Elegant Efficient e^3 Easy to Use

ERL

TESLA 4000 Power System Monitoring Recorder

Model 4000-A

Product Overview

TESLA 4000 is an easy-to-use, state of the art, multi-time frame (simultaneous) power system monitoring recorder. Its integrated Phasor Measurement Unit (PMU) functionality streams synchrophasor data for wide area monitoring. The IEC 61850 Ed2 protocol enabled in the TESLA 4000 has advanced communication capabilities and, together with its powerful recording features, provides the most versatile and complete monitoring of power system health.

Model 4000-A, with over 1000 user definable triggers, creates records simultaneously in 3 time domains – fault (fast), swing (slow) and trend records, and also creates event logs.

Its CDR creates continuous records without triggers which (together with the fault, swing and trend records) provide wide area visibility of system performance. The CDR also creates redundancy in PMU data.

Model 4000-A has 256 virtual inputs to record digital status changes contained in IEC 61850 GOOSE messages, thus expanding its monitoring capabilities.

- Easy-to-use settings and analysis software
- Streams synchrophasor per IEEE/IEC 60255-118-1-2018 (IEEE C37.118.1). Fully compliant PMU for P and M class
- Advanced cybersecurity features
- Advanced communication protocols
- PTP 1588, IRIG-B and SNTP Time sync.
- SCADA support with DNP3, Modbus and IEC 61850 Ed2
- Optional PRP and RSTP redundancy
- CDR meets NERC PRC-002 DME standards
- Power quality monitoring (power frequency, voltage/current magnitude and voltage/current harmonics)
- Remote input modules save on costly wiring runs
- Lossless data compression for fast file transfer

Model 4000-A is available in 2 models with 36 analog/64 digital inputs/8 digital outputs, or with 18 analog/32 digital inputs/4 digital outputs.

Model 4000-A Power System Monitoring Recorder

DFR	DSR	SER	PQR	LTR	CDR	PMU
Digital Fault Recorder	Dynamic Swing Recorder	Sequence of Event Recorder	Power Quality Recorder	Long Term Trend Recorder	Continuous Disturbance Recorder	Real Time Monitoring
0 - 60 sec	1 - 30 min	1 msec resolution	32 - 512 samples/ cycle	1 - 90 days	4 - 140 days	Continually Streaming Phasor Data

dnp Distributed Network Protocol

10 Year WARRANTY

Applications

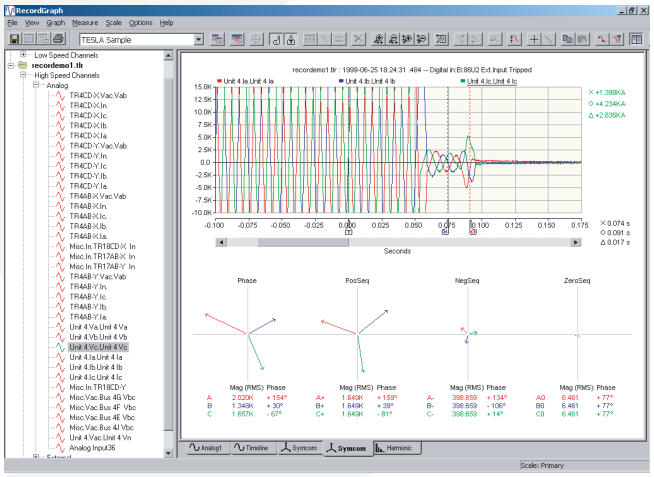
Multi-Timeframe Power System Recorder and Monitor

Use transient fault (fast) records to:

- Verify operation of relays and breakers
- Improve relay and breaker settings
- Confirm system and device models and improve coordination

Use up to 60 user-defined trends to:

- Monitor seasonal variations of load
- Analyze and model system component



Use dynamic swing (slow) records to:

- Review loading and stability criteria
- Monitor generator performance
- Verify power swing damping to improve stability
- Study SVC and PSS performance
- Detect power systems oscillations
- Understand out-of-step tripping

As a PQR:

