TESLA 4000 Power System Monitoring Recorder

Model 4000

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 protocol enabled TESLA has advanced communication capabilities and, together with its powerful recording features, provides the most versatile and complete monitoring of power system health.

The TESLA, 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.

TESLA 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 synchrophasors per C37.118.1-2011 (IEEE C37.118.1a-2014) standards
- Advanced cybersecurity features
- Advanced communication protocols
- SCADA support with DNP3, Modbus and IEC 61850
- Optional PRP, HSR and RSTP redundancy
- CDR meets NERC PRC-002 DME standards
- Remote input modules save on costly wiring runs
- Lossless data compression for fast file transfer

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

TESLA 4000 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 - 384 samples/ cycle	1 - 90 days	11 - 412 days	Continually Streaming Phasor Data

*Software merges overlapping records from multiple triggers

UK CA CE 10 Year WARRANTY

Applications

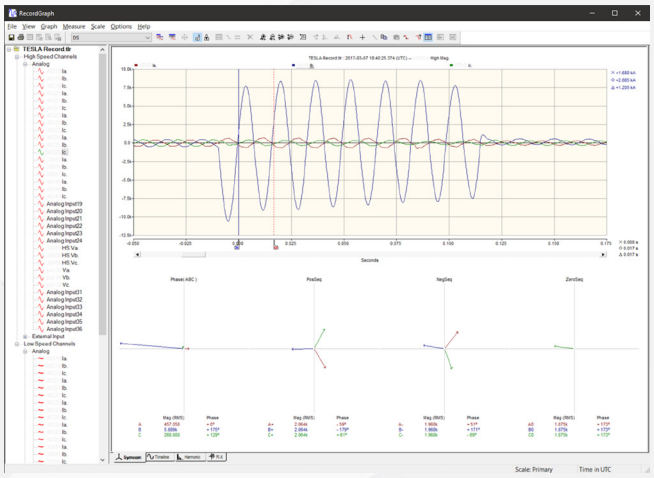
Multi-Timeframe Power System Recorder and Monitor

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 sub-harmonic oscillations
- Understand out-of-step tripping

As a PQR:

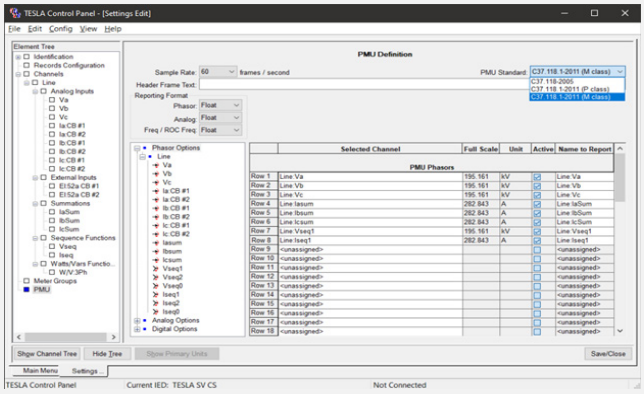
- Monitor single harmonic,THD and sub-harmonics
- Understand voltage sag/swell conditions
- Analyze and tune filter performance

As an SER:

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

PMU for Wide Area Monitoring

- Streams synchrophasors per C37.118.1-2011 (IEEE C37.118.1a-2014) standards
- 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
- Improve transmission reliability planning



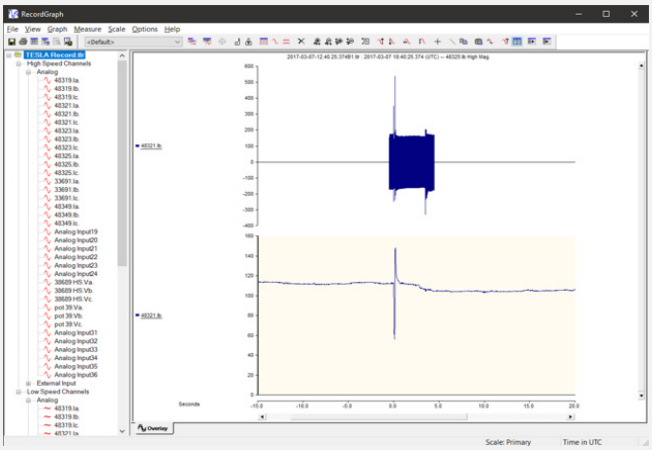
CDR (Continuous Disturbance Recorder)

- Provide continuous disturbance recording of magnitude, phase angle and frequency (without triggers) at 1 sample/cycle
- Store up to 412 days of continuous records
- Meet NERC PRC-002 DME requirements
- Create redundant storage of PMU data
- Understand long term power system behavior

