TESLA 4000 Power System Recorder

IEC 61850-9-2 LE & 61869-9 Sampled Values Subscriptions

TESLA 4000-SV

Product Overview

TESLA 4000 is an easy-to-use, state-of-the-art, multi-time frame (simultaneous) power system monitor with IEC 61850-9-2 LE as well as IEC 61869-9 process bus sampled values and IEC 61850-8-1 station bus capabilities. These advanced communication capabilities together with its powerful recording features, provides standardization and interoperability of fault and disturbance recording solutions as the industry moves towards fully digital substations.

With over 1000 user definable triggers, TESLA 4000 creates records simultaneously in 3 time domains - fault (fast), swing (slow) and trend records, and also creates event logs. Its integrated Phasor Measurement Unit (PMU) functionality streams synchrophasor data for wide area monitoring. Its Continuous Disturbance Recorder (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 4000-SV is capable of subscribing to 36 SV inputs from 8 SV data streams. It has 256 virtual inputs to record digital status changes contained in IEC 61850 GOOSE messages. It also provides 64 wired digital inputs and 8 digital outputs.

- IEC 61850 Station Bus protocol and Process Bus protocol
- IEC 61850-9-2 LE and IEC 61869-9 sampled values subscriptions
- IEC 61850 Ed. 2 LGOS and LSVS logical nodes for monitoring GOOSE subscriptions and SV respectively
- Synchrophasor streaming per IEEE/IEC 60255-118-1-2018 (IEEE C37.118.1)
- Optional PTP/IEEE 1588 time synchronization uses the IEEE C37.238 Power Profile as well as IEEE/IEC 61850-9-3 Utility Profile
- Optional PRP redundancy
- Advanced cybersecurity features
- Flexible, cost saving architecture
- Lossless data compression for fast file transfer

Now with IEC 61850-9-2 LE & 61869-9 Sampled Values support!

TESLA 4000 with Sampled Values

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	Up to 288 samples/ cycle	1 - 90 days	11 - 412 days	Continually Streaming Phasor Data

*Software merges overlapping records from multiple triggers

Features & Benefits

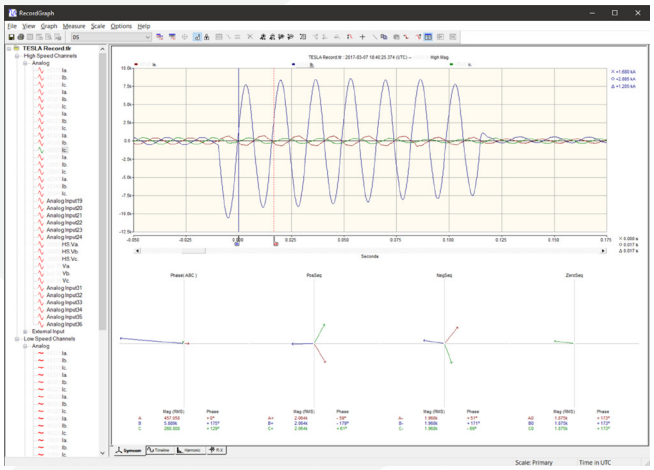
Multi-Timeframe Power System Recorder and Monitor

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:

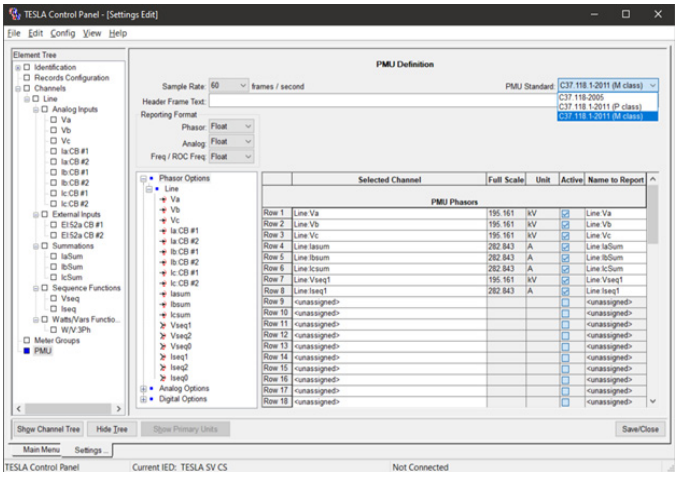
- Monitor single harmonic, THD and sub-harmonics
- Understand voltage sag/swell conditions
- Analyze and tune filter performance

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 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, positive/negative, zero sequence, and summated phasors
- Additionally streams up to 24 analog quantities of Watts, VARS, VA, THD and frequency, 64 digital (status) quantities and 256 GOOSE Boolean Virtual Input Status data
- 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)

