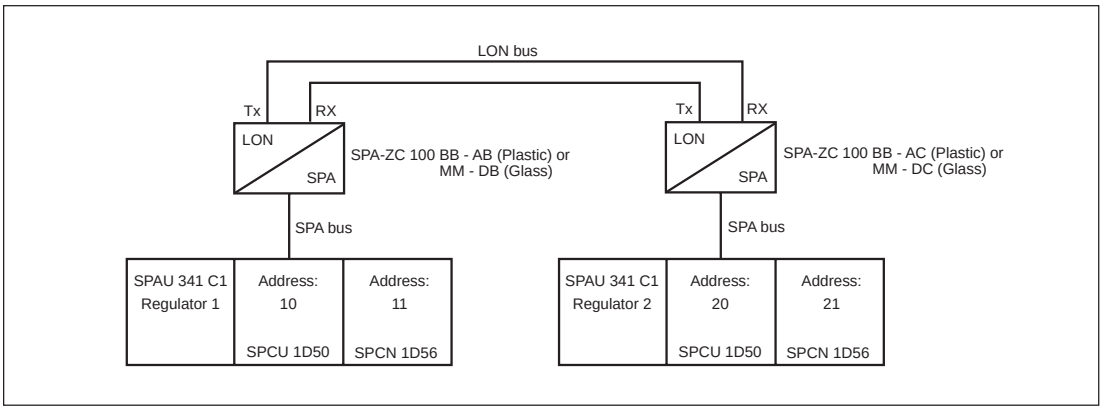


Fig. 4. Parallel operation of two regulators, using the minimizing circulation current principle.

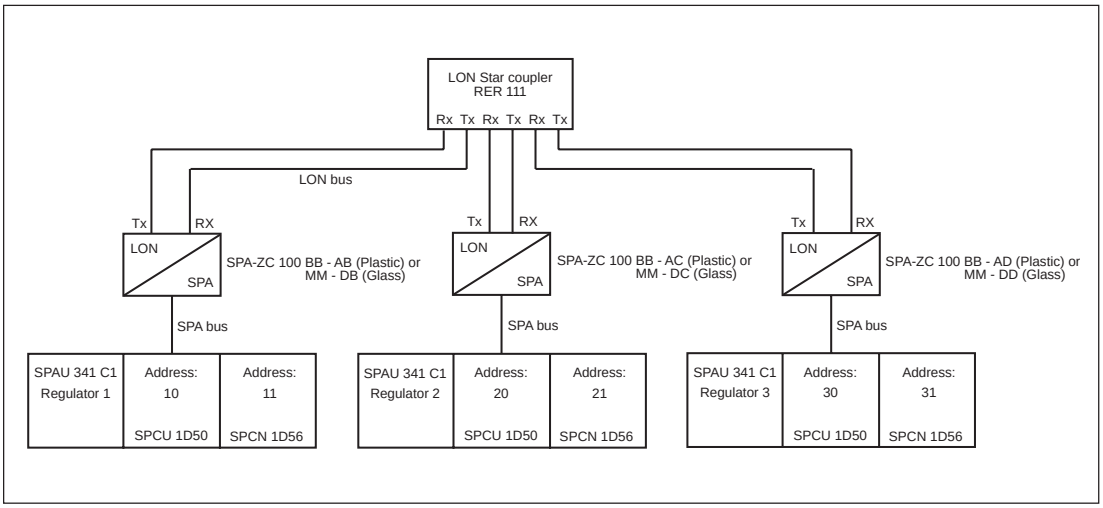


Fig. 5. Parallel operation of three regulators, using the minimizing circulation current principle.

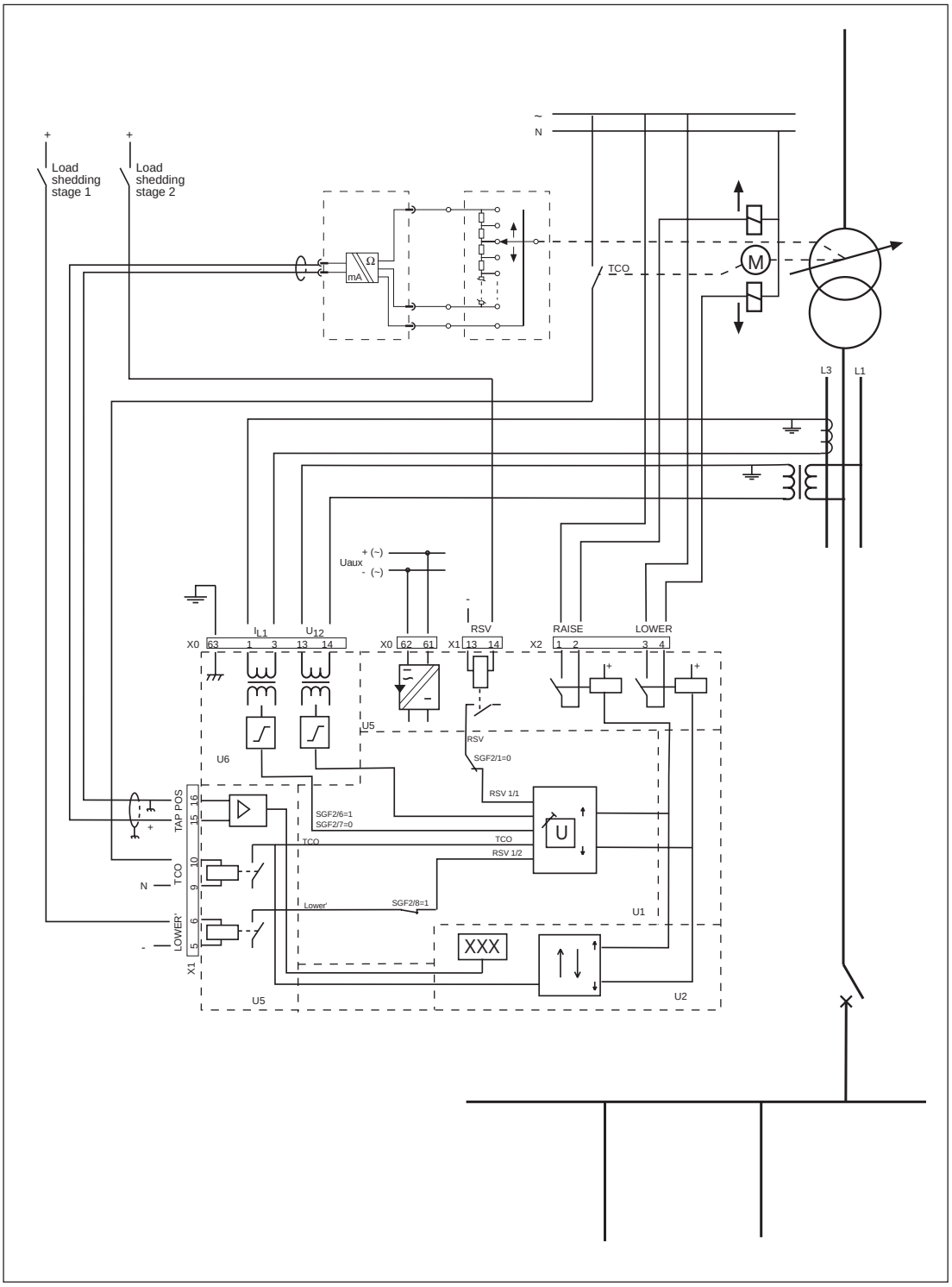


Fig. 6. Application example for the voltage regulator SPAU 341 C1. The overcurrent blocking and the undervoltage blocking features complement each other, as the voltage is measured from phases L1 and L2 and the current from phase L3. Load shedding in two stages. Stage 1 reduces the set voltage by half the setting value RSV, and stage 2 reduces the set voltage to the full extent of setting value RSV. Tap-changer operation feedback is connected to the regulator. Tap-changer position is measured.

(modified 2003-11)

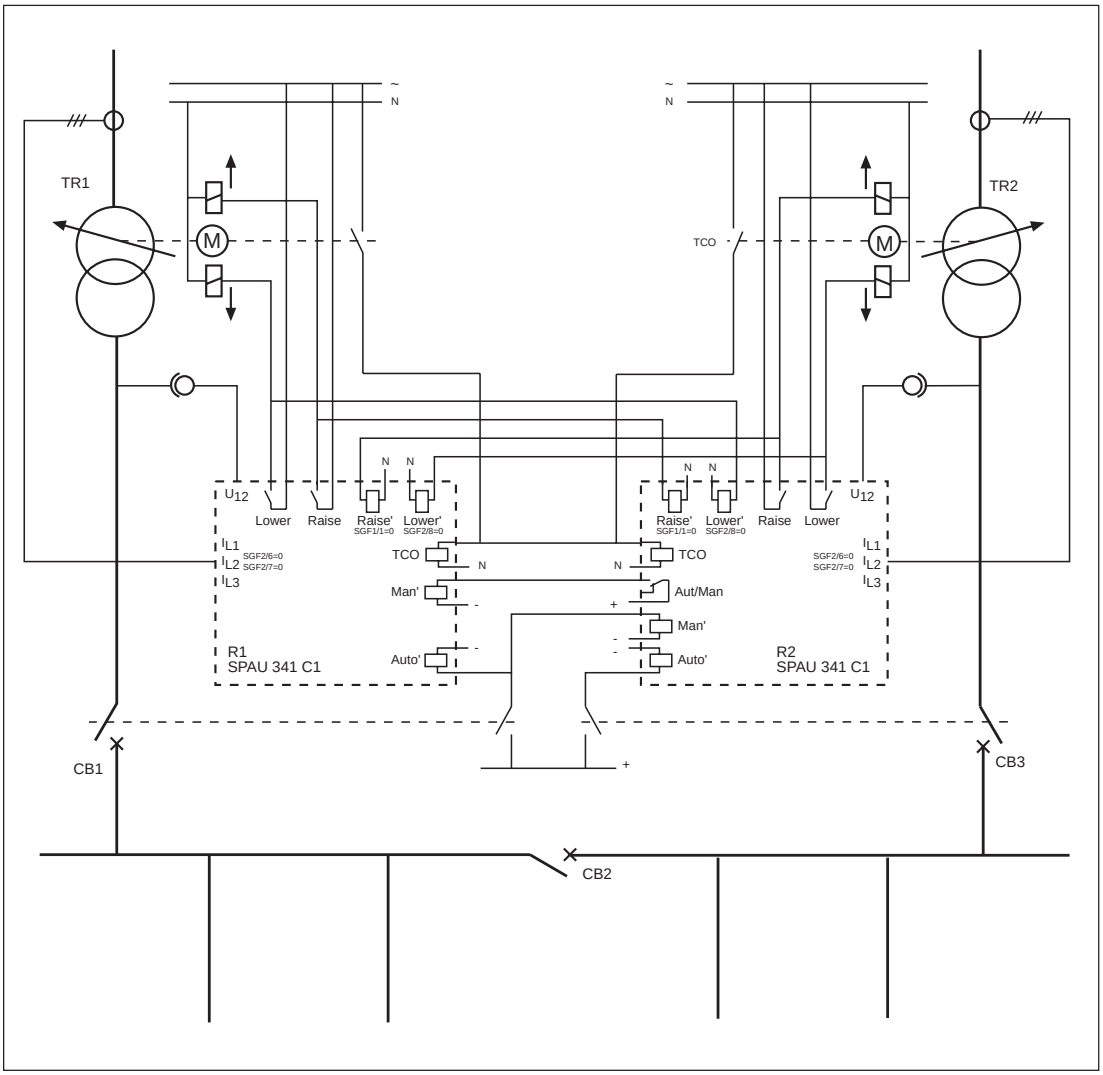


Fig. 7. The voltage regulator SPAU 341 C1 in parallel operation using the master/slave principle. Three phase currents measured on the primary side of the transformer for overcurrent blocking purpose. No line drop compensation used. Automatic selection of master regulator using digital inputs. The TCO signal from the tap-changer with the longest operate time is connected to the regulators to prevent regulating pulses during tap-changer operation.

Table 1. Regulator mode compared to circuit breaker configuration

CB 1	CB 3	Regulator 1	Regulator 2
open	open	as before	as before
closed	open	automatic (master)	manual (slave)
open	closed	manual (slave)	automatic (master)
closed	closed	automatic (master)	manual (slave)

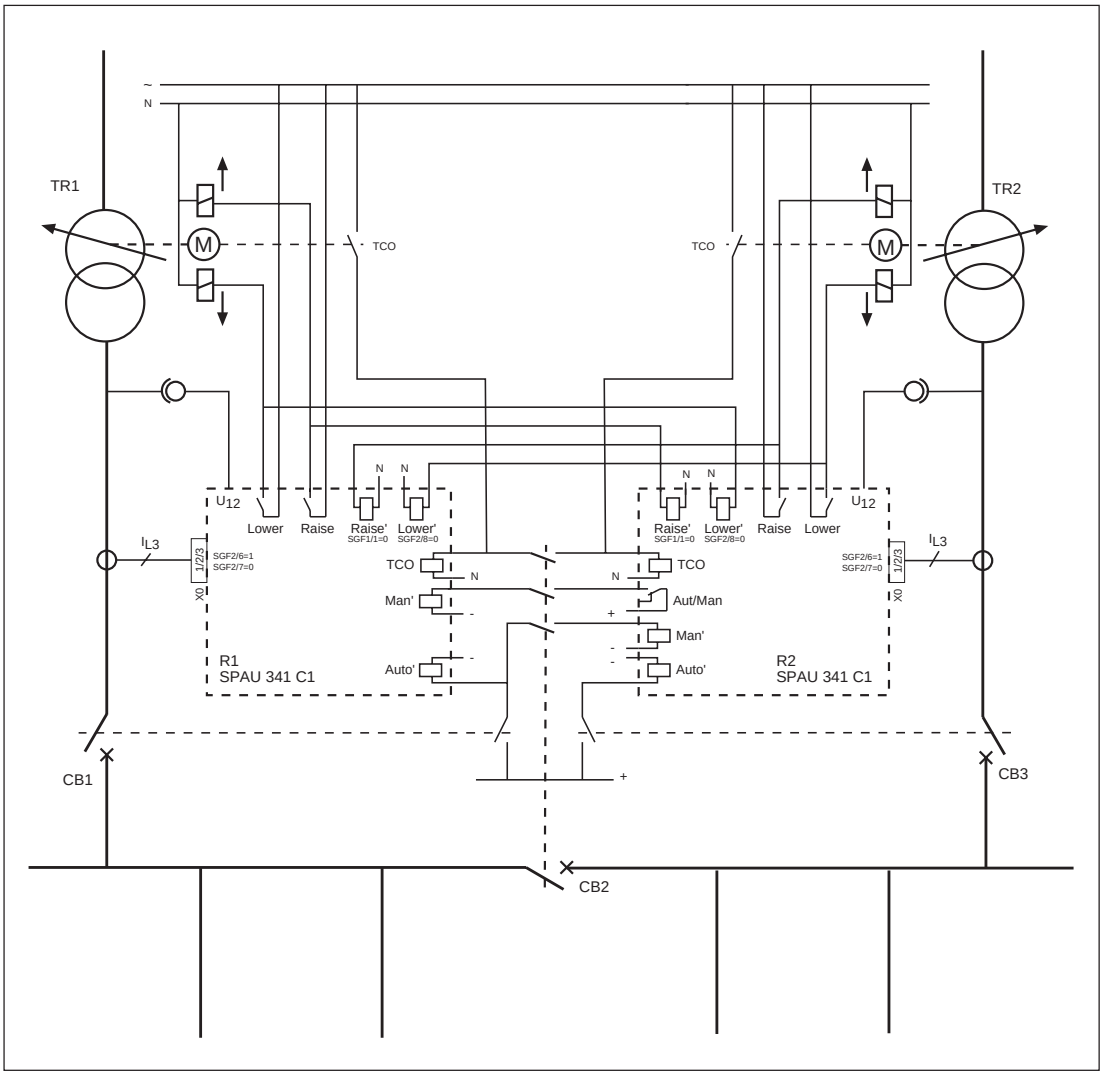


Fig. 8. The voltage regulator SPAU 341 C1 in parallel operation using the master/slave principle. Automatic selection of master regulator via digital inputs. When CB 2 is opened, the regulators starts operating individually in automatic mode and the tap-changers have to be synchronized before CB 2 is closed again. When CB 2 is closed, the TCO signals from both tap-changers are connected to the regulators. Thus, the longest operate time will prevent regulating pulses during tap-changer operation.

Table 2. Regulator mode compared to circuit breaker configuration

CB 1	CB 2	CB 3	Regulator 1	Regulator 2
open	open	open	as before	as before
open	closed	open	as before	as before
closed	closed	open	automatic (master)	manual (slave)
open	closed	closed	manual (slave)	automatic (master)
closed	closed	closed	automatic (master)	manual (slave)
open	open	closed	as before	automatic
closed	open	open	automatic	as before
closed	open	closed	automatic	automatic

Note!
The above mode of regulation according to the master/slave principle of Table 2 requires that the regulator is controlled solely with the circuit breakers CB1, CB2 and CB3. If the control is carried out with the push buttons on the front panels of the concerned regulators, the functions of Table 2 are not valid. If you wish to control the regulators by means of the push buttons on the front panel, you must, before returning to the master/slave mode, reset the regulator to the same state, which is valid for the concerned circuit breaker configuration as of Table 2.

