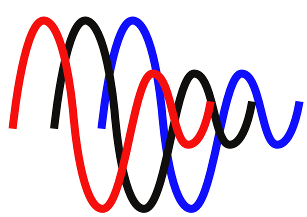
TESLA 4000

Power System Recorder
Model 4000-SV



User Manual

Version 1.6 Revision 0

Preface

Information in this document is subject to change without notice.

This manual is part of a complete set of product documentation that includes detailed drawings and operation. Users should evaluate the information in the context of the complete set of product documentation and their particular applications. ERLPhase assumes no liability for any incidental, indirect or consequential damages arising from the use of this documentation.

While all information presented is believed to be reliable and in accordance with accepted engineering practices, ERLPhase makes no warranties as to the completeness of the information.

All trademarks used in association with B-PRO, B-PRO Multi Busbar, Multi Busbar Protection, F-PRO, iTMU, L-PRO, ProLogic, S-PRO, T-PRO, TESLA, I/O Expansion Module, TESLA Control Panel, Relay Control Panel, RecordGraph and RecordBase are trademarks of ERLPhase Power Technologies Ltd.

Windows® is a registered trademark of the Microsoft Corporation.

HyperTerminal® is a registered trademark of Hilgraeve.

Modbus® is a registered trademark of Modicon.

Contact Information

ERLPhase Power Technologies Ltd

Website: www.erlphase.com

Email: info@erlphase.com

Technical Support

Email: support@erlphase.com

Toll Free: 1-833-502-2160 x 1 (US and Canada)

Tel: 1-204-477-0591 x 1

Using This Guide

This User Manual describes the installation and operation of the TESLA power system recorder and the accompanying TESLA Control Panel user interface software. It is intended to support the first time user and clarify the details of the equipment.

The manual uses a number of conventions to denote special information:

Example	Describes
Start>Settings>Control Panel	Choose the Control Panel submenu in the Settings submenu on the Start menu.
Right-click	Click the right mouse button.
Recordings	Menu items and tabs are shown in italics.
service	User input or keystrokes are shown in bold.
Text boxes similar to this one	Relate important notes and information.
..	Indicates more screens.

Table of Contents

Version Compatibility

For version compatibility, refer to the following documents on the ERLPhase website, www.erlphase.com:

- D04835 - TESLA 4000-SV Firmware User Release Description

PC System Requirements and Software Installation

Hardware

The minimum hardware requirements are:

- 1 GHz processor
- 2 GB RAM
- 20 GB available hard disk space
- USB port
- Serial communication port

Operating System

The following software must be installed and functional prior to installing the applications:

- Microsoft Windows 10
- Microsoft Windows 11

Software Installation

All required software for user interface, settings and record analysis is available directly from the ERLPhase website. The following relevant software and documentation is available:

- TESLA Control Panel
- ERL 61850 Configurator Tool
- RecordGraph
- USB Driver
- TESLA 4000-SV User Manual

Anti-virus/Anti-spyware Software

If an anti-virus/anti-spyware software on your local system identifies any of the ERLPhase applications as a “potential threat”, it will be necessary to configure your anti-virus/anti-software to classify it as “safe” for its proper operation. Please consult the appropriate anti-virus/anti-spyware software documentation to determine the relevant procedure.

1 Overview

1.1 TESLA System Description

The TESLA 4000-SV power system recorder is a multi-time domain recording system used to monitor electrical power systems. The TESLA 4000-SV can record 36 analog channels, 64 external input channels and 256 virtual input channels and store up to 2500 recordings with extended storage. Up to four recorders can be operated as a cooperative group or up to eight recorders can be operated as Group Record Trigger (GRT) mode to achieve greater numbers of channels.

The TESLA can record data simultaneously in three time domains: high speed transient fault (seconds), low speed dynamic swing (minutes), and continuous disturbance recording and trend (10 second to 1 hour intervals). A wide variety of triggers are available to initiate recording.

The integrated Phasor Measurement Unit (PMU) functionality streams synchrophasor data for wide area monitoring as per IEEE C37.118 and IEEE/IEC 60255-118:1:2018 standards. It can stream up to 36 phasors, 24 analog quantities and 320 binary digital statuses and up to two PDCs. The integrated CDR creates continuous records without triggers which together with the fault, swing and trend records provides wide area visibility of system performance.

The TESLA 4000-SV supports Sampled Value (IEC 61850 9-2 LE) as well as IEC 61869-9 subscription as a method for obtaining analog measurement data and can subscribe to up to 8 Sampled Value Streams.

TESLA Control Panel user interface software provides tools to configure the recorder, retrieve and manage records and display real time measured values. TESLA Control Panel also includes RecordGraph, a graphical record display and analysis software tool.

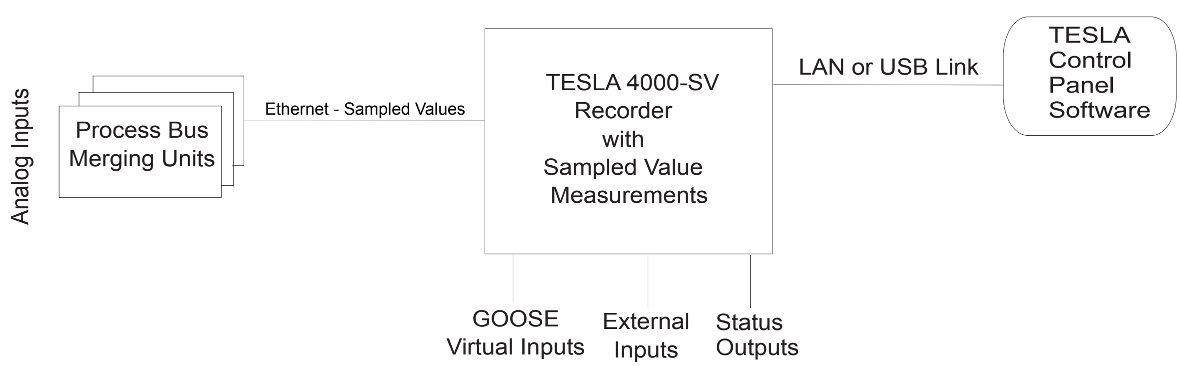


Figure 1.1: TESLA System Overview

1.2 TESLA 4000-SV Features

Installation

- 19" rack-mount format
- Small 3U footprint

Data Acquisition

- Subscribe up to 8 streams of sampled value according to IEC 61850-9-2 LE as well as IEC 61869-9
- 64 external (digital) input channels
- 256 GOOSE Virtual Input channels
- Simultaneous operation in transient fault, dynamic swing and long term trend time frames
- Sample rate for transient fault recording: 80, 96, 256 samples per cycle, 4800, 14400 Hz
- Sample rate for dynamic swing recordings: 1 or 2 samples per cycle
- Continuous trend logging at sample intervals from 10 seconds to one hour
- Continuous disturbance recording at rates from 6 samples/second to 60 samples/second at 60 Hz, from 5 samples/second to 50 samples/second at 50 Hz.
- Calculated channels: summations, watts, vars, power factor, positive, negative and zero sequence components, impedance, THD, fault location, frequency and harmonics

Triggers

- Rates and level triggering on all input and calculated channels with individual controls for delay, logging, record initiation and alarm contact activation
- Configurable logic channels for creating custom triggers
- User-assigned trigger priorities help identify critical events and records
- IEC 61850 recording triggering via 256 Virtual Inputs (GOOSE)

Records

- Transient fault records from 0.2 to 15.0 seconds with automatic record extension up to 30.0 seconds under multiple trigger conditions
- Dynamic swing record from 10 seconds to 15 minutes with automatic record extension up to 30 minutes under multiple trigger conditions
- Combined transient and swing records can capture a fault and the resultant system dynamic response
- Record compression to reduce record size, maximize storage capacity and minimize transmission time

Cooperative Group

- Up to 4 recorders can be operated as a cooperative group
- Automatic cross triggering over a LAN with time source synchronized time stamps
- Automatic record retrieval with consolidation into a single group record

Logging

- 1000 entries event log (circular)
- 90 day analog measurement trend log (circular or alarm when full)

- 90 day long-term event log (circular or alarm when full)
- Voltage sag and swell logging

Fault Location

- Automatic fault location on up to 10 lines
- Fault location data available in the event log, in recording and IEC 61850

User Interface

- Intuitive power system element model simplifies complex configurations
- Integrated record and configuration management tools
- Offline mode allows records to be viewed and configurations created without connecting to the recorder
- Record display shows record summaries with trigger event lists so that a preliminary evaluation can be made before the record is transferred
- Real-time metering display shows all input and calculated quantities in user-customizable layouts

Analysis Tools

- Recorder configuration and event information is embedded in each record
- Record graphics provide a flexible multi-page interactive display and measurement of all channels including calculated ones
- COMTRADE record export facility

Output Contacts

- Six user-configurable output contacts can be activated by triggers
- Cross-trigger contact can activate other devices
- Recorder inoperative contact

Communication Ports and Network Redundancy

- Front USB 2.0 interface, Rear serial RS-232 COM port
- Front copper and rear copper or optical Ethernet ports
- Optional PRP/RSTP network redundancy

Communication Protocols

- Standard TCP/IP used to communicate with TESLA Control Panel
- IEC 61850 Station Bus (GOOSE and MMS) and Process Bus (Sampled Values)
- PMU
- Syslog (RFC 5426)
- FTP

Time Coordination

- IRIG-B time code input - unmodulated. Supports IEEE 1344 and IEEE C37.118 extensions.
- PTP (IEEE 1588) synchronization (only available if hardware supports network redundancy).
- 1 ms event timetagging of events and records
- Time synchronization indicator in each record

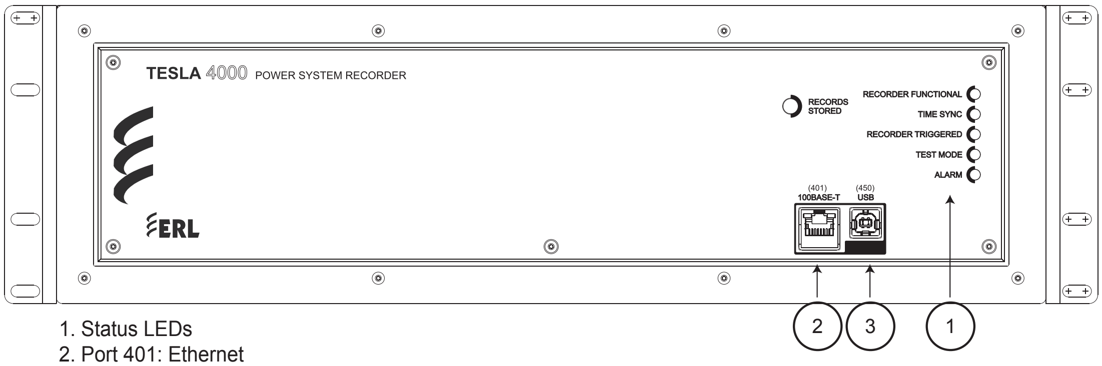
Reliability

- Self-monitoring supervisory software with self-checking circuit and failure contact ensures reliable operation
- Flash memory for record storage with separate Flash memory for program storage
- Compliance with IEC standards for temperature range, transient withstand and RF immunity

1.3 Ordering Options and Product Configuration ID

The TESLA 4000-SV is available with many different configurations available at time of ordering. When each of the options are concatenated, they form the Product Configuration ID (example: TESLA 4000 S2-16-0-0-0-60-0-0-0-0-A). See the ordering template at www.erlphase.com for more details.

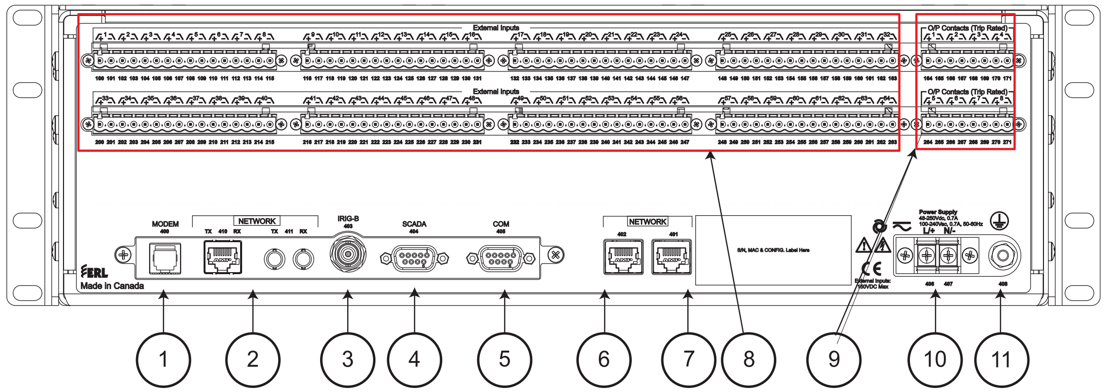
1.4 Front Panel



1. Status LEDs
2. Port 401: Ethernet
3. Port 450: USB

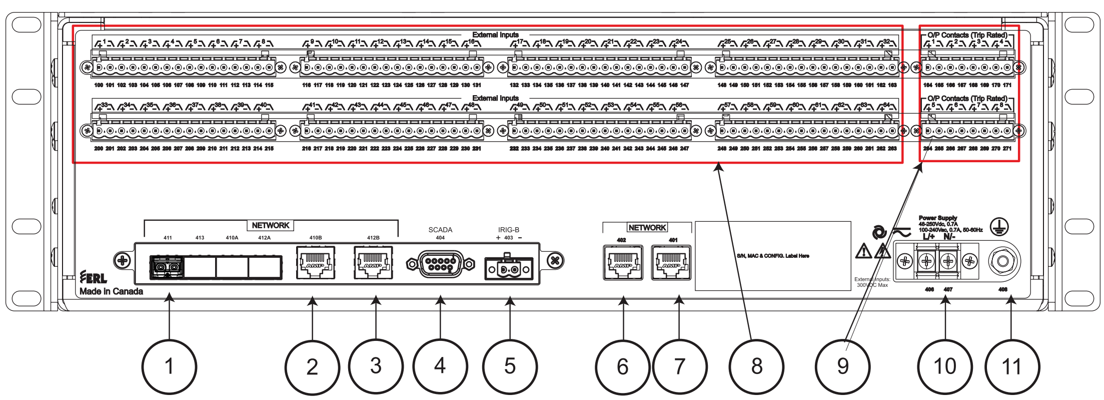
Figure 1.2: Front Panel

1.5 Rear Panel



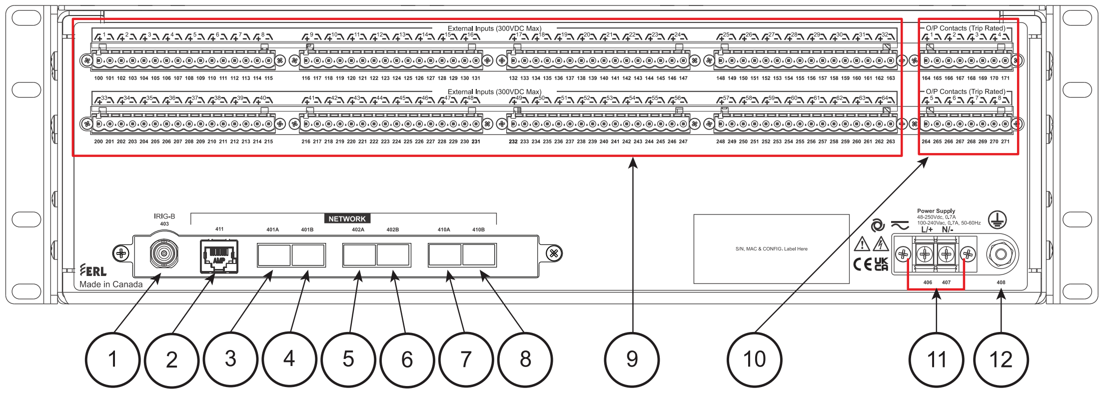
1. Port 400: Internal Modem *(currently unused)*
2. Ports 410-411: Ethernet Network Ports
3. Port 403: IRIG-B External Clock
4. Port 404: EIA 232 SCADA Communication (DNP3 or Modbus) *(currently unused)*
5. Port 405: EIA 232 Serial Connection
6. Port 402: 1000Base-T Ethernet Network Port
7. Port 401: 100Base-T Ethernet Network Port
8. Ports 100-163, 200-263: External (digital) Input Channels
9: Ports 164-171, 264-271: Output Contacts
10: Ports 406-407: Power Supply
11: Port 408: Chassis Ground

Figure 1.3: Rear Panel, LAN Media Option 0, No Redundancy



1. Port 411: 100Base-FX Optical Ethernet port
2. Port 410: 100Base-T Copper Ethernet port, redundant with Port 412
3. Port 412: 100Base-T Copper Ethernet port, redundant with Port 410
4. Port 404: SCADA serial port (currently unused)
5. Port 403: IRIG-B port
6. Port 402: 1000Base-T Copper Ethernet port
7. Port 401: 100Base-T Copper Ethernet port
8. Ports 100-163, 200-263: External Inputs 1-64
9. Ports 164-171, 264-271: Output Contacts 1-8
10. Ports 406-407: Power Supply
11. Port 408: Chassis Ground

Figure 1.4: Rear Panel, LAN Media Option 3, Single Redundancy



1. Port 403: IRIG-B port (Unmodulated)
2. Port 411: 100Base-T Copper Ethernet port
3. Port 401A: 100/1000Base SFP
4. Port 401B: 100/1000Base SFP
5. Port 402A: 100/1000Base SFP
6. Port 402B: 100/1000Base SFP
7. Port 410A: 100Base SFP
8. Port 410B: 100Base SFP
9. Ports 100-163, 200-263: External Inputs 1-64
10. Ports 164-171, 264-271: Output Contacts 1-8
11. Ports 406-407:Power Supply
12. Port 408: Chassis Ground

Figure 1.5: LAN Media Option 5, Multiple Redundancy

> Not all possible ordering configurations are shown in the diagram above.

2 Installation and Safety Instructions

2.1 Introduction

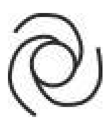
This section deals with the installation of the TESLA power system recorder when first delivered. The section covers the physical mounting, AC and DC wiring and the Communication wiring.

The following symbols are used in this manual and on the unit. They should be understood before working on the unit:


Caution: refer to equipment documentation


Caution: risk of electric shock


Protective Earth (or Ground) Terminal


Autoranging power supply


Both direct and alternating current

The equipment ratings, operating instructions and installation instructions shall be checked before commissioning or maintenance. It is the responsibility of the user to ensure that the equipment is installed, operated and used for its intended function in the manner specified in this manual. If this is not the case then any safety protection provided by the equipment may be impaired.

2.2 Physical Mounting

The recorder is designed to be mounted in a standard 19-inch equipment rack. It is 3 rack units (5.25 inches) high and 12.725 inches deep. An additional 3 inches of depth is required for rear connections and cables. A complete mechanical drawing is shown in “TESLA 4000-SV Drawings” on page Appendix G-1.

To install the relay the following is needed:

- 19 inch rack
- 4 - #10 or M6 screws

> **WARNING!**
>
> This equipment is intended for use by trained personnel in restricted areas only. Hazardous voltages may be present at the rear of the unit and a suitable protective barrier must be provided to protect against electric shock due to accidental contact.

2.3 Case Grounding

WARNING!

The ground terminal (also known as the protective earth) on the rear of the unit and the modules must be connected as shown in Figure 2.1: Protective Earth Connection on page 2-3 before the unit is energized in order to prevent electric shock. Refer to the diagram of the rear of the unit, “Rear Panel, LAN Media Option 0, No Redundancy” on page 1-7 for the location of the ground terminal. The protective earth connection shall be checked before carrying out any other actions and shall not be removed when the unit is energized.

The terminal used must be made of a material that is galvanically compatible with the zinc plated washers, nut and stud provided with the unit. Tinned terminals are acceptable. The recommended minimum protective earth conductor wire size is 3.3 mm² unless otherwise required by local or country wiring regulations. Copper wire is recommended and must be must be low-inductance and as short as possible.

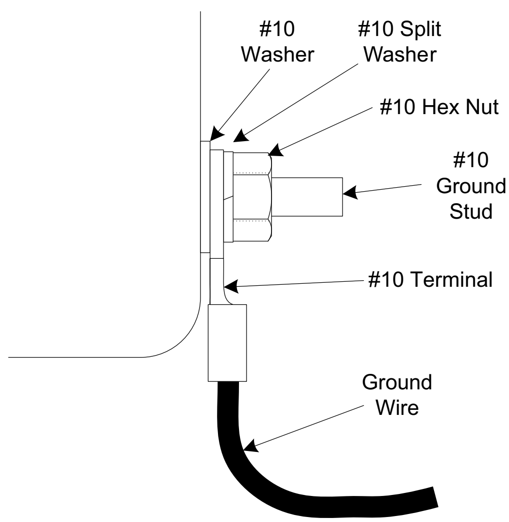


Figure 2.1: Protective Earth Connection

2.4 Power Supply

A wide range power supply is standard. The nominal operating range is 48 - 250 Vdc, 100 - 240 Vac, 50/60 Hz (see Appendix A for more details). External overcurrent protection is required for the TESLA power supply input (5A 250V time delay, high breaking capacity fuse or 5A, 250V single pole circuit breaker in the AC LINE or DC POSITIVE power input connection).

Ensure that the chassis is grounded for proper operation and safety. The wire used for the power supply wiring should be at least 18 AWG (0.82 mm^2), 600 V.

There are no power switches on the recorder. When the power supply is connected, the recorder starts its initialization process. See "Startup Sequence" on page 2-7 for the start up process details.

#6 ring or spade terminals must be used to connect to the power supply terminals. Bare wires should never be terminated directly to the screw terminals.

The use of an external surge protection device is required to pass the surge immunity requirements of IEC/EN 60255-22-5 Criterion A. Suitable surge arrestors are to be selected and installed to limit to 1.1KV (L-N) and 1.5KV (L-PE) levels with suitable energy handling capacity. Contact ERLPhase technical support for assistance in selecting an appropriate device if needed. One surge protector can be used to protect multiple units as long as the current limit of the surge protection device is not exceeded.
Note that this is a consumable item and not covered by ERLPhase warranty.

2.5 Signal Connections

Wiring

Pluggable terminal blocks are used for the external inputs and output contacts on the rear of the TESLA. The maximum strip length of the wire installed into these connectors should not exceed 7 mm.

Shielded wire shall be used for all connections that run outside of the panel in which the TESLA is installed. The shield must be grounded only at one end at the point where the cable enters the panel. The IRIG input is the ONLY exception which uses unbalanced co-ax cable.

In addition the individual port cabling shall comply with the following:

- External Inputs: 28 AWG (0.08 mm^2), 600 V minimum AWG and voltage rating
- Output Contacts: Minimum 16 AWG (1.31 mm^2), 600 V minimum AWG and voltage rating
- DCE ports 405: 10m Maximum cable length
- RJ-45 ethernet ports: shielded CAT5 or better cable

Ensure the power supply input and the AC and DC wires are de-energized before working on the wiring. Failure to do so could result in electric shock.

External Input Channels

The recorder's external inputs are dry inputs intended for use with signals from a 48 - 250 Vdc station battery (3 order configurable input levels, see Appendix A for more details). Maximum voltage is limited to 150 Vdc when CE compliance is required. The external inputs are isolated and protected against transient surges.

Alarm Contacts

The alarm contacts on the rear of the unit are dry contacts. They are isolated and protected against transient surges. The contacts are designated as follows:

1 Recorder Inoperative. Closed on failure
2 User-configurable
3 User-configurable
4 Cross-trigger
5 User-configurable
6 User-configurable
7 User-configurable
8 User-configurable

The cross-trigger contact is used to initiate recording on another recorder when this unit triggers. When activated, the cross-trigger contacts close for 0.10 seconds, regardless of the duration of the triggering condition. This ensures that the cross-trigger function does not become blocked by a continuous trigger condition.

The user-configurable alarm contacts can be defined for use as part of the recorder's trigger configuration.

The maximum voltage that may be applied to alarm contacts is limited to 150 Vdc when CE compliance is required.

IRIG-B Time Signal

The IRIG-B input provisions on the rear of the unit accepts unmodulated IRIG-B time signals, with or without the 1344 extensions.

Communication Ports

See "Ports" on page 4-1.

2.6 Startup Sequence

Table 2.1: Startup Sequence

For ~10-20 seconds after Power Up	Front panel Test Mode LED turns on to indicate the presence of power.
~20-30 seconds after Power Up	Test Mode LED turns off
~30-40 seconds after Power Up	Records Stored and IRIG Functional LEDs turn on, if records are stored and IRIG source is present, respectively.
~70-80 seconds after Power Up	Test Mode LED turns on
~80-100 seconds after Power Up	Recorder Functional LED turns on. Test Mode LED turns off. The Startup Sequence is complete.

