Description of operation

The combined overcurrent and earth-fault relay is a secondary relay to be connected to the current transformers of the protected object. The three-phase overcurrent unit and the earth-fault unit continuously measure the phase currents and the neutral current of the protected object. On detection of a fault the relay starts, trips the circuit breaker, initiates auto-reclosing, provides alarm, records fault data etc. in accordance with the application and the configured relay functions.

When the phase current exceeds the set start current of the low-set stage I>, the overcurrent unit starts delivering a start signal after a preset ~60 ms start time. When the set operate time at definite time operation or the calculated operate time at inverse time operation elapses, the overcurrent unit operates. In the same way the high-set stage I>> of the overcurrent unit starts delivering a start signal after a preset ~40 ms start time, when the set start current is exceeded. When the set operate time elapses, the overcurrent unit operates.

When the earth-fault current exceeds the set start current of the low-set stage I_0>, the earth-fault unit starts delivering a start signal after a preset ~60 ms start time. When the set operate time at definite time operation or the calculated operate time at inverse time operation elapses, the earth-fault unit operates. In the same way the high-set stage I_0>> of the earth-fault unit starts delivering a start signal after a preset ~40 ms start time, when the set start current is exceeded. When the set operate time elapses, the earth-fault unit operates.

The low-set stage of the overcurrent unit and the low-set stage of the earth-fault unit may be given definite time or inverse definite minimum time (IDMT) characteristic. When the IDMT characteristic is chosen six time/current curves are available. Four of the curves comply with the BS 142 and IEC 60255 and are named "Normal inverse", "Very inverse", "Extremely inverse" and "Long-time inverse". The two additional inverse time curves called the "RI-curve" and the "RXIDG-curve" are also provided.

By appropriate configuration of the output relay matrix, the start signals of the overcurrent and earth-fault units are obtained as contact functions. The start signals can be used for blocking co-operating protection relays, for signalling and for initiating auto-reclosing.

The relay includes one external binary input, which is controlled by an external control voltage. The function of the control input is determined by selector switches in the protection relay module. The control input can be used for blocking the operation of one or more protection stages, for resetting a latched output relay in the manual reset mode or for enforcing a new set of relay setting parameters by remote control.

