TPU T450

CLP 500

INTRODUCTION

TPU T450 is a state of the art transformer protection relay suitable for the protection of transformers, including two or three winding transformers, auto-transformers or shunt reactors.

TPU T450 offers additional control, measurement and recording functions for easy and reliable power system management. TPU T450 further combines user programmability to deliver all the required functions for bay protection and control in a single unit.

Based on the 450 IED high-performance platform, TPU T450 provides flexible I/O options and has been designed with IEC 61850 and other open standards in mind, being future-proof and integration friendly.

As part of the Efacec CLP 500 family, TPU T450 provides object-oriented engineering, system tools and full IEC 61850 open design that allows users to straightforwardly apply the product in different system architectures.

PROTECTION

- (Auto-)Transformer Differential (2 or 3 windings)
- Restricted Earth-Fault
- Remote Tripping
- (Directional) Phase Overcurrent
- (Directional) Earth-Fault Overcurrent
- (Directional) Negative Sequence Overcurrent
- Thermal Overload
- Switch-Onto-Fault
- 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
- Lockout
- VT Supervision
- CT Supervision
- Circuit Breaker Control / Supervision
- Circuit Switch Control / Supervision
- Transformer Protection Supervision
- Distributed Automation
- Programmable Automation (IEC 61131-3 based) IEC 61131-3

MONITORING / RECORDING

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

COMMUNICATION

- IEC 61850 Server / GOOSE IEC 61850
- 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

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OVERVIEW

The TPU T450 is a transformer protection relay that provides a high performing solution for power system protection while offering additional control, measurement and recording functions for an easy and reliable power system management.

The TPU T450 is suitable for the protection of transformers, including two- or three-winding transformers, auto-transformers, or shunt reactors.

Low-level internal faults can be selectively detected by its sensitive differential protection, which also offers high immunity against inrush phenomena and close-in external faults with CT saturation and a correct behaviour over a broad frequency range. CT matching and vector group compensation is automatically done by the unit, no interposing CTs being required for its operation.

Main transformer differential protection can be complemented by the restricted earth-fault function to improve sensitivity to high impedance faults in the transformer. Several other current, voltage and frequency protection functions are also available.

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.

High configurability via flexible binary and analogue I/O configurations, advanced user-programmable functions and a comprehensive library of selectable built-in firmware functions allows the user to adapt the device to different substation topologies as well as protection and control schemes. Integration in a state of the art engineering toolset allows straightforward engineering throughout the system life-cycle without compromising user requirements.

Designed with IEC 61850 and other open standards in mind the TPU T450 is flexible, future-proof and can be seamlessly integrated in multivendor distributed protection, automation and control systems.

FEATURE SUMMARY

	TPU T450
Size	
1/2 x 19" rack / height 6U	●
A.C. Analogue Inputs	
Maximum Number of Inputs	12
Maximum Number of Current Inputs	12
Maximum Number of Voltage Inputs	4
D.C. Analogue Inputs	
Maximum Number of Inputs	8
Binary Inputs / Outputs	
Maximum Number of Inputs	104
Maximum Number of Outputs	55
Base I/O	
8 Binary Inputs + 7 Binary Outputs + Watchdog Output	●
Availability	
Hardware Watchdog and Auto-reset	●
Software Failure Detection and Recovery	●
User Interface	
640 x 480 Graphic Colour LCD	●
Programmable Alarms / Indication LEDs	16
Function Keys	9
Relay Status LEDs	3
Integrated Webserver	●
Time Synchronization	
IRIG-B Input	○
SNTP Client	●
By Communication Protocol	●
Communication Interfaces (Rear Panel)	
3 RS-232 / RS-485 / Glass / Plastic Fibre	○
Dual Ethernet 10/100BASE-TX or 100BASE-FX Interface	●
RSTP-enabled Interface **	○
PRP-enabled Interface	○
Single Ethernet 10/100BASE-TX or 100BASE-FX Interface	●
IEC 61850 Communications	
IEC 61850-8-1 Server and GOOSE	○
Communication Protocols	
Maximum Number of Simultaneous Protocols	4
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

			Two-Windings (option A1)	Three-Windings (option A2)	
General					
Three-Phase Tripping			●	●	
Single Breaker Arrangements			●	●	
Protection Functions	**ANSI**	**IEC 61850**			
(Auto-)Transformer Differential (2 windings)	87T	PDIF, PHAR	●(1)		
(Auto-)Transformer Differential (2 or 3 windings)	87T	PDIF, PHAR		●(1)	
Restricted Earth Fault	87N	PDIF	○(2)	○(2)	(a)
Remote Tripping	85	PSCH	●(1)	●(1)	
Phase Overcurrent	50/51	PTOC		●(3)	
(Directional) Phase Overcurrent	50/51/67	PTOC, RDIR	●(2)		
Earth-Fault Overcurrent	50N/51N 50G/51G	PTOC		●(5)	
(Directional) Earth-Fault Overcurrent	50N/51N/67N 50G/51G/67G	PTOC, RDIR	●(4)		
Negative Sequence Overcurrent	46	PTOC		●(3)	
(Directional) Negative Sequence Overcurrent	46/67	PTOC, RDIR	●(2)		
Editable Time-Current Curves			●	●	
Inrush Restraint	68	PHAR	●	●	
Thermal Overload	49	PTTR	●(1)	●(1)	
Switch-Onto-Fault	50HS	RSOF, PIOC	●(1)	●(1)	
Phase Undervoltage	27	PTUV	●(1)		
Phase Overvoltage	59	PTOV	●(1)		
Residual Overvoltage	59N	PTOV	●(1)		
Negative Sequence Overvoltage	47	PTOV	●(1)		
Underfrequency	81U	PTUF	●(1)		
Overfrequency	81O	PTOF	●(1)		
Frequency Rate-of-Change	81RC	PFRC	●(1)		
Overexcitation **	24	PVPH	●(1)		
Control and Supervision Functions	**ANSI**	**IEC 61850**			
Trip Logic	94	PTRC	●(2)	●(3)	
Trip Circuit Supervision	74TC	STRC	●(2)	●(3)	
Circuit Breaker Failure	50BF	RBRF	●(2)	●(3)	
Circuit Breaker Close Lock / Lockout	86	RCBL	●(1)	●(1)	
Fuse Failure / VT Supervision	60	RVTS	●(1)		
CT Supervision		RCTS	●(2)	●(3)	
Circuit Breaker Control / Supervision	52	CSWI, XCBR	●(2)	●(3)	
Circuit Breaker Condition Monitoring		SCBR	●	●	
Circuit Switch Control / Supervision	89	CSWI, XSWI	●(6)	●(6)	
Transformer Protection Supervision	94T	SPTR	●	●	
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	●(2)	●(3)	
Single-Phase Measurements		MMXN	●(3)	●(3)	
Metering		MMTR	●(1)		
Statistics **		MMXU (or user defined)	●	●	
Sags and Swells **		QVVR	●		
Harmonics **		MHAI	●		
Disturbance Recorder		RDRE	●	●	
Chronological Event Log / SOE			●	●	
Fault Report			●	●	
Load Diagram / Trend Recorder **			●	●	
Histogram **			●	●	
Power Quality Event Recorder **			●		
Self-tests and Watchdog			●	●	

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

Functional restrictions according to order code:
(a) With Restricted Earth-Fault (option D2)

TECHNICAL SPECIFICATIONS

A.C. Analogue Inputs (General Data)		
Number	Max. 12	
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	24 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. 12 (depends on the type of expansion board)	
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 the type of expansion board)	
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

D.C. Analogue Inputs		
Number	Max. 8	
Current ranges	Operation ranges (configurable by user)	± 1 mA; ± 5 mA; ± 10 mA; ± 20 mA; 0 .. 1 mA; 0 .. 5 mA; 0 .. 10 mA; 0 .. 20mA; 4.. 20mA
	Thermal withstand	0.1 A continuous 0.5 A for 1 s
	Input impedance	50 Ω
Low voltage ranges	Operation ranges (configurable by user)	± 5 V; ± 10 V
	Thermal withstand	20 V continuous 50 V for 1 s
	Input impedance	45 kΩ
High voltage ranges	Operation ranges (configurable by user)	± 150 V; ± 300 V
	Thermal withstand	360 V continuous 420 V for 1 s
	Input impedance	1.3 MΩ
Acquisition	ADC type	Sigma-Delta, auto-ranging with PGA
	Resolution	16 bit + sign
	Accuracy	< 0.2 % full-range
	Normal-mode rejection ratio	> 110 dB
	Common-mode rejection ratio	> 130 dB
	Scan cycle	100 ms

Power Supply		
Rated values / voltage ranges	24 / 48 / 60 V d.c.	(19 .. 72 V d.c.)
	110 / 125 / 220 / 250 V d.c. 115 / 230 V a.c.	(88 .. 350 V d.c. / 80 .. 265 V a.c.)
	48 / 60 / 110 / 125 V d.c.	(38 .. 150 V d.c.)
Burden	Quiescent state (maximum configuration)	< 30 W (d.c.) < 50 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	8
	Maximum	104
Rated values / voltage thresholds (configurable by user)	24 V d.c.	V_{LOW} ≤ 8 V d.c. V_{HIGH} ≥ 20 V d.c.
	48 / 60 V d.c.	V_{LOW} ≤ 26 V d.c. V_{HIGH} ≥ 38 V d.c.
	110 / 125 V d.c.	V_{LOW} ≤ 66 V d.c. V_{HIGH} ≥ 85 V d.c.
	220 / 250 V d.c.	V_{LOW} ≤ 132 V d.c. V_{HIGH} ≥ 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	7 + Watchdog
	Maximum	55 + 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	Max. 3 (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 or Glass FO)	
Galvanic option	Connector	D9 female connector
	Input voltage level	5 V, 12 V or 24 V
	Voltage range	± 20% of input voltage level
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.)

