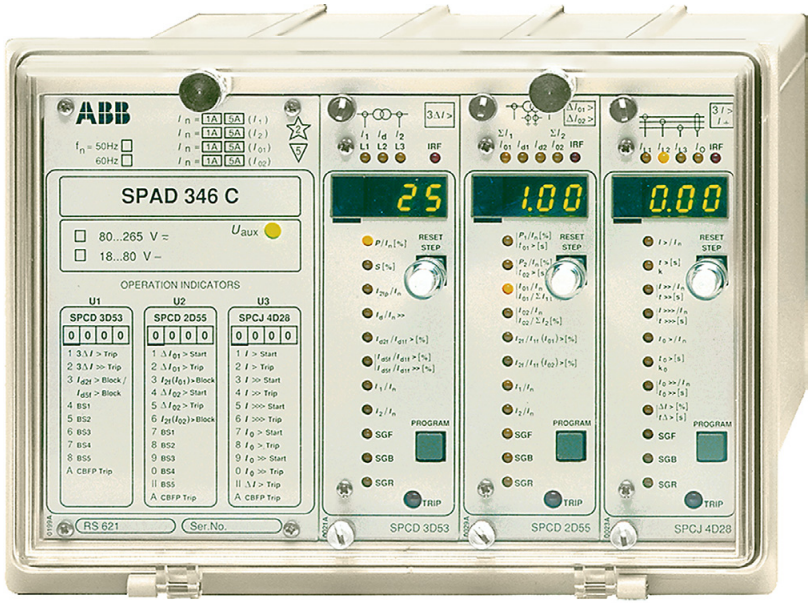
Stabilized Differential Relay SPAD 346

Product Guide



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Features

- Integrated three-phase differential relay, three-phase overcurrent relay and multi-configurable earth-fault relay
- Alarm channels activated by normally open or normally closed contact
- Stabilized differential relay module providing winding short-circuit and interturn fault protection for two-winding power transformers and generator-transformer units, and interwinding short-circuit protection for generators
- Earth-fault relay module providing protection for transformer HV and LV side according to the principle selected: stabilized differential current principle, high-impedance principle, residual current principle or neutral current principle
- Three-stage overcurrent module providing protection for power transformers and generators and two-stage back-up earth-fault protection
- Short operate time even at partial saturation of the current transformers
- Operation characteristic of differential relay module easily adapted for different applications
- Stabilized against unwanted operations at faults occurring outside the protected area and at transformer inrush currents
- Second harmonic restraint for prevention of unwanted relay operations at transformer inrush currents
- Fifth harmonic restraint for prevention of unwanted relay operations at transformer overexcitation. The fifth harmonic restraint can be aborted if the ratio of the fifth harmonic and the basic frequency component rises too high at dangerous overvoltages
- Wide CT ratio correction range: accurate correction through digital setting
- No interposing current transformers needed for the protection of two-winding power transformers: numerical vector group matching on HV and LV side
- Four heavy-duty output relays for circuit breaker tripping and five output relays for signalling
- Five programmable external control inputs intended for alarm and trip signals from gas relays, oil temperature sensors and other sensors of transformer auxiliary devices
- Integrated circuit-breaker failure protection with adjustable operate time
- Differential relay and earth-fault relay modules provided with integrated disturbance recorder functions for analog and digital signals: signals to be used for triggering selectable
- Sensitive phase current and phase angle displays facilitate checking of energizing circuit connections and vector group matchings
- High immunity to electrical and electromagnetic interference allows the relay to be used in severe environments
- High availability and system reliability due to continuous supervision of hardware and software
- Powerful software supports relay parameterization and reading of measured and recorded values and event data
- Member of the SPACOM product family and ABB's Distribution Automation system
- CE marking according to the EC directive for EMC

Application

The stabilized differential relay SPAD 346 C is designed for protecting two-winding power transformers and generator-transformer units against winding short-circuit, interturn fault, earth fault and short circuit, and generators and motors against interwinding faults and pole short circuit. In addition, the relay can be used for the protection of three-winding power transformers, provided 75% of the short circuit power to the power transformer is supplied from the same direction, and for the protection of compensating chokes and short cable lines.

No interposing transformers are needed for the protection of two-winding power transformers, as the relay allows the vector group matching, the elimination of the zero-sequence component of the phase currents and the CT ratio corrections to be carried out numerically.