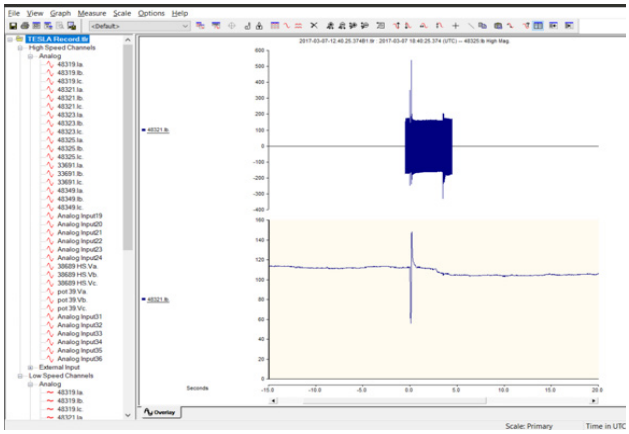
- Provide continuous disturbance recording of magnitude, phase angle and frequency (without triggers) at a configurable sampling rate of up to 1 sample/cycle
- Store up to 1082 days of continuous records
- Meet NERC PRC-002 and PRC-028 DME requirements
- Create redundant storage of PMU data
- Understand long term power system behavior

Simultaneous Multi-Functional Recording and Event Logging

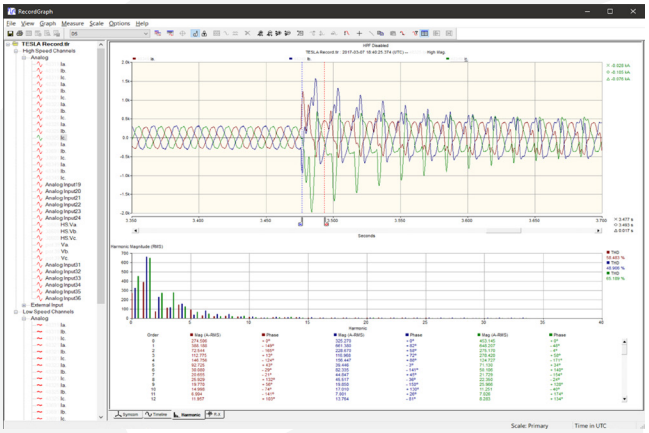
- 36 sampled values inputs (IEC 61850 9-2 LE & IEC 61869-9 sampled values subscription and recording)
- 256 virtual inputs (IEC 61850 GOOSE subscription and recording)
- High-speed transient fault recording:
  - 256 samples/cycle (15360 Hz)
  - 0.2 to 60 second auto extend/merged records
- Dynamic swing (disturbance) recording:
  - 1 or 2 sample/cycle
  - 10 second to 30 minute records
- Trend logging:
  - Configurable sampling rate: 1 sample per 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 Trigger mode also has the capability to trigger up to 8 recorders via IEC 61850 (Model 4000 and Model 4000-A also combined)



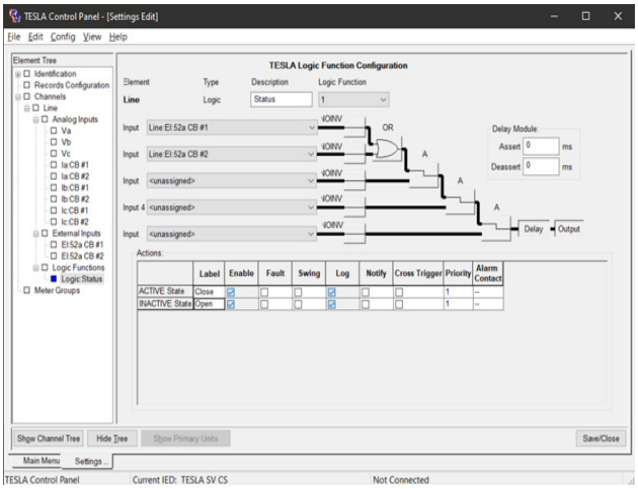
Over 130 Calculated Channels



- 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

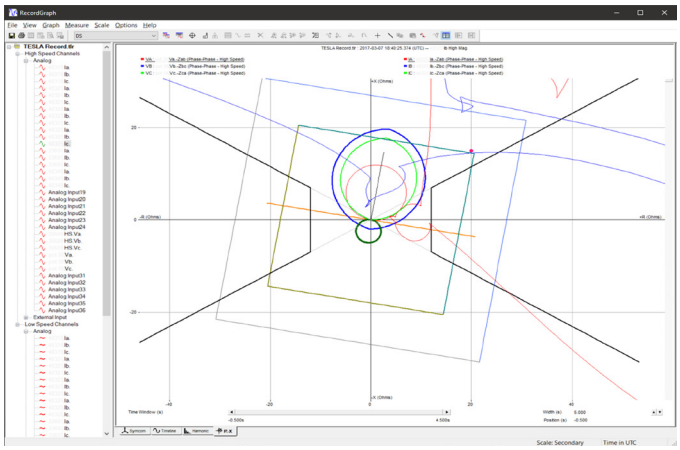
Easy-to-Use, Intuitive Windows-Based Setting and Analysis Software

