SPAS 348 C
Feeder Protection Relay

User´s manual and Technical description

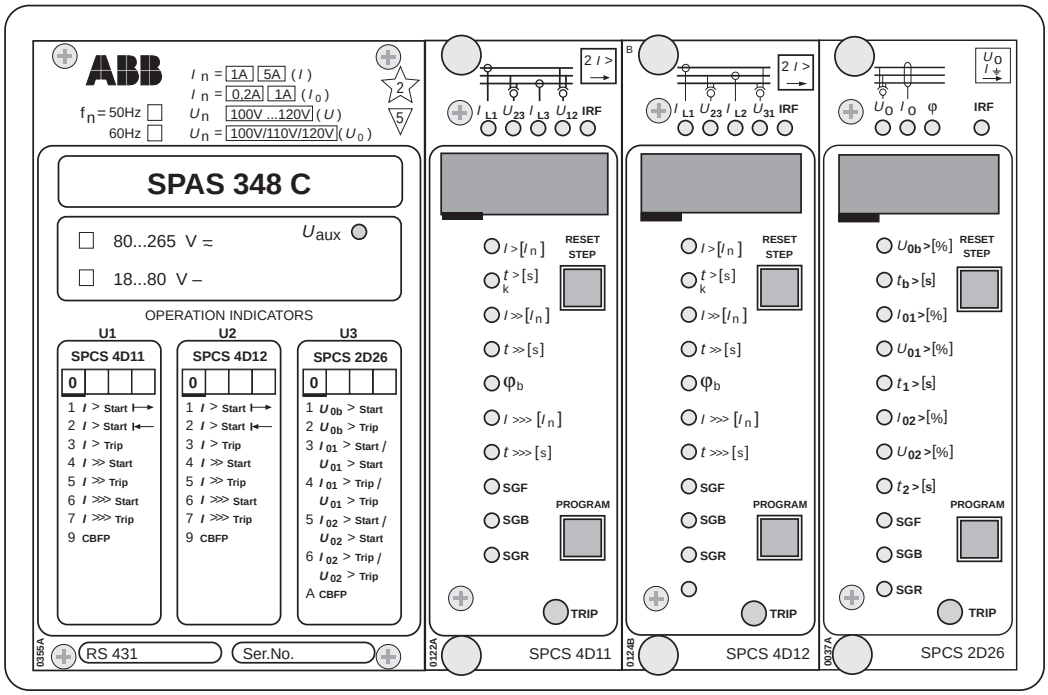


ABB Automation

1MRS 750114-MUM EN

Issued 96-04-11
Modified 96-11-26
Version B
Checked TK
Approved TK

Data subject to change without notice

SPAS 348 C
Feeder Protection Relay

Contents

In addition to this general part the following descriptions of the individual modules are included in the complete manual of the feeder terminal relay SPAS 348 C:

Directional overcurrent relay modules SPCS 4D11 and SPCS 4D12	1MRS 750115-MUM EN
Directional or non-directional earth-fault relay module SPCS 2D26	1MRS 750100-MUM EN
General characteristics of D-type SPC relay modules	1MRS 750066-MUM EN

Features

Three-phase overcurrent protection with two directional stages and one non-directional high-set stage

Special memory circuit for maintaining the stability and reliability of directional measurement at close three-phase faults

Two-stage directional earth-fault protection or alternatively three stage-residual voltage protection

Five external control inputs enabling, for example, switching between main and second settings

Eight freely configurable output relays and output relay for internal relay fault

Four heavy-duty output relays for circuit-breaker tripping

Recording of measured data to be used for analyzing network condition

Transfer of data over serial communication bus

Continuous self-supervision and internal fault diagnosis

Reading and writing of setting values via display and front panel push-buttons, a PC with setting software or from higher systems levels over serial bus

Application

The feeder protection relay SPAS 348 C is designed to be used in applications requiring directional phase overcurrent, directional short-circuit and directional earth-fault protection. Typically, the relay is used for the overcurrent and earth-fault protection of infeeders and busbars in distribution substations provided with multiple infeeders supplied from the same high-voltage busbar system via power transformers.

The relays are also applied for the selective short-circuit and earth-fault protection of parallel feeders between substations and for feeder protection in ring-type and meshed distribution networks.

Further, the directional relay is used for the protection of radial feeders with a small back-feed of energy from a generator in the consumer-end of the feeder.

Description of operation

The feeder protection relay SPAS 348 C is a secondary relay system to be connected to the current and voltage transformers of the network section to be protected.

The feeder protection relay includes three protection relay modules:
two directional overcurrent relay modules SPCS 4D11 and SPCS 4D12, and one directional earth-fault relay module type SPCS 2D26.

Directional overcurrent relay modules SPCS 4D11 and SPCS 4D12

The directional overcurrent modules SPCS 4D11 and SPCS 4D12 are intended to be used for single-phase or two-phase directional overcurrent protection. When the two directional overcurrent modules are used together three-phase directional overcurrent protection is achieved.

Each module includes three overcurrent stages: two directional stages I>, I>> and one non-directional stage I>>>. An overcurrent stage starts, as soon as the current on one of the phases exceeds the setting value of the stage and, if directional operation is selected the directional criteria must be fulfilled. Should the stage still be started when the operate time selected for the stage elapses, it trips the circuit breaker by delivering the trip signal configured.

The low-set stages I> may have a definite time or an inverse time characteristic, whereas the high-set stages operate according to the definite time characteristic only. The operation of the stages can be totally blocked by means of the configuration switches.

The directional control of the relay modules is based on measuring the phase angle between the phase current and the opposite phase-to-phase voltage, say, L1 and U23.

To secure a reliable relay operation at close three-phase faults characterized by an exremely low phase-to-phase voltage, a memory function is implemented. At sudden loss of voltage in a fault situation this memory function gives the directional stage an additional 2.5 s time to operate after a total loss of voltage (=voltage level below 7%).

Further, if the circuit breaker is closed against a fault, which means that the voltage does not rise to such a level that the direction of the current can be determined, the high-set stage I>> will operate non-directionally.

Directional earth-fault relay module SPCS 2D26

The directional earth-fault relay module SPCS 2D26 has two protection stages: a low-set stage I_{01}> and a high-set stage I_{02}>. The start value of the deblocking voltage U_{0b}> is the same for both I_{01}> and I_{02}>. The protection is based on measuring the neutral current I_0, the residual voltage U_0 and the phase angle between these. An earth-fault stage starts, if the neutral current and the residual voltage exceed the set values and the phase angle is within the specified operating sector $\varphi_b \pm \Delta\varphi$. When these conditions remain fulfilled during the set operate time, the stage provides a trip signal.

The earth-fault relay module SPCS 2D26 can also be configured to operate as a three-stage residual voltage relay by replacing the two neutral current stages by two voltage stages. The three residual voltage stages measure the same voltage, but they can be given separate start values and operate times.

Circuit-breaker failure protection

The circuit-breaker failure protection integrated into the relay modules SPCS 4D11, SPCS 4D12 and SPCS 2D26 enables a secured circuit breaker trip system. The breaker fail function is linked to the output relay TS1, which means that if the local circuit breaker fails to trip, the trip signal is rerouted directly to the upstream circuit breaker.

Note !

When the relay SPAS 348 C is wired according to a connection diagram of this user guide, the operation direction "forward" is the direction of the normal load current. If the relay is to trip when the current starts flowing in the opposite direction to the normal load current, the operation direction "reverse" shall be selected by means of the SGF switches.