Rear Ethernet Ports - System Interface		
Number	Dual-interface (10/100BASE-TX or 100BASE-FX) + 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	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, ½ x 19'' rack
	Weight	< 7 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 V7m
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, 11ms
	EN 60870-2-2	Class Cm, 30 g, 11 ms
Bump tests	EN 60255-21-2	Class 1, 10 g, 16ms
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

(Auto-)Transformer Differential		
Number of independent functions		1 function
Number of stages (per function)		2 stages
Transformer characteristics	Number of windings	Maximum 3
	Winding connection type	Y-wye or D-delta
	Vector group compensation	0 - 11
	CT matching	Automatic
	Zero sequence elimination	Optional
Unrestrained stage	Setting range	[1 .. 25.0] × I_r ; step 0.01
	Accuracy	± 5% I_{op} (minimum ± 5% I_r)
	Dropout ratio	> 96%
	Pickup time	20 ms min. < 23 ms typ. for I > 2 × I_{op}
	Reset time	30 ms typ.
Restrained stage	Minimum operate current	[0.1 .. 1.0] × I_r ; step 0.01
	Slope (section 2)	[0.1 .. 1.0] I_{diff}/I_{bias} ; step 0.01
	Slope (section 3)	[0.5 .. 2.0] I_{diff}/I_{bias} ; step 0.01
	Slope switch current	[1.0 .. 20.0] × I_r ; step 0.01
	Accuracy	± 3% I_{op} (minimum ± 3% I_r)
	Dropout ratio	> 96%
	Pickup time	28 ms min. < 33 ms typ. for I > 2 × I_{op}
	Reset time	30 ms typ.
Inrush blocking	Restriction mode	Second harmonic / waveform analysis
	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
	Cross-block maximum time	[0 .. 15000] ms ; step 1
Overexcitation blocking	Restriction mode	Fifth harmonic
	Fifth harmonic ratio	[0.1 .. 1.0] I_{5h}/I_{1h} ; step 0.01
	Cross-block	One phase out of three, two phases out of three or disabled

Restricted Earth Fault		
Number of independent functions		2 functions
Number of stages (per function)		1 stage
Operation characteristic	Minimum operate current	[0.05 .. 1.0] × I_r ; step 0.01
	Slope	[0.0 .. 1.0] I_{diff}/I_{bias} ; step 0.01
	Slope switch current	[1.0 .. 20.0] × I_r ; step 0.01
	Accuracy	± 3% I_{op} (minimum ± 3% I_r)
	Dropout ratio	> 96%
	Pickup time	20 ms min. < 33 ms typ. for I > 2 × I_{op} and directional characteristic enabled
	Time delay	[0 .. 60000] ms ; step 1
	Time accuracy	± 3% (minimum ± 10 ms)
	Reset time	30 ms typ.
Directional characteristic	Open angle	[60.0 .. 90.0]° ; step 1.0

Remote Tripping		
Number of independent functions		1 function
Operation	Signal transmission prolongation time	[0 .. 10000] ms ; step 1
	Operate time delay	[0 .. 10000] ms ; step 1
	Time accuracy	± 3% (minimum ± 10 ms)

(Directional) Phase Overcurrent		
Number of independent functions		3 functions
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	32 ms typ. for I > 2 × I_{op}
	Time delay	[0 .. 60000] ms ; step 1
	Time accuracy	± 3% (minimum ± 20 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
	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		5 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	32 ms typ. for I > 2 × I_{op}
	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 (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		3 functions
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	32 ms typ. for I > 2 × I_{op}
	Time delay	[0 .. 60000] ms ; step 1
	Time accuracy	± 3% (minimum ± 20 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
	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

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	17 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

Phase Undervoltage		
Number of independent functions		1 function
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	32 ms typ.
	Time delay	[0 .. 300000] ms ; step 10
	Time accuracy	± 3% (minimum ± 20 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		1 function
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	32 ms typ.
	Time delay	[0 .. 300000] ms ; step 10
	Time accuracy	± 3% (minimum ± 20 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		1 function
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] × U_r ; step 0.005 (phase-earth rated voltage)
	Accuracy	± 1% U_{op} (minimum ± 1% U_r)
	Dropout ratio	> 96%
Definite time (all stages)	Pickup time	32 ms typ.
	Time delay	[0 .. 300000] ms ; step 10
	Time accuracy	± 3% (minimum ± 20 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] × U_r ; step 0.005 (phase-earth rated voltage)
	Accuracy	± 1% U_{op} (minimum ± 1% U_r)
	Dropout ratio	> 96%
Definite time (all stages)	Pickup time	32 ms typ.
	Time delay	[0 .. 300000] ms ; step 10
	Time accuracy	± 3% (minimum ± 20 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] × 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 ± 20 ms)
	Reset time	< 100 ms
Block voltage	Setting range	[0.15 .. 1.0] × U_r ; step 0.005
	Accuracy	± 1% U_{op} (minimum ± 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] × 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 ± 20 ms)
	Reset time	< 100 ms
Block voltage	Setting range	[0.15 .. 1.0] × 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] ∪ [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 × 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 ± 20 ms)
	Reset time	< 100 ms
Frequency supervision (optional)	Setting range	[0.8 .. 1.2] × f_r ; step 0.0001
	Accuracy	± 10 mHz
Block voltage	Setting range	[0.15 .. 1.0] × U_r ; step 0.005
	Accuracy	± 1% U_{op} (minimum ± 1% U_r)

Trip Logic		
Number of independent functions		3 functions
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		3 functions
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		3 functions
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] × I_r
	Operational range	[0.05 .. 1.5] × I_r
	Accuracy	± 1% I_{op} (minimum ± 1% I_r)
Operation time	Re-trip time delay	[0 .. 30000] ms
	External trip time delay	[50 .. 30000] ms
	Time accuracy	± 3% (minimum ± 10 ms)
	Reset time	15 ms typ.

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	22 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	22 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		3 functions
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	17 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	17 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		3 functions
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		3 functions
CB command	Minimum open command time	[0 .. 60000] ms
	Minimum close command time	[0 .. 60000] ms
	Adaptive pulse	Disabled / enabled
	Number of close (re)tries	[1 .. 500]
	Retry interval	[1 .. 60] s
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 open pole time	[0 .. 60000] ms
Condition monitoring	Contact travel time monitoring	Independent for open and close operations
	Open operation time correction	[0 .. 500] ms
	Close operation time correction	[0 .. 500] ms
	Maximum operation counter	[0 .. 100000]
	Switched current exponent	[1.0 .. 3.0]
	Maximum switched square current sum	[1.0 .. 99999.0] kA^2
	Contact wear monitoring criterion	Disabled / remaining operations alarm / remaining operations warning / contact wear alarm / contact wear warning
	Contact wear warning level	[10000 .. 1] opening operations [1 .. 10000] × 0.01 %
	Contact wear alarm level	[10000 .. 1] opening operations [1 .. 10000] × 0.01 %

Circuit Switch Control		
Number of independent functions		6 functions
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

Circuit Switch Supervision		
Number of independent functions		6 functions
SW command	Minimum open command time	[0 .. 60000] ms
	Minimum close command time	[0 .. 60000] ms
	Adaptive pulse	Disabled / enabled
SW status supervision	Intermediate state filtering	Disabled / enabled
	Filter time for intermediate state	[0 .. 60000] ms
SW operation supervision	Maximum start time	[0 .. 60000] ms
	Maximum operation time	[0 .. 60000] ms
	Maximum operation counter	[0 .. 100000]

Three-Phase Measurements		
Number of independent functions		3 functions
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		3 functions
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%

Disturbance Recorder		
Recording	Number of records	Max. 250
	Sampling rate	80 samples per cycle at rated frequency (4 kHz @ f_r = 50 Hz; 4.8 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 24 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	5
Scheduling	Pre-emptive multi-tasking (1 thread per task)
Distinct task priority levels	5
Maximum number of programs	64
Code area size	128 KB
Global area size (data and stack)	512 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
	Optional channel arithmetic	Selection / transformer compensation / magnitude and phase angle correction
	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]
DC analogue inputs	Conversion function	Polynomial / piecewise linear
	Number of coefficients (polynomial function)	Up to 8
	Number of points (piecewise linear function)	Up to 8
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. 16
	Mode	Off / On / Test
	Set of functions	Free association of functions (built-in or user-defined)
Setting groups	Number of groups	8 (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	16
	Colour	Red or yellow (configurable by user)
	Entities	Max. 16 entities per alarm (logical OR)
	Mode of operation	Unlatched or latched (resettable by user)
	Blinking (latched alarms)	Configurable by user
Function keys	Number	9
	Mode of operation	Status and/ or control, shortcut, selection from a list of options
Display	Type	640 × 480 graphic colour LCD
	Language	Portuguese / English / Spanish / French / Russian Others available (please contact)
	Information handling	Menu and mimic 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. The mimic structure is defined by the user.
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.