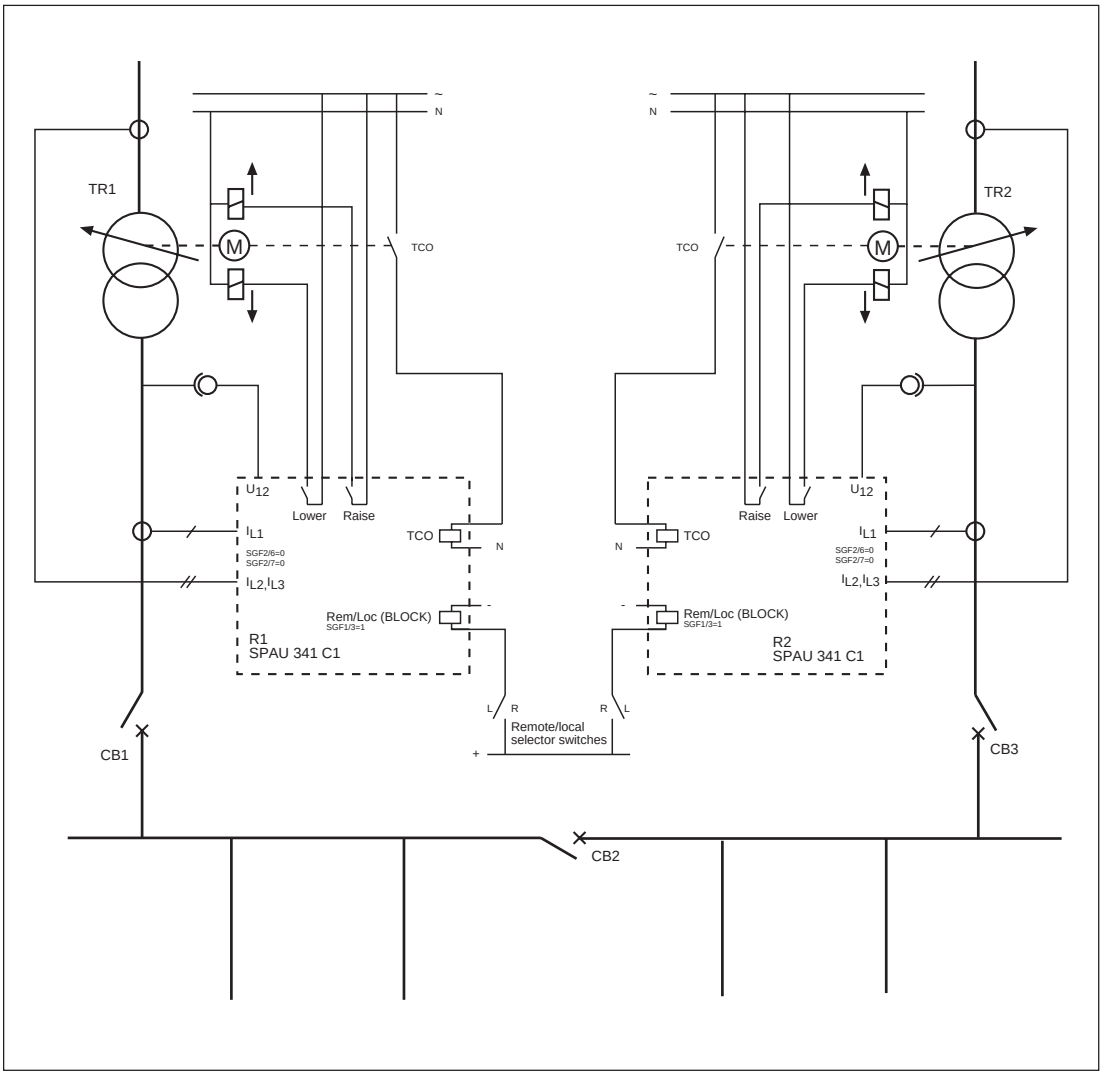


Fig. 9. Voltage regulators SPAU 341 C1 in parallel operation using the negative reactance principle. Depending on the position of the Remote/local selector switches, the operation mode of the regulators can be selected via remote control (serial link) or local control (push-buttons). The phase currents I_{L2},I_{L3} are measured on the primary side of the transformer mainly for overcurrent blocking purposes, while the phase current I_{L1} is measured on the secondary side for the parallel operation.

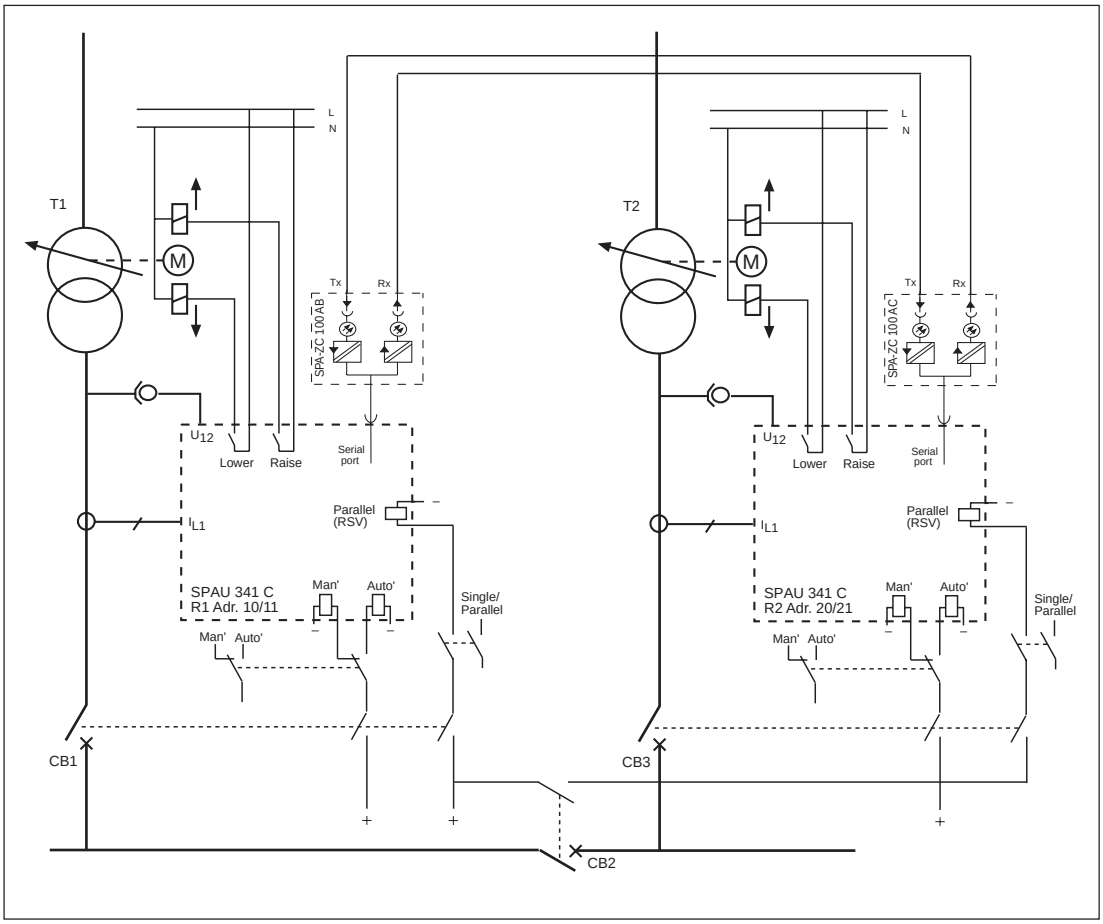


Fig. 10. Voltage regulators SPAU 341 C1 in parallel operation using the minimizing circulating current principle. The operation mode of the regulators is automatically selected according to the circuit breaker configuration. The communication between the regulators is achieved by using SPA/LON gateways.

Table 3. Regulator mode compared to circuit breaker configuration

CB 1	CB 2	CB 3	Regulator 1	Regulator 2
open	closed	open	manual	manual
closed	closed	open	automatic	manual
open	closed	closed	manual	automatic
closed	closed	closed	parallel	parallel
open	open	closed	manual	automatic
closed	open	open	automatic	manual
closed	open	closed	automatic	automatic

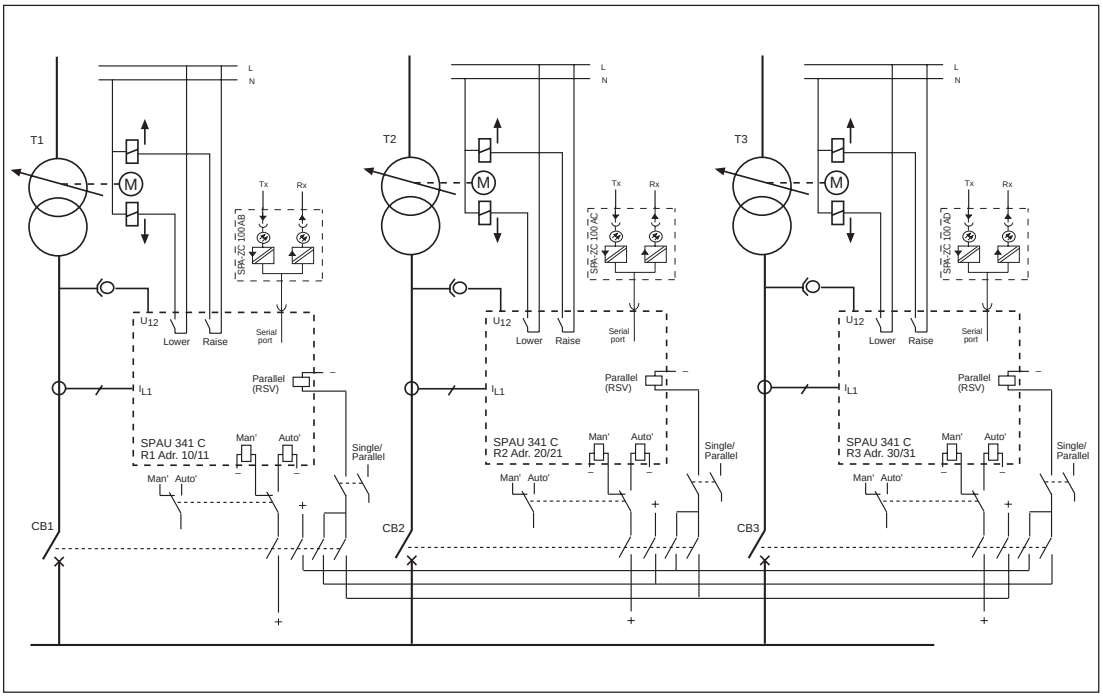


Fig. 11. Three voltage regulators type SPAU 341 C1 operating in parallel using the minimizing circulating current principle. The parallel mode of operation of the regulators is automatically selected when the transformers are connected in parallel. When one of the transformars is connected for single operation, the concerned regulator also switches over to the same mode of operation (automatic/manual) it had before the parallel operation.

Start-up

Before starting the regulator, take the following precautions:

Check that the phasing of the measured voltage and current is correct, and that the current to be measured is properly selected using the software switches. This is easily done by comparing the phase shift measured by the module SPCU 1D50 with the actual phase shift of the network.

Check the connection of the raise and lower outputs by switching the regulator to manual mode and operating the tap-changer in any direction.

If the TCO (tap-changer operating) input is connected, check that the corresponding LED on the front panel of module SPCN 1D56 is lit during tap-changer operation. If the TCO input is not connected, the setting of OPD (output pulse duration) should be shorter than the operate time of the tap-changer, but enough close to it to prevent regulating pulses during tap-changer operation.

It should be remembered that the setting values of a regulator always are a compromise between the amount of regulating pulses during a certain time and the stability of the regulated voltage. If the setting values are too sensitive, the tap-changer is operated too often and unnecessary wear is caused. The setting values affecting the sensitivity of the regulator are: ΔU_s, T1, T2, U_r, U_x and Stability. The stability setting value is only used in parallel operation.

The ΔUs setting value should be selected according to the power transformer's step voltage, approximately as high as the step voltage, relative to the nominal voltage. During start-up the time delays T1 and T2 should be rather long, for instance, 60 s and 30 s. If required, the settings can be changed after start-up.

If parallel operation is used, the stability setting value should be very small, for example, 10%, when the operation is started. Check that the transformers are equally loaded by reading the phase shifts from the automatic voltage regulating modules SPCU 1D50. When transformers are connected in parallel, the phase shifts should be equal or, practically, equal. By increasing the stability setting value, the optimal regulation is achived.

For additional information about the settings see the manual of the automatic voltage regulating module SPCU 1D50.

Maintenance and repair

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

If the environmental conditions such as temperature and humidity differ from those specified, or if the atmosphere on site contains chemically active gases or dust, the regulator should be visually inspected, whenever the module is withdrawn from the case. The visual inspection should focus on:

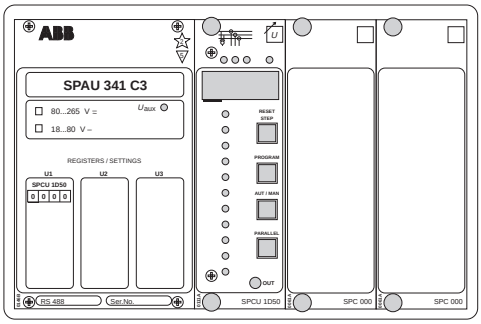
- Signs of mechanical damage to regulator module, contacts and case.
- Accumulation of dust inside the case, remove using compressed air
- Corrosion on terminals, case or inside the regulator.

If the regulator fails in operation or if the operating values considerably differ from those specified, the regulator should be given a proper overhaul. Minor measures such as change of I/O module and recalibration of the mA input and voltage measurement can be taken by the customers, but any major measures involving the electronics should be taken by the manufacturer. For further information, please contact the manufacturer or his nearest representative.

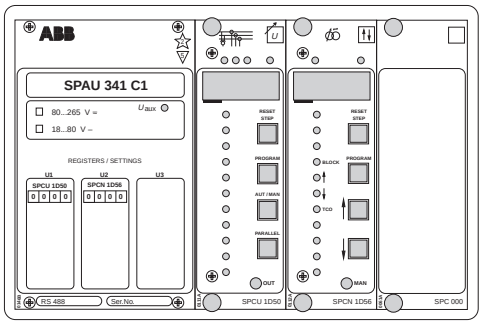
Spare parts

Automatic voltage regulating module	SPCU 1D50
Manual voltage regulating module	SPCN 1D56
Power supply module	
- U_{aux}= 80…265 V ac/dc (operative range)	SPGU 240 A1
- U_{aux}= 18…80 V dc (operative range)	SPGU 48 B2
Case (including connection module)	SPTK 4B19
I/O module	SPTR 6B32
Bus connection module	SPA-ZC 17_ or SPA-ZC 21_
Parallel operation bus connection module	SPA-ZC 100_

Delivery alternatives



Voltage regulator SPAU 341 C3, basic version



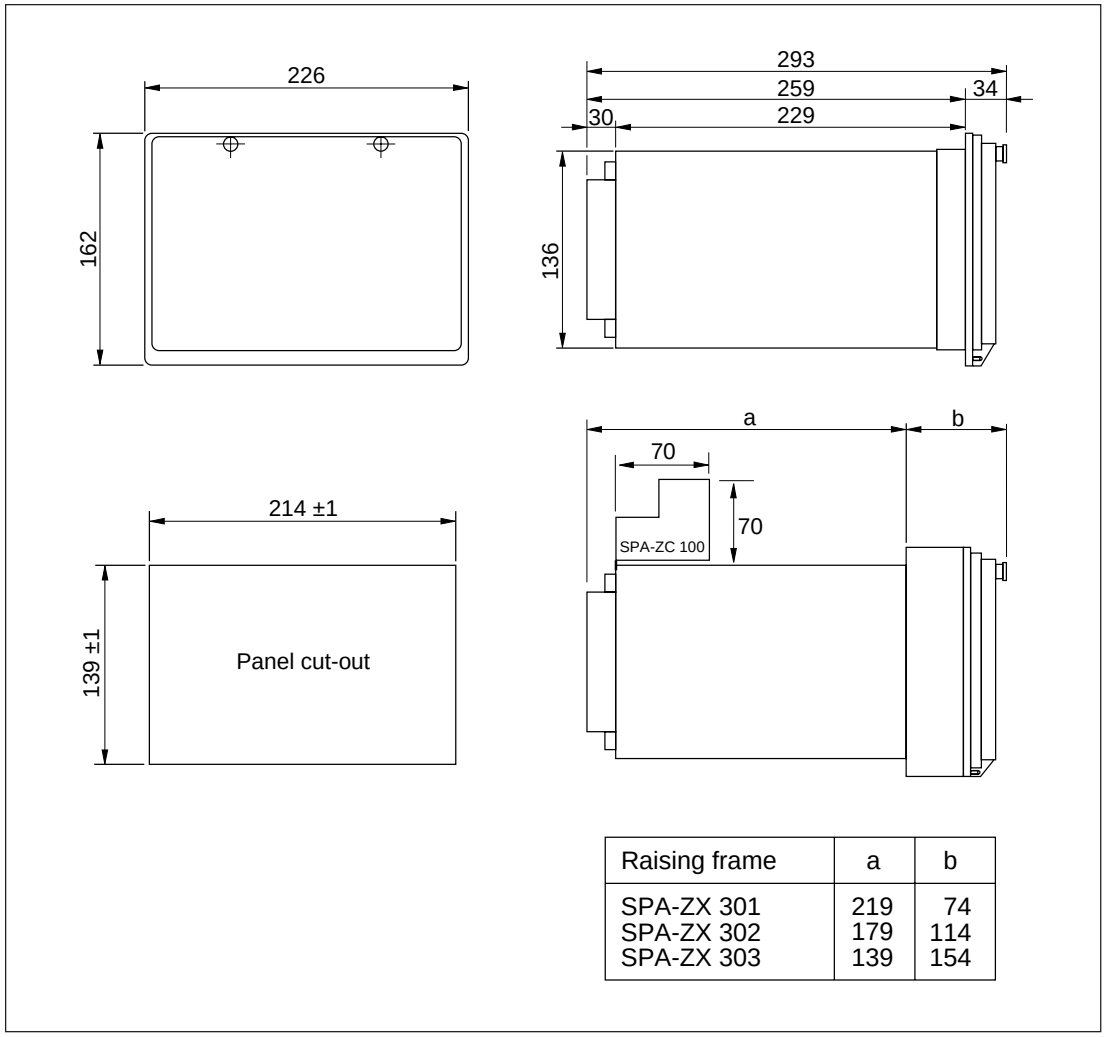
Voltage regulator SPAU 341 C1, Manual regulating module included

Fig. 12. Voltage regulator SPAU 341 C, delivery alternatives

Dimensions and mounting

The basic model of the regulator case is designed for flush-mounting but, when required, the mounting depth of the case can be reduced by means of raising frames.

Three types of raising frames are available: type SPA-ZX 301 reduces the depth by 40 mm, type SPA-ZX 302 by 80 mm and type SPA-ZX 303 by 120 mm.



Raising frame	a	b
SPA-ZX 301	219	74
SPA-ZX 302	179	114
SPA-ZX 303	139	154

Fig. 13. Dimension and mounting drawings for voltage regulator SPAU 341 C.

The regulator case is made of profile aluminium and finished in beige.

The rubber gasket fitted to the mounting collar provides an IP 54 degree of protection by enclosure between the regulator case and the mounting base.

The hinged cover of the case is made of transparent, UV-stabilized polycarbonate polymer and provided with two sealable locking screws. The rubber gasket of the cover provides an IP 54 degree of protection between the case and the cover.