If the flash drive is almost full there may be some delay to this sequence.

2.7 Front Panel LEDs

Table 2.2: Front Panel LEDs

Front Panel LED	Indications
Recorder Functional	Normally active green LED that is turned on approximately 25-30 seconds after power up, indicating the unit is functional. If an internal fault is detected, the LED is turned off. The LED state corresponds directly with the Recorder Inoperative.
Time Sync	Green LED that is active when a valid external time synchronization signal is detected either IRIG-B, SNTP or PTP.
Recorder Triggered	Green LED that is active while the recorder is in the process of creating a record
Records Stored	Green LED that turns on when there are records stored in the recorder’s memory. The LED will flash to indicate the Storage Alarm limit has been reached if so configured
Test Mode	Normally inactive red LED that turns on immediately on power up and goes of after the self-test has been completed (approximately 20-30 seconds)
Alarm	Normally inactive red LED that indicates a failure has been detected by the software. The presence of the Alarm LED means much of the system is functioning and can be accessed for diagnosis

3 TESLA Control Panel Installation

> Installation of TESLA Control Panel software may require changes to your Windows system configuration for proper operation. Please review the instructions in this chapter to ensure proper setup.

3.1 Installing TESLA Control Panel

You must be logged on to the target computer as a user with local administrator privileges to install TESLA Control Panel. Once installed, you may be logged in as a Limited User, as administrator privileges are not generally required for operation of the program.

Overview

Instructions for installing TESLA Control Panel and configuring Windows for its use are covered in the following sections.

The procedure has the following parts:

1. Install TESLA Control Panel.
2. Install the Null Modem driver.

> Once these steps are complete, go to the First Time Start-Up section for details on launching TESLA Control Panel (see "First Time Start-Up" on page 3-5).

> The user must install ERLPhase's USB driver, available at www.erlphase.com. See section "USB Link" on page 6-2 for instructions.

Step 1: Install TESLA Control Panel Software

1. Go to www.erlphase.com and navigate to *Support* > *Software* where the TESLA Control Panel installation link is available.
2. Click the installation link which downloads a ZIP file containing the TESLA Control Panel installer.
3. Open up the downloaded ZIP file and double-click on the installer to begin the installation.
4. Follow the installation prompts. During installation a prompt appears asking whether your TESLA recorders are 50 Hz or 60 Hz units. For proper operation it is important to select the correct one. If you need to change this in the future, re-install TESLA Control Panel.
5. When the installation is complete, a TESLA Control Panel icon is placed on the desktop. Use the icon to launch TCP. If preferred, start TESLA Control Panel through the Windows start menu (*Start>Programs>ERLPhase> TESLA Control Panel).*

Step 2: Installing Null Modem Driver Software

A virtual software modem called a “Null Modem” must be set up for direct serial cable communication between this computer and a TESLA recorder. A Null Modem driver is provided with the TESLA installation.

This section provides step by step instructions on how to install the Null Modem driver. If you are going to communicate with a 4000 series product please ensure that you connect your computer to the front USB port of a powered up 4000 series unit prior to following these steps.

1. Start Windows Control Panel by going to *Start>Control Panel*.
2. Double-click the *Phone and Modem Options* icon.
3. Select the *Modems* tab. Select *Add* to open the Add Hardware Wizard.
4. Select *Don't detect my modem; I will select it from a list,* then select the *Next* button.

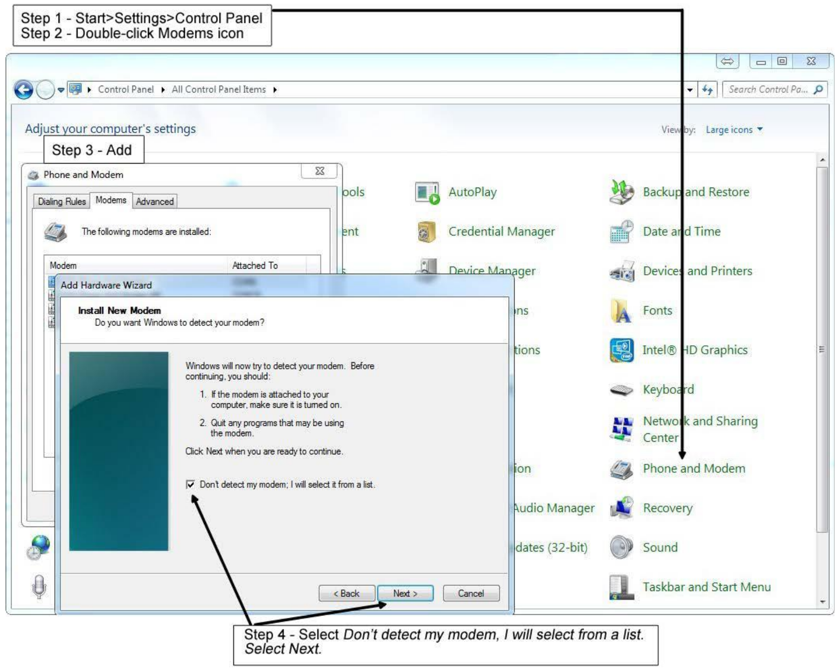


Figure 3.1: Null Modem Driver Installation

5. Select the *Have Disk* button, select *Browse*. To find the file go to *C:\Program Files (x86)\ERLPhase\TESLA Control Panel\Null_mdm.Inf.* Select *OK*. This is the default location for TESLA Control Panel. If you selected a different location to install TESLA Control Panel, you will find the Null Modem driver (Null_mdm.Inf) in that directory.

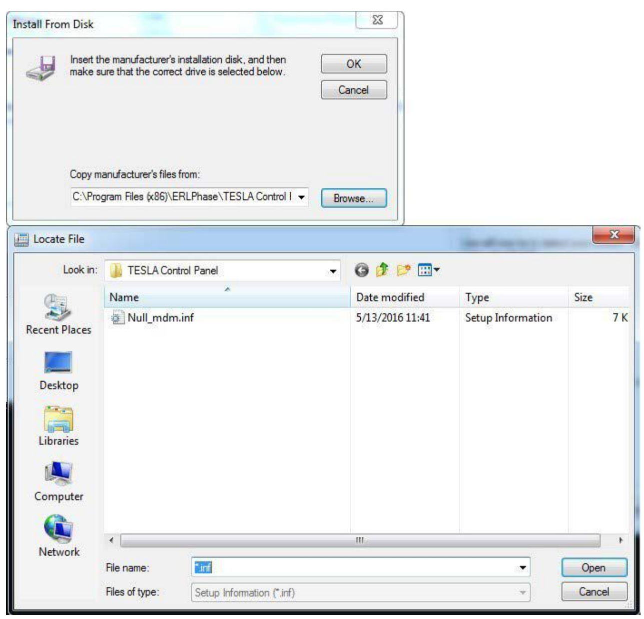


Figure 3.2: Browse for Null_mdm.Inf

6. Select the *ERLPhase Null Modem* driver and select *Next*.
7. Select the serial port you wish to use. You are setting up a serial port to be used for a direct cable connection to a TESLA. Typically COM1 or COM2 are available on a PC for this purpose. Select *Next*.

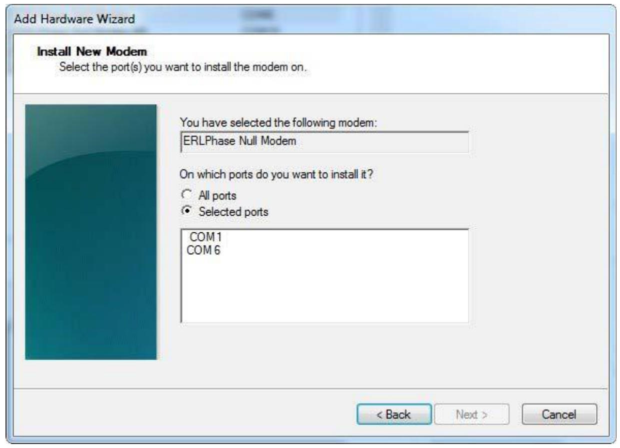


Figure 3.3: Select Serial Port

8. Select *Finish* and close the Phone and Modem Options and Control Panel dialog boxes.

3.2 First Time Start-Up

Starting TESLA Control Panel

To start TESLA Control Panel, double-click the *TESLA Control Panel* icon placed on your desktop by the installation process or select *Start>Program Files>ERLPhase>TESLA Control Panel.*

Data Location

TESLA Control Panel uses a data location on your computer to store records and settings from your recorders. By default it is *C:\Program Files (x86)\ERLPhase\TESLA Control Panel,* although you may change this later by using the *File\Data Location* command from the Main Menu.

When you change the data location, previously configured IEDs will not be affected. Only newly created IEDs will use the new data location. To edit the data location of existing IEDs use the Main Menu *Edit* button.

Note Microsoft Windows security may prevent non-Administrative user accounts from storing data under *C:\Program Files(x86)*; it may be necessary to change the default record and config storage locations for the IEDs.

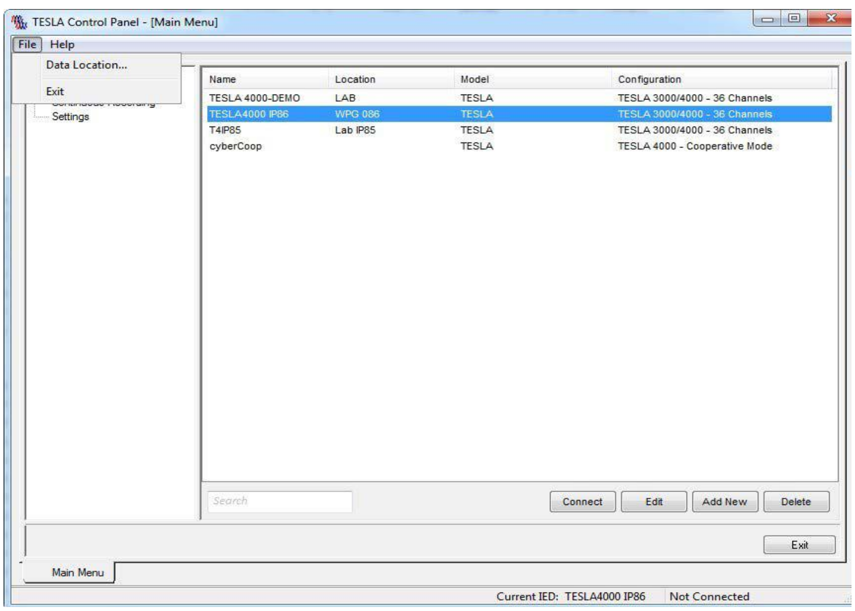


Figure 3.4: Data Location

4 Ports

This chapter describes the ports that are used to communicate with the TESLA 4000-SV and the communication options available to establish a connection with the TESLA 4000-SV.

4.1 Communication Ports

The TESLA recorder has multiple physical communication ports for local and remote access to its user interface and communication services.

The network ports and their available speeds and services are summarized in the table below.

Table 4.1a: Summary of Network Communication Ports with No Redundancy

Network Port	Physical Connection	Speed	Available services							
			PTP	PRP/RSTP	IEC61850 GOOSE Publish	IEC61850 GOOSE Subscribe	IEC61850 MMS	IEC61850 Sample Value Subscribe	TESLA Control Panel, FTP	PMU
401	RJ45	100M	No	No	Yes	Yes	Yes	No	Yes	Yes
402	RJ45	GigE	No	No	Yes	Yes	Yes	Yes	Yes	No
410	RJ45 or ST	100M	No	No	Yes	Yes	Yes	No	Yes	Yes
411	ST	100M	No	No	Yes	Yes	Yes	No	Yes	Yes

Table 4.1b: Summary of Network Communication Ports with Single Redundancy										
Network Port	Physical Connection	Speed	Available services							
			PTP	PRP/RSTP	IEC61850 GOOSE Publish	IEC61850 GOOSE Subscribe	IEC61850 MMS	IEC61850 Sample Value Subscribe	TESLA Control Panel, FTP	PMU
401	RJ45	100M	No	No	Yes	Yes	Yes	No	Yes	Yes
402	RJ45	GigE	No	No	Yes	Yes	Yes	Yes	Yes	No
410/412	RJ45 or LC	100M	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
411	LC	100M	No	No	Yes	Yes	Yes	No	Yes	Yes

Table 4.1c: Summary of Network Communication Ports with Multiple Redundancy										
Network Port	Physical Connection	Speed	Available services							
			PTP	PRP	IEC61850 GOOSE Publish	IEC61850 GOOSE Subscribe	IEC61850 MMS	IEC61850 Sample Value Subscribe	TESLA Control Panel, FTP	PMU
401A/ 401B	RJ45 or LC	GigE	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
402A/ 402B	RJ45 or LC	GigE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
410A/ 410B	RJ45 or LC	100M	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
411	RJ45	100M	No	No	Yes	Yes	Yes	No	Yes	Yes

Detailed descriptions of all of the communication ports capabilities are described in Table 4.2a: Communication Ports - Non-Redundant Configuration and Table 4.2b: Communication Ports - Single Redundant Configuration.

Table 4.2a: Communication Ports - Non-Redundant Configuration

The non-redundant configurations are LAN Media Options 0, 1 and 2. Refer to “Ordering Options and Product Configuration ID” on page 1-5 for more details.

Port	Function
Front Panel	
401	RJ-45 receptacle, 100BASE-T Ethernet interface. Default IP = 192.168.100.80 Maintenance Port.
450	USB-B receptacle, High speed USB 2.0 interface. Used for user interface access Default fixed baud rate 115,200 N81 (no parity, 8 data bits, 1 stop bit)
Rear Panel	
400	**CURRENTLY NOT USED** RJ11 receptacle, Internal modem interface.
401	RJ-45 receptacle, 100BASE-T Ethernet Interface. Refer to Table 4.1a for details on available port services. Same IP address as front panel Port 401.
402	RJ-45 receptacle, 1000BASE-T (GigE). Default IP = 192.168.101.80. Refer to Table 4.1a for details on available port services.
403	BNC receptacle, IRIG-B Interface. Un-modulated, 680 ohm impedance
404	**CURRENTLY NOT USED** RS-232 DCE female DB9.
405	RS-232 DCE female DB9. Used for user interface and communication protocol access.
410	RJ-45 receptacle or ST type optical receptacle (ordering option). 100BASE-T or 100BASE-FX (1300nm, multi-mode) Ethernet interface. Refer to Table 4.1a for details on available port services. Default IP = 192.168.102.80
411	RJ-45 receptacle or ST type optical receptacle (ordering option). 100BASE-T or 100BASE-FX (1300nm, multi-mode) Ethernet interface. Refer to Table 4.1a for details on available port services. Default IP = 192.168.103.80

When configured with optical network ports, this is a Class I laser product and is considered safe. However, viewing fibre-optic output ports directly is not recommended.

Table 4.2b: Communication Ports - Single Redundant Configuration	
The Redundant configurations are LAN Media Options 3 and 4. Refer to "Ordering Options and Product Configuration ID" on page 1-5 for more details.	
Port	**Function**
Front Panel	
401	RJ-45 receptacle, 100BASE-T Ethernet interface. Default IP = 192.168.100.80. Maintenance Port.
450	USB-B receptacle, High speed USB 2.0 interface. Used for user interface access Default fixed baud rate 115,200 N81 (no parity, 8 data bits, 1 stop bit)
Rear Panel	
400	**CURRENTLY NOT USED** RJ11 receptacle, Internal modem interface.
401	RJ-45 receptacle, 100BASE-T Ethernet Interface. Refer to Table 4.1a for details on available port services. Same IP address as front panel Port 401.
402	RJ-45 receptacle, 1000BASE-T (GigE). Default IP = 192.168.101.80. Refer to Table 4.1a for details on available port services.
403	Pluggable terminal block, IRIG-B Interface. Modulated or un-modulated, 680 ohm impedance
404	**CURRENTLY NOT USED** RS-232 DCE female DB9.
411	LC type optical receptacle,1300nm multi-mode, SFP (small form-factor pluggable), 100BASE-FX Ethernet Interface. Default IP = 192.168.103.80. Refer to Table 4.1a for details on available port services. SFPs should only be installed or removed when the unit is powered off.
410A	Redundant with Port 412A. LC type optical receptacle, 1300nm multi-mode, SFP (small form-factor pluggable), 100BASE-FX Ethernet Interface. Default IP = 192.168.102.80, Network Redundancy Service Default IP = 192.168.102.81. Refer to Table 4.1a for details on available port services. Port is only active when an SFP transceiver is installed. When an SFP is installed it will disable 410B. SFPs should only be installed or removed when the unit is powered off.
412A	Redundant with Port 410A.LC type optical receptacle, 1300nm multi-mode, SFP (small form-factor pluggable), 100BASE-FX Ethernet Interface. Default IP = 192.168.102.80, Network Redundancy Service Default IP = 192.168.102.81. Refer to Table 4.1a for details on available port services. Port is only active when an SFP transceiver is installed. When an SFP is installed it will disable 412B. SFPs should only be installed or removed when the unit is powered off.
410B	Redundant with Port 412B. RJ-45 receptacle, 100BASE-T Ethernet Interface. Default IP = 192.168.102.80, Network Redundancy Service Default IP = 192.168.102.81. Refer to Table 4.1a for details on available port services. Port is disabled when SFP is installed in Port 410A.
412B	Redundant with Port 410B. RJ-45 receptacle, 100BASE-T Ethernet Interface. Default IP = 192.168.102.80, Network Redundancy Service Default IP = 192.168.102.81. Refer to Table 4.1a for details on available port services. Port is disabled when SFP is installed in Port 412A.
413	**CURRENTLY NOT USED.**

Table 4.2c: Communication Ports - Multiple Redundant Configuration	
The redundant configurations are LAN Media Option 5. Refer to “Ordering Options and Product Configuration ID” on page 1-5 for more details.	
Port	**Function**
Front Panel	
411	RJ-45 receptacle, 100BASE-T Ethernet interface. Default IP = 192.168.103.80. Maintenance Port.
450	USB-B receptacle, High speed USB 2.0 interface. Used for user interface access Default fixed baud rate 115,200 N81 (no parity, 8 data bits, 1 stop bit)
Rear Panel	
401A	SFP, 100/1000BASE, Configurable via Port 401: Disabled, Non-Redundant, PRP (LAN_A). Default IP = 192.168.100.80
401B	SFP, 100/1000BASE, Configurable via Port 401: Disabled, Disabled when set to Non-Redundant, PRP (LAN_B). Default IP = 192.168.100.80
402A	SFP, 100/1000BASE, Configurable via Port 402: Disabled, Non-Redundant, PRP (LAN_A). Default IP = 192.168.101.80
402B	SFP, 100/1000BASE, Configurable via Port 402: Disabled, Disabled when set to Non-Redundant, PRP (LAN_B). Default IP = 192.168.101.80
410A	SFP, 100BASE, Configurable via Port 410: Disabled, Non-Redundant, PRP (LAN_A). Default IP = 192.168.102.80
410B	SFP, 100BASE, Configurable via Port 410: Disabled, Disabled when set to Non-Redundant, PRP (LAN_B). Default IP = 192.168.102.80
403	Pluggable terminal block, IRIG-B Interface. Un-modulated, 680 ohm impedance
411	RJ-45 receptacle, 100BASE-T Ethernet interface. Default IP = 192.168.103.80. Maintenance Port.

4.2 IRIG-B Time Input

The TESLA is equipped to handle unmodulated GPS satellite time IRIG-B signals. The IRIG-B time signal is connected to the port 403 IRIG-B connection on the back of the recorder (BNC or pluggable terminal block). When the IRIG-B signal is provided to the recorder the Time Sync LED comes on and the recorder clock is referenced to this signal.

For more information on IRIG-B time input and time settings see "Time Synchronization Settings and Display" on page 8-18.

4.3 Network Redundancy

The principle of network redundancy is to create two or more data paths within a network so that a single point of failure will not disrupt network communication. There are two hardware configurations which support network redundancy: Single Redundancy (LAN Media Option 3 or 4) or Multiple Redundancy (LAN Media Option 5)

4.3.1 Single Redundancy

Redundant Port Configuration

The single redundant TESLA 4000-SV port configuration is shown in Figure 1.4: Rear Panel, LAN Media Option 3, Single Redundancy on page 1-7 and below in Figure 4.5: Redundant communication ports.

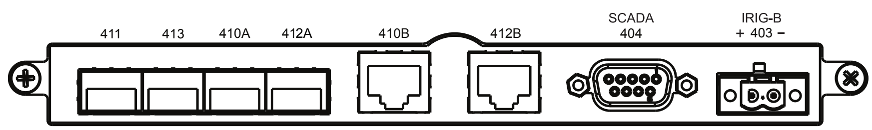


Figure 4.5: Redundant communication ports

Single Redundancy on the TESLA 4000-SV is handled by a redundancy management processor. This processor handles the communication on ports 410, 411, 412 and 413. The redundant pair is operated on port 410 and port 412. A and B refer to different receptacle in this hardware configuration.The detailed hardware configuration for ports 410, 411, 412 and 413 is:

- 410A and 412A are LC type optical receptacle SFP, 100BASE-FX Ethernet interfaces
- 410B and 412B are RJ-45 receptacles, 100BASE-T Ethernet interfaces
- 411 is a non-redundant port with LC type optical receptacle SFP, 100BASE-FX Ethernet interface
- Port 413 is not used.

Redundancy Modes

The TESLA 4000-SV (Must be configure at the factory, see “Ordering Options and Product Configuration ID” on page 1-5) is capable of redundancy with the following protocols on Port 410 and 412.

- RSTP (Rapid Spanning Tree Protocol; IEEE 802.1w) is for networks with multiple paths from source to target (like a mesh). RSTP uses hardware with algorithms to prevent network packets from being passed within the redundant paths and to use the quickest path from source to target. All hardware must be RSTP capable. *One data packet has many routes to get to the target.*
- PRP (Parallel Redundancy Protocol; IEC 62439-3 Clause 3). PRP is a type of redundancy where two completely separate paths are used simultaneously with the same data. The first data to arrive will be used and the second data (copy) will be discarded. Hardware at each end of the paths must be PRP capable. *There are two identical data packets, each travelling on its own independent network to the target.*

Both PRP and RSTP are available when the PRP or RSTP option is ordered. If redundancy is not required, select RSTP and only connect to port 410, leaving port 412 unconnected. Select the redundancy mode in the Active Mode pull-down on the Network Redundancy screen (see “Active Mode Selection” on page 8-11).

Redundancy Profiles

The combination of the redundancy mode and VLAN mode define the Redundancy Profiles. These profiles are selected via the “Active Mode” selection on the Network Redundancy screen (see “Active Mode Selection” on page 8-11).

For each of the Redundancy modes (RSTP/PRP), there are the following six available Redundancy Profiles:

- RSTP/PRP_410U_411U_<Revision>
- RSTP/PRP_410U_411T_<Revision>
- RSTP/PRP_410T_411U_<Revision>
- RSTP/PRP_410T_411T_<Revision>
- RSTP/PRP_410P_411X_<Revision>
- RSTP/PRP_MAINTENANCE_410_<Revision>

The first five profiles are to be used for normal operation of the TESLA 4000-SV. The “Maintenance” profile is only to be used as directed by ERLPhase Customer service. The U, T, P and X notation refers to the VLAN mode (see “VLAN Modes” on page 4-9). The factory default is the 410U_411U profile for the ordered redundancy configuration.

The *Time* > *PTP* screen settings and the *Communication* > *Network Redundancy* screen settings are both stored on the Network Redundancy Module on the Comm Board. These settings are linked to the Redundancy Profile selected via the Active Mode on the *Communication* > *Network Redundancy* screen. When the settings are changed and saved, they are saved to the currently selected Redundancy Profile. When the Redundancy Profile is changed, the settings on the *Time* > *PTP* screen settings and the *Communication* > *Network*

Redundancy screens will be updated with those last saved to the new Redundancy Profile.

VLAN Modes

There are multiple VLAN modes which affect the VLAN tagging of packets on Ports 410/412 and 411. The VLAN modes are described below in the table below.

Table 4.3: VLAN Modes for Redundant Network Configuration

VLAN Mode	Behaviour of Ingress Packets			Behaviour of Egress Packets	
	With defined VLAN ID	With undefined VLAN ID	Without VLAN ID	With VLAN Tag	Without VLAN Tag
U - Untagged	Accept	Deny	Accept	Strip VLAN tag	unchanged
T - Tagged	Accept	Deny	Accept	Transmit with defined VLAN ID	Tagged with native VLAN ID
P - Pass Through	Accept	Accept	Accept	Transmit with any VLAN ID	unchanged
X - Disable	Deny	Deny	Deny	No packet sent	No packet sent

The following are the pre-defined VLAN ID along with Native VLAN ID to be used for each redundancy profile. Redundancy hardware supports up to 16 user-defined VLAN ID, if a user-defined VLAN ID is required or the Native VLAN ID is needed to be changed, please contact ERLPhase Customer Service team for the assistance.