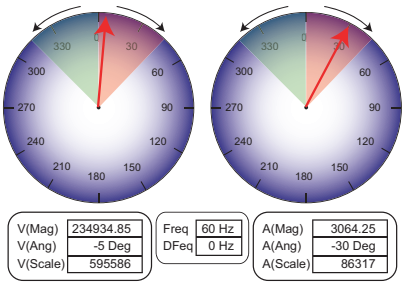
- Monitor single harmonic and total harmonic distortion (THD)
- Understand voltage sag/swell conditions
- Analyze and tune filter performance

As an SER:

- Verify operation of relays and breakers
- Reconstruct events
- Record events at 1 ms resolution

PMU for Wide Area Monitoring

- Streams synchrophasor per IEEE/IEC 60255-118-1-2018 (IEEE C37.118.1). Fully compliant PMU for P and M class
- Streams up to 36 user-selectable single-phase, 3-phase, +/-, zero sequence, and summated phasors
- Additionally streams up to 24 analog quantities of Watts, VARS, VA, THD, DC and frequency and 64 digital (status) quantities
- Streams up to 2 PDCs through Ethernet ports with independent MAC addresses
- GPS time synchronized to 500 ns accuracy
- PMU reporting rates: up to 60 frames/second
- Monitor voltage stability with real time phasor magnitude and phase angle supervision



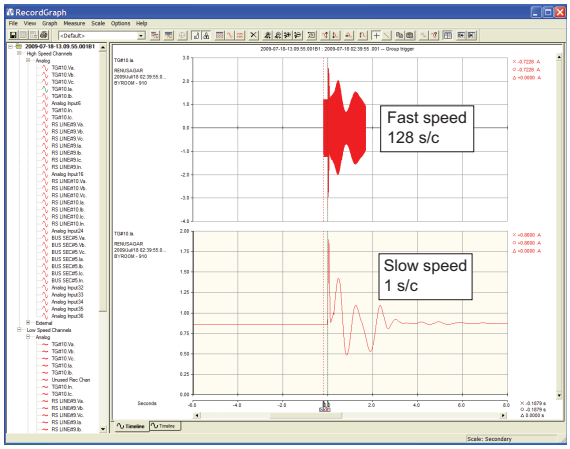
CDR (Continuous Disturbance Recorder)

- Provide continuous disturbance recording of magnitude, phase angle and frequency (without triggers) at 1 or 2 samples/cycle
- Store up to 140 days of continuous records
- Meet NERC PRC-002 DME requirements
- Create redundant storage of PMU data
- Understand long term power system behavior

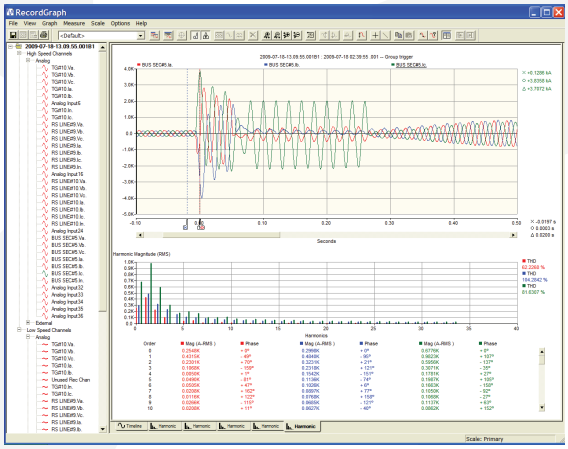
Features and Benefits

Simultaneous Multi-Functional Recording and Event Logging

- 36 analog and 64 digital inputs
- 256 IEC 61850 GOOSE virtual inputs and GOOSE recording
- High-speed transient fault recording:
  - 512 samples/cycle 30720 Hz (60 Hz System)
  - 0.2 to 60 second auto extended/merged records
- Dynamic swing (disturbance) recording:
  - 1 or 2 samples/cycle (60 Hz)
  - 10 second to 30 minute records
- Trend logging:
  - 10 to 3600 seconds for 60 channels
- Co-operative mode: view records from multiple TESLAs as single record