The required input and output circuits are connected to the screw terminals on the rear panel. Terminal block X0 consists of screw terminals fitted to the rear panel of the relay. The terminal blocks X1 and X2 are provided with disconnectable multi-pole screw terminals. The male parts of the disconnectable terminal blocks are attached to the I/O module. The female parts are included in the delivery. The female part can be locked to the male part with fixing accessories and screws.

Measured data, auxiliary voltage and protective earth are wired to the terminal block X0. Each terminal screw is dimensioned for one wire of maximum 6 mm2 or two wires of maximum 2.5 mm^2.

Binary input and output signals are connected to the multi-pole terminal blocks X1 and X2. Each screw terminal is dimensioned for one wire of maximum 1.5 mm^2 or two wires of maximum 0.75 mm^2.

The 9-pole D-type connector is intended for serial communication.

Ordering information

Voltage regulator SPAU 341 C1: RS 488 003-AA, CA, DA, FA
Voltage regulator SPAU 341 C3: RS 488 005-AA, CA, DA, FA

The letter combinations of the order number indicate the rated frequency f_n and the operative range of the auxiliary supply:

AA: f_n = 50 Hz, U_{aux} = 80…265 V ac/dc
CA: f_n = 50 Hz, U_{aux} = 18…80 V dc
DA: f_n = 60 Hz, U_{aux} = 80…265 V ac/dc
FA: f_n = 60 Hz, U_{aux} = 18…80 V dc

Bus connection module SPA-ZC 100 for parallel operation:
1MRS 090704 - AB, AC, AD, DB, DC, DD

The first letter of the letter combinations indicates the type of LON interface:

Glass fibre or plastic fibre.
A: plastic fibre
D: glass fibre

The second letter of the letter combinations indicates the type of configuration of the module.

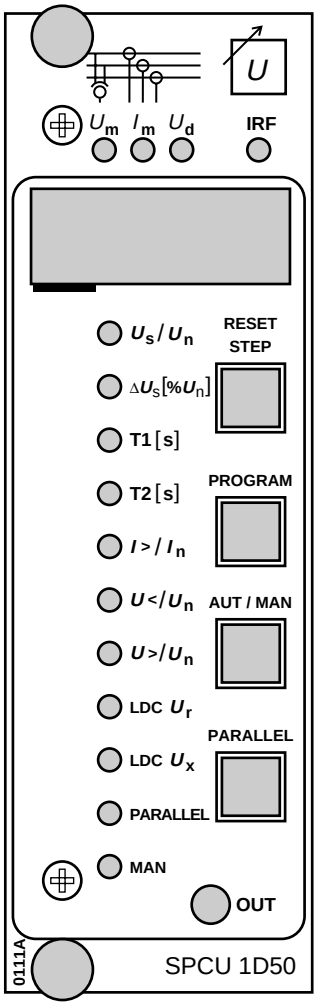
A: No configuration
B: Configured to operate with the regulator #1 in parallel operation
C: Configured to operate with the regulator #2 in parallel operation
D: Configured to operate with the regulator #3 in parallel operation

Ordering example: 1 SPA-ZC 100 unit , RS 951 022-AB
Delivery: Bus connection module SPA-ZC 100 with plastic fibre LON interface and a default configuration for voltage regulator #1 in parallel operation

Glass fibres and plastic fibres: Please contact the manufacturer or his nearest representative for further information

SPCU 1D50
Automatic voltage regulating module

User´s manual and Technical description



1MRS 750111-MUM EN

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Modified 2003-11-03
Version F
Checked KN
Approved MÖ

SPCU 1D50
Automatic voltage regulating module

Data subject to change without notice

Contents

Features

Measured quantities: one phase-to-phase voltage and three phase currents

Stable transformer secondary voltage regardless of the loading situation

Line-drop compensation

Detects undervoltage, overvoltage and overcurrent

Parallel operation of transformers feeding the same busbar, by the master/slave, negative reactance or minimizing circulating current principle

Digital display of set and recorded values

All settings can be keyed in via the MMI on the front panel or via the serial interface using a portable PC and a downloading program.

Self-supervision system continuously monitoring the operation of the electronics and the microprocessor. When a permanent fault is detected, the alarm output relay operates and the other outputs are blocked.

Operation principle

The voltage regulating module SPCU 1D50 compares the measured secondary voltage U_m of the transformer to the control voltage U_p. The control voltage U_p is composed of the setting value U_s, the line-drop compensation value U_z, the circulating current compensation value U_{ci} and the reduce set voltage value U_{rsv}, i.e. $U_p = U_s \pm U_z \pm U_{ci} - U_{rsv}$.

The parameter ΔU_s denotes the hysteresis, which is active around U_p, within which no regulation takes place. If, for instance, U_p = 100 V and ΔU_s = 1.5%, the module does not generate a raise or lower command, when the measured voltage is in the range U_m = 98.5… 101.5 V. If the measured voltage is below 98.5 V or above 101.5 V, the adjustable delay time T1 starts. This delay time is running as long as U_m is outside the ΔU_h limits. The factory setting of ΔU_h is 90% of ΔU_s. If U_m does not rise or fall within the limits of ΔUh during the delay time, the output signal is activated. Should, however, the voltage U_m rise or fall within the ΔU_h limits during the delay time, the delay counter is reset and the module does not provide a control signal.

After the first control signal from the regulating module, the voltage U_m may still be outside the limits of ΔU_s. Then the second adjustable delay time T2 starts. The setting of this delay is normally shorter than T1. T1 and T2 can both be given either a fixed value or a value depending on the difference between U_m and U_p. This deviation $U_m - U_p$, expressed as U_d, can be read on the display of the module. When the delay time depends on the deviation, it is inversely proportional to the $U_d/\Delta U_s$ ratio and thus also depending on the set value of ΔU_s.

Control voltage U_p

The voltage regulating module constantly regulates the secondary voltage towards U_p. The control expression has the following form:

$U_p = U_s \pm U_z \pm U_{ci} - U_{rsv}$

U_s = reference voltage
U_z = line-drop compensation value
U_{ci} = circulating current compensation value
U_{rsv} = reduce set voltage value

Reduce set voltage

The reduce set voltage feature can be used for load shedding or simple line drop compensation purposes. The set voltage is reduced by activating the RSV 1/2 or RSV 1/1 binary input. Activating the RSV 1/2 input reduces the set voltage by half the setting value RSV and activating the RSV 1/1 input reduces the set voltage to the full extent of setting value RSV. If both inputs are active, the RSV 1/1 input has priority and the set voltage is reduced to the full extent. The setting value RSV is selectable in the range 0.00...9.00%. Software switch SGF2/8 has to be set and SGF2/1 has to be cleared if both inputs are used.

Second settings

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

1) Over the serial communication, using the command V150.
2) Via the push-buttons on the front panel and subregister 4 of register A. The setting 0 activates the main settings and the setting 1 activates the second settings.
3) By setting the switch SGF1/6 into position 1. Then the selection of main or second settings depends on the regulator operation mode. If single operation is used, main settings are valid and if parallel operation is used, second settings are valid. Setting the switch SGF1/6 into position 1 deactivates parameter V150 and subregister 4 of register A. Note! To become active, the switch must be set into position 1 in both setting banks.

Line-drop compensation U_z *(modified 2003-11)*

The line-drop compensation feature of the voltage regulating module SPCU 1D50 compensates resistive and reactive voltage drop of the line fed by the transformer. Thus the module can maintain the reference voltage U_s in the line end. The compensation parameters to be given, U_r and U_x, are percentage values of U_n according to the following expressions:

$$U_r\,[\%] = \frac{\sqrt{3} \times I_{load} \times R}{U_n} \times 100$$

$$U_x\,[\%] = \frac{\sqrt{3} \times I_{load} \times X}{U_n} \times 100$$

I_{load} = network load current or max. current
U_n = rated phase-to-phase voltage of the power transformer
R = resistance of the line, Ω/phase
X = reactance of the line, Ω/phase

U_r[%] indicates the resistive voltage drop of the line, and U_x[%] the reactive voltage drop of the line. When calculated by the module, the real compensation value for the voltage drop takes into account the phase shift of the network and the measured current. The current is selected with the software switches.

If the compensation parameters R and X are unknown, the voltage can be calculated by measuring the voltage in both ends of the line and the current and the phase angle of the network. To ensure that the tap-changer remains in the same position during the measurement, the module has to be in manual mode.

The voltage in the beginning of the line and the current and the phase angle of the network can be read on the display of the voltage regulating module.

Then U_r[%] and U_x[%] can be calculated from the following expressions:

$$U_r[\%] = \frac{\cos\varphi \times U_{l0} \times \sqrt{3}}{U_n} \times \frac{I}{I_{nt}}$$

$$U_x[\%] = \frac{\sin\varphi \times U_{l0} \times \sqrt{3}}{U_n} \times \frac{I}{I_{nt}}$$

I_{nt} = rated current of the power transformer
U_n = rated phase-to-phase voltage of the power transformer
φ = phase shift of the network
U_{l0} = voltage drop
I = selected current

Line drop compensation with parallel transformers

Line-drop compensation is also possible with parallel transformers. When the **master/slave principle** is used, an unlimited number of power transformers can be operated in parallel. The voltage regulating module operating as master, calculates the voltage drop on the basis of its own measurements, assuming that the power transformers are equally loaded. The general rule for calculating the parameters U_r% and U_x% is, that the line and transformer ratings for single operation are entered.

When the **negative reactance principle** is used, the regulator uses the load phase-shift setting value and the measured current amplitude as references for calculating the line drop. The phase shift measured by the regulator does not affect the line drop compensation at all. In a case, where the actual load phase shift is equal to the setting value, a line drop compensation with full resistive and reactive compensation is achieved. When calculating the U_r% and U_x% parameters, the resistance and reactance used in the formulas should be the values of the network in common. I_{nt}, the rated current of the power transformer, should be the sum of the rated currents of the transformers operating in parallel. If the transformer is used in both single and parallel operation, the correct line drop compensation can be established by entering different setting values for U_r% and U_x% in the main and second setting banks. Switch SGF1/6 can be used to change the setting bank according to the operation mode used.

When the **minimizing circulating current** principle is used, the voltage regulating modules obtain current and phase-shift information from the other modules. Therefore, they also hold information about the load distribution between the power transformers, and the load phase-shift setting value does not have to be entered. The compensating parameters U_r% and U_x% are calculated in the same way as for the negative reactance principle. For the line drop compensation to work satisfactorily, it is important that the I_{nt} value and the I_{nt}/I_{ct} ratio for each voltage regulating module is set. Switch SGF1/6 can be used to change the setting bank according to the operation mode used.

Manual/automatic mode or parallel operation

The operation mode of the regulator can be selected in three ways: via external control inputs, push-buttons, or control commands over the serial communication link. If the remote/local control with the external control input BLOCK is used, either the push-buttons or the serial communication can be selected to be active. Direct control via external control inputs is always active. Manual tap-changer control can be performed in the same three ways as the selection of the operation mode. The figure below illustrates the different control commands and the associated logic of the module SPCU 1D50.

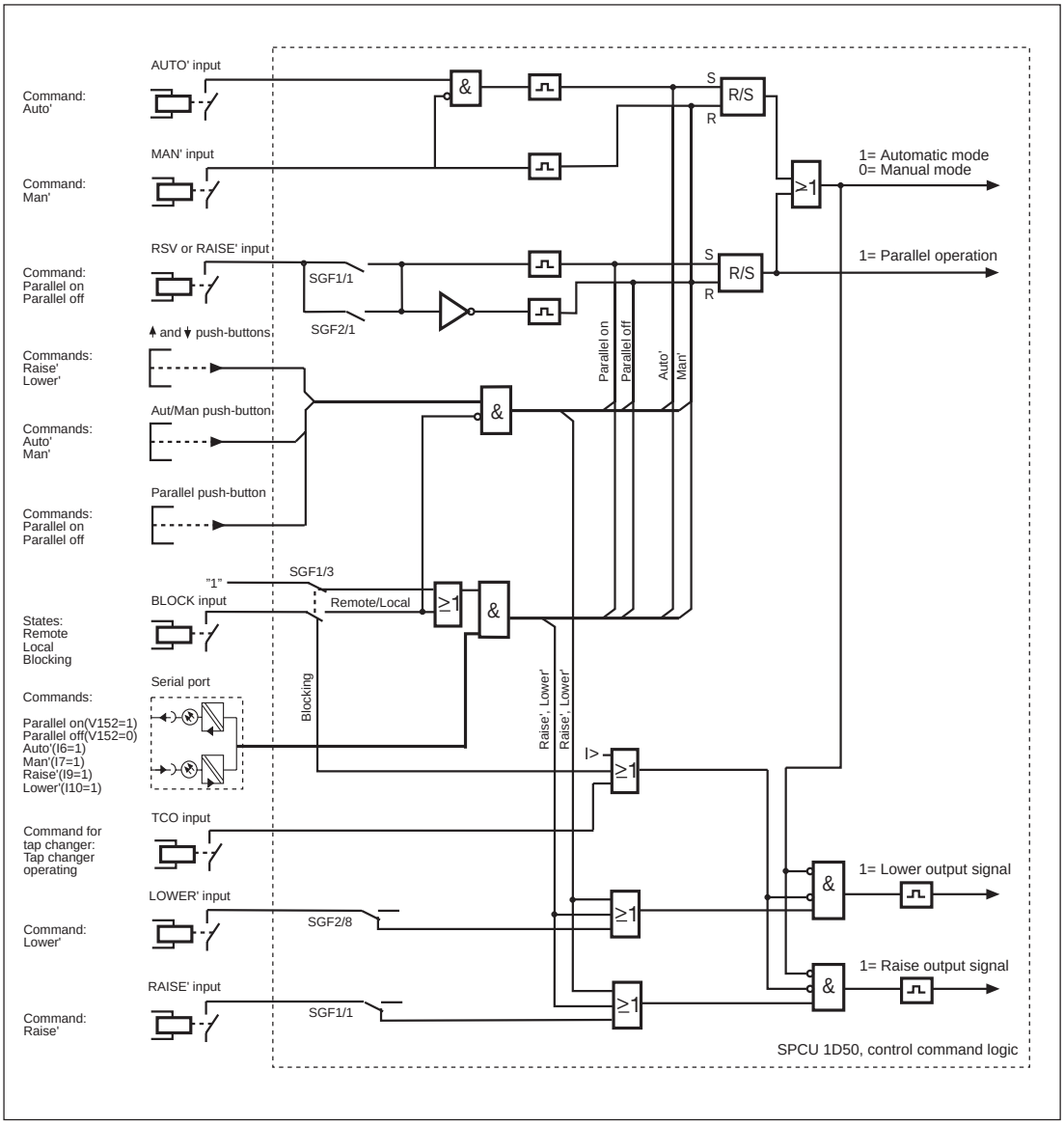


Fig. 1. Manual/automatic mode or parallel operation, control command logic.

Negative reactance principle

If the software switch SGF1/2=1 and parallel operation has been selected, the regulator starts operating according to the modified negative reactance principle. By comparing the actual phase-shift measured with the set load phase-shift value, and measuring the current, the compensating value U_{ci} can be calculated. The compensating value U_{ci} affects the regulator control voltage U_p in such a way, that a stable voltage control of parallel operating transformers is obtained once the reactive load is relatively stable.

The compensating value U_{ci} is obtained from the following expression:

$$U_{ci} = \frac{I_{ci}}{I_{nt}} \times \frac{\text{stability}}{100} \times U_n$$

I_{ci} = circulating current [kA]
I_{nt} = rated current of the power transformer [kA]
U_n = rated phase-to-phase voltage of the power transformer
stability = percentage setting value

If the parallel operating transformers have different rated currents, the regulator stability setting value should be proportional to the rated currents, i.e. the higher the rated current the higher the stability setting value.

Minimizing circulating current

If the software switch SGF1/2=0 and parallel operation has been selected, the regulator starts operating according to the minimizing circulating current principle. Each voltage regulating module transmits its own current and phase-shift values to the other modules operating in parallel. Then the modules calculate the total value of the busbar current and the phase-shift and compare it with its own values measured. This calculation gives the circulating current to be minimized. The same formula as for the negative reactance principle is used for calculating the compensating value U_{ci}. In this case, the same stability setting value can be set for the separate regulators, since the regulators take into account differences in the transformers's rated currents.

Remote/local control

If the software switch SGF1/3=1, the module can be switched between remote and local control via the external control input BLOCK.

When the external control input is energized, the regulator mode and operation is controlled remotely using the serial communication parameters I6, I7, I9, I10 and V152. When the external control input is deenergized, local push-button control is enabled. Control of regulator mode and operation via external control inputs MAN', AUTO', RAISE', LOWER' and RSV is always enabled.

Front panel

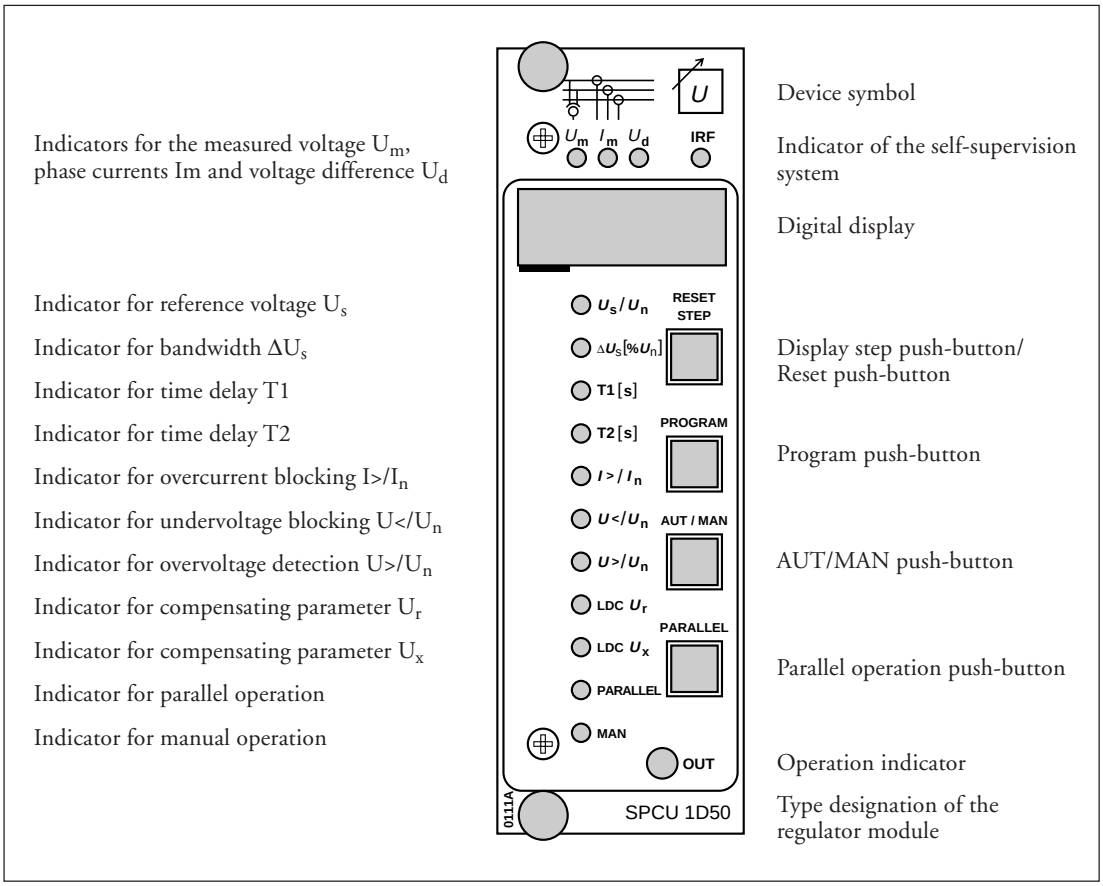


Fig. 2. Front panel of the automatic voltage regulating module SPCU 1D50.

