TPU S220

PROTECTION

- (Directional) Phase Overcurrent
- (Directional) Earth-Fault Overcurrent
- (Directional) Negative Sequence Overcurrent
- Cold Load Pickup
- Thermal Overload
- Switch-Onto-Fault
- Broken Conductor Check
- Undercurrent
- Directional Earth-Fault Overcurrent for Non-Earthed Systems
- Directional Power
- Phase Undervoltage
- Phase Overvoltage
- Residual Overvoltage
- Negative Sequence Overvoltage
- Underfrequency
- Overfrequency
- Frequency Rate-of-Change

CONTROL / SUPERVISION

- Three-Phase Trip Logic
- Trip Circuit Supervision
- Circuit Breaker Failure
- Automatic Reclosing
- Synchronism and Voltage Check
- Lockout
- VT Supervision
- CT Supervision
- Circuit Breaker Control / Supervision
- Distributed Automation
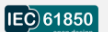- Programmable Automation (IEC 61131-3 based)

MONITORING / RECORDING

- Three-Phase Measurements
- Single-Phase Measurements
- Metering
- Fault Locator
- Disturbance Recorder
- Event Recorder / SOE
- Fault Report
- Self-tests and Watchdog

COMMUNICATION

- IEC 61850 Server / GOOSE
- IEC 60870-5-101/103/104
- DNP 3.0 (TCP/IP or Serial)
- Modbus (TCP/IP or Serial)
- Other serial and IP protocols available

TIME SYNCHRONIZATION

- IRIG-B Input
- SNTP Client

AUTOMATION STUDIO-READY

- Integrated configuration and programming
- Simplified engineering and handling

INTRODUCTION

TPU S220 compact protection and control relay, part of Efacec CLP 500 platform, is a cost-effective and secure solution for line/feeder protection. They can also be used for backup or auxiliary protection and control of transformers or other equipment in HV/MV systems.

Drawing on the experience obtained with previous field-proven product families, TPU S220 protection algorithms have been significantly enhanced, with new and additional features included. A careful design of protection functions and device architecture provides an adequate balance between speed, sensitivity and accuracy.

Several built-in functions and options enable the correct operation of the protection relay in high or medium voltage networks with grounded, low-impedance, isolated or compensated neutral. Several independent stages for main protection functions, in a true full-scheme design, enable versatile device applications.

Each TPU S220 device combines protection, control, measurement and recording, in a fit-for-purpose design that allows plug-and-play engineering. The built-in logic engine, fully programmable in IEC 61131-3 languages, allows further application flexibility, providing alternatives for customization of protection schemes and implementation of user-defined PLC logic.

By fully supporting IEC 61850 and other open communication standards, TPU S220 is future-proof and easy to integrate into either existing or new systems. The relays were designed with IEC 61850 in mind in every aspect and thereby provide full compatibility with other compliant devices, engineering tools and systems, with significant cost-savings.

TPU S220 is easy to specify, configure, troubleshoot and maintain. Full integration in the Automation Studio toolset allows simple configuration, programming and management, either in system or standalone applications.

The built-in user interface permits interaction with the device and associated power system locally.

The device provides self-supervision of all hardware components and software modules. Diagnostic information can be accessed through the engineering toolset or communication interfaces.

OVERVIEW

The TPU S220 is a compact multifunction protection relay that provides a cost-effective solution for power system protection while offering additional control, measurement and recording functions for easy and reliable power system management.

The main application of TPU S220 is the protection of power system overhead lines or underground cables, in high or medium voltage networks, with grounded, low-impedance, isolated or compensated neutral. It also fits transformer applications, as backup protection for main transformer differential protection. TPU S220 can also be used as backup to other protection relays in more complex applications.

Several control and supervision functions extend the application of the relay, with option for additional user-defined automation functions and logic (for example, interlocking logic or load transfer and restoration schemes). Accurate measured and metered values and a wide range of records and other stored information add value to the base application. The relay can thus conveniently replace a set of separate auxiliary devices in the switchgear cubicle, such as measuring instruments, control switches and pushbuttons.

This compact relay can be used standalone or system integrated, taking advantage of its multiple communication protocols options. The availability of several device models, with pre-defined and fit-for-purpose function sets and configuration, ensures adequacy to each user application.

VARIANTS

TPU S220-I

The basic product variant consists of a simple overcurrent and earth-fault protection relay, with integrated circuit breaker control and supervision and enhanced recording functions, such as one millisecond resolution event log, disturbance recorder with multi-trigger options and complete reports for the last power system faults.

TPU S220-R

With the same four current inputs as the first variant, TPU S220-R offers an extra set of protection and control functions, such as negative sequence overcurrent, switch-onto-fault protection or broken conductor check. Automatic reclosing and circuit breaker failure are also integrated in the device, thus avoiding the use of additional relays to perform these functions.

TPU S220-U

With four additional voltage analogue inputs, TPU S220-U complements phase and earth fault protection functions with directional options, enabling its application in meshed networks or in systems with significant levels of distributed generation. Both under and overvoltage functions are also added to this variant as well as other monitoring and recording functions such as metering and load diagram.

TPU S220-S

TPU S220-S is a full featured multifunction relay. Several underfrequency, overfrequency and frequency rate-of-change protection stages enable the implementation of complex load shedding and restoration schemes. Synchronism check with optional operation in asynchronous networks or an accurate fault locating algorithm, among other functions, make this variant prepared for the most demanding applications.

FEATURE SUMMARY

TPU S220	-I	-R	-U	-S
Size				
1/3 x 19" rack / height 6U	●	●	●	●
A.C. Analogue Inputs				
Maximum Number of Inputs	4	4	8	8
Current Inputs	4	4	4	4
4th current input with high sensitivity			○	○
Voltage Inputs			4	4
Binary Inputs / Outputs				
Maximum Number of Inputs	4	8	24	24
Maximum Number of Outputs	4	8	24	24
Base I/O				
4 Binary Inputs + 4 Binary Outputs + Watchdog Output	●			
8 Binary Inputs + 8 Binary Outputs + Watchdog Output		●	●	●

	(all variants)
Availability	
Hardware Watchdog and Auto-reset	●
Software Failure Detection and Recovery	●
User Interface	
4 x 20 Alphanumeric LCD	●
Programmable Alarms / Indication LEDs	8
Function Keys	5
Relay Status LEDs	3
Integrated Webserver	●
Time Synchronization	
IRIG-B Input	●
SNTP Client	●
By Communication Protocol	●
Communication Interfaces (Rear Panel)	
1 RS-232 / RS-485	●
1 RS-232 / RS-485 / Glass / Plastic Fibre	○
1 Single / Dual Ethernet 10/100BASE-TX or 100BASE-FX Interface	○
RSTP-enabled Interface	○
PRP/HSR-enabled Interface **	○
IEC 61850 Communications	
IEC 61850-8-1 Server and GOOSE	○
Communication Protocols	
Maximum Number of Simultaneous Protocols	2
Protocol Up / Slave	
IEC 60870-5-104 (TCP/IP) / IEC 60870-5-101 (Serial)	○
IEC 60870-5-103 (Serial)	○
DNP 3.0 (TCP/IP or Serial)	○
Modbus (TCP/IP or Serial)	○
Others available	(please contact)
Configuration, Operational Support & Programming	
Automation Studio (Automation Studio license not included)	●
Industry-specific function libraries	(please contact)

● - Base feature
○ - Optional feature
** - Currently under development

TPU S220			-I	-R	-U	-S
General						
Three-Phase Tripping			●	●	●	●
Single Breaker Arrangements			●	●	●	●
Protection Functions	**ANSI**	**IEC 61850**				
Phase Overcurrent	50/51	PTOC	●(1)	●(1)		
(Directional) Phase Overcurrent	50/51/67	PTOC, RDIR			●(1)	●(1)
Earth-Fault Overcurrent	50N/51N 50G/51G	PTOC	●(2)	●(2)		
(Directional) Earth-Fault Overcurrent	50N/51N/67N 50G/51G/67G	PTOC, RDIR			●(2)	●(2)
Negative Sequence Overcurrent	46	PTOC		●(1)		
(Directional) Negative Sequence Overcurrent	46/67	PTOC, RDIR			●(1)	●(1)
Editable Time-Current Curves			●	●	●	●
Inrush Restraint	68	PHAR	●	●	●	●
Cold Load Pickup		RCLP	●(1)	●(1)	●(1)	●(1)
Thermal Overload	49	PTTR	●(1)	●(1)	●(1)	●(1)
Switch-Onto-Fault	50HS	RSOF, PIOC		●(1)	●(1)	●(1)
Broken Conductor Check / Phase Unbalance	46BC	RBCD		●(1)	●(1)	●(1)
Undercurrent / Loss of Load	37	PTUC		●(1)	●(1)	●(1)
Directional Earth-Fault Overcurrent for Non-Earthed Systems	32N	PSDE			●(2)	●(2)
Directional Power	32	PDOP, PDUP			●(1)	●(1)
Phase Undervoltage	27	PTUV			●(2)	●(2)
Phase Overvoltage	59	PTOV			●(2)	●(2)
Residual Overvoltage	59N	PTOV			●(2)	●(2)
Negative Sequence Overvoltage	47	PTOV			●(1)	●(1)
Underfrequency	81U	PTUF				●(1)
Overfrequency	81O	PTOF				●(1)
Frequency Rate-of-Change	81RC	PFRC				●(1)
Control and Supervision Functions	**ANSI**	**IEC 61850**				
Trip Logic	94	PTRC	●(1)	●(1)	●(1)	●(1)
Trip Circuit Supervision	74TC	STRC	●(1)	●(1)	●(1)	●(1)
Circuit Breaker Failure	50BF	RBRF		●(1)	●(1)	●(1)
Automatic Reclosing	79	RREC		●(1)	●(1)	●(1)
Synchronism and Voltage Check	25	RSYN				●(1)
Circuit Breaker Close Lock / Lockout	86	RCBL	●(1)	●(1)	●(1)	●(1)
Fuse Failure / VT Supervision	60	RVTS			●(1)	●(1)
CT Supervision		RCCS	●(1)	●(1)	●(1)	●(1)
Circuit Breaker Control / Supervision	52	CSWI, XCBR	●(1)	●(1)	●(1)	●(1)
Distributed Automation		GGIO (or user defined)	●	●	●	●
Programmable Automation (IEC 61131-3)		GAPC (or user defined)	●	●	●	●
Monitoring and Recording Functions	**ANSI**	**IEC 61850**				
Three-Phase Measurements		MMXU, MSQI	●(1)	●(1)	●(1)	●(1)
Single-Phase Measurements		MMXN			●(1)	●(1)
Metering		MMTR			●(1)	●(1)
Statistics **		MMXU (or user defined)	●	●	●	●
Fault Locator	21FL	RFLO				●(1)
Disturbance Recorder		RDRE	●	●	●	●
Chronological Event Log / SOE			●	●	●	●
Fault Report			●	●	●	●
Load Diagram / Trend Recorder **					●	●
Histogram **					●	●
Self-tests and Watchdog			●	●	●	●

● - Base feature
○ - Optional feature
** - Currently under development
(n) - Maximum number of instances

TECHNICAL SPECIFICATIONS

A.C. Analogue Inputs (General Data)		
Number	Max. 8 (depends on product variant)	
Rated frequency	f_r = 50 or 60 Hz (configurable by user)	
Angular reference	Any of the AC analogue inputs (configurable by user)	
Acquisition	ADC type	Sigma-Delta
	Resolution	16 bit
	Sampling rate	160 samples per cycle at rated frequency (8 kHz @ f_r = 50 Hz; 9.6 kHz @ f_r = 60 Hz)

A.C. Current Inputs		
Number	Max. 4	
Standard option	Rated current	I_r = 1 or 5 A (configurable by user)
	Operation range	[0.05 .. 50.0] × I_r
	Thermal withstand	500 A for 1 s
		150 A for 10 s
		20 A continuous
	Dynamic load-carrying withstand	1250 A one half wave
	Burden	< 0.05 VA @ I_r = 1 A
		< 0.15 VA @ I_r = 5 A
Sensitive option	Rated current	I_r = 1 or 5 A (configurable by user)
	Operation range	[0.005 .. 5.0] × I_r
	Thermal withstand	250 A for 1 s
		10 A continuous
	Dynamic load-carrying withstand	750 A one half wave
	Burden	< 0.05 VA @ I_r = 1 A
		< 0.25 VA @ I_r = 5 A

A.C. Voltage Inputs		
Number	Max. 4 (depends on product variant)	
Standard range (configurable by user)	Rated voltage	U_r = 100/3, 110/3, 115/3 or 120/3 V (residual)
		U_r = 100/√3, 110/√3, 115/√3 or 120/√3 V (phase-earth)
		U_r = 100, 110, 115 or 120 V (phase-phase)
	Operation range	[0.25 .. 220] V_{rms}
	Thermal withstand	500 V for 1 s
		460 V continuous
	Burden	< 0.05 VA @ U_r
Extended range (configurable by user)	Rated voltage	U_r = 100/√3, 110/√3, 115/√3 or 120/√3 V (residual)
		U_r = 100, 110, 115, 120 V or 230 V (phase-earth)
		U_r = 100×√3, 110×√3, 115×√3, 120×√3 V or 400 V (phase-phase)
	Operation range	[0.5 .. 440] V_{rms}
	Thermal withstand	500 V for 1 s
		460 V continuous
	Burden	< 0.25 VA @ U_r