Design

The feeder protection relay is provided with six energizing inputs for phase currents and inputs for residual or neutral currents. The relay is also equipped with nine output relays for CB control, signalling, etc.

The differential relay consists of three protection relay modules, i.e. a differential relay module, an earth-fault relay module and a combined overcurrent and earth-fault relay module. The modules are withdrawable as are the power supply module and the I/O relay module located behind the system front panel.

Differential relay module SPCD 3D53

The differential relay module includes three protection units, i.e. a stabilized differential current unit, an instantaneous differential current unit and a circuit-breaker failure protection unit. In addition, the module contains a disturbance recorder unit.

The stabilized differential current unit constitutes the main differential protection. The unit is provided with second and third harmonic restraint, selectable transformer vector group, zero-sequence current elimination, numerical correction of CT ratios and flexible configuration of tripping, blocking and control signals.

The instantaneous, non-stabilized differential current unit functions as an ultra-fast protection unit with an operate time less than 30 ms at heavy faults.

The circuit-breaker failure protection unit is activated by the main trip signal of the other protection units and it provides a second trip signal to be routed to a back-up circuit breaker if the main CB fails to operate.

The differential relay module also incorporates a digital disturbance recorder module. The module continuously monitors the object protected and stores pre- and post-fault network information, which can be used for post-fault analysis.

Earth-fault relay module SPCD 2D55

The earth-fault relay module measures the neutral current and/or residual current on both sides of the object protected. The earth-fault protection can be implemented by four different principles, i.e. the high-impedance principle, the numerical stabilized differential current principle, the residual overcurrent principle or the neutral overcurrent principle. Both sides of the object can be protected independent of each other, which means that the protection principle on one side does not have to be the same as that of the other side.

The circuit-breaker failure protection unit is activated by the main trip signal of the protection units and it provides a second trip signal to be routed to a back-up circuit breaker if the main CB fails to operate.

The earth-fault relay module also incorporates a digital disturbance recorder module. The module continuously monitors the object protected and stores pre- and post-fault network information, which can be used for post-fault analysis.

Combined overcurrent and earth-fault relay module SPCJ 4D28

The combined overcurrent and earth-fault module includes four protection units, i.e. an overcurrent unit, an earth-fault unit, a phase discontinuity unit and a circuit-breaker failure protection unit.

The three-phase overcurrent unit comprises three overcurrent stages, i.e. a low-set stage I>, a high-set stage I>> and a super high-set stage I>>>. The low-set stage can be given definite time characteristic or inverse time characteristic while the high-set stage and the super high-set stage have a definite time characteristic.

The non-directional earth-fault unit comprises two protection stages, i.e. a low-set stage I_0> and a high-set stage I_0>>. The low-set stage can be given definite time characteristic or inverse time characteristic while the high-set stage has a definite time characteristic.

The phase discontinuity protection unit measures the phase unbalance and has a definite time characteristic.

The circuit-breaker failure protection unit is activated by the main trip signal of the protection units and it provides a second trip signal to be routed to a back-up circuit breaker if the main CB fails to operate.

Design (cont´d)

Data communication

The feeder protection relay is equipped with a serial communication port on the rear panel. The serial port is used for connecting the relay to the SPA bus via an optional bus connection module. Two bus connection module types are available: SPA-ZC 17 and SPA-ZC 21. The former can be powered from the host relay and from a separate power source at the same time, while the latter is powered from the host relay via the D-type connector.

Output relays and circuit breaker control

The feeder protection relay is provided with nine output auxiliary relays, four of which are heavy-duty output relays for the direct control of the circuit breaker. Single-pole or double-pole circuit breaker control can be used. One of the five signalling relays is permanently allocated for the self-supervision system. The function of the other four relays can be defined by the user.

Self-supervision

The relay incorporates a sophisticated self-supervision system with auto-diagnosis, which increases the availability of the relay and the reliability of the system. The self-supervision system continuously monitors the hardware and the software of the relay. The system also supervises the operation of the auxiliary supply module and the voltages generated by the module.

Auxiliary supply voltage

The auxiliary supply of the relay is obtained from an internal plug-in type power supply module. Two auxiliary power module versions are available: type SPGU 240A1 for the supply voltage range 80…265 V ac/dc and type SPGU 48B2 for the supply voltage range 18…80 V dc. The power supply module forms the internal voltages required by the protection relay and the I/O module.