Operation indicators

When the voltage regulating module delivers a raise or lower pulse, the yellow LED indicator OUT in the bottom right corner of the front panel is lit, and remains so as long as the pulse is active. When the voltage U_m is outside the range defined by ΔU_s, either the lower or the raise delay counter is on. If $U_m > \Delta U_s$ (upper limit), the bottom segment of the leftmost digit starts flashing to indicate a lower pulse to come after the set time delay. If $U_m < \Delta U_s$ (lower limit), the top segment of the leftmost digit starts flashing to indicate a raise pulse to come after the set time delay.

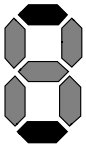
Indicator	Segment	Explanation
	raise	Starts flashing, when the time delay of the raise pulse is running
	lower	Starts flashing, when the time delay of the lower pulse is running

Fig. 3. Start indications of the delay counter, when U_m is selected to be presented.

Settings
(modified 2003-09)

The setting values are indicated by the three rightmost digits of the display. The LED indicators adjacent to the setting value symbols indicate the setting value being presented on the display. Additional setting values are indicated by the leftmost red digit of the display. The settings can be entered from the push-buttons on the front panel or over the serial port.

Symbol	Description	Setting range	Default
U_s	Reference voltage Setting of the reference voltage U_s. The voltage U_s can be set in two different ways; with two decimals' accuracy, or tree decimals' accuracy. - Setting of U_s with two decimals' accuracy is done as usually in the main menu for U_s. Setting range 0.85...1.15 x U_n. - Setting of Us with three decimals' accuracy is done in the submenu for Us, which is presented as U_s-U_n in percent. Setting range -15.0...+15.0% of U_n. Negative percentages are entered in the following way: The leftmost green digit can be browsed and set in the following sequence 1, 2, 3,.., 9, -0, -1, -2, -3,.., -9, 0, 1, 2. The minus sign appears in front of the leftmost red digit. *Note! The submenu for setting Us with three digits' accuracy has been incorporated in the relay from program version 118K and later.*	0.850…1.150 x U_n	1.000
ΔU_s	Bandwidth	0.60...9.00% x U_n	1.50%
T1	Delay time for the first control pulse	0.0...300 s	60.0 s
T2	Delay time for the following control pulse, unless U_m is within the ΔU_s limits after the first pulse	0.0...300 s	30.0 s
I>	Overcurrent blocking. Blocks any control operation during an overcurrent situation	1.00...2.00 x I_n	2.00
U<	Undervoltage blocking. Blocks automatic control during an undervoltage situation	0.70... 0.95 x U_n	0.70
U>	Overvoltage detection. If the measured voltage exceeds the setting value, lower pulses are given faster than normally	1.05...1.25 x U_n	1.25
U_r[%]	Resistive line-drop compensating factor	0.0...25.0% x U_n	0.0
U_x[%]	Reactive line-drop compensating factor	0.0...25.0% x U_n	0.0
1	Checksum of switchgroup SGF1	0...255	16
2	Checksum of switchgroup SGF2	0...255	28
3	Operation counter. Shows the number of raise and lower operations. Note! The control pulses given manually by using push-buttons are not counted.		0
4	Reduce set voltage (RSV). Setting range 0.00...9.00% x U_n		0
5	Rated current Int of the power transformer. To be set, when the module is used in parallel operation. Setting range 0.10...5.00 kA		0.10

Symbol	Description	Setting range	Default
6	I_{nt}/I_{ct} ratio, i.e. the ratio between the rated current of the power transformer and the rated primary current of the current transformer. Setting range 0.60...1.50		1
7	Stability factor. Setting range 0...70% x Un		0
8	Output pulse duration (OPD). Setting range 0.5...10.0 s		1.5
9	Load phase-shift, only used with the negative reactance principle Note! For negative setting values: The sign (-) can be set only from the leftmost green digit.	0...±60° +° inductive load -° capacitive load	0°

When the module is used in parallel operation attention should be paid to the settings of U_s, T1 and T2 as follows:

Us	All voltage regulating modules operating in parallel must have the same voltage setting as they control transformers feeding the same busbar. If the U_s value of one of the voltage regulating modules is higher than that of the others, the resulting voltage level will be higher than desired, because it will be determined by the mean value of the U_s settings of all the voltage regulating modules. In this case the transformer controlled by the higher setting value will feed circulating current to the busbar.
T1, T2	The minimum recommended setting of the delay times T1 and T2 is 10 s when definite time delay is used, and 25 s when inverse time delay is used. Inverse time is recommended in order to avoid unnecessary operation and wear of the tap-changer.

When the module is used in parallel operation in accordance with the negative reactance principle, attention should be paid to the settings of U_r%, U_x%, stability and load phase-shift as follows:

U_r%, U_x%	Setting as for single operation, except for the calculation of the values, which is made on the basis of the common network.
Stability	The "gain" of the parallel operation. The setting should be proportional to the rated currents of the parallel operating transformers. Start with small values and increase them to obtain the optimal voltage regulation.
Load phase-shift	The expected phase-shift of the load. This setting value is calculated as an average of the phase-shiftvalues appearing in the load.

When the module is used in parallel operation in accordance with the minimizing circulating current principle, attention should be paid to the settings of U_r%, U_x%, stability, I_{nt} and I_{nt}/I_{ct}, as follows:

U_r%, U_x%	Setting as for single operation, except for the calculation of the values, which is made on the basis of the common network.
Stability	The "gain" of the parallel operation. The same setting should be used for all the parallel operating regulators. Start with small values and increase them to get the optimal voltage regulation.
I_{nt}	The rated current of the power transformer should be set, when the minimizing circulating current principle is used.
I_{nt}/I_{ct}	Matching transformer compensation should be set, when the minimizing circulating current principle is used.

Selector switches

The software switchgroups SGF1 and SGF2 are used for selecting additional functions required for different applications. The switch numbers, 1…8, and the position of the switches, 0 or 1, are shown on the display, when the switches are being set using the push-buttons on the front panel. Normally only the checksums of the switchgroups are displayed. These can be found in the main menu of the regulating module, see chapter "Menu chart". The tables below also show the default settings of the switches and the corresponding checksums.

Switchgroup SGF1

<table>
<tr><th>Switch</th><th>Function</th><th>Default</th></tr>
<tr><td>SGF1/1</td><td>External control input connection
When SGF1/1=1, the raise' input is connected as parallel control input
When SGF1/1=0, the raise' input is connected as raise control input</td><td>0</td></tr>
<tr><td>SGF1/2</td><td>Selection of parallel operation principle
When SGF1/2=1, the negative reactance principle is used
When SGF1/2=0, the minimizing circulating current or the master/slave principle is used</td><td>0</td></tr>
<tr><td>SGF1/3</td><td>External control input connection
When SGF1/3=1, the blocking input is connected as remote/local control input. The regulator is controlled remotely when the external control input is energized and controlled locally when it is not energized.
When SGF1/3=0, the blocking input is connected as blocking input. The automatic and manual voltage regulation is blocked when the external control input is energized.</td><td>0</td></tr>
<tr><td>SGF1/4</td><td>Display mode
When SGF1/4=1, the measured voltage U_m will be displayed continuously when 5 minutes have passed from the latest front panel operation
When SGF1/4=0, the display turns dark when 5 minutes have passed from the latest front panel operation</td><td>0</td></tr>
<tr><td>SGF1/5</td><td>Selection of inverse/definite time
When SGF1/5=1, the inverse time characteristic is in use
When SGF1/5=0, the definite time characteristic is in use</td><td>1</td></tr>
<tr><td>SGF1/6</td><td>Main/second setting bank during parallel operation
When SGF1/6=1, the main setting bank is used in single operation and the second setting bank in parallel operation. Parameter V150 and the setting value in submenu 4 of register A are disabled.
Note! To become active, the switch must be set in both setting banks.
When SGF1/6=0, the main and second setting banks are controlled by the parameter V150 and the setting value in submenu 4 of register A</td><td>0</td></tr>
<tr><td>SGF1/7
SGF1/8</td><td>Selection of rated voltage U_n
<table>
<tr><th>SGF1/7</th><th>SGF1/8</th><th>Rated voltage</th></tr>
<tr><td>0</td><td>0</td><td>100 V</td></tr>
<tr><td>1</td><td>0</td><td>110 V</td></tr>
<tr><td>0</td><td>1</td><td>120 V</td></tr>
<tr><td>1</td><td>1</td><td>not in use</td></tr>
</table></td><td>0
0</td></tr>
<tr><td>∑SGF1</td><td></td><td>16</td></tr>
</table>

Switchgroup SGF2

<table>
<tr><th>Switch</th><th>Function</th><th>Default</th></tr>
<tr><td>SGF2/1</td><td>External control input connection
When SGF2/1 = 1, the RSV input is connected as parallel control input
When SGF2/1 = 0, the RSV input is connected as RSV 1/1 control input</td><td>0</td></tr>
<tr><td>SGF2/2</td><td>I> output relay connection
When SGF 2/2=1, U> overvoltage detection activates the I> output relay, and disables manual voltage regulation and the LEDs U> and I> lit.
When SGF2/2=0, I> overcurrent blocking activates the I> output relay, and disables manual voltage regulation and LED I> lit.</td><td>0</td></tr>
<tr><td>SGF2/3</td><td>I> overcurrent blocking
When SGF2/3=1, I> overcurrent blocking is in use
When SGF2/3=0, I> overcurrent blocking is not in use</td><td>1</td></tr>
<tr><td>SGF2/4</td><td>When SGF2/4=1, U< undervoltage blocking is in use
When SGF2/4=0, U< undervoltage blocking is not in use</td><td>1</td></tr>
<tr><td>SGF2/5</td><td>When SGF2/5=1, U> overvoltage detection is in use
When SGF2/5=0, U> overvoltage detection is not in use</td><td>1</td></tr>
<tr><td>SGF2/6
SGF2/7</td><td>Selection of measured current
<table>
<tr><th>SGF2/6</th><th>SGF2/7</th><th>Measured current</th></tr>
<tr><td>0</td><td>0</td><td>only I_{L1}, or all currents I_{L1}, I_{L2} and I_{L3}</td></tr>
<tr><td>0</td><td>1</td><td>only I_{L2}</td></tr>
<tr><td>1</td><td>0</td><td>only I_{L3}</td></tr>
<tr><td>1</td><td>1</td><td>not in use</td></tr>
</table></td><td>0
0</td></tr>
<tr><td>SGF2/8</td><td>External control input connection
When SGF2/8=1, the LOWER' input is connected as RSV 1/2 control input
When SGF2/8=0, the LOWER' input is connected as lower control input</td><td>0</td></tr>
<tr><td>∑SGF2</td><td></td><td>28</td></tr>
</table>

Measured data
(modified 2003-09)

The measured data is displayed by the three rightmost digits of the display. The yellow LED indicators above the display indicate the value being displayed. For further information on how to move in the menu, see "Menu chart".

Indicator	Measured value
U_m	Phase-to-phase voltage. Measuring range 0...1.28 x U_n
U_m, submenu	Difference between the phase-to-phase voltage and the rated voltage U_m-U_n. Measuring range -100...28% x U_n
I_m	Phase current on phase one. Measuring range 0...2.50 x I_{nt}
I_m, submenu	Phase current on phase two. Measuring range 0...2.50 x I_{nt}
I_m, submenu	Phase current on phase three. Measuring range 0...2.50 x I_{nt}
U_d	Difference (U_m - U_p) between the measured voltage and the control voltage U_p. Measuring range -100...43% x U_n
U_d, submenu	Phase shift of the network, measured by the voltage regulating module. Positive phase shift when having inductive load and negative phase shift at capacitive load. - - - means a too low I- or U -measurement, to be able to define the phaseshift.

Recorded information

The leftmost red digit indicates the address of the register and the three rightmost digits indicate the "recorded value".

<table>
<tr><th>Register/ STEP</th><th>Recorded information</th><th>Default setting</th></tr>
<tr><td>3</td><td>
Operation counter. Shows the number of raise and lower operations. Note! The control pulses given manually from the push-buttons are not counted.

Registers 1 to 7 of the submenu are enabled when the communication with SPA/LON gateway is established between voltage regulators. These monitor registers show the transferred data essential for parallel operation as described below.
(Note! These parameters have been incorporated since the program version 118H)

1 Status information (SI) of all three regulators is available in the submenu register 1, which enables simultaneous monitoring of all regulators. The status information consists of:
- Right green digit (digit #1) shows always SI (1...5) from its own regulator
- Middle green digit (digit #2) shows SI (0...5) from one of the other two regulators
- Left green digit (digit #3) shows SI (0...5) from the other one of the other two regulators

The meaning of the digit #1, #2, #3 depends on which regulator is inspected. When using the factory settings of SPA-ZC 100s, the digit numbers #1, #2, #3 are mapped according to the tables below:

Inspection of SI on SPCU 1D50 with address A10
(connected to SPA-ZC 100 xB):
<table>
<tr><th>Red digit</th><th>Digit #3</th><th>Digit #2</th><th>Digit #1</th></tr>
<tr><td>1</td><td>SI from A30</td><td>SI from A20</td><td>Own SI</td></tr>
</table>
Inspection of SI on SPCU 1D50 with address A20
(connected to SPA-ZC 100 xC):
<table>
<tr><th>Red digit</th><th>Digit #3</th><th>Digit #2</th><th>Digit #1</th></tr>
<tr><td>1</td><td>SI from A30</td><td>SI from A10</td><td>Own SI</td></tr>
</table>
Inspection of SI on SPCU 1D50 with address A30
(connected to SPA-ZC 100 xD):
<table>
<tr><th>Red digit</th><th>Digit #3</th><th>Digit #2</th><th>Digit #1</th></tr>
<tr><td>1</td><td>SI from A20</td><td>SI from A10</td><td>Own SI</td></tr>
</table>
Status information:
0 = no communication with SPA/LON gateway
1 = the operation of the voltage regulator is blocked
2 = single operation
3 = waiting for establishment of the parallel operation
4 = parallel operation by using negative reactance principle (NRP)
5 = parallel operation by using minimizing circulating current (MCC)
</td><td>0</td></tr>
</table>

<table>
<tr><th>Register/
STEP</th><th>Recorded information</th><th>Default</th></tr>
<tr><td></td><td>
Example of how the status information is changing when three regulators are entering parallel operation from single operation.
Inspection of SPCU 1D50 with address code 10.

Three regulators running in single operation
<table>
<tr><th>Red digit</th><th>SI from A30</th><th>SI from A20</th><th>Own SI (A10)</th></tr>
<tr><td>1</td><td>2</td><td>2</td><td>2</td></tr>
</table>
Regulator A10 selected in parallel operation
<table>
<tr><th>Red digit</th><th>SI from A30</th><th>SI from A20</th><th>Own SI (A10)</th></tr>
<tr><td>1</td><td>2</td><td>2</td><td>3</td></tr>
</table>
Regulator A20 selected in parallel operation
<table>
<tr><th>Red digit</th><th>SI from A30</th><th>SI from A20</th><th>Own SI (A10)</th></tr>
<tr><td>1</td><td>2</td><td>5</td><td>5</td></tr>
</table>
Regulator A30 selected in parallel operation
<table>
<tr><th>Red digit</th><th>SI from A30</th><th>SI from A20</th><th>Own SI (A10)</th></tr>
<tr><td>1</td><td>5</td><td>5</td><td>5</td></tr>
</table>
2 Present value of I_n (nominal current) from regulator A20*)
0.00...5.00 kA
3 Measured current in phase L1 from regulator A20*)
0.00...2.55 x I_n
4 Measured phase angle from regulator A20*)
0.00…+-180 ∞
5 Present value of In (nominal current) from regulator A30*)
0.00...5.00 kA
6 Measured current in phase L1 from regulator A30*)
0.00...2.55 x I_n
7 Measured phase angle from regulator A30*)
0.00…+-180 ∞

*) Inspection of SPCU 1D50 with address code 10.
</td><td></td></tr>
</table>

<table>
<tr><th>Register/
STEP</th><th>Recorded information</th><th>Default
setting</th></tr>
<tr><td>0</td><td>Display of external control signals
<table><tr><th></th><th>Value</th><th>Input</th></tr><tr><td>First digit</td><td>1
2</td><td>Raise’
Lower’</td></tr><tr><td>Second digit</td><td>1
2</td><td>Auto’
Manual’</td></tr><tr><td>Third digit</td><td>1
2
4</td><td>Blocking
TCO
RSV</td></tr></table>The TEST mode can be entered from register 0.
In this mode the output signals can be activated one by one:
<table><tr><th>Indicator</th><th>Designation</th><th>Output signal</th></tr><tr><td>O
O
O
O
O
O</td><td>Us/Un
ΔUs[%Un]
T1[s]
T2[s]
I> /In
U</td><td>U<, Undervoltage blocking
U>, Overvoltage detection
I>, Overcurrent blocking
Lower
Raise
Aut/Man</td></tr></table>A detailed description of the TEST mode is given in the manual "General characteristics of D type relay modules".</td><td></td></tr>
<tr><td>A</td><td>Address code of the regulator module, required for the communication system. Register A contains the following subregisters:

1. Data communication rate of the module.
Selectable values 4.8 or 9.6 kBd.
2. Bus communication monitor. If the module is connected to a communication system that is operating, the reading of the bus communication monitor is 0, otherwise the numbers 0…255 are rolling on the display.
3. Password needed for remote control of settings.
The password must always be entered (parameter V160) before a setting can be altered via the serial communication.
4. Selection of main or second settings (V150). Main setting as default setting.</td><td>

9.6 kBd

1

0</td></tr>
</table>

Registers, address code of the relay module, communication rate and password will not be erased by a voltage supply failure. The setting of the address code and the communication rate is described in the manual "General characteristics of D type relay modules".