Power Supply		
Rated values / voltage ranges	24 / 48 / 60 V d.c.	(19 .. 72 V d.c.)
	48 / 60 / 110 / 125 / 220 / 250 V d.c.	(38 .. 350 V d.c. / 60 .. 265 V a.c.)
	115 / 230 V a.c.	
Burden	Quiescent state (minimum configuration)	< 9 W (d.c.)
	Quiescent state (maximum configuration)	< 12 W (d.c.)
		< 24 VA (a.c.)
	Additional burden per actuated binary output	0.3 W
Ripple at d.c. auxiliary power supply		≤ 12%
Earthing arrangements for d.c. supply	Floating (free from earth)	Class EF

Binary Inputs		
Number	Base	4 (TPU S220-I) or 8 (other variants)
	Maximum	24
Rated values / voltage thresholds (configurable by user)	24 V d.c.	$V_{LOW} \leq 8$ V d.c.
		$V_{HIGH} \geq 20$ V d.c.
	48 / 60 V d.c.	$V_{LOW} \leq 26$ V d.c.
		$V_{HIGH} \geq 38$ V d.c.
	110 / 125 V d.c.	$V_{LOW} \leq 66$ V d.c.
		$V_{HIGH} \geq 85$ V d.c.
	220 / 250 V d.c.	$V_{LOW} \leq 132$ V d.c.
		$V_{HIGH} \geq 170$ V d.c.
Maximum permitted voltage		300 V d.c.
Burden	24 V d.c.	< 0.05 W (1.5 mA @ 24 V d.c.)
	48 / 60 V d.c.	< 0.1 W (1.5 mA @ 48 V d.c.)
	110 / 125 V d.c.	< 0.2 W (1.5 mA @ 125 V d.c.)
	220 / 250 V d.c.	< 0.4 W (1.5 mA @ 250 V d.c.)
Inrush current	Peak	50 mA ± 20% @ V_r
	Impulse time constant	10 ms ± 20%
	Total impulse duration	Approx. 50 ms
Filtering	Debounce time	[1 .. 128] ms
	Oscillation filter	Max [2 .. 255] changes in [2 .. 10000] ms

Binary Outputs		
Number	Base	4 (TPU S220-I) or 8 (other variants) + Watchdog
	Maximum	24 + Watchdog
Standard option	Rated voltage	250 V a.c./ d.c.
	Rated current	8 A
	Making capacity	1 s @ 10 A
		0.2 s @ 30 A
	Breaking capacity	d.c.: 1 / 0.4 / 0.2 A @ 48 / 110 / 220 V; L/R < 40 ms
		a.c.: 1250 VA (250 V / 5 A); cos φ > 0,4
	Voltage across open contacts (1 min)	1 kV$_{rms}$
Pulse configuration	Pulse time	[0 .. 60000] ms
	Delay time	[0 .. 60000] ms
	Reset time	[0 .. 60000] ms

Serial Ports - System Interface

Number	Base interface	1 (RS-232/RS-485)
	Additional interface	1 (RS-232/RS-485, Plastic FO or Glass FO)
Transmission rate	Setting range	600 to 57600 baud
RS-232 option	Connector	D9 male connector
RS-485 option	Connector	D9 male connector
Plastic fibre optics option	Fibre type	Plastic fibre optics (POF) 1mm
	Wavelength	650 nm
	Connector	Snap-in type
	Maximum distance	45 m
	Optical power budget with 1 mm POF	10.4 dB (min.)
Glass fibre optics option	Fibre type	Multimode glass fibre optics 50/125 μm or 62.5/125 μm
	Wavelength	820 nm
	Connector	ST
	Maximum distance	1.7 km using an optical fibre 62.5/125 μm
	Optical power budget with 50/125 μm fibre	4.2 dB (min.)
	Optical power budget with 62.5/125 μm fibre	8.0 dB (min.)

Clock Synchronization Ports - IRIG-B Interface

Number	1	
Galvanic option	Connector	D9 female connector
	Input voltage level	5 V, 12 V or 24 V
	Voltage range	± 20% of input voltage level

Rear Ethernet Ports - System Interface

Number	Dual-interface (10/100BASE-TX or 100BASE-FX) or Single-interface (10/100BASE-TX or 100BASE-FX)	
Copper interface option	Media type	10/100BASE-TX
	Connector	RJ-45
Fibre interface option (100 Mbps)	Media type	100BASE-FX
	Fibre type	Multimode glass fibre optics 50/125 μm or 62.5/125 μm
	Wavelength	1300 nm
	Connector	MT-RJ or LC Duplex
	Maximum distance	2 km
	Output optical power (62.5/125 μm, NA = 0.275)	-20.0 dBm … -14.0 dBm
	Output optical power (50/125 μm, NA = 0.20)	-23.5 dBm … -14.0 dBm
	Receiver sensitivity	-31.0 dBm (max.)
	Receiver overload	-14.0 dBm (min.)

Front Ethernet Port - Service Interface

Copper interface	Media type	10/100BASE-TX
	Connector	RJ-45

Case

Design	Dimensions	6U, 1/3 x 19'' rack
	Weight	< 4,5 kg

Environmental Conditions

Operating temperature range	- 10 °C to + 60 °C, temporarily can be up to 70 °C (tested for 72 hours); Recommended: - 5 °C to + 55 °C
Storage temperature range	- 25 °C to + 70 °C
Relative humidity	10 to 95%
Pollution degree	2
Altitude	< 2000 m

CE Marking		
Electromagnetic Compatibility Directive (2004/108/CE)	Immunity	EN 61000-6-2: 2005 EN 60870-2-1: 1996 EN 60255-26: 2009 EN 50263: 1999
	Emission	EN 61000-6-4: 2007 + A1: 2011 EN 60870-2-1: 1996 EN 60255-26: 2009 EN 50263: 1999
Low Voltage Directive (2006/95/CE)		EN 60950-1: 2006 + A1: 2010 + A11: 2009 + A12: 2011 EN 60255-27: 2005 EN 60255-5: 2001

Insulation Tests		
High voltage test	EN 60255-5 EN 60255-27	2.0 kV a.c. 1 min 50 Hz 2.8 kV d.c. 1 min (power supply)
Impulse voltage test	EN 60255-5 EN 60255-27	5 kV 1.2/50 µs, 0.5 J
Insulation resistance test	EN 60255-5 EN 60255-27	> 100 MΩ @ 500 V d.c.
Protective bonding resistance test	EN 60255-27	< 0.1 Ω

EMC – Immunity Tests		
Electrostatic discharge immunity test	EN 61000-4-2 EN 60255-22-2	8 kV contact; 15 kV air
Electromagnetic field immunity test	EN 61000-4-3 EN 60255-22-3	80 MHz – 1000 MHz; 30 V/m 1000 MHz – 3000 MHz; 10 V/m
Fast transient disturbance immunity test	EN 61000-4-4 EN 60255-22-4	4 kV, 5/50 ns
Surge immunity test	EN 61000-4-5 EN 60255-22-5	4/2 kV, 1.2/50 µs
Conducted RF disturbance test	EN 61000-4-6 EN 60255-22-6	10 V r.m.s., 150 kHz – 80 MHz @ 1 kHz 80% am
Power frequency magnetic field immunity test	EN 61000-4-8	100 A/m, cont; 1000 A/m, 3 s
Damped oscillatory magnetic field immunity test	EN 61000-4-10	100 A/m, 0.1 MHz and 1 MHz
Voltage variations immunity test	EN 61000-4-11 EN 60255-11	500 ms @ 70%; 200 ms @ 40% 500 ms @ 40%;
	EN 61000-4-29 EN 60255-11	500 ms @ 70%; 200 ms @ 40% 500 ms @ 40%;
Voltage interruptions immunity test	EN 61000-4-11 EN 60255-11	5, 10, 20, 50, 100, 200 and 500 ms
	EN 61000-4-29 EN 60255-11	5, 10, 20, 50, 100, 200 and 500 ms
Ring waves immunity test	EN 61000-4-12	4 kV common mode
Conducted, common mode disturbances in the frequency range 0 Hz to 150 kHz	EN 1000-4-16 EN 60255-22-7	150 V (differential mode) 100 Ω, 0.1 µF 300 V (common mode) 220 Ω, 0.47 µF
Damped oscillatory waves immunity test	EN 61000-4-18 EN 60255-22-1	2.5 kV common mode 1 kV differential mode

EMC – Emission Tests		
Radiated emission	EN 55022 EN 60255-25	30 – 1000 MHz class A
Conducted emission	EN 55022 EN 60255-25	0.15 – 30 MHz class A
Harmonic currents emission test	EN 61000-3-2	Class A
Voltage fluctuation and flicker emission test	EN 61000-3-3	Class A

Mechanical Tests

Vibration tests	EN 60255-21-1		Class 2, 2 g, 10 Hz to 150 Hz
	EN 60870-2-2		Class Cm, 2 g, 9 Hz to 200 Hz
Shock tests	EN 60255-21-2		Class 2, 30 g, 11 ms
	EN 60870-2-2		Class Cm, 30 g, 11 ms
Bump tests	EN 60255-21-2		Class 1, 10 g, 16 ms
Free fall test	EN 60870-2-2		Class Cm, 0.25 m
	EN 60068-2-31		Method 1, 0.25 m
Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)	EN 50102		IK07

Environmental Tests

Cold test	EN 60068-2-1	Operational	- 10 °C, 72h (Test Ad)
		Storage	- 25 °C, 72h (Test Ab)
Dry heat test	EN 60068-2-2	Operational	+ 70 °C, 72h (Test Bd)
		Storage	+ 85 °C, 72h (Test Bb)
Damp heat test, cyclic (12h+12h cycle)	EN 60068-2-30		+ 25 °C (97%) to + 40 °C (93%), 6 cycles
Damp heat test, steady state	EN 60068-2-78		+ 40 °C, 93% RH, 10 days
Degree of protection frontal side, flush mounted	EN 60529		IP50
Degree of protection, rear side	EN 60529		IP30

FUNCTIONAL SPECIFICATIONS

(Directional) Phase Overcurrent		
Number of independent functions		1 function
Number of stages (per function)		4 stages
Operational current	Setting range	[0.05 .. 40.0] × I_r ; step 0.01 (stages 1 and 2)
		[0.05 .. 20.0] × I_r ; step 0.01 (stages 3 and 4)
	Accuracy	± 1% I_{op} (minimum ± 1% I_r)
	Dropout ratio	> 96%
	Maximum cold load pickup multiplier	[1.0 .. 20.0] ; step 0.01 (independent per stage)
Definite time (all stages)	Pickup time	20 ms typ. for I > 2 × I_{op} , non-directional
		35 ms typ. for I > 2 × I_{op} , directional
	Time delay	[0 .. 60000] ms ; step 1
	Time accuracy	± 3% (minimum ± 10 ms)
	Reset type	Instantaneous or delayed
	Reset time	30 ms typ.
	Dropout delay	[0 .. 60000] ms ; step 1
Inverse time (stages 3 and 4 only)	Curve types (ANSI/ IEEE)	Extremely Inverse, Very Inverse, Normal Inverse, Moderately Inverse, Long Time Extremely Inverse, Long Time Very Inverse, Long Time Inverse
	Curve types (IEC)	Normal Inverse, Very Inverse, Extremely Inverse, Short Time Inverse, Long Time Inverse
	Curve types (Recloser)	104 (N), 105 (R), 116 (D), 117 (B), 132 (E), 133 (C), 138 (W), 162 (KP)
	User defined curves	6 to 25 points
	Time multiplier	[0.05 .. 15.0] ; step 0.01
	Constant time adder	[0 .. 30000] ms ; step 1
	Minimum operation time	[0 .. 60000] ms ; step 10
	Maximum operation time	[0 .. 60000] ms ; step 10
	Start value	[1.0 .. 4.0] × I_{op} ; step 0.01
	Accuracy class	ANSI/ IEEE C37.112, Class 5
		IEC 60255-3, Class 5
	Reset type	Instantaneous or dynamic
	Reset time	30 ms typ.
Directionality	Direction options	Non-directional, forward or reverse (independent stage selection)
	Polarization	Negative-sequence voltage, positive-sequence voltage and voltage memory, according to actual fault condition;
		Cross phase-phase voltage and voltage memory, according to actual fault condition, in option
	Characteristic angle	[-90.0 .. 90.0]° ; step 1.0
	Phase angle accuracy	± 2°
	VT failure action	Non-directional trip or function block
Inrush restraint	Operation	Disabled / enabled (independent stage selection)
	Restriction mode	Second harmonic
	Second harmonic ratio	[0.1 .. 1.0] I_{2h}/I_{1h} ; step 0.01
	Cross-block	One phase out of three, two phases out of three or disabled