Technical data

Table 1: Energizing inputs

Terminals		X0/1-3, 4-6, 7-9, X0/13-15, 16-18, X0/19-21, 25-27 X0/37-39	X0/1-2, 4-5, 7-8, X0/13-14, 16-17, X0/19-20, 25-26, X0/37-38
Rated current I_n		1 A	5 A
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
Rated frequency f_n, according to order		50 Hz or 60 Hz	

Table 2: Output contact ratings

Type of contact		Tripping	Signalling
Terminals		X1/11-12-13-14 X1/15-16-17-18 X2/3-4, 5-6	X2/7-8, 9-10 X2/11-12-13 X2/14-15 X2/16-17-18
Rated voltage		250 V ac/dc	
Thermal withstand capability	Carry continuously	5 A	5 A
	Make and carry for 0.5 s	30 A	10 A
	Make and carry for 3 s	15 A	8 A
Breaking capacity for dc, when the signal circuit time constant L/R ≤ 40 ms, at the signalling voltage levels	220 V dc	1 A	0.15 A
	110 V dc	3 A	0.25 A
	48 V dc	5 A	1 A

Table 3: External control inputs

Terminals		X1/1-2, 3-4, 5-6, 7-8, 9-10
Control voltage	Operative range	18…265 V dc or 80…265 V ac
Current drain of activated control input		2…20 mA
Active state of input	Input active when	energized
	Input active when	non-energized

Table 4: Auxiliary supply modules

Terminal numbers			X2/1-2
Type of module	Rated voltages U_n	SPGU 240A1	110/120/230/240 V ac 110/125/220 V dc
		SPGU 48B2	24/48/60 V ac
	Operative range	SPGU 240A1	80…265 V ac/dc
		SPGU 48B2	18…80 V dc
	Power consumption	under quiescent conditions	~10 W
		under operating conditions	~15 W

Technical data (cont´d)

Table 5: Stabilized differential relay module SPCD 3D53

Selectable rated frequency f_n		16 $^2/_3$…60 Hz
CT ratio correction range on power transformer HV side I_1/I_n		0.40…1.50
CT ratio correction range on power transformer LV side I_2/I_n		0.40…1.50
Stabilized differential current stage 3ΔI>		
Basic start ratio P/I_n		5…50%
Starting ratio setting S		10…50%
Second turning point I_{2tp}/I_n of characteristic curve		1.0…3.0
Harmonics blocking ratio I_{d2f}/I_{d1f}		7…20%
Harmonics blocking ratio I_{d5f}/I_{d1f}		10…50%
Harmonics deblocking ratio I_{d5f}/I_{d1f}		10…50%
Operate time (including heavy-duty output relays	at currents 1.5…4 × operate value	<50 ms
	at currents above 4 × operate value	<45 ms
Operation accuracy		±4% of set value or ±2% × I_n
Instantaneous differential current stage 3ΔI>>		
Start ratio I_d/I_n>>		5…30
Operate time (including heavy-duty output relays	at ratios in the range of 1.1…2.6 × I_d/I_n>>	<35 ms
	at ratios above 2.6 × I_d/I_n>>	<30 ms
Operation accuracy		±4% of set value of 2% × I_n
Circuit-breaker failure protection		
Operate time		0.1…1.0 s
Integrated disturbance recorder		
Recording length		38 cycles
Recording memory capacity		1 recording = 38 cycles
Sampling frequency		40 samples/cycle
Signals to be recorded		6 analog signals 11 digital signals
Triggering	when the selected digital signal	is activated
	when the selected digital signal	resets
Length of recording preceding triggering		0…38 cycles

Table 6: Earth-fault relay module SPCD 2D55

Selectable rated frequency f_n	16 $^2/_3$…60 Hz
Stabilized differential relay principle	
Basic start ratio on HV side P_1/I_n	5…50%
Operate time on HV side t_{01}>	0.03…100 s
Basic start ratio on LV side P_2/I_n	5…50%
Operate time setting on LV side t_{02}>	0.03…100 s
Correction range of HV side neutral connection CT ratio I_{01}/I_n	0.40…1.50
Setting of minimum ratio of HV side neutral current and residual current of phase currents $I_{01}/\Sigma I_1$	0…20%
Correction range of LV side neutral connection CT ratio I_{02}/I_n	0.40…1.50
Setting of minimum ratio of LV side neutral current and residual current of phase currents $I_{02}/\Sigma I_2$	0…20%
Second harmonics restraint ratio I_{2f}/I_{1f} of HV side neutral current I_{01}	10…50%
Second harmonics restraint ratio I_{2f}/I_{1f} of LV side neutral current I_{02}	10…50%
Correction range of HV side phase CT ratio I_1/I_n	0.40…1.50
Correction range of HV side phase CT ratio I_2/I_n	0.40…1.50
Operate time at minimum delay (including heavy-duty output relays)	30…40 ms