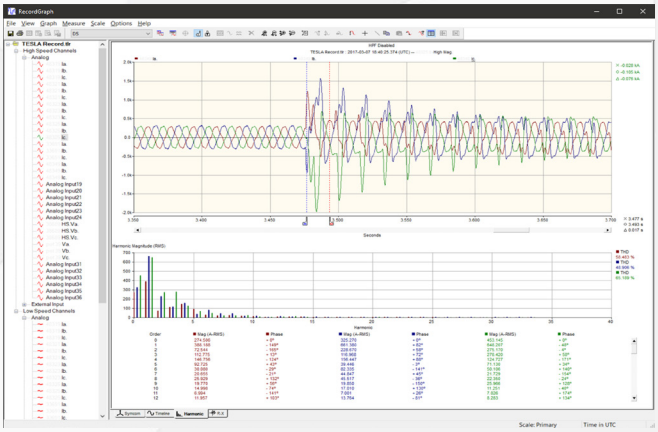
Features and Benefits

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:
  - 384 samples/cycle (23040 Hz)
  - 0.2 to 60 second auto extended/merged records
- Dynamic swing (disturbance) recording:
  - 1 sample/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



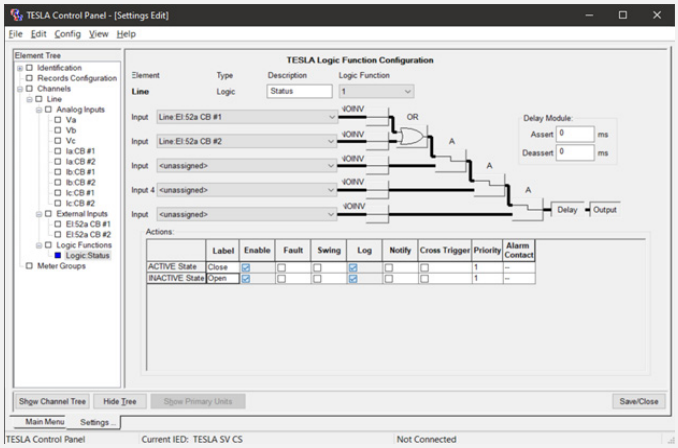
Over 120 Calculated Channels



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

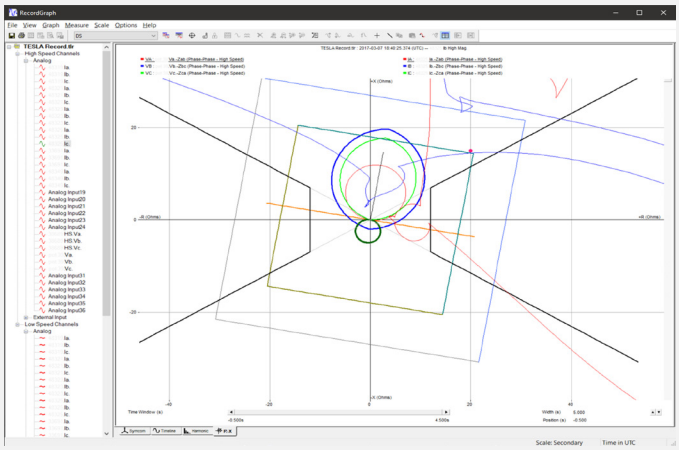
Easy-to-Use, Intuitive Windows-Based Setting and Analysis Software

- 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

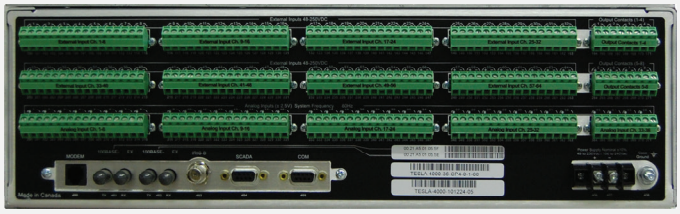


RecordBase Central Station™ for Wide Area Monitoring

- 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 station bus protocol
- SCADA support with DNP3, Modbus and IEC 61850
- User-configurable DNP3 point list mapping
- Two Ethernet ports (copper/fiber optic) with independent MAC addresses[1] (see table for details)
- IRIG-B time sync, modulated or un-modulated
- Primary/secondary SNTP time network sync
- PRP, HSR, 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