(Directional) Earth-Fault Overcurrent		
Number of independent functions		2 functions
Number of stages (per function)		4 stages
Operational current	Quantity	Residual current (calculated sum of three phase currents) or neutral current (independent input)
	Setting range (normal CT input)	[0.05 .. 40.0] × I_r ; step 0.001 (stages 1 and 2) [0.05 .. 20.0] × I_r ; step 0.001 (stages 3 and 4)
	Setting range (sensitive CT input)	[0.005 .. 4.0] × I_r ; step 0.001
	Accuracy	± 1% I_{op} (minimum ± 1% I_r)
	Dropout ratio	> 96%
	Maximum cold load pickup multiplier	[1.0 .. 20.0] ; step 0.01 (independent per stage)
Definite time (all stages)	Pickup time	25 ms typ. for I > 2 × I_{op} , non-directional 35 ms typ. for I > 2 × I_{op} , directional
	Time delay	[0 .. 60000] ms ; step 1 (stages 1 and 2) [0 .. 300000] ms ; step 1 (stages 3 and 4)
	Time accuracy	± 3% (minimum ± 10 ms)
	Reset type	Instantaneous or delayed
	Reset time	30 ms typ.
	Dropout delay	[0 .. 60000] ms ; step 1
Inverse time (stages 3 and 4 only)	Curve types (ANSI/ IEEE)	Extremely Inverse, Very Inverse, Normal Inverse, Moderately Inverse, Long Time Extremely Inverse, Long Time Very Inverse, Long Time Inverse
	Curve types (IEC)	Normal Inverse, Very Inverse, Extremely Inverse, Short Time Inverse, Long Time Inverse
	Curve types (Recloser)	111 (8+), 113 (8), 131 (9), 135 (2), 140 (3), 141 (11)
	Curve types (other)	Logarithmic
	User defined curves	6 to 25 points
	Time multiplier	[0.05 .. 15.0] ; step 0.01
	Constant time adder	[0 .. 30000] ms ; step 1
	Minimum operation time	[0 .. 60000] ms ; step 10
	Maximum operation time	[0 .. 60000] ms ; step 10
	Start value	[1.0 .. 4.0] × I_{op} ; step 0.01
	Accuracy class	ANSI/ IEEE C37.112, Class 5 IEC 60255-3, Class 5
	Reset type	Instantaneous or dynamic
	Reset time	30 ms typ.
Directionality	Direction options	Non-directional, forward or reverse (independent stage selection)
	Polarization	Residual voltage and/or neutral current; negative-sequence voltage/current in option
	Characteristic angle	[-90.0 .. 90.0]° ; step 1.0
	Minimum polarization voltage	[0.01 .. 1.0] × U_r ; step 0.005 (phase-earth rated voltage)
	Minimum polarization current	[0.05 .. 1.0] × I_r ; step 0.01
	Accuracy	± 1% U_{pol} (minimum ± 1% U_r) ± 1% I_{pol} (minimum ± 1% I_r)
	Phase angle accuracy	± 2°
	VT failure action	Non-directional trip or function block
Inrush restraint	Operation	Disabled / enabled (independent stage selection)
	Restriction mode	Second harmonic
	Second harmonic ratio	[0.1 .. 1.0] I_{2h}/I_{1h} ; step 0.01

(Directional) Negative Sequence Overcurrent		
Number of independent functions		1 function
Number of stages (per function)		4 stages
Operational current	Setting range	[0.05 .. 4.0] × I_r ; step 0.01
	Accuracy	± 1% I_{op} (minimum ± 1% I_r)
	Dropout ratio	> 96%
Definite time (all stages)	Pickup time	25 ms typ. for I > 2 × I_{op} , non-directional
		35 ms typ. for I > 2 × I_{op} , directional
	Time delay	[0 .. 60000] ms ; step 1
	Time accuracy	± 3% (minimum ± 10 ms)
	Reset type	Instantaneous or delayed
	Reset time	30 ms typ.
	Dropout delay	[0 .. 60000] ms ; step 1
Inverse time (stages 3 and 4 only)	Curve types (ANSI/IEEE)	Extremely Inverse, Very Inverse, Normal Inverse, Moderately Inverse, Long Time Extremely Inverse, Long Time Very Inverse, Long Time Inverse
	Curve types (IEC)	Normal Inverse, Very Inverse, Extremely Inverse, Short Time Inverse, Long Time Inverse
	Curve types (Recloser)	104 (N), 105 (R), 116 (D), 117 (B), 132 (E), 133 (C), 138 (W), 162 (KP)
	User defined curves	6 to 25 points
	Time multiplier	[0.05 .. 15.0] ; step 0.01
	Constant time adder	[0 .. 30000] ms ; step 1
	Minimum operation time	[0 .. 60000] ms ; step 10
	Maximum operation time	[0 .. 60000] ms ; step 10
	Start value	[1.0 .. 4.0] × I_{op} ; step 0.01
	Accuracy class	ANSI/IEEE C37.112, Class 5
		IEC 60255-3, Class 5
	Reset type	Instantaneous or dynamic
	Reset time	30 ms typ.
Directionality	Direction options	Non-directional, forward or reverse (independent stage selection)
	Polarization	Negative-sequence voltage
	Characteristic angle	[-90.0 .. 90.0]° ; step 1.0
	Minimum polarization voltage	[0.01 .. 1.0] × U_r ; step 0.005
	Accuracy	± 1% U_{pol} (minimum ± 1% U_r)
	Phase angle accuracy	± 2°
	VT failure action	Non-directional trip or function block

Cold Load Pickup		
Number of independent functions		1 function
Operational current multiplier	Dynamic	0 to 100 % of overcurrent function setting
Operational time	Pickup delay	[0 .. 60] min ; step 1
	Pickup time	[0 .. 720] min ; step 1
	Reset delay	[0 .. 60] min ; step 1
	Reset time	[0 .. 720] min ; step 1
Loss of supply / return of supply detection	External activation	Optional (dedicated binary input)
	Maximum dead voltage	[0.05 .. 0.80] × U_r ; step 0.01
	Minimum live voltage	[0.20 .. 1.20] × U_r ; step 0.01

Thermal Overload		
Number of independent functions		1 function
Thermal characteristics	Time constant	[1 .. 60000] s ; step 1
	Maximum continuous current	[0.0 .. 999999.9] A ; step 0.1
	Maximum temperature rise	[0.0 .. 250.0] °C ; step 1.0
	Environment temperature	[-50.0 .. 200.0] °C ; step 1.0
Operate levels	Curve types	IEC 60255-8
	Initial temperature option	Environment or steady-state temperature
	Alarm temperature level	[0.0 .. 250.0] °C ; step 1.0
	Trip temperature level	[0.0 .. 250.0] °C ; step 1.0
	Reclose temperature level	[0.0 .. 250.0] °C ; step 1.0
	Accuracy class	Class 5

Switch-Onto-Fault		
Number of independent functions		1 function
Number of stages (per function)		1 independent overcurrent stage; association with other protection function stages via trip logic
Operational current	Setting range	[0.5 .. 40.0] × I_r ; step 0.01
	Accuracy	± 1% I_{op} (minimum ± 1% I_r)
	Dropout ratio	> 96%
Instantaneous time	Pickup time	20 ms typ. for I > 2 × I_{op}
	Reset time	30 ms typ.
Activation	Origin	External order (CB close command) or dead line detection
	Maximum activation time (after CB closed)	[40 .. 60000] ms ; step 10
Dead line detection	Maximum dead current	[0.05 .. 1.5] × I_r ; step 0.01
	Maximum dead voltage	[0.05 .. 0.8] × U_r ; step 0.01
	Confirmation time	[40 .. 10000] ms ; step 10

Broken Conductor Check / Phase Unbalance		
Number of independent functions		1 function
Detection	Principle	Negative-sequence current / positive-sequence current ratio
	Ratio I_2/I_1	[0.2 .. 1.0] ; step 0.01
	Minimum operating negative-sequence current	2.5% I_r
	Accuracy	2% $(I_2/I_1)_{op}$
	Dropout ratio	> 97% (I_2 > 0.05 × I_r) > 94% (I_2 < 0.05 × I_r)
	Minimum phase current	[0.05 .. 0.3] × I_r ; step 0.01
Operation time	Alarm delay	[100 .. 60000] ms ; step 1
	Reset delay	[0 .. 60000] ms ; step 1
	Time accuracy	± 3% (minimum ± 20 ms)

Undercurrent / Loss of Load

Number of independent functions		1 function
Number of stages (per function)		2 stages
Operational current	Setting range	[0.005 .. 5.0] × I_r ; step 0.001
	Accuracy	± 1% I_{op} (minimum ± 1% I_r)
	Dropout ratio	< 104% I_{op} (minimum dead band 2% I_r)
	Pickup criterion	Any phase or all phases
Definite time (all stages)	Pickup time	55 ms typ.
	Time delay	[0 .. 300000] ms ; step 10
	Time accuracy	± 3% (minimum ± 20 ms)
	Reset type	Instantaneous or delayed
	Reset time	55 ms typ.
	Dropout delay	[0 .. 60000] ms ; step 10
Block conditions	Trip inhibition	Disabled / CB open
	Block time	[0 .. 7200] s ; step 1

Directional Earth-Fault Overcurrent for Non-Earthed Systems

Number of independent functions		2 functions
Principle	Operation quantities	Residual (or neutral) voltage; Residual (or neutral) voltage and residual (or neutral) current
Operational voltage	Setting range	[0.01 .. 3.0] × U_r ; step 0.005 (phase-earth rated voltage)
	Accuracy	± 1% U_{op} (minimum ± 1% U_r)
	Dropout ratio	> 96%
Operational current	Quantity	Residual (or neutral) current
	Setting range (normal CT input)	[0.05 .. 1.0] × I_r ; step 0.001
	Setting range (sensitive CT input)	[0.005 .. 1.0] × I_r ; step 0.001
	Accuracy	± 1% I_{op} (minimum ± 1% I_r)
	Dropout ratio	> 96%
Definite time	Pickup time	35 ms typ.
	Pickup time delay	[0 .. 300000] ms ; step 1
	Operation time delay	[0 .. 300000] ms ; step 1
	Time accuracy	± 3% (minimum ± 20 ms)
	Reset time	35 ms typ.
Directionality	Direction options	Non-directional, forward or reverse
	Polarization	Residual voltage
	Measuring principle	Wattmetric (minimum power) or current phase angle (minimum current magnitude)
	Characteristic angle	[0.0 .. 90.0]° ; step 1.0
	Open angle	[10.0 .. 90.0]° ; step 1.0
	Phase angle accuracy	± 2°
Alarm	Principle	Voltage unbalance
	Minimum voltage	[0.1 .. 2.0] × U_r ; step 0.01
	Maximum voltage	[0.1 .. 2.0] × U_r ; step 0.01

Directional Power		
Number of independent functions		1 function
Number of stages (per function)	Overpower stages	2 stages
	Underpower stages	2 stages
Overpower stages	Operational power	[0.001 .. 1000.0] MVA ; step 0.001
	Accuracy	± 3% S_{op} (minimum ± 1% S_r)
	Dropout ratio	[0.80 .. 0.96] × S_{op} ; step 0.01
	Characteristic angle	[0.0 .. 360.0]° ; step 1.0
Underpower stages	Operational power	[0.001 .. 1000.0] MVA ; step 0.001
	Accuracy	± 3% S_{op} (minimum ± 1% S_r)
	Dropout ratio	[1.04 .. 1.20] × S_{op} ; step 0.01
	Characteristic angle	[0.0 .. 360.0]° ; step 1.0
Definite time (all stages)	Pickup time	35 ms typ. for I > 2 × I_{op}
	Time delay	[0 .. 60000] ms ; step 1
	Time accuracy	± 3% (minimum ± 20 ms)
	Reset time	35 ms typ.
	Dropout delay	[0 .. 60000] ms ; step 1

Phase Undervoltage		
Number of independent functions		2 functions
Number of stages (per function)		2 stages
Operational voltage	Quantity	Phase-phase or phase-earth voltages, in option
	Setting range	[0.01 .. 2.0] × U_r ; step 0.005
	Accuracy	± 1% U_{op} (minimum ± 1% U_r)
	Dropout ratio	< 104%
Definite time (all stages)	Pickup time	35 ms typ.
	Time delay	[0 .. 300000] ms ; step 10
	Time accuracy	± 3% (minimum ± 10 ms)
	Reset time	35 ms typ.
Inverse time (stage 2 only)	Time multiplier	[0.05 .. 15.0] ; step 0.01
	Accuracy class	Class 5
	Reset type	Instantaneous

Phase Overvoltage		
Number of independent functions		2 functions
Number of stages (per function)		2 stages
Operational voltage	Quantity	Phase-phase or phase-earth voltages, in option
	Setting range	[0.01 .. 2.0] × U_r ; step 0.005
	Accuracy	± 1% U_{op} (minimum ± 1% U_r)
	Dropout ratio	> 96%
Definite time (all stages)	Pickup time	35 ms typ.
	Time delay	[0 .. 300000] ms ; step 10
	Time accuracy	± 3% (minimum ± 10 ms)
	Reset time	35 ms typ.
Inverse time (stage 2 only)	Time multiplier	[0.05 .. 15.0] ; step 0.01
	Accuracy class	Class 5
	Reset type	Instantaneous

Residual Overvoltage

Number of independent functions		2 functions
Number of stages (per function)		2 stages
Operational voltage	Quantity	Residual voltage (calculated or open-delta VT) or neutral voltage
	Setting range	$[0.01 .. 3.0] \times U_r$; step 0.005 (phase-earth rated voltage)
	Accuracy	$\pm 1\%\ U_{op}$ (minimum $\pm 1\%\ U_r$)
	Dropout ratio	> 96%
Definite time (all stages)	Pickup time	35 ms typ.
	Time delay	$[0 .. 300000]$ ms ; step 10
	Time accuracy	$\pm 3\%$ (minimum ± 10 ms)
	Reset time	35 ms typ.
Inverse time (stage 2 only)	Time multiplier	$[0.05 .. 15.0]$; step 0.01
	Accuracy class	Class 5
	Reset type	Instantaneous