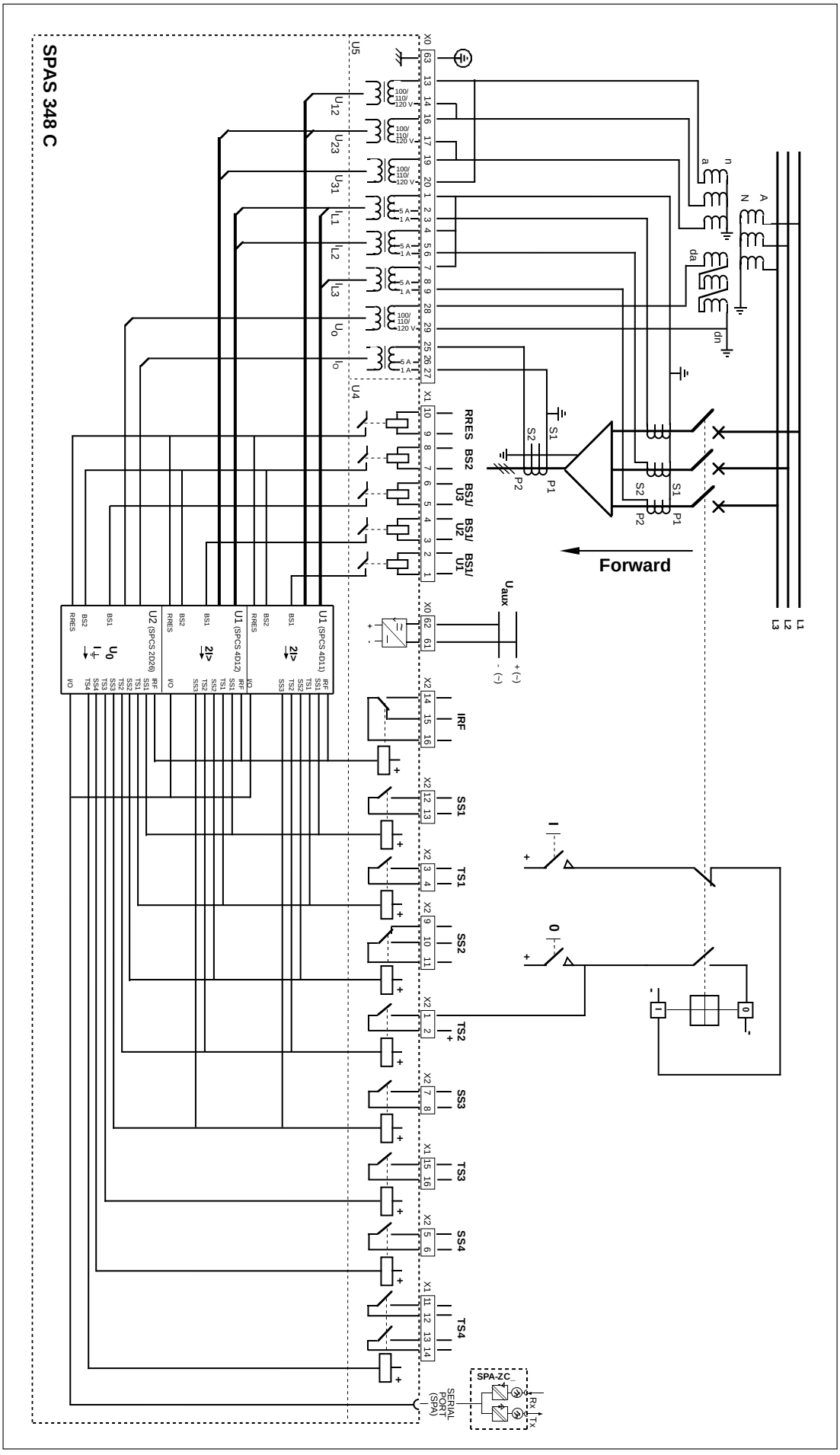


Fig. 1. Connection diagram for feeder protection relay SPAS 348 C

U_{aux}	Auxiliary voltage
TS1...TS4	Output relays (heavy-duty)
SS1...SS4	Output relays (alarms, blockings, etc.)
IRF	Self-supervision output relay
BS1, BS2, RRES	Control signals
U1	Directional overcurrent relay module SPCS 4D11
U2	Directional overcurrent relay module SPCS 4D12
U3	Directional earth-fault relay module SPCS 2D26
U4	I/O module
U5	Energizing input module
SERIAL PORT	Serial communication port
SPA-ZC	Bus connection module
Rx/Tx	Fibre-optic cable connections

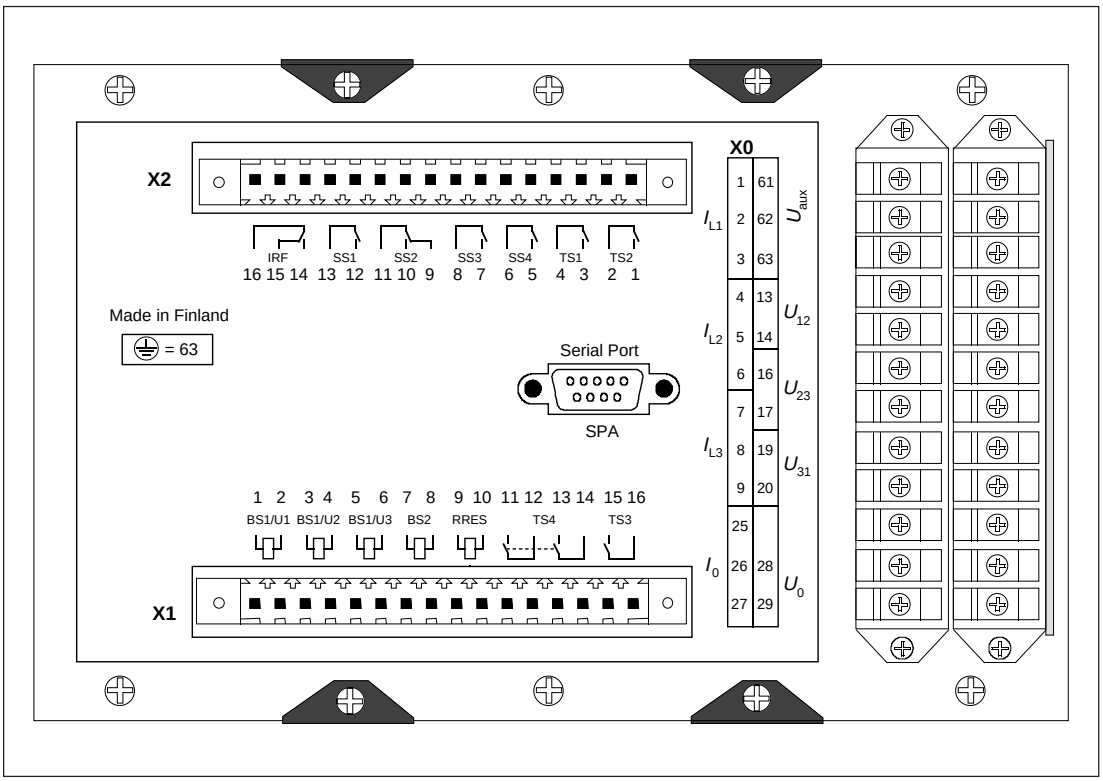


Fig. 2. Terminals of feeder protection relay SPAS 348 C

Specification of input and output terminals

Terminal group	Terminal interval	Function
XO	1—2	Phase current I_{L1} (5 A). Directional overcurrent protection
	1—3	Phase current I_{L1} (1 A). Directional overcurrent protection
	4—5	Phase current I_{L2} (5 A). Directional overcurrent protection
	4—6	Phase current I_{L2} (1 A). Directional overcurrent protection
	7—8	Phase current I_{L3} (5 A). Directional overcurrent protection
	7—9	Phase current I_{L3} (1 A). Directional overcurrent protection
	13—14	Phase-to-phase voltage U_{12} (100 V). Directional overcurrent protection
	16—17	Phase-to-phase voltage U_{23} (100 V). Directional overcurrent protection
	19—20	Phase-to-phase voltage U_{31} (100 V). Directional overcurrent protection
	25—26	Neutral current I_0 (5 A). Directional earth-fault protection. (SPCS 2D26)
	25—27	Neutral current I_0 (1 A). Directional earth-fault protection. (SPCS 2D26)
	28—29	Residual voltage U_0 (100 V). Earth-fault protection. (Selection of rated voltage 110 V- and 120 V- possible)
	61—62	Auxiliary voltage supply. The positive pole of the DC supply is connected to terminal 61. Auxiliary voltage range marked on the front plate.
	63	Protective earth
X1	1—2	External control signal BS1/U1
	3—4	External control signal BS1/U2
	5—6	External control signal BS1/U3
	7—8	External control signal BS2
	9—10	External control signal RRES
	11—12—13—14	Output relay TS4 (heavy-duty; terminals 12 and 13 must be connected together if double-pole connection not used)
	15—16	Output relay TS3 (heavy-duty)
X2	1—2	Output relay TS2 (heavy-duty)
	3—4	Output relay TS1 (heavy-duty)
	5—6	Output relay SS4
	7—8	Output relay SS3
	9—10—11	Output relay SS2
	12—13	Output relay SS1
	14—15—16	Output relay IRF

The protection relay connects to the fibre-optic data bus via the D connector on the rear panel and a bus connection module type SPA-ZC 17 or SPA-ZC 21. The optical fibres are connected to the counter contacts Rx and Tx of the module. The selector switches of the bus connection module are set into the position "SPA".

Signal flow diagram
(modified 96-11)

Fig. 4 illustrates the internal signals of the feeder protection relay and their configuration. The numbers given in the small squares refer to the configuration switches for be used to connecting the control signals to obtain the required functions and thus configuring the start and trip signals to operate as desired output signals.