Technical data (cont´d)

Table 6: Earth-fault relay module SPCD 2D55

Operation accuracy		±4% of set value or ±2% of I_n
Principle based on calculated residual current		
Basic start ratio $P_1/I_{n\ on\ HV\ side}$		5…50%
Operate time t_{01}> on HV side		0.03…100 s
Basic start ratio P_2/I_n on LV side		5…50%
Operate time setting t_{02}> on LV side		0.03…100 s
Correction range of HV side phase CT ratio I_1/I_n		0.40…1.50
Correction range of HV side phase CT ratio I_2/I_n		0.40…1.50
Operate time at minimum delay (including heavy-duty output relays)		30…40 ms
Operation accuracy		±4% of set value or ±2% of I_n
Principle based on measured residual current or neutral current		
Basic start ratio $P_1/I_{n\ on\ HV\ side}$		5…50%
Operate time t_{01}> on HV side		0.03…100 s
Basic start ratio P_2/I_n on LV side		5…50%
Operate time setting t_{02}> on LV side		0.03…100 s
Correction range of HV side neutral connection CT ratio I_{01}/I_n		0.40…1.50
Correction range of LV side neutral connection CT ratio I_{02}/I_n		0.40…1.50
Second harmonics restraint ratio I_{2f}/I_{1f} of HV side neutral current I_{01}		10…50%
Second harmonics restraint ratio I_{2f}/I_{1f} of LV side neutral current I_{02}		10…50%
Operate time at minimum delay (including heavy-duty output relays)		30…40 ms
Operation accuracy		±4% of set value or ±2% of I_n
Restricted earth-fault principle (high-impedance type earth-fault protection)		
Basic start ratio $P_1/I_{n\ on\ HV\ side}$		5…50%
Operate time t_{01}> on HV side		0.03…100 s
Basic start ratio P_2/I_n on LV side		5…50%
Operate time setting t_{02}> on LV side		0.03…100 s
Correction range of HV side neutral connection CT ratio I_{01}/I_n		0.40…1.50
Correction range of LV side neutral connection CT ratio I_{02}/I_n		0.40…1.50
Operate time at minimum delay (including heavy-duty output relays)		30…40 ms
Operation accuracy		±4% of set value or ±2% of I_n
Circuit-breaker failure protection		
Operate time		0.1…1.0 s
Integrated disturbance recorder		
Recording length		30 cycles
Recording memory capacity		1 recording = 30 cycles
Sampling frequency		40 samples/cycle
Signals to be recorded		8 analog signals 12 digital signals
Triggering	when the selected digital signal	is activated
	when the selected digital signal	resets
Length of recording preceding triggering		0…30 cycles

Technical data (cont´d)

Table 7: Relay module SPCJ 4D28, overcurrent unit

Features		Stage I>	Stage I>>	Stage I>>>
Start current	at definite time	0.5…5.0 × I_n	0.5…40.0 × I_n and ∞	0.5…40.0 × I_n and ∞
	at inverse time	0.5…2.5 × I_n	–	–
Start time, typically		70 ms	40 ms	40 ms
Operate time at definite time characteristic		0.05…300 s	0.04…300 s	0.04…30 s
Time/current characteristic at inverse time mode		Extremely inverse Very inverse Normal inverse Long-time inverse RI type inverse RXIDG type inverse	–	–
Time multiplier k		0.05…1.0	–	–
Reset time, typically		40 ms	40 ms	40 ms
Retardation time		<30 ms		
Reset ratio, typically		0.96		
Operate time accuracy at definite time mode		±2% of set value or ±25 ms		
Accuracy class index E at inverse time mode		5	–	–
Operation accuracy		±3% of set value	±3% of set value	±3% of set value