Negative Sequence Overvoltage

Number of independent functions		1 function
Number of stages (per function)		2 stages
Operational voltage	Quantity	Negative sequence voltage
	Setting range	$[0.01 .. 3.0] \times U_r$; step 0.005 (phase-earth rated voltage)
	Accuracy	$\pm 1\%\ U_{op}$ (minimum $\pm 1\%\ U_r$)
	Dropout ratio	> 96%
Definite time (all stages)	Pickup time	35 ms typ.
	Time delay	$[0 .. 300000]$ ms ; step 10
	Time accuracy	$\pm 3\%$ (minimum ± 10 ms)
	Reset time	35 ms typ.
Inverse time (stage 2 only)	Time multiplier	$[0.05 .. 15.0]$; step 0.01
	Accuracy class	Class 5
	Reset type	Instantaneous

Underfrequency

Number of independent functions		1 function
Number of stages (per function)		5 stages
Operational frequency	Quantity	Phase-phase or phase-earth voltages
	Setting range	$[0.8 .. 1.2] \times f_r$; step 0.0001
	Accuracy	± 10 mHz
	Dropout differential	< 20 mHz
Definite time (all stages)	Pickup time	70 ms typ.
	Time delay	$[0 .. 120000]$ ms ; step 10
	Time accuracy	$\pm 3\%$ (minimum ± 10 ms)
	Reset time	< 100 ms
Block voltage	Setting range	$[0.15 .. 1.0] \times U_r$; step 0.005
	Accuracy	$\pm 1\%\ U_{op}$ (minimum $\pm 1\%\ U_r$)

Overfrequency

Number of independent functions		1 function
Number of stages (per function)		5 stages
Operational frequency	Quantity	Phase-phase or phase-earth voltages
	Setting range	$[0.8 .. 1.2] \times f_r$; step 0.0001
	Accuracy	± 10 mHz
	Dropout differential	< 20 mHz
Definite time (all stages)	Pickup time	70 ms typ.
	Time delay	$[0 .. 120000]$ ms ; step 10
	Time accuracy	± 3% (minimum ± 10 ms)
	Reset time	< 100 ms
Block voltage	Setting range	$[0.15 .. 1.0] \times U_r$; step 0.005
	Accuracy	± 1% U_{op} (minimum ± 1% U_r)

Frequency Rate-of-Change

Number of independent functions		1 function
Number of stages (per function)		5 stages
Rate-of-change of frequency	Quantity	Phase-phase or phase-earth voltages
	Setting range	$[-10.0 .. -0.1] \cup [0.1 .. 10.0]$ Hz/s ; step 0.05
	Accuracy	± 0.1 Hz/s
	Dropout differential	< 0.1 Hz/s
Definite time (all stages)	Pickup time	100 ms typ. for $|df/dt| > 2 \times df/dt_{op}$
	Observation time interval for average calculation	$[10 .. 50]$ cycles ; step 1
	Time delay	$[0 .. 120000]$ ms ; step 10
	Time accuracy	± 3% (minimum ± 10 ms)
	Reset time	< 100 ms
Frequency supervision (optional)	Setting range	$[0.8 .. 1.2] \times f_r$; step 0.0001
	Accuracy	± 10 mHz
Block voltage	Setting range	$[0.15 .. 1.0] \times U_r$; step 0.005
	Accuracy	± 1% U_{op} (minimum ± 1% U_r)

Trip Logic

Number of independent functions		1 function
Operation	Number of circuit breakers	1
	Trip mode	Three-phase
	Switch-onto-fault interaction	Instantaneous trip with SOTF active (for selected protection relay stages)
	Additional outputs	General protection pickup and trip

Trip Circuit Supervision

Number of independent functions		1 function
Supervision	Number of supervised circuits	2 (main and backup)
	Alarm delay	$[500 .. 60000]$ ms
	Reset time	$[500 .. 60000]$ ms

Circuit Breaker Failure		
Number of independent functions		1 function
Number of stages		1 or 2 (only external trip / re-trip and external trip)
Operation principles		Current and / or circuit breaker status supervision
Operational current	Start range	$[0.05 .. 20.0] \times I_r$
	Operational range	$[0.05 .. 1.5] \times I_r$
	Accuracy	$\pm 1\% \, I_{op}$ (minimum $\pm 1\% \, I_r$)
Operation time	Re-trip time delay	[0 .. 30000] ms
	External trip time delay	[50 .. 30000] ms
	Time accuracy	$\pm 3\%$ (minimum ± 10 ms)
	Reset time	15 ms typ.

Automatic Reclosing		
Number of independent functions		1 function
Number of reclose shots		Maximum 5 shots
Channels	Number of channels	5
	Start inputs per channel	Maximum 5 protection function stages associated with each channel
Operation	Channel action options (first 2 cycles)	Ignore / block auto-reclose sequence / start new cycle (wait for protection trip) / start new cycle (auto-reclose trip)
	Channel action options (last 3 cycles)	Ignore / block auto-reclose sequence / start new cycle (wait for protection trip)
	Auto-reclose trip delay (first 2 cycles)	[0 .. 60000] ms
	Dead time (independent per channel and per cycle)	[100 .. 180000] ms
	Wait for master before close command	Optional
	Reclaim time	[100 .. 300000] ms
Block conditions	Maximum CB open time	[10 .. 1000] ms
	Maximum CB close time	[10 .. 1800000] ms
	Maximum wait time for protection trip	[10 .. 300000] ms
	Synchronism check	Disabled / enabled
	Maximum wait time for synchronism	[0 .. 60000] ms
	Maximum dead time	[500 .. 3000000] ms
	CB ready for OFO evaluation	Disabled / before start of auto-reclose sequence / before close command / before start of auto-reclose sequence and before close command
	Block time after successful reclose sequence	[0 .. 300000] ms
	Block time after manual close command	[0 .. 300000] ms
Coordination	Block high-speed protection element	Disabled / always / before second reclose shot / before third reclose shot / before fourth reclose shot / before fifth reclose shot
	Zone Sequence Coordination	Disabled / enabled
Frequent operation alarm	Observation time	[0 .. 720] min
	Maximum number of reclose shots	[1 .. 200]

Synchronism and Voltage Check		
Number of independent functions		1 function
Operation	Operating modes	U_1 dead / U_2 dead
		U_1 live / U_2 dead
		U_1 dead / U_2 live
		U_1 live / U_2 live (synchronous)
		U_1 live / U_2 live (asynchronous)
		Unconditional release
	Command origin	Independent settings for manual and automatic CB close commands
Voltage check	Quantity	Phase-phase or phase-earth voltages
	Maximum dead voltage	$[0.05 .. 0.8] \times U_r$
	Minimum live voltage	$[0.2 .. 1.2] \times U_r$
	Maximum voltage	$[0.5 .. 1.5] \times U_r$
	Accuracy	$\pm 1\% \, U_{op}$ (minimum $\pm 1\% \, U_r$)
	Dropout differential	$< 2\% \, U_r$
Frequency check	Permitted operating range	$f_r \pm 3$ Hz
Magnitude difference	Setting range	$[0.01 .. 0.5] \times U_r$
	Accuracy	$\pm 1\% \, U_r$
Phase angle difference	Setting range	$[2.0 .. 80.0]°$
	Accuracy	$\pm 2°$
Frequency difference	Setting range	$[0.01 .. 1.0]$ Hz
	Accuracy	± 10 mHz
Asynchronous operation	Maximum frequency difference	$[0.02 .. 2.0]$ Hz
	CB close time	$[10 .. 500]$ ms
Confirmation time	Minimum measuring time	70 ms
	Time delay	$[0 .. 60000]$ ms
	Time accuracy	$\pm 3\%$ (minimum ± 10 ms)
Measurements	Magnitude difference accuracy	$1\% \, U_r$
	Phase angle difference accuracy	$2°$
	Frequency difference accuracy	20 mHz

Circuit Breaker Close Lock / Lockout		
Number of independent functions		1 function
Lock	Mode	Latched (resettable by user); unlatched; timed
	Reset time (for unlatched lock)	$[0 .. 3600]$ s
	Lock time (for timed lock)	$[1 .. 3600]$ s

Fuse Failure / VT Supervision		
Number of independent functions		1 function
Operation principles		MCB status supervision; analogue signal validation (asymmetrical / symmetrical failures)
Asymmetrical failure detection	Principle	Voltage and current unbalance (residual and negative-sequence components)
	Residual voltage threshold	[0.01 .. 1.0] × U_r (phase-earth rated voltage)
	Residual current threshold	[0.05 .. 1.0] × I_r
	Negative-sequence voltage threshold	[0.01 .. 1.0] × U_r (phase-earth rated voltage)
	Negative-sequence current threshold	[0.05 .. 1.0] × I_r
	Operation time	25 ms typ.
	Latch time	[1000 .. 20000] ms
Symmetrical failure detection	Principle	Three-phase undervoltage and current variation
	Voltage threshold	[0.01 .. 1.0] × U_r
	Current variation	[0.1 .. 1.0] × I_r
	Operation time	25 ms typ.
Voltage measurement evaluation	Alarms	Voltage absence check; polarity and sequence check
	Evaluation time	[1000 .. 60000] ms
Minimum current	Setting range	[0.05 .. 1.0] × I_r

CT Supervision		
Number of independent functions		1 function
Operation principles		Analogue signal validation (asymmetrical / symmetrical failures)
Asymmetrical failure detection	Principle	Comparison with reference current and/or voltage
	Residual current threshold	[0.05 .. 4.0] × I_r
	Reference residual current threshold	[0.05 .. 4.0] × I_r
	Reference residual voltage threshold	[0.01 .. 1.0] × U_r
	Operation time	25 ms typ.
Symmetrical failure detection	Principle	Three-phase current drop and variation of reference current and/or voltage
	Pre-fault current threshold	[0.1 .. 1.0] × I_r
	Operation time	25 ms typ.
Alarm time	Time delay	[0 .. 60000] ms
Current measurement evaluation	Alarms	Polarity and sequence check
	Evaluation time	[1000 .. 60000] ms
	Minimum current	[0.05 .. 1.0] × I_r

Circuit Breaker Control		
Number of independent functions		1 function
Blocking / release conditions	Block inputs (per type of command)	Independent for open and close commands
	Block inputs (per origin)	Independently defined for: general block, local manual command block, remote manual command block, automatic command block
	Interlocking	Freely programmed by user
	Synchronism check (for close commands)	Interaction with synchronism check function (disabled / enabled)
	Maximum wait time for synchronism	[0 .. 600000] ms
Block / interlocking bypass	Mode	Latched / timed
	Bypass time	[0 .. 3600] s
Hit & run	Open command delay	[0 .. 300] s
	Close command delay	[0 .. 300] s

Circuit Breaker Supervision

Number of independent functions		1 function
CB command	Minimum open command time	[0 .. 60000] ms
	Minimum close command time	[0 .. 60000] ms
	Adaptive pulse	Disabled / enabled
CB status supervision	Intermediate state filtering	Disabled / enabled
	Filter time for intermediate state	[0 .. 60000] ms
CB operation supervision	Maximum start time	[0 .. 60000] ms
	Maximum operation time	[0 .. 60000] ms
	Maximum operation counter	[0 .. 100000]
	Maximum switched square current sum	[1.0 .. 99999.0] kA^2

Three-Phase Measurements

Number of independent functions		1 function
Orientation		Forward or reverse
Current	Measurements	Phase, residual, neutral, symmetrical components
	Magnitude accuracy	0.25% I_r
	Phase angle accuracy	0.2°
	Range	[0.05 .. 2.0] × I_r
Voltage	Measurements	Phase-earth, phase-phase, residual, neutral, symmetrical components
	Magnitude accuracy	0.25% U_r
	Phase angle accuracy	0.2°
	Range	[0.05 .. 2.0] × U_r
Power	Measurements	Active, reactive, apparent and power factor (total and per phase)
	Accuracy	0.5% S_r
	Range	[0.05 .. 2.0] × S_r
Frequency	Accuracy	10 mHz
	Range	f_r ± 3 Hz

Single-Phase Measurements

Number of independent functions		1 function
Orientation		Forward or reverse
Current	Measurements	Phase, residual or neutral
	Magnitude accuracy	0.25% I_r
	Phase angle accuracy	0.2°
	Range	[0.05 .. 2.0] × I_r
Voltage	Measurements	Phase-earth, phase-phase, residual or neutral
	Magnitude accuracy	0.25% U_r
	Phase angle accuracy	0.2°
	Range	[0.05 .. 2.0] × U_r
Power	Measurements	Active, reactive, apparent and power factor
	Accuracy	0.5% S_r
	Range	[0.05 .. 2.0] × S_r
Frequency	Accuracy	10 mHz
	Range	f_r ± 3 Hz

Metering		
Number of independent functions		1 function
Orientation		Forward or reverse
Energy counters	Active	Forward, reverse and total
	Reactive	Forward, reverse and total
	Apparent	Total
Accuracy		0.5%

Fault Locator		
Number of independent functions		1 function
Line parameters	Line section length	[0.1 .. 1000.0] length units
	Length units	km / miles
	Positive sequence resistance	[0.01 .. 500.0] Ω
	Positive sequence reactance	[0.01 .. 500.0] Ω
	Zero sequence resistance	[0.01 .. 500.0] Ω
	Zero sequence reactance	[0.01 .. 500.0] Ω
Fault location	Measuring principle	Local quantities (phase currents and voltages)
	Outputs	Fault type, fault loop, fault impedance, fault loop resistance and reactance, fault resistance, fault distance
	Fault distance	In ohm, km, miles and percentage of total line length
	Accuracy	2% of total line length (30° < φ < 90°)