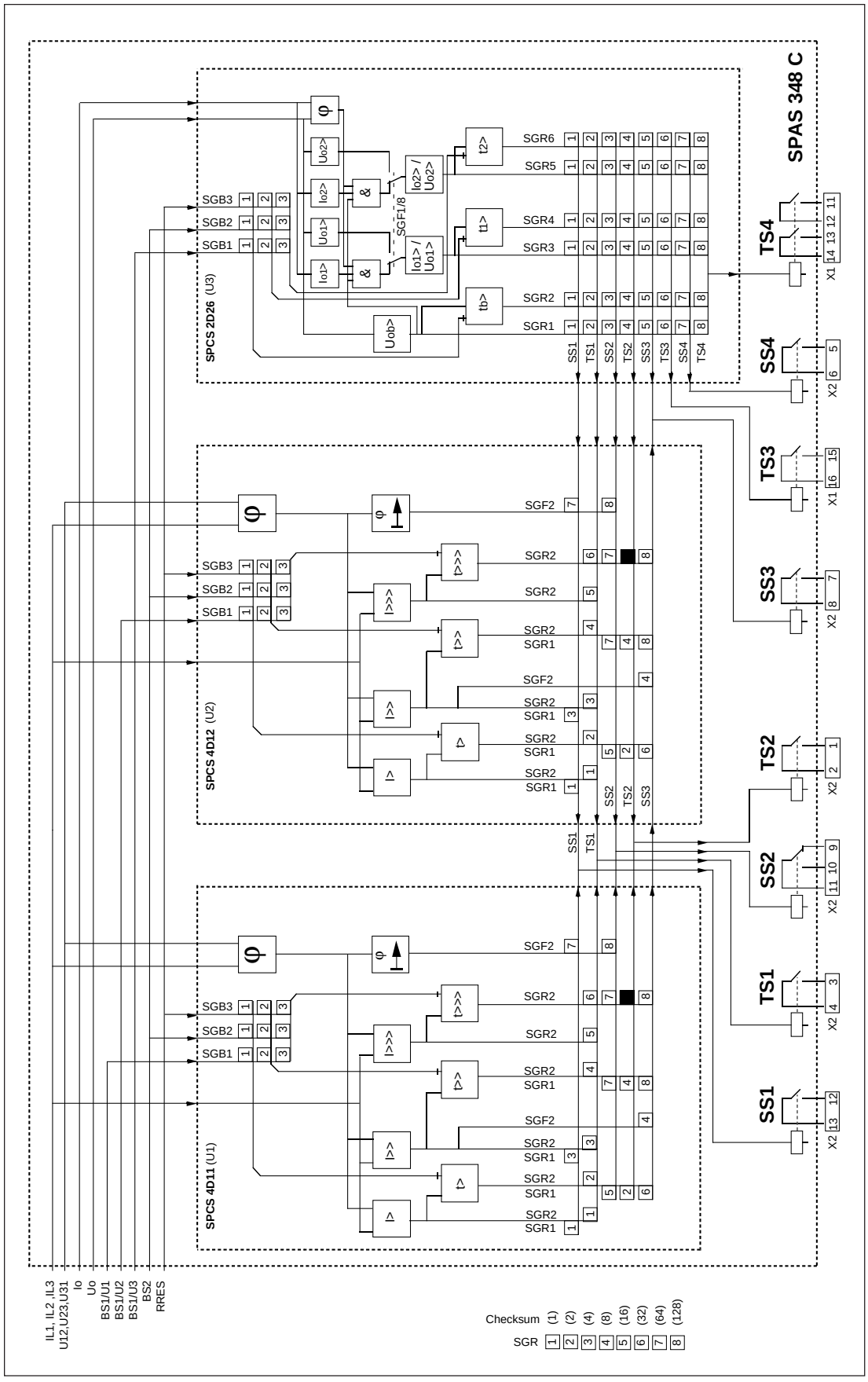


Fig. 3. Internal signals of feeder protection relay SPAS 348 C

Operation indicators

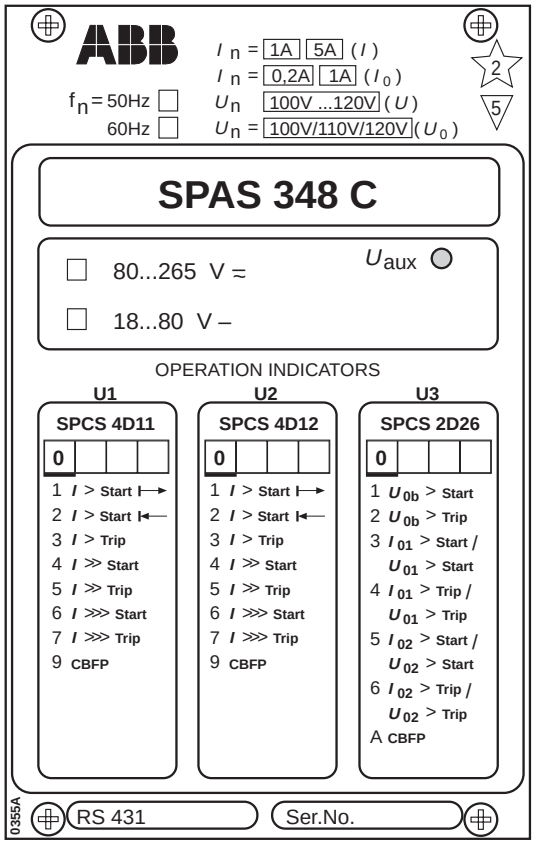


Fig. 4. Front panel of feeder protection relay SPAS 348 C

1. The green LED U_{aux} on the system panel is lit when the power supply unit is operating.

2. Measured values, settings and start and trip data are indicated on the display of the relay modules. Starting and tripping are indicated by the red operation code to the left of the display. The operation codes are explained in the manuals of the separate protection relay modules and on the system panel of the feeder protection relay.

   The start indications can be programmed to remain on even though the stage resets. Normally, the numbers indicating start are automatically reset, whereas the trip codes have to be reset by pressing the RESET push-button. The TRIP indicator at the bottom part of the front panel can be set to indicate starting and tripping. The BS1, BS2 and RRES signals can be configured to reset the trip indicators automatically. An unreset operation indicator does not affect the operation of the relay module.

3. Measured values and settings presented on the display are identified by yellow LEDs on the front panel.

4. A permanent fault detected by the self-supervision system is indicated by the IRF indicator of the concerned relay module. The fault code appearing on the display when a fault occurs should be recorded to facilitate maintenance and repair.

The operation indicators are described in detail in the manuals of the individual relay modules.

I/O module

The I/O module of the feeder protection relay SPAS 348 C is fitted in the rear part of the relay, in the same direction as the mother PC board. The module can be withdrawn after undoing the fixing screws and disconnecting the protective earth conductor of the cover and the flat cable connected to the mother PC board.

The I/O module incorporates the output relays (8 pcs + IRF), the control circuits of the relays, the electronic circuits for the five external control inputs and the D connector required for serial communications. The input and output signals of the I/O module are linked to the mother board over a flat cable.

The output signals SS1...SS4, TS1...TS3 and TS4 control an output relay with the same designation. The operation of the stages are not fixed to a particular output relay, but can be programmed to the desired output relays. It should, however, be noted that the output relays TS1, TS2, TS3 and TS4 can be used for circuit breaker control. The configuration of the switchgroups is described in detail in the relay module manuals.

The operation of the external control inputs is determined by the setting of the configuration switchgroups of the relay modules. The control inputs can be used for blocking one or several protection stages, for resetting latched output relays, selecting second settings, etc.

Power supply module

The power supply module forms the voltages required for the relay modules and the auxiliary relay module. The power supply module is located behind the system panel of the protection relay and can be withdrawn after removal of the system panel.

The power supply module is available in two versions as follows:

SPGU 240A1:
- 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 48B2
- rated voltage U_n = 24/48/60 V dc
- operative range U = 18...80 V dc

The voltage range of the power supply module fitted into the relay is marked on the system panel of the relay.

The power supply module is transformer-connected, i.e. the primary side and the secondary circuits are galvanically isolated. The primary side is protected by a fuse, F1, located on the PC board of the module. The fuse used in SPGU 240A1 is 1 A (slow) and that one used in SPGU 48B2 is 4 A (slow).

The green LED U_{aux} on the front panel is lit when the power supply module is in operation. The supervision of the voltages supplying the electronic circuits is integrated into the relay modules. A self-supervision alarm is received, if a secondary voltage deviates from its rated value by more than 25%.