Calibration of voltage measurement

The phase-to-phase voltage measurement U_m can be calibrated by writing a measurement correction value to the serial parameter V176. The permitted measurement correction range is -5.00 to +5.00% of U_n. If a certain input voltage is applied, and the measurement is corrected with a positive value, the module will display a voltage higher than that applied. If the measurement is corrected with a negative value, the module will display a lower value. The correction value is stored in the EEPROM and cannot be erased by a supply voltage failure or by formatting the EEPROM.

Menu chart
(modified 2003-09)

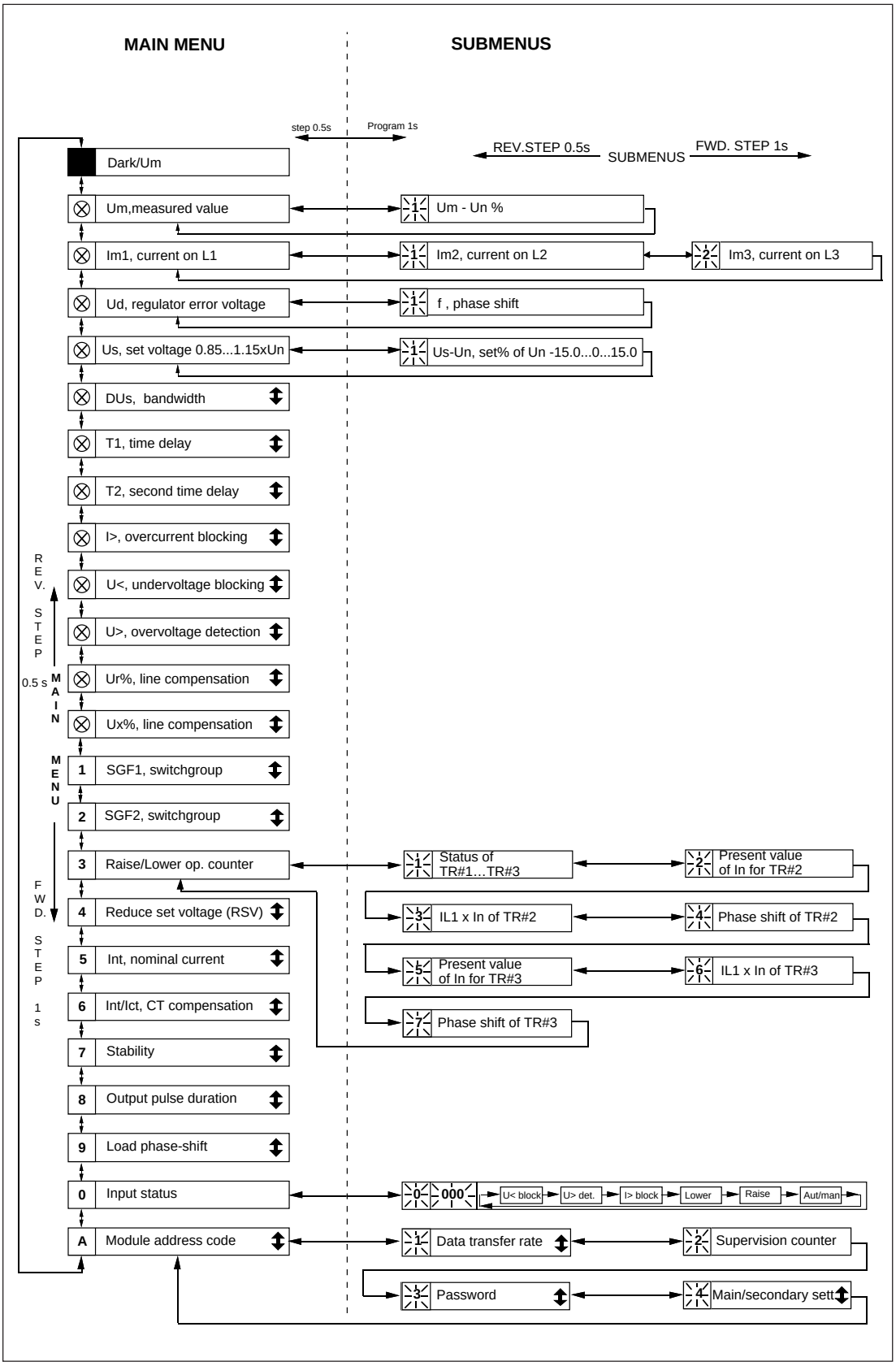


Fig. 4. Menu chart of the automatic voltage regulating module SPCU 1D50.

The procedure for entering a submenu or a setting mode, the configuration of the module and the operation of the TEST mode are described in detail in "General characteristics of the D-type relay modules". Below a short guide to the operations:

Desired step or operation	Push-button	Action
Forward step in main or submenu	STEP	Press > 0.5 s
Rapid scan forward in main menu	STEP	Keep depressed
Reverse step in main or submenu	STEP	Press < 0.5 s
Entering a submenu from a main menu	PROGRAM	Press 1 s
Entering or leaving the setting mode	PROGRAM	Press for 5 s
Increasing a value in the setting mode	STEP	Press about 0.5s
Moving the cursor in the setting mode	PROGRAM	Press about 1 s
Storing a value in the setting mode	STEP & PROGRAM	Press simultaneously

Inverse time characteristic

T1: The first delay time to start, when the measured voltage exceeds or falls below the limit value.

T2: The second delay time to start, when the first voltage regulation fails.

Both T1 and T2 can be given definite time characteristic or inverse time characteristic. The minimum time at inverse time characteristic is 1 s, even though T1 and T2 have the setting 0 s.

The inverse time function is defined by the following expression :

$$B = \frac{U_d}{\Delta U_s}$$

$$t = \frac{T}{2^{(B-1)}}$$

where
U_d = U_m - U_p, differential voltage
ΔU_s = bandwidth
T = T1 or T2

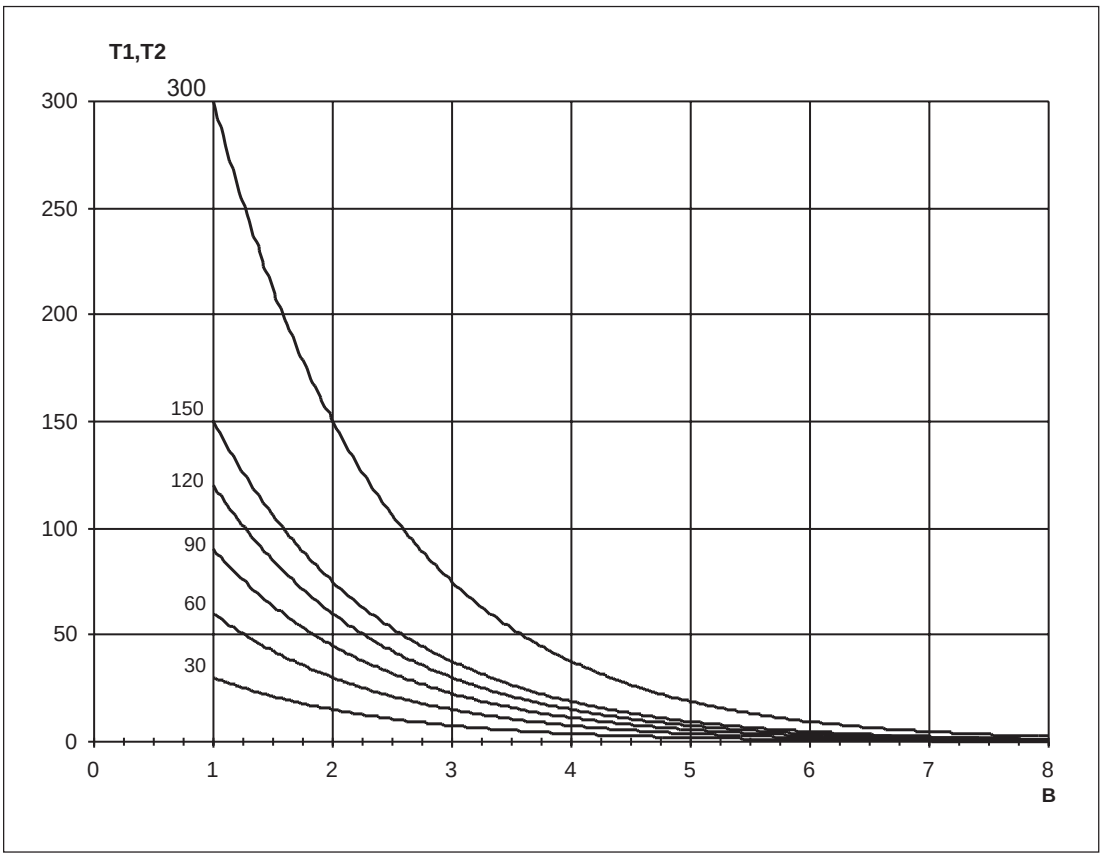


Fig. 5. Time characteristics of the automatic voltage regulating module SPCU 1D50

Technical data

Delay time setting range	0.0...300 s
Operate time accuracy at definite time characteristic	±1% of set value or ±250 ms
Operate time accuracy at inverse time characteristic	±250 ms and the inaccuracy appearing, when the measured voltage varies ±0.4%
Minimum operate time at inverse time characteristic	1 s
Minimum values at which the phase shift calculation is enabled	0.04 x I_n 0.05 x U_n

Serial communication parameters

Event codes

When the voltage regulating module SPCU 1D50 is connected to a control data communicator over the SPA bus, the module generates events in the format: time, text and event code, spontaneously to the control data communication. The text is defined by the user.

Most of the events can be included in or excluded from the event reporting by writing an event mask number (V155…V159) to the module. The parameters of the event mask are presented in the tables below.

The event mask is a binary number given in the form of a decimal number. The events E1… E33 are represented by the weighting factors 1, 2, 4…128. The event mask number is obtained by multiplying the above weighting factors by either 0 (event report excluded) or by 1 (event report included). and then adding the products received. The event mask numbers are calculated in the same way as the checksums of the switchgroups.

The events E50…E54 cannot be excluded from the event reporting.

At a maximum eight events can be stored in the event buffer. If a ninth event message is received, the code E51 is recorded in the buffer. The buffer and the code E51 are reset by giving the parameter WC the value 0.

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

More information about the SPA bus communication is given in the manual "SPA Bus Communication Protocol", 34 SPACOM 2EN1.

The event codes of the voltage regulating module SPCU 1D50 are:

Code	Event	Weighting factor	Default
E1	Raise counting started	1	0
E2	Raise counting reset	2	0
E3	Lower counting started	4	0
E4	Lower counting reset	8	0
E5	Raise output signal activated	16	1
E6	Raise output signal deactivated	32	0
E7	Lower output signal activated	64	1
E8	Lower output signal deactivated	128	0
	Default value of event mask V155		80
E9	Auto' input activated	1	0
E10	Auto' input deactivated	2	0
E11	Manual' input activated	4	0
E12	Manual' input deactivated	8	0
E13	Raise' input activated	16	0
E14	Raise' input deactivated	32	0
E15	Lower' input activated	64	0
E16	Lower' input deactivated	128	0
	Default value of event mask V156		0

Code	Event	Weighting factor	Default
E17	TCO input activated	1	0
E18	TCO input deactivated	2	0
E19	RSV input activated	4	0
E20	RSV input deactivated	8	0
E21	Blocking input activated	16	0
E22	Blocking input deactivated	32	0
E23	U>, output signal activated	64	0
E24	U>, output signal deactivated	128	0
	Default value of event mask V157		0
E25	I>, output signal activated	1	0
E26	I>, output signal deactivated	2	0
E27	U<, output signal activated	4	0
E28	U<, output signal deactivated	8	0
E29	Aut/Man output signal activated (automatic mode)	16	0
E30	Aut/Man output signal deactivated (manual mode)	32	0
E31	Parallel operation activated	64	0
E32	Parallel operation deactivated	128	0
	Default value of event mask V158		0
E33	The measured voltage outside the bandwidth range for 7 minutes	1	0
	Default value of event mask V159		0
E50	Restarting of microprocessor	*	-
E51	Overflow of event register	*	-
E52	Temporary disturbance in data communication	*	-
E53	No response from the relay module over the SPA bus	*	-
E54	Relay module responds again over the SPA bus	*	-

0 not included in event reporting
1 included in event reporting
* no weighting factor
- cannot be programmed

Remote transfer data
(modified 2003-09)

In addition to the event codes (E events) the substation level control data communicator is able to read all input data (=I data), set values (=S data), control parameters (=V data) and some other data from the regulator module over the SPA bus. Some of the data can be altered via commands given over the SPA bus. All information is available on the 0 channel, which does not have to be written in the communication instructions.

When a setting value is to be changed, either from the push-buttons on the front panel or via the SPA bus, the regulator checks whether the parameter values are legal, i.e. within the permitted setting ranges.

Parameters can be changed only by opening the password. The password is a value within the range 1…199. Default value is 1.

The password can be changed via the SPA bus or using the push-buttons on the relay module. The password is opened by writing a value to the parameter V160 and closed by writing the same value to parameter V161. The password is also closed by voltage failures. When using the push-buttons, the password is changed in subregister 3 of register A, where the old password is replaced by the new one.

If the wrong password is given 7 times, it turns to zero and can no longer be opened via the bus. Then the password can be given a new value only from the push-buttons.

R = data can be read from the module
W = data can be written to the module
(P) = password to be opened before writing is possible

Inputs

The measured voltage, currents and the status of external control signals can be read from the parameters I1...I18. Some of the external control signal parameters also allow writing. If the value 1 is written to a parameter that is 0, the module treats it as a short energizing pulse on the corresponding control signal, and when the command has been executed, the parameter value returns to 0.

Note!
Reading of the parameters I9 and I10 gives the status of the external control signals, whereas writing the value 1, always activates the internal raise and lower control signals. Hence, software switches SGF1/1 and SGF2/8 do not influence the writing of parameters I9 and I10. SGF1/3 needs to be 1 and the blocking input in remote state, to enable the activation of the internal raise and lower signals, by the parameters I9 and I10.

Data	Parameter	Read or write	Value (range)
Inputs			
Measured phase-to-phase voltage U_m	I1	R	0.00…1.28 x U_n
Measured current on phase L1	I2	R	0.00…2.50 x I_n
Measured current on phase L2	I3	R	0.00…2.50 x I_n
Measured current on phase L3	I4	R	0.00…2.50 x I_n
Measured phase shift	I5	R	0.00…±180°
Auto	I6	R, W	0 = deactivated 1 = activated
Manual	I7	R, W	0 = deactivated 1 = activated
Tap-changer operating (TCO)	I8	R	0 = deactivated 1 = activated
Raise	I9	R, W	0 = deactivated 1 = activated
Lower	I10	R, W	0 = deactivated 1 = activated
Reduce set voltage (RSV)	I11	R	0 = deactivated 1 = activated
Blocking	I12	R	0 = no blocking 1 = blocking
Measured current selected with switches SGF2/6 and SGF2/7	I18	R	0.00…2.50 x I_n

Parameters O1...O6 indicate the state of output signals at the moment of reading. The value of the Aut/Man output signal (parameter O6) is 1 when the module is in automatic mode and 0 when the module is in manual mode. Parameters O11...O16 can be used for forced activation of the output signals. Reading these parameters gives the most recent value written and not the actual output signal states. The parameter O21 that enables the active signals of parameters O11...O16 to be transferred to the output relays, is not affected by normal voltage regulation.