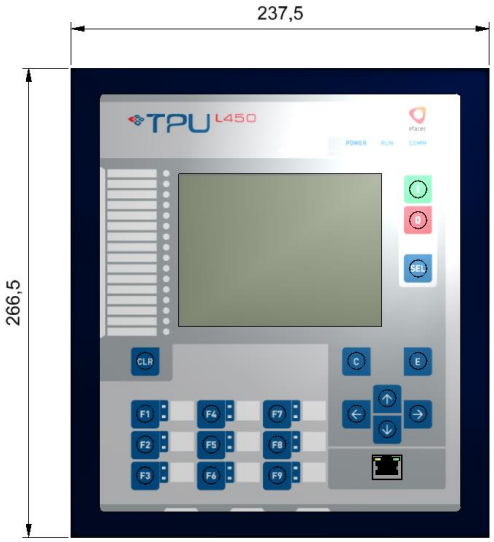
RTC and Clock Synchronization		
Application clock	Resolution	1 ms
	Time deviation (internal clock)	Max. 0.003%
	Synchronization	IRIG-B, NTP/ SNTP time slave or through communication protocol
	Backup power	Yes, lithium battery
	Local time offset	Adjustable
	Daylight savings configuration	Adjustable

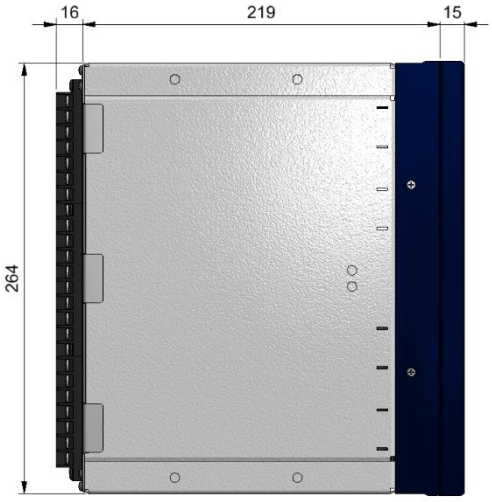
IEC 61850		
IEC 61850-8-1 Server	Number of simultaneous clients	Max. 6
	Number of datasets	Max. 128
	Number of data attributes per dataset	Max. 128
	Maximum report control blocks (RCB)	Max. 128
	Buffered / unbuffered reports	Yes
IEC 61850-8-1 GOOSE	Number of published GOOSE control blocks	64
	Number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

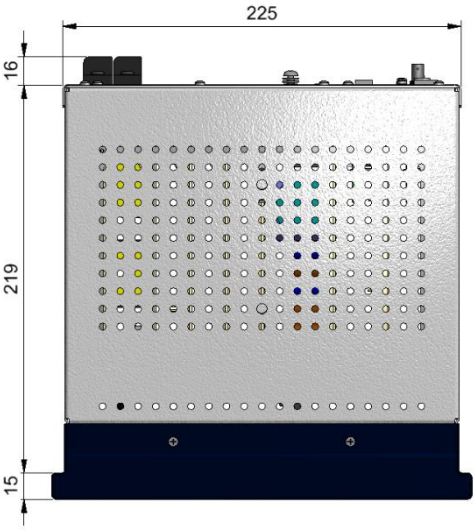
Other Communication Protocols	
Protocols Up/ Slave	IEC 60870-5-104 (TCP/IP) / IEC 60870-5-101 (Serial) IEC 60870-5-103 (Serial) DNP 3.0 (TCP/IP or Serial) Modbus (TCP/IP or Serial) Others available (Please Contact)