Table 4.4: Default VLAN ID for Redundancy Profiles

Redundancy Profile	Default pre-defined VLAN ID	Native VLAN ID
410U	1	99
410T	1,2,4,6,8,20,40,60	99
411U		3
411T	3,5,7,9,10,30	98

For ports 401 and 402, all network traffic is accepted whether it is tagged or untagged. GOOSE packets egress tagged if GOOSE publication is enabled.

Note that for the non-redundancy network configuration (see “Ordering Options and Product Configuration ID” on page 1-5), all network traffic is accepted whether it is tagged or untagged for ports 401, 402, 410 and 411. GOOSE packets egress tagged if GOOSE publication is enabled.

IP Addresses

There are three IP addresses associated with the redundancy configuration:

- 1 IP address for port 411
- 1 IP address for redundant ports 410/412 A and B
- 1 IP address for the redundancy management processor on the redundancy communication board. The IP address selection should be compatible with the devices on the network connected to port 410/412. This address is configurable via the Network Redundancy screen (see “Configuration” on page 8-11). The redundancy management processor is only accessible via port 410/412 if the “Advanced Configuration” box is checked on the Network Redundancy screen. Advanced configuration should only be selected under the direction of ERLPhase Customer Service.

4.3.2 Multiple Redundancy

When TESLA 4000-SV equipped with hardware configuration LAN Media option 5 which is shown in Figure 1.5: on page 1-8 and below in Figure 4.6:, there are 3 redundancy pairs: 401A/B, 402A/B and 410A/B. A and B refer to LAN A and LAN B in PRP mode.

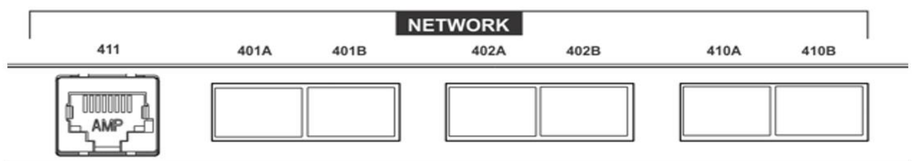


Figure 4.6: LAN Media Option 5, Multiple Redundancy

Port Configuration

Each redundancy pair can be configured into 3 different operation modes via TESLA Control Panel Ethernet Communication setting as follows:

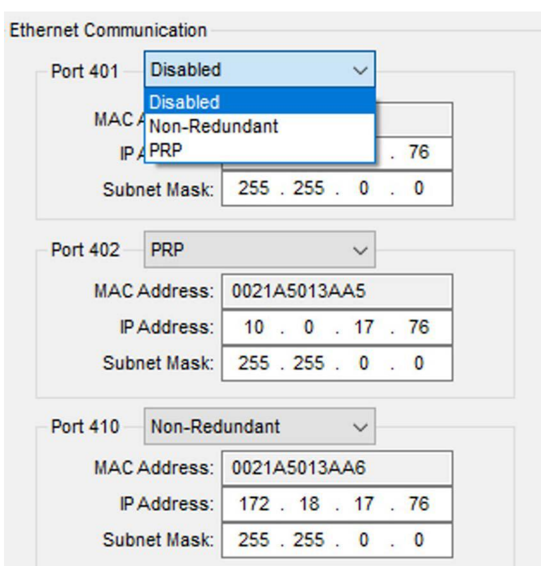


Figure 4.7: Redundancy Mode configuration

- Disabled: The port is disabled. Not accessible.
- Non-Redundant: Only LAN A is enabled, LAN B is disabled. No redundancy feature is enabled in this mode.
- PRP: Both LAN A and LAN B are accessible as redundancy pair according to IEC 62439-3.

> Note: Changing the Ethernet Redundancy Setting requires communication board soft reboot. TESLA Control Panel will disconnect from the unit after saving. Communication to the unit may get interrupted during this period of time.

VLAN Support

Additional VLAN Configuration is not needed on those ports, they will be operated as VLAN unaware mode. Therefore, VLAN configuration shall be done properly on the Ethernet Switch that connected to those ports if proper traffic regulation is required.

PTP Support

PTP time sync can be enabled on any one of those redundancy ports: 401 A/B, 402 A/B, 410 A/B if the corresponding port is enabled as Non-Redundant or PRP mode. When at PRP mode, PTP time sync can be operated over PRP. For detail PTP configurations please refer to “PTP Configuration” on page 8-22.

5 Services

The purpose of this section is to give an overview of the services available on the TESLA 4000-SV. This section uses the term “services” to refer to application level communication protocols providing access to TESLA functions and data. The services are categorized into two groups:

- Data Communication Services
- Interactive User Services

The services and the ports they are available on are shown in Table 5.1: Services and ports.

Table 5.1: Services and ports

<table>
<tr><th colspan="2" rowspan="2">Service</th><th rowspan="2">Service can be disabled</th><th rowspan="2">Physical Port Number</th><th colspan="2">TCP/IP Port</th></tr>
<tr><th>Default Port</th><th>Configurable</th></tr>
<tr><td colspan="6">Data Communication Services</td></tr>
<tr><td rowspan="3">IEC 61850</td><td>MMS</td><td>Yes</td><td>401, 402,
410, 411</td><td>102</td><td>No</td></tr>
<tr><td>GOOSE</td><td>Yes</td><td>401, 402,
410, 411</td><td>Ethernet</td><td>N/A</td></tr>
<tr><td>SV</td><td>Yes</td><td>402</td><td>Ethernet</td><td>N/A</td></tr>
<tr><td colspan="2">PMU</td><td>Yes</td><td>401
410, 411</td><td>4712</td><td>Yes</td></tr>
<tr><td colspan="2">SNTP</td><td>Yes</td><td>401, 402, 410,411</td><td>123/UDP</td><td>No</td></tr>
<tr><td colspan="2">Syslog</td><td>Yes</td><td>401, 402,
410, 411</td><td>514</td><td>Yes</td></tr>
<tr><td colspan="2">PTP
(No Redundancy hardware)</td><td>N/A</td><td>Not supported</td><td>N/A</td><td>N/A</td></tr>
<tr><td colspan="2">PTP (Single Redundancy hardware)</td><td>Yes</td><td>410/412</td><td>Ethernet</td><td>N/A</td></tr>
<tr><td colspan="2">PTP (Multiple Redundancy hardware)</td><td>Yes</td><td>401/402/410</td><td>Ethernet</td><td>N/A</td></tr>
<tr><td colspan="6">Interactive User Services</td></tr>
<tr><td colspan="2" rowspan="2">TESLA
Control
Panel</td><td rowspan="2">No</td><td>401, 402, 410, 411</td><td>7631</td><td>Yes</td></tr>
<tr><td>405, 450</td><td></td><td></td></tr>
<tr><td colspan="2">FTP</td><td>Yes</td><td>401, 402, 410, 411</td><td>20,21</td><td>Yes</td></tr>
<tr><td colspan="2">Terminal UI</td><td>No</td><td>450</td><td></td><td></td></tr>
</table>

5.1 Data Communication Services

IEC 61850

The TESLA 4000-SV is an IEC 61850 enabled device. For details on the IEC 61850 implementation on the TESLA 4000-SV, refer to “IEC 61850 Implementation Overview” on page 19-1. Also, refer to Appendix H for the relevant conformance statements and data mapping specification.

The IEC 61850 port configuration is available in TESLA Control Panel on the *Communication > Ethernet* and *Communication > IEC 61850* screens.

PMU

The Phasor Measurement Unit (PMU) module is a standard feature on the TESLA 4000-SV. The phasor information is available via the Ethernet ports at rates up to 60 frames each second. For more information on PMU, see Chapter 17 PMU Functionality and Appendix D PMU Standards.

The PMU port selection, and other communication configuration settings, is available in TESLA Control Panel on the *Communication > PMU* screen.

Syslog

The Syslog protocol is available on TESLA 4000-SV for use with RFC5424/ RFC5426 compliant server. Messages available to server are restricted to Cyber Security activity only. For information on Syslog protocol settings see “Syslog Communication Settings” on page 8-31.

The Syslog port selection, and other communication configuration settings, is available in TESLA Control Panel on the *Communication > Syslog* screen.

PTP (IEEE 1588)

The Precision Time Protocol (IEEE 1588) is a network based time source which provides high accuracy over an Ethernet Network connection. The TESLA 4000-SV uses the IEEE C37.238 Power Profile as well as IEEE/IEC 61850-9-3 Utility Profile making it suitable for use in Power System applications. In Sampled Value applications high time accuracy is critical, making PTP the best synchronization source for Sampled Value usage.

For more details on PTP see “PTP” on page 8-21.

SNTP

An SNTP time source has a lower order of precedence from a valid IRIG-B source. SNTP operation (primary and secondary) requires network access and the selection and configuration of suitable SNTP network sources. The SNTP time may be configured for re-synchronization cycles ranging from 15 minutes to 36 hours, adjusting the IED system time to an accuracy within +/- 1 second. Use of an SNTP time source for PMU and CDR applications is not recommended, however is considered suitable for data recording and trending purposes.

5.2 Interactive User Services

TESLA Control Panel (TCP)

TESLA Control Panel (TCP) is the main user interface for the TESLA 4000-SV recorder. TCP is a Windows software used for configuration, metering, log management and maintenance. TCP communicates with IEDs over Ethernet LAN or Serial communications. For more information on working with TCP, see "Working with TESLA Control Panel" on page 6-8. Other sections throughout the manual describe how to use various functions within TCP.

FTP

The TESLA 4000-SV supports File Transfer Protocol (FTP) for transferring records directly from the IED and for loading IEC 61850 configuration files to the IED. The FTP protocol is protected by the TESLA Cyber Security system and can only be accessed using valid login credentials. The access to folders and files within the IED are limited depending on which roles are assigned to the user, as shown in Table 5.2: FTP Access and Roles.

Table 5.2: FTP Access and Roles

<table>
<tr><th>Privilege</th><th>Roles</th><th>Notes</th></tr>
<tr><td>View Record List, Read Records</td><td>OPERATOR, ENGINEER, RCDREADER, UPDATE, RBCS</td><td>Used by third party record readers</td></tr>
<tr><td>View communication (IEC 61850 only) configuration</td><td rowspan="2">ENGINEER, INSTALLER, SECADM</td><td rowspan="2">Used by ERL61850 Configurator Tool</td></tr>
<tr><td>Change communication (IEC 61850 only) configuration</td></tr>
</table>

Terminal UI

The Terminal User Interface (UI) is used for restoring the security configuration to factory default and for retrieving the network configuration. It is accessed using a terminal emulation software such as HyperTerminal and is only available on the front USB Port 450. For more information on using the Terminal UI, see "Default Security Configuration Settings" on page 8-38 and "Network Configuration Recovery Utility" on page 8-7.

6 Communicating with the Recorder

The user interface and communication services are accessed by:

- Front or rear Ethernet network link (user interface and IEC 61850)
- Front USB 2.0 interface (user interface)
- Rear serial RS-232 interface (user interface)

This chapter describes first the communication links with the TESLA 4000-SV and then describes working with the main user interface, TESLA Control Panel.

6.1 Communication Links

The TESLA offers communication interfaces on both the front and rear panel of the IED. The recorder front panel provides one USB Standard-B receptacle and one Ethernet connection port. The rear panel provides up to five Ethernet ports and up to one serial port, depending on ordering configuration, available for unit communications.

Ethernet LAN Link

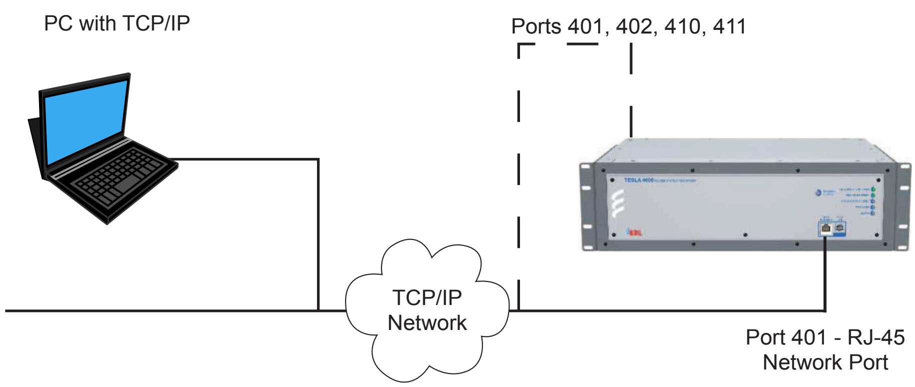


Figure 6.1: Ethernet LAN Link connection example using Non-redundancy or Single Redundancy hardware

An Ethernet LAN link via the Ethernet ports is used to access the user interface and communication protocols (IEC 61850, PMU, Syslog). For the Non-redundancy hardware or Single redundancy hardware, the rear Ethernet ports 401 (100BASE-T) and 402 (1000BASE-T) are copper interface with an RJ-45 connector. The rear ports 410, 411 and 412 are either copper interface with RJ-45 connector or optical interface with ST type optical receptacle connector (see “Ordering Options and Product Configuration ID” on page 1-5).

The front Port 401 is 100BASE-T copper interface with an RJ-45 connector.

Each port's IP address and network mask and the default gateway may be edited on the Ethernet tab on the Communication screen in TESLA Control Panel. See "Ethernet Configuration" on page 8-6.

VLAN IDs

For the non-redundant network hardware configuration (see "Ordering Options and Product Configuration ID" on page 1-5), all network traffic is accepted whether it is tagged or untagged for all network ports (401, 402, 410 and 411). GOOSE packets egress tagged if GOOSE publication is enabled.

For the Single redundancy hardware (see "Ordering Options and Product Configuration ID" on page 1-5), Ports 411 and 410/412 have various VLAN modes based on the Redundancy Profile. See for details "VLAN Modes" on page 4-9). For Ports 401 and 402, all network traffic is accepted whether it is tagged or untagged. GOOSE packets egress tagged if GOOSE publication is enabled.

USB Link

Your PC must be appropriately configured for USB communication (see "TESLA Control Panel Installation" on page 3-1).

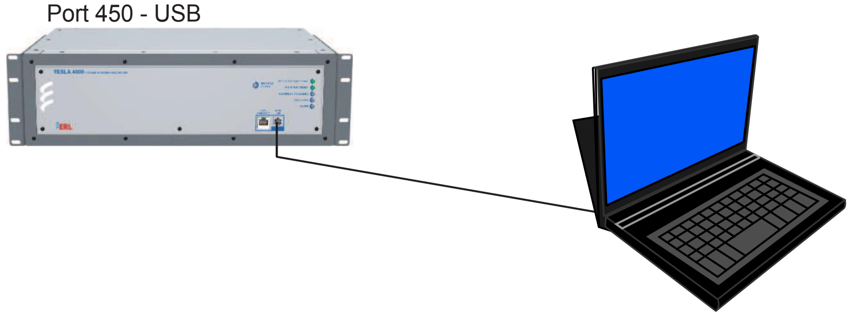


Figure 6.2: USB Link

To create an USB link between the recorder and the computer, first the USB driver for the ERLPhase 4000 Series Device needs to be installed, as follows:

Unzip the file (can be obtained from ERLPhase website):

ERLPhase_USB_driver.zip

In this case we assume you unzipped to the Desktop.

In Windows 7 or Windows 10

Connect a USB port of the PC to Port 450 (USB front) of the TESLA 4000-SV. The TESLA 4000-SV was already powered on.

In the window

"Welcome to the Found New Hardware Wizard"

"Can Windows connect to Windows Update to search for software?"

Check the option "No, not this time"

In the window

“This wizard helps you install software for:”

ERLPhase 4000 Series Device

“What do you want the wizard to do?”

Check the option “Install from a list or specific location (Advanced)”

In the window

“Please choose your search and installation options”

“Search for the best driver in these locations”

“Uncheck the option “Search removable media (floppy, CD-ROM.)”
Check the option “Include this location in the search”
Browse for the following folder:
C:\WINDOWS\tiinst\TUSB3410

In the window

“Hardware Installation”

“The software you are installing for this hardware”

“ERLPhase 4000 Series Device”

“Windows can’t verify the publisher”

Hit *Continue Anyway*

In the window

“Completing the Found New Hardware Wizard”

“The wizard has finished installing the software for”

“ERLPhase 4000 Series Device”

Hit *Finish*

To verify the installation was successful, and to which comm port is the ERLPhase 4000 Series Device configured, do the following:

In Windows 7 ‘small icons’ view, go to

Start>Control Panel>Device Manager>Ports

Look for the port number associated to this device.“ERLPhase 4000 Series Device”

Look for a COM#, where “#” can be 1, 2, 3, etc. Leave the default settings for this port.

It is recommended to restart the PC after the USB driver installation.

The default baud rate for the recorder USB Port 450 is 115200, however to double check it login to the recorder display and go to:

Main Menu> System> Recorder Comm Setup

To establish a USB link between the recorder and your computer, connect your computer’s USB port and Port 450 on the recorder’s front panel. Use a standard USB peripheral cable.

1. Ensure the recorder port and your PC's port have the same baud rate and communication parameters.
    - The recorder's USB port appears as a serial port to the PC and is fixed at 8 data bits, no parity and 1 stop bit and has a default baud rates of 115,200 bauds.
    - The baud rate and communication parameters of your computer's USB port is set automatically by TESLA Control Panel *(Edit IED>Communication>Direct Serial Link*)
2. Choose the target recorder from the *Select IED* list in TESLA Control Panel's Main Menu.
    - If there is not already an entry for this recorder, create one using the *Add New* button.
    - The method of communication with the recorder is specified as part of its IED definition. Use the *Edit* button to view or change this information. Ensure the *Direct Serial Link* option is selected.
    - For details on IED definitions see "Working with TESLA Control Panel" on page 6-8.
3. Initiate the connection by selecting the *Connect* button.
    - A dialog box will appear to show connection progress.
    - The connection state and the current IED you are connected to is shown on the Windows status bar at the bottom of the screen.

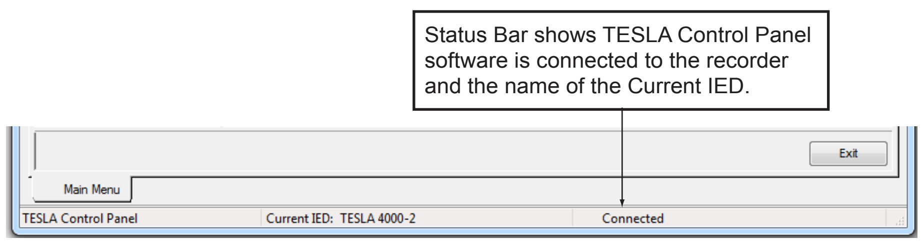


Figure 6.3: Status Bar

If the connection fails, check the following:

- The communication parameters are the same on both ends (see Step 1 above).
- The correct serial port has been selected on your computer.

Direct Serial Link

> Your PC must be appropriately configured for serial communication (see “TESLA Control Panel Installation” on page 3-1) and Port 405 must be available on the IED to enable a direct serial link.

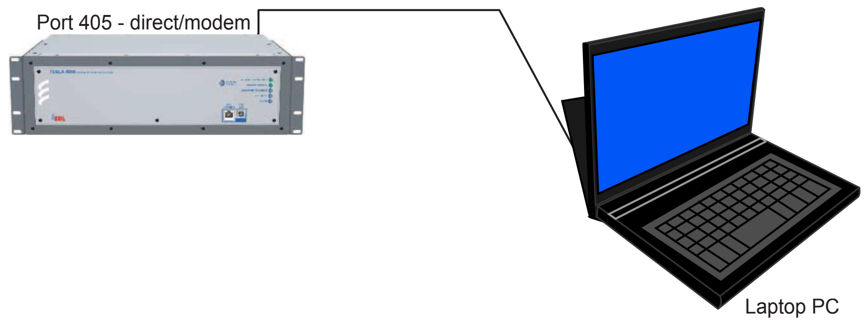


Figure 6.4: Direct Serial Link

To create a serial link between the recorder and your computer, connect your computer’s serial port (or USB port with USB to Serial converter) and Port 405 on the recorder’s rear panel.

The serial port is configured as EIR RS-232 Data Communications Equipment (DCE) devices with female DB9 connectors. This allows it to be connected directly to a PC serial port with standard straight-through male-to-female serial cable.

1. Ensure the recorder port and your PC’s port have the same baud rate and communication parameters.
    - Port 405 is fixed at 8 data bits, no parity and 1 stop bit and has a default baud rate of 38,400 baud (configurable).
    - The baud rate and communication parameters of your computer's USB port is set automatically by TESLA Control Panel *(Edit IED>Communication>Direct Serial Link*)
2. Choose the target recorder from the *Select IED* list in TESLA Control Panel’s Main Menu.
    - If there is not already an entry for this recorder, create one using the *Add New* button.
    - The method of communication with the recorder is specified as part of its IED definition. Use the *Edit* button to view or change this information. Ensure the *Direct Serial Link* option is selected.
    - For details on IED definitions see “Working with TESLA Control Panel” on page 6-8.
3. Initiate the connection by selecting the *Connect* button.
    - A dialog box will appear to show connection progress.
    - The connection state and the current IED you are connected to is shown on the Windows status bar at the bottom of the screen.

> Most new computers do not have serial ports. A USB serial converter adapter can provide a surrogate serial port for a direct connection to the TESLA recorder.

TESLA Control Panel Setup

1. Ensure that the computer running TESLA Control Panel has access to the Ethernet network or USB port to which the recorder has been connected.
2. Start TESLA Control Panel.
3. Choose the target recorder from the *Select IED* list in TESLA Control Panel's Main Menu.
   - If there is not already an entry for this recorder, create one using the *Add New* button

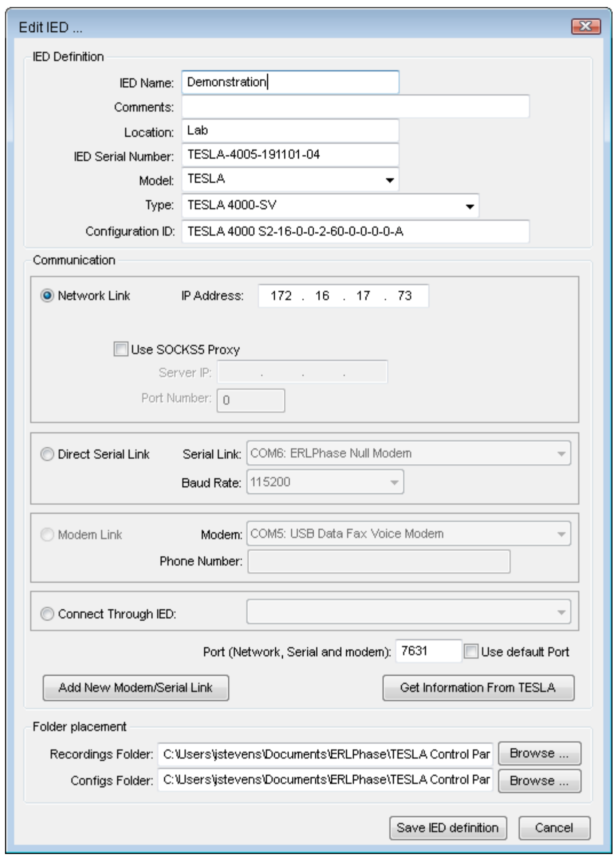


Figure 6.5: Add New/Edit IED

- The method of communication with the recorder is specified as part of its IED definition. The *Network Link* option is shown in the figure above. The recorder's IP address is entered. Alternatively, the Direct Serial Link may be selected and used.