Technical data

Energizing inputs

Rated current I_n	1 A	5 A
Terminal numbers	X0/1-3	X0/1-2
	X0/4-6	X0/4-5
	X0/7-9	X0/7-8
	X0/25-27	X0/25-26
Thermal current withstand		
- continuously	4 A	20 A
- for 10 s	25 A	100 A
- for 1 s	100 A	500 A
Dynamic current withstand		
- half-wave value	250 A	1250 A
Input impedance	<100 mΩ	<20 mΩ

Voltage inputs

Rated voltage U_n	100 V (110 V/120 V)
Terminal numbers	X0/13-14, 16-17, 19-20, 28-29
Continuous voltage withstand	2 x U_n
Rated burden of voltage input at U_n	<0.5 VA

Output contacts

Trip contacts	
Terminal numbers	X1/15-16, 11-12-13-14
	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 the control voltage levels	
- 220 V dc	1 A
- 110 V dc	3 A
- 48 V dc	5 A
Contact material	$AgCdO_2$

Signalling contacts	
Terminal numbers	X2/5-6, 7-8, 9-10-11 X2/12-13, 14-15-16
- rated voltage	250 V ac/dc
- continuous current carrying capacity	5 A
- make and carry for 0.5 s	10 A
- make and carry for 3 s	8 A
Breaking capacity for dc when the control circuit time constant L/R ≤40 ms at the control voltage levels	
- 220 V dc	0.15 A
- 110 V dc	0.25 A
- 48 V dc	1 A
Contact material	$AgCdO_2$

External control inputs

Blocking/control (BS1/U1, U2, U3)	
- terminal numbers	X1/1-2, 3-4, 5-6
Blocking/control (BS2)	
- terminal number	X1/7-8
Blocking/control (RRES)	
- terminal number	X1/9-10
External control voltage	
- operative range	18...250 V dc or 80...250 V ac
Current drain of activated control input	2...20 mA

Auxiliary power supply

Voltage ranges of power supply modules:	
SPGU 240A1	
- 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 48B2	
- rated voltage	U_n = 24/48/60 V dc
- operative range	U = 18...80 V dc
Power consumption, under quiescent/ operation conditions	10 W/15 W

Combined overcurrent and earth-fault relay module SPCS 4D11, SPCS 4D12

- see "Technical data" in the manual for the module.

Directional earth-fault relay module SPCS 2D26

- see "Technical data" in the manual for the module.

Data communication

Transmission mode	Fibre-optic serial bus
Coding	ASCII
Data transfer rate, selectable	4800 Bd or 9600 Bd
Electrical/optical bus connection module powered from the host relay	
- for plastic core cables	SPA-ZC 21BB
- for glass fibre cables	SPA-ZC 21 MM
Electrical/optical bus connection module powered from the host relay or from an external power source	
- for plastic core cables	SPA-ZC 17BB
- for glass fibre cables	SPA-ZC 17 MM

Test voltages *)

Dielectric test voltage (IEC 255-5)	2 kV, 50 Hz, 1 min
Impulse test voltage (IEC 255-5)	5 kV, 1.2/50 μs, 0.5 J
Insulation resistance (IEC 255-5)	>100 MΩ, 500 V dc

EMC tests

CE-approved and tested according to	EN 50081-2 EN 50082-2

Disturbance tests *)

High-frequency (1 MHz) disturbance test (IEC 255-22-1)	
- common mode	2.5 kV
- differential mode	1.0 kV
Electrostatic discharge test (IEC 255-22-2 and IEC 801-2), class III	
- air discharge	8 kV
- contact discharge	6 kV
Fast (5/50 ns) transients	
- IEC 255-22-4, class III	
- IEC 801-4, level IV	
- power supply inputs	4 kV
- other inputs	2 kV

Mechanical environmental test

Vibration test (IEC 255-21-1)	class 2
Chock/bump test (IEC 255-21-2)	class 2
Seismic test (IEC 255-21-3)	class 2

Environmental conditions

Service temperature range	-10...+55°C
Transport and storage temperature range (IEC 68-2-8)	-40...+70°C
Temperature influence	0.2%/°C
Damp heat test (IEC 68-2-30)	93...95%, +55°C, 6 cycles
Degree of protection by enclosure of flush mounting relay case (IEC 529)	IP 54
Weight of fully equipped relay	6 kg

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

Application examples

Example 1
Directional overcurrent protection of a parallel feeder and protection of the busbar system

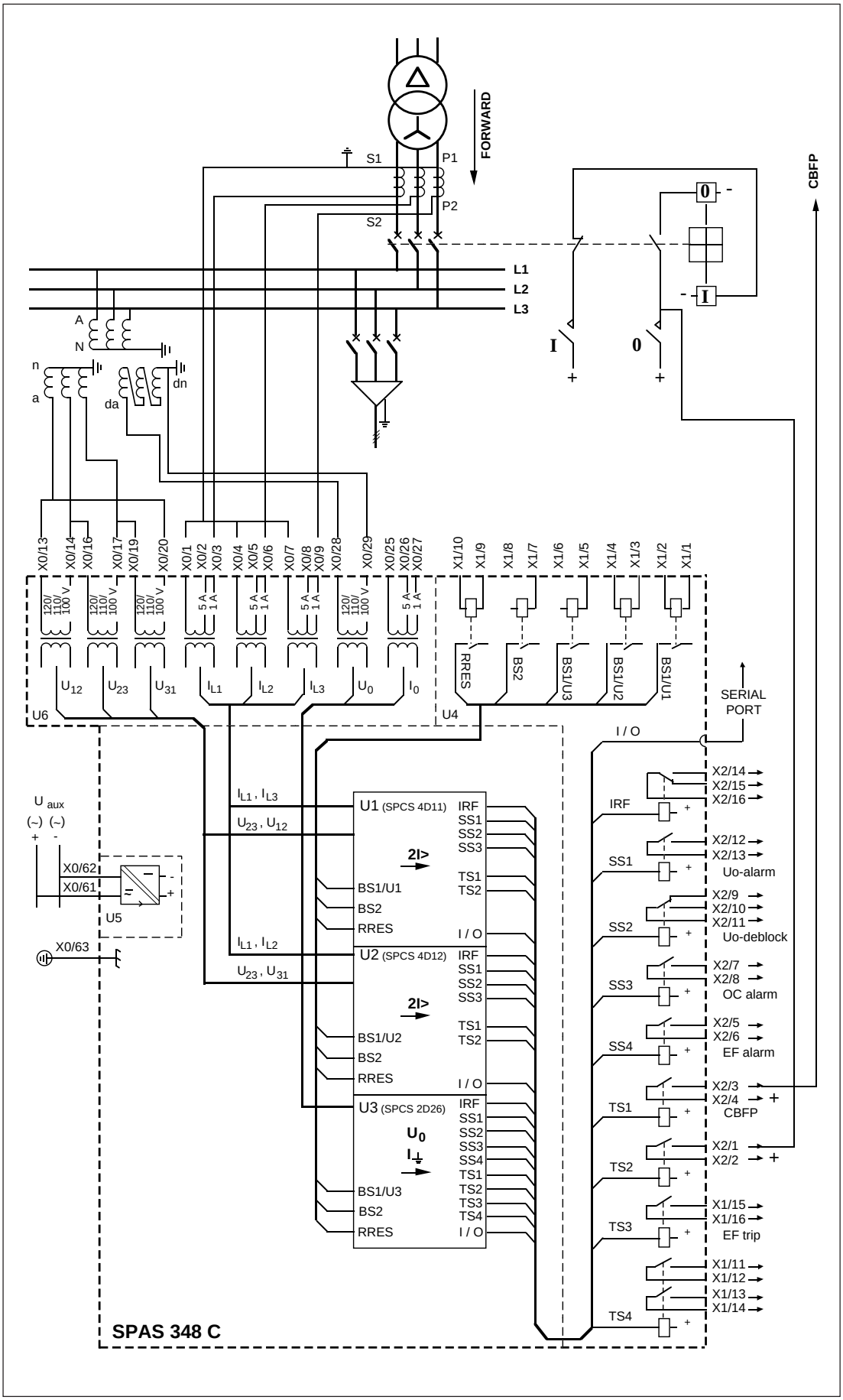


Fig. 5. Feeder protection relay SPAS 348 C used for protecting an infeeder cubicle

Parallel feeders

The block diagram on page 13 shows the relay SPAA 348 C sited at the infeeder of a substation. This connection can be be used for protecting parallel feeders as shown in the Fig 6. When parallel feeders are used, it is necessary to apply directional relays at the receiving end, while non-directional relays are sufficient at the feeding end. Selectivity is then achieved by setting the directional relays and their directional elements to look into the protected line, and giving them time and current settings lower than those of the non-directional relays in the feeding end.

Since the relay SPAS 348 C includes three overcurrent stages and a versatile earth-fault module, one relay can be used for the overcurrent and earth-fault protection of the busbar system and for the protection of the parallel feeders.

A possible DC component does not have to be considered in the current setting, because due to the peak-to-peak measurement method used, asymmetry does not affect the sensitivity of the start operations.