Table 8: Relay module SPCJ 4D28, earth-fault and phase discontinuity unit

Features	Stage I_0>	Stage I_0>>	Stage ΔI>
Start current	0.1…0.8 × I_n	0.1…10.0 × I_n and ∞	10…100% and ∞
Start time, typically	70 ms	50 ms	150 ms
Operate time at definite time characteristic	0.05…300 s	0.05…300 s	1…300 s
Time/current characteristic at inverse time mode	Extremely inverse Very inverse Normal inverse Long-time inverse RI type inverse RXIDG type inverse	–	–
Time multiplier k	0.05…1.0	–	–
Reset time, typically	40 ms	40 ms	80 ms
Retardation time	<30 ms	<30 ms	–
Reset ratio, typically	0.96	0.96	0.90
Operate time accuracy at definite time mode	±2% of set value or ±25 ms		
Accuracy class index E at inverse time mode	5	–	–
Operation accuracy	±3% of set value	±3% of set value	±1 unit ±3% of set value

Technical data (cont´d)

Table 9: Data communication

Transmission mode		Fibre-optic serial bus
Data code		ASCII
Data transfer rate, selectable		4800 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 21MM
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 17MM

Table 10: Tests and standards

Test voltages	Dielectric test voltage (IEC 60255-5)	2 kV, 50 Hz, 1 min
	Impulse test voltage (IEC 60255-5)	5 kV, 1.2/50 μs, 0.5 J
	Insulation resistance (IEC 60255-5)	>100 MΩ, 500 V dc
Interference tests	High frequency disturbance test (IEC 60255-22-1), common mode	2.5 kV, 1 MHz
	High frequency disturbance test (IEC 60255-22-1), differential mode	1.0 kV, 1 MHz
	Electrostatic discharge (IEC 60255-22-2 and IEC 61000-4-2), air discharge	8 kV
	Electrostatic discharge (IEC 60255-22-2 and IEC 61000-4-2), contact discharge	6 kV
	Fast transients (IEC 60255-22-4 and IEC 61000-4-4), power supply inputs	4 kV
	Fast transients (IEC 60255-22-4 and IEC 61000-4-4), other inputs	2 kV
Environmental conditions	Service temperature range	-10…+55°C
	Long term damp heat withstand (IEC 60068-2-3)	<95%, +40°C, 56 d/a
	Temperature influence	0.1%/°C
	Damp heat test (IEC 60068-2-30)	93…95%, +55°C, 6 cycles
	Transport and storage temperature range (IEC 60068-2-8)	-40…+70°C
	Degree of protection by enclosure of flush mounting relay case (IEC 60529)	IP 54
	Weight of fully equipped relay	~6 kg