4. Initiate the connection by selecting the *Connect* button.
   - A dialog box will appear to show connection progress.
   - The connection state and the current IED you are connected to is shown on the Windows status bar

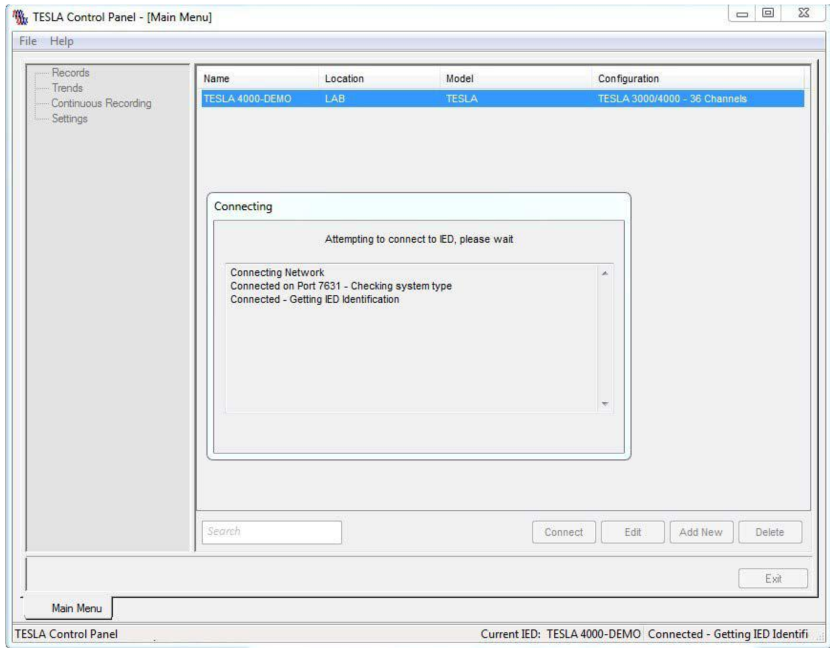


Figure 6.6: Connect Button Dialog Box

6.2 Working with TESLA Control Panel

In order to access each screen in TESLA Control Panel the user account must have proper security roles assigned. For more information, see “User Account Management” on page 8-33 and “Authentication and Authorization System” on page 18-5.

Recorder Workspace

TESLA Control Panel supports multiple recorders. Each recorder has its own workspace within TESLA Control Panel that stores its communications parameters, records and configuration files.

A separate workspace should be created for each recorder on your system to store its configuration files and records.

When first installed, TESLA Control Panel includes a workspace for a recorder called TESLA 4000 Demo Unit. It contains sample records and configuration files and is configured for network connection with an evaluation unit.

Selecting a Recorder Workspace

To work with a particular recorder, select it from the *Select IED* box on the *Main Menu* tab. If you are already connected to an IED you will not be able to select a different IED until you disconnect.

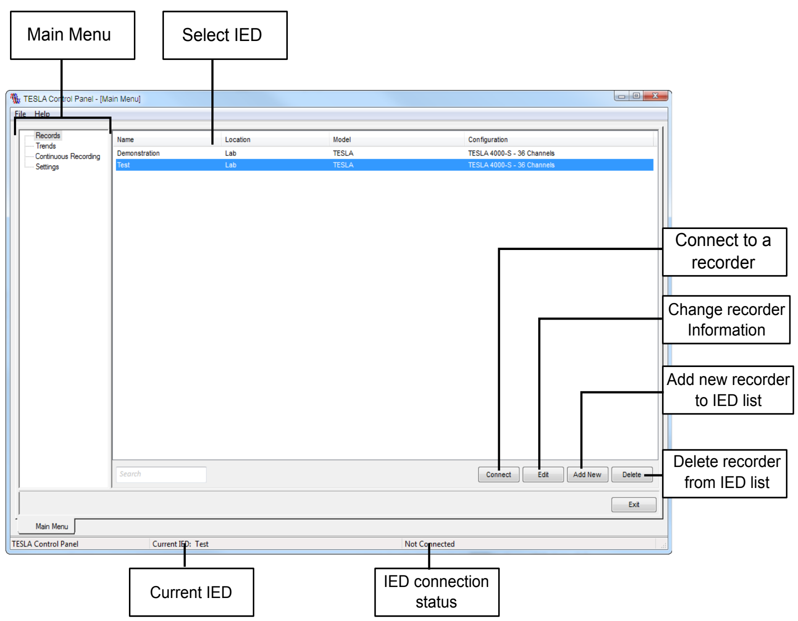


Figure 6.1: Selecting a Recorder Workspace

Current IED

Selecting a recorder sets TESLA Control Panel’s focus to that recorder’s workspace, known as the Current IED. The records and configuration files belong to the selected recorder.

If you initiate a connection using TESLA Control Panel, it connects to the current IED using the communication parameters specified for this IED.

> The name of the Current IED is always displayed in the Status Bar at the bottom of the TESLA Control Panel window (for details see Figure 6.1: Selecting a Recorder Workspace on page 6-8).

TESLA Control Panel assumes that the recorder it is communicating with is the one identified as the Current IED. Forcing a connection with a different recorder (i.e. moving the serial cable without telling TESLA Control Panel to disconnect), can cause the records and configuration files of that recorder to be mixed with those of the Current IED.

Adding/Editing a Recorder Workspace Definition

Recorder workspaces are added, modified or deleted from the TESLA Control Panel Main Menu using controls in the *Select IED* dialog box (for details see Figure 6.1: Selecting a Recorder Workspace on page 6-8) The *Edit* button displays the selected recorder's definition screen. The *Add New* button is used to create a new recorder definition. The *IED* definition is shown in Figure 6.2: Recorder Workspace Definition and the settings are described in the following table.

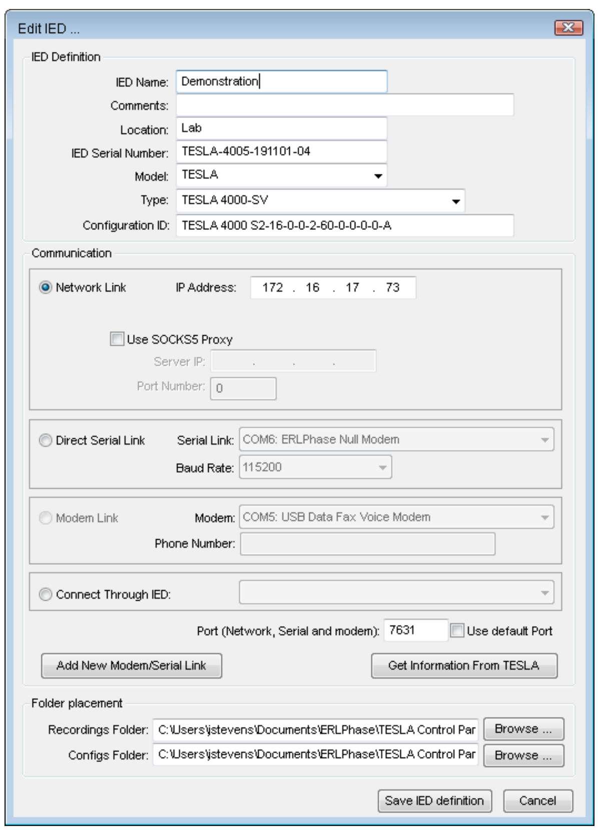


Figure 6.2: Recorder Workspace Definition

Table 6.1: IED Workspace Settings	
IED Definition	
IED Name	The IED Name is the name you assign to this recorder's workspace. It appears in the IED selection and the Current IED display at the bottom of the TESLA Control Panel window. We recommend that you use the same name for this workspace as the Unit Name given to the recorder ("Unit Identification" on page 8-2).
Comments	User-defined, for your reference only.
Location	User-defined, for your reference only.
IED Serial Number	Enter the IED Serial Number to match the serial number of the actual recorder.
Get Information from IED	Connects to the recorder and retrieves its configured name, location and serial number. The corresponding fields in the IED Definitions are overwritten.
Model	TESLA 2000 / 3000 / 4000 18 or 36 channel, TESLA 4000-A, TESLA 4000-SV, TESLA 3000 /4000 Cooperative IED, TESLA 4000-SV/A Cooperative IED
Configuration ID	The configuration string identifies the ordering options of the specific IED (number of channels, communication ports etc.). During offline mode this field must be filed manually.
Configuration	
IP Address	IP addresses of the recorder. The recorder's default factory IP addresses are 192.168.100.80 and 192.168.101.80. It is changed from the *Communication > Ethernet* screen in TESLA Control Panel,
Communication	
Direct Serial Link	Connect to this recorder through a serial cable.
Network Link	Connect to this recorder via a TCP/IP network.
Connect Through IED	Connect to this recorder through another recorder that is providing a modem-Lan gateway. An IED Definition for the selected recorder must already exist.
Port	Set the port number for the corresponding connection communication protocol. If "Set to Default" is checked, then the default ERLPhase IANA port 7631 is used (for some legacy products TCP auto-detects the default port as port 2000).
Folder Placement	The Default Folder directory applied to new IED definitions can be modified with the *File>Data Locations* command from the Main Menu.
Recordings Folder	The directory where the IED's retrieved records are stored.
Configs Folder	The directory where the IED's configuration files are saved.

You can share configuration files and records with other TESLA Control Panel users by using common folders

Online and Offline Operation

TESLA Control Panel can be used with or without a connection to the selected recorder. Both offline and online modes work within the selected Current IED workspace.

Offline (Not Connected)

In Offline mode, you can manage and display a recorder's local (previously uploaded) records and create and edit configuration files without being connected to the unit.

Online (Connected)

In Online mode you are connected to the recorder and have access to both local and remote data and functions:

- Records (both local and on the recorder)
- Event log
- Metering (real-time readings of input and calculated channels)
- Channel and trigger configurations (the one presently active in the recorder and any saved ones you may have created)
- Setup utilities and record configuration screens
- Record graphics display
- Trend logs
- Maintenance functions

Connection Status

The Status Bar at the bottom right side of the TESLA Control Panel window shows if you are presently online or offline.

Navigating TESLA Control Panel

TESLA Control Panel uses a split screen format. The left pane is used for navigation or selection. The right pane is the working area for each of the program's main sections. To bring up the Control Tabs, shown below, you must select the appropriate item on the Navigation Tree by double-clicking.

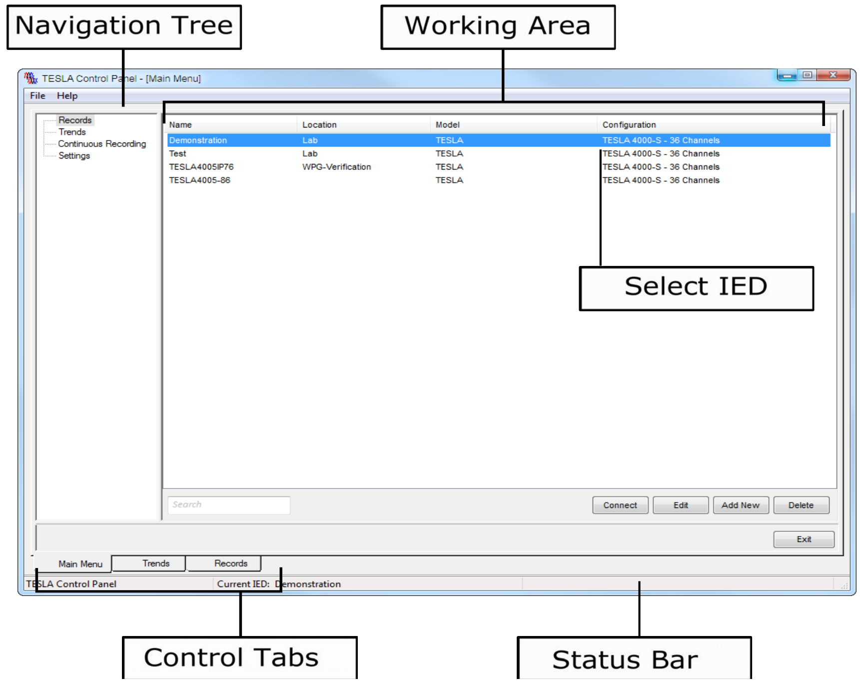


Figure 6.3: TESLA Control Panel Display Sections Navigation Tree

The left pane provides a means of moving between TESLA Control Panel functions or selecting items within a function (e.g. channels from a record). TESLA Control Panel functions—Records, Trend, Events, Metering, Utilities and Configuration are activated by a double-click.

You can optimize the screen space between the tree and the working area to create a larger working area. Some screens have a *Hide Tree* button to maximize the working area.

Working Area

The Working Area on the right pane of the display represents the main working area of each section of the TESLA Control Panel.

Control Tabs

The Control Tabs are a row of selection tabs near the bottom of the screen. Each time you start a function, a corresponding tab is created. Select the control tabs to navigate from one screen to another or the *Main Menu* item. Use the *Close* button to close the screen.

Status Bar

The Status Bar at the bottom of the TESLA Control Panel displays the name of the selected recorder workspace and the status of the connections.

7 Metering Display

The recorder has a full set of real-time metering displays that provide present readings from the analog and digital input channels, and the calculated channels.

The Metering display is accessed through the *Metering* item in the *Main Menu* tab's function list.

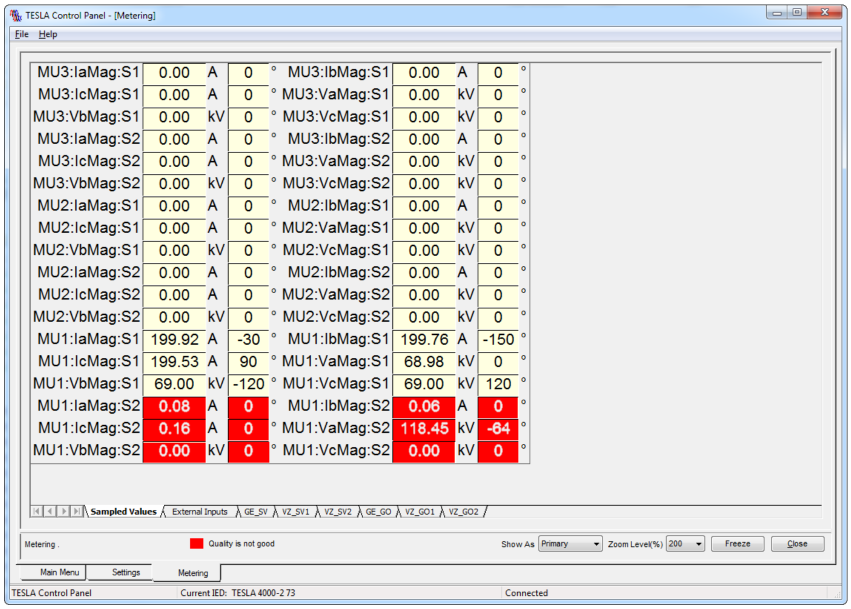


Figure 7.1: Metering Display

Standard Metering Screens

The Metering display provides tabs at the bottom to select among multiple display screens. The first two tabs, *Analogs* and *Digitals* are the default tabs and present the readings from the analog inputs and external inputs.

User-Defined Metering Screens

You can define an additional ten user-defined metering screens. Setup of these additional screens is part of the recorder's configuration (see "Meter Groups" on page 9-54).

Angle Reference

Angle information displayed on the metering screen may be referenced to any angle reference setting in the configuration file. This feature modifies the display of information on the metering screen and has no impact on recording or communications.

Primary/ Secondary

Metered values can be shown as either system primary or secondary quantities.

Display Zoom

The magnification of metering screens can be adjusted using the *Zoom Level* (%) control. This allows the display to be enlarged for easy viewing while commissioning or testing.

Freeze

The *Freeze* button provides a way to temporarily stop the update of the display. It can be used to ensure a synchronized set of readings for documentation purposes. The metering display can be exported to another program using Windows built-in Alt PrintScreen key and standard paste functions.

> Phase angle readings displayed in meter groups are based on the configured Phase Angle Reference Channel (see “Phase Angle Reference Channel” on page 9-17).

Metering Quality

If the associated metering data does not have “Good” quality (i.e. data quality is “Questionable” or “Invalid”) then the cell for this channel will be displayed with a Red background. For more information on data quality, see “Data Quality” on page 20-1.

8 Recorder Setup

The TESLA recorder has global setup parameters that establish its identity and define its operation. Setup parameters define:

- Unit identification
- Communication port parameters
- Ethernet configuration
- Network Redundancy configuration
- FTP Communication configuration
- IEC 61850 Port Configuration
- Recording configuration
- Trend Recording configuration
- Time Synchronization Settings and Display
- Syslog configuration
- Security accounts

Multiple screens in TESLA Control Panel contain the setup parameters. TESLA Control Panel must be communicating with the IED, and the user account must have appropriate security roles assigned to access the desired screens.

For details on security roles and privileges see "Authentication and Authorization System" on page 18-5.

For details on connecting to the recorder using TESLA Control Panel software see "Network Redundancy" on page 4-7.

8.1 Unit Identification

The Unit Identification screen identifies a particular recorder and its records. Navigate to *Identification* from the Main Menu.

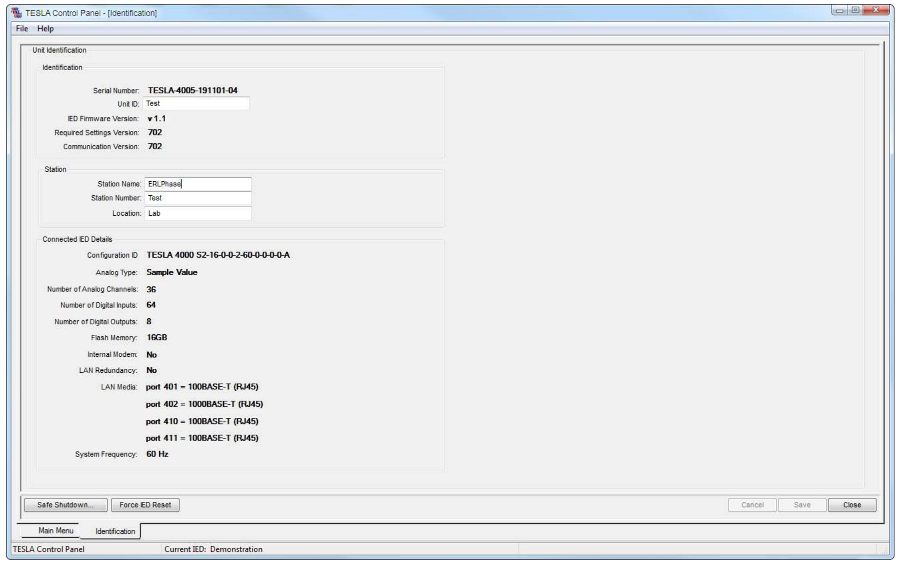


Figure 8.2: Recorder Setup - Unit Identification

Settings

The following table describes the Unit Identification Settings:

Table 8.1: Unit Identification Settings	
Identification	
Serial Number	Read-only field, displays the serial number of the TESLA unit currently connected.
Unit ID	User-entered field that identifies the unit. It is part of the name given to records produced by the unit to identify their origin. By convention, this name should be the same as the “IED Name” assigned to the recorder and recorder’s workspace. The name must not contain the following: “,” “/” “\” “:” or any other character not valid for a Windows file name.
IED Firmware Version	Read-only field that displays the firmware version of the currently connected TESLA unit.
Required Settings Version	Describes the version of the settings file required by the connected recorder. TESLA Control Panel is capable of creating older versions of settings files for use with recorders whose firmware has not been updated (see “Managing Settings File” on page 9-1).
Communication Version	Read-only field that displays the version of the communications protocol used by the currently connected TESLA unit.
System Frequency	Read-only field that displays the assumed power system frequency of the recorder. This is a factory setting.
Station	

Table 8.1: Unit Identification Settings	
Station Name	User-defined, for your reference only.
Station Number	User-defined, for your reference only.
Location	User-defined, for your reference only.
Safe Shutdown Mode	This command suspends TESLA Application for 15 minutes to allow user safely power off the unit. While TESLA Application is suspended, the front Test and Alarm LEDs are flashing alternatively. If IED is not powered off within 15 minutes, TESLA Application resumes. See“Safe Shutdown Mode” on page 12-6 for more details.
Force IED Reset	This command initiates an IED hardware reboot immediately after pressing the TESLA Control Panel button.

8.2 Serial Communication Settings

The Serial Communication settings control the modes and baud rates of the recorder's communication ports. The serial communication port settings are access through the Communication screen on the Serial Tab.

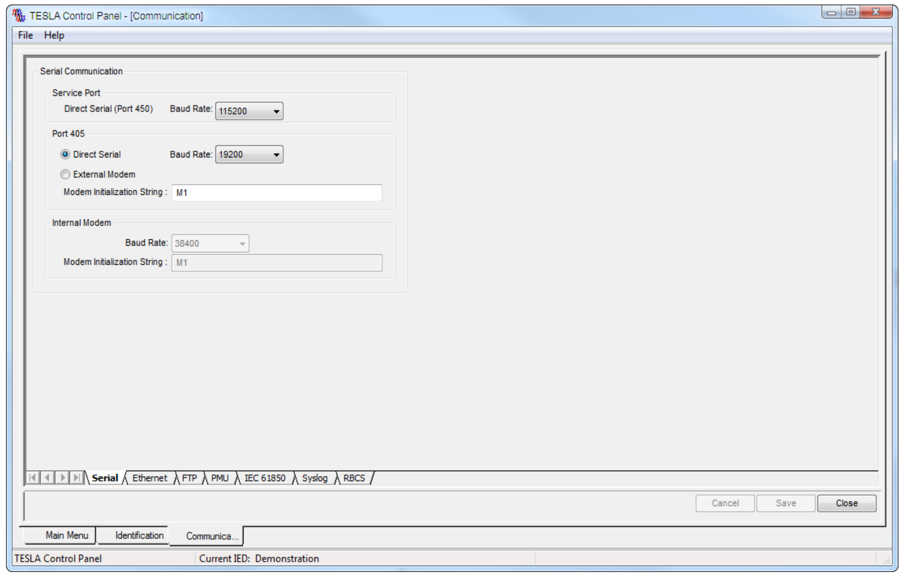


Figure 8.3: Serial Communication Setup

Settings

The following table describes the Serial Communication Port Settings:

Table 8.2: Serial Communication Settings	
Service Port	
The Service Port is Port 450 on the front of the recorder. It can be used for connection with TESLA Control Panel or a terminal program (to access the Terminal UI).	
Baud Rate	Sets the baud rate of the port. The default baud rate is 115,200 N81 baud. Note: The baud rate must match that of the port of the computer connected to this port. For best results, use the maximum baud rate that your communication link and equipment can sustain.

Table 8.2: Serial Communication Settings	
Direct/Modem Port	
The Direct/Modem Port refers to either the recorder’s rear panel Port 405 or its Internal Modem port (not supported), depending on the Port Select setting. Direct/Modem Port functionality is not available on all TESLA 4000-SV IED configurations.	
Port Select	Direct Serial: Port 405 is enabled for a direct serial connection with TESLA Control Panel or a terminal program (to access the Terminal UI). Only supported on non-redundant network configuration (see “Ordering Options and Product Configuration ID” on page 1-5) (Currently Not Supported) External Modem: Port 405 can be used to connect to an external modem through a serial link. (Currently Not supported) Internal Modem: Enables a modem connection through the recorder’s rear panel RJ-11 Internal Modem Port. Requires that the recorder has the internal modem option installed.
Baud Rate	Sets the baud rate of port 405. The default baud rate is 38,400 baud. For a direct serial connection on Port 405, the baud rate must match that of the port of the computer connected to this port. For best results, use the maximum baud rate that your communication link and equipment can sustain.
Modem Initialization String	When using an internal or external modem, a modem initialization string can be entered containing modem control codes. The factory default for this field is “M1”. Refer to the modem manual for details.

8.3 Ethernet Configuration

The IED Ethernet Configuration is accessed from the Communication screen on the Ethernet tab.

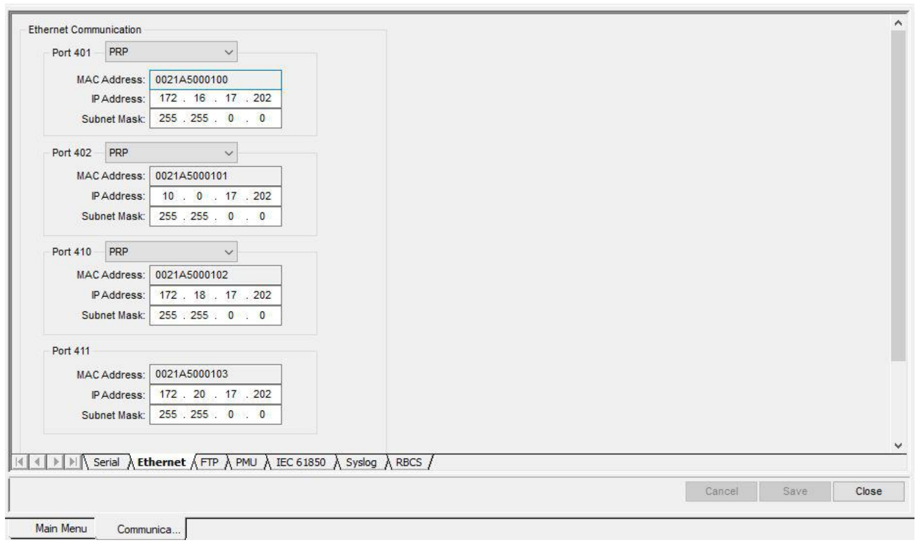


Figure 8.4: Communication - Ethernet Configuration

Settings

The following table describes the Ethernet Settings:

Table 8.3: Ethernet Settings	
Ethernet Communication	
Port 401	Displays MAC address of Port 401. Set the IP Address and Subnet mask. Default IP Address = 192.168.100.80
Port 402	Displays MAC address of Port 402. Set the IP Address and Subnet mask. Default IP Address = 192.168.101.80
Port 410	Displays MAC address of Port 410. Set the IP Address and Subnet mask. Default IP Address = 192.168.102.80
Port 411	Displays MAC address of Port 411. Set the IP Address and Subnet mask. Default IP Address = 192.168.103.80
Default Gateway	Set the Default Gateway.
Packet Forwarding enabling	This setting must be enabled for cooperative mode functionality with a modem and for modem LAN gateway communication.
TCP/IP Port Selection	Set the TCP/IP Port. Range is 1025 to 65535. Default is ERLPhase Registered IANA Port 7631.
Redundancy Configuration	Only available in Multiple Redundancy hardware, can be configured as Disabled, Non-Redundant, PRP. Details please see “4.3.2 Multiple Redundancy” on page 4-10.