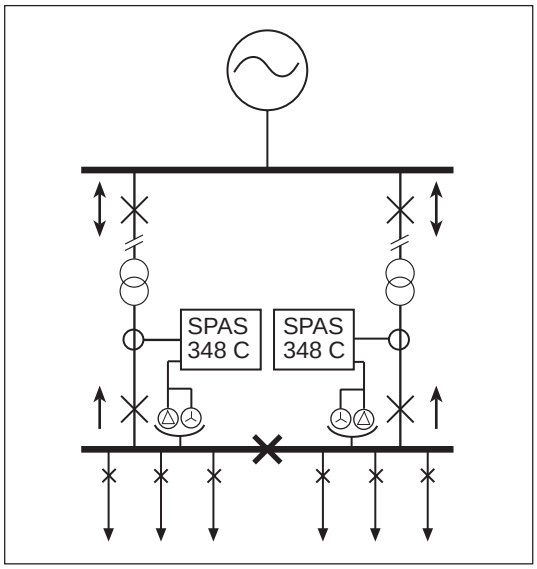


Fig. 6. Directional relays protecting parallell feeders

Directional overcurrent relay modules SPCS 4D11 and SPCS 4D12

The directional low-set stages I> are set to look into the protected line. This means that the low set-stages I> are set to operate in reverse direction by means of SGF switches. When definite time function is used, the operate times of the directional low-set stages I> should be at least 150 ms shorter than those of the non-directional stages of the relays in the feeding end . The current settings of the directional stages looking in reverse direction is normally 50% of the normal full load of the protected circuit.

The directional high-set stages I>> are used for the short-circuit protection of the busbar system and, if required, the non-directional high-set stage can be used as backup protection for the outgoing feeders and the busbar system.

Definite time operation has been used in Example 1, but inverse time characteristic can be selected for the stage I> as well.

Directional or non-directional earth-fault relay module SPCS 2D26

In the network illustrated in this example the relay module SPCS 2D26 is used for the earth-fault protection of the busbar system and as backup earth-fault protection of the outgoing feeders.

An earth-fault somewhere in a galvanically connected power system causes residual voltage. The residual overvoltage protection of the module SPCS 2D26 measures the residual voltage from the open delta winding of the voltage transformers.

The low-set stage U_{0b}> of the module indicates beginning earth-faults. Normally the residual voltage in a healthy isolated network is very small, even less than 1% of the maximum residual voltage value. Thus the low-set residual voltage stage can be given a low setting value.

The start signal of the low-set stage U_{0b}> can be used for enabling the non-directional earth-fault current measuring relays of the feeders. To prevent unnecessary operation of the earth-fault relays during a short circuit or when a motor is started, the tripping of the non-directional earth-fault relays of the outgoing feeders are normally blocked. If the outgoing feeders are provided with directional earth-fault relays, no enable signal is required.

The trip signal of the U_{0b}> stage is used as alarm signal for high resistivity earth faults (earth faults not detected by any other protection unit).

The residual voltage stages U_{01}> and U_{02}> are used to protect the busbar system and serve as non-selective back-up protection for the feeder earth-fault protection. The stage U_{01}> can be used to open the bus section breaker or to disconnect the feeder(s) most prone to faults. Should a fault still persist after tripping of this stage, the second stage U_{02}> opens the infeeder circuit breaker finally.

In the case described in example 1 the switches of the feeder protection relay SPAA 348 C can be configured as follows:

Configuration of SPCS 4D11 and SPCS 4D12

Switch-group	Serial comm. parameter	Checksum	Operation
SGF1	S28	040	Definite time operation, CBFP in use, I>> directional
SGF2	S29	032	Automatic reset of start indicators, I>>> not in use
SGB1	S30	000	No blocking/control by the BS1 signal
SGB2	S31	000	No blocking/control by the BS2 signal
SGB3	S32	000	No blocking/control by the RRES signal
SGR1	S33	170	I> and I>> trip signal linked to output contact TS2 I> and I>> trip signal linked to output contact SS3
SGR2	S34	128	I>>> trip signal linked to output contact SS3

Configuration of SPCS 2D26

Switch-group	Serial comm. parameter	Checksum	Operation
SGF1	S49	128	Configured as a three-stage residual voltage module
SGF2	S50	000	Resetting time of stage U_{01}> = 80 ms, rated voltage of U_0 = 100 V
SGF3	S51	040	Signals TS2 and TS3 activate the TRIP LED
SGF4	S52	016	TS2 starts the circuit-breaker failure protection
SGF5	S53	000	No auto-reclosing
SGB1	S54	000	No blocking/control by the BS1 signal
SGB2	S55	000	No blocking/control by the BS2 signal
SGB3	S56	000	No blocking/control by the RRES signal
SGR1	S57	004	U_{0b}> start signal linked to output contact SS2
SGR2	S58	001	U_{0b}> trip signal linked to output contact SS1
SGR3	S59	000	U_{01}> start signal not linked to output contacts
SGR4	S60	096	U_{01}> trip signal linked to trip contact TS3 and SS4
SGR5	S61	000	U_{02}> start signal not linked to output contacts
SGR6	S62	096	U_{02}> trip signal linked to trip contacts TS2 and SS4

(modified 96-11)

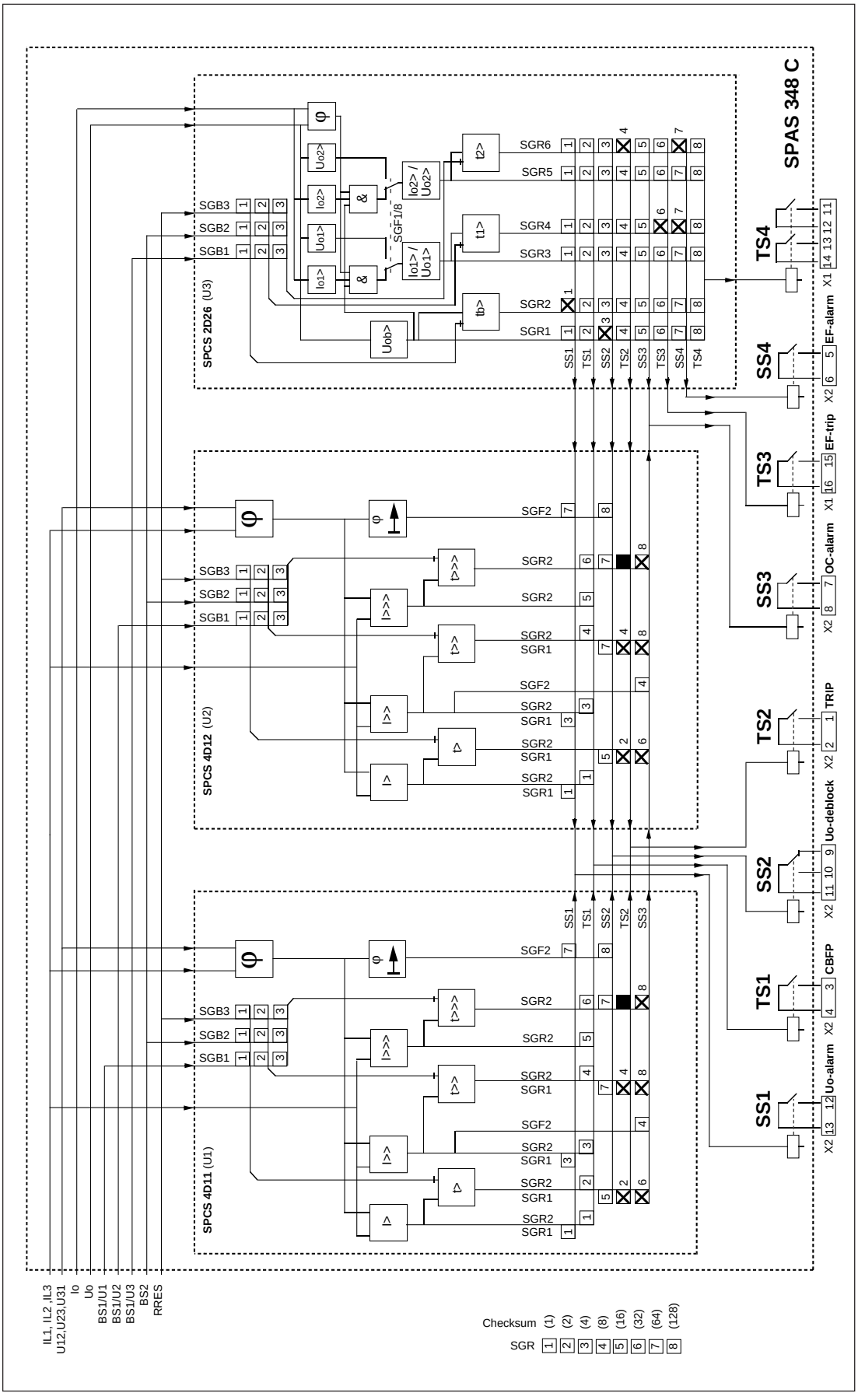


Fig. 7. Configuration of the internal signals of SPAS 348 C in application example 1