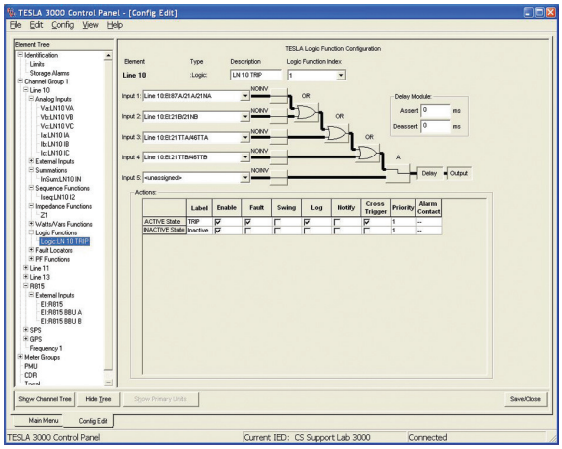
Over 130 Calculated Channels



- Frequency: 12 channels
- Summation: 48 channels
- Sequence: 24 channels
- Watts/Vars: 18 channels
- Impedance: 18 channels
- Logic: 30 channels
- Power Factor: 18 channels
- Fault Locator: 10 channels

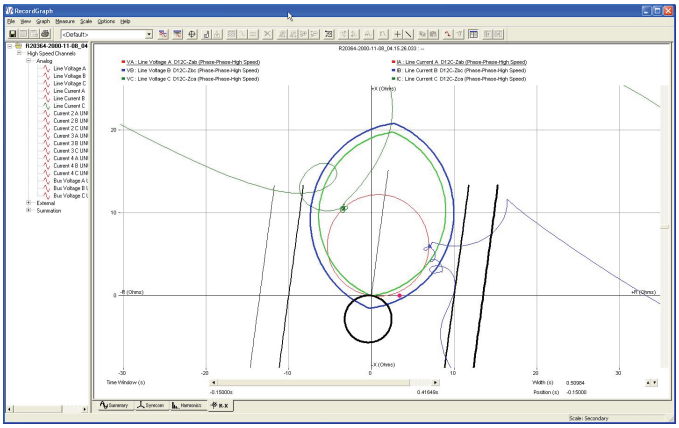
Easy-to-Use, Intuitive Windows-Based Setting and Analysis Software

- Lossless data compression for fast file transfer
- Offline mode to view records and set configurations
- Over 1000 user-definable triggers
- User-assigned trigger priorities
- User-programmable control logic
- User-configurable report templates



RecordGraph™ and RecordBase View™ Waveform Analysis Software

- Display multiple channels simultaneously and combine records
- Display multiple component voltage, current or summed channels
- Display THD, harmonic magnitude
- Use zoom, alignment, scaling, unit functions
- Record summaries including event lists
- Export via COMTRADE, PTI, CSV and MS Excel

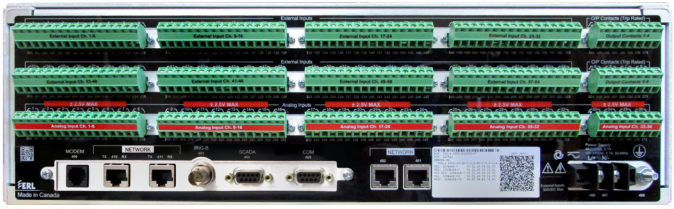


RecordBase Central Station™ for Wide Area Monitoring

- Central cross-triggering of TESLA recorders provides system-wide dynamic swing recordings for stability analysis
- Automated record transfer from on a scheduled call-out or by recorder initiation
- Supports COMTRADE, PTI and Excel output formats
- Company-wide access on existing Windows® computers through the corporate LAN

Advanced Communications

- IEC 61850 Ed2 station bus protocol
- SCADA support with DNP3, Modbus and IEC 61850 Ed2
- User-configurable DNP3 point list mapping
- Ethernet ports (copper/fiber optic) with independent MAC addresses[1] (see table for details)
- PTP (IEEE 1588), IRIG-B input (modulated or unmodulated), or SNTP Time Sync
- PRP and RSTP redundancy



Flexible, Cost Saving Architecture

- 36 analog and 64 digital inputs – 144 analog/256 digital with 4 units in cooperative mode
- 256 virtual inputs to record digital status changes contained in IEC 61850 GOOSE messages
- Remote input modules provide isolation and save costly PT and CT wiring runs
- On-board non-volatile flash memory stores up to 1000 records — no mechanical moving parts
- Easy one-time calibration
- Smallest footprint among recorders allows easy retrofit and installation
- Settings and adjustments done outside the box after installation avoids outages
- Configurable inputs — mix and match AC and DC signals with simple module changes
- AC/DC isolation module allows for inputs from any standard instrument or transducer
- Split core CTs allow easy installation while CT in service, avoiding power outages
- Pluggable terminal blocks

