



Transformer Protection Relay

T-PRO 4000

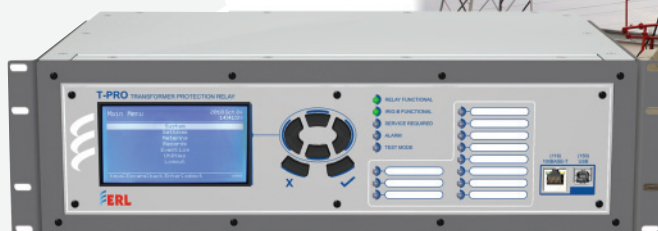
Product Overview

The IEC 61850 station bus embedded T-PRO 4000 relay provides complete three-phase multi-winding transformer fault and overload protection, DFR-quality fault oscillography, fault logging, sequence of event logging, trend recording, transformer monitoring and overload early warning (TOEWS™) integrated with advanced communications in a flexible, cost effective package.

Apply the T-PRO 4000 system for high speed protection and complete control of multi-winding transformers with the HV and LV windings connected to ring or breaker-and-a-half arrangements.

- Easy-to-use, intuitive setting and analysis software
- IEC 61850 communication via optical/copper ports
- Internal magnitude and phase shift compensation, eliminating requirements for external CT connections and auxiliary CTs
- 2nd and 5th harmonic restraint algorithm that improves security for energization, inrush and overfluxing
- THD alarm function that alerts to the degree of current waveform distortion and therefore harmonic content
- Asset management to maximize use of transformer capacity (ANSI/IEEE C57.91-1995)
- Through Fault Monitoring function to measure the duration, current peak RMS and accumulated I^2t values for each phase during through fault (use this information for analysis and preventive maintenance planning)
- Ambient Temperature Adaption (ADP) adjusts the pickup level of the time overcurrent protection (51HV) based on the ambient temperature
- High quality fault recording, trending and event log
- 8 setting groups to accommodate for various operating conditions
- Ethernet ports with 2 unique MAC addresses accommodate network access security needs

**IEC 61850
Compliant!**



Distributed
Network
Protocol

**10 Year
WARRANTY**

Application

- Primary and back-up protection, and management of small, medium and large power transformers, and reactors.
- Transformer asset monitoring using thermal overload based on hottest spot or top oil temperature, Transformer Overload Early Warning System (TOEWS™), and Through Fault Monitoring¹

Protection & Control

- Protection functions include IEEE devices 87, 87N, 49, 67, 50/51, 50N/51N, 51ADP, 50BF (each winding), 24INV/DEF, 59N, 59, 60, 81U/O, THD, 27, Temperature Control and TOEWS™¹
- TOEWS function provides accurate thermal overload protection of transformers with predictive 15 and 30 minute alarms
- Software control compensates current magnitude and angle

Features & Benefits

Ease of Use

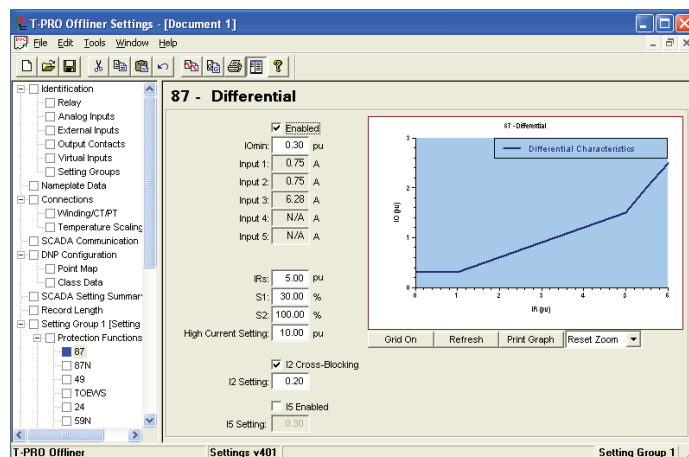
- Easy-to-use, install and maintain
- Easy to order – no complex product codes
- User-friendly, Windows®-based relay setting and record analysis software
- Setting software tool – relay specific application
- On-line setting tool
- Flexible programmable logic for building customized schemes with ProLogic™ statements – 24 control logic statements (total of 192 statements)