Output signal	Parameter	Read or write	Value (range)
Outputs			
Raise	O1	R	0 = not active 1 = active
Lower	O2	R	0 = not active 1 = active
Overcurrent blocking	O3	R	0 = no blocking 1 = blocking
Undervoltage blocking	O4	R	0 = no blocking 1 = blocking
Overvoltage detection	O5	R	0 = no detection 1 = detection
Aut/Man	O6	R	0 = not active 1 = active
Raise	O11	R,W(P)	0 = not active 1 = active
Lower	O12	R,W(P)	0 = not active 1 = active
Overcurrent blocking	O13	R,W(P)	0 = no blocking 1 = blocking
Undervoltage blocking	O14	R,W(P)	0 = no blocking 1 = blocking
Overvoltage	O15	R	0 = no detection 1 = detection
Auto	O16	R,W(P)	0 = not active 1 = active
Forced activation of output relays (O11…O16)	O21	R,W(P)	0 = operation blocked 1 = operation enabled
Settings used			
Reference voltage U_s	S1	R	0.850…1.150 x U_n
Bandwidth ΔU_s	S2	R	0.60…9.00% of U_n
Time delay T1	S3	R	0.0…300 s
Time delay T2	S4	R	0.0…300 s
Overcurrent blocking I>	S5	R	1.00.....2.00 x I_n
Undervoltage blocking U<	S6	R	0.70…0.95 x U_n
Overvoltage detection U>	S7	R	1.05…1.25 x U_n
U_r, line-drop compensation	S8	R	0.0…25.0% of U_n
U_x, line-drop compensation	S9	R	0.0…25.0% of U_n
Checksum of switchgroup SGF1	S10	R	0…255
Checksum of switchgroup SGF2	S11	R	0…255
Reduce set voltage (RSV)	S12	R	0.0…9.00% of U_n
I_{nt}, rated current of the power transformer	S13	R	0.10…5.00 kA
I_{nt}/I_{ct}, matching transformer compensation	S14	R	0.60…1.50
Stability	S15	R	0…70% of U_n
Output pulse duration (OPD)	S16	R	0.5…10.0 s
Load phase-shift	S17	R	0...±60°

Data	Para-meter	Read or write	Value (range)
Main settings			
Reference voltage U_s	S21	R,W	0.850…1.150 x U_n
Bandwidth ΔU_s	S22	R,W(P)	0.60…9.00% of U_n
Time delay T1	S23	R,W(P)	0.0…300 s
Time delay T2	S24	R,W(P)	0.0…300 s
Overcurrent blocking I>	S25	R,W(P)	1.00…2.00 x I_n
Undervoltage blocking U<	S26	R,W(P)	0.70…0.95 x U_n
Overvoltage detection U>	S27	R,W(P)	1.05…1.25 x U_n
U_r, line-drop compensation	S28	R,W(P)	0.0…25.0% of U_n
U_x, line-drop compensation	S29	R,W(P)	0.0…25.0% of U_n
Checksum of switchgroup SGF1	S30	R,W(P)	0…255
Checksum of switchgroup SGF2	S31	R,W(P)	0…255
Reduce set voltage (RSV)	S32	R,W(P)	0.00…9.00% of U_n
I_{nt}, rated current of the power transformer	S33	R,W(P)	0.10…5.00 kA
Int/Ict, matching transformer compensation	S34	R,W(P)	0.60…1.50
Stability	S35	R,W(P)	0…70% of U_n
Output pulse duration (OPD)	S36	R,W(P)	0.50…10.0 s
Load phase-shift	S37	R,W(P)	0…±60°
Second settings			
Reference voltage U_s	S41	R,W	0.850…1.150 x U_n
Bandwidth ΔU_s	S42	R,W(P)	0.60…9.00% of U_n
Time delay T1	S43	R,W(P)	0.0…300 s
Time delay T2	S44	R,W(P)	0.0…300 s
Overcurrent blocking I>	S45	R,W(P)	1.00…2.00 x I_n
Undervoltage blocking U<	S46	R,W(P)	0.70…0.95 x U_n
Overvoltage detection U>	S47	R,W(P)	1.05…1.25 x U_n
Ur, line-drop compensation	S48	R,W(P)	0.0…25.0% of U_n
Ux, line-drop compensation	S49	R,W(P)	0.0…25.0% of U_n
Checksum of switchgroup SGF1	S50	R,W(P)	0…255
Checksum of switchgroup SGF2	S51	R,W(P)	0…255
Reduce set voltage (RSV)	S52	R,W(P)	0.00…9.00% of U_n
Int, rated current of the power transformer	S53	R,W(P)	0.10…5.00 kA
Int/Ict, matching transformer compensation	S54	R,W(P)	0.60…1.50
Stability	S55	R,W(P)	0…70% of U_n
Output pulse duration (OPD)	S56	R,W(P)	0.50…10.0 s
Load phase-shift	S57	R,W(P)	0...±60°
Measured values			
U_m - U_n	V1	R	-100…+28% of U_n
U_d = U_m - U_p, voltage difference	V2	R	-100…+43% of U_n
Status parameter	V3	R	1…5 4 = parallel operation, negative reactance principle 5 = parallel operation, minimizing circulating current
U_p - U_n	V6	R	-25…+25% of U_n
Operation counter	V7	R	0…999

Data	Para-meter	Read or write	Value (range)
Control parameters			
Remote control of settings	V150	R, W	0 = main settings active 1 = second settings active
Parallel operation	V152	R, W	0 = not active 1 = active
Event mask	V155	R, W	0...255, see paragraph "Event codes"
Event mask	V156	R, W	0...255, see paragraph "Event codes"
Event mask	V157	R, W	0...255, see paragraph "Event codes"
Event mask	V158	R, W	0...255, see paragraph "Event codes"
Event mask	V159	R, W	0...255, see paragraph "Event codes"
Opening of password	V160	W	1...999
Closing or changing of password	V161	W (P)	0...999
Activation of self-supervision	V165	W	1 = self-supervision output activated and IRF LED lit
LED test	V166	W (P)	0…3, 5…15, 21
Factory final test	V167	W (P)	1 = display segment test 2 = format EEPROM
Internal error code	V169	R	0…255
Um, voltage measurement calibration parameter	V176	R, W (P)	-5.00…+5.00% of U_n
Module address code	V200	R, W	1…254
Data transfer rate	V201	R, W	4.8 or 9.6 KBd
Software version code	V205	R	118_

Data	Para-meter	Read or write	Value (range)
Reading of event register	L	R	time, channel number and event code
Re-reading of event register	B	R	time, channel number and event code
Module type designation	F	R	SPCU 1D50
Reading of status data	C	R	0 = normal state 1 = module been subject to automatic reset 2 = overflow of event register 3 = events 1 and 2 together
Resetting of status data	C	W	0 = resetting
Time reading or setting	T	R,W	00.000…59.999 s

The event register can be read with the L command only once. Should a fault occur e.g. in the data transfer, the B command can be used to re-read the contents of the event register. When required, the B command can be repeated. In general, the substation-level control data communicator reads the event data and forwards the information to an output device. The control data communicator also resets abnormal state message, so this data is normally zero.

The parameters S1...S17 are the setting values used by the regulator program. The parameters S21...S37 contain the main settings and the parameters S41...S57 the second settings. The settings allow both reading and writing. A condition for writing is that the password V160 for remote setting has been opened.

When setting values are changed the module checks that the parameter values are within the limits specified for the module. An attempt to write an incorrect value, manually or via the serial bus, will be rejected by the module, which retains the previous setting.

Fault codes

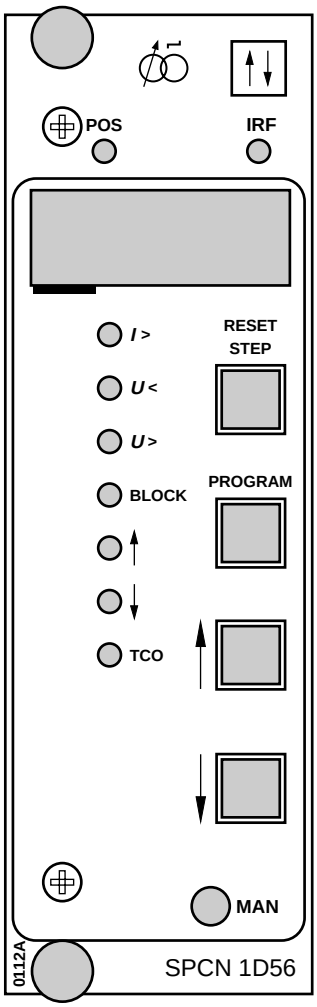
When the self-supervision system has detected a permanent internal fault the red IRF indicator is lit. Simultaneously the relay module delivers a control signal to the output relay of the self-supervision system. In most fault situations an autodiagnostic fault code appears on the display of the module. The fault code consists of a red number 1, and a green, one to three digit code number. The fault code should be recorded and stated when service is ordered.

The table below lists some of the fault codes of the voltage regulating module SPCU 1D50:

Fault code	Fault type
4	Faulty or missing regulator control circuit
30	Faulty program memory (ROM)
50	Faulty work memory (RAM)
51	Faulty parameter memory (EEPROM), block 1
52	Faulty parameter memory (EEPROM), block 2
53	Faulty parameter memory (EEPROM), checksum of blocks 1 and 2 differ
56	Faulty parameter memory key (EEPROM). Formatting by writing V167:2
253	No interruption from A/D converter

SPCN 1D56
Manual voltage regulating module

User´s manual and Technical description



1MRS 750112-MUM EN

Issued 96-03-12
Version B
Checked YK
Approved TK

SPCN 1D56
Manual voltage regulating module

Data subject to change without notice

Contents

Characteristics

Manual tap-changer control based on raise and lower pulses.

Tap-changer position indication.

Recording of highest and lowest tap-changer position.

Digital display of setting values and recorded data.

All settings to be keyed in via the MMI on the front panel or via the serial interface using a portable PC and a downloading program.

Self-supervision system continuously monitoring the operation of the electronics and the microprocessor. When a permanent fault is detected, the alarm output relay operates and the other outputs are blocked.

Description of operation

Manual tap-changer control

By switching the regulator for manual mode, the manual voltage regulating module is activated, and the tap-changer can be controlled from the push-buttons. Pressing the raise or lower button once makes the corresponding LED flash. This indicates that the module is ready for a raise or lower command. If a command cannot be executed because of an overcurrent or external blocking situation, the I> or BLOCK indicator will be lit and any operation will be prevented. When the module is ready to accept a command, press the active button to start the operation. To interrupt the operation, press the reset button. Then the raise or lower LED will stop blinking. When the operation is started, the corresponding raise or lower LED is lit and will remain so as long as the output pulse is active. The TCO (tap-changer operating) LED will be lit during the operation of the tap-changer, if the input is activated by the TCO output signal from the tap-changer. Tap-changer position is displayed in the first display position, and can easily be observed during local operation.

Function of control inputs

Tap-changer operating input (TCO)

The tap-changer operating input is used to declare that a raise or lower command is executed.

I >, U< internal blocking inputs

These inputs are activated by the automatic control module SPCU 1D50 in an overcurrent or undervoltage situation. Manual control is blocked by an overcurrent situation. In an undervoltage situtation, however, manual control is still enabled. A LED indicator is provided for each blocking.

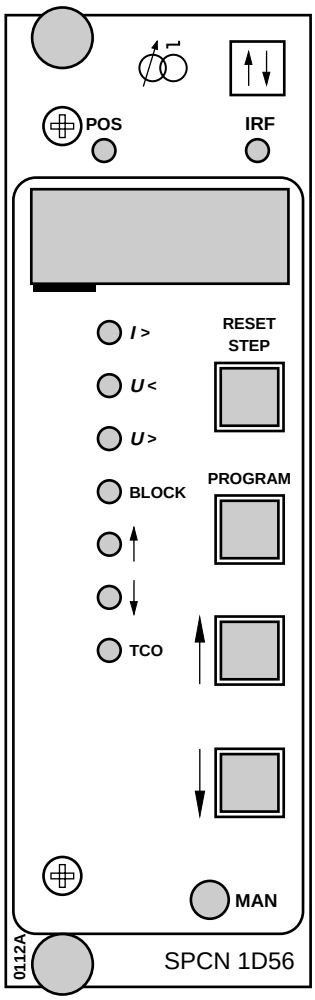
External blocking input

If the unit is externally blocked by the control input, the corresponding blocking LED is lit and any tap-changer control is prevented.

U > , overvoltage detection input

This input is activated by the module SPCU 1D50 in an overvoltage situation. During such a condition, an indicating LED is lit, but manual tap-changer control is still possible.

Front panel



Simplified device symbol

Self-supervision alarm indicator
Position indication LED

Display for setting values, position indication and measured values

Reset and display step push-button

LED indicators for blockings, raise/lower control and tap-changer operation

Program push-button

Raise push-button

Lower push-button

Manual control indication LED

Type designation of the module

Fig 1. Front panel of the manual voltage regulating module SPCN 1D56

Operation indicators

Raise LED: Indicates by blinking that the unit is issuing a raise pulse. When the output is activated, the LED is lit.

Lower LED: Indicates by blinking that the unit is issuing a lower pulse. When the output is activated, the LED is lit.

TCO LED: Indicates that the tap-changer is operating.

MAN LED: Indicates that the regulator is in manual mode and ready to accept raise or lower commands from the push-buttons.

The self supervision alarm indicator IRF indicates that the self-supervision system has detected a permanent fault. The red LED is lit about 1.5 minutes after the fault has been detected. At the same time, the plug-in module delivers a signal to the self-supervision system output relay of the regulator assembly.

In addition, in most cases, a fault code appears on the display of the module. This fault code, which consists of a red figure "1" and a green code number, indicates the nature of the fault and cannot be erased by resetting. The fault code should be recorded and stated, when service is ordered.

mA input calibration

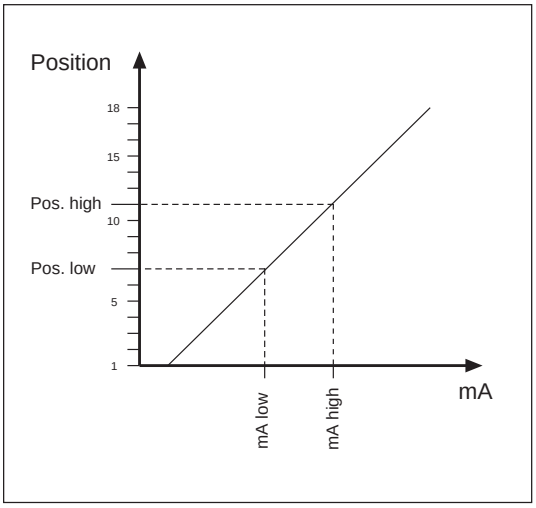
After installation of the voltage regulator and the converter/transmitter of the tap-changer position information the mA input is calibrated as follows:

Start by raising the tap-changer manually to a high position. Then store the mA signal as the "mA input high value" and the corresponding tap-changer position as the setting value "tap-changer position high".

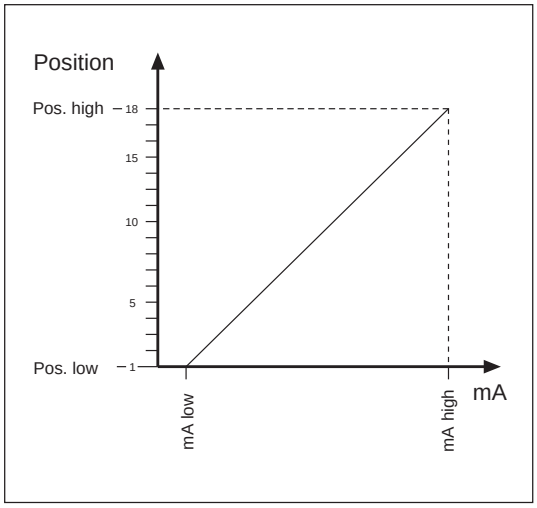
Then lower the tap-changer manually to a low position. Then store the mA signal measured as the "mA input low value"and the corresponding tap-changer position as the setting value "tap-changer position low".

The tap-changer positions high and low, from which the mA input signal is stored, does not necessarily have to be the highest and lowest position of the transformer, but the measurement accuracy increases with the distance between the points stored. After the calibration the manual voltage regulating module SPCN 1D56 shows the actual tap-changer position according to the mA input signal.

Storing the mA input signals: Store the mA input signals in the same way as the setting values. First select the setting value "tap-changer position" high or low. Then choose the submenu by pressing the program button for 1 s. The number "1" starts flashing to indicate that you have entered submenu 1. Proceed by pressing the program push-button once again for about 5 s, until the middle segments of the three rightmost digits start flashing. Finally, store the present mA input signal as the high or low signal by pressing the program and reset/step buttons simultaneously.



Ex. 1. mA input calibration with the transformer in service. Normal operating tap-changer position is 9 and the tap-changer is raised and lowered two steps for calibration.



Ex. 2. mA input calibration with the transformer out of service. The tap-changer is raised and lowered to minimum and maximum positions for calibration.

Settings

All settings can be entered either via the front panel push-buttons or over the serial communication.

The setting values are displayed by the right-most three digits of the display. The left-most digit shows, which setting value is indicated on the display. How to locate the setting values with the man-machine interface, is described in the section "Menu chart".

Register/ STEP	Setting	Description	Setting range/ Default value
1	SGF1	Switchgroup, see section "selector switches" for further details	0…255 /0
2	Tap position low	Low tap-changer position	0…34 /0
[1] Submenu	Low level mA signal	Current corresponding to the low tap-changer position	0…20.0 mA /0
3	Tap position high	High tap-changer position	1…35 /35
[1] Submenu	High level mA signal	Current corresponding to the high tap-changer position	0…20.0 mA /20
4	OPD	Output pulse duration	0.5…10.0s /1.5

Settings for the serial communication is dealt with in the section "Recorded data".

Selector switches

The checksum of the programming switchgroup SGF1 is indicated on the display, when the corresponding setting value is selected. An example of calculating the checksum and detailed information of the push-button operations are given in the general description of the D-type SPC relay modules.

The number of the switches, 1...8, and the switch positions, 0 and 1, are displayed during the setting procedure. In normal service only the checksum is displayed.

Switchgroup SGF1

Switch	Function	Default
SGF1/1..3	Not in use.	0
SGF1/4	Display mode When SGF1/4=1, the display starts indicating the tap-changer position continuously 5 min after the latest push-button operation. When SGF1/4=0, the display turns dark 5 min after the latest push-button operation.	0
SGF1/5...8	Not in use.	0
∑ SGF1		0

Measured data

The LED "pos" is lit and the two right-most digits indicate the tap-changer position.

LED	Measured value
Pos	Display of measured tap-changer position.

Recorded information

The left-most red digit of the display shows the address code of the register and the other three digits the value of the register.

Register/ STEP	Recorded information
0	Display of external and internal control signals. The left-most digit indicates the state of the control inputs, Aut and TCO, while the middle green digit indicates U> and Blocking. The left-most green digit represents the control inputs U< and I >. Each of the six input signals is represented by a number. These numbers are added two and two to form the digits displayed. Display value: 0...3. First number: 1 = Auto, internal control signal 2 = TCO, external control signal Second number: 1 = U>, internal control signal 2 = Blocking, external control signal Third number: 1 = U<, internal control signal 2 = I >, internal control signal
A	Address code of the manual voltage regulating module, required for serial communication. Register A has four subregisters with the following contents: 1) Selection of data transfer rate for the serial communication. Selectable values 4800 or 9600 Bd (4.8 or 9.6 kBd). 2) Bus traffic monitor. If the module is connected to a data communication system, which is operating, the value of the monitor is zero (0). Otherwise the numbers 0...255 are rolling on the display. 3) Password required for remote setting. 4) Selection of main/second settings. (0 = main settings, 1 = second settings).

The settings and recorded data are not erased by a voltage failure. Instructions for setting the address code and the data transfer rate are described in the manual "General characteristics of D-type relay modules".