Disturbance Recorder		
Recording	Number of records	Max. 200
	Sampling rate	40 samples per cycle at rated frequency (2 kHz @ f_r = 50 Hz; 2.4 kHz @ f_r = 60 Hz)
	Trigger options	External (user command), internal (analogue and binary channel supervision) or both
	Retrigger	Disabled / enabled
	Pre-fault time	[50 .. 500] ms
	Post-fault time	[50 .. 2000] ms
	Maximum record duration	[200 .. 10000] ms
	Maximum record duration (manual trigger)	[200 .. 10000] ms
	Action when memory is full	Overwrite older records
Analogue channels	Number	Up to 10 channels
	Trigger options	Defined by trigger levels (high / low) or none (only register)
	High trigger level	[0.0 .. 999999.9] (in A for currents, kV for voltages)
	Low trigger level	[0.0 .. 999999.9] (in A for currents, kV for voltages)
Binary channels	Number	Up to 96 channels
	Trigger options	Rising edge, falling edge, none (only register)

Event Log		
Recording	Total number of events	Max. 25000
	Chronological order of events	Ascendant / descendant
	Time resolution	1 ms
	Local HMI visualization	Last 100 events
	Action when memory is full	Overwrite older records
Entities	Number	Max. 3000
	Reason for inclusion	Configurable (data-change, quality-change, data-update, range-change)

Fault Report		
Recording	Total number of reports	Max. 50
	Trigger	General protection pickup (trip logic)
	Fault type	Record a report every time a fault occurs or only in case a protection function tripped
	Recorded information	Fault summary, timeline, pre-fault and fault measurements, correlated disturbance records
	Local HMI visualization	Last report
	Action when memory is full	Overwrite older records

User Programmable Automation / Logic	
Maximum number of tasks	3
Scheduling	Preemptive multi-tasking (1 thread per task)
Distinct task priority levels	3
Maximum number of programs	64
Code area size	32 KB
Global area size (data and stack)	32 KB
On-event program execution	Yes, multi-event
Execution triggering events	Multiple device data changes / updates High-performance timers Control execution Cycle
Basic data types	Boolean, Floating points (32, 64 bits) and Integers (8, 16, 32, 64 bits)
Date / time	Yes
Programming languages	IEC 61131-3 ST and FBD
Standard library	Full
User function block libraries	Yes
In-tool code simulation	Available
Logical device association	Free association of user functions to logical devices
Setting groups	Settings freely defined for user functions

Input / Output Processing		
AC analogue inputs	Channel inputs	Phase-earth, phase-phase or neutral inputs
	Orientation	Forward or reverse
	Primary rated value	[0.0 .. 10000.0] (in A for currents, kV for voltages)
	External measuring transformer ratio	[1.0 .. 20000.0]
Binary inputs	Types of entities	Single status / double status / integer status / pulse counters
	Intermediate state filtering (double status)	Disabled / enabled
	Filter time for intermediate state (double status)	[0 .. 30000] ms
	Code (integer status)	Binary / Gray / BCD / 1-of-N / Signed BCD
	Number of inputs (integer status)	Max. 32 bits (1-of-N code) Max. 6 bits (other codes)
	Pulse type (pulse counters)	Rising edge, falling edge or both
Binary outputs	Types of entities	Single / double (status or controls)
	Number of entities per output	Max. 16 entities per output (logical OR)

Device and Function Management

Logical devices	Number	Max. 4
	Mode	Off / On / Test
	Set of functions	Free association of functions (built-in or user-defined)
Setting groups	Number of groups	4 (per logical device)
	Switchover	Via engineering tool, local HMI, remote control or logical condition (freely programmed by user)
Switching hierarchy	Switching authority levels	Process, bay, station and control centre
	Multilevel control	Disabled (only one switching authority allowed) / enabled (more than one switching authority)

Human-Machine Interface

|		
IED status indications	Available indications	POWER, RUN and COMM
	Blinking (RUN indication)	Configurable by user
Alarms	Number	8
	Colour	Red
	Entities	Max. 16 entities per alarm (logical OR)
	Mode of operation	Unlatched or latched (resettable by user)
	Blinking (latched alarms)	Configurable by user
User-defined function keys	Number	3
	Mode of operation	Status and/ or control, shortcut, selection from a list of options
Event log keys	Number	1
Local / remote keys	Number	1
CB command	Command keys	3 (selection key, CB open and CB close commands)
	Command confirmation	Confirmation required / Press 2 keys / Press 2 keys with confirmation
Display	Type	20 × 4 alphanumeric LCD
	Language	Portuguese / English / Spanish / French / Russian Others available (please contact)
	Information handling	Menu oriented
	Available information	Operation and control, management of operational settings, active setting groups and operating modes, IED status monitoring, access to measurements and records, among other actions, are available in the menu structure.
Web interface	Access	Local (via service front Ethernet port) or remote (via system rear Ethernet ports)
	Available information	Visualization of operational settings, active setting groups and operating modes, IED status monitoring, access to measurements and records, among other actions.

RTC and Clock Synchronization

Application clock	Resolution	1 ms
	Time deviation (internal clock)	Max. 0.005%
	Synchronization	IRIG-B, NTP/ SNTP time slave or through communication protocol
	Backup power	Yes, lithium battery
	Local time offset	Adjustable
	Daylight savings configuration	Adjustable

IEC 61850		
IEC 61850-8-1 Server	Number of simultaneous clients	Max. 6
	Number of datasets	Max. 128
	Number of data attributes per dataset	Max. 128
	Maximum report control blocks (RCB)	Max. 128
	Buffered / unbuffered reports	Yes
IEC 61850-8-1 GOOSE	Number of published GOOSE control blocks	64
	Number of subscribed GOOSE control blocks	64

Other Communication Protocols	
Protocols Up/ Slave	IEC 60870-5-104 (TCP/IP) / IEC 60870-5-101 (Serial)
	IEC 60870-5-103 (Serial)
	DNP 3.0 (TCP/IP or Serial)
	Modbus (TCP/IP or Serial)
	Others available (Please Contact)

Automation Studio Engineering Software Integration	
IED configuration editors	Yes
IEC 61131-3 programming	Yes
Advanced 2D mimic design tools	Yes
System Engineering tools	Yes
Compound mimic symbols	Available
SVG and raster import	Available
Library projects	Yes
Device templates	Available
Settings static validation	Yes
Microsoft Excel® iterative import / export	Yes
Settings comparison	Yes
In-tool simulation	Available for user defined functions, mimics and RTDB
IEC 61850 SCL import / export	Yes
IEC 61850 user logical node designer	Available
SCL cross-validator integration	Available
Online monitoring integration	Available (IEC 61850 based and proprietary protocol)
Logics monitoring	Available
Add live device to project	Yes
Deploy / extract configuration settings	Yes
Extract records	Yes
Integrated analysis tools	COMTRADE, Fault Reports, SOE, System Logs, Statistical Data Trends
Team revision control system	Yes
Auto data retrieval and handling	Yes

DIMENSIONS
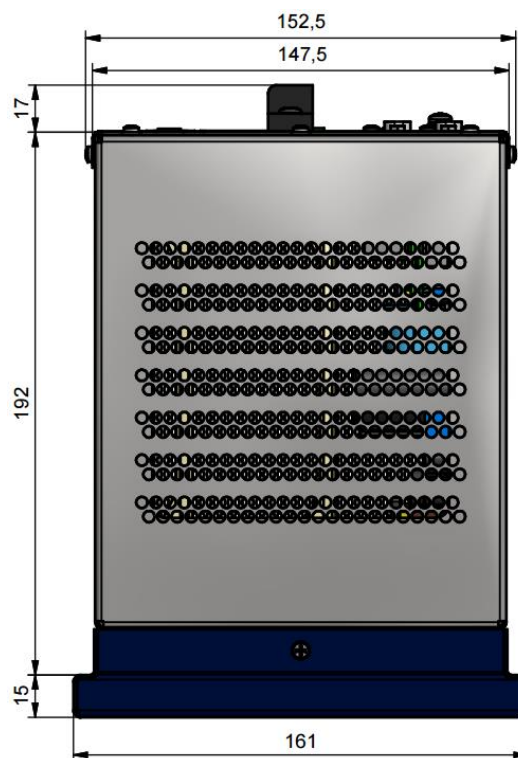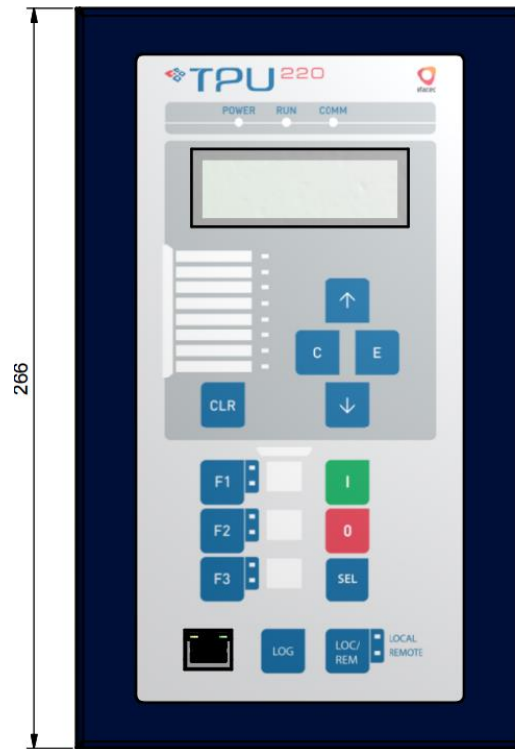
All dimensions in millimetres
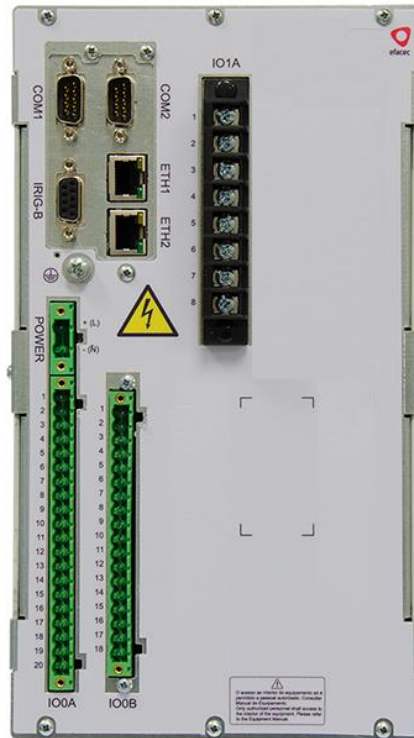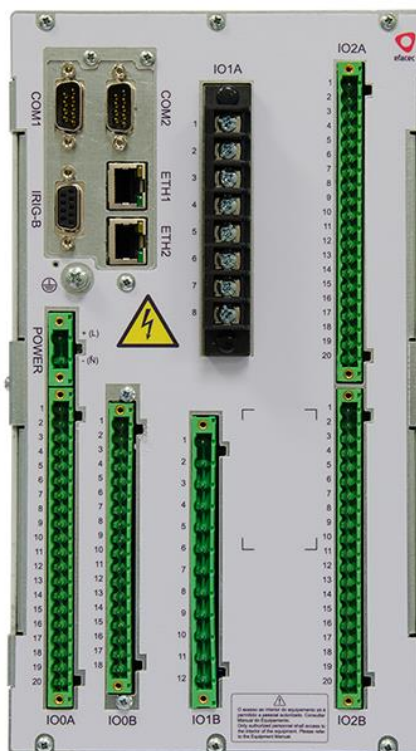
Mounting

150

264
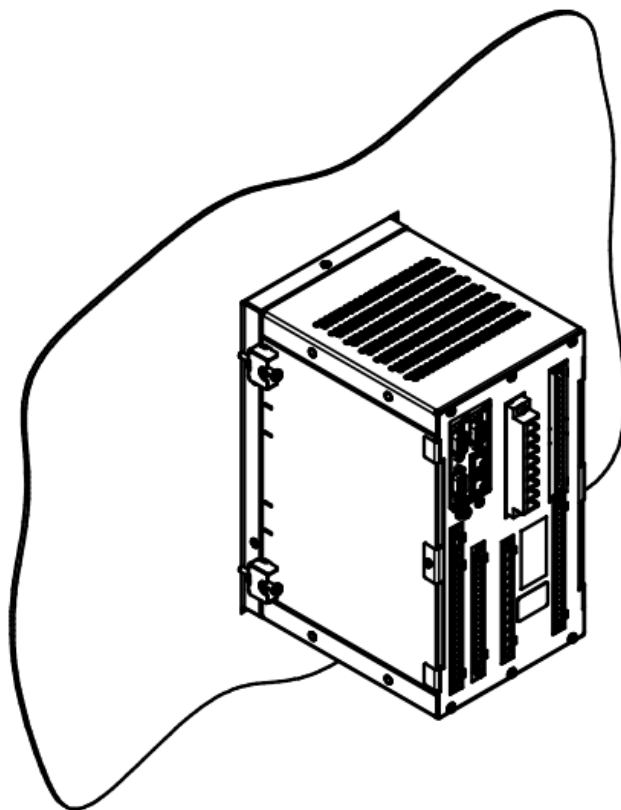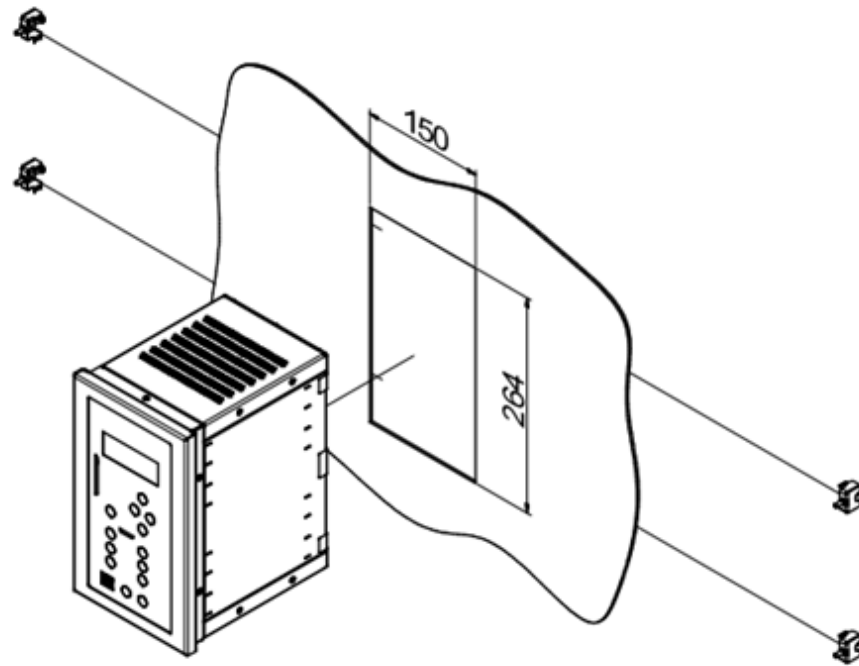
All dimensions in millimetres