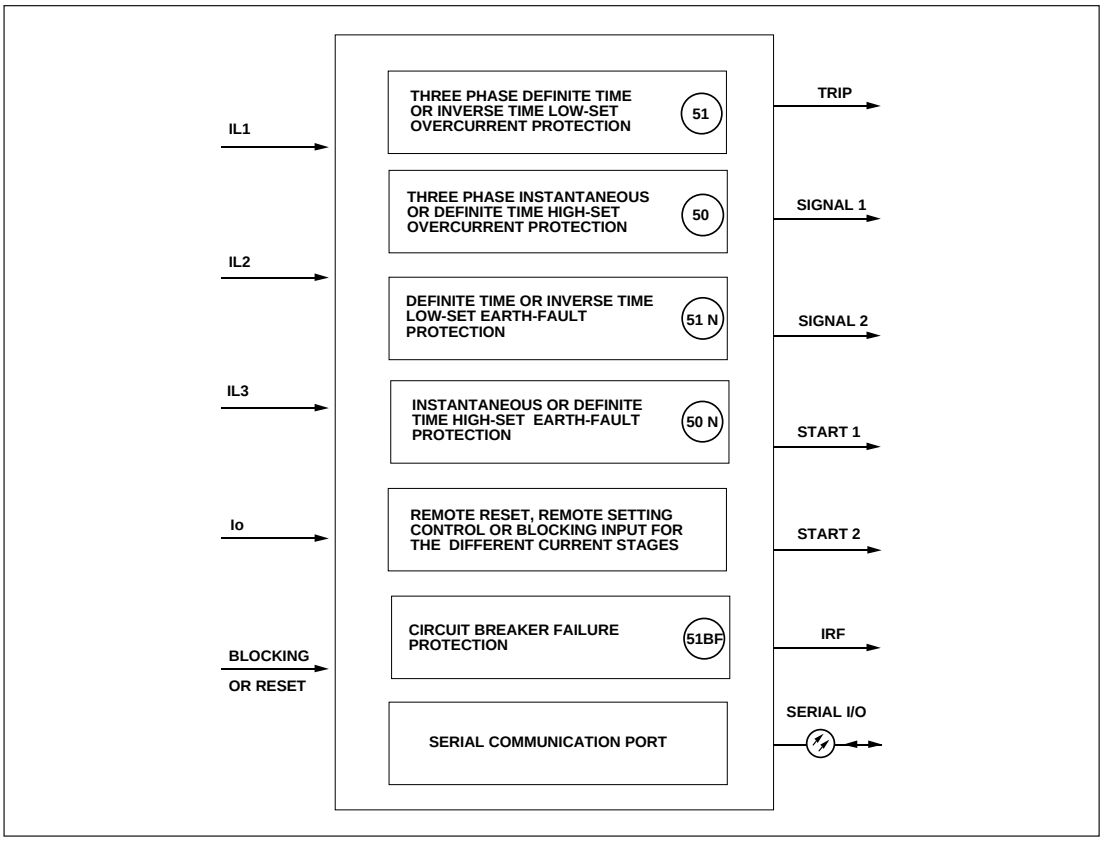


Fig. 1. Protection functions of the combined overcurrent and earth-fault relay type SPAJ 140 C.

Connections
(modified 2003-09)

