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.

With over 1000 user definable triggers, it 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.

Model 4000-A is IEEE Synchrophasor Certified.

- Easy-to-use settings and analysis software
- Streams P and M class synchrophasor per IEEE C37.118.1.2011-2014a standards
- Meets all NERC PRC-002 and PRC-028 disturbance monitoring (DME) and reporting requirements
- Advanced cybersecurity features
- PTP 1588, IRIG-B and SNTP Time sync.
- SCADA support with DNP3, Modbus and IEC 61850 Ed2
- Optional PRP and RSTP redundancy
- Remote input modules save on costly wiring runs

Model 4000-A is available in 4 models with 36 analog/64 digital inputs/8 digital outputs, 18 analog/32 digital inputs/4 digital outputs, 12 analog/32 digital inputs/4 digital outputs and 8 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	36 - 1082 days	Continually Streaming Phasor Data

*Software merges overlapping records from multiple triggers

UK CA CE 10 Year WARRANTY

Applications

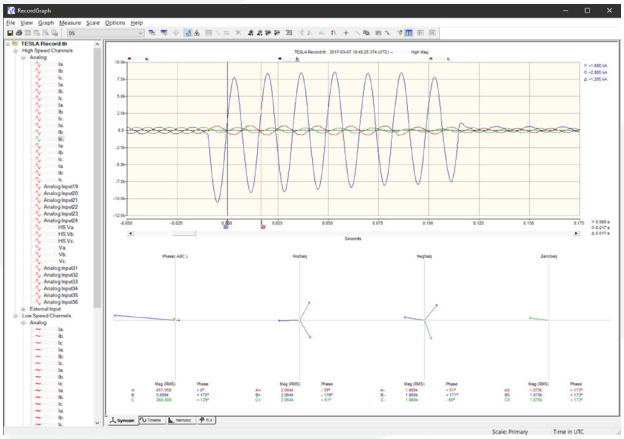
Multi-Timeframe Power System Recorder and Monitor

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

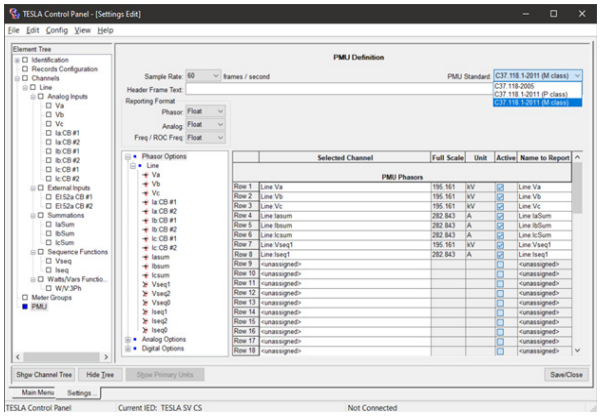
As an SER:

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

PMU for Wide Area Monitoring

Monitor voltage stability with real time phasor magnitude and phase angle supervision

- IEEE Synchrophasor Certified in accordance with IEC/IEEE 60255-118-1:2018
- 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, frequency, 64 digital (status) quantities and 256 virtual inputs
- Streams to 2 PDCs through Ethernet ports with independent MAC addresses
- PMU reporting rates: up to 60 frames/second



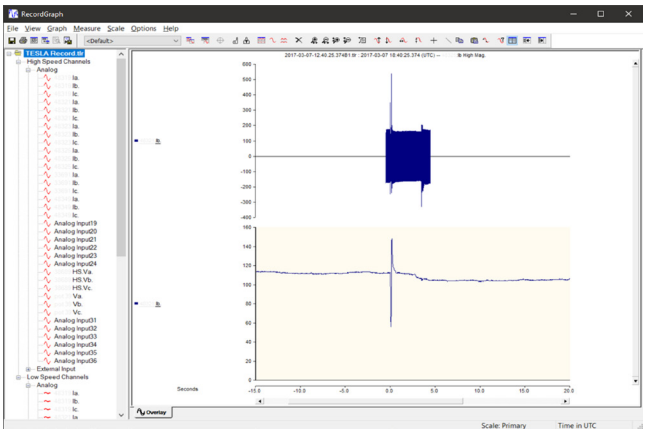
CDR (Continuous Disturbance Recorder)