- 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



RecordGraph™ 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
- Reduce graph re-creation processing time when viewing multiple records using viewer templates



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 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
- IEC 61850 process bus protocol
- PTP/IEEE 1588 time sync (optional)
- Ethernet ports (copper/fiber optic) with independent MAC addresses (see table for details)
- IRIG-B time sync, modulated or un-modulated
- Primary/secondary SNTP time network sync
- PRP and RSTP redundancy (optional)

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
- Audit trail capability with the ability to communicate with a Syslog Server in accordance to RFC5424 (“The Syslog Protocol”) and RFC5426 (“Transmission of Syslog Messages Over UDP”) standards.

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-SV 36 channel: 24.0 lbs (10.9 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: 20 - 36 W
Sample Rate	80 or 256 s/c for IEC 61850-9-2 LE SV stream 4000, 4800, 14400 Hz for IEC 61869-9 SV stream	The harmonic response varies due to different sample rate configuration
Sampled Value Subscription Accuracy	Subscription Amplitude Accuracy: better than 0.01% at full scale (FS) SV stream value. (Voltage FS is 2 times of nominal and Current FS is 40 times of nominal)	Overall measurement accuracy is governed by the accuracy of the merging unit which is the primary measurement device
Temperature	IEC 60068-2-1/IEC 60068-2-2	-10°C to 55°C Operating -40°C to 85°C Storage
Operating Humidity	IEC 60068-2-30	Up to 95% without condensation
Recording and Logging		
Transient Fault	Record length 0.2 to 15 seconds, 60 second extended/merged	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 Storage	64GB and 1TB can store up to 2500 records 5-second fault records with all 36 channels 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 (sampled values)	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
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	

Item	Quantity/Specs	Notes
Channels and Triggers (cont.)		
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 states apply to Boolean. Enumerated data type uses a 'Change' state	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 External Inputs and 256 GOOSE Boolean Virtual Input Status data	Status data reported as 16 bit digital words
Continuous Disturbance Recording (CDR)		
CDR	5/6 to 50/60 (depending on the system frequency) RMS records/second for up to 36 channels Minimum capacity of 10 days data retention of 50/60 RMS records/sec on all 36 channels	Can store from 22 to 673 days of continuous records with 64GB Can store from 36 to 1082 days of continuous records with 1TB
Interface and Communication		
Front Panel Indicators	6 LEDs	Recorder Functional, Time Sync, Recorder Triggered, Records Stored, Test Mode, Alarm
Front User Interfaces	USB port and 100BASE-T Ethernet port	
Rear Ethernet User Interfaces	LAN Ports: Copper, Optical (ST) style connector or Optical (LC) Style Connector	Non-Redundancy hardware, Single Redundancy hardware and Multiple Redundancy hardware have different port assignments and connector. Please refers to ordering template for details.
Serial User Interface	Two serial RS-232 DCE devices	Female DB9 connectors
Internal Modem currently not used	No modem	
SCADA Interface	MMS or DNP3 or Modbus	Ethernet: MMS or DNP3 RS-232: MMS or DNP3 or Modbus
Configurable Alarms	6 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 Standard 200-04 B004/B005/B124/B125	IRIG-B modulated or unmodulated Input impedance = 330 ohms

Item	Quantity/Specs	Notes
Inputs and Outputs		
IEC 61850 Sampled Values Support	80 or 256 s/c for IEC 61850-9-2 LE SV stream 4000, 4800, 14400 Hz for IEC 61869-9 SV stream	8 data streams per unit. 36 channels per unit 144 maximum using 4 units in “Cooperative Mode” 288 maximum using 8 units in Group Record Trigger Mode
Virtual Inputs	256 GOOSE virtual inputs	Boolean and Enumerated data types of Dbpos (DPS Double Point Status), Health, Int32 and Int32u
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 Specified voltages are over full ambient temperature range
Alarm Contacts	8 contacts per unit 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 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
Time Synchronization and Accuracy		
External Time Source	Synchronized using IRIG-B input (modulated or unmodulated) auto detect or PTP/IEEE 1588 (optional)	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		
Insulation Test (Hi-Pot)	IEC 60255-5	
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	

Item	Quantity/Specs	Notes
Environmental (cont.)		
Radiated RF Susceptibility	IEC 61000-4-6 Level 3, IEC 60255-22-3 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	

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