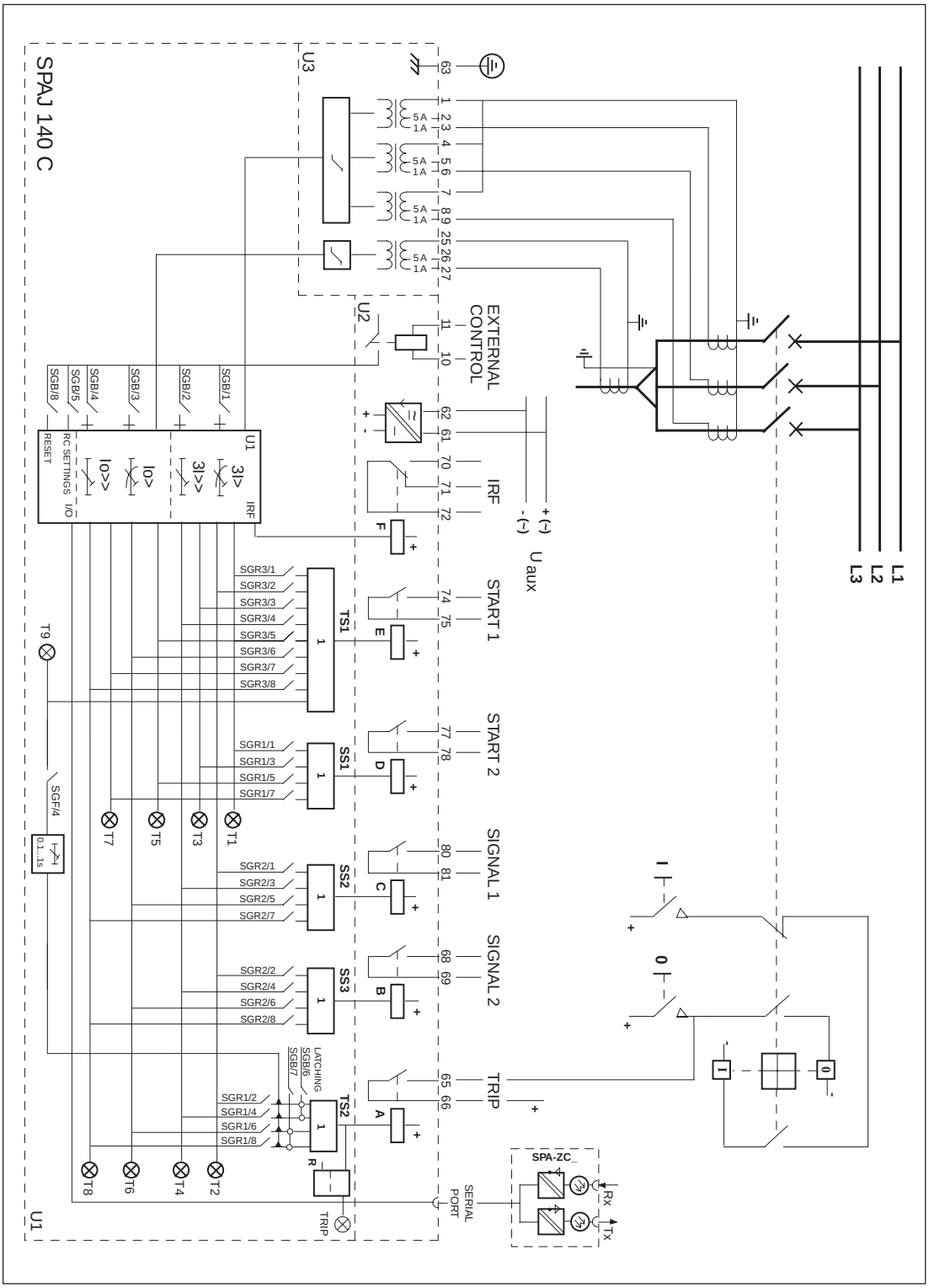


Fig. 2. Connection diagram for the combined overcurrent and earth-fault relay type SPAJ 140 C.

U_{aux}	Auxiliary voltage
A, B, C, D, E, F	Output relays
IRF	Self-supervision
SGR	Switchgroups for the configuration of the output relays
SGB	Switchgroup for the configuration of the blocking or control signal
TRIP	Trip output relay
SIGNAL 1	Signal on operation of the overcurrent unit
SIGNAL 2	Signal on operation of the earth-fault unit
START 1	Starting or auxiliary trip signal as selected with switchgroup SGR3
START 2	Start signal of the low-set overcurrent stage I>
U1	Overcurrent and earth-fault relay module SPCJ 4D29
U3	Input module SPTE 4E1
U2	Power supply and output relay module SPTU 240 R1 or SPTU 48 R1
T1…T9	Start and operation indications
SERIAL PORT	Serial communication port
SPA-ZC_	Bus connection module
Rx/Tx	Receiver bus terminal (Rx) and transmitter bus terminal (Tx) of the bus connection module