Reduced Installation and Operation Cost

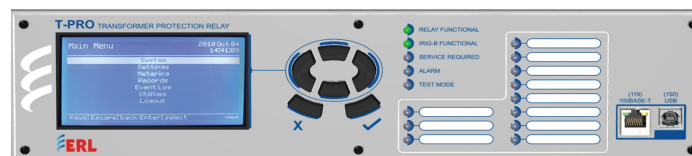
- Substation automation cost – includes IEC 61850 protocol to display and transfer operational data via local-area network (LAN) for local HMI and wide-area network (WAN) for remote monitoring SCADA
- Engineering, installation and commissioning cost – IEC 61850 messages communicate high-speed information between IEDs on the substation LAN such as transfer trips, interlocking, load-shedding and commands
- Product setting time – 240 x 128 LCD graphical user interface provides convenient means to check/change specific settings and parameters
- Front Panel Indicators – 11 user configurable LEDs,

- Applicable for transformers installed in substations with bus bar arrangement in a ring bus or breaker-and-a-half configuration

- Enhanced user-configurable logic – with ProLogic™ which includes 24 control logic statements
- 8 setting groups with unique Group Logic Control Statements – full Boolean graphics to create logic for setting groups switching based on a combination of given conditions
- Asset management to maximize use of transformer capacity (ANSI/IEEE C57.91-1995)



and 5 pre-configured LEDs as Relay Functional, IRIG-B Functional, Service Required, Test Mode, Alarm



Flexible Communications

- 2 rear ports, 100BASE-TX RJ-45 or 100BASE-FX 1300 nm multimode optical with ST style connector
- Ethernet ports with 2 unique MAC addresses that easily accommodate network access security needs
- Front panel USB and 100BASE-TX RJ-45 Ethernet port interfaces

Substation Automation – Ethernet Ready

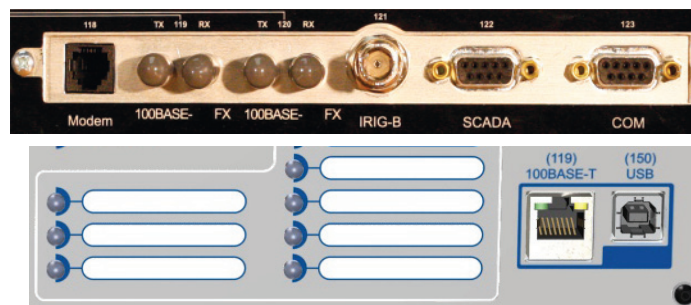
- Standard IEC 61850 Station Bus on a dedicated optical/copper Ethernet port
- Enhanced DNP3 SCADA communication protocol including user-selectable point lists, class support and multiple master station support
- Modbus SCADA communication protocol

Multi-Functional Recording and Event Logging

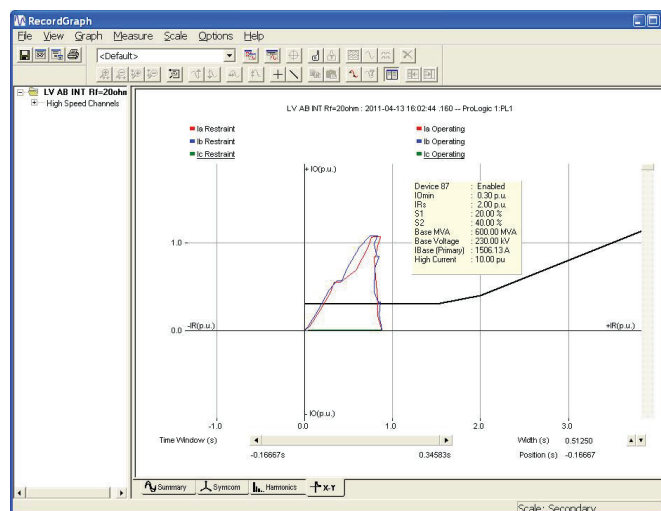
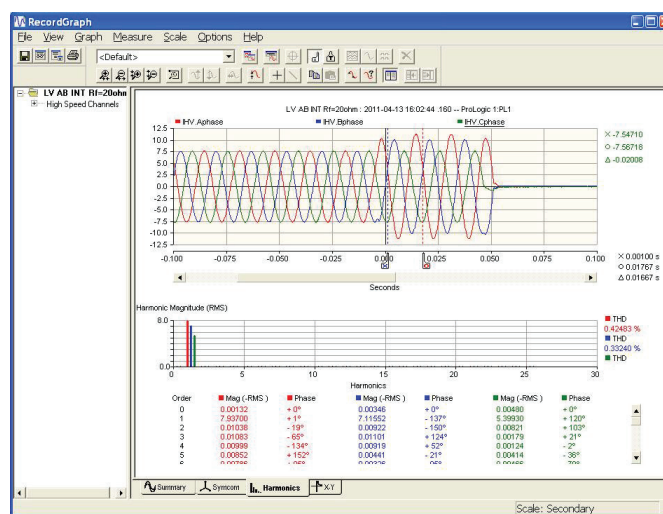
- Exceptional fault recording capabilities (with 96 samples/cycle or 5760 Hz)
- Fault location — information provided by event log access or analog input point for SCADA
- Up to 15 x 10 second transient records or combination of transient, and optionally event and trend records
- Continuous, slow-speed trend recording of the transformer and its characteristics with an adjustable sample period from 3 to 60 minutes per sample
- Breaker monitoring
- Metering functions for each input connection
- Sequence of event recorder – 250 events with 1 ms resolution
- Compressed event record capabilities – a compressed sequence of event file is created approximately every 230 events