Cyber security features

- Role based access control for enhanced access management with support for up to 32 users
- Configurable password complexity and change frequency rules
- Audit trail for security events monitoring
- Disabling of all unused open TCP ports
- Automatic disconnection from an IED if no activity detected for a programmable period of time
- Configurable user account validity periods
- FTP access to specific folders according to assigned roles
- Syslog

Detailed Specifications

Item	Quantity/Specs	Notes
General		
Overvoltage Category	Overvoltage Category III	
Pollution Degree	Pollution Degree 2	
Ingress Protection	IP30 Standard	
Insulation Class	Class I	
Weight	24 lbs (10.8 kg)	
Dimensions	3U high (5.25"), 19" wide, 12.725" deep	Rack mount
Nominal Frequency	50 or 60 Hz	
Power Supply	48 - 250 Vdc, 100 – 240 Vac	Voltage tolerance: AC = +/-10%, DC = +20%/-10% Maximum current: 0.7 A Maximum power consumption: 34 W
Sample Rate	32, 64, 96, 128, 256, 384 and 512 samples/cycle (s/c)	Frequency response of 8th (32 s/c) to the 100th (512 s/c) harmonic of fundamental frequency
Measurement Accuracy	Amplitude Measurement Accuracy: Better than 0.1% of full scale Frequency Measurement Accuracy: ±0.001 Hz at system frequency Phase Measurement Accuracy: ±0.1 degrees at system frequency	
Noise	Signal to Noise ratio: 70dB at full scale Common mode rejection: 70dB at full scale Crosstalk: -07dB	
Temperature	-10°C to 55°C Operating -40°C to 85°C Storage	
Operating Humidity	Up to 95% without condensation	
A/D Resolution	16 bits, 65536 counts full scale	
Recording and Logging		
Transient Fault	Record length 0.2 to 15 seconds, 30 second extended/merged	User-configurable 32 to 512 samples/cycle User-configurable prefault length 0 to 8 seconds
Dynamic Swing	Record length 10 seconds to 15 minutes, 30 minute extended	1 or 2 samples/cycle User-configurable prefault length 0 to 900 seconds
Record Capacity	Standard capacity with 16GB flash up to 1000 5- second fault records with all 36 channels sampled at 96 samples/cycle or a combination of fault and swing records.	
Trending	User-selectable sampling interval from 10 to 3600 seconds Up to 60 channels can be trended simultaneously The recorder can store 90 days of data from each trend channel	5 accumulation modes – Damped, Undamped, Avg, Min, Max. Each mode is treated as a separate channel. Evaluated phasor magnitude and angle quantities will be recorded as separate channels.
Event Logging	1000 events in the regular log	Up to 1000 events can be stored as a daily trend record
Channels and Triggers		
Analog Inputs	High and low threshold, positive and negative rate of change, harmonic level, THD level, sags, swells	All triggers have independent controls for delay, logging, transient or swing record initiation, alarm contact activation and cross triggering

Item	Quantity/Specs	Notes
Channels and Triggers (cont.)		
Summations	High/low threshold, +/- rate of change	2 or 3 channels
Positive Sequence	High/low threshold, +/- rate of change	
Negative Sequence	High level	
Zero Sequence	High level	
Watts/VARs	High/low threshold, +/- rate of change	
Frequency	High/low threshold, +/- rate of change	
Impedance	Positive sequence circle with absolute rate of change	
External Inputs (digital)	Rising edge, falling edge or both	
GOOSE Virtual Inputs (digital)	Active, Inactive or both	256 virtual inputs available
Logic	Rising edge, falling edge or both	
Fault Locator	Triggered by internal or external events	
Sags and Swells	Sag and swell detection can be enabled on any voltage analog input channel	
Phasor Measurement Unit (PMU)		
PMU	36 user-selectable phasors	Single-phase quantities or 3-phase positive, negative or zero sequence phasors/summated phasors
	1 frequency channel	ROCOF reported based on user-configured frequency channel
	24 analog values	MWatts, MVars, THD, DC and frequency
	64 digital status data	Status data reported as 16 bit digital words
Continuous Disturbance Recording (CDR)		
CDR	6 to 60 RMS records/second for up to 36 channels. Minimum capacity 10 days data retention of 60 RMS records/ sec on all 36 channels.	Can store from 10 to 412 days of continuous records
Interface and Communication		
Front Panel Indicators	6 LEDs	Recorder Functional, IRIG-B Functional, Recorder Triggered, Records Stored, Test Mode, Alarm
Front User Interfaces	USB port and 100BASE-T Ethernet port	
Rear Ethernet User Interfaces	LAN Ports: Four independent Ethernet Ports, three 100MB and one 1GB, with options for Copper, Optical (ST) style connector or Optical (LC) Style Connector	Copper: RJ-45, 100BASE-T (Port 401, option for Port 410/411/412), 1000BASE-T (Port 402) Optical (ST): 100BASE-FX, Multimode, 1300nm, ST (option for Port 410/411/412) Optical (LC): 100BASE-FX, Multimode, 1310nm, LC (option for Port 410/411/412)
Serial User Interface	Two Serial RS-232 ports to 115 kbd	10 meters maximum cable length