Menu chart

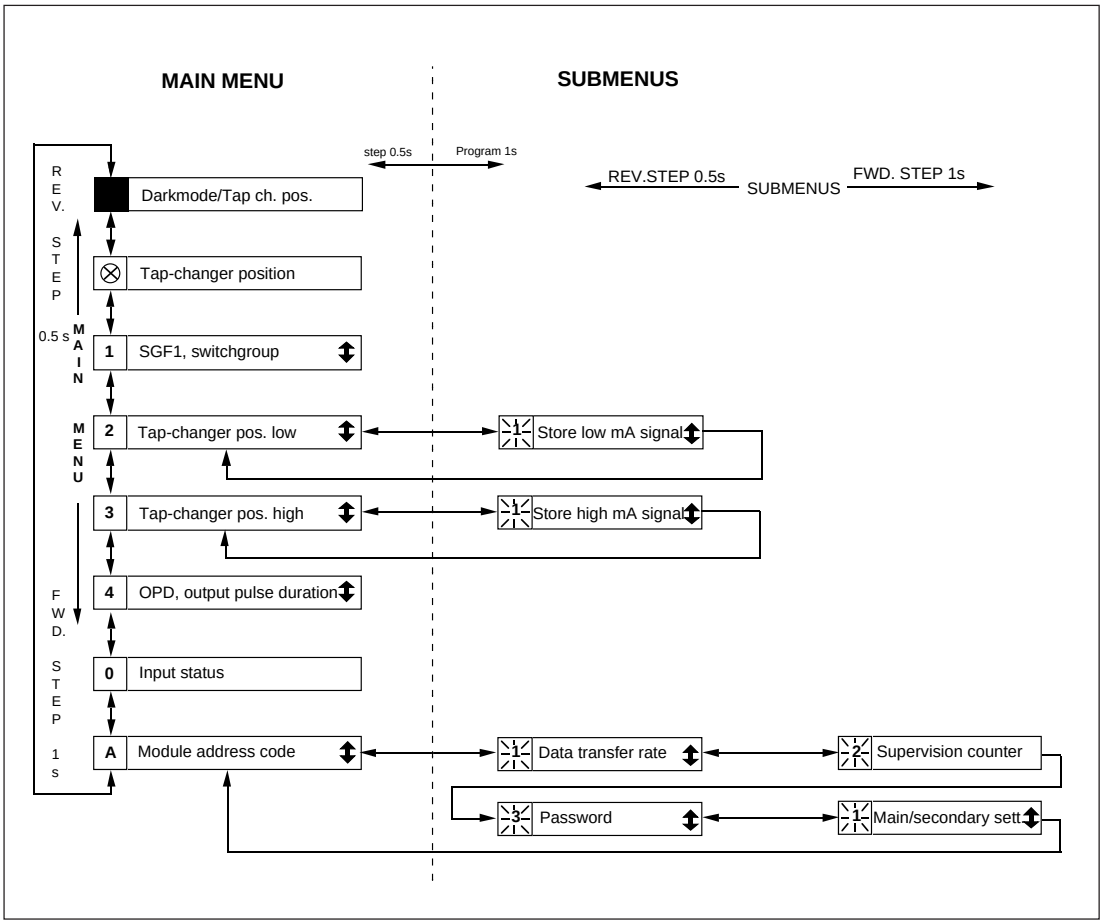


Fig 2. Main menus and submenus of manual voltage regulating module SPCN 1D56

The procedure for entering a submenu or a setting mode, the configuration of the module and the operation of the TEST mode are described in detail in "General characteristics of the D-type relay modules". Below a short guide to the operations:

Desired step or operation	Push-button	Action
Forward step in main or submenu	STEP	Press > 0.5 s
Rapid scan forward in main menu	STEP	Keep depressed
Reverse step in main or submenu	STEP	Press < 0.5 s
Entering a submenu from a main menu	PROGRAM	Press 1 s
Entering or leaving the setting mode	PROGRAM	Press for 5 s
Increasing a value in the setting mode	STEP	Press about 0.5s
Moving the cursor in the setting mode	PROGRAM	Press about 1 s
Storing a value in the setting mode	STEP & PROGRAM	Press simultaneously

Technical data

Accuracy, mA input signal	±1% of FSR
Output pulse duration, selectable	0.50 ... 10 s in 0.1 s steps

Event codes

When linked to a control data communicator over the SPA bus, the module SPCN 1D56 provides event markings, for instance, to a printer. The events are printed out in the format: time, text, which the user may have programmed, and event code.

Most event codes can be included in or excluded from event reporting by writing an event mask V155 for the events. The parameters for the event masks are shown in the event table below. The codes E50...E54 and the associated events cannot be excluded from the event reporting.

Up to eight events can be stored in the event buffer. When the ninth event occurs, the code E51 is obtained. The event buffer and the E51 code is cleared by WC:0.

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

More information about the serial communication over the SPA bus can be found in the manual "SPA-BUS COMMUNICATION PROTOCOL", 34 SPACOM 2 EN 1.

Output events

Code	Event	Number representing the event	Default value of the event factor
E4	Tap-changer operating time exceeded 20 s	8	0
E5	Raise output signal activated	16	1
E6	Reset of raise output signal	32	0
E7	Lower output signal activated	64	1
E8	Reset of lower output signal	128	0
	Event mask		V155 = 80

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

Remote transfer data

In addition to the event data all input data (I-data), setting values (S-data), control parameters (V-data), and some other data of the module can be read over the SPA bus. Also, part of the data can be altered by commands given over the SPA bus.

Data	Para-meter	Data direct.	Values
Inputs			
Aut	I1	R	0 = manual 1 = auto
Tap-changer operating (TCO)	I2	R	0 = TCO not activated 1 = TCO activated
Outputs			
Raise	O1	R	0 = signal not active 1 = signal active
Lower	O2	R	0 = signal not active 1 = signal active
Raise	O11	R,W(P)	0 = signal not active 1 = signal active
Lower	O12	R,W(P)	0 = signal not active 1 = signal active
Enable parameters 011...012	O21	R,W(P)	0 = output relays disabled 1 = output relays enabled
Settings used			
Present checksum of switchgroup SGF1	S1	R	0…255
Present value of tap-changer position corresponding to low mA signal	S2	R	0…34
Present value of tap-changer position corresponding to high mA signal	S3	R	1…35
Present value of output pulse duration	S4	R	0.5…10.0 s
Main settings			
Main checksum of switchgroup SGF1	S21	R,W(P)	0…255
Main value of tap-changer position corresponding to low mA signal	S22	R,W(P)	0…34
Main value of tap-changer position corresponding to high mA signal	S23	R,W(P)	1…35
Main value of output pulse duration	S24	R,W(P)	0.5…10.0 s
Second settings			
Second checksum of switchgroup SGF1	S41	R,W(P)	0…255
Second value of tap-changer position corresponding to low mA signal	S42	R,W(P)	0…34
Second value of tap-changer position corresponding to high mA signal	S43	R,W(P)	1…35
Second value of output pulse duration	S44	R,W(P)	0.5…10.0 s

Data	Para-meter	Data direct.	Values
Measured values			
Highest tap-changer position	V1	R,W	0…35
Lowest tap-changer position	V2	R,W	0…35
Present tap-changer position	V3	R	0…35
Control parameters			
Remote control of settings	V150	R,W	0 = main settings activated 1 = second settings activated
Event mask for output signals	V155	R,W	0…255, see event codes
Opening of password for remote settings	V160	W	1…999
Changing or closing of password for remote settings	V161	W(P)	0...999
Activation of self-supervision output	V165	W	1 = self supervision output is activated and IRF LED is lit
LED test	V166	W(P)	1, 5..10, 21
Factory final test	V167	W(P)	1 = display segment test 2 = format EEPROM
Fault code generated by the self-supervision system	V169	R	0…255
Data comm. address of the module	V200	R,W	1…254
Data transfer rate	V201	R,W	4.8 or 9.6 KBd
Programme version number	V205	R	119_
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	SPCN 1D56
Reading of module state data	C	R	0 = normal state 1 = module been subject to an automatic reset 2 = overflow of event register 3 = events 1 and 2 together
Resetting of module state data	C	W	0 = resetting
Time reading and setting	T	R,W	00.000....59.999

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

The event register can be read by the L command only once. Should a fault occur e.g. in the data transfer, the B command can be used to re-read the contents of the event register. When required, the B command can be repeated. In general, the control data communicator reads the event data and forwards the information to an output device continuously. The control data communicator also resets abnormal status data, so this data is normally a zero.

All settings allow reading and writing. However, a condition for writing is that the remote set password has been opened.

When settings are changed, the regulator module checks that the given values are legal. If the module is given a value outside the permitted limits, either manually or by remote setting, the module will not store the new value but retains the previous one.

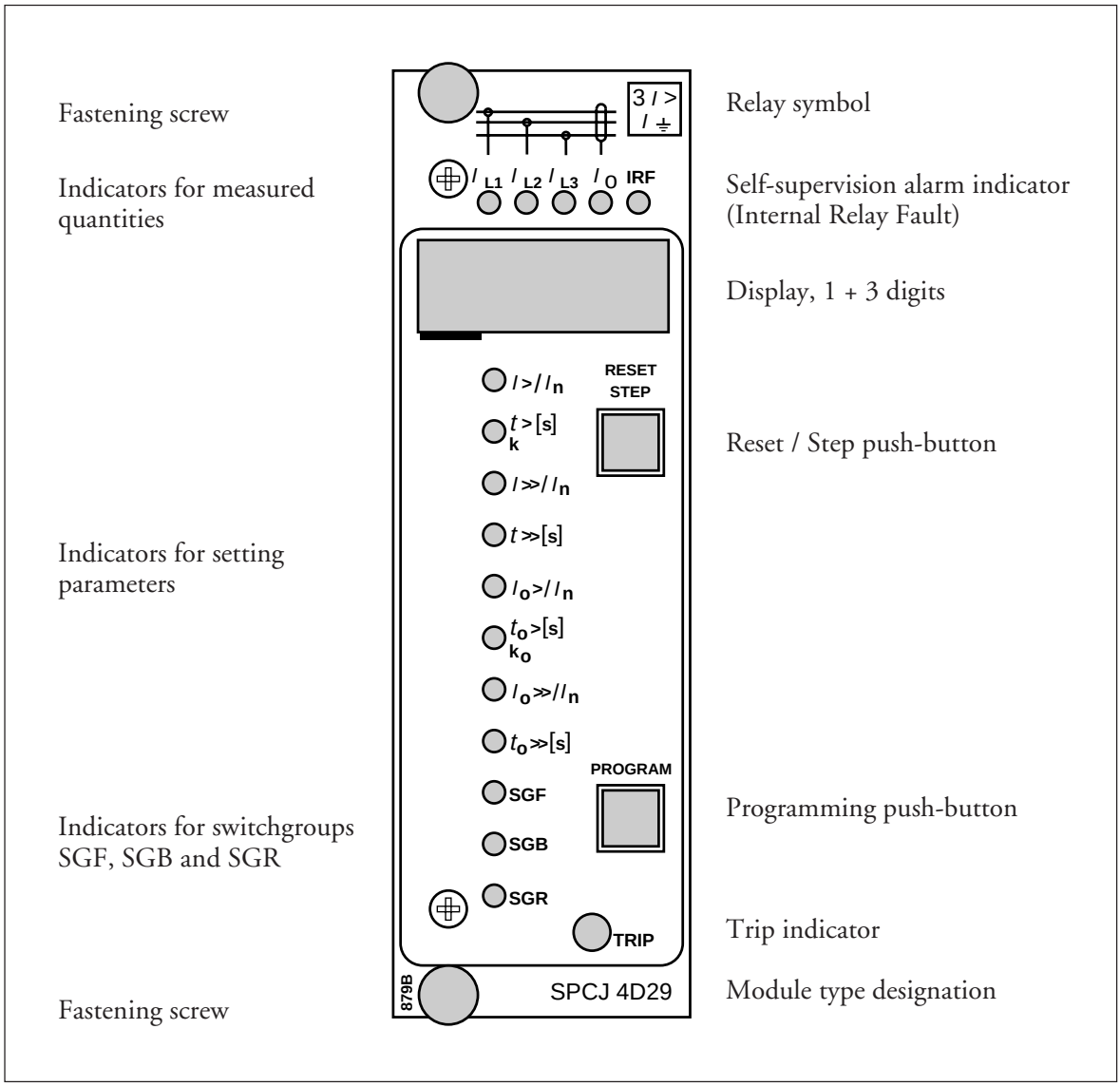
Fault codes

When the internal self-supervision system has detected a permanent fault, the red IRF indicator is lit and the output relay of the self-supervision system operates. In addition, in most fault situations an autodiagnostic code is displayed. The code is composed of a red figure 1 and a green code number. Below is a list of some of the most general fault codes appearing in the module SPCN 1D56.

Fault code	Type of error
4	Output relay path broken or relay board missing
30	Faulty program memory
50	Faulty working memory (RAM)
51…54	Parameter memory (EEPROM) faulty
56	Parameter memory (EEPROM) key faulty. Format by writing "2" to variable V167
195	Reference channel voltage too low
203	Reference channel voltage too high

General characteristics of D-type relay modules

User´s manual and Technical description



1MRS 750066-MUM EN

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Checked JH
Approved TK

General characteristics of D type relay modules

Contents

Control push-buttons

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

Display

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

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

Display main menu

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

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

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

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

Display submenus

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

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

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

Selector switch-groups SGF, SGB and SGR

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

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

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

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

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

Settings

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

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

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

Setting mode

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

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

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

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

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

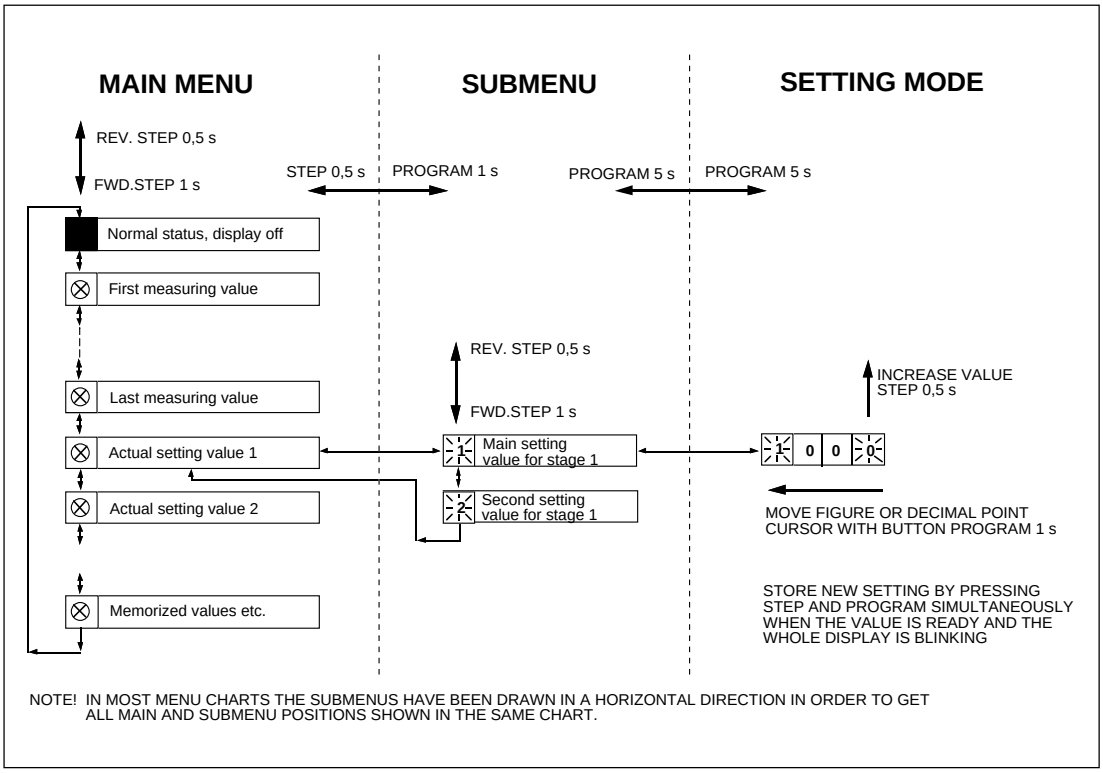


Fig.3. Basic principles of entering the main menus and submenus of a relay module.

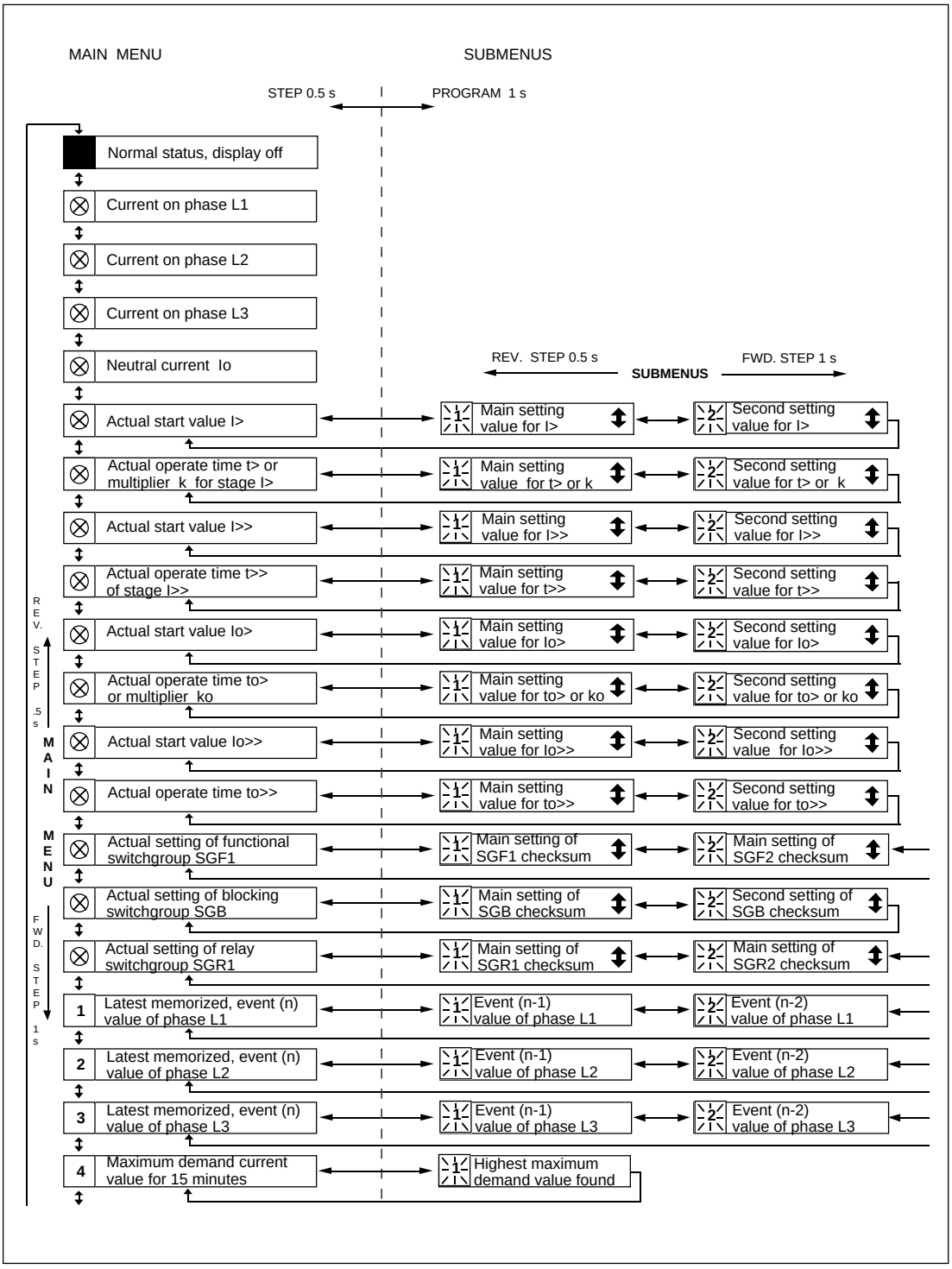
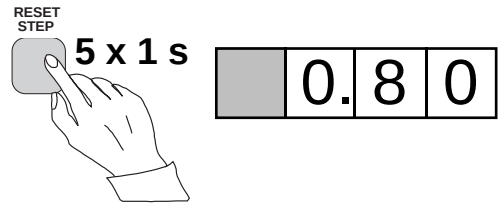


Fig. 4. Example of part of the main and submenus for the settings of the overcurrent and earth-fault relay module SPCJ 4D29. The settings currently in use are in the main manu and they are displayed by pressing the STEP push button. The main menu also includes the measured current values, the registers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

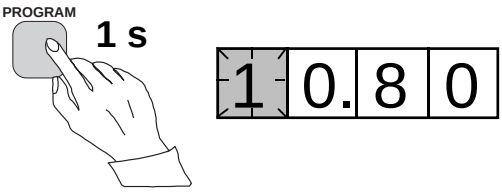
Example 1

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

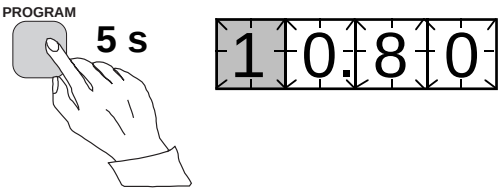
a)
Press push button STEP repeatedly until the LED close to the I> symbol is lit and the current start value appears on the display.