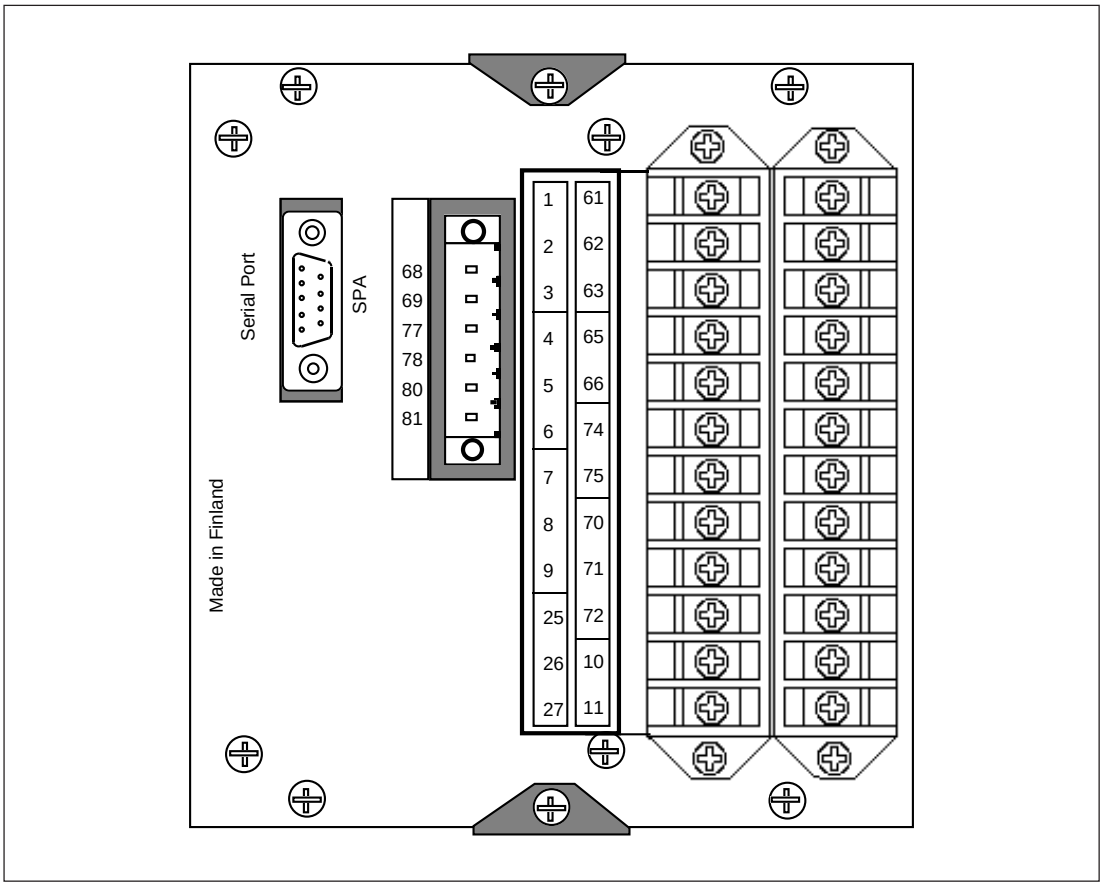


Fig. 3. Terminal arrangement of the overcurrent and earth-fault relay type SPAJ 140 C.

The energizing currents of the overcurrent unit are connected to terminals 1-2, 4-5 and 7-8, when the rated current of the CT secondary circuits is I_n = 5 A. When the rated current of the CT secondary circuits is I_n = 1 A, terminals 1-3, 4-6 and 7-9 are used. The relay can also be used in single-phase or two-phase applications simply by leaving one or two energizing inputs unoccupied. In single-phase applications the same energizing current can be routed through two energizing inputs, which may increase the operating speed of the overcurrent unit, especially at instantaneous operation.

The energizing current for the earth-fault unit is connected to terminals 25-26 when the rated current I_n = 5 A and to terminals 25-27 when the rated current I_n = 1 A.

The control input 10-11 can be used in three different ways, i) as control input for an external blocking signal, ii) as the control input for unlatching the trip relay, or iii) as the control input for the remote control of relay settings. The requested function is selected by means of switches switchgroup SGB in the main menu of the protection relay module.

The auxiliary supply voltage of the relay is connected to terminals 61-62. At d.c. supply the positive lead is connected to terminal 61. The level of the voltage to be applied to the terminals depends on the type of power supply and output relay module inserted in the relay. For further details see the description of the power supply module. The permitted auxiliary voltage range of the relay is marked on the relay front panel.

Output relay A is a heavy-duty trip relay capable of controlling most circuit breakers. The operate signals of the different protection stages are routed to the trip relay with switches 2,4,6 and 8 of switchgroup SGR1. On delivery from the factory all the protection stages are routed to the trip relay. A latching of the output relay A can be selected with switches 6 and 7 of switchgroup SGB.

Output relays B and C can be used for signalling on operation of the relay module. The signals to be routed to the output relays B and C are selected with switches1...8 of switchgroup SGR2. The switch matrixes for routing operate signals to the output relays B and C are identical. Normally output relay B is used for signalling on operation of the overcurrent unit and C for signalling on operation of the earth-fault unit. This is also the default setting of the relay on delivery from the factory.

The start signals of the protection stages of the relay are routed to output relay D. The signals to be routed to output relay D are selected by means of switches 1, 3, 5 and 7 of switchgroup SGR1, which is a software switchgroup found in the main menu of the protection relay module. The start signals of the low-set and high-set stage of the overcurrent unit are selected with switches 1 and 3, and the start signals of the high-set and low-set stage of the earth-fault unit with switches 5 and 7.

The output relay E is a heavy-duty relay as output relay A. It can be controlled by the start and operate signals of the protection stages. Output relay E is also used a trip relay for the circuit breaker failure protection (CBFP), when the CBFP protection is used. In this case the trip signal can be used either to control a circuit breaker upstreams or to control a second trip coil on the main circuit breaker to increase the redundancy of the circuit breaker.

Output relay F functions as output relay for the self-supervision system of the protection relay. The F relay is energized under normal operating conditions and contact gap 70-72 is closed. If a fault is detected by the self-supervision system, or on loss of auxiliary supply, the output relay drops off and the NO contact 71-72 closes.

By means of bus connection modules type SPA -ZC17 and SPA-ZC21 the relay connects to the fibre-optic SPA bus via a 9-pole, D-type subminiature connector located at the rear panel of the relay. The terminals of the fibre-optic cables are connected to the counter terminals Rx (receiver) and Tx (transmitter) of the bus connection module. The fibre-optic cables are linked from one relay to another and to the substation level communication unit, for instance type SRIO 1000M.