RecordGraph™ and RecordBase View™

- Display multiple channels simultaneously and combine records
- Display multiple component voltage, current or summed channels
- Display THD, harmonic magnitude
- Display sub-harmonic THD, sub-harmonic magnitude
- Zoom, alignment, scaling, unit functions
- Record summaries including event lists
- COMTRADE, PTI and MS Excel export



- IRIG-B port (through BNC connector) for precise time stamping and sample synchronization
- Serial communication port
- 30 virtual inputs for local and remote control
- Optional internal modem



Best in Class Human-Machine Interface

Large LCD display, allows for better metering display

Navigation controls allow for an easy experience through settings, maintenance, service and view menus

Programmable target LEDs provide tripping information to expedite response to systems events

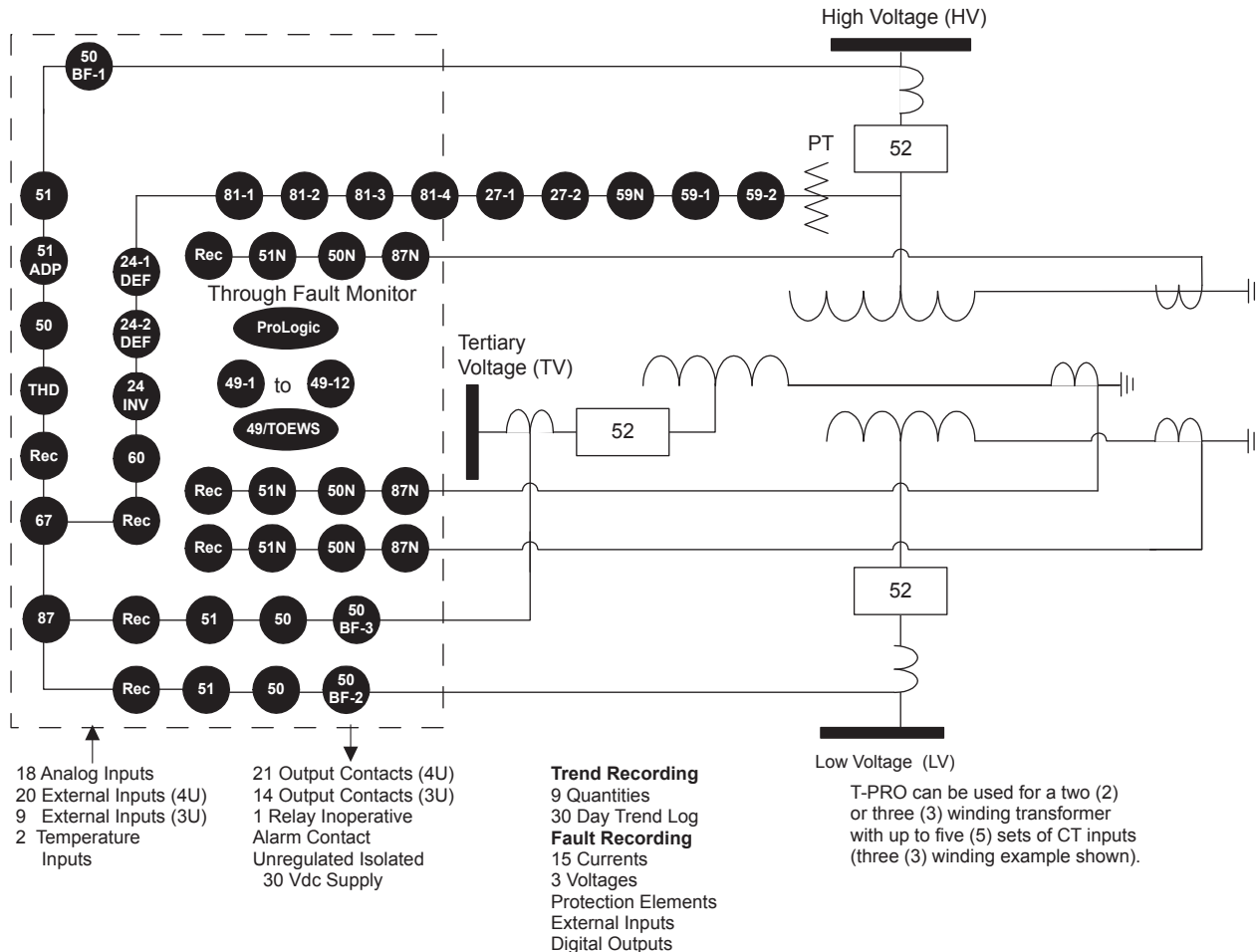


New faster processor and hardware platform

Rear optical ports ready for IEC 61850

Unique front panel USB and Ethernet ports provide easy and fast access to settings and set up

Protection & Control Function Diagram



Detailed Specifications

T-PRO 4000 Transformer Protection Relay

Item	Quantity/Specs	Notes
General		
Nominal Frequency	50 or 60 Hz	
Operating Time	12 – 25 ms typical	Including relay output operation
Power Supply	Range: 43 – 275 Vdc, 90 – 265 Vac	Power Consumption: 25 – 30 VA (ac) 25 – 30 W (dc)
Memory	Settings and records are stored in non-volatile memory	Records are stored in a circular buffer
Protection Functions		
IEEE Device 87, 87N, 49, 50/51, 50N/51N, 51ADP, 50BF (each winding), 24INV/DEF, 59N, 59, 60, 81, THD, 27, 67, Temperature Control and TOEWS™ 1	2 or 3 winding transformer with 5 sets of 3-phase current inputs, 1 set of 3-phase voltage inputs. 2 optional temperature inputs (4 – 20 mA dc)	Breaker-and-a-half and ring bus configuration, fault protection, monitoring, fault, temperature and trend recording
ProLogic™	24 statements per setting group	5 inputs per ProLogic™ statement
Group Logic	8 (16 group logic statements per setting group)	5 inputs per group logic statement