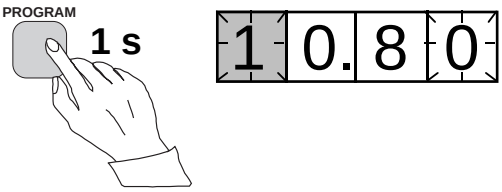
b)
Enter the submenu to get the main setting value by pressing the PROGRAM push button more than one second and then releasing it. The red display digit now shows a flashing number 1, indicating the first submenu position and the green digits show the set value.



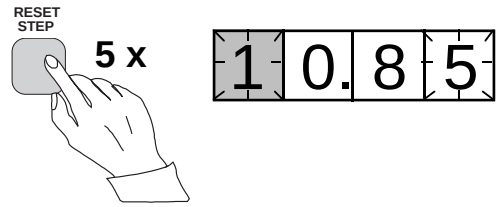
c)
Enter the setting mode by pressing the PROGRAM push button for five seconds until the display starts flashing.



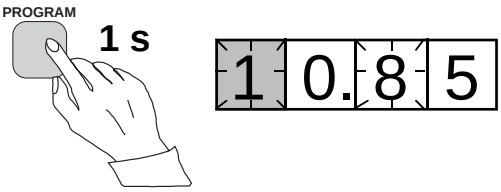
d)
Press the PROGRAM push button once again for one second to get the rightmost digit flashing.



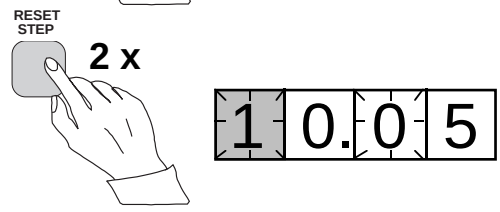
e)
Now the flashing digit can be altered. Use the STEP push button to set the digit to the desired value.



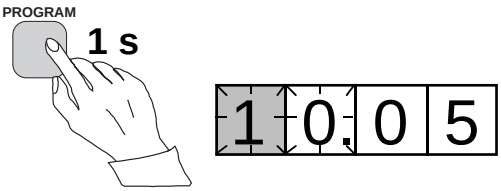
f)
Press the PROGRAM push button to make the middle one of the green digits flash.



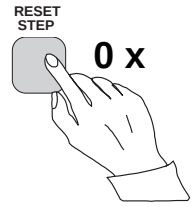
g)
Set the middle digit with of the STEP push button.

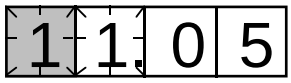


h)
Press the PROGRAM push button to make the leftmost green digit flash.

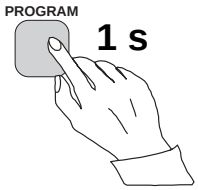


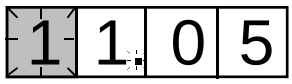
i)
Set the digit with the STEP push button.



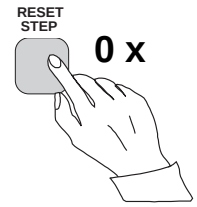


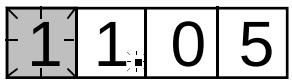
j)
Press the PROGRAM push button to make the decimal point flash.



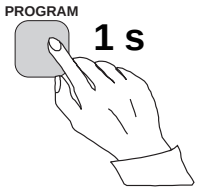


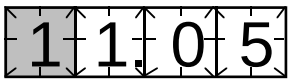
k)
If needed, move the decimal point with the STEP push button.



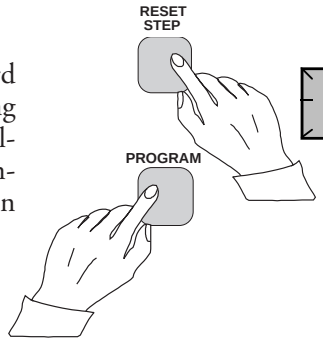


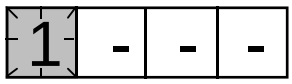
l)
Press the PROGRAM push button to make the whole display flash. In this position, corresponding to position c) above, one can see the new value before it is recorded. If the value needs changing, use the PROGRAM push button to alter the value.



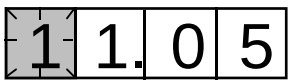


m)
When the new value has been corrected, record it in the memory of the relay module by pressing the PROGRAM and STEP push buttons simultaneously. At the moment the information enters the memory, the green dashes flash once in the display, i.e. 1 - - -.

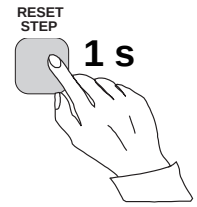


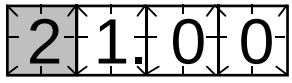


n)
Recording of the new value automatically initiates a return from the setting mode to the normal submenu. Without recording one can leave the setting mode any time by pressing the PROGRAM push button for about five seconds, until the green display digits stop flashing.



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



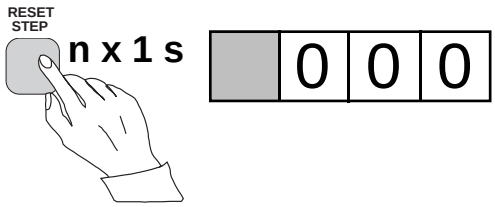


Enter the setting mode as in step c) and proceed in the same way. After recording of the requested values return to the main menu is obtained by pressing the STEP push button until the first digit is switched off. The LED still shows that one is in the I> position and the display shows the new setting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

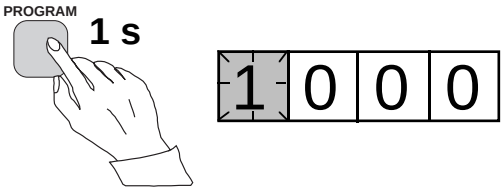
Example 2

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

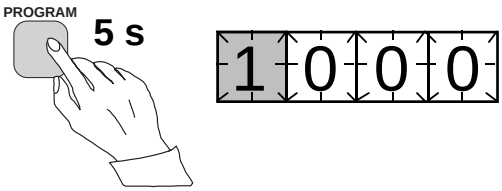
a)
Press push button STEP until the LED close to the SGF symbol is lit and the checksum appears on the display.



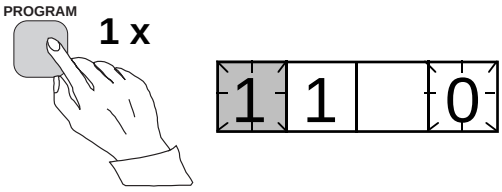
b)
Enter the submenu to get the main checksum of SGF1 by pressing the PROGRAM push button for more than one second and then releasing it. The red display now shows a flashing number 1 indicating the first submenu position and the green digits show the checksum.



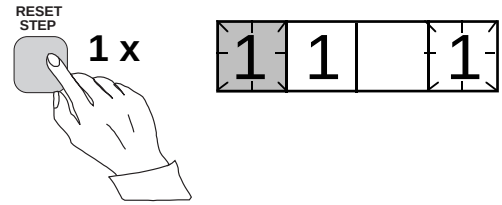
c)
Enter the setting mode by pressing the PROGRAM push button for five seconds until the display starts flashing.



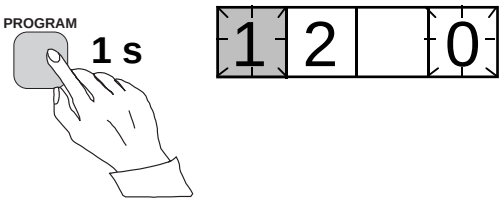
d)
Press the PROGRAM push button once again to get the first switch position. The first digit of the display now shows the switch number. The position of the switch is shown by the rightmost digit.



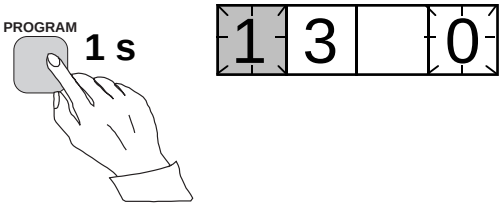
e)
The switch position can now be toggled between 1 and 0 by means of the STEP push button and it is left in the requested position 1.



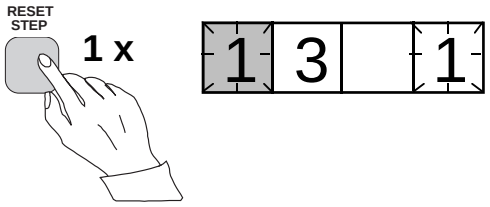
f)
When switch number 1 is in the requested position, switch number 2 is called up by pressing the PROGRAM push button for one second. As in step e), the switch position can be altered by using the STEP push button. As the desired setting for SGF1/2 is 0 the switch is left in the 0 position.



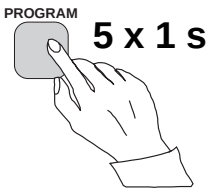
g)
Switch SGF1/3 is called up as in step f) by pressing the PROGRAM push button for about one second.



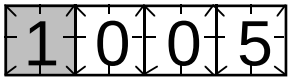
h)
The switch position is altered to the desired position 1 by pressing the STEP push button once.



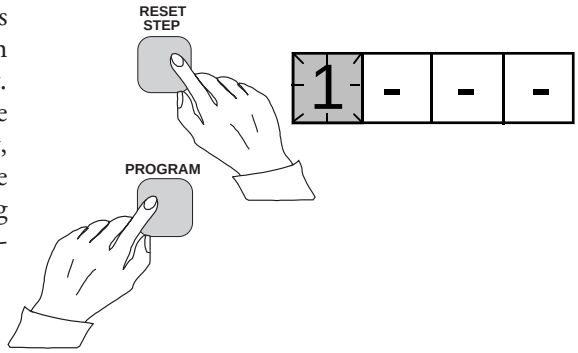
i)
Using the same procedure the switches SGF 1/ 4...8 are called up and, according to the example, left in position 0.



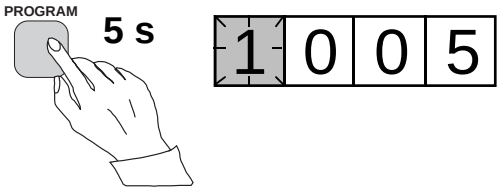
j)
In the final setting mode position, corresponding to step c), the checksum based on the set switch positions is shown.



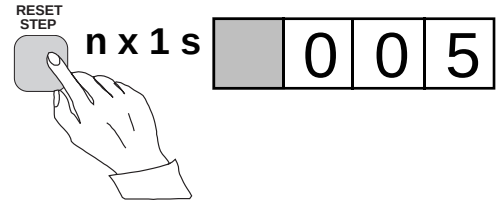
k)
If the correct checksum has been obtained, it is recorded in the memory by pressing the push buttons PROGRAM and STEP simultaneously. At the moment the information enters the memory, the green dashes flash in the display, i.e.1 - - -. If the checksum is incorrect, the setting of the separate switches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



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



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



Recorded information

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

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

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

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

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

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

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

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

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

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

Trip test function

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

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

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

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

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

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

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

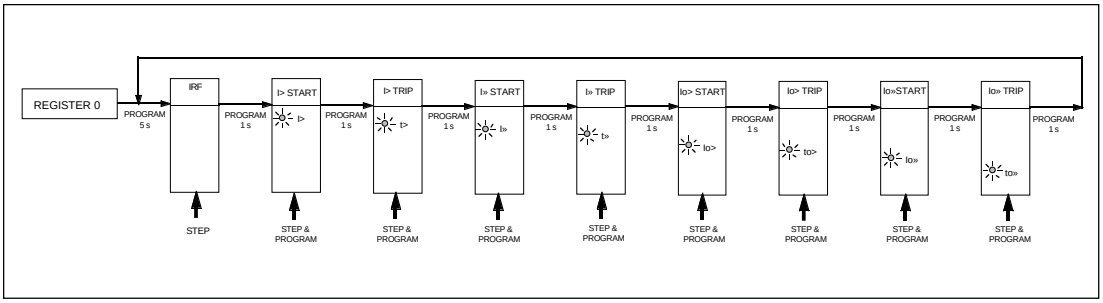


Fig. 5. Sequence order for the selection of output signals in the Trip test mode

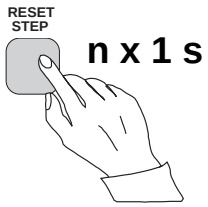
If, for instance, the indicator of the setting t> is flashing, and the push buttons STEP and PROGRAM are being pressed, the trip signal from the low-set overcurrent stage is activated. Return to the main menu is possible at any stage of the trip test sequence scheme, by pressing the PROGRAM push button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

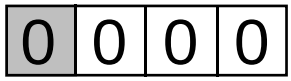
Note!
The effect on the output relays then depends on the configuration of the output relay matrix switchgroups SGR 1...3.

Example 3

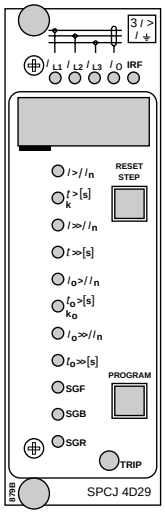
Trip test function. Forced activation of the outputs.

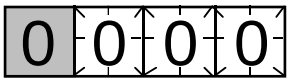
a)
Step forward on the display to register 0.





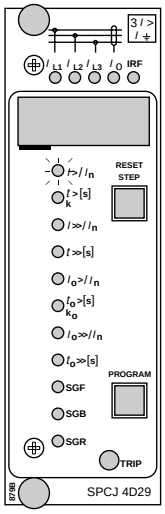
b)
Press the PROGRAM push button for about five seconds until the three green digits to the right.

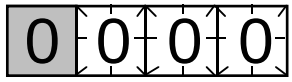




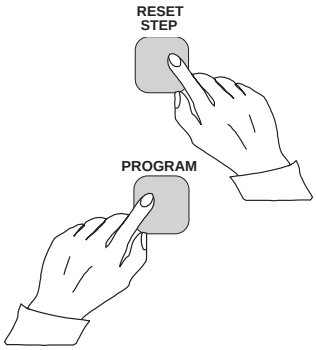
c)
Hold down the STEP push button. After one second the red IRF indicator is lit and the IRF output is activated. When the step push button is released the IRF indicator is switched off and the IRF output resets.

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

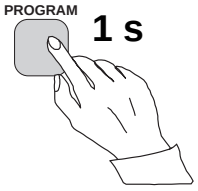


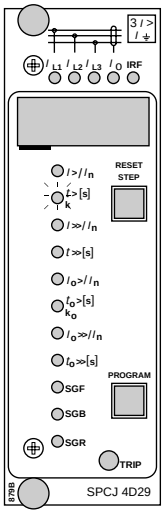


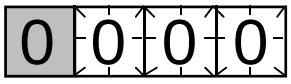
e)
If a start of the first stage is required, now press the push-buttons PROGRAM and STEP simultaneously. The stage output will be activated and the output relays will operate according to the actual programming of the relay output switchgroups SGR.



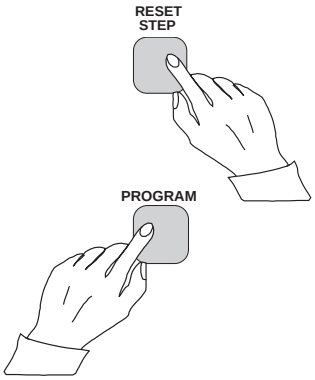
f)
To proceed to the next position press the PROGRAM push button for about 1 second until the indicator of the second setting starts flashing.

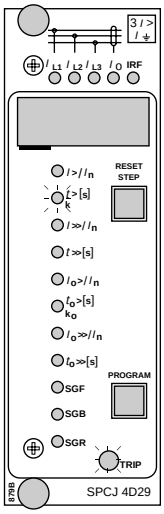


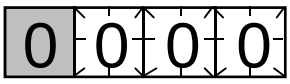




g)
Press the push buttons PROGRAM and STEP simultaneously to activate tripping of stage 1 (e.g. the I> stage of the overcurrent module SPCJ 4D29). The output relays will operate according to the actual programming of the relay switchgroups SGR. If the main trip relay is operated the trip indicator of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







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

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

Operation indication

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

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

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

Fault codes

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

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

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

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