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

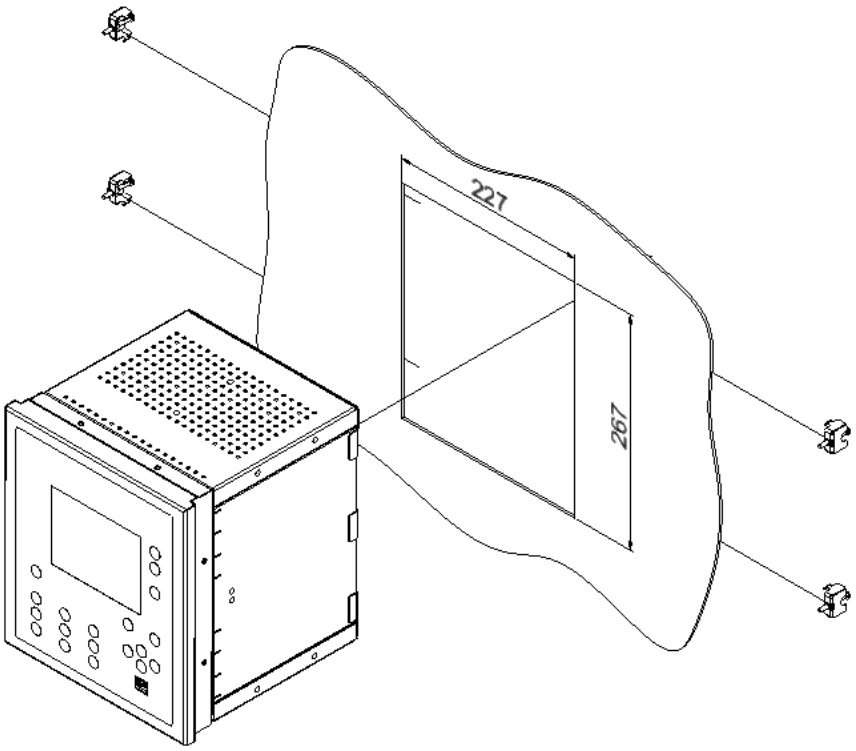


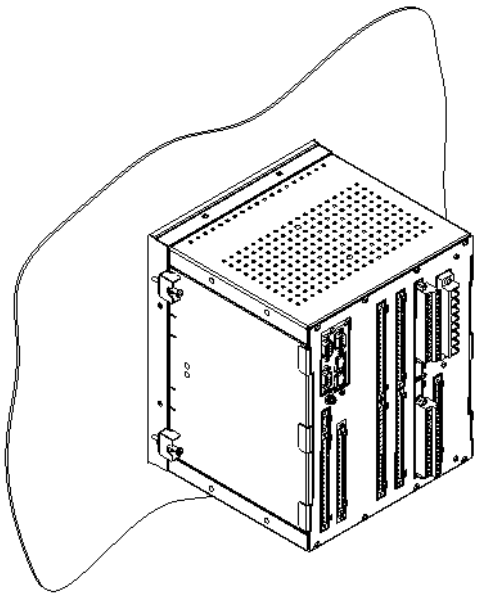




All dimensions in millimetres

MOUNTING

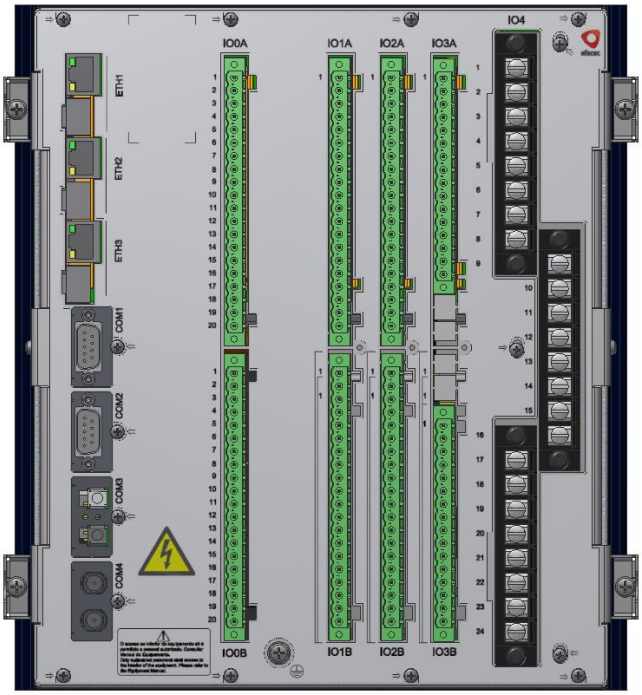




All dimensions in millimetres

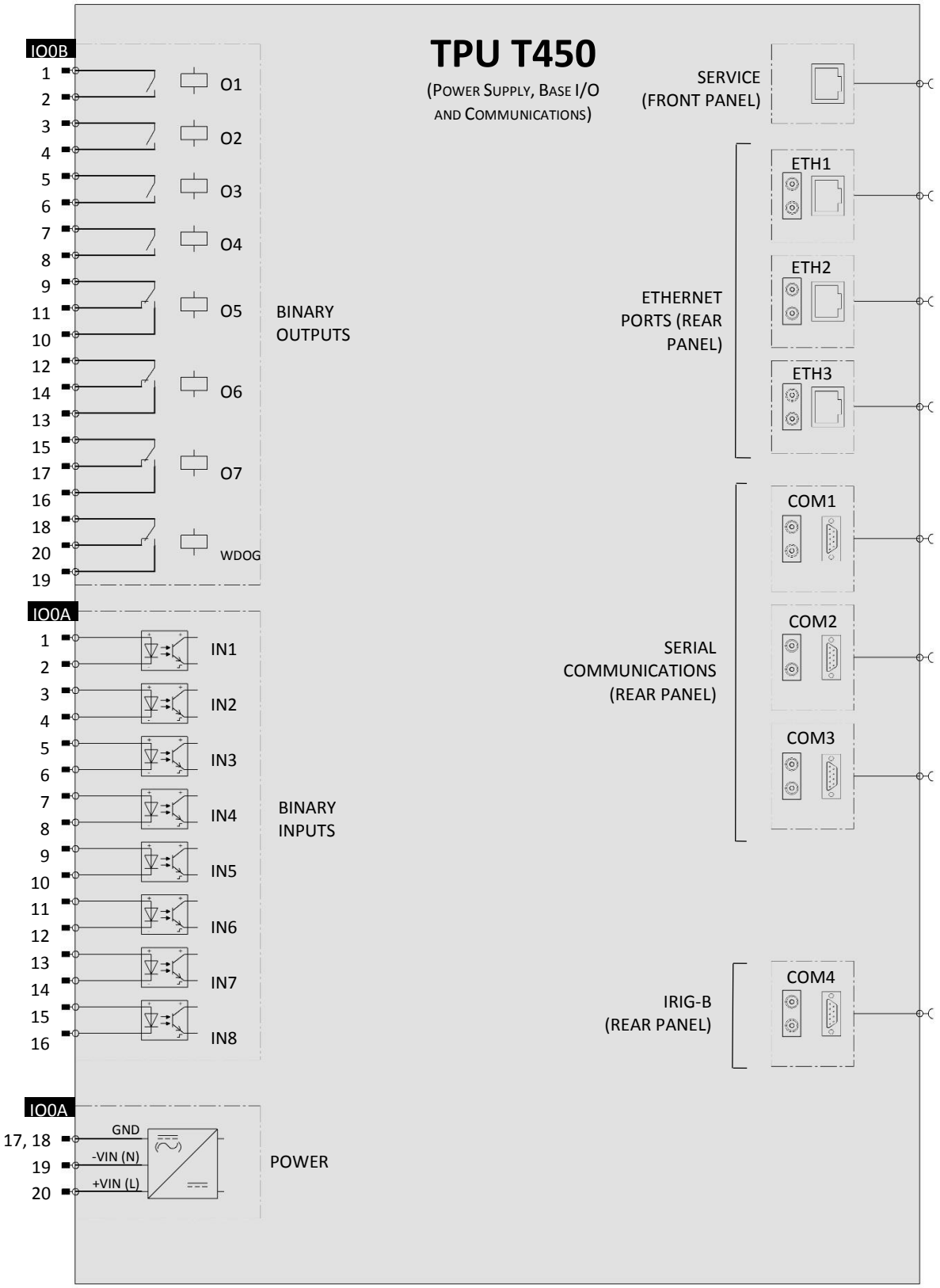
CONNECTORS IDENTIFICATION

BACK SIDE VIEW

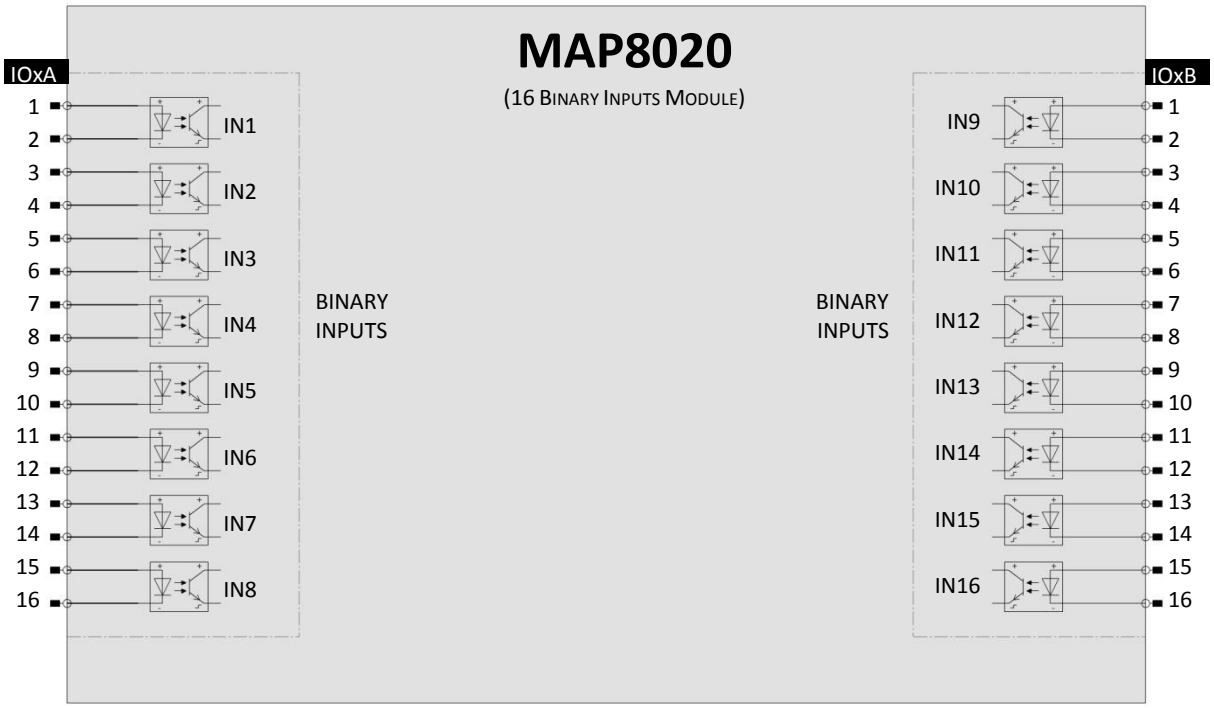


WIRING DIAGRAMS

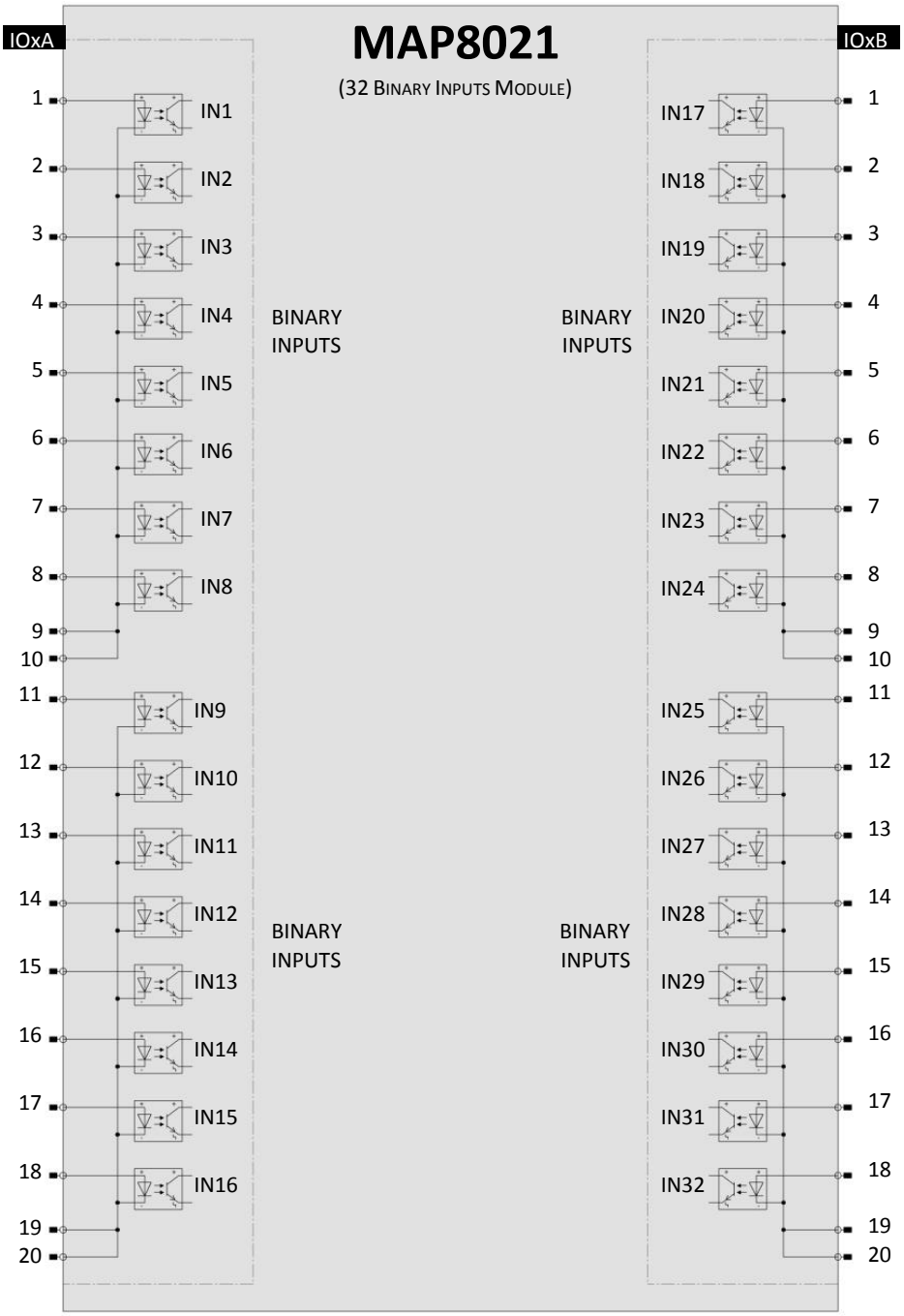
POWER SUPPLY, BASE I/O AND COMMUNICATIONS