Signal diagram

The figure below schematically illustrates how the start, trip, control and blocking signals can be configured to obtain the required protection functions.

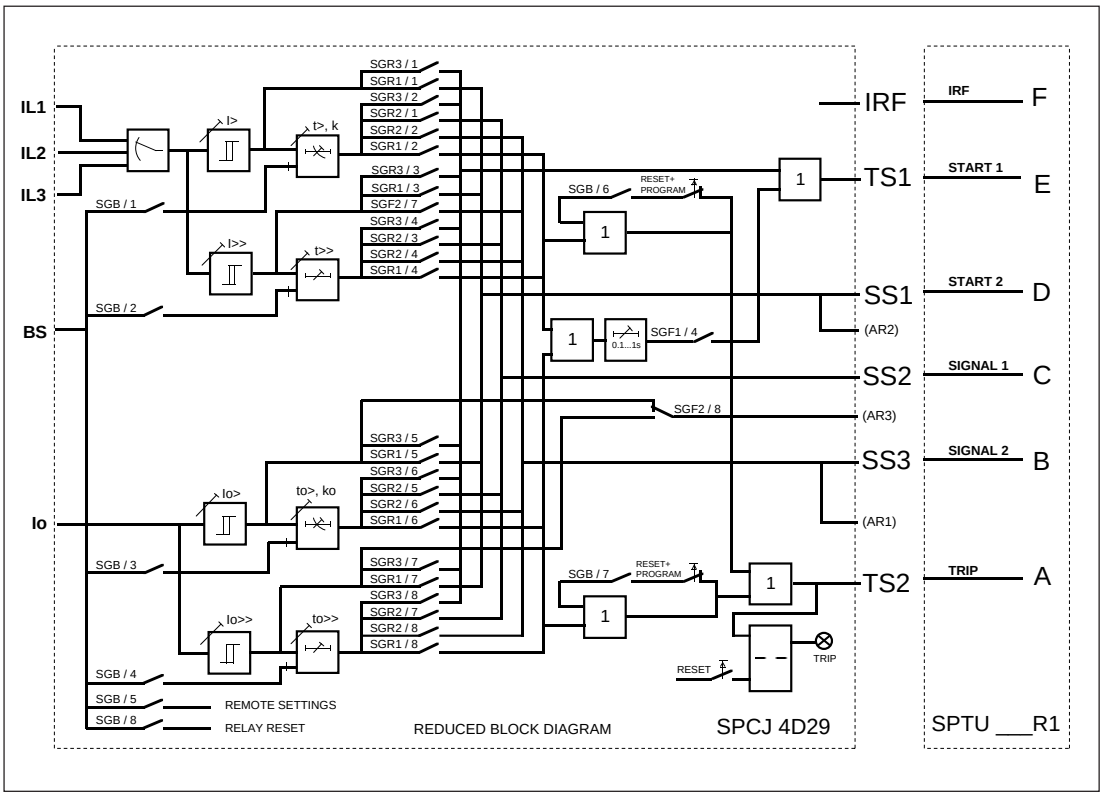


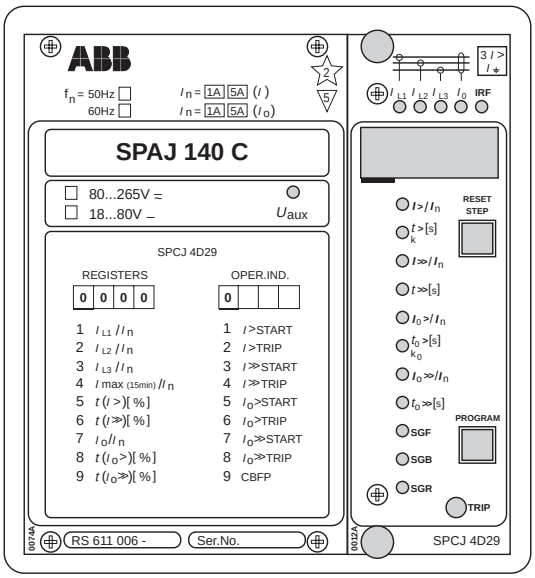
Fig. 4. Signal diagram of the combined overcurrent and earth-fault relay type SPAJ 140 C

The functions of the blocking and start signals are selected with the switches of switchgroups SGF, SGB and SGR. The checksums of the switchgroups, are found in the setting menu of the protection relay module. The functions of the different switches are explained in detail in the user´s manual of the protection relay module SPCJ 4D29.