- Provide continuous disturbance recording of magnitude, phase angle, frequency and DC channel inputs (without triggers) at 1 sample/cycle
- Store up to 1082 days of continuous records
- Meets all of NERC PRC-002 and PRC 028 DME requirements (SER, FR and DDR recording/reporting)
- Create redundant storage of PMU data
- Understand long term power system behavior

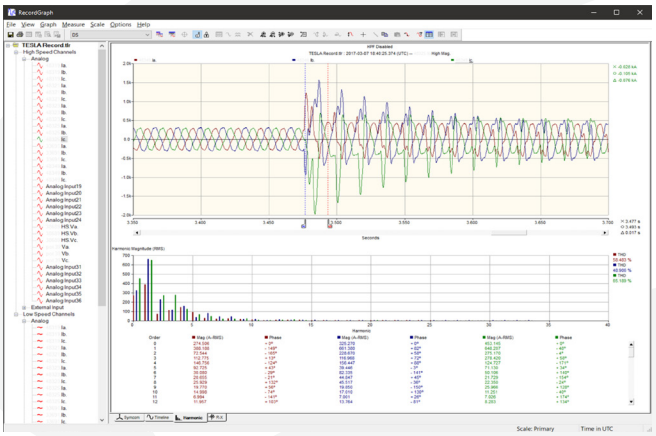
Features and Benefits

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:
  - Up to 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
  - Stitching
- Trend logging:
  - 10 to 3600 seconds for 60 channels
- Sequence of events recording
  - 1000 event circular buffer with automatic overwrite
  - Event recorded at 1 ms resolution
- Coop Mode and Group Trigger Mode:
  - Event seen on one TESLA cross triggers 3 other TESLAs to create records giving complete view of the event
  - Group mode also has the capability to trigger up to 8 recorders via IEC 61850 (Model 4000 and Model 4000-A may be combined)



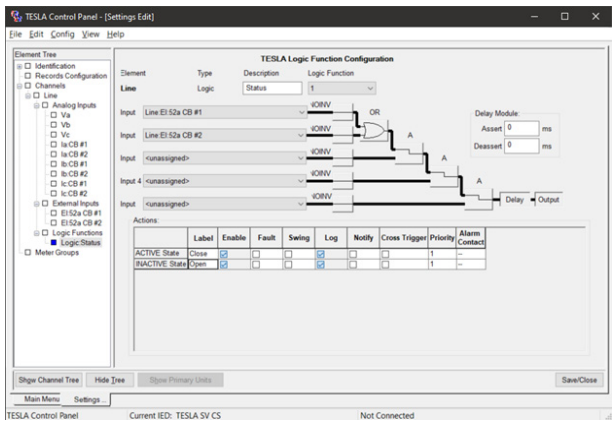
Over 130 Calculated Channels



- 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

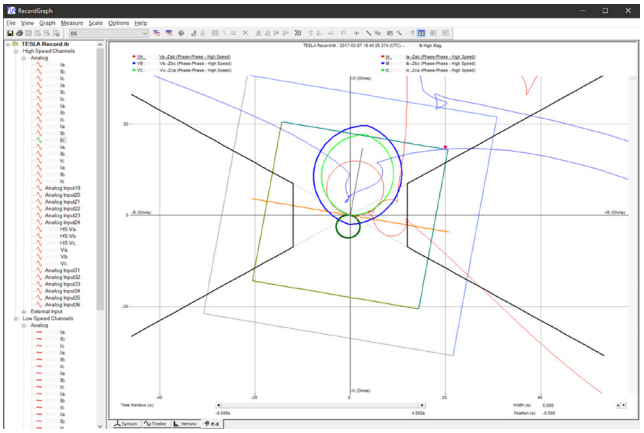
Easy-to-Use, Intuitive Windows-Based Setting and Analysis Software