After a setting has been changed, the IED must be manually rebooted in order for the changes to take place.

Network Configuration Recovery Utility

The TESLA 4000-SV contains a contingency feature for recovering the network configuration. This utility allows for viewing of the Port 401 IP Address. Network Mask and Port via a USB serial connection and a terminal emulator program such as HyperTerminal. This utility is to be used if the user is unable to establish a serial or network connection to the TESLA 4000-SV via TESLA Control Panel.

Connecting to the Network Configuration Recovery Utility

To connect to the Network Configuration Recovery Utility use a terminal emulator program. HyperTerminal is used for here for demonstration purposes. To connect to the Network Configuration Recovery Utility:

1. Connect USB cable from PC to front USB Port 450 on the TESLA 4000-SV.

> This procedure assumes that the ERLPhase driver has already been installed to create a USB serial connection to the TESLA. See “Network Redundancy” on page 4-7 for more details.

2. Open HyperTerminal.
3. Create a new connection. Click OK.

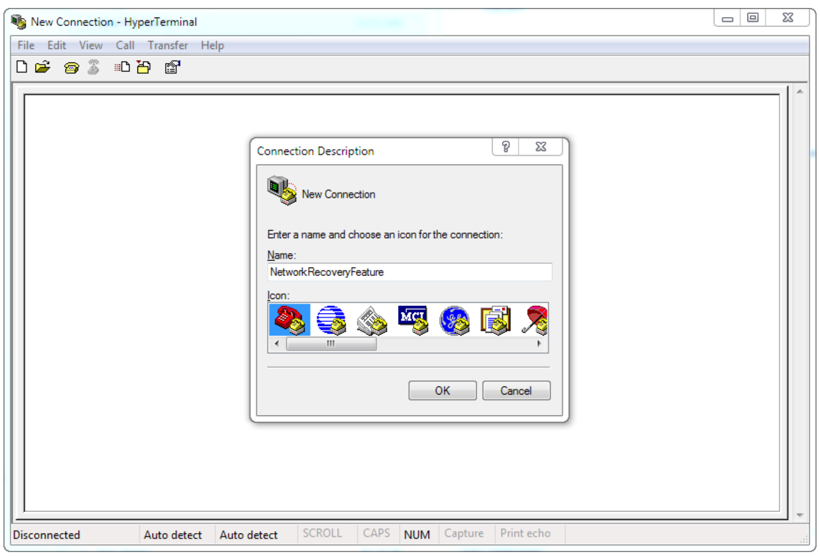


Figure 8.5: New connection

4. Select COM Port connected to the TESLA. Click OK.

To see which COM Port the TESLA is connected to on your PC, check *Control Panel > Device Manager > Ports*.

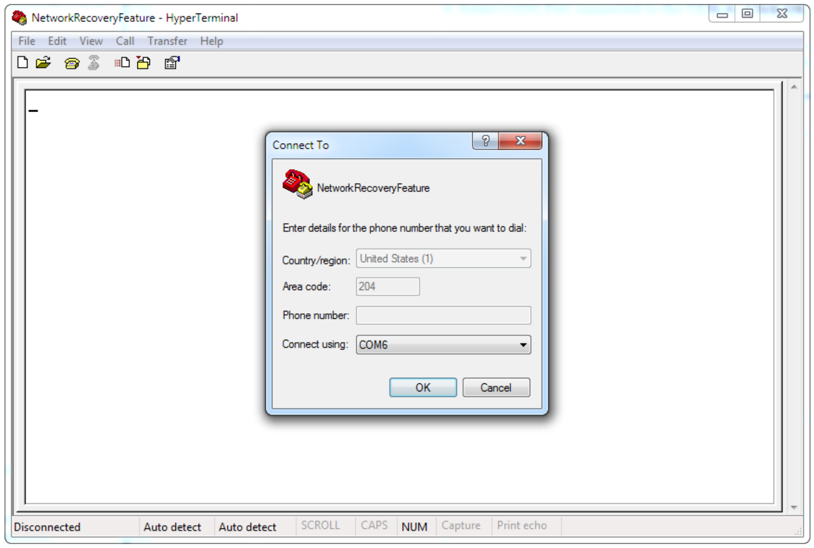


Figure 8.6: Select COM Port

5. Choose Baud Rate of 115,200. Click OK.

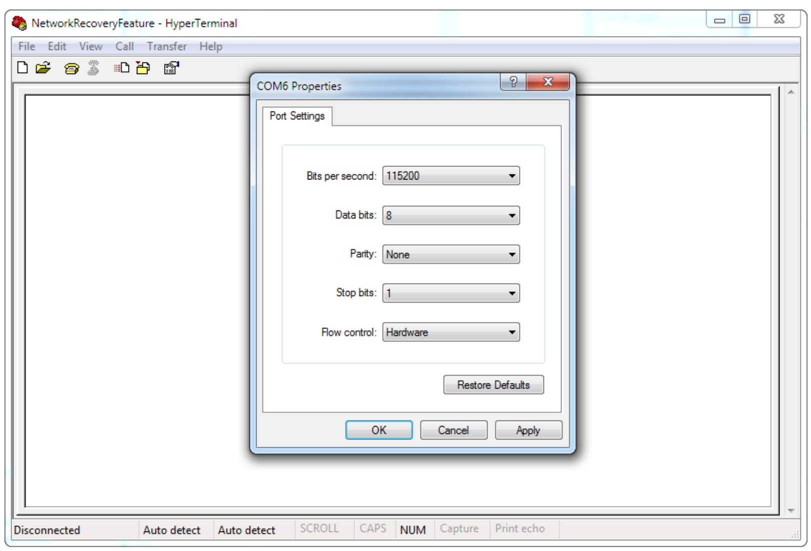


Figure 8.7: Set Baud Rate

6. Enter a '?' character. This launches the network recovery utility. If another character is entered before the '?', the network recovery utility will not launch. User must disconnect, reconnect, and then try again.

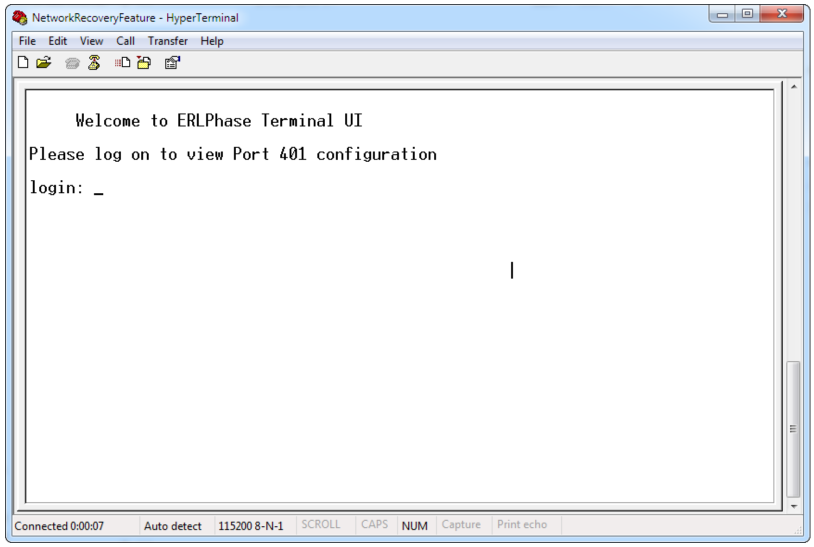


Figure 8.8: Launch Network Recovery Utility

7. The Network Recovery Utility is protected by the Role-Based Access Control security system. Enter valid login credentials and press *Enter* to login to the Utility. The user account must have adequate Roles assigned to read the communication configuration. The default "service" account is shown here as an example. For more information on Role assignments, see "TESLA Role List" on page 18-7. For more information on Default Accounts, see "Default User Accounts" on page 8-39.

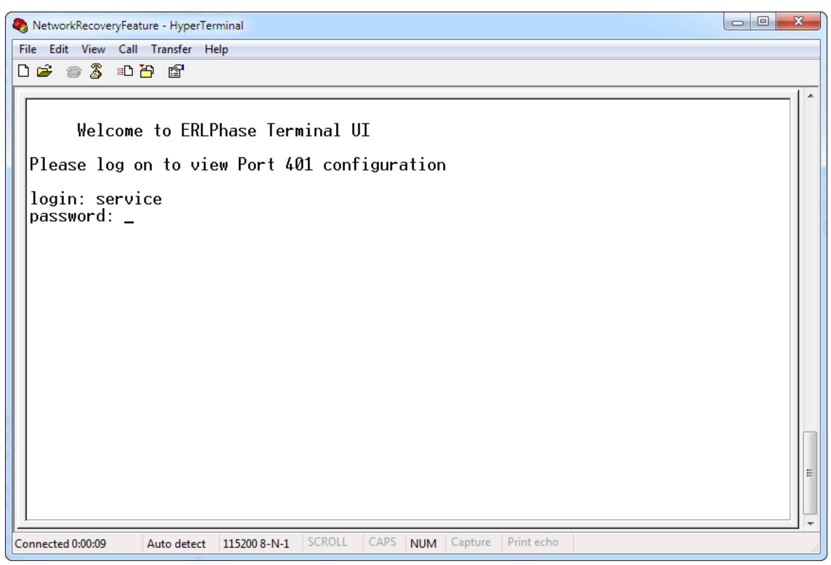


Figure 8.9: Enter valid login credentials

8. The Port 401 Network Configuration is displayed once valid login credentials have been entered.

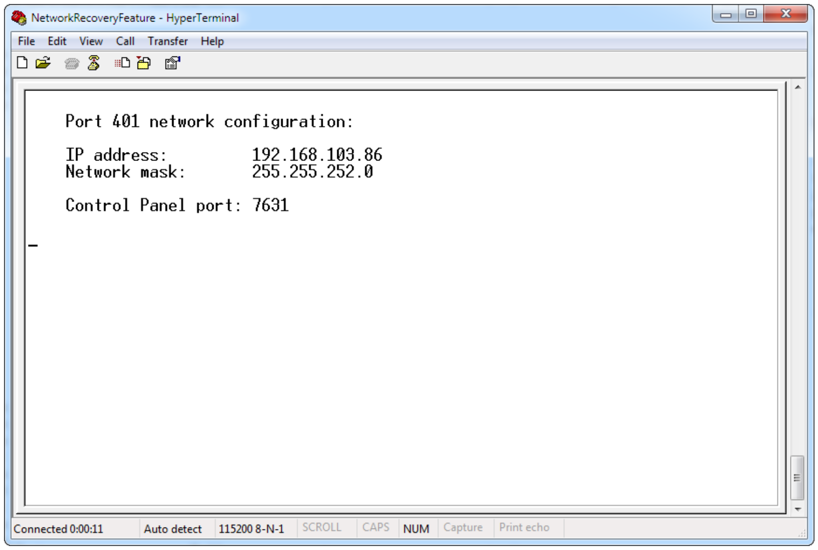


Figure 8.10: View the network configuration

8.4 Network Redundancy Configuration

The Network Redundancy Configuration screen is used to perform the configuration of the Network Redundancy profiles, Redundancy network configuration and provides identification information of the redundancy module. This configuration is only available in Single Redundancy hardware. For the Multiple Redundancy hardware, the redundancy configuration is done in Ethernet Communication screen.

The *Communication* > *Network Redundancy* screen settings and the *Time* > *PTP* screen settings are both stored on the redundancy communication board. These settings are linked to the Active Mode selected in the *Communication* > *Network Redundancy* screen. When the settings are changed and saved, they are saved to the currently selected Active Mode. When the Active Mode is changed, the settings on the *Time* > *PTP* screen settings and the *Communication* > *Network Redundancy* screens will be updated with those last saved to the new Active Mode profile.

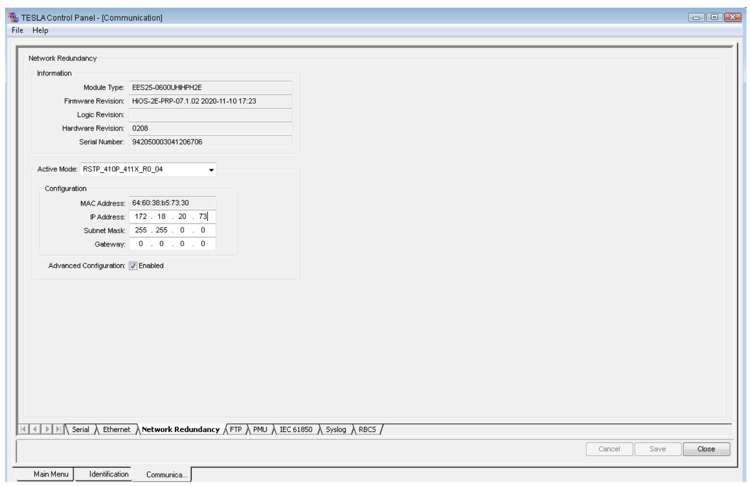


Figure 8.11: Network Redundancy Configuration

Information

The Information section of the Network Redundancy screen provides identification information of the built-in redundancy module, including the module type, firmware revision, logic revision, hardware revision and serial number. This information is read-only.

Configuration

The Configuration section of the Network Redundancy screen allows for configuration of the network settings of the built-in redundancy module. Under normal circumstances, these network settings are not required to be changed. If using the Advanced Configuration, as directed by ERLPhase Customer Service, then the redundancy network configuration may need to be changed.

Active Mode Selection

The Active Mode drop-down box is where the redundancy profile is selected. Refer to "Redundancy Profiles" on page 4-8 for more details.

Advanced Configuration

The Advanced Configuration is only to be used as directed by ERLPhase Customer Service. It allows for advanced configuration of the redundancy hardware.

8.5 FTP Communication Configuration

The FTP Communication configuration is accessed from the Communication screen on the FTP tab. FTP Communication is used for transferring files to and from the IED via peripheral software tools. ERL 61850 IED Configurator uses the FTP protocol to transfer configurations to and from the TESLA.

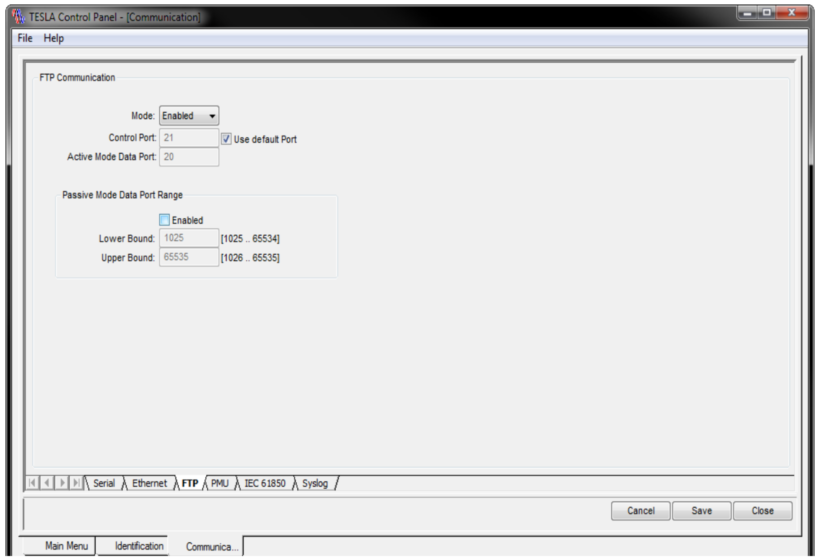


Figure 8.12: FTP Communication Screen

> FTP Communication must be enabled and the port settings must match the ERL 61850 IED Configurator software to ensure that the software can communicate with the TESLA.

Settings

The following table describes the FTP Communication Settings:

Table 8.4: FTP Communication Settings

FTP Communication	
Mode	Enabled/Disabled
Control Port	FTP Control Port setting. Default value is 21.
Use Default Port	Check-box used to revert setting to default value.
Active Mode Data Port	Port setting is read-only. Value is automatically set to the Control Port value minus one. i.e. If Control Port is set to 21, Active Mode Data Port is set to 20.
Passive Mode Data Port Range	
Enabled Check-box	Enable or disable the Passive Mode Data Port Range
Lower Bound	User configurable lower bound
Upper Bound	User configurable upper bound

8.6 IEC 61850 Port Configuration

The *Communication > IEC 61850* screen allows the user to enable or disable each of the four Ethernet ports for IEC 61850 GOOSE and Sampled Value communication. When the port is enabled, the GOOSE and Sampled Value communication is available, according to the IEC 61850 configuration loaded to the unit via the CID file (using the ERL 61850 Configurator Tool).

Note that MMS communication can be disabled only if all the 61850 ports are disabled, otherwise it will be enabled on all ports.

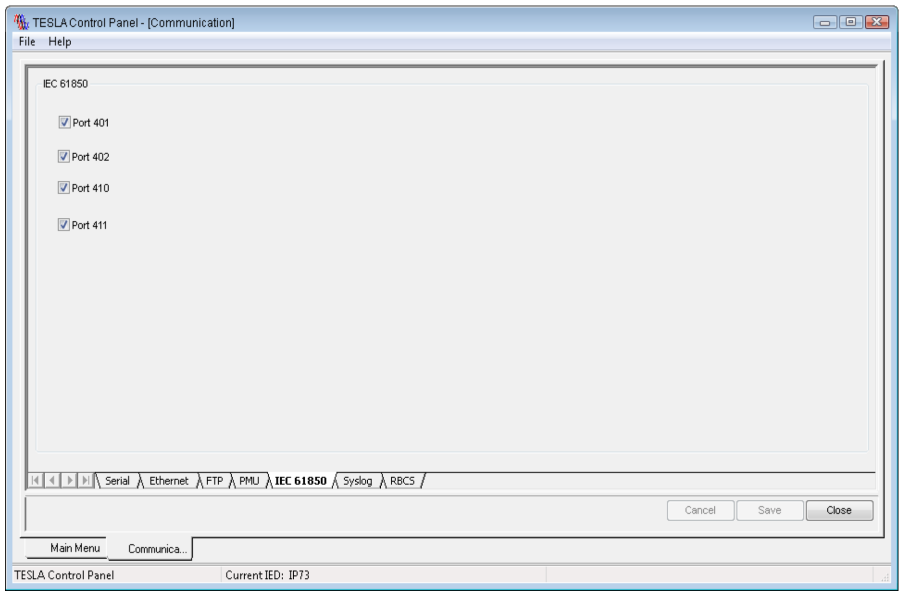


Figure 8.13: IEC 61850 Port Configuration Screen

Settings

The following table describes the IEC 61850 Port Settings:

Table 8.5: IEC 61850 Port Settings

Port	Setting	Services Affected by setting
Port 401	Enabled/Disabled	GOOSE subscription and publication MMS for all 4 ports
Port 402	Enabled/Disabled	GOOSE Publication/Subscription, SMV subscriptions, MMS for all ports
Port 410	Enabled/Disabled	GOOSE Publication/Subscription, MMS for all ports.
Port 411	Enabled/Disabled	GOOSE Publication/Subscription, MMS for all ports.

8.7 Recording Configuration

The Recording Configuration displays the High and Low Speed Recording Configuration and allows the user to configure record storage parameters.

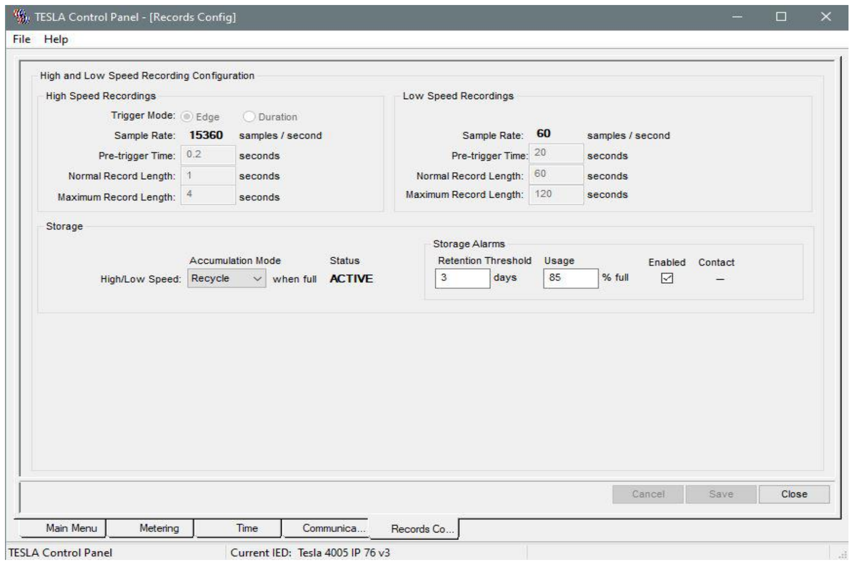


Figure 8.14: Records Configuration Screen

The High and Low Speed Recording Configuration section displays the current recording configuration as read-only text. The configuration of the record length parameters are handled in the Settings file (see “Recording Configuration” on page 9-8 for more details).

Settings

The following table describes the recording storage control settings:

Table 8.6: Recording Storage Configuration	
Storage	
High/Low Speed Accumulation Mode	Selects whether to overwrite the oldest transient or swing records when the storage space is full or the 1000 record limit has been reached or to stop storing new records. The Storage Alarm can be used in conjunction with the Stop setting to provide notification in advance of the full condition.

Table 8.6: Recording Storage Configuration	
High/Low Speed Storage Alarm Limits	When accumulation Mode is set as Stop, High/Low Speed record storage alarm can be enabled and activated when Usage percentage setting is meet or exceeded. Usage setting can be configured between 60 to 99 percent. When accumulation Mode is set as Recycle, High/Low Speed record storage alarm can be enabled and activated when both retention period in days setting and usage percent setting are meet or exceeded. Retention period setting is configurable between 1 to 100 days, the real time retention period is estimated and displayed in Records screen above record percentage progress bar when connecting to the IED. The retention period is calculated using the current IED time minus the oldest records time and displayed in days and hours. The storage alarm condition is indicated by flashing the front panel “Record Storage” LED and activating a selected alarm contact. Note: the alarm contact assigned to this is displayed as a read-only value. It’s set as part of the recorder’s configuration (see “TESLA Alarms” on page 9-7).

8.8 Trend Recording Configuration

The Trend Recording Configuration is available on the Trend Recording Configuration screen in TESLA Control Panel.

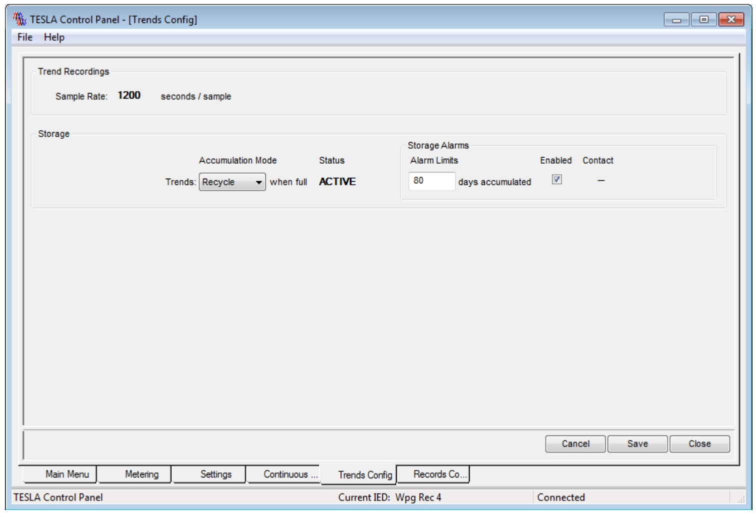


Figure 8.15: Trend Recording Configuration Screen

Settings

The following table describes the recording control settings:

Table 8.7: Trend Recording Configuration	
Trends Recordings	
Sample Rate	Read-only display of the trending interval in seconds. The trend logging rate is configured in the recorder's setting file (see "Trend Logging" on page 9-55).
Storage	
Trend Accumulation Mode	Selects whether to overwrite the oldest trend data when the 90 day storage limit has been reached or to stop trend. The Storage Alarm can be used in conjunction with the Stop setting to provide notification in advance of the full condition.
Trend Storage Alarm Limits	When enabled, you can enter a limit giving the number of days of accumulated trend information that causes an alarm condition. Enter a number of days between 10 and 90. The storage alarm condition is indicated by flashing the front panel "Record Storage" LED and activating a selected alarm contact. Note: the alarm contact assigned to this is displayed as a read-only value. It's set as part of the recorder's configuration (see "TESLA Alarms" on page 9-7).