Signal abbreviations

I_{L1}, I_{L2}, I_{L3}	Energizing current of phase L1, L2 and L3
I_0	Neutral current (Residual current)
BS	Blocking or control signal
SS1	Start signal 1
SS2	Start signal 2
SS3	Start signal 3
TS1	Operate signal 1 (Trip signal 1)
TS2	Operate signal 2 (Trip signal 2)
BS	Blocking signal
AR1...3	Auto-reclose start signals (not in use in relay SPAJ 140 C)
IRF	Internal relay failure
SGF	Switchgroup for functions
SGB	Switchgroup for blockings
SGR	Switchgroup for relay configuration

Operation indicators



A) The indicator TRIP is lit when one of the protection stages operates. When the protection stage resets, the red indicator remains lit.

B) If the display is dark when one of the protection stages I>, I>>, I_0> or I_0>> operates, the faulty phase or the neutral circuit is indicated with a yellow LED. If, for instance, the TRIP indicator glows red, and the indicators I_{L1} and I_{L2} at the same time are lit, overcurrent has occurred on phase L1 and L2.

C) Besides being a code number at data presentation, the leftmost red digit in the display serves as a visual operation indicator. An operation indicator is recognized by the fact that the red digit alone is switched on. The following table named OPERATION IND. on the relay front panel is a key to the function code numbers used.

Indication	Explanation	
1	I> START	= The low-set stage I> of the overcurrent unit has started
2	I> TRIP	= The low-set stage I> of the overcurrent unit has operated
3	I>> START	= The high-set stage I>> of the overcurrent unit has started
4	I>> TRIP	= The high-set stage I>> of the overcurrent unit has operated
5	I_0> START	= The low-set stage I_0> of the earth-fault unit has started
6	I_0> TRIP	= The low-set stage I_0> of the earth-fault unit has operated
7	I_0>> START	= The high-set stage I_0>> of the earth-fault unit has started
8	I_0>> TRIP	= The high-set stage I_0>> of the earth-fault unit has operated
9	CBFP	= Circuit breaker failure protection has operated

D) The TRIP indications persist when the protection stage returns to normal. The indicator is reset by pushing the RESET/STEP push-button.

Further, the indicators may be reset via the external control input 10-11 by applying a control voltage to the input, provided switch SGB/8 is in position 1.

The basic protection relay functions are not depending on the state of the operation indicators, reset or non-reset. The relay is permanently operative.

If a protection stage starts, but not operates, because the energizing quantity goes below the set start current before the operate time circuit has timed out, the start indicators are normally automatically switched off. However, by means of the switches SGF2/1…4 the start indications may be made persistant which means that they are to be manually reset by pushing the RESET/STEP push-button. The persistent indications are obtained through the following switch settings.

SGF2/1 = 1 manual reset of I> start indication
SGF2/2 = 1 manual reset of I>> start indication
SGF2/3 = 1 manual reset of I_0> start indication
SGF2/4 = 1 manual reset of I_0>> start indication

On delivery of the relay from the factory the switches SGF2/1…4 are preset at 0.

E) Shortly after the internal self-supervision system has detected a permanent relay fault the red IRF indicator is switched on and the output relay of the self-supervision system operates. Further, in most fault situations an autodiagnostic fault code is shown in the display. The fault code is composed of a red figure 1 and a green code number which indicates fault type. The fault code persists until the STEP/RESET push-button is pressed. When a fault code appears on the display, the code number should be recorded for statistical and maintenance purposes.

Power supply and output relay module

To be able to operate the relay needs a secured auxiliary voltage supply. The power supply module forms the voltages required by the protection relay module and the auxiliary relays. The withdrawable power supply and output relay module is located behind the system front panel, which is fixed by means of four cross-slotted screws. The power supply and output relay module contains the power supply unit, all output relays, the control circuits of the output relays and the electronic circuitry of the external control inputs.

The power supply and output relay module can be withdrawn after removing the system front panel. The primary side of the power supply module is protected with a fuse, F1, located on the PCB of the module. The fuse size is 1 A (slow).