- 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



Waveform Analysis Software

- Display multiple channels simultaneously and combine records
- Present records' quantities in multiple views, e.g. Timeline/ Overlay, Symmetrical Components, Harmonics, Impedance, Sub-harmonic and Phasor
- 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

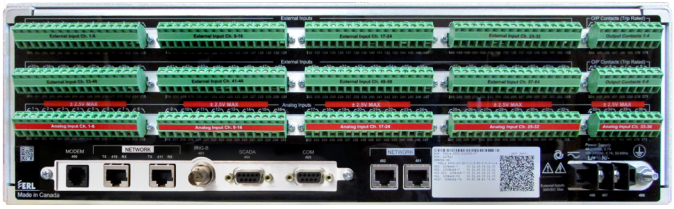


RecordBase Central Station™ for Wide Area Monitoring

- 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

- 288 analog/512 digital with 8 units in Group Record Trigger 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 2500 records — no mechanical moving parts
- Easy one-time calibration
- Small footprint 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

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		
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	
Temperature	-10°C to 55°C Operating -40°C to 85°C Storage	
A/D Resolution	16 bits, 65536 counts full scale	
Recording and Logging		
Transient Fault	Record length 0.2 to 15 seconds, 60 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 60 seconds
Record Capacity	Standard capacity with 16GB of 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.	64GB and 1TB can store up to 2500 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
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/256 virtual inputs	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 with 16GB Can store from 36 to 1082 days of continuous records with 16GB and 1TB
Interface and Communication		
Front Panel Indicators	6 LEDs	Recorder Functional, Time Functional, Recorder Triggered, Records Stored, Test Mode, Alarm
Front User Interfaces	USB port and 100BASE-T Ethernet port	
Rear Ethernet User Interfaces	LAN Port 1: Copper (100 BASE-T) LAN Port 2: Copper (1000 BASE-T) LAN Port 3: Copper or Optical (100 BASE-T) - optional redundant port with RSTP and PRP LAN Port 4: Copper or Optical (100 BASE-T)	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) Optical (LC): 100BASE-FX, Multimode, 1310nm, LC (option for Port 410/411/412)

Item	Quantity/Specs	Notes
Serial User Interface	Two Serial RS-232 DCE devices	Female DB9 connectors
Interface and Communication (cont.)		
SCADA Interface	MMS or DNP3 or Modbus	Ethernet: MMS or DNP3 RS-232: MMS or DNP3 or Modbus
Configurable Alarms	6 or 2 contacts/unit	Normally open
Cross-Trigger	1 contact (#4)	Normally open
Self Checking/ Recorder Inoperative	1 contact (#1)	Normally closed
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) PTP/IEEE 1588	IRIG-B 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	8, 12, 18 or 36 per unit, 144 maximum using 4 units in Cooperative Mode 288 maximum using 8 units in Group Record Trigger Mode
External Inputs (digital)	Will turn on: >= 38 Vdc Will not turn on: <= 25 Vdc Maximum input: <300 Vdc Burden: > 0.2 W @ 300 Vdc	32 or 64 per unit, 256 maximum using 4 units in Cooperative Mode 512 maximum using 8 units in Group Record Trigger Mode Externally wetted
Alarm Contacts	4 or 8 contacts per unit 300 Vdc max, externally wetted Trip rated contacts on rear: Make: 30 A per IEEE C37.90 Carry: 8 A for 5 minutes, 6 A for 60 minutes, 5 A continuous Break: 0.9 A at 125 Vdc resistive 0.35 A at 250 Vdc resistive	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.

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