CONNECTORS IDENTIFICATION

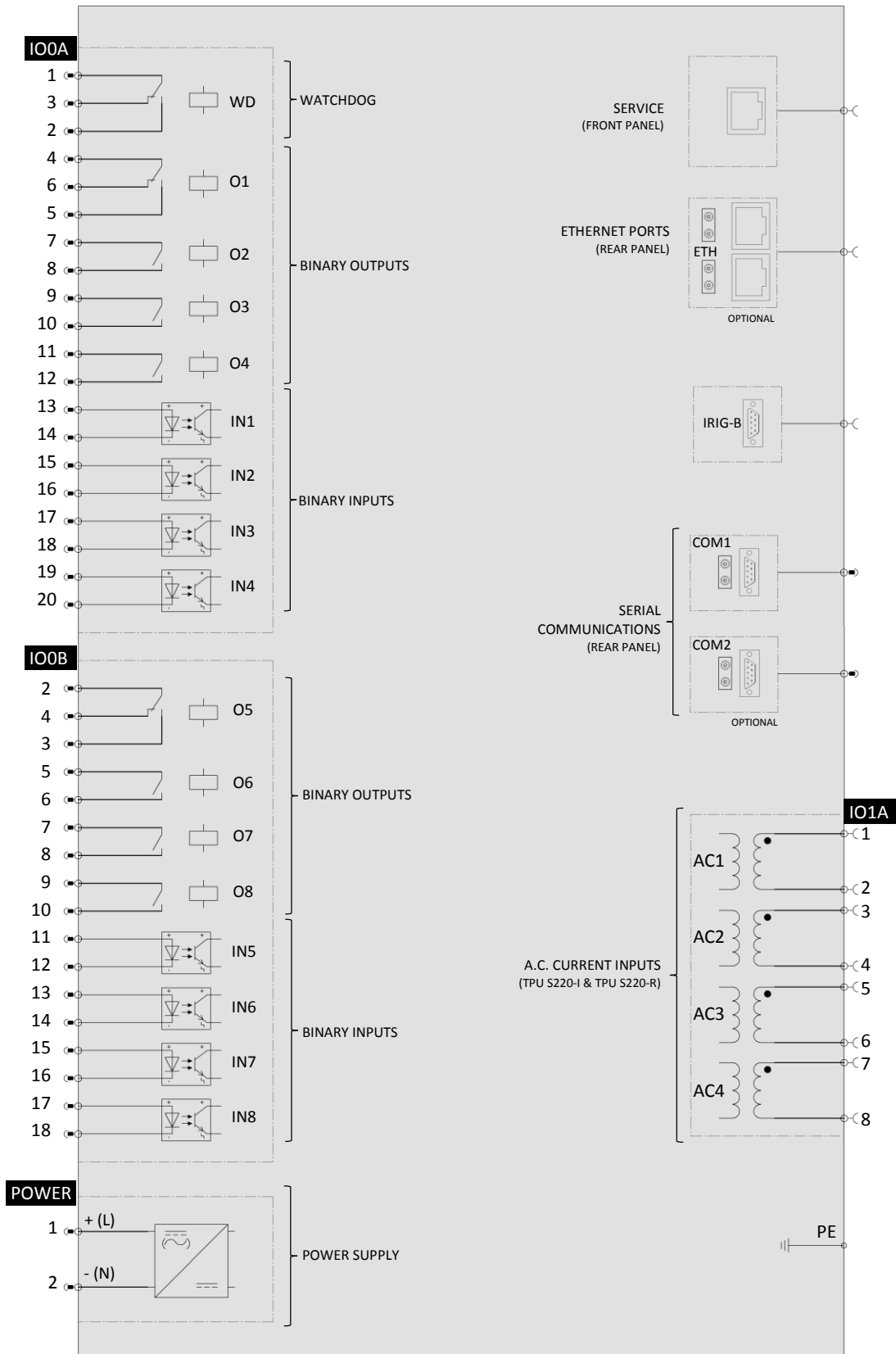## 1/3 x 19'' CASE WITH 4 A.C. ANALOGUE INPUTS, BACK SIDE VIEW

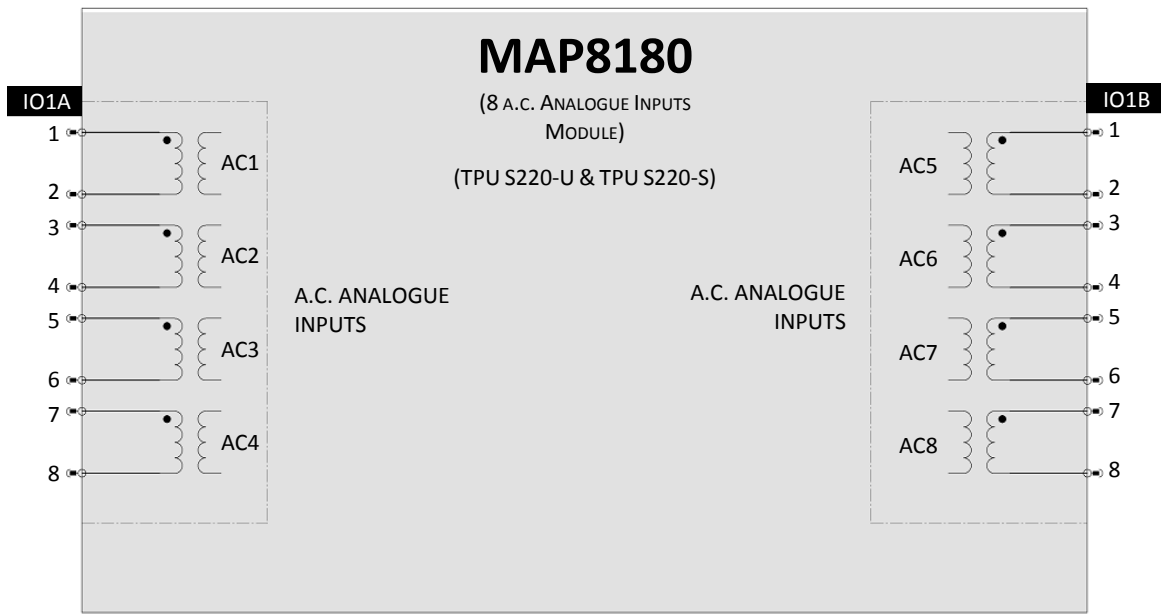## 1/3 x 19'' CASE WITH 8 A.C. ANALOGUE INPUTS AND EXPANSION BINARY IO, BACK SIDE VIEW
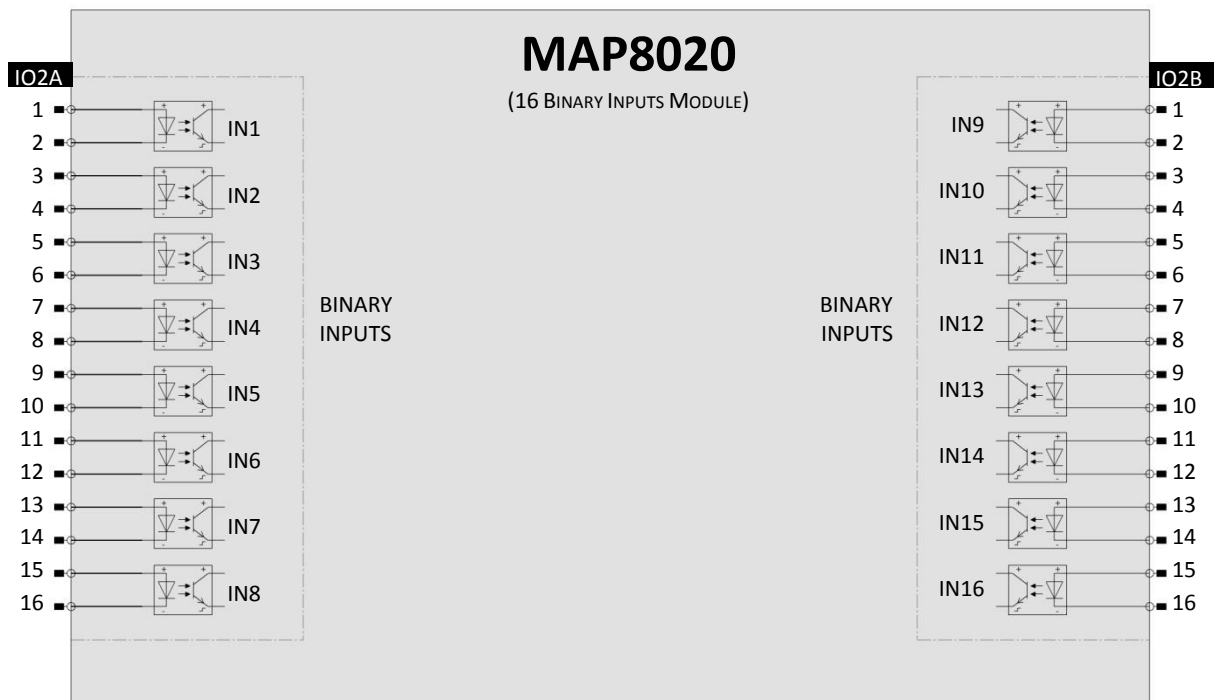
WIRING DIAGRAMS

## POWER SUPPLY, BASE I/O AND COMMUNICATIONS (MAP8100)

IO0A

1		
3	WD	WATCHDOG
2		

4		
6	O1	
5		
7	O2	
8		BINARY OUTPUTS
9	O3	
10		
11	O4	
12		

13	IN1	
14		
15	IN2	
16		BINARY INPUTS
17	IN3	
18		
19	IN4	
20		

IO0B

2		
4	O5	
3		
5	O6	
6		BINARY OUTPUTS
7	O7	
8		
9	O8	
10		

11	IN5	
12		
13	IN6	
14		BINARY INPUTS
15	IN7	
16		
17	IN8	
18		

POWER

| 1 | + (L) | |
| 2 | - (N) | POWER SUPPLY |

SERVICE
(FRONT PANEL)

ETHERNET PORTS
(REAR PANEL)
ETH
OPTIONAL

IRIG-B

SERIAL
COMMUNICATIONS
(REAR PANEL)
COM1
COM2
OPTIONAL

IO1A

AC1 — 1, 2
AC2 — 3, 4
AC3 — 5, 6
AC4 — 7, 8

A.C. CURRENT INPUTS
(TPU S220-I & TPU S220-R)