Recording		
Transient (fault)	96 s/c oscillography of all analog and external input digital channels	User-configurable 0.2 to 10 seconds record length and 0.1 to 2.0 seconds pre trigger record length
Trend	3 – 60 minute sample logging of MW, MVAR, I, ambient temperature and loss of life. Trend recording from 30 up to 600 days	When “trend auto save” is enabled, a compressed trend record is created once the trend period is completed
Sequence of Events Recorder	250 events circular log with 1ms resolution	When event auto save is enabled, a compressed event record is created every 250 events
Record Capacity	Up to 150 sec transient records, trend and event records	
Input & Output		
Analog Voltage Inputs 1 set of 3-phase voltage inputs	Nominal voltage Continuous rating over voltage Maximum over-scale thermal rating Burden	Vn = 69 Vrms 2 x Vn = 138 Vrms 3 x Vn = 207 Vrms for 10 seconds <0.15 VA @ 69 Vrms
Analog Current Inputs 5 sets of 3-phase current inputs (15 current channels)	Nominal current Full scale/continuous Maximum full-scale rating Thermal Rating Burden	In = 5 or 1 Arms 3 x In = 15 or 3 Arms 40 x In = 200 Arms or 40 Arms symmetrical 400 Arms for 1 second <0.25 VA @ 5 Arms <0.10 VA @ 1 Arms
Optional Temperature Inputs — Ambient and Top Oil	2, 4 – 20 mA current loops	External temperature sensor can be self-powered or from T-PRO relay. Unregulated 30 Vdc supply – output 40 mA @ 24 Vdc.
Analog Sampling Rate	96 samples/cycle for recording 8 samples/cycle for protection	Records up to 25th harmonic
Burden	Burden resistance: > 10 k ohms	
External Inputs (digital)	9 isolated inputs (3U chassis) 20 isolated inputs (4U chassis)	Optional 48, 110/125 or 220/250 Vdc nominal, externally wetted
Isolation	2 KV optical isolation	
Output Relays (contacts)	14 programmable outputs (3U chassis) and 1 relay inoperative contact (N.C.) 21 programmable outputs (4U chassis) and 1 relay inoperative contact (N.C.)	Externally wetted Make: 30 A as per IEEE C37.90 Carry: 8 A Break: 0.9 A at 125 Vdc resistive 0.35 A at 250 Vdc resistive
Virtual Inputs	30 Virtual Inputs	