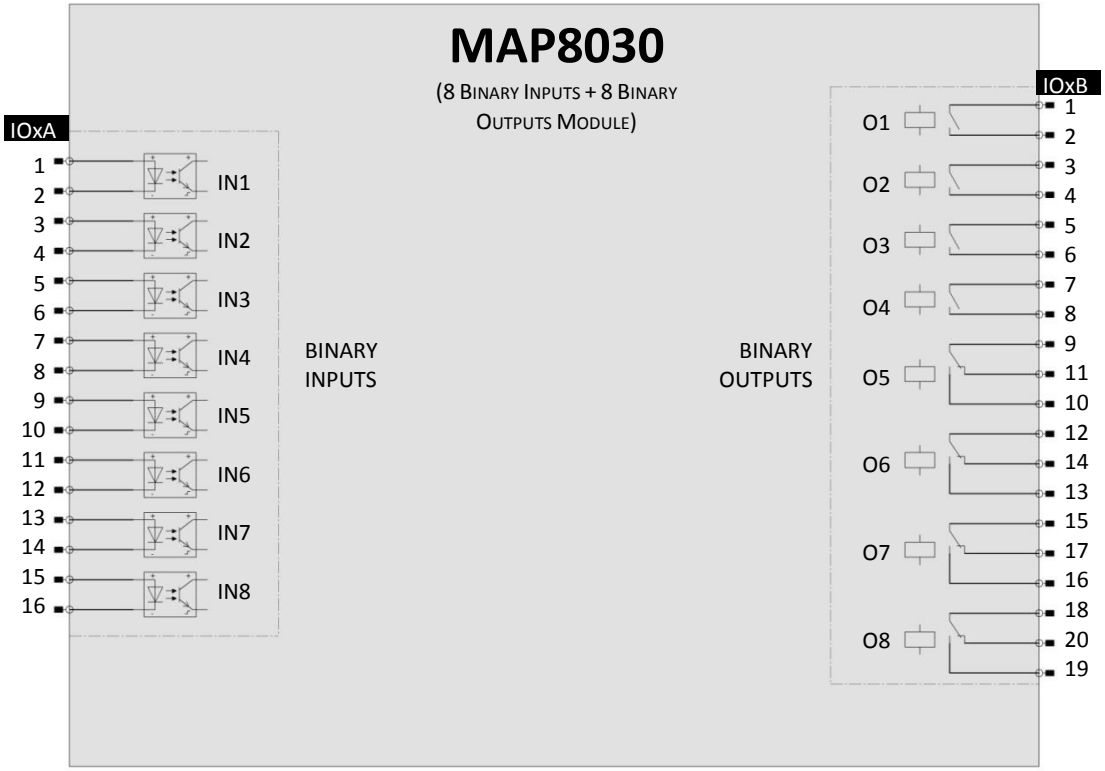
16 BINARY INPUTS MODULE (MAP8020, ORDER CODE A)



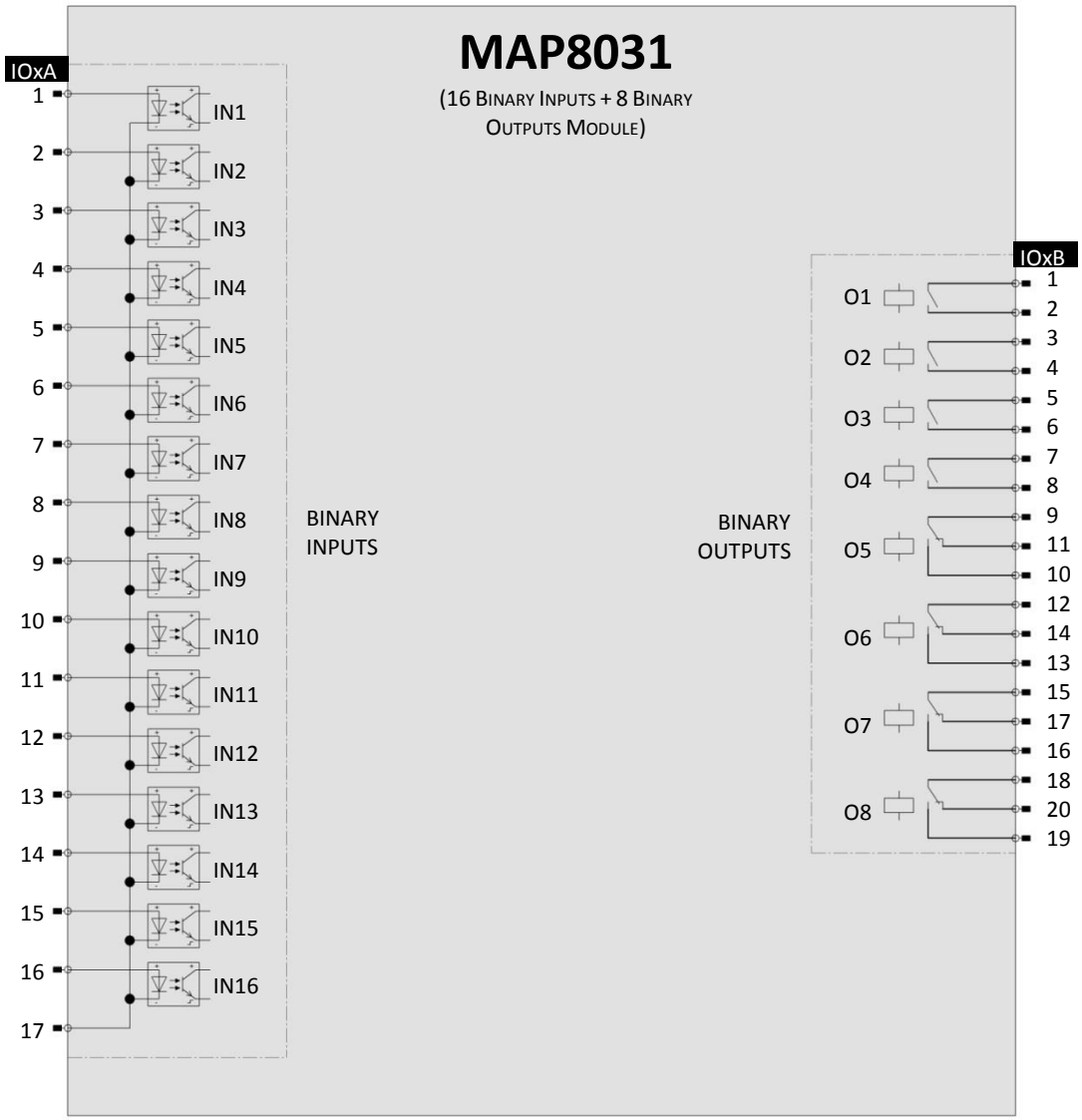
32 BINARY INPUTS MODULE (MAP8021, ORDER CODE B)



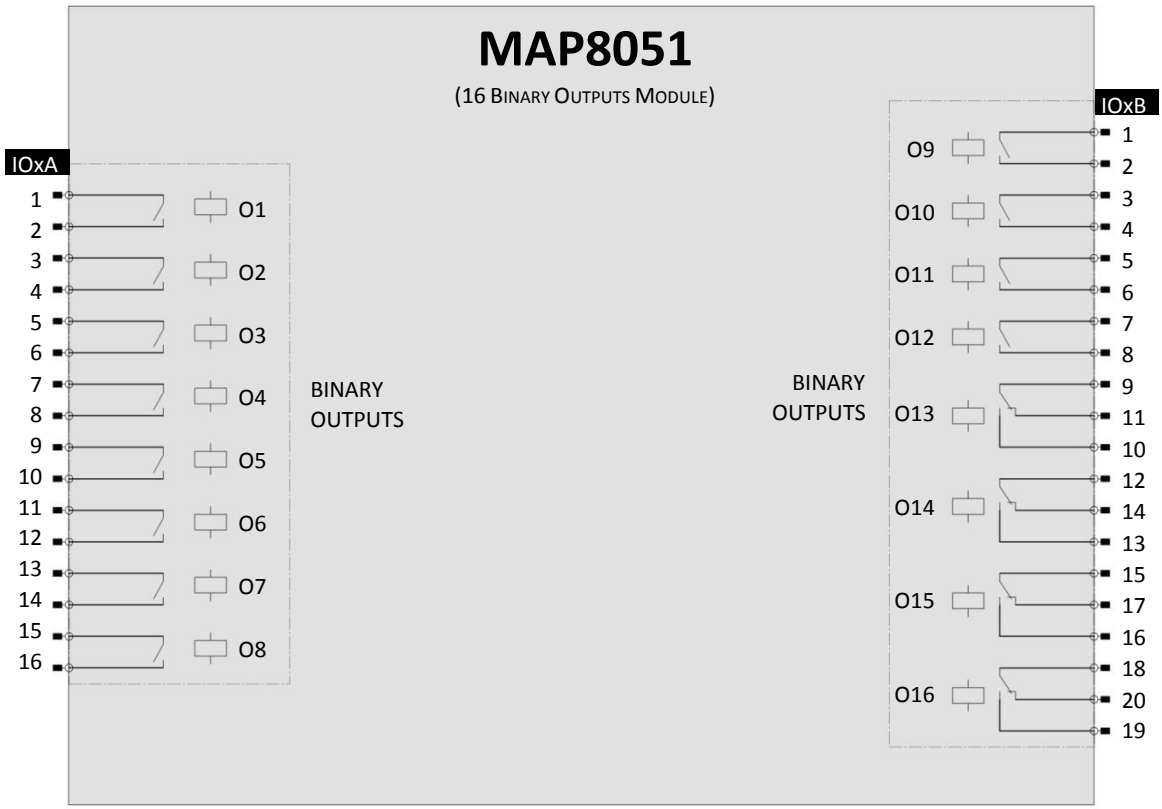
8 BINARY INPUTS + 8 BINARY OUTPUTS MODULE (MAP8030, ORDER CODE C)