8.9 Time Synchronization Settings and Display

TESLA Control Panel provides configuration options for the IED time settings and for the display of timestamps on the various TESLA Control Panel screens. The IED time is determined by the Time Source configuration and the settings on the Time screen. The display of timestamps on the various screens in TESLA Control Panel is determined by a combination the *Options > Time Display Settings*, the IED time and the local PC time settings.

The display and setting of the IED time and the TESLA Control Panel timestamps are described in detail in the following section.

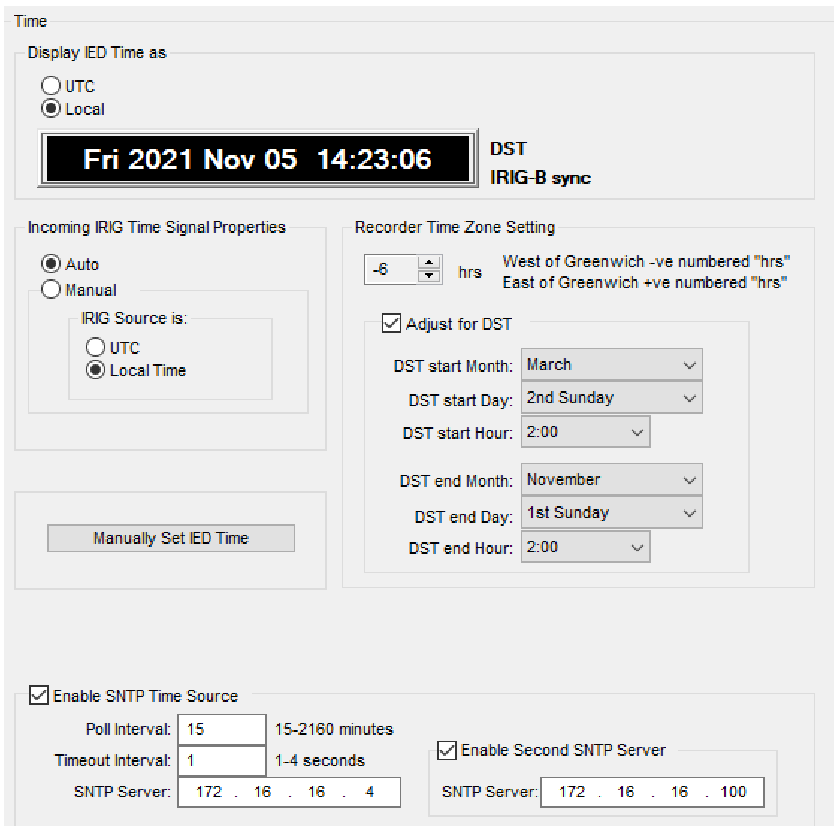


Figure 8.16: Recorder Setup Utilities - Time

The TESLA 4000-SV uses time as the basis of data recording and requires the presence of a source time signal on the IED. The recorder supports the following time sources:

- IRIG-B (unmodulated)
- PTP (IEEE 1588)
- System Sync
- RTC (Real-Time clock) internal free-running oscillator
- SNTP

IRIG-B

Using IRIG-B as a time source is a high accuracy option suitable for use in PMU and CDR applications. The IRIG-B signal is acquired via the IRIG-B on the rear of the recorder.

IRIG-B Signal Interpretation

The IRIG-B source format may or may not contain the following fields; Year (Y), Offset (O) and DST (D). The TESLA provides Auto and Manual mode for interpreting the IRIG-B source information to account for the many different IRIG-B formats.

In Auto mode (recommended setting), the TESLA attempts to automatically interpret the information available in the IRIG-B source. If the IRIG-B source does not contain all relevant fields (Y, O, D), then the user settings are automatically used to supplement the missing fields (see Table 8.8). Since Auto mode may use the user settings (see Figure 8.17 for available user settings), it is important to set the DST, Offset and Year correctly, even when using Auto mode. This ensures that even if the IRIG-B source doesn't include all fields, they will be replaced with the correct information.

> TESLA is expected to correctly interpret any IRIG format in Auto mode. Please contact ERLPhase customer support if Auto mode setting results in incorrect time.

> Regardless of the mode setting, the TESLA automatically switches to Auto mode when C37.118-2011 compliant IRIG-B source is detected.

In Manual mode, the TESLA relies on the user settings to interpret the IRIG-B source and calculate displayed time. The available user settings are; Year (Y1), Time (T1), Time Zone Offset Setting (O1) and DST (D1) as shown in the figure below. Refer to Table 8.8 for more details on how Manual mode is used.

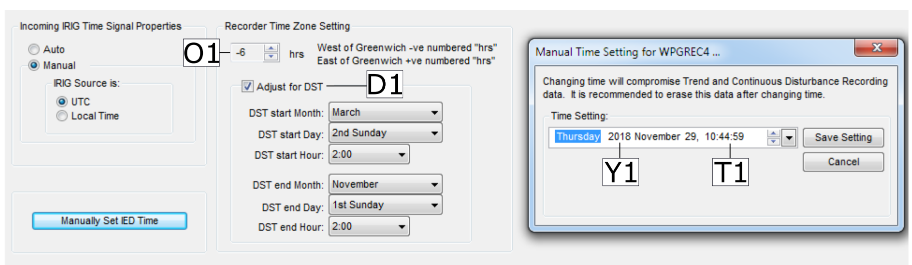


Figure 8.17: User Settings for IRIG-B Interpretation

The following table describes how the TESLA determines the displayed time depending on the Mode setting, the information available in the IRIG-B source and the user settings:

Table 8.8: IRIG-B Signal Interpretation

Mode	Time Field	IRIG-B Source	User Setting	Fields used to determine displayed time
Auto	Year	Y	Y1	Y - if available. Y1 - if Y is not available.
	Time	T	T1	T - if O and D are available. T adjusted by O1 and/or D1 - if O and/or D are not available. T1 is always ignored if an IRIG-B source is present.
	Offset	O	O1	O - if available. O1 - if O is not available.
	DST	D	D1	D - if available. D1 - if D is not available.
Manual	Year	Y	Y1	Y - if available. Y1 - if Y is not available.
	Time	T	T1	T adjusted by O1 and D1. T1 is always ignored if an IRIG-B source is present.
	Offset	O	O1	O - if source is C37.118-2011 compliant[a]. O1 - if source is not C37.118-2011 compliant.
	DST	D	D1	D - if source is IEEE1344 extension[b]. D1 - if source is not IEEE1344 extension.

a. If the IRIG-B source is C37.118-2011 compliant, the mode will automatically revert to Auto after saving the time configuration.

b. IEEE1344 extension includes the following IRIG-B formats:
- IEEE1344
- C37.118-2005
- C37.118-2011

PTP

The TESLA 4000-SV supports synchronization via the Precision Time Protocol (PTP) if redundant network configuration is selected at time of ordering (see “Ordering Options and Product Configuration ID” on page 1-5).

The Precision Time Protocol (IEEE 1588) is a network based time source which provides high accuracy over an Ethernet Network connection.

The TESLA 4000-SV uses the IEEE C37.238 Power Profile as well as IEEE/IEC 61850-9-3 Utility Profile making it suitable for its use in Power System applications.

In Sampled Value applications high time accuracy is critical, making PTP the best synchronization source for Sampled Value usage.

In Single Redundancy hardware, the *Time > PTP* screen settings and the *Communication > Network Redundancy* screen settings are both stored on the redundancy communication board. These settings are linked to the Active Mode selected in the *Communication > Network Redundancy* screen. When the settings are changed and saved, they are saved to the currently selected Active Mode. When the Active Mode is changed, the settings on the *Time > PTP* screen settings and the *Communication > Network Redundancy* screens will be updated with those last saved to the new Active Mode profile.

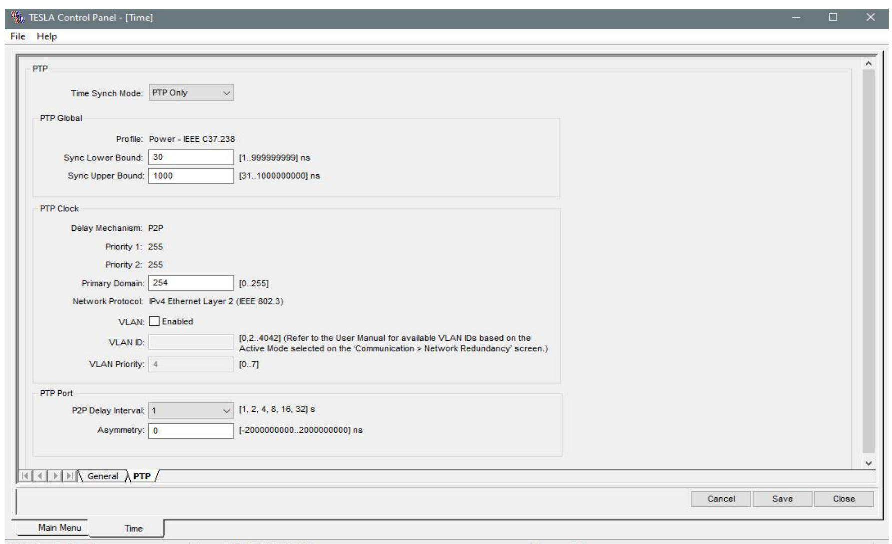


Figure 8.18: Time > PTP Configuration Screen in Single Redundancy hardware

PTP Configuration

The PTP Configuration is performed on the PTP tab of the Time screen. Ensure that the PTP Settings match that of the Master clock. The settings are described in the table below in Single Redundancy hardware:

Table 8.9: Time > PTP Settings

Setting	Range/Options	Description
Time Synch Mode	PTP Only or IRIG Only	PTP Only mode uses PTP exclusively and will ignore IRIG signal. IRIG Only mode uses IRIG exclusively and will ignore PTP signal. All settings below are greyed-off when IRIG Only mode is selected.
PTP Global		
Profile	Power - IEEE C37.238 (read-only)	
Sync Lower Bound	1 to 999999999 ns (Default = 30 ns)	The lower threshold value in nanoseconds for the path difference between the local clock and the reference time source (Grandmaster). If the path difference falls below this value once, then the local clock is classified as synchronized.
Sync Upper Bound	Sync Lower Bound to 1000000000 ns (Default = 1000 ns)	The upper bound in nanoseconds for the path difference between the local clock and the reference time source (Grandmaster). If the path difference exceeds this value once, then the local clock is classified as unsynchronized.
PTP Clock Global		
Delay Mechanism	P2P (read only)	Peer-to-peer
Priority 1	255 (read only)	
Priority 2	255 (read only)	
Primary Domain	0 to 255 (Default = 254)	The domain in which PTP traffic occurs, all other domains are ignored
Network Protocol	IPv4 Ethernet Layer 2 (IEEE 802.3) (read-only)	Transport layer used for PTP communication
VLAN	Enabled/Disabled (Default = Disabled)	If enabled, VLAN ID and Priority are enabled and configurable.

Table 8.9: Time > PTP Settings

VLAN ID	0, 2 to 4042 (Default = 0)	Refer to “VLAN Modes” on page 4-9 for available VLAN IDs based on Active Mode selection
VLAN Priority	0 to 7 (Default =4)	
PTP Clock Port		
P2P Delay Interval	1, 2, 4, 8, 16, 32 s (Default = 1s)	Specifies the interval in seconds at which the port measures the Peer-to-Peer delay
Asymmetry	-2000000000 to 2000000000 ns (Default = 0 ns)	Corrects the measured delay value corrupted by asymmetrical transmission path

In Multiple Redundancy hardware, PTP or IRIG-B can be enabled from Time Sync Mode setting in Time source configuration. When PTP time sync is desired, only one port from Port 401 A/B, Port 402 A/B and Port 410 A/B can be enabled for PTP time sync.

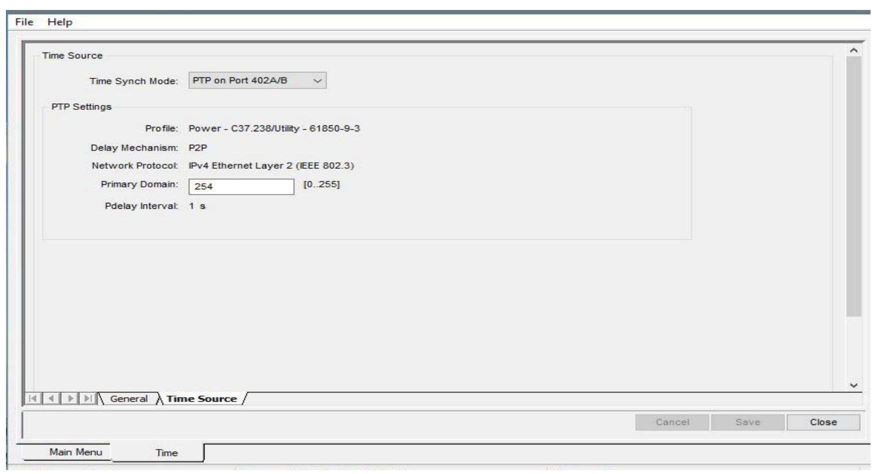


Figure 8.19: Time Source configuration in Multiple Redundancy hardware.

System Sync

The TESLA 4000-SV supports synchronization via the ERLPhase System Sync time source from the IO Expansion IED. The IO Expansion IED may act as a stand-alone clock using an IRIG type signal. This signal is acquired via the IRIG-B port on the rear of the recorder. For more information regarding the System Sync source, refer to the IO Expansion user manual.

RTC

An internal free-running oscillator, referred to here as a Real-Time Clock (RTC), is always present on the IED and, in the absence of any external time source, will become the default mode of time synchronization. The IED comes equipped with an internal free-running oscillator used to generate a 1 PPS time signal in the absence of any alternate available time source. Use of this oscillator as the primary IED time source requires manual time configuration, with the general accuracy subject to user input parameters, and is recommended primarily for stand-alone, unsynchronized applications. The internal oscillator carries a lifetime accuracy (including temperature effects and aging) of +/-25 ppm.

Order of Precedence

The TESLA 4000-SV implements the following order of precedence to determine which time source will be used at any given time:

1. PTP or IRIG-B
2. SNTP
3. RTC

General Time Settings

The following table describes the time settings on the *Time* > *General* screen:

Table 8.10: Time > General Settings

Display IED Time as	
UTC	Sets the time display to Universal Coordinated Time (UTC). Note that UTC time is not affected by the Record Time Zone setting or Daylight Savings Time.
Local	Sets the time display on the Time screen to Local Time. Local time includes time zone offset and one hour DST adjustment, if DST is applicable. Local time is converted from UTC using the Recorder Time Zone and DST setting.
Current Time Display	When connected to a recorder, the recorder's current time is shown and continually updated. The specified time settings (e.g. Local Time) are applied to the displayed time.
DST Indicator	A text field which is displayed when DST is applicable and in effect in the currently displayed time.
Synchronization Indicator	A text field which is displays the recorder's current time synchronization status. The possible synchronization status indicators are: • IRIG-B Sync • IRIG-B Unlocked • PTP Sync • System Sync • No Sync
Incoming IRIG-B Signal Properties	
This group of settings defines how the recorder interprets the incoming IRIG-B signal.	
Auto	Recommended Setting. Instructs the recorder to decode the IRIG-B signal automatically by interpreting the IRIG-B fields. See Table 8.8 for details on how Auto mode is used.
Manual	Instructs the recorder to use user settings for interpreting the IRIG-B signal. See Table 8.8 for details on how Manual mode is used.

Table 8.10: Time > General Settings	
IRIG Source is:	When Manual mode is selected, the setting instructs the recorder to interpret IRIG-B time of day as UTC or Local. Setting must match the IRIG-B source configuration.
Recorder Time Zone Setting	
Offset	Provides the offset from local time to UTC in hours. For example, Central Time has a -6 hour offset from UTC.
Adjust for DST	Instructs recorder to perform Daylight Savings Time calculations, if the IRIG-B DST flag is not used.
DST Start Time	Instructs recorder when (Month, Day, Hour) Daylight Savings Time begins.
DST End Time	Instructs recorder when (Month, Day, Hour) Daylight Savings Time ends.
Manually Set IED Time	
Allows the recorder's clock to be manually set. Year and Time of Year may be set manually. If a synchronization source (IRIG-B) is present, some or all of the manually set time settings may be overridden by the time source. For more details on how the manually set time settings work with an IRIG-B source, see Table 8.8.	
SNTP Time Source	
Enable SNTP Time Source	Activates the IED to attempt SNTP time synchronization based on the user configuration parameters (primary and secondary) for IED synchronization in the absence of an IRIG-B time source.
SNTP Poll Interval	User configurable parameter for defining SNTP server synchronization time cycle (primary and secondary).
SNTP Timeout Interval	User configurable time duration to wait for a server response following an attempted SNTP network synchronization before considering the target server lost.
SNTP Server	IP address for network based primary and secondary SNTP servers to be used as IED time sources (if enabled) in the absence of a valid IRIG-B signal.

Changing time manually and/or IRIG-B re-synchronization causes discontinuity in the trend and continuous disturbance recording data.

IED Time Display

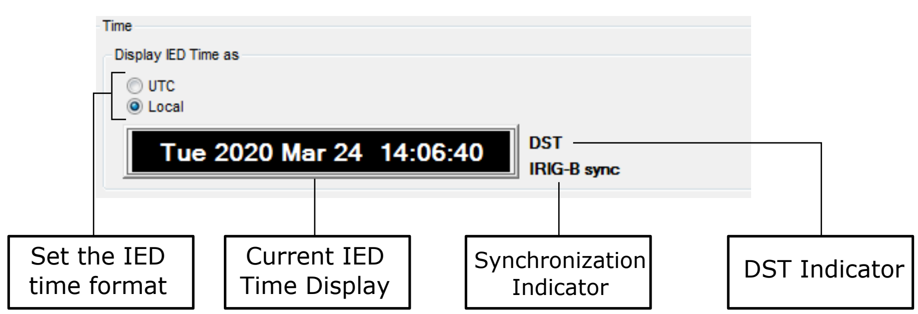


Figure 8.20: Time Screen IED Time display

The Time screen provides the current IED time display. The time and date value displayed is the result of the time source selection and time calculations, regardless of where the time value, time zone offset and DST information comes from (external source or internal clock).

The time format is determined by the UTC/Local selection. Local time includes time zone offset and one hour DST adjustment, if DST is applicable.

If DST is applicable and in effect then a “DST” indication is shown on right side of the displayed Time.

The current time source is also shown on the right side of the displayed time.

Time Display Settings

TESLA Control Panel provides configuration of the timestamp display format. The *Option > Time Display Setting* dialog box controls the time display format on the Events, Records, CDR and Trend screens. The Time Display Setting appears in the Options menu only when viewing these four screens.

The Time Display Settings and how they affect the various TESLA Control Panel screens, are shown below.

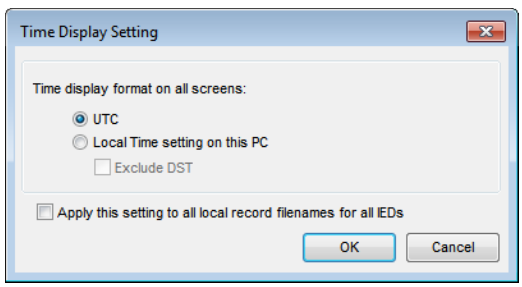


Figure 8.21: Time Display Settings

Table 8.11: Time Display Settings

Time display format on all screens:	
UTC	Displays the timestamps according to the Coordinated Universal Time (Offset = +0:00).
Local Time setting on this PC	Displays the timestamps according to the time settings on the local PC. Uses the Time Zone and DST settings of the PC to determine the timestamp displayed in the record.
Exclude DST	Displays the timestamps according to the time settings on the local PC. Uses the Time Zone, but excludes the DST setting of the PC to determine the timestamp displayed in the record.

Table 8.11: Time Display Settings	
Apply this setting to all local record filenames for all IEDs	When this setting is applied, all local record names for all IEDs in the IED list (on the Main Menu screen) will be converted to the selected format. Note: A progress bar is displayed during the renaming process with an option to cancel the process. If the process is cancelled, the records which have already been renamed will not be reverted to their original name. Note: This setting does not modify records which use the IEEE C37-232-2011 Long Filename format as these always use UTC format as defined by the standard.

A Time Display Setting change made in TESLA Control Panel will automatically be set in RecordGraph, RecordBase and RecordBase View (if these software applications are installed).

It is not recommended to repeatedly switch between time display settings as it may cause confusion when determining the sequence of events and recordings. ERLPhase recommends “setting-and-forgetting” the Time Display Setting.

Event Timestamps

The Event Log timestamps on the Events screen are displayed according to the Time Display Setting and are updated dynamically when the setting is changed. A UTC Offset field on the Event Log displays the UTC Offset recorded by the IED (not the local PC). The timestamp column title changes according to the Time Display Setting. The possible timestamp column titles are “UTC Time”, “Local Time” or “Local Time (exclude DST)”.

Audit Trail Timestamps

The Audit Trail timestamps are always displayed according to the IED local time. The Time Display Setting does not apply to the Audit Trail. Refer to the TESLA 4000-SV Security Notification Guide for further details on the Audit Trail time format.

Record Timestamps

The Records screen timestamps are affected by the *Options > Time Display Setting,* as described below:

Table 8.12: Record Screen Time Display	
Record List (LHS)	
On IED (Remote)	The Remote Record names are displayed according to the Time Display Setting and are updated dynamically when a Time Display Setting change is made.

Table 8.12: Record Screen Time Display	
Local	Local files are renamed when the Time Display Setting is toggled and the 'apply this setting to all local record filenames' is selected. A progress dialog will be displayed with a Cancel button while this is happening. If the renaming process is cancelled, all local records already renamed will remain in that state (i.e. the cancelled action will not be rolled back). Note: The local records which use the IEEE C37-232-2011 Long Filename format are not affected by the Time Display Settings and are always displayed in UTC as required by the standard.
Record Summary	
The Record Summary title will display as "Record Summary (UTC)" if the Time Display Setting is set to UTC and will display as "Record Summary" otherwise.	
Trigger Time	The Trigger Time is displayed according the Time Display Setting and is updated dynamically when a Time Display Setting change is made.
UTC Offset	Displays the IED UTC Offset determined by the IED time source and the DST and time zone settings on the Time screen. Not affected by the Time Display Setting.
Events	
Event Timestamp	The Event timestamp is displayed according the Time Display Setting and is updated dynamically when a Time Display Setting change is made.

Record Export Timestamps

COMTRADE records exported from TESLA Control Panel/Record Graph contain data displayed according to the UTC time. The Time Display Setting is not applicable to the COMTRADE export as well as view the COMTRADE records.

CSV records exported from TESLA Control Panel contain data displayed according to the current Time Display setting. An indication of the time display format in the file's header.

CDR Timestamps

The Continuous Disturbance Recording screen timestamps are affected by the *Options > Time Display Setting,* as described below:

Table 8.13: CDR Screen Time Display
The CDR Record Summary title will display as "Record Summary (UTC)" if the Time Display Setting is set to UTC and will display as "Record Summary" otherwise.
Record List (LHS)

Table 8.13: CDR Screen Time Display	
Local	Local files are renamed when the display format is toggled if the ‘apply this setting to all local record filenames’ is selected; a progress dialog will be displayed with a Cancel button while this is happening. If the renaming process is cancelled, all local records already renamed will remain in that state (i.e. the cancelled action will not be rolled back). Note: The records which use the IEEE C37-232-2011 Long Filename format are not affected by the Time Display Settings and are always displayed in UTC as required by the standard.
Data Summary	
Retention Period	The 'Retention Period' will adjust according to the Time Display Setting. The Retention Period title will display as “Retention Period (UTC)” if the Time Display Setting is set to UTC and will display as “Retention Period” otherwise.
Start Date	The 'Start Date' will adjust according to the Time Display Setting. The Start Date title will display as “Start Date (UTC)” if the Time Display Setting is set to UTC and will display as “Start Date” otherwise.