Item	Quantity/Specs	Notes
Interface and Communication (cont.)		
Internal Modem *Currently not used*	38.4 Kbps, V.32 bis	Optional
SCADA Interface	DNP3 or Modbus	Ethernet: DNP3 RS: 232: DNP3 or Modbus
Configurable Alarms	6/3 contacts/unit	Normally open
Cross-Trigger	1 contact (#4)	Normally open
Self Checking/ Recorder Inoperative	1 contact (#1)	Normally closed
IRIG Time Sync	1 BNC or pluggable terminal block connector/unit IEEE Std. C37. 118-2011 (IRIG Standard 200-04 B004/B005/B124/B125) IEEE Std. C37. 118-2005 (IRIG Standard 200-04 B004/B005/B124/B125)	Modulated or unmodulated Input impedance = 330 ohms
Inputs and Outputs		
Remote Analog Inputs	4 input current module, 3 or 4 input voltage module, 3 or 4 input DC isolation module or split-core CTs. See module datasheets for more information.	Modules mount up to 1200 meters (4000 feet) away from recorder chassis using twisted/shielded communication wiring
Analog Input Channels Ratings	For module specific ratings refer to the modules data sheets refer to Appendix G of the TESLA Manual	18 or 36 per unit, 144 maximum using 4 units in "Cooperative Mode"
External Inputs (digital)	64 per unit Burden: 0.03W @ 48Vdc 0.07W @ 125Vdc 0.14W @ 250Vdc 0.17W @ 300Vdc Isolation: Optically Isolated Turn-on voltage: 48 Vdc range = 38 to 40 Vdc 125 Vdc range = 80 to 90 Vdc 250 Vdc range = 165 to 180 Vdc	Optional 48, 110/125 or 220/250 Vdc nominal, externally wetted. The 220/250 Vdc option is not available if CE compliance is required. Specified voltages are over full ambient temperature range
Alarm Contacts	300 Vdc max, externally wetted 150 Vdc max, for CE compliance Make: 30 A Vdc per IEEE C37.90 Carry: 8 A Vdc for 5 minutes, 6A Vdc for 60 minutes, 5 A continuous 0.9 A at 125 Vdc resistive 0.35 A at 250 Vdc resistive	4 or 8 per unit Contact #1: "Recorder Functional" Normally closed contact. Opens ~45 seconds after recorder power is applied during the IED boot-up sequence. Closed on failure. Contacts #2 to #8 - Normally Open contacts that close when triggered. Contact #4: Cross trigger contact – Pick-up <10 ms, latch 100 ms User-definable trigger alarm contacts – Pick-up <1.0 s, latch 1.0 s All contacts can be active simultaneously
Virtual Inputs	256 GOOSE virtual inputs	
Time Synchronization and Accuracy		
External Time Source	Synchronized using PTP (IEEE 1588), IRIG-B input (modulated or unmodulated), or SNTP	Upon the loss of an external time source, the recorder maintains time with a maximum 0.236 seconds drift per year at a constant temperature of 25°C. The recorder can detect loss or re-establishment of external time source and automatically switch between internal and external time.
Type Tests		