PE

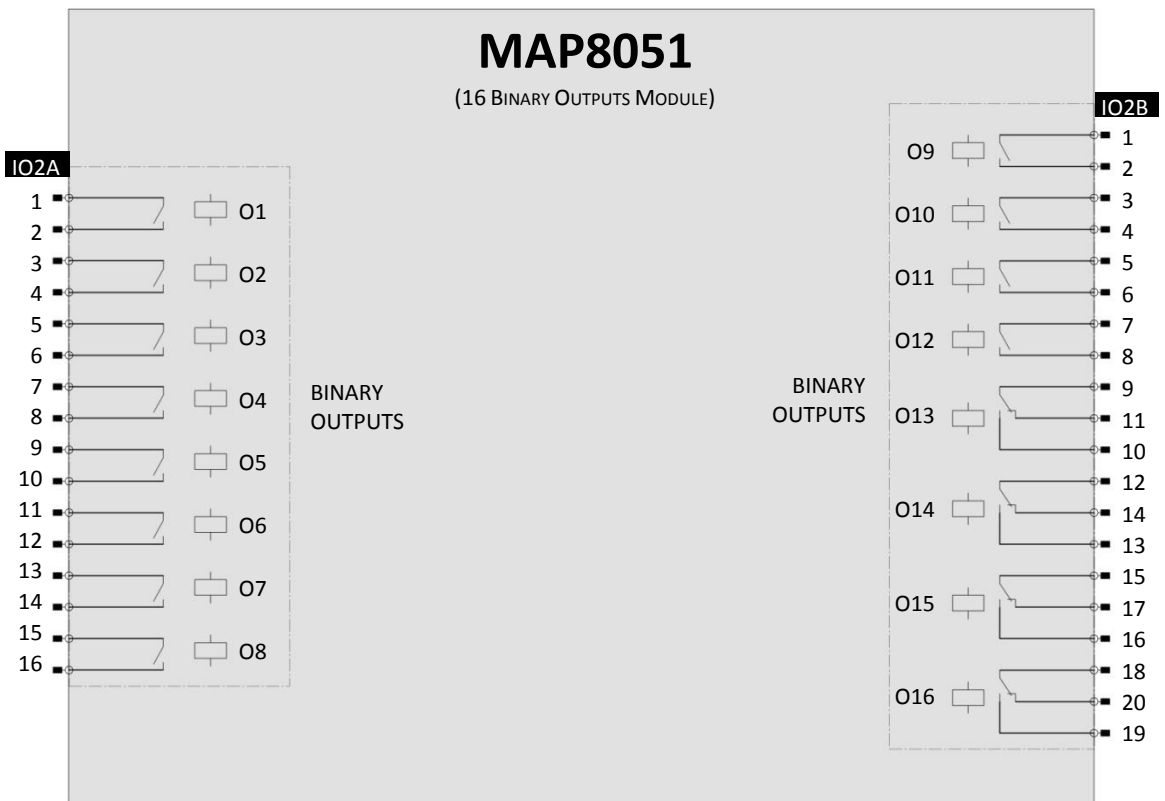## 8 A.C. ANALOGUE INPUTS MODULE (MAP8180)

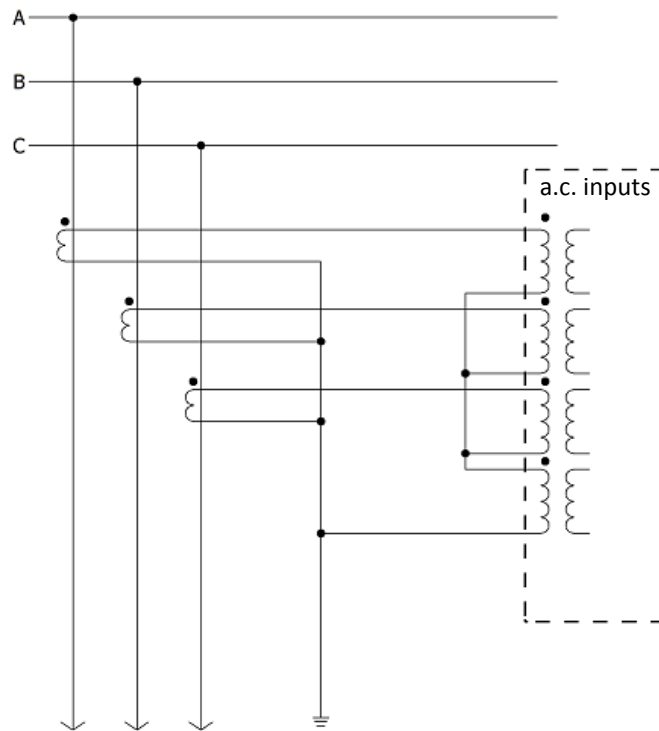

16 BINARY INPUTS MODULE (MAP8020)

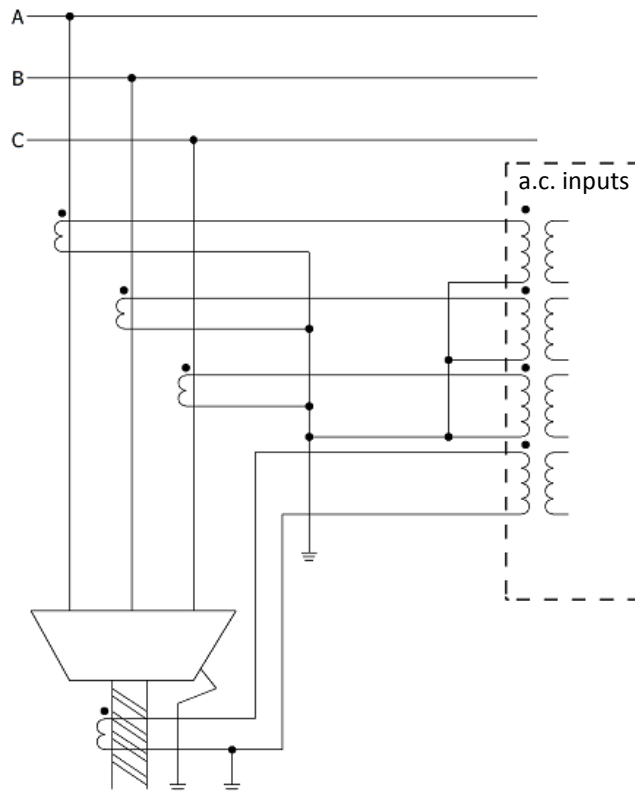### 8 BINARY INPUTS + 8 BINARY OUTPUTS MODULE (MAP8030)
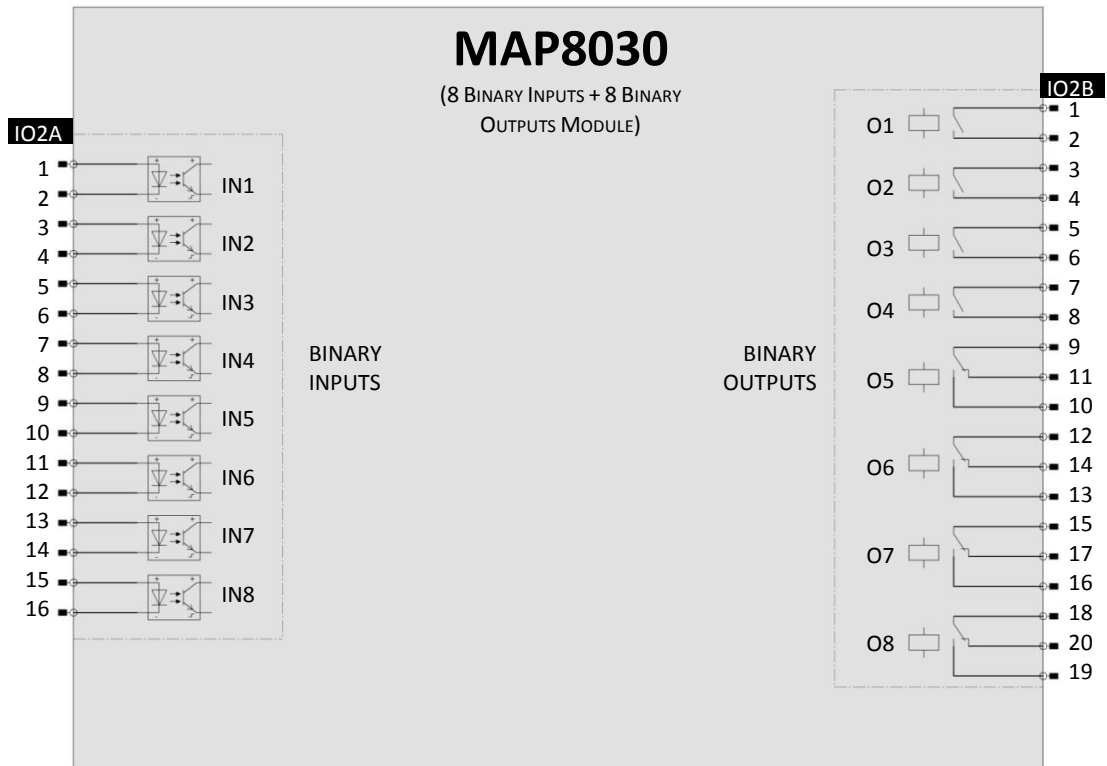
### 16 BINARY OUTPUTS MODULE (MAP8051)

TYPICAL CONNECTIONS FOR A.C. CURRENT INPUTS

Phase and earth current inputs connection, with residual current obtained from the three phase currents by external Holmgreen circuit. Typical for low-impedance earthed systems.


Phase and earth current inputs connection, with an independent phase-balance neutral current transformer for earth current measurement. Required in the case of isolated or compensated networks and for sensitive earth-fault detection.
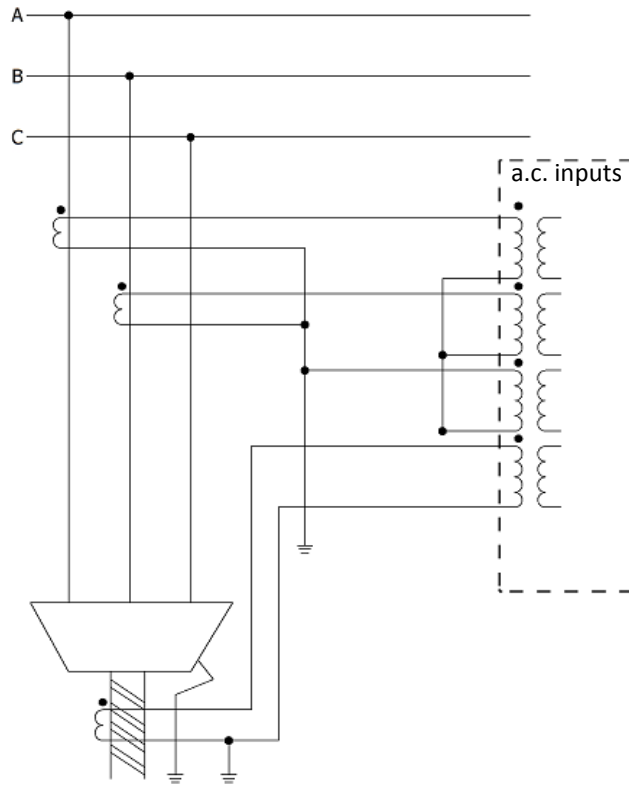
Phase and earth current inputs connection, with current transformers in only two phases. An independent neutral current transformer is required for earth current measurement. Optionally, the third phase current can be obtained from the other two by external circuitry.

TYPICAL CONNECTIONS FOR A.C. VOLTAGE INPUTS
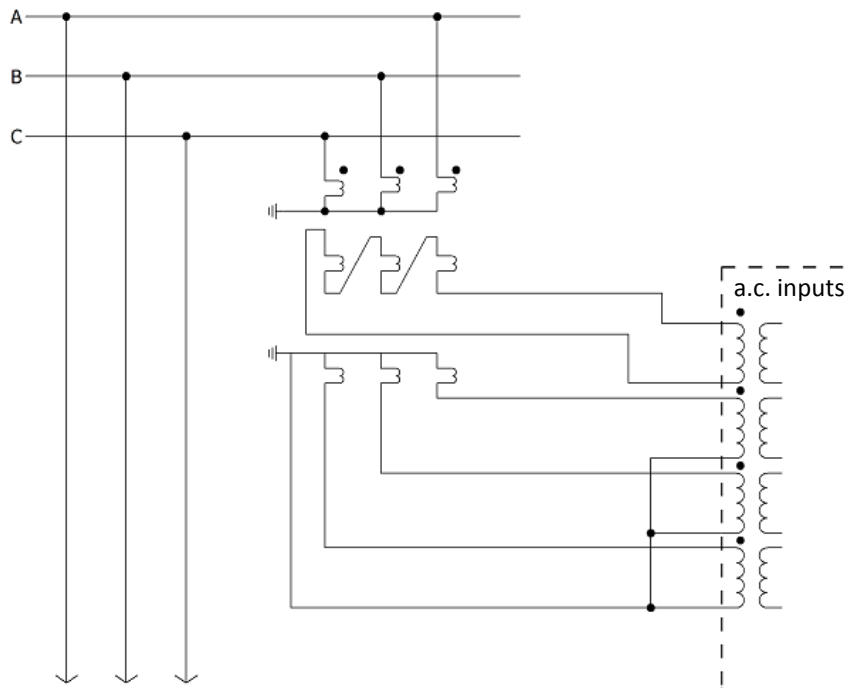
Three phase-to-earth voltage transformer connection, with an independent open-delta connected winding for residual voltage measurement. The fourth voltage input can provide polarization for directional earth-fault protection.
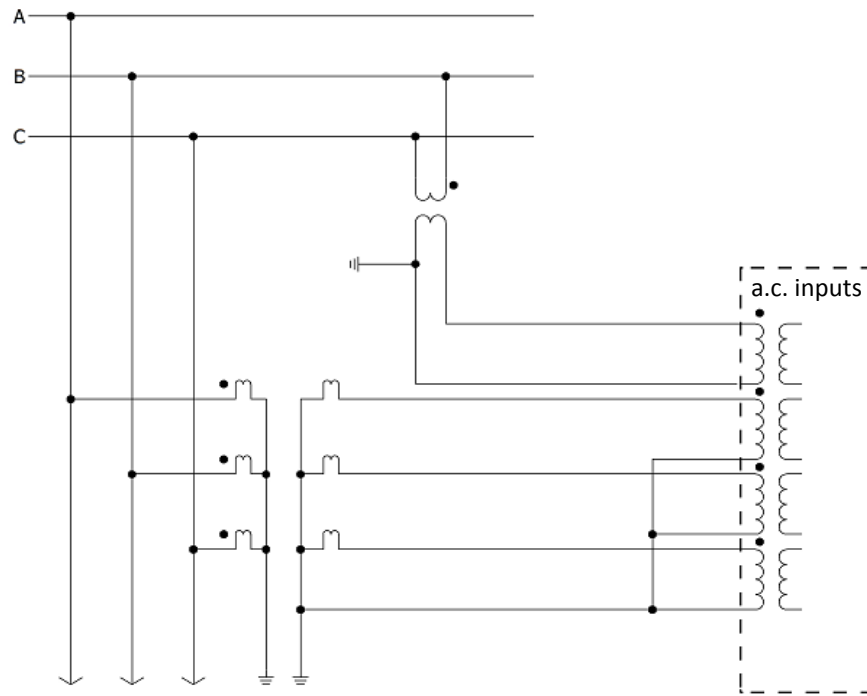
Three phase-to-earth voltage transformer connection and an additional phase-to-phase voltage input for busbar voltage measurement. Fourth voltage connection required for synchronism check applications. Polarization for directional earth-fault protection can be obtained from the internal sum of phase-to-earth voltages.
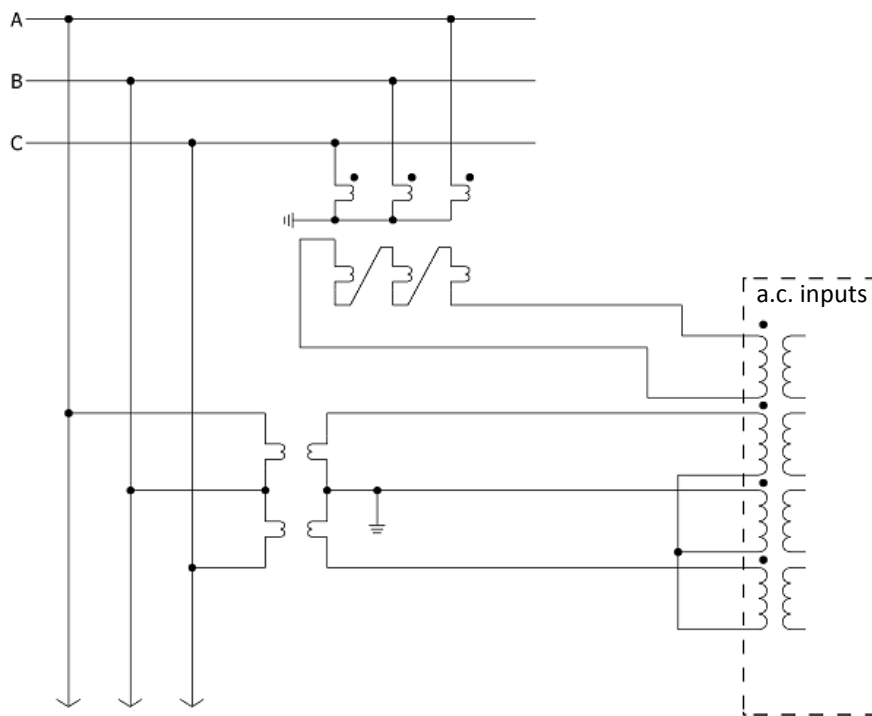
Alternative voltage transformer connection, with three phase-to-earth voltages obtained from two phase-to-phase voltage transformers (Aron circuit). Independent open-delta connected winding is required for residual voltage measurement.