CDR data during a DST crossover period (when DST is moving from ON to OFF or OFF to ON) may not be retrieved correctly if the Time Display Setting is set to Local.

It is recommended to use Local (Exclude DST) or UTC Time Display option when retrieving CDR data for a period which includes a DST crossover.

Trend Timestamps

The Trends screen contains timestamps are affected by the *Options > Time Display Setting,* as described below:

Table 8.14: Trend Screen Time Display	
Range of Dates for Trends and Events	
From	The “From” range is adjusted according to the Time Display Setting.
To	The “To” range is adjusted according to the Time Display Setting.
Events	
Time column	Event time stamp is dynamically changed according to Time Display Setting. Column title will change from “UTC Time” to “Local Time” to “Local Time (exclude DST)”.
UTC Offset	Displays the UTC Offset recorded by the IED and is not affected by the Time Display Setting.

Settings Timestamps

The Time Display Setting does not apply to the Settings screen. The Name column timestamps are based on the local time of the PC which retrieved the settings file. The Settings Date column timestamps are based on the local time of the PC which created or modified the settings file.

System Diagnostics Log Timestamps

The System Diagnostics Log on the *Maintenance* > *System Diagnostics* screen is always displayed in UTC time. The Time Display Setting does not apply to the System Diagnostics Log.

8.10 Syslog Communication Settings

The Syslog communication settings are accessed via the Syslog Screen in the Communication menu. For more information on the Security Notification System and the Syslog protocol implementation, see “Security Notification System” on page 18-10.

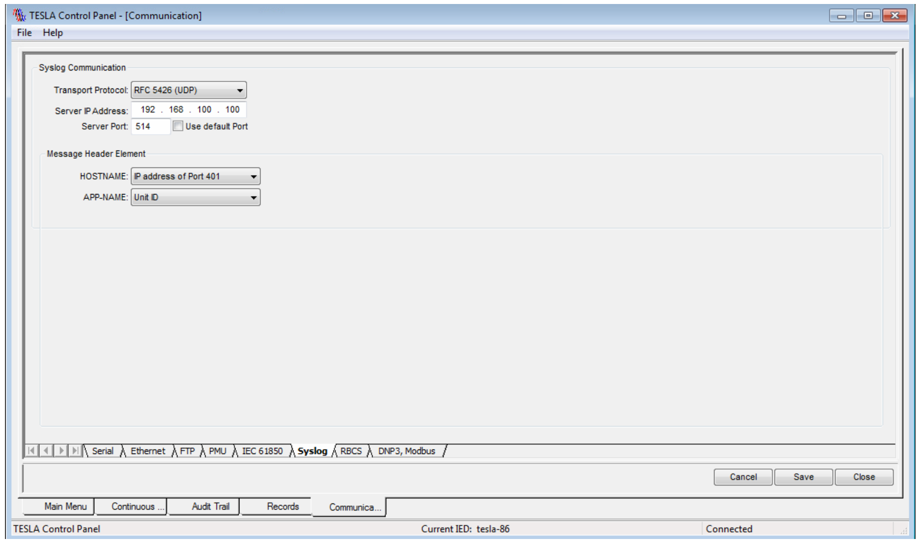


Figure 8.22: Syslog Communication Settings

Settings

The following table describes the Syslog Communication settings:

Table 8.15: Syslog Communication Settings

Transport Protocol	Set to Disabled or RFC 5426 (UDP). If set to disabled, the communication to the Syslog server is disabled. If set to RFC 5426 (UDP) the UDP protocol is used for communication with Syslog server.
Server IP Address	This parameter defines the Syslog server IP Address.
Server Port	This parameter defines Syslog server IP port for receiving Syslog messages. It can be set to default (514) or to any port number from 1 to 65535.
Message Header Element	
HOSTNAME	This setting is used for the Syslog message HOSTNAME field. May be set to “IP address of Port 401”, “IP address of Port 402”, “IP address of Port 410” or “IP address of Port 411”.
APP-NAME	This setting is used for the Syslog message device identifier APP-NAME field. May be set to one of the following values: • Not Used • Serial Number • Unit ID • Product Model

8.11 Security Setup

The TESLA 4000-SV features a comprehensive cyber-security system. This section describes how a security administrator can setup user accounts within this system. For more detailed information on the cyber-security features employed in the TESLA 4000-SV see Section 18 Cyber Security.

Security Screen

The security configuration for the TESLA 4000-SV is performed on the Security screen. To access the Security screen, the user must login with an account that has “SECADM” privileges. On the initial security setup, use the default “secadmin” account. Once logged in to the IED using the “secadmin” account, click on *Security* from the *Main Menu*. For more information on default user accounts, see “Default Security Configuration Settings” on page 8-38.

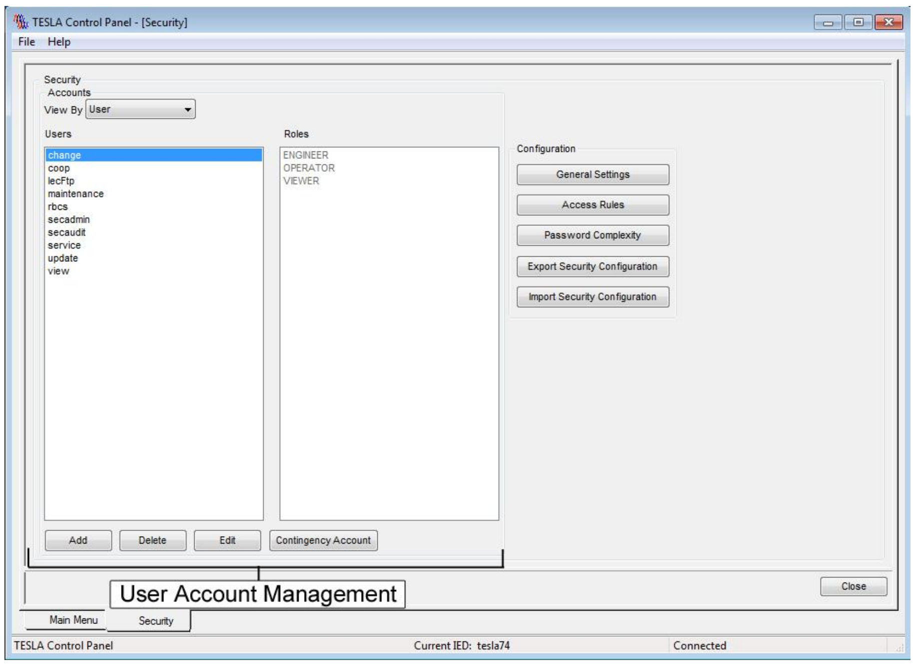


Figure 8.23: Security Screen

The left side of the Security screen provides options to configure and manage individual user accounts. The right side of the Security screen provides options for general security configuration and management.

User Account Management

The security screen provides means to add, delete and edit user accounts.

View By

There are two views available on the security screen: *View By Role* and *View By User*. Toggle between these views using the *View By* drop-down box.

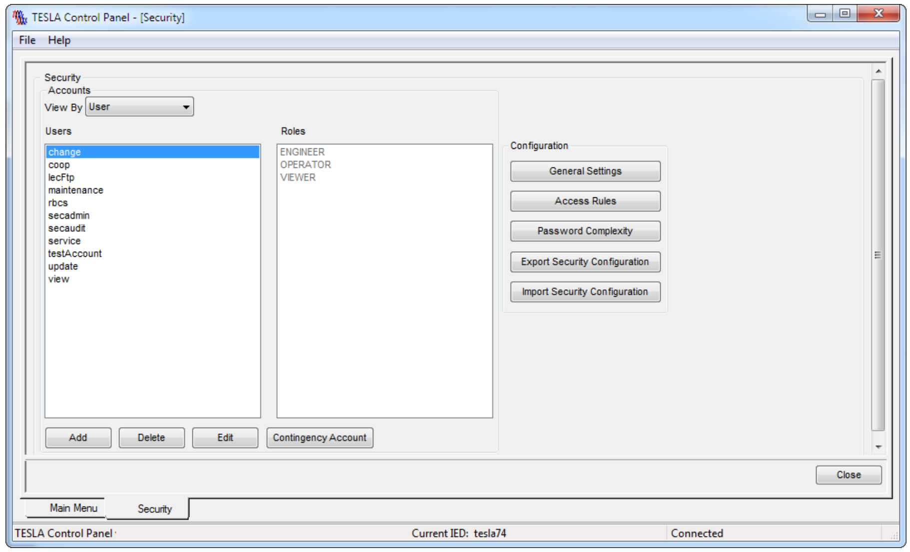


Figure 8.24: View By User

View By User displays all user accounts in the left window. Selecting a user displays the assigned roles for that user in the right window.

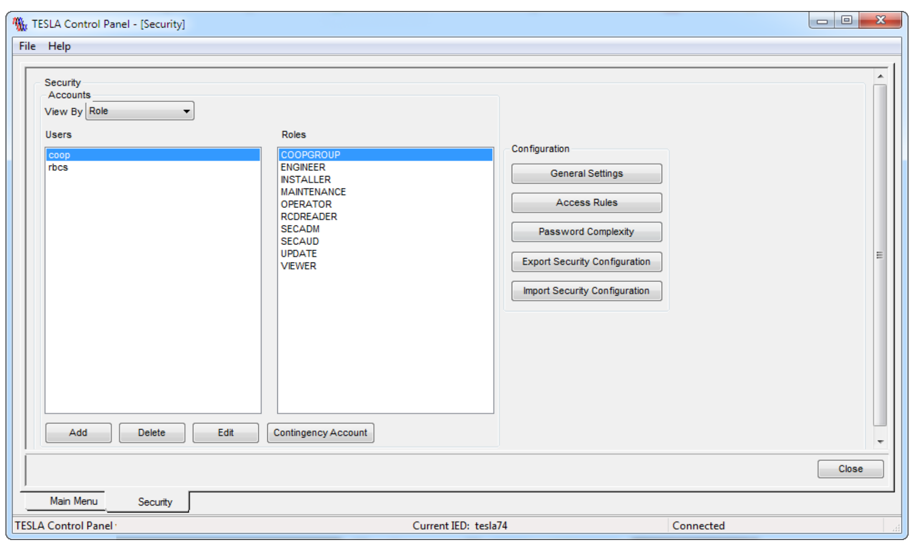


Figure 8.25: View by Role

View By Role displays all roles in the right window. Selecting a role displays the user accounts which are assigned that role in the left window.

Adding a New User

Clicking on *Add* launches a pop-up window for creating a new user account. This window provides means to define account activation rules and role assignments.

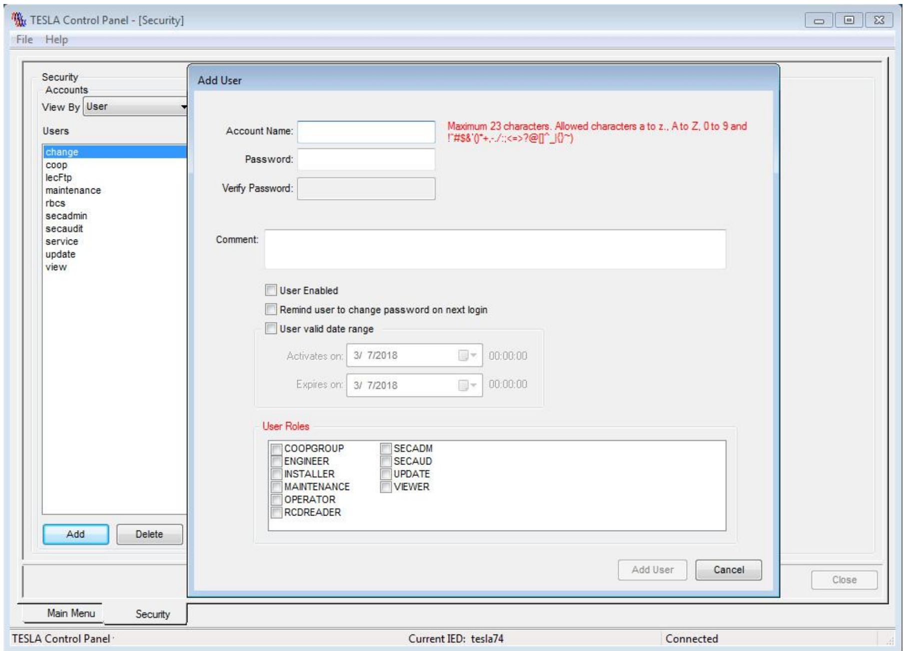


Figure 8.26: Add User

For more information on the individual user account settings, see “User Accounts” on page 18-5.

ERLPhase recommends that during the initial setup Security Administrator change the default passwords for all accounts.

Deleting a User

To delete a user account, select a user account from the left side window and then press the *Delete* button.

Editing a User

To edit an existing user account, select the user from the left side window and press the *Edit* button. Upon pressing the *Edit* button, an *Edit User* window opens (similar to the *Add User* window) and all account settings can be modified.

Contingency Account

A Contingency Account for restoring security configuration to factory default is provided. The Contingency Account uses a “Challenge-Response” method for restoring Security Configuration to Factory Defaults. To view the Challenge, or to generate a new Challenge, click on the *Contingency Account* button. For more information on the Contingency Account and how to restore to factory default, see “Security Configuration Restoration to Factory Defaults” on page 8-40.

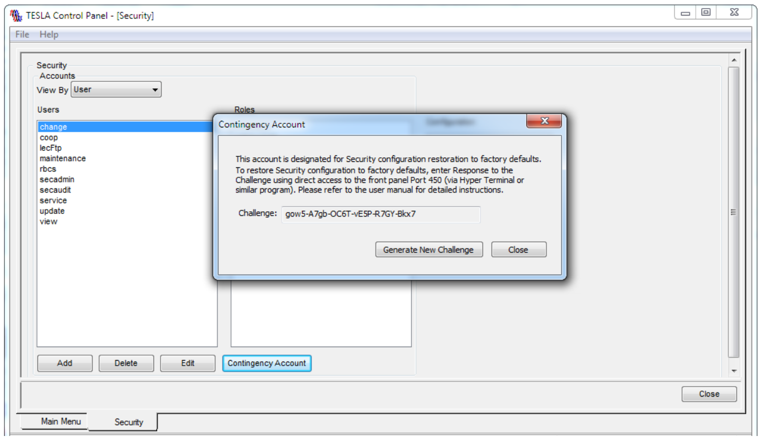


Figure 8.27: Contingency Account

General Settings

The *General Settings* window provides means to enable or disable Remote Firmware Update.

If Remote Firmware Update is enabled, users assigned the “Update” role have the ability to perform a firmware update over Ethernet LAN. If Remote Firmware Update is disabled, users assigned the “Update” role will only have the ability to perform a firmware update with front panel USB (Port 450) connection.

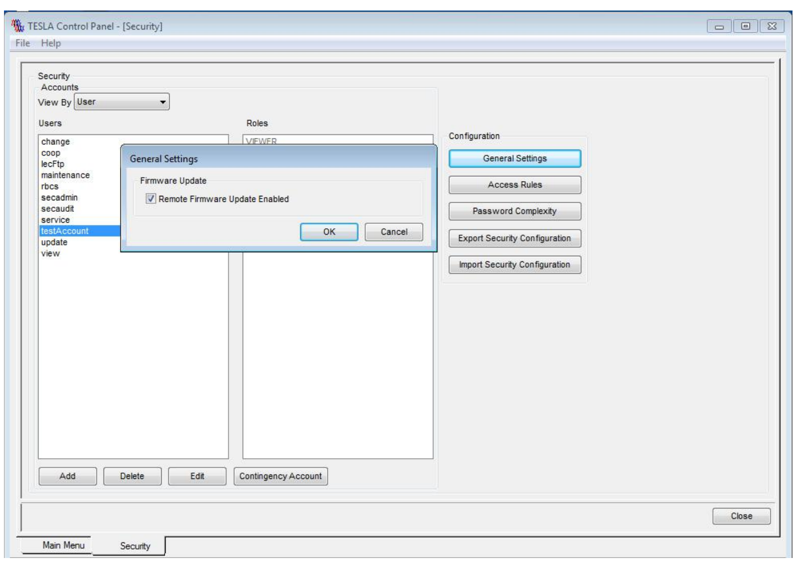


Figure 8.28: General Settings

Access Policies

The *Access Policies* window provides configuration of user login and session duration rules. For more information, see “Access Rules” on page 18-3.

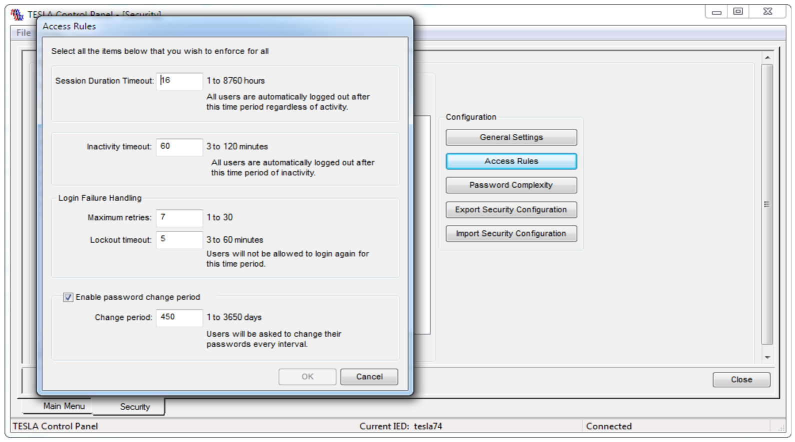


Figure 8.29: Access Policies

Password Complexity

The *Password Complexity Rules* window provides configuration of user account password complexity rules. For more information on the Password Complexity rules, see “Password Complexity Rules” on page 18-3.

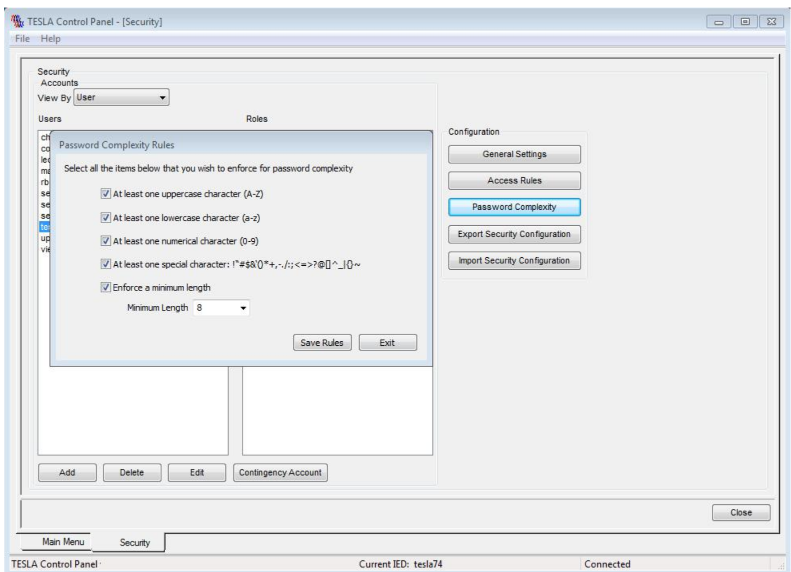


Figure 8.30: Password Complexity rules

Export and Import Security Configuration

The Export Security Configuration option allows the security administrator to save an entire security configuration to a file location. The Import Security Configuration option allows this security configuration to be imported back to the IED to restore a previously saved configuration. The exported security configuration is encrypted to ensure that critical security information is not accessible. All security configurations outlined in the previous sections are included in the exported security configuration file.

To export the security configuration, select the *Export Security Configuration* button, select a file location for saving, and select *Save*. To import a security configuration, select the *Import Security Configuration* button, select a previously saved configuration, and select *Open*.

The Imported Security Configuration takes effect immediately and does not require IED reboot.

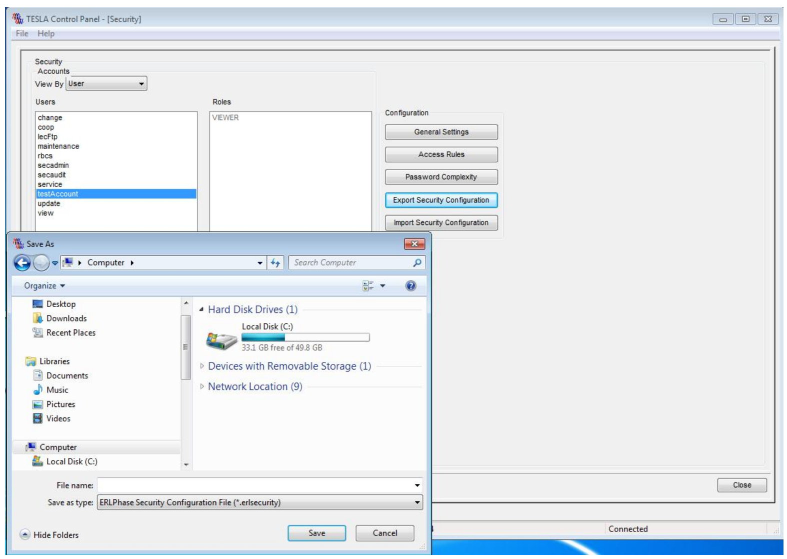


Figure 8.31: Export Security Configuration

Default Security Configuration Settings

The TESLA 4000-SV is shipped from the factory configured with Default Security Configuration settings. The Default Security Configuration settings are shown in Section Table 8.16: Default Security Configuration settings and Section Table 8.17: Default User Accounts.

Table 8.16: Default Security Configuration settings

Group	Name	Value	Notes
General Settings	Remote Firmware Update Enabled	OFF	
Access Rules	Session Duration Timeout	16	Hours
	Session Inactivity Timeout	60	Minutes
	Failed login handling:		
	Maximum Retries	7	
	Lockout Timeout	5	Minutes
	Password Change Period:		
	Enable	OFF	
	Change Period	450	Days
Password Complexity Rules	At least one upper case character	OFF	
	At least one lower case character	OFF	
	At least one numerical character	OFF	
	At least one special character	OFF	
	Enforce a minimum length	OFF	
	Minimum length	OFF	
User Accounts	Refer to Section Table 8.17: Default User Accounts		“User Enabled” is set to ON; “Change password on the next login” is set to OFF; “User valid date range” is set to OFF.

Table 8.17: Default User Accounts

User Name	Password	Assigned Roles
view	view	VIEWER, OPERATOR
change	change	VIEWER, OPERATOR, ENGINEER
service	service	VIEWER, OPERATOR, ENGINEER, UPDATE, MAINTENANCE
update	Update@2015	UPDATE
maintenance	Maintenance@2015	MAINTENANCE
coop	Coop@2015	COOPGROUP
rbcs	Rbcs@2015	RBCS
rcdreader	Rcdreader@2015	RCDREADER
secadmin	Secadmin@2015	SECADM
secaudit	Secaudit@2015	SECAUD
IecFtp	ERLPhase2010	INSTALLER

Security Configuration Restoration to Factory Defaults

The Security Configuration restoration to Factory Defaults is available only to Terminal User Interface (UI) service. The Terminal UI is accessed using any Terminal emulation software, such as Microsoft HyperTerminal, and is only available on the front USB serial port 450. The Terminal UI Service implements a Challenge-Response protocol described in “Contingency Account” on page 18-6.

The Terminal UI service performs the following functions:

1. Read Challenge
2. Update Challenge
3. Restore Security Configuration to Factory Defaults

Starting the Terminal User Interface service

Prepare a USB link as described in “USB Link” on page 6-2.

Start a terminal emulation software such as HyperTerminal. Configure the terminal emulation program for a serial connection (115200; 8-bit data, no parity, 1 stop bit, hardware flow control) using “ERLPhase 4000 Series Device”. Ensure that the terminal emulation program is logically disconnected.

Press the ‘#’ symbol to start the Terminal UI service. If another key is accidentally pressed before the ‘#’, the utility will not launch. User must disconnect, reconnect, and then try again. The service shows a greeting and offers menu option selection as shown in Section Figure 8.32: Security Terminal User Interface service.

```
         Welcome to ERLPhase Security UI
This UI restores IED's security configuration to factory defaults.
Restoration process is protected by the Challenge-Response method.
Please contact ERLPhase customer support to generate Response
for the Challenge shown below.

     email: support@erlphase.com
     pnone: 204-477-0591

Current Challenge is: 'n88m-G31g-mcoN-1wZ5-fQGR-ekGc'

Please select one of the following options:

1. Enter Response to restore security configuration.
2. Enter '+' to update Challenge.
3. Press 'Enter' to exit.

#
```

Figure 8.32: Security Terminal User Interface service

Single quotes at the beginning and end of the Challenge are text delimiters and are not part of the Challenge.

The Terminal UI executes the selected option and then exits. The Access Policies are applied to the Terminal UI sessions. The IED closes the Terminal UI session when the “Session Duration Timeout” or “Session Inactivity Timeout” expire.