Note! The above configuration is not the factory default settings

When the switches are set as shown on page 16 the output contacts of SPAS 348 C have the following functions:

Contact	Relay	Function
X2/12-13	SS1	Earth fault detected only by the delayed alarm stage $U_{0b}>$
X2/3-4	TS1	CPFP (= Circuit-Breaker Failure Protection)
X2/9-11	SS2	Blocking signal to the earth-fault current relays of the feeders
X2/1-2	TS2	Circuit breaker trip signal (infeeder circuit breaker)
X2/7-8	SS3	Alarm signal, overcurrent trip
X1/15-16	TS3	Trip signal $U_{0b}>$ for bus section breaker or feeders most prone to faults
X2/5-6	SS4	Alarm signal, earth-fault trip
X1/11-14	TS4	Not used

Example 2
Directional overcurrent and earth-fault protection of a feeder, resonant earthed system

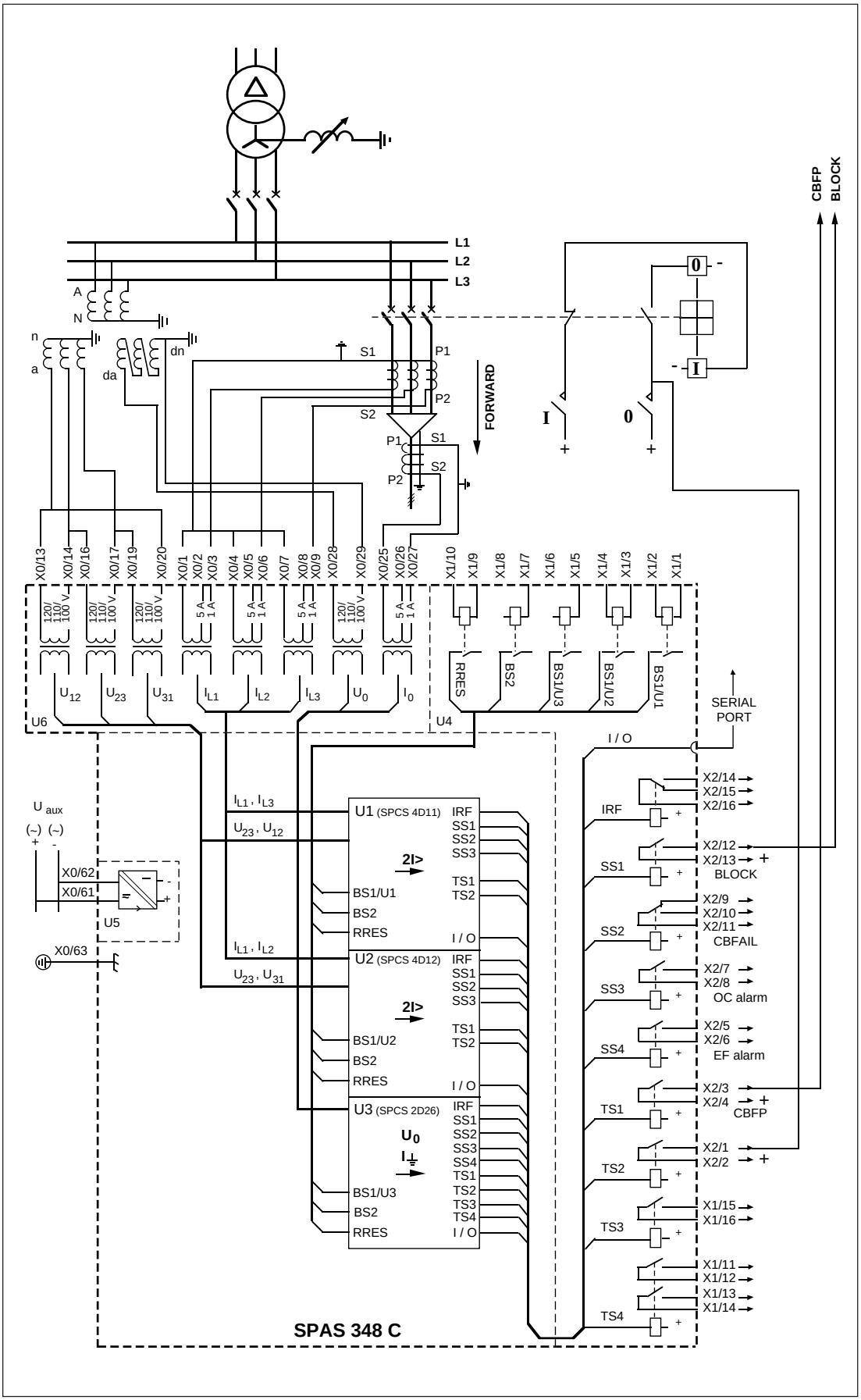


Fig. 8. Feeder protection relay SPAS 348 C used for protecting a feeder in a resonant earthed network

Directional overcurrent relay module SPCS 4D11 and SPCS 4D12

The overcurrent relay modules SPCJ 4D11 and SPCS 4D12 include three overcurrent stages. By using all three stages and giving each overcurrent stage its own operate value and operate time good selectivity with short operate times can be obtained.
The operation of the short-circuit protection in this example is based on blockings between the protection levels. This means that when starting, the I>> stage of the overcurrent relay module of the feeder provides a blocking signal to the I>> stage of the overcurrent relay module of the infeeder. When no blocking signal is received, the infeeder overcurrent relay module perceives the fault as being within its own protection zone and trips the circuit breaker. Thus it is possible to use a minimum operate time of 120 ms at busbar system faults.

The low-set stage I> is used as a directional stage operating in "forward" direction. Definite time operation has been used in this example, but inverse time characteristic can also be selected for this stage. The current setting of the stage I> must extend to the setting of the following protection stage.

The high-set stage I>> is also used as a directional stage that operates in the same direction as the low-set stage. The current setting of this stage has been selected so that the stage operates at short circuits occurring close to the substation. Further, the start of the stage I>> is used to block the infeeder protection if the fault is located on the outgoing feeder.

The non-directional high-set stage I>>> is not used in this example. When long operate times are used for the directional stages, the second high-set stage should however be used as back-up protection. The stages I> and I>> can determine the direction of the current for about 2.5 s after a total collapse of the voltage. If a trip signal is not delivered within 2.5 s after a voltage collapse, the trip must be performed non-directionally by the second high-set stage I>>>.

The directional element of each phase current, determines the direction of the current by measuring the phase difference between the current and the opposite phase-to-phase voltage. Since, in this case, the relay is used to protect a feeder with the zero-sequence source behind the relaying point, the base angle -30° should be, as shown in Fig. 9 below, selected.

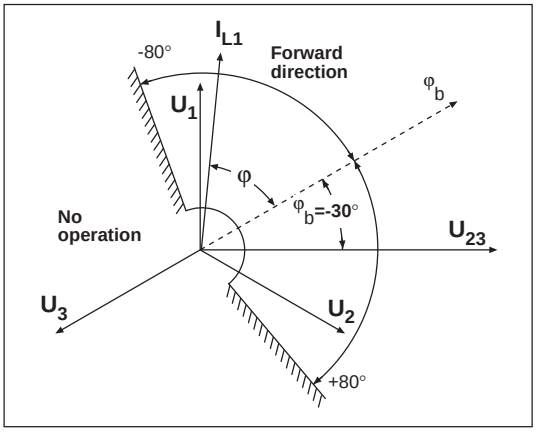


Fig. 9. Directional element of phase L_1

Directional or non-directional earth-fault relay module SPCS 2D26

In the resonant earthed network illustrated in this example the relay module SPCS 2D26 is used for the directional earth-fault protection of the feeders.

Directional earth fault relays should also be used at frequent network changes or when high sensitivity is to be achieved. A directional earth-fault relay allows earth faults with fault resistances of several thousand ohms to be detected in overhead lines. Changes in the extension of the network due to varying the network configuration do not cause inselectivity, because the direction of the earth fault current of a faulty feeder is opposite to that of a healthy feeder.

The basic angle of the relay module SPCS 2D26 can be set at 0°, -30°, -60° or -90°. When the network to be protected is resonant earthed or earthed via a resistor as in this example , the basic angle should be set at 0°. When an isolated neutral system is protected the basic angle is set at -90°. In addition it is possible to use an external control signal BS1 or BS2 for selecting the basic angle (0°/-90°) to be automatically determined by the earthing situation of the network. When the control voltage is connected, the basic angle φ_b = -90°.

The start value of the low-set stage of the earth-fault relay module should be set low enough to fulfil the sensitivity requirements of the safety regulations. The requirements regarding operate times are mainly fulfilled by the operation of the high-set stage I_{02}>.