PINOUT TABLES

POWER SUPPLY

POWER	
1	Power Supply + (L)
2	Power Supply - (N)

BASE BINARY I/O MODULE (MAP8100)

Base Binary I/O Module (MAP8100), see connectors description below					
IO0A			**IO0B**		
1		Common	1	Not Connected	
2	Watchdog Output	Normally Open	2		Common
3		Normally Closed	3	Binary Output 5	Normally Open
4		Common	4		Normally Closed
5	Binary Output 1	Normally Open	5	Binary Output 6	Normally Open
6		Normally Closed	6		
7	Binary Output 2	Normally Open	7	Binary Output 7	Normally Open
8			8		
9	Binary Output 3	Normally Open	9	Binary Output 8	Normally Open
10			10		
11	Binary Output 4	Normally Open	11	Binary Input 5	+
12			12		-
13	Binary Input 1	+	13	Binary Input 6	+
14		-	14		-
15	Binary Input 2	+	15	Binary Input 7	+
16		-	16		-
17	Binary Input 3	+	17	Binary Input 8	+
18		-	18		-
19	Binary Input 4	+			
20		-			

BASE ANALOGUE I/O MODULE (MAP8100 OR MAP8180)

Base Analogue I/O Module (MAP8100 or MAP8180), see connectors description below		Order Code					Order Code	
IO1A		F	G	H	**IO1B**		F	G & H
1	a.c. Analogue Input 1	CT	CT	CT	1	a.c. Analogue Input 5	-	VT
2					2			
3	a.c. Analogue Input 2	CT	CT	CT	3	a.c. Analogue Input 6	-	VT
4					4			
5	a.c. Analogue Input 3	CT	CT	CT	5	a.c. Analogue Input 7	-	VT
6					6			
7	a.c. Analogue Input 4	CT	CT	Sensitive CT	7	a.c. Analogue Input 8	-	VT
8					8			
					9	Not Connected		
					10			
					11			
					12			

16 Binary Inputs Module (MAP8020)

16 Binary Inputs Module (MAP8020), see connectors description below						
IO2A				**IO2B**		
1	Binary Input 1	+		1	Binary Input 9	+
2		-		2		-
3	Binary Input 2	+		3	Binary Input 10	+
4		-		4		-
5	Binary Input 3	+		5	Binary Input 11	+
6		-		6		-
7	Binary Input 4	+		7	Binary Input 12	+
8		-		8		-
9	Binary Input 5	+		9	Binary Input 13	+
10		-		10		-
11	Binary Input 6	+		11	Binary Input 14	+
12		-		12		-
13	Binary Input 7	+		13	Binary Input 15	+
14		-		14		-
15	Binary Input 8	+		15	Binary Input 16	+
16		-		16		-
17	Not connected			17	Not connected	
18				18		
19				19		
20				20		

8 Binary Inputs + 8 Binary Outputs Module (MAP8030)

8 Binary Inputs + 8 Binary Outputs Module (MAP8030), see connectors description below						
IO2A				**IO2B**		
1	Binary Input 1	+		1	Binary Output 1	Normally Open
2		-		2		
3	Binary Input 2	+		3	Binary Output 2	Normally Open
4		-		4		
5	Binary Input 3	+		5	Binary Output 3	Normally Open
6		-		6		
7	Binary Input 4	+		7	Binary Output 4	Normally Open
8		-		8		
9	Binary Input 5	+		9	Binary Output 5	Common
10		-		10		Normally Open
11	Binary Input 6	+		11		Normally Closed
12		-		12	Binary Output 6	Common
13	Binary Input 7	+		13		Normally Open
14		-		14		Normally Closed
15	Binary Input 8	+		15	Binary Output 7	Common
16		-		16		Normally Open
17	Not connected			17		Normally Closed
18				18	Binary Output 8	Common
19				19		Normally Open
20				20		Normally Closed

16 BINARY OUTPUTS MODULE (MAP8051)

16 Binary Outputs Module (MAP8051), see connectors description below						
IO2A				**IO2B**		
1	Binary Output 1	Normally Open		1	Binary Output 9	Normally Open
2				2		
3	Binary Output 2	Normally Open		3	Binary Output 10	Normally Open
4				4		
5	Binary Output 3	Normally Open		5	Binary Output 11	Normally Open
6				6		
7	Binary Output 4	Normally Open		7	Binary Output 12	Normally Open
8				8		
9	Binary Output 5	Normally Open		9	Binary Output 13	Common
10				10		Normally Open
11	Binary Output 6	Normally Open		11		Normally Closed
12				12	Binary Output 14	Common
13	Binary Output 7	Normally Open		13		Normally Open
14				14		Normally Closed
15	Binary Output 8	Normally Open		15	Binary Output 15	Common
16				16		Normally Open
17	Not Connected			17		Normally Closed
18				18	Binary Output 16	Common
19				19		Normally Open
20				20		Normally Closed

SERIAL PORTS

COM1 & COM2	RS-232	RS-485
1	Not Connected	Not Connected
2	RxD *(Input Receive Data)*	DATA-
3	TxD *(Output Transmit Data)*	Not Connected
4	Not Connected	Not Connected
5	GND *(Ground)*	GND
6	Not Connected	Not Connected
7	RTS *(Output Request To Send)*	DATA+
8	CTS *(Input Clear To Send)*	Not Connected
9	Not Connected	Not Connected

IRIG-B

IRIG-B	
1	Not Connected
2	Not Connected
3	5 V Level Input
4	12 V Level Input
5	GND *(Ground)*
6	Not Connected
7	24 V Level Input
8	Not Connected
9	Not Connected

CONNECTORS DESCRIPTION

The next table lists all the external connectors included and supplied with the equipment:

CONNECTOR FOR POWER SUPPLY

Phoenix Front-GMSTB 2.5/2-STF-7.62 (1805987) type connector, 2 contacts. Accepts conductors with section from 0.2 mm² to 2.5 mm². The connection is made by screw with the help of a screw driver size 0.6 x 3.5 mm. Tightening torque: 0.5 – 0.6 Nm.

CONNECTOR FOR BINARY INPUTS AND BINARY OUTPUTS (EXCEPT IO0B)

Phoenix Front-MSTB 2.5/20-STF-5.08 (1777976) type connector, 20 contacts. Accepts conductors with section from 0.2 mm² to 2.5 mm². The connection is made by screw with the help of a screw driver size 0.6 x 3.5 mm. Tightening torque: 0.5 – 0.6 Nm.

CONNECTOR FOR BINARY INPUTS AND BINARY OUTPUTS (IO0B)

Phoenix Front-MSTB 2.5/18-STF-5.08 (1778140) type connector, 18 contacts. Accepts conductors with section from 0.2 mm² to 2.5 mm². The connection is made by screw with the help of a screw driver size 0.6 x 3.5 mm. Tightening torque: 0.5 – 0.6 Nm.

CONNECTOR FOR A.C. VOLTAGE INPUTS (IO1B)

Phoenix Front-GMSTB 2.5/12-STF-7.62 (1806106) type connector, 12 contacts. Accepts conductors with section from 0.2 mm² to 2.5 mm². The connection is made by screw with the help of a screw driver size 0.6 x 3.5 mm. Tightening torque: 0.5 – 0.6 Nm.

TERMINAL FOR CONNECTION OF A.C. CURRENT INPUTS (IO1A)

Terminal Barrier type connector, 8 contacts. Accepts M3.5 or M4 ring-type lug terminals (max. 8 mm external diameter) for conductors with cross-sections from 1.5 to 4.0 mm². The connection is made by DIN 5.5 x 1.0 screwdriver or a PZ2 screwdriver. Tightening torque: 0.8 – 1.0 Nm.

TERMINAL FOR CONNECTION TO EARTH PROTECTION

Terminal to be fitted by M4 screw, for connection to Earth Protection. This connection is essential for the correct operation of the TPU S220. It should be solid for security reasons.

ORDER FORM

TPU S220 - 2 - A - B - C - D - E - F - G - H - I - J - K

Variant

	I
	R
	U
	S

Region

Standard ⌂	1
Eastern Europe and Central Asia	2

Power Supply

24 / 48 / 60 V d.c.	1
48 / 60 / 110 / 125 / 220 / 250 V d.c.; 115 / 230 V a.c. ⌂	2

Binary Input Rated Voltage

24 V d.c.	A
48 / 60 V d.c.	B
110 / 125 V d.c.	C
220 / 250 V d.c.	D

Base Binary I/O

For Variant I:	
4 Binary Inputs + 4 Binary Outputs	A
For Variants R, U and S:	
8 Binary Inputs + 8 Binary Outputs	B

Base Analogue I/O

For Variants I and R:	
4 CT	F
For Variants U and S:	
4 CT + 4 VT ⌂	G
3 CT + 1 sensitive CT + 4 VT	H

Expansion I/O

Not used ⌂	X
Only for Variants U and S:	
8 Binary Inputs + 8 Binary Outputs	P
16 Binary Outputs	Q
16 Binary Inputs	R

COM1 Interface

RS-232 ⌂	1
RS-485	2

COM2 Interface

Not used ⌂	X
RS-232	1
RS-485	2
Plastic Fibre Optics	3
Glass Fibre Optics	4

ETH Interface

Not used	X
Single 10/100BASE-TX ⌂	1
Single 100BASE-FX (MT-RJ connector)	2
Dual RSTP-enabled 10/100BASE-TX	3
Dual RSTP-enabled 100BASE-FX (MT-RJ connector)	4
Dual PRP/HSR-enabled 10/100BASE-TX **	5
Dual PRP/HSR-enabled 100BASE-FX **	6
Dual RSTP-enabled 100BASE-FX (LC Duplex connector)	8

Communication Protocols

According to protocol list	XX

** Currently under development

⌂ Preferred Options

COMMUNICATION PROTOCOL CODES (FIELD K)

Slave / Server protocols	Code
None	X
IEC 60870-5-101/104	A
IEC 60870-5-103	B
IEC 61850-8-1 MMS Server and GOOSE publisher / subscriber	C
DNP 3.0 (Serial and/or TCP/IP)	D
Modbus (Serial and/or TCP/IP)	E
Others, please contact	

Notes:

♦ A maximum of 2 simultaneous protocols is allowed.

Slave / Server protocols	Code

NOTES