Block diagram

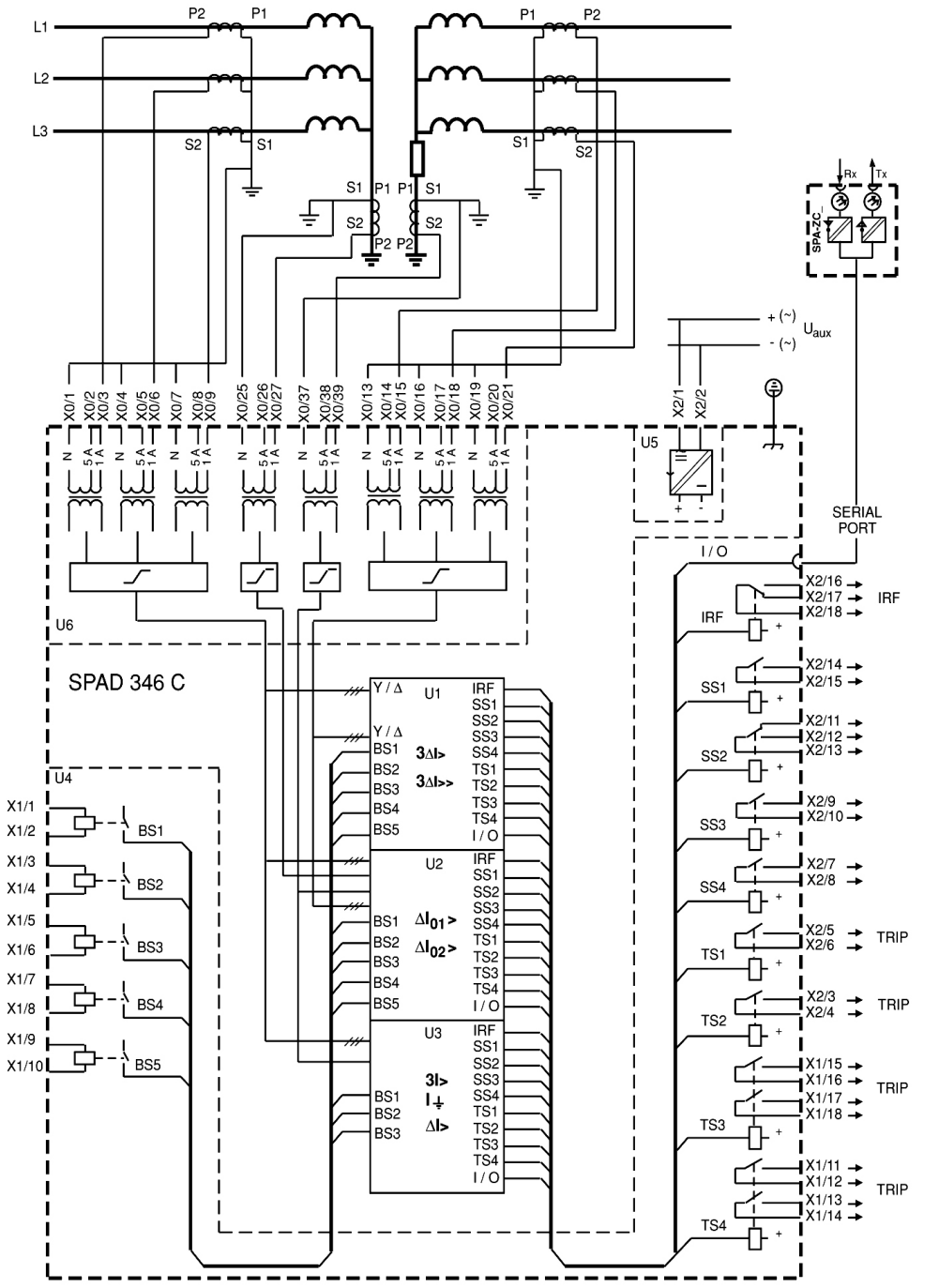

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Fig. 1 Block diagram and sample connection diagram

Mounting and dimensions

Flush mounting

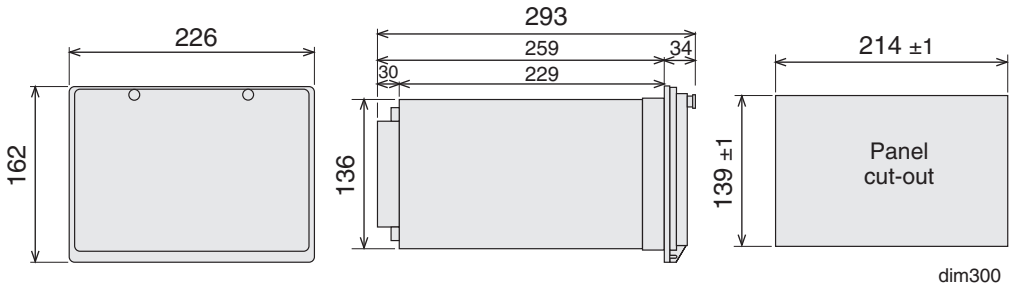
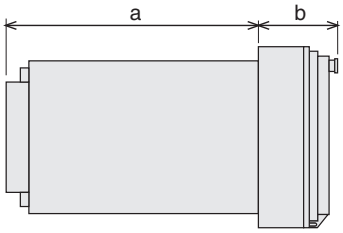


Fig. 2 Flush-mounting relay case (dimensions in mm)

Semi-flush mounting



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

SFM300_1

Fig. 3 Semi-flush mounting relay case (dimensions in mm)

Mounting in 19 inch cabinets and frames

An ancillary mounting plate, height 4U (~177 mm), is recommended to be used when the protection relays are to be mounted in 19 inch frames or cabinets. The ancillary mounting plate type SPA-ZX 304 accommodates two size 300 relays and type SPA-ZX 305 one size 300 relay.

Projecting mounting

When projecting mounting is preferred, a relay case type SPA-ZX 317 is used. The relay case for projecting mounting is provided with front connectors.