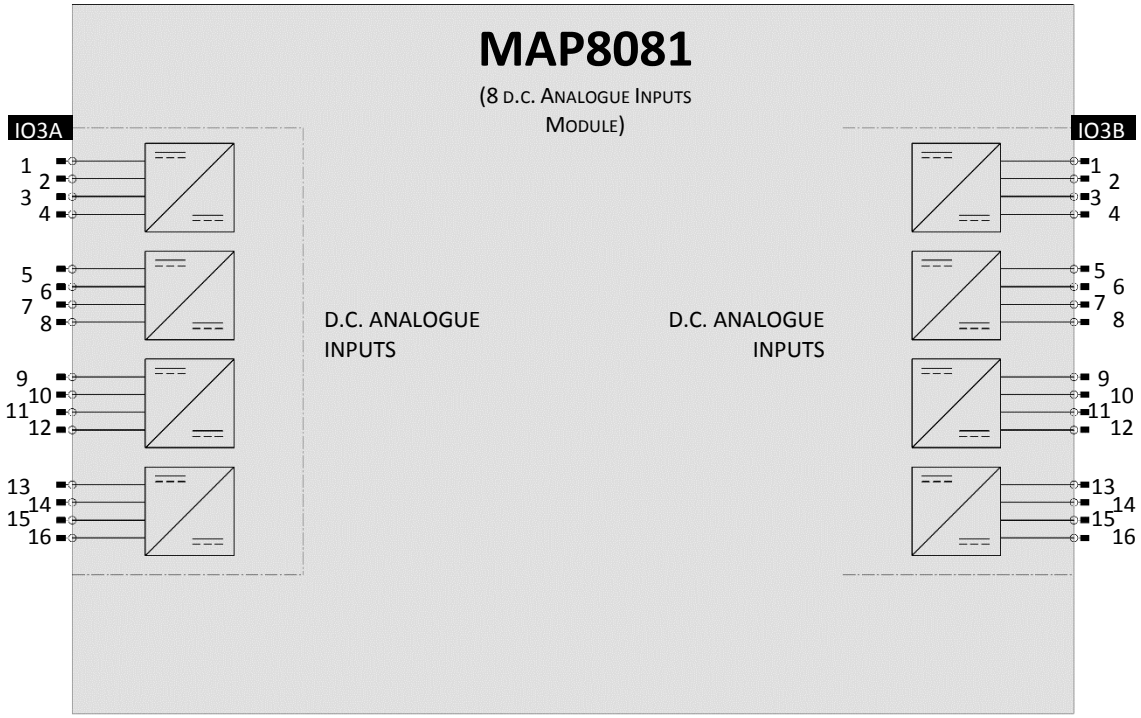
16 BINARY INPUTS + 8 BINARY OUTPUTS MODULE (MAP8031, ORDER CODE D)



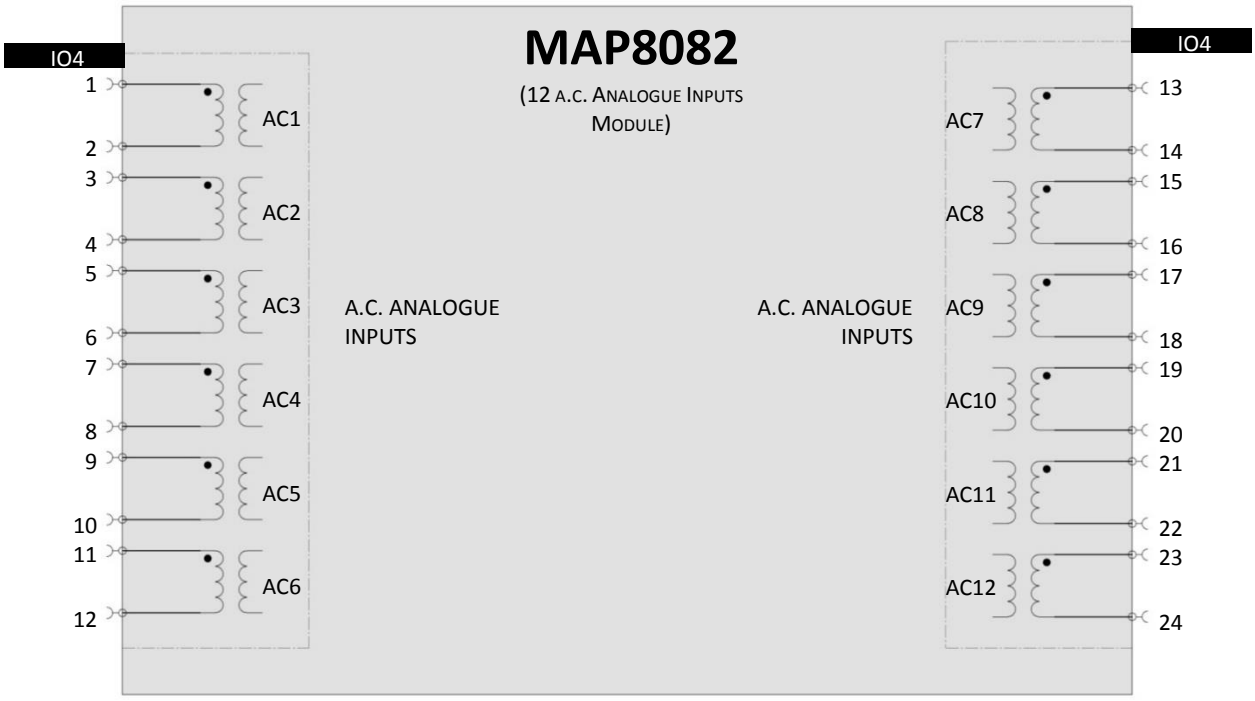
16 BINARY OUTPUTS MODULE (MAP8051, ORDER CODE E)



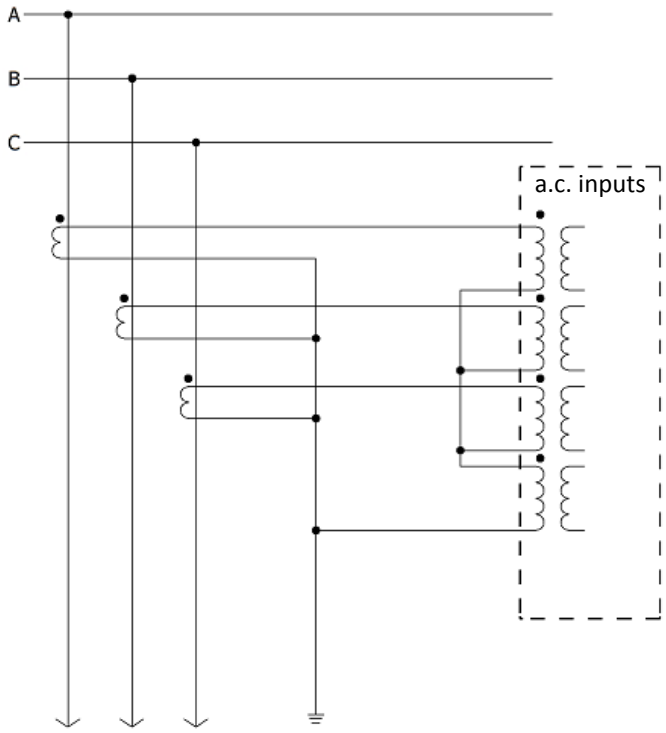
8 D.C. ANALOGUE INPUTS MODULE (MAP8081, ORDER CODE J)



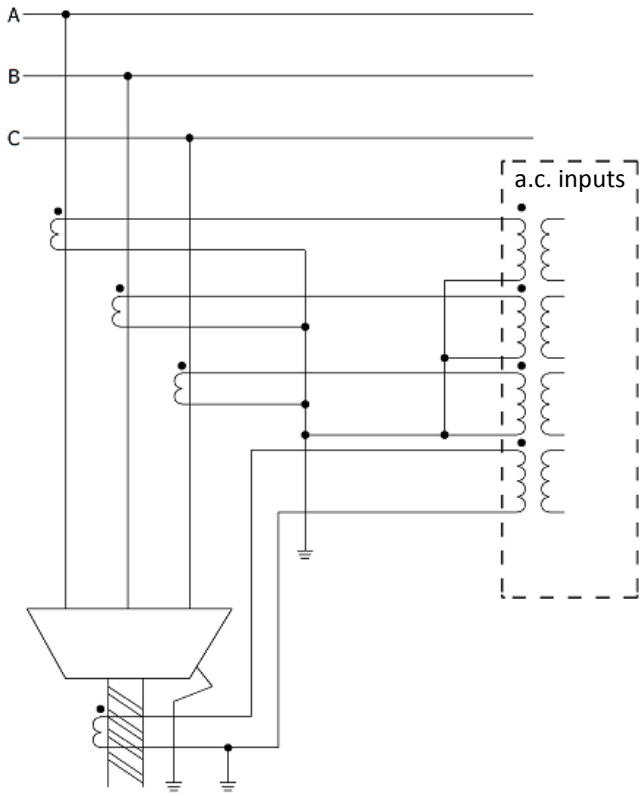
12 A.C. ANALOGUE INPUTS MODULE (MAP8082, ORDER CODES P, Q & S)