T-PRO 4000 Transformer Protection Relay

Item	Quantity/Specs	Notes
Interface & Communication		
Front Display	240 x 128 pixels graphics LCD	Target (11), Relay Functional, IRIG-B Functional, Service Required, Test Mode, Alarm
Front Panel Indicators	16 LEDs: 11 programmable and 5 fixed	
Front User Interfaces	USB port and 100BASE-T Ethernet port	
Rear User Interfaces	LAN Port 1: 100BASE – copper or optical 1300 nm LAN Port 2: 100BASE – copper or optical 1300 nm	
Internal Modem	Two serial RS-232 ports to 115 kbd 33.6 Kbps, V.32 bis	USB 2.0, RJ-45 Copper: RJ-45, 100BASE-T Optical: 100BASE-FX, Multimode ST style connector Com port can support an external modem Optional internal modem
SCADA Interface	IEC 61850, DNP3 (RS-232 or Ethernet) or Modbus (RS-232)	Rear port
Time Sync	IRIG-B, BNC connector B003,B004,B123 and B124 Time Codes	Modulated or unmodulated, auto-detect
Self Checking/Relay Inoperative	1 contact	Closed when relay inoperative
Environmental		
Ambient Temperature Range	-40°C to 85°C for 16 hours -40°C to 70°C continuous	IEC 60068-2-1, 2 LCD contrast impaired for temperatures below -20°C and above 70° C
Humidity	Up to 95% without condensation	IEC 60068-2-30
Insulation Test (Hi-Pot)	Power supply, analog inputs, external inputs, output contacts at 2.0 kVrms, 50/60 Hz, 1 minute	IEC 60255-5, ANSI/IEEE C37.90
Electrical Fast Transient	Tested to level 4 – 4.0 kV 2.5/5 kHz on power and I/O lines	ANSI/IEEE C37.90.1, IEC/EN 60255-22-4, IEC 61000-4-4 Level 4
Oscillatory Transient	Test level = 2.5 kV	ANSI/IEEE C37.90.1, IEC/EN 60255-22-1, IEC61000-4-12 Level 3
RFI Susceptibility	10 V/m modulated, 35 V/unmodulated	ANSI/IEEE C37.90.2, IEC 60255-22-3, IEC 61000-4-3 Level 3
Conducted RF Immunity	150 kHz to 80 MHz	IEC 60255-22-6 / IEC 61000-4-6 Level 3
Shock and Bump	5 g and 15 g	IEC 60255-21-2, IEC/EN 60068-2-27: Class 1
Sinusoidal Vibration	10 Hz to 150 Hz, 1.0 octave/min, 40 sweeps	IEC/EN 60255-21-1, IEC/EN 60068-26, Class 1
Voltage Interruptions	200 ms interrupt	IEC 60255-11 / IEC 61000-4-11
Physical		
Weight	3U chassis - 9.55 Kg/21 lbs 4U chassis - 11.9 kg /32 lbs	5.2 height x 19 width rack mount x 12.9 depth 6.93” x 19 x 12.9
Dimensions	3U chassis: 13.2 cm height x 48.26 cm width rack mount x 32.8 cm depth 4U chassis 17.7 cm x 48.3 cm x 32.8 cm	
Time Synchronization and Accuracy		
External Time Source	Synchronized using IRIG-B input (modulated or unmodulated) auto detect	In the absence of an external time source, the relay maintains time with a maximum 90 seconds drift per year at a constant temperature of 25C. The relay can detect loss of re-establishment of external time source and automatically switch between internal and external time.
Synchronization Accuracy	Sampling clocks synchronized with the time source (internal or external).	