SPA-ZX304
SPA-ZX305
SPA-ZX201

SPA-ZX306
SPA-ZX307
SPA-ZX317
SPA-ZX318

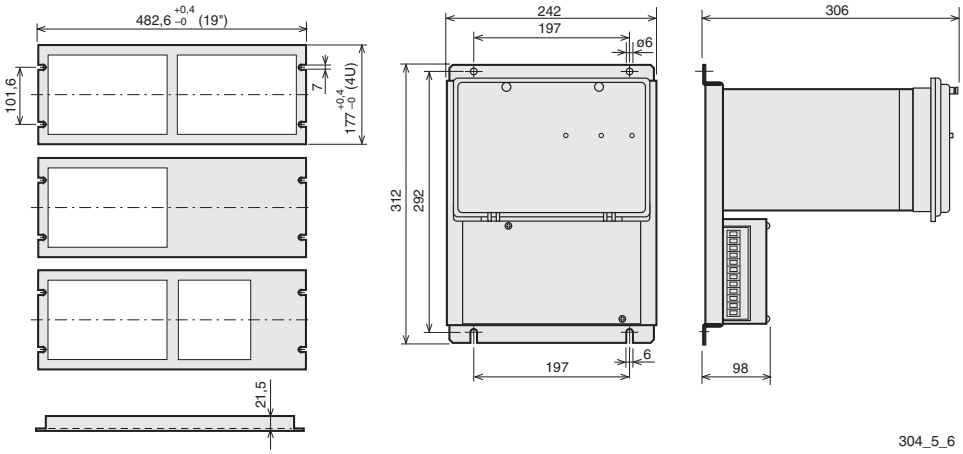


Fig. 4 Mounting cabinets and frames as well as projecting mounting (dimensions in mm)

Ordering

When ordering, please specify:

Ordering information	Ordering example
1. Type designation and quantity	SPAD 346 C, 5 pieces
2. Order number	RS 621 002-AA
3. Rated values	I_n=5 A, f_n=50 Hz
4. Auxiliary voltage	U_{aux} =110 V dc
5. Accessories	-
6. Special requirements	-

Order numbers

Stabilized differential relay SPAD 346 C_	
SPAD 346 C complete	RS 621 002-AA, CA, DA, FA
SPAD 346 C1, incl. modules SPCD 3D53 and SPCD 2D55	RS 621 003-AA, CA, DA, FA
SPAD 346 C2, incl. modules SPCD 3D53 and SPCJ 4D28	RS 621 004-AA, CA, DA, FA
SPAD 346 C3, incl. module SPCD 3D53	RS 621 005-AA, CA, DA, FA
SPAD 346 C4, incl. modules SPCD 2D55 and SPCJ 4D28	RS 621 006-AA, CA, DA, FA
SPAD 346 C5, incl. module SPCD 2D55	RS 621 007-AA, CA, DA, FA
SPAD 346 C6, incl. module SPCJ 4D28	RS 621 008-AA, CA, DA, FA
The last two letters of the order number indicate the rated frequency f_n and the auxiliary voltage U_{aux} of the relay as follows:	AA equals f_n = 50 Hz and U_{aux} = 80…265 V ac/dc
	CA equals f_n = 50 Hz and U_{aux} = 18…80 V dc
	DA equals f_n = 60 Hz and U_{aux} = 80…265 V ac/dc
	FA equals f_n = 60 Hz and U_{aux} = 18…80 V dc

Stabilized differential relay SPAD 346 C_ including a test adapter type RTXP18	
SPAD 346 C complete	RS 621 202-AA, CA, DA, FA
SPAD 346 C1, incl. modules SPCD 3D53 and SPCD 2D55	RS 621 203-AA, CA, DA, FA
SPAD 346 C2, incl. modules SPCD 3D53 and SPCJ 4D28	RS 621 204-AA, CA, DA, FA
SPAD 346 C3, incl. module SPCD 3D53	RS 621 205-AA, CA, DA, FA
SPAD 346 C4, incl. modules SPCD 2D55 and SPCJ 4D28	RS 621 206-AA, CA, DA, FA
SPAD 346 C5, incl. module SPCD 2D55	RS 621 207-AA, CA, DA, FA
SPAD 346 C6, incl. module SPCJ 4D28	RS 621 208-AA, CA, DA, FA
The last two letters of the order number indicate the rated frequency f_n and the auxiliary voltage U_{aux} of the relay as follows:	AA equals f_n = 50 Hz and U_{aux} = 80…265 V ac/dc
	CA equals f_n = 50 Hz and U_{aux} = 18…80 V dc
	DA equals f_n = 60 Hz and U_{aux} = 80…265 V ac/dc
	FA equals f_n = 60 Hz and U_{aux} = 18…80 V dc

References

Additional information

User’s manual and technical description “Stabilized differential relay SPAD 346 C”	1MRS 750096-MUM EN

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