Type Tests

Test	Description		Test Level
	Type Test	Test Points	
Electromagnetic Compatibility			
CISPR 11 & 32 FCC 15 - ICES 003 IEC 60255-26	Power Line Conducted Emissions	Power ports	Class A
	Radiated Emissions	Enclosure	Class A
IEC 60255-26 IEC 61000-4-2 IEEE C37.90.3	Electro-Static Discharge	Enclosure contact	± 8kV
		Enclosure air	± 15kV
IEC 60255-26 IEC 61000-4-3	Radiated Field Immunity	Enclosure	10V/m: 80 MHz – 1 GHz and 1.4 GHz – 2.7 GHz
IEC 60255-26 IEC 61000-4-4	Electrical Fast Transients (Bursts)	Power ports	±4kV
		Communication ports	±2kV
		I/O ports	±4kV
IEC 60255-26 IEC 61000-4-5	Surge Immunity	DC power ports	±2kV L-L, ±4kV L–G
		Communication ports	±4kV L–G
		I/O ports	±2kV L-L, ±4kV L–G
IEC 60255-26 IEC 61000-4-6	Conducted RF Immunity	Power ports	10 Vrms: 150 kHz – 80 MHz
		Communication ports	10 Vrms: 150 kHz – 80 MHz
		I/O ports	10 Vrms: 150 kHz – 80 MHz
IEC 60255-26 IEC 61000-4-8	Power Frequency Magnetic Field	Enclosure	100 A/m Continuous (60s) 1000 A/m Pulse (3s)
IEC 60255-26 IEC 61000-4-11	AC Voltage Dips and Interrupts	AC power port	100% reduction for 100ms
IEC 60255-26 IEC 61000-4-16	Power Frequency	External Input ports	150Vrms Differential 300Vrms Common
IEC 60255-26 IEC 61000-4-17	AC Ripple on DC Power Port	DC power port	15% of Rated DC Value 100/120 Hz
IEC 60255-26 IEC 61000-4-18	Damped Oscillatory Wave Immunity Test	Power ports	±1kV Differential ±2.5kV Common
		Communication ports	±1kV Common
		I/O ports	±1kV Differential ±2.5kV Common
IEC 60255-26 IEC 61000-4-29	DC Voltage Dips and Interrupts	DC power port	100% for 100ms
IEC 60255-26 Clause 7.2.13	Gradual Shutdown/ Start-up	DC power port	Shut-down ramp: 60s Power off: 5min Start-up ramp: 60s
Safety			
IEC 60255-27 Clause 10.6.4.2	HV Impulse	I/O ports and boards	±5kV
		Power ports	±5kV
IEC 60255-27 Clause 10.6.4.3	Dielectric / HiPot	Communication ports	0.5kV
		Power ports	2.2kV (AC)
		I/O ports	2.2kV (AC)
IEC 60255-27 Clause 10.6.4.4	Insulation Resistance	Communication ports	500V (DC)
		Power ports	500V (DC)
		I/O ports	500V (DC)

Type Tests (cont.)			
Test	Description		Test Level
	Type Test	Test Points	
Environmental Tests			
IEC 60068-2-1	Cold (operating and storage)	Enclosure	-40°C, 16Hrs
IEC 60068-2-2	Hot (operating and storage)	Enclosure	+55°C, 16Hrs
IEC 60068-2-14	Change of Temperature	Enclosure	5 cycles of 1.5hrs at -10°C and 1.5hrs at 60°C
IEC 60068-2-30	Cyclic Temperature with Humidity	Enclosure	6 cycles of: +55°C and 93% rh, 12Hrs +25°C and 95% rh, 12Hrs
IEC 60068-2-78	Damp Heat Steady State	Enclosure	10 days at 40°C, 93% rh
Mechanical			
IEC 60068-2-6 IEC 60255-21-1	Sinusoidal Vibration	Enclosure	Class 1: 1g, 10 Hz to 150 Hz, 20 sweep cycles per axis
IEC 60255-21-3	Earthquake	Enclosure	Class 1: 0.5g X & 1.0g Y, 5 Hz to 35Hz, one sweep cycle per axis
IEC 60068-2-27 IEC 60255-21-2	Shock	Enclosure	Class 1: 15g, 3 pulses per direction per axis
IEC 60068-2-27 IEC 60255-21-2	Bump	Enclosure	Class 1: 10g, 1000 pulses per direction per axis

ERLPhase Power Technologies
Tel: 204-477-0591
Email: info@erlphase.com