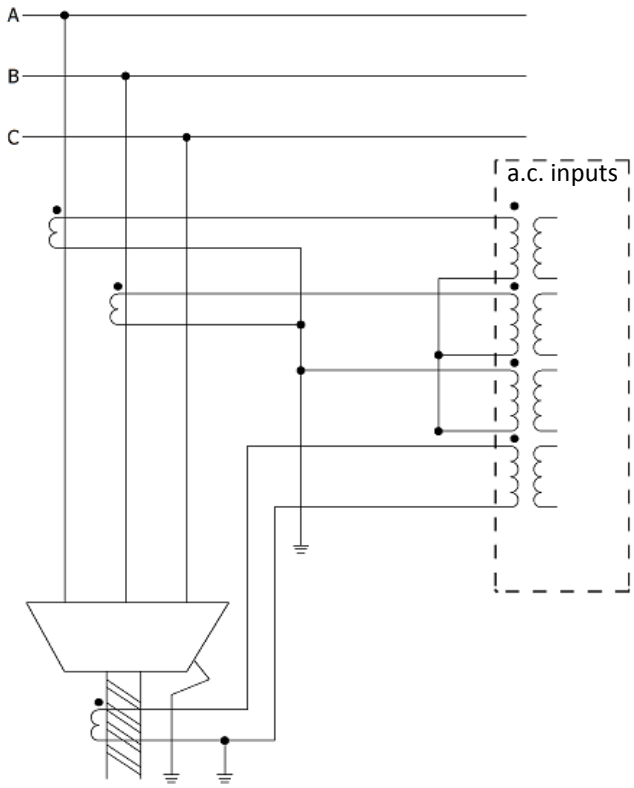
TYPICAL CONNECTIONS FOR A.C. CURRENT INPUTS



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.

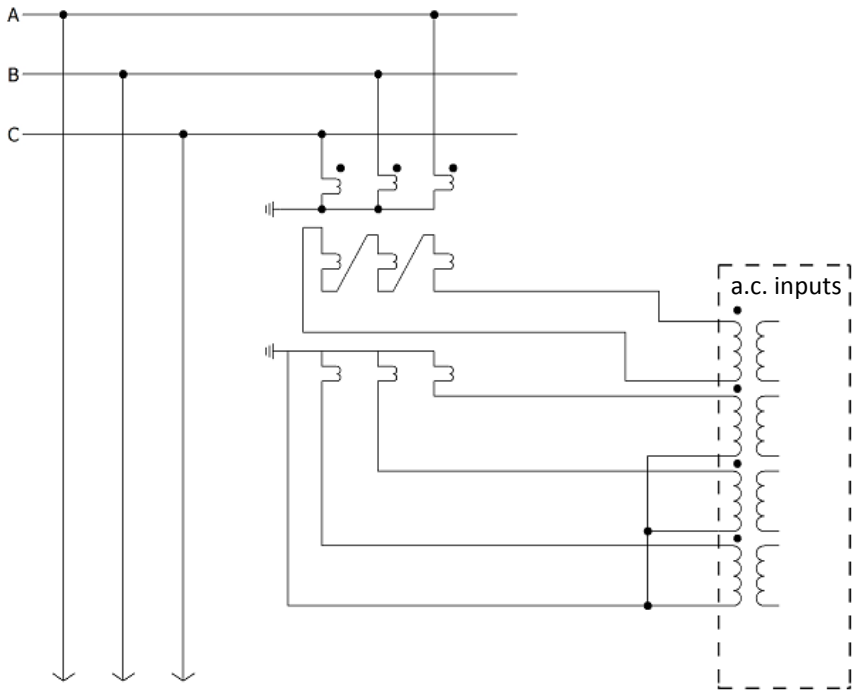


Phase and earth current inputs connection, with an independent phase-balance neutral current transformer for earth current measurement. Required in the case of isolated or compensated networks and for sensitive earth-fault detection.

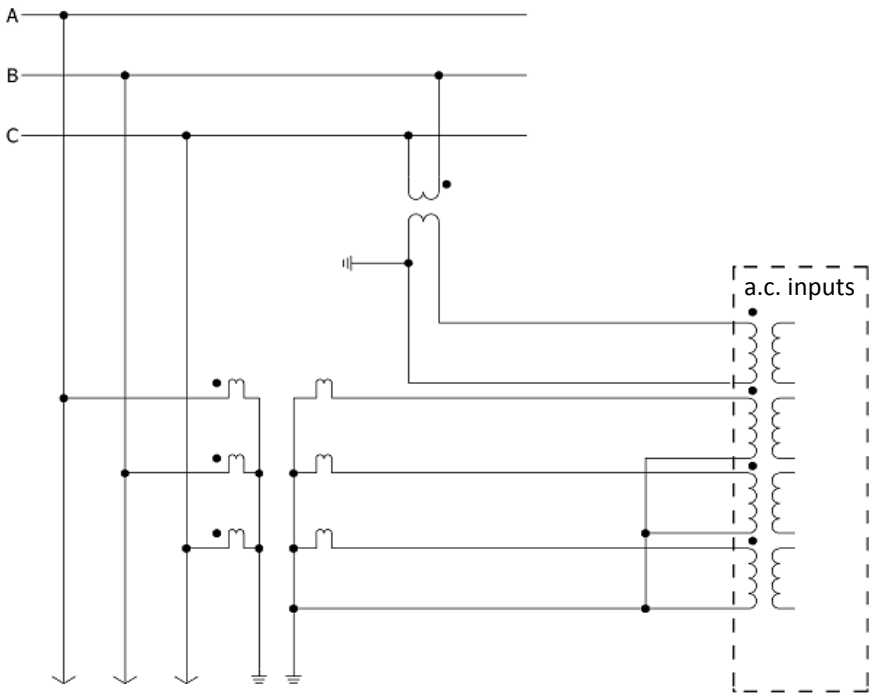


Phase and earth current inputs connection, with current transformers in only two phases. An independent neutral current transformer is required for earth current measurement. Optionally, the third phase current can be obtained from the other two by external circuitry.

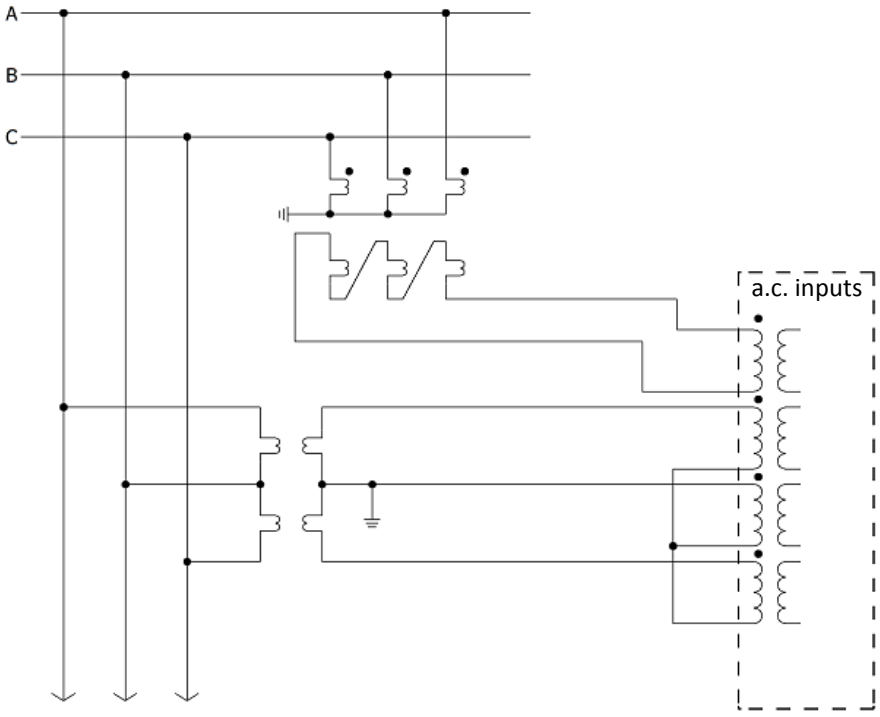
TYPICAL CONNECTIONS FOR A.C. VOLTAGE INPUTS



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 AND BASE I/O MODULE (MAP8011)

Power Supply and Base I/O Module (MAP8011), see connectors description below

IO0A			IO0B		
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	Power Supply GND		17		Normally Closed
18	Power Supply GND		18	Watchdog Binary Output	Common
19	Power Supply - (N)		19		Normally Open
20	Power Supply + (L)		20		Normally Closed