The power supply unit is a pulse-width modulated (PWM) dc/dc converter with galvanically isolated primary and secondary sides. It forms the dc secondary voltages required by the protection relay module; that is +24 V, ±12 V and +8 V. The output voltages ±12 V and +24 V are stabilized in the power supply module, while the +5 V logic voltage required by the protection relay module is stabilized in the protection relay module.

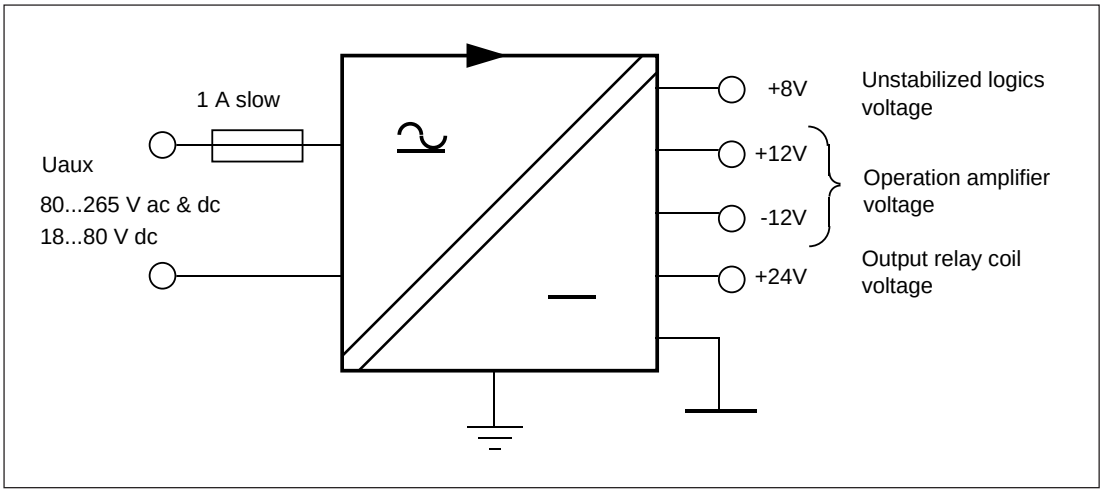


Fig. 5. Voltage levels of the power supply unit

A green LED indicator U_{aux} on the system front panel is lit when the power supply module is in operation. The supervision of the voltages supplying the electronics is located in the protection relay module. If a secondary voltage differs too much from its rated value, a self-supervision alarm will be generated. An alarm is also issued when the power supply module is withdrawn from the relay case, or on loss of auxiliary supply.

There are two versions of power supply and output relay modules available. For both types, the secondary sides and the relay configurations are identical, but the input voltage ranges differ.

Insulation test voltage between the primary and secondary side and the protective earth
2 kV, 50 Hz, 1 min

Rated power P_n 5 W

Voltage ranges of the power supply modules:
- SPTU 240 R1 U_{aux} = 80...265 V dc/ac
- SPTU 48 R1 U_{aux} = 18...80 V dc

The SPTU 240 R1 module can be fed from either an ac source or a dc source. SPTU 48 R1 is designed for dc supply only. The permitted auxiliary voltage range of the relay is marked on the relay system front panel.

Technical data

(modified 2002-04)

Energizing inputs

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

Output contact ratings

Tripping contacts	
Terminals	65-66, 74-75
Rated voltage	250 V dc/ac
Continuous carry	5 A
Make and carry for 0.5 s	30 A
Make and carry for 3.0 s	15 A
Breaking capacity for dc, when the trip circuit time-constant L/R ≤ 40 ms, at 48/110/220 V dc	5 A/3 A/1 A
Signalling contacts	
Terminals	70-71-72, 68-69, 77-78, 80-81
Rated voltage	250 V dc/ac
Continuous carry	5 A
Make and carry for 0.5 s	10 A
Make and carry for 3.0 s	8 A
Breaking capacity for dc, when the signal circuit time-constant L/R ≤ 40 ms, at 48/110/220 V dc signal circuit voltage	1 A/0.25 A/0.15 A

External control inputs

Blocking, remote reset or remote setting input	10-11
Control voltage level	18...265 V dc or 80...265 V ac
Control current of activated input	2…20 mA

Power supply and output relay module

Supply and output relay module, type SPTU 240 R1	80...265 V dc/ac
Supply and output relay module, type SPTU 48 R1	18...80 V dc
Power consumption under quiescent/operating conditions	~4 W/ ~6 W