TESLA 4000 Power System Monitoring Recorder

Item	Quantity/Specs	Notes
General		
Overvoltage Category	Overvoltage Category III	
Pollution Degree	Pollution Degree 2	
Ingress Protection	IP30 standard	
Insulation Class	Class I	
Weight	TESLA 4000 18 channel: 16.7 lbs (7.6 kg) TESLA 4000 36 channel: 17.8 lbs (8.1 kg)	
Dimensions	3U high (5.25"), 19" wide, 12.9" 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 and 384 samples/cycle (s/c)	Frequency response of 8th (32 s/c) to the 100th (384 s/c) harmonic of fundamental frequency
Measurement Accuracy	Amplitude Measurement Accuracy: Better than 0.1% of full scale Phase Measurement Accuracy: ±0.5 degrees at system frequency Frequency Measurement Accuracy: ±0.001 Hz at system frequency	±0.5% of reading (above 1% of full scale)
Noise	Signal to Noise ratio: 70dB at full scale Common mode rejection: 70dB at full scale Crosstalk: -07dB	
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 384 samples/cycle User-configurable prefault length 0 to 8 seconds
Dynamic Swing	Record length 10 seconds to 15 minutes, 30 minute extended	1 sample/cycle User-configurable prefault length 0 to 900 seconds
Record Storage	Standard capacity with 4GB flash up to 1000 2-second fault records with all 36 channels sampled at 96 samples/cycle channels or a combination of fault and swing records. Extended Capacity (16 gb) flash up to 1000 5-second fault records with all 36 channels sampled at 256 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	500 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	36/18 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
	32/64 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. Standard Capacity min. 10 days data retention below 30 RMS records/second on all 36 channels. Extended Capacity min. 10 days data retention of 60 RMS records/sec on all 36 channels.	Can store from 10 to 140 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 Port 1: Copper or Optical LAN Port 2: Copper or Optical	Copper: RJ-45, 100BASE-T Optical: 100BASE-FX, Multimode, 1300 nm, ST style connector
Serial User Interface	Two Serial RS-232 DCE devices	Female D89 connectors
Internal Modem	38.4 Kbps, V.32 bis	Optional
SCADA Interface	MMS, DNP3 or Modbus	Ethernet: MMS or DNP3 RS: 232: MMS, DNP3 or Modbus
Configurable Alarms	6/3 contacts/unit	Normally open

Item	Quantity/Specs	Notes
Interface and Communication (cont.)		
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)	IRIG-B modulated or unmodulated Input impedance = 330 ohms
Inputs and Outputs		
Remote Analog Input Modules	4 input current module, 3 or 4 input voltage module or 4 input dc isolation module and split-core CTs. See module data sheets 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 Appendix G of the TESLA Manual.	18 or 36 per unit, 144 maximum using 4 units in "Cooperative 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" Externally wetted
Alarm Contacts	300 Vdc max, externally wetted If labelled "trip rated" on rear: 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 If not labelled "trip rated" on rear: Make: 8 A Vdc Carry: 8 A Vdc for 5 minutes, 6 A Vdc for 60 minutes, 4 A continuous Break: 0.15 A at 125 Vdc 0.10 A at 250 Vdc	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 8ms User-definable contacts – Pick-up <1.0 s, latch 1.0 s New units are shipped with trip rated contacts All contacts can be active simultaneously
Virtual Inputs	256 virtual inputs	
Time Synchronization and Accuracy		
External Time Source	Synchronized using IRIG-B input (modulated or unmodulated) auto detect	Upon the loss of an external time source, the recorder maintains time with a maximum 160 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.
Synchronization Accuracy	Sampling clocks synchronized with the time source (internal or external)	
Environmental		
Ambient Temperature Range	IEC 60068-2-1/IEC 60068-2-2	-10°C to 55°C
Humidity	IEC 60068-2-30	Up to 95% without condensation
Insulation Test (Hi-Pot)	IEC 60255-5	Power supply, analog inputs (through external isolation modules), external inputs, output contacts – 2 kV, 50/60 Hz, 1 minute

Item	Quantity/Specs	Notes
Environmental (cont.)		
Electrostatic Discharge	IEC 61000-4-2 Level 4, IEEE C37.90.3, IEC 60255-22-2 Level 4	
Voltage Dips, Interruptions, Variations	IEC 6100-4-11, IEC 60255-11	200 ms interrupt
Conducted RF Immunity	IEC 61000-4-6 Level 3, IEC 60255-22-6 Level 3	Inputs using DC Modules meet Level 2
Radiated RF Susceptibility	IEC 61000-4-6 Level 3, IEC 60255-22-3 Level 3	Inputs using DC Modules meet Level 3
Electrical Fast Track/Burst	IEC 61000-4-4 Level 4 (4 kV), IEC 60255-22-4 Class IV (4 kV)	
Oscillatory Transient	ANSI/IEEE C37.90.1-1989, IEC 61000-4-12 Level 3, IEC 60255-22-1 Level 3	
Oscillatory Vibration	IEC 60068-2-6, IEC 60255-21-1 Class 1	
Seismic	IEC 60068-3-3, IEC 60255-21-3 Class 1	
Shock and Bump	IEC 60255-21-2 Class 1	
RF Emissions	IEC/EN 60255-25 Class A	DC Modules, if used, do not meet Class A
Conducted Emissions	IEC/EN 60255-25 Class A	DC Modules, if used, do not meet Class A

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