In the case described in example 1 the switches of feeder protection relay SPAA 348 C can be configured as follows:

Configuration of SPCS 4D11

Switch-group	Serial comm. parameter	Checksum	Operation
SGF1	S28	040	Definite time operation, CBFP in use, I>> directional
SGF2	S29	032	Automatic resetting of start indicators, I>>> not used
SGB1	S30	000	No blocking/control by the BS1 signal
SGB2	S31	000	No blocking/control by the BS2 signal
SGB3	S32	000	No blocking/control by the RRES signal
SGR1	S33	170	I> trip signal linked to TS2 I> and I>> start signal linked to output contact SS1 I>> trip signal linked to TS2
SGR2	S34	000	Not used

Configuration of SPCS 2D26

Switch-group	Serial comm. parameter	Checksum	Operation
SGF1	S49	003	Earth-fault stages I_{01}> & I_{02}> operate in forward direction, basic angle $\varphi_b = 0°$
SGF2	S50	000	Resetting time of stages I_{01}/U_{01} = 80 ms, rated voltage of U_0 = 100 V, $\Delta\varphi = \pm 80°$
SGF3	S51	008	Signal TS2 controls TRIP LED
SGF4	S52	016	U_0 deblocking criterion in use, TS2 starts the circuit-breaker failure protection
SGF5	S53	000	No auto-reclosing
SGB1	S54	000	No blocking/control by the BS1 signal
SGB2	S55	000	No blocking/control by the BS2 signal
SGB3	S56	000	No blocking/control by the RRES signal
SGR1	S57	000	U_{0b}> start signal not linked to output contacts
SGR2	S58	000	U_{0b}> trip signal not linked to output contacts
SGR3	S59	000	I_{01}> start signal not linked to output contacts
SGR4	S60	072	I_{01}> trip signal linked to trip contact TS2 and SS4
SGR5	S61	000	I_{02}> start signal not linked to output contacts
SGR6	S62	072	I_{02}> trip signal linked to trip contacts TS2 and SS4

(modified 96-11)

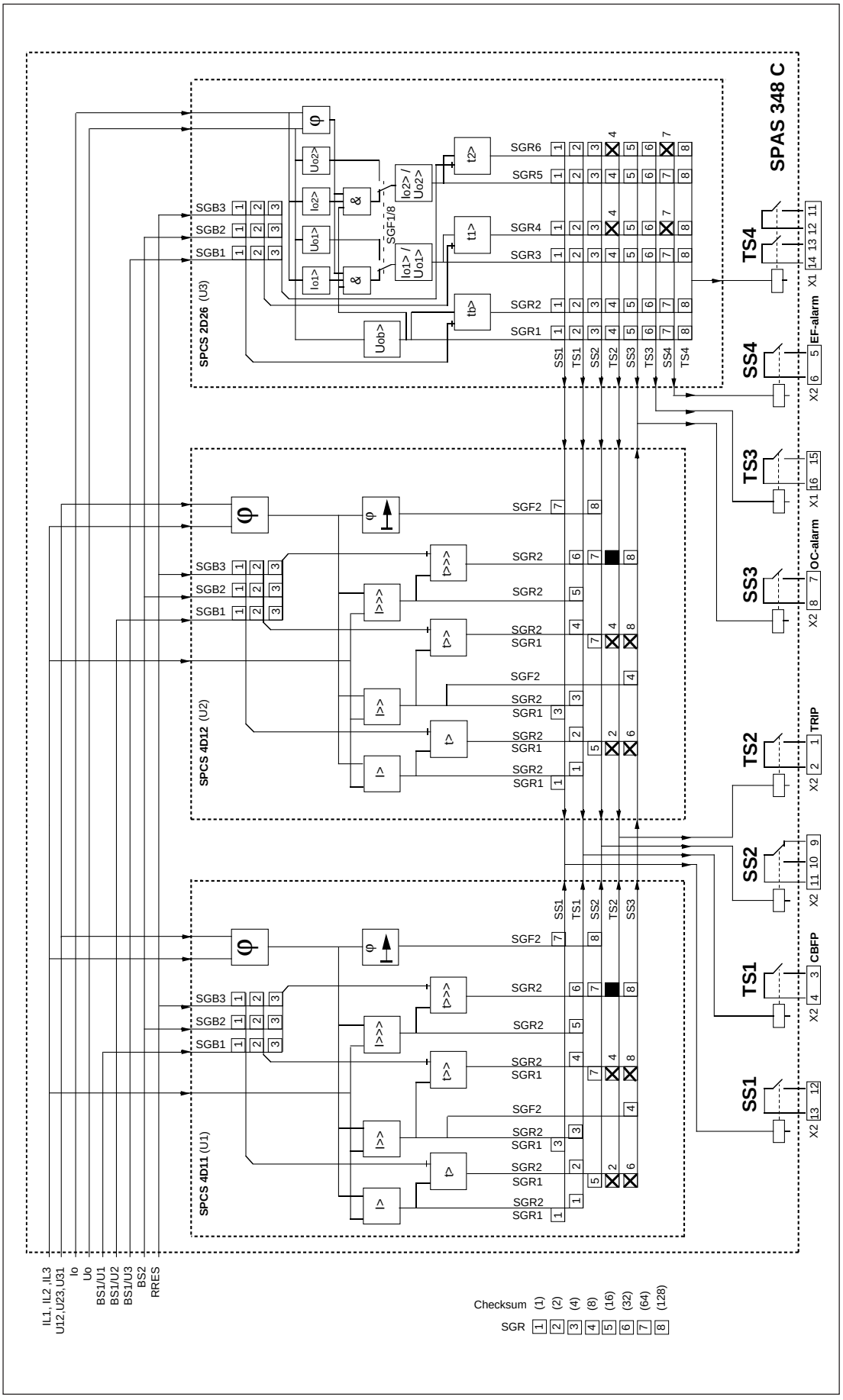


Fig. 10. Configuration of the internal signals of SPAS 348 C, application example 2

Note! The above configuration is not the factory default settings

Testing

The relay should be subjected to regular tests in accordance with national regulations and instructions. The manufacturer recommends an interval of five years between the tests.

The test should be carried out as a primary test, which includes the whole protection arrangement from the instrument transformers to the circuit breakers.

The test can also be carried out as a secondary injection test. Then the relay has to be disconnected during the test procedure. However, it is recommended to check the condition of the signal and trip circuits as well.

Note!
Make sure that the secondary circuits of the current transformers under no circumstances open or are open, when the relay is disconnected and during the test procedure.

The test is recommended to be carried out using the normal setting values of the relay and the energizing inputs used. When required, the test can be extended to include more setting values.

As the settings of the relay modules vary in different applications, these instructions present the general features of the test procedure. Ordinary current and voltage supply units and instruments for measuring current, voltage and time can be used for the tests.

During the test procedure the relay records currents, voltages and relay operations. If the recorded data are used for the collection of information for longer time periods (for example, start counters), these registers should be read before the test procedure is started. After the test the registers are reset.

The relay settings may have to be changed during testing. To make sure that the original settings are restored when the test has been completed, a PC program is recommended to be used to read the relay settings before starting the test .

Testing of overcurrent relay modules SPCS 4D11 and SPCS 4D12

General

The protection stages used (I>, I>>, I>>>) are tested as follows:

- start value (the high-set stages for all three phases)
- start time
- trip time
- trip indication, output relay operation and signalling
- circuit-breaker failure protection (CBFP)

Start value

The directional stages have to be tested with voltage and current fed to the relay simultaneously. To enable relay operation, the phase angle between the current and voltage has to be within the operation sector selected for the relay.

Start the test by applying voltage to the relay and then gradually raise the current, starting from zero, until the relay starts. Record the current value required for starting. The value should be within the permitted tolerances.

The directional operation can be tested by connecting current and voltage to the relay (the current should be above the setting value) and changing the phase angle until the relay starts and resets.

To test resetting, when required, raise the current until the relay starts and then reduce it until the relay resets.

When multi-stage protection relays are tested it is recommended to start the test from the highest stage and then proceed to the lower stages. The advantage of this method is that the original settings of the stages really are restored.

Start and trip times

Switch a current that is 2...2.5 times the setting value of the protection stage to the relay. Measure the operate time, i.e. the time from the closing of the switch until the relay operates. The operate time should be within the permitted tolerances, except when the injected current is below 2 times the setting value. In such a case the protective algorithm adds about 20 ms to the operate times.

When inverse times are measured the measurement can be made with different supply currents, for example, 2 times and 10 times the setting value, if required. The resetting time is measured from opening of the current switch until resetting of the relay.

Testing of directional earth-fault relay module SPCS 2D26

General

Testing of the protection stages in use (U_{0b}>, U_{01}>/I_{01}> and U_{02}>/I_{02}>) includes:

- start value(s)
- start time
- trip time
- trip indication, output relay operation and signalling
- circuit-breaker failure protection (CBFP)

Start value

Measure the start value of the U_{0b}> stage by gradually raising the voltage, starting from zero, until the relay starts. Record the voltage value required for starting. The value should be within the permitted tolerances.