Overall T-PRO Accuracies

Current	±2.5% of inputs from 0.1 to 1.0 x nominal current (In) ±1.0% of inputs from 1.0 to 40.0 x nominal current (In)
Voltage	±1.0% of inputs from 0.01 to 2.0 x nominal voltage (Vn)
Differential Element	±5.0% of set value I _{Omin} from 0.10 to 1.0 per unit (pu)
Directional Phase Angle	±2.5% or > 2.0 of set value from 0.01 to 360.0
Frequency Elements	±0.001 Hz (fixed level) ±0.05 Hz (df/dt)
Inverse Overcurrent Timers	±2.5% or 1 cycle of selected curve

Detailed Environmental Tests

Test	Description Type Test	Test Points	Test Level
FCC Part 15	RF emissions	Enclosure ports	Class A: 30 – 1000 MHz
	Conducted emissions	ac/dc power ports	Class A: 0.15 – 30 MHz
IEC/EN 60255-25	RF emissions	Enclosure ports	Class A: 30 – 1000 MHz
	Conducted emissions	ac/dc power ports	Class A: 0.15 – 30 MHz
IEC/EN 61000-3-2	Power line harmonics	ac power port	Class D: max.1.08, 2.3, 0.43, 1.14, 0.3, 0.77, 0.23 A.... for 2nd to nth harmonic
		dc power port	N/A
IEC/EN 61000-3-3	Power line fluctuations	ac power port	THD/ 3%; $P_{st} < 1$, $P_{it} < 0.65$
		dc power port	N/A
IEC/EN 61000-4-2	ESD	Enclosure contact	+/- 6 kV
IEC/EN 60255-22-2		Enclosure air	+/- 8 kV
IEEE C37.90.3	ESD	Enclosure contact	+/- 8 kV
		Enclosure air	+/- 15 kV
IEC/EN 61000-4-3	Radiated RFI	Enclosure ports	10 V/m: 80 – 1000 MHz
IEC/EN 60255-22-3			
IEEE C37.90.2	Radiated RFI	Enclosure ports	35 V/m: 25 – 1000 MHz
IEC/EN 61000-4-4	Burst (fast transient)	Signal ports	+/- 4 kV @2.5 kHz
IEC/EN 60255-22-4		ac power port	+/- 4 kV
IEEE C37.90.1		dc power Port	+/- 4 kV
		Earth ground ports	+/- 4 kV
IEC/EN 61000-4-5	Surge	Communication ports	+/- 1 kV L-PE
IEC/EN 60255-22-5		Signal ports	+/- 4 kV L-PE, +/-2 kV L-L
		ac power port	+/- 4 kV L-PE, +/-2 kV L-L
		dc power port	+/- 2 kV L-PE, +/-1 kV L-L
IEC/EN 61000-4-6	Induced (conducted) RFI	Signal ports	10 Vrms: 0.150 – 80 MHz
IEC/EN 60255-22-6		ac power port	10 Vrms: 0.150 – 80 MHz
		dc power port	10 Vrms: 0.150 – 80 MHz
		Earth ground ports	10 Vrms: 0.150 – 80 MHz

Detailed Environmental Tests

Test	Description	Type Test	Test Points	Test Level
IEC/EN 60255-22-7	Power frequency		Binary input ports: Class A	Differential = 150 Vrms Common = 300 Vrms
IEC/EN 61000-4-8	Magnetic field		Enclosure ports	40 A/m continuous, 1000 A/m for 1 s
IEC/EN 61000-4-11	Voltage dips & interrupts		ac power port	30% for 1 period, 60% for 50 periods
			dc power port	100% for 5 periods, 100% for 50 periods
IEC 60255-11	Voltage dips & interrupts		dc power port	30% for 0.1 s, 60% for 0.1 s, 100% for 0.05 s
IEC/EN 61000-4-12	Damped oscillatory		Communication ports	100% reduction for up to 200 ms
IEC/EN 60255-22-1			Signal ports	1.0 kV Common, 0 kV Diff
			ac power port	2.5 kV Common, 1 kV Diff
			dc power port	2.5 kV Common, 1 kV Diff
IEEE C37.90.1	Oscillatory		Signal ports	2.5 kV Common, 0 kV Diff
			ac power port	2.5 kV Common, 0 kV Diff
			dc power port	2.5 kV Common, 0 kV Diff
IEC/EN 61000-4-16	Mains frequency voltage		Signal ports	30 V continuous, 300 V for 1 s
			ac power port	30 V continuous, 300 V for 1 s
IEC/EN 61000-4-17	Ripple on dc power supply		dc power port	10%

NOTE:

The T-PRO 4000 is available with 5 or 1 amp current input. All current specifications change accordingly.

¹ TOEWS and Transformer asset monitoring require the optional temperature inputs

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The specifications and product information contained in this document are subject to change without notice.
In case of inconsistencies between documents, the version at www.erlphase.com will be considered correct. (D02773R14)