16 BINARY INPUTS MODULE (MAP8020)

16 Binary Inputs Module (MAP8020), see connectors description below

IOxA			IOxB		
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		

32 BINARY INPUTS MODULE (MAP8021)

32 Binary Inputs Module (MAP8021), see connectors description below					
IOxA			**IOxB**		
1	Binary Input 1	+	1	Binary Input 17	+
2	Binary Input 2	+	2	Binary Input 18	+
3	Binary Input 3	+	3	Binary Input 19	+
4	Binary Input 4	+	4	Binary Input 20	+
5	Binary Input 5	+	5	Binary Input 21	+
6	Binary Input 6	+	6	Binary Input 22	+
7	Binary Input 7	+	7	Binary Input 23	+
8	Binary Input 8	+	8	Binary Input 24	+
9	Common to Binary Inputs 1 to 8	-	9	Common to Binary Inputs 17 to 24	-
10		-	10		-
11	Binary Input 9	+	11	Binary Input 25	+
12	Binary Input 10	+	12	Binary Input 26	+
13	Binary Input 11	+	13	Binary Input 27	+
14	Binary Input 12	+	14	Binary Input 28	+
15	Binary Input 13	+	15	Binary Input 29	+
16	Binary Input 14	+	16	Binary Input 30	+
17	Binary Input 15	+	17	Binary Input 31	+
18	Binary Input 16	+	18	Binary Input 32	+
19	Common to Binary Inputs 9 to 16	-	19	Common to Binary Inputs 25 to 32	-
20		-	20		-

8 BINARY INPUTS + 8 BINARY OUTPUTS MODULE (MAP8030)

8 Binary Inputs + 8 Binary Outputs Module (MAP8030), see connectors description below					
IOxA			**IOxB**		
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 INPUTS + 8 BINARY OUTPUTS MODULE (MAP8031)

16 Binary Inputs + 8 Binary Outputs Module (MAP8031), see connectors description below						
IOxA			**IOxB**			
1	Binary Input 1	+	1	Binary Output 1	Normally Open
2	Binary Input 2	+	2		
3	Binary Input 3	+	3	Binary Output 2	Normally Open
4	Binary Input 4	+	4		
5	Binary Input 5	+	5	Binary Output 3	Normally Open
6	Binary Input 6	+	6		
7	Binary Input 7	+	7	Binary Output 4	Normally Open
8	Binary Input 8	+	8		
9	Binary Input 9	+	9	Binary Output 5	Common
10	Binary Input 10	+	10		Normally Open
11	Binary Input 11	+	11		Normally Closed
12	Binary Input 12	+	12	Binary Output 6	Common
13	Binary Input 13	+	13		Normally Open
14	Binary Input 14	+	14		Normally Closed
15	Binary Input 15	+	15	Binary Output 7	Common
16	Binary Input 16	+	16		Normally Open
17	Common to Binary Inputs 1 to 16	-	17		Normally Closed
18	Not Connected		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					
IOxA			**IOxB**		
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

8 D.C. ANALOGUE INPUTS MODULE (MAP8081)

8 d.c. Analogue Inputs Module (MAP8081), see connectors description below					
IO3A			**IO3B**		
1	d.c. Analogue Input 1	High Voltage (+)	1	d.c. Analogue Input 5	High Voltage (+)
2		Low Voltage (+)	2		Low Voltage (+)
3		Current (+)	3		Current (+)
4		Common (-)	4		Common (-)
5	d.c. Analogue Input 2	High Voltage (+)	5	d.c. Analogue Input 6	High Voltage (+)
6		Low Voltage (+)	6		Low Voltage (+)
7		Current (+)	7		Current (+)
8		Common (-)	8		Common (-)
9	d.c. Analogue Input 3	High Voltage (+)	9	d.c. Analogue Input 7	High Voltage (+)
10		Low Voltage (+)	10		Low Voltage (+)
11		Current (+)	11		Current (+)
12		Common (-)	12		Common (-)
13	d.c. Analogue Input 4	High Voltage (+)	13	d.c. Analogue Input 8	High Voltage (+)
14		Low Voltage (+)	14		Low Voltage (+)
15		Current (+)	15		Current (+)
16		Common (-)	16		Common (-)

12 A.C. ANALOGUE INPUTS MODULE (MAP8082)

12 a.c. Analogue Inputs Module (MAP8082), see connectors description below				
		Order Code		
IO4		**P**	**Q**	**S**
1	a.c. Analogue Input 1	CT	CT	CT
2				
3	a.c. Analogue Input 2	CT	CT	CT
4				
5	a.c. Analogue Input 3	CT	CT	CT
6				
7	a.c. Analogue Input 4	CT	CT	Sensitive CT
8				
9	a.c. Analogue Input 5	CT	CT	CT
10				
11	a.c. Analogue Input 6	CT	CT	CT
12				
13	a.c. Analogue Input 7	CT	CT	CT
14				
15	a.c. Analogue Input 8	CT	CT	Sensitive CT
16				
17	a.c. Analogue Input 9	CT	VT	VT
18				
19	a.c. Analogue Input 10	CT	VT	VT
20				
21	a.c. Analogue Input 11	CT	VT	VT
22				
23	a.c. Analogue Input 12	CT	VT	VT
24				

SERIAL PORTS

COM1 to COM3	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

COM4	IRIG-B, Galvanic Option
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:

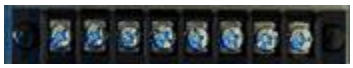
CONNECTOR FOR POWER SUPPLY, BINARY INPUTS AND STANDARD BINARY OUTPUTS

Phoenix Front-MSTB 2.5/20-STF-5.08 (1777976) type connector, 20 contacts. Accepts conductors with section from 0.2 mm^2 to 2.5 mm^2. 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 D.C. ANALOGUE INPUTS

Phoenix Front-MSTB 2.5/16-STF-5.08 (1777934) type connector, 16 contacts. Accepts conductors with section from 0.2 mm^2 to 2.5 mm^2. 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. ANALOGUE INPUTS



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 mm^2. 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 T450. It should be solid for security reasons.

ORDER FORM

TPU T450 - 1 - A - B - C - D - E - F - G - H - I - J - K - L - M *to next table...*

Region

Standard ♁	1
Eastern Europe and Central Asia	2

HMI

Graphic Display	B

Power Supply

24 / 48 / 60 V d.c.	1
110 / 125 / 220 / 250 V d.c.; 115 / 230 V a.c.	2
48 / 60 / 110 / 125 V d.c. ♁	3

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

Expansion I/O

Slot 1	*
Slot 2	*
Slot 3	*
Slot 4	*

COM1 Interface

Not used ♁	X
RS-232	1
RS-485	2
Plastic Optical Fibre	3
Glass Optical Fibre	4

COM2 Interface

Not used ♁	X
RS-232	1
RS-485	2
Plastic Optical Fibre	3
Glass Optical Fibre	4

COM3 Interface

Not used ♁	X
RS-232	1
RS-485	2
Plastic Optical Fibre	3
Glass Optical Fibre	4

COM4 Interface

Not used ♁	X
IRIG-B Optical Fibre	5
IRIG-B Galvanic	6

Reserved	XX

...from previous table	N	-	O	-	P	-	Q
ETH1 / ETH2 Interface							
Dual RSTP-enabled 10/100BASE-TX **	**3**						
Dual RSTP-enabled 10/100BASE-TX or 100BASE-FX **	**4**						
Dual PRP-enabled 10/100BASE-TX	**5**						
Dual PRP-enabled 10/100BASE-TX or 100BASE-FX	**6**						
ETH3 Interface							
10/100BASE-TX			**1**				
10/100BASE-TX or 100BASE-FX			**2**				
Communication Protocols							
According to protocol list					**XXXX**		
Application / Function Packages							
Two-Winding Transformers						**A1**	
Two and Three-Winding Transformers						**A2**	
Without Restricted Earth-Fault							**D1**
With Restricted Earth-Fault							**D2**

* See Expansion boards option codes

** Currently under development

👍 Preferred Options

EXPANSION BOARD CODES (FIELDS E TO H)

Expansion boards option codes table		
Board type	**Board name**	**Code**
16 Binary Inputs	MAP8020	A
32 Binary Inputs ♁	MAP8021	B
8 Binary Inputs + 8 Binary Outputs	MAP8030	C
16 Binary Inputs + 8 Binary Outputs ♁	MAP8031	D
16 Binary Outputs ♁	MAP8051	E
8 d.c. Analogue Inputs	MAP8081	J
12 a.c. Analogue Inputs (12 CT) ♁	MAP8082 OP6	P
12 a.c. Analogue Inputs (8 CT + 4 VT)	MAP8082 OP8	Q
12 a.c. Analogue Inputs (6 CT + 2 sensitive CT + 4 VT)	MAP8082 OP12	S
Inexistent or unavailable slot	-	X

♁ - preferred option

Notes:

- Slot 4 (field H) can only have one of three codes: 'P', 'Q' or 'S'.

MAXIMUM NUMBER OF ACCEPTABLE EXPANSION BOARDS

Maximum number of a.c. analogue input boards; Available slots	**Maximum number of binary I/O expansion boards; Available slots**	**Maximum number of d.c. analogue input boards; Available slots**
1 x MAP8082 / slot 4	Max. 3 / slots 1 to 3	Max. 1 / slot 3

COMMUNICATION PROTOCOL CODES (FIELD P)

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 4 simultaneous protocols is allowed.

** - Currently under development

NOTES

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