Test the stages U_{01}>/I_{01}> and U_{02}>/I_{02}> in the same way as the U_{0b}> stage, if they are configured to operate as U_0 stages. Otherwise current and voltage should be fed to the relay simultaneously. Start by setting the voltage above the setting value and raise the current until the relay starts. Record the value of the start current. Then set the current above the setting value and raise the voltage, until the relay starts. Record the value of the start voltage.

The operation of the U_{01}>/I_{01}> stage and the U_{02}>/I_{02}> stage can be directional or non-directional. If directional operation has been selected for the stage, the phase angle between the current and voltage to be applied to the relay has to be equal to the basic angle selected for the relay, to enable relay operation. The directional operation can be tested by setting the current and voltage above their setting values and changing the phase angle, until the relay starts and resets.

To measure the resetting values, the current should be set above the setting value. Then reduce the current, until the relay resets.

Start and trip times

Switch a voltage and/or a current about 2...2.5 times the setting value of the protection stage to the relay. Measure the operate time, i.e. the time from closing the switch until the relay operates. The operate times should be within the permitted tolerances, except when the injected current is below 2 times the setting value. In such a case the protective algorithm adds about 20 ms to the operate times. The resetting time is the time from the opening of the current switch until the relay resets.

Maintenance and repairs

When the feeder protection relay is used under the conditions specified in "Technical data", it requires practically no maintenance. The feeder protection includes no parts or components that are sensitive to physical or electrical wear under normal operating conditions.

Should the temperature and humidity on the operating site differ from the values specified, or the atmosphere contain chemically active gases or dust, the relay should be visually inspected in association with the secondary testing of the relay. This visual inspection should focus on:

- Signs of mechanical damage to relay case and terminals
- Collection of dust inside the relay case; remove with compressed air
- Signs of corrosion on terminals, case or inside the relay

If the relay malfunctions or the operating values differ from those specified, the relay should be overhauled. Minor measures can be taken by the customer but any major repair involving the electronics has to be carried out by the manufacturer. Please contact the manufacturer or his nearest representative for further information about checking, overhaul and recalibration of the relay.

The protection relay contains circuits sensitive to electrostatic discharge. If you have to withdraw a relay module, ensure that you are at the same potential as the module, for instance, by touching the case.

Note!
Protective relays are measuring instruments and should be handled with care and protected against damp and mechanical stress, especially during transport.

Spare parts

Directional overcurrent relay module	SPCS 4D11
Directional overcurrent relay module	SPCS 4D12
Directional earth-fault relay module	SPCS 2D26
Power supply modules	
- U = 80...265 V ac/dc (operative range)	SPGU 240A1
- U = 18...80 V dc (operative range)	SPGU 48B2
I/O module	SPTR 9B25
Case (including connection module)	SPTK 8B20
Bus connection module	SPA-ZC 17_ SPA-ZC 21_

Delivery alternatives

Type	Equipment	SPCS 4D11	SPCS 4D12	SPCS 2D26
SPAS 348 C	Basic version, including all relay modules	x	x	x
SPAS 348 C1	Basic version excluding earth-fault relay module	x	x	
SPAS 348 C2	Basic version excluding relay module SPCS 4D12	x		x
SPAS 348 C3	Basic version excluding earth-fault relay module and relay module SPCS 4D12	x		

Delivery alternatives of feeder protection relay SPAS 348 C

Order numbers

Feeder protection relay SPAS 348 C without test adapter:

SPAS 348 C:	RS 431 020-AA, CA, DA, FA
SPAS 348 C1:	RS 431 021-AA, CA, DA, FA
SPAS 348 C2:	RS 431 022-AA, CA, DA, FA
SPAS 348 C3:	RS 431 023-AA, CA, DA, FA

Feeder protection relay SPAS 348 C with test adapter RTXP 18:

SPAS 348 C:	RS 431 220-AA, CA, DA, FA
SPAS 348 C1:	RS 431 221-AA, CA, DA, FA
SPAS 348 C2:	RS 431 222-AA, CA, DA, FA
SPAS 348 C3:	RS 431 223-AA, CA, DA, FA

The letter combinations of the order number denote the rated frequency f_n and auxiliary voltage U_{aux} of the protection relay:

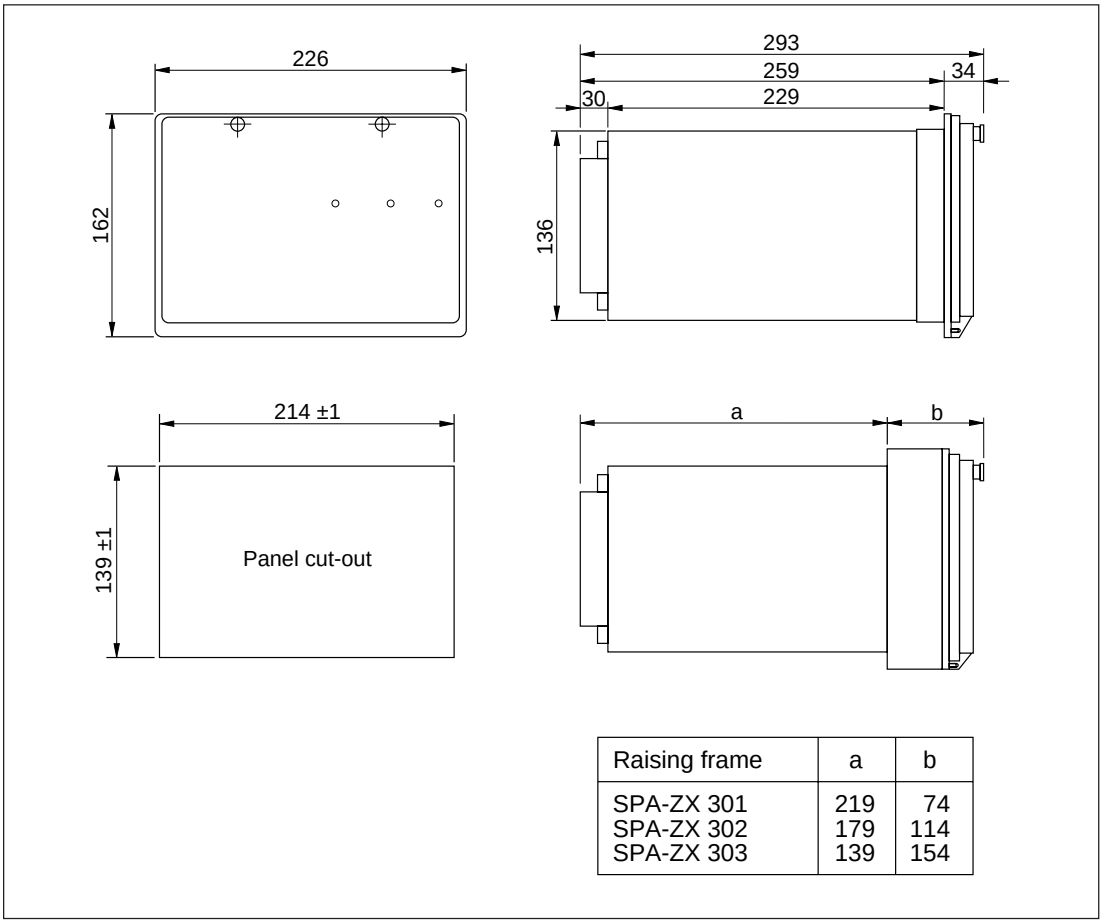
AA: f_n = 50 Hz and U_{aux} = 80...265 V ac/dc
CA: f_n = 50 Hz and U_{aux} = 18...80 V dc
DA: f_n = 60 Hz and U_{aux} = 80...265 V ac/dc
FA: f_n = 60 Hz and U_{aux} = 18...80 V dc

Order data

	Example
1. Number and type designation	10 relays type SPAS 348 C
2. Order number	RS 431 020 -AA
3. Rated frequency	f_n = 50 Hz
4. Auxiliary voltage	U_{aux} = 110 V dc
5. Accessories	10 bus connection modules SPA-ZC 17 MM2A
6. Special requirements	–

Dimension drawings and mounting

The basic model of the protection relay case is designed for flush-mounting. When required, the mounting depth of the case can be reduced by using raising frames: 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. For projecting mounting a relay case type SPA-ZX 317 is used. This relay case is provided with front connectors.



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

Fig. 11. Dimension and mounting drawings for feeder protection relay SPAS 348 C

The relay 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 relay 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 signals 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 mm^2 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 used for serial communication.

The bus connection modules (SPA-ZC 17, -21 or -22) and fibre-optic cables recommended by the manufacturer should always be used for serial communication.

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