Restoring Security Configuration to Factory Default

To restore the Security Configuration to Factory Default, enter the Response at the prompt and press *Enter.* The IED executes the operation as shown in Section Figure 8.33: Security Configuration restoration to Factory Default example**.**

```
        Welcome to ERLPhase Security UI
This UI restores IED's security configuration to factory defaults.
Restoration process is protected by the Challenge-Response method.
Please contact ERLPhase customer support to generate Response
for the Challenge shown below.

     email: support@erlphase.com
     phone: 204-477-0591

Current Challenge is: 'n88m-G31g-mcoN-1wZ5-fQGR-ekGc'

Please select one of the following options:

1. Enter Response to restore security configuration.
2. Enter '+' to update Challenge.
3. Press 'Enter' to exit.

#3EPf-RjbO-+okB-9hpU-Kmpo-ROnY

Processing Response. Please wait...

Operation successful.
Exiting
```

Figure 8.33: Security Configuration restoration to Factory Default example

User entered Response is shown in red text.

Updating the Challenge

To update the Challenge, enter '+' character and press enter. The IED executes operation and prints a new Challenge as shown in .

```
        Welcome to ERLPhase Security UI
This UI restores IED's security configuration to factory defaults.
Restoration process is protected by the Challenge-Response method.
Please contact ERLPhase customer support to generate Response
for the Challenge shown below.

     email: support@erlphase.com
     phone: 204-477-0591

Current Challenge is: 'T48d-elj/-JH/V-M2ns-Zbu3-aDt6'

Please select one of the following options:

1. Enter Response to restore security configuration.
2. Enter '+' to update Challenge.
3. Press 'Enter' to exit.

#+
New Challenge is: 'p6QI-3cVQ-a01X-hwm0-taSM-L22r'

Exiting
```

Figure 8.34: Challenge update example

9 Recorder Settings

This chapter describes the Settings File which defines the individual channels and record triggers.

The Settings file identifies and adjusts the recorder's input channels, derived (calculated) channels, record triggers, recording configuration, metering displays and trend logs. The settings file is created and managed by TESLA Control Panel and loaded into the recorder's non-volatile memory through the communications link.

9.1 Managing Settings File

TESLA Control Panel's *Settings* screen creates and manages Settings files and handles transfer to and from the recorder.The *Settings* screen can be opened directly from the *Main Menu*.

The settings shown on the *Settings* screen are specific to the selected Current IED. To work with settings from another recorder, you must first select that unit as the Current IED (from the Main Menu).

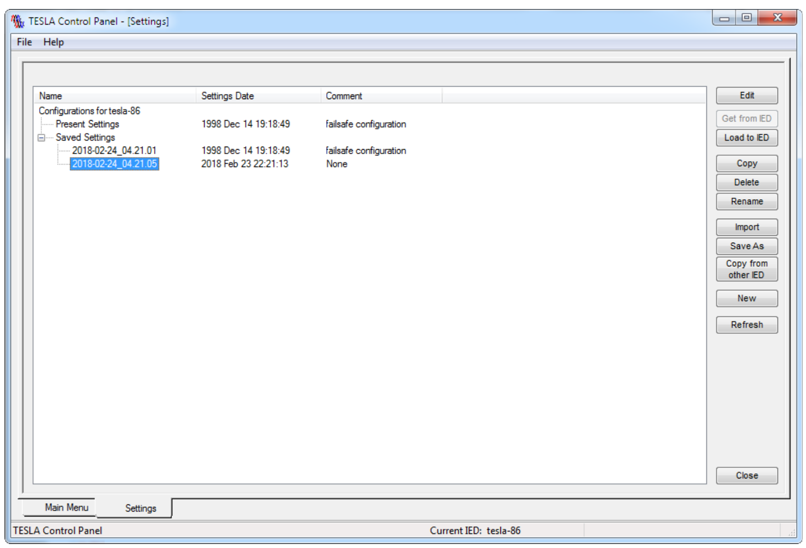


Figure 9.1: Settings Manager

If a communication link to the Current IED is available, you can work directly with the recorder's Settings by either double-clicking on the *Present Settings* item in the list or by selecting *Present Settings* and clicking the *Edit* button.

Editing a Recorder's Present Settings

Figure 9.2: Recorder Settings access

When you close the Settings Editor, you are given an option of loading the configuration back into the recorder. This gives you a quick way to make changes on the fly.

You can also save recorder Settings into a file in TESLA Control Panel using the *Get from IED* button. The Settings appear on the Saved Settings list, when transfer is completed.

Saved Settings Files

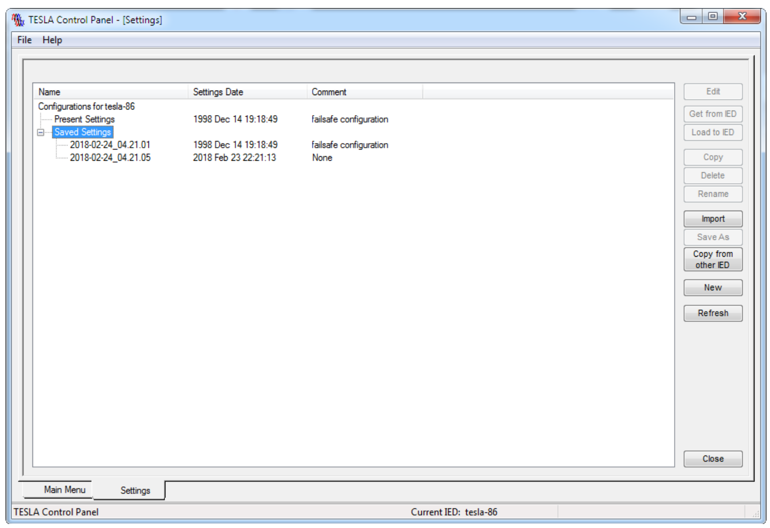


Figure 9.3: Saved Configurations

Saved settings are shown under the Saved Settings heading in the list. TESLA Control Panel can store many Settings files, limited only by hard disk and Windows operating system constraints.

Settings files can be created, displayed and modified, copied, renamed, deleted or loaded into the recorder. Select the desired Settings file from the list, then select the appropriate action button on the right of the screen. Double-clicking is equivalent to clicking the *Edit* button.

> It is recommended that you maintain a copy of each recorder's current Settings as a Saved Setting for a backup. It can be loaded into a replacement recorder if the unit ever needs to be serviced.

> **Note:** A Settings file must be compatible with the recorder's Firmware in order to be loaded. Compatibility is defined by the *Settings Version,* a number which identifies the version of settings file a given version of firmware requires.
>
> TESLA Control Panel will either prevent incompatible settings files from being loaded or will offer to make the setting compatible before it loads it.

Loading a Saved Setting

To load a Settings file to the IED, you must be logged into the recorder. Initiate the load by selecting the desired Settings file and clicking the *Load to IED* button. The recorder will immediately load and run the new Settings. Complex Settings can take a few minutes to transfer and load, depending in part on communications rate.

> **Note:** The recorder will automatically go through a reset when loaded with a Settings that changes its sample rate. This will add approximately two minutes to the load time.

Creating a New Setting

Use the *New* button to create a new Settings file. New Settings files are compatible with the latest Setting Version by default. The Settings Version can be changed when creating Settings files for older recorders.

The fixed information in the Device Configuration screen is derived from the IED Definition ("Adding/Editing a Recorder Workspace Definition" on page 6-9).

Using Another Recorder's Settings as a Starting Point

You can use the *Copy from Other IED* button to create a Settings for the current recorder based on an existing one from another recorder. The Settings can be selected from the Saved Settings list of the other IEDs.

9.2 Settings Editor

The Settings Editor provides the means to create, display and modify Settings for the recorder. To start the editor from the Settings Manager screen, either double-click on a Settings name or select a Settings name and click on the *Edit* button.

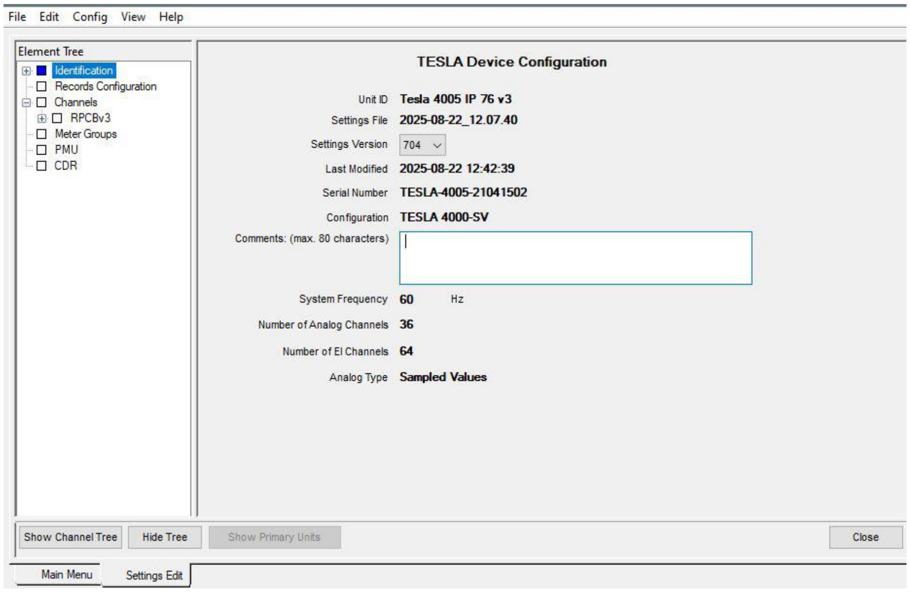


Figure 9.4: TESLA Settings Editor

Navigation Tree

The left-side pane of the Settings Editor window provides a navigation tree to access the various sections of the Settings. Selecting an item in the tree changes the large right pane view to the appropriate section. Double-clicking on a tree branch in the left pane that has a small "+" to its left or selecting on the "+" expands or collapses the tree.

Right-Click Menu

A right-click in the editor provides you with options appropriate to your present context. For example, you can create a new element by selecting the appropriate channel group, right-clicking and selecting *Add Element*. Alternatively, the same function is in the *Config* menu.

Closing

The Close button is available to you when you are finished viewing or making changes to the Settings. If you made changes, the text on the Close button changes to Save/Close as a reminder that TESLA Control Panel gives you an opportunity to save your changes to a file (or send them to the IED) before closing the Settings Editor. To close without saving changes, use the *Save/ Close* button and then select *Exit Without Saving* and *Discard* on the subsequent screens.

9.3 Identification

Device Configuration

The Device Configuration screen is displayed when you select the Identification item in the Navigation Tree (“TESLA Settings Editor” on page 9-4). It provides information about the selected IED and the particular configuration file being edited. Most of the information is drawn from the IED Definition and identifies the target recorder (“Adding/Editing a Recorder Workspace Definition” on page 6-9).

The Device Configuration screen has three configuration values that are detailed below.

Settings Version

Recorders with older firmware may require older versions of settings files. Compatibility between a settings file and firmware versions is defined by the *Settings Version.*

The Settings Version required by a TESLA recorder is shown on the Unit Identification screen of the Utilities menu (“Unit Identification” on page 8-2). You must be connected to the recorder to view this information. Settings Version requirements are also listed in the compatibility table in the Firmware Release. The TESLA 4000-SV Settings Versions begin at 701.

The version of a Settings file is controlled through the *Settings Version* field in the main identification screen (see: “TESLA Settings Editor” on page 9-4). Changing the Settings automatically converts the Settings file to the selected Settings Version. If the conversion results in the loss of Settings from the file (i.e. the target version does not support functions which were enabled in the original), a list of the affected Settings is displayed and you have the choice of canceling the conversion or continuing. If the conversion results in the addition of new functionality, the settings for the new functions will be in a default or disabled state. If you choose to close the Settings file without saving, the conversion is also abandoned.

A new Settings file is set to the latest Setting Version by default. To create a new Settings file for a recorder with older firmware, change the Setting Version appropriately after creating the new Settings.

> TESLA Control Panel should be updated as needed whenever you update the firmware on your recorders. This will ensure it can generate Settings files with the latest Settings Version.
>
> Since TESLA Control Panel can work with old versions of Settings files and can communicate with recorders with older firmware, the newest version of TESLA Control Panel can always be safely installed.

Comments

In the Comments section you can enter a description of the Settings for reference purposes. This description is also displayed in the *Settings* screen to identify saved Settings.

Chatter Limits

The *Limits* screen, accessed by expanding the *Identification* branch in the Navigation tree, lets you define how the recorder behaves when dealing with numerous, repetitive triggers.

The chatter limit settings can be enabled or disabled for both External Inputs and Analog Inputs by selecting the Detection Enabled checkbox. User can configure the following chatter detection criteria:

Table 9.18: Chatter Limits

Detection Threshold	Number of chatters detected within the Detection window. The Detection Threshold is monitored individually per External Input (EI) and per Analog trigger condition. If the number of triggers within the Detection Window exceeds the threshold for a given EI or Analog trigger, then block further triggers on that EI or trigger until number of triggers are less than the Threshold setting within the Recovery Time. No records or events are created for a given EI or Analog trigger when blocking is active. All other EIs and triggers remain active and operate normally. Range = 2 to 31, default = 4
Detection Window	Duration where it counts for the number of chatters detected within its setting range. Range = 1 to 10 seconds, steps of 1/8 cycle, default =1s
Recovery Time	Duration to reset the chatter alarm for the given input when number of chatters is less than the Threshold setting. Range = 1x to 31x of Detection Window, default =1x
Alarm Pickup Delay	Delays to issue the chatter alarm to avoid unwanted chatter alarm. Range = 0 to 31x of Recovery Time, steps of 1x, default = 0s

Figure 9.5: Chatter limits configuration

The following example in Figure 9.6 demonstrates the chatter detection logic details. For example, if the threshold setting is equal to 3, the chatter SOE and its associated recording will be validated within the detection window, if the number of chatters exceeded the threshold setting, the next chatter after the threshold will be marked with invalid data quality and the rest of the chatters will be ignored in SOE as well as in recording. When the number of chatter is still more than the threshold setting within the recovery window, the chatter alarm will be activated at the end of the recovery window if the alarm pick is set to equal to the recovery window. The recovery window will continue to extend to monitor the chatter condition, if the number of chatter is less than the threshold setting within the last recovery window, at the end of the recovery window, the chatter alarm condition will be deactivated.

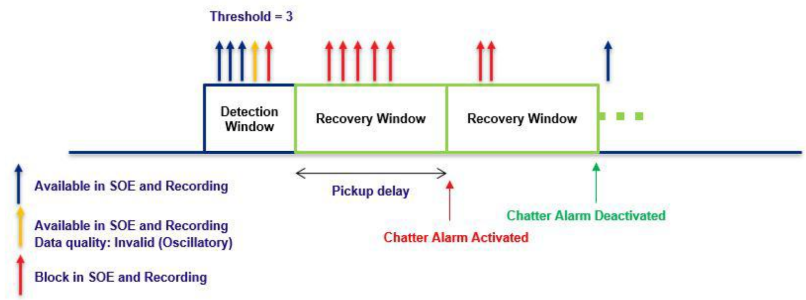


Figure 9.6: Chatter detection operation logic example

TESLA Alarms

The TESLA Alarms screen, accessed by expanding the Identification branch in the Settings Editor Navigation tree, lets you select the output contact to be closed when the following alarm conditions are meet: High speed and low speed records storage alarm: It activates when selected alarm conditions is detected. See Table 9.4 for storage alarm trigger setting conditions details. Trend records storage alarm: It activates when trend limit setting is exceeded. See Table 8.6 for trend storage alarm limit settings details. Time sync loss alarm: It activates when external time source is not detected. IEC 61850 GOOSE communication alarm: It activates when any one of the subscribed GOOSE is not detected. Chatter alarm: It activates when chatter alarm condition is meet. See “Chatter Limits” for details.

9.4 Recording Configuration

The Recording Configuration controls the durations of the High Speed Recording and Low Speed Recording.

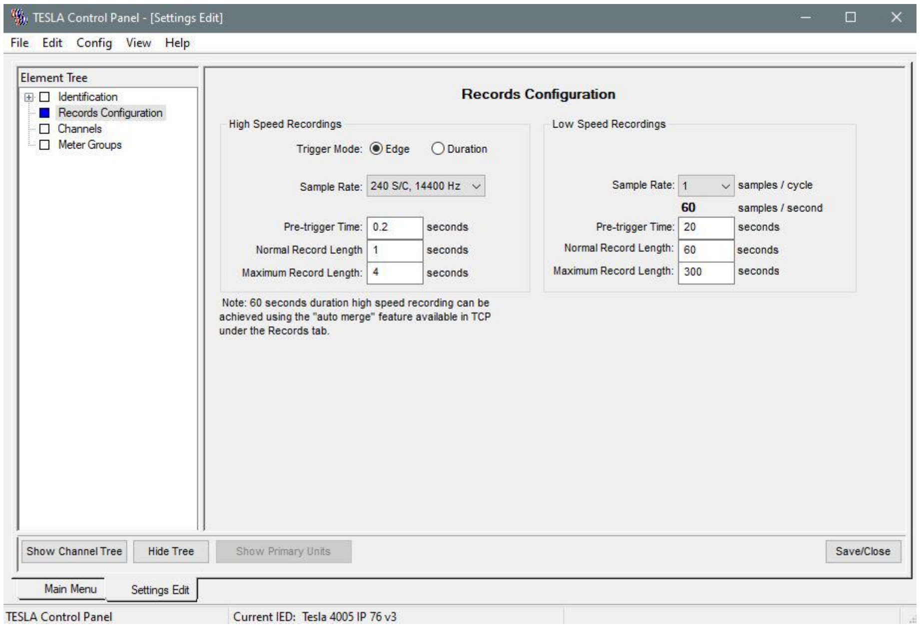


Figure 9.7: Records Configuration Screen

For High Speed and Low Speed Recording the TESLA recorder can create up to three records simultaneously. The TESLA employs sophisticated trigger combination algorithms used to combine data from multiple events into a single record and also to reduce the amount of redundant data in the records. In addition, the TESLA will combine data captured using multiple time-frames into a single record.

There are two modes of capturing data; Edge Recording and Duration Recording. Both modes are available for High Speed Recording, only Edge Recording is available for Low Speed Recording.

Edge Mode

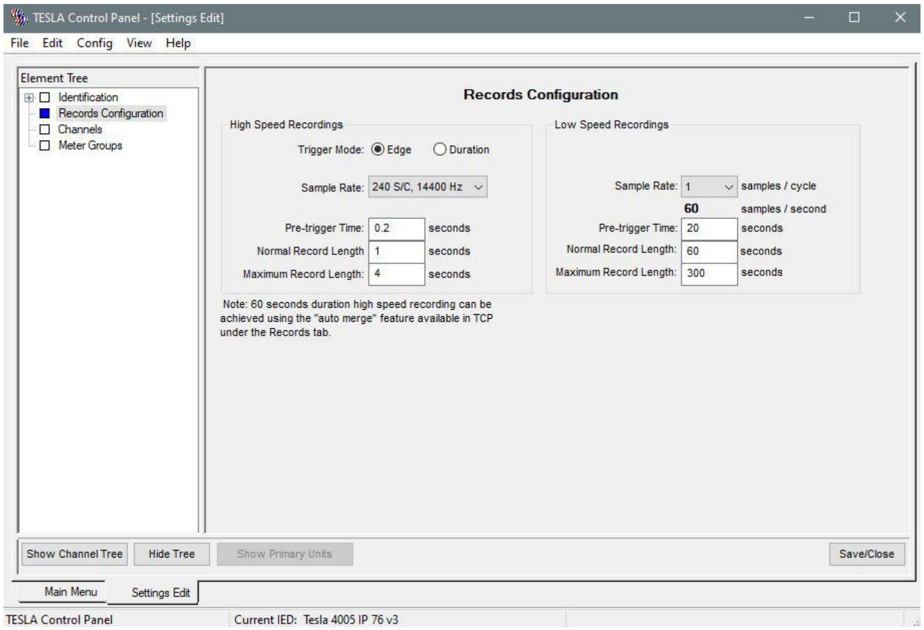


Figure 9.8: Records Configuration - Edge Recording

In Edge Recording, the rising edge of the trigger is used to create a record that has a set amount of pre-trigger data and a set amount of post-trigger. This is known as a normal length record. If another trigger is processed while the record is being created, the record may be extended to the full normal length of data associated with the new trigger. Multiple extensions can occur up to the Maximum Record Length limit. Records with combined High Speed and Low Speed data can only be extended during the High Speed data capture portion of the record.

Edge Recording mode tends to create smaller records that contain useful fault data around the start of the trigger, but may not capture data for the entire duration of the trigger.

To enable record auto-extension for multiple triggers, the Maximum record Length must be larger than the Normal Record Length.

A small amount of pre-trigger time is recommended to ensure the triggering event is included in the records.

Duration Mode

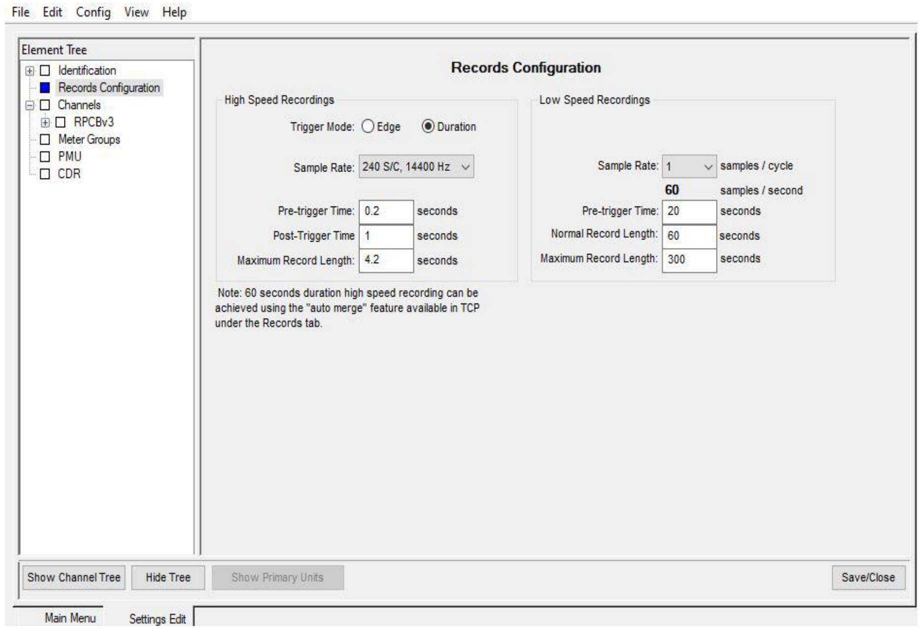


Figure 9.9: Records Configuration - Duration Recording

In Duration Recording, the duration of the trigger determines the record length. The record stores the configured amount of pre-trigger data, continues to record while the trigger is active and then records a configured amount of post-trigger data. If a trigger remains active, the TESLA stops recording once the Maximum Record Length limit is reached. If a subsequent trigger occurs while a record is being created, it will be combined with the first trigger using a logical OR operation as long as it is not near to the maximum record length limit. If the trigger is processed near the end of the record, a new overlapping record will be created instead of combining the triggers. Records with combined High Speed and Low Speed data can only be combined during the High Speed data capture portion of the record.

Duration Recording mode captures all the data during the fault trigger, but tends to create larger records that may contain unimportant data.

Sample Rate

The *High Speed Recordings Sample Rate* setting controls the rate at which the TESLA 4000-SV reads its analog and digital input channels. The setting determines the number of samples per second stored in high speed fault records and used to display calculated high speed channels. The high speed recordings sample rate does not affect the data rate of derived (calculated) data that generate data for low speed swing recordings, low speed calculated channels, the metering display update rate or the trending rate.

The *High Speed Recordings Sample Rate* also determines the frequency response of the front-end anti-aliasing filters and therefore the bandwith of the analog channels. See the following tables:

Table 9.1: High Speed Recordings Sample Rate (60 Hz System Frequency)

High Speed Recordings Sample Rate (per cycle)	Samples / Second	Analog Channels	Highest Harmonic*	Approx. Record Size** (kbytes)
256	15,360	36	66	410
240	14,400	36	62	360
80	4,800	36	20	210

Table 9.2: High Speed Recordings Sample Rate (50 Hz System Frequency)

High Speed Recordings Sample Rate (per cycle)	Samples / Second	Analog Channels	Highest Harmonic*	Approx. Record Size** (kbytes)
288	14,400	36	75	380
256	12,800	36	66	350
96	4,800	36	25	230
80	4,000	36	20	180

*Limited by the anti-aliasing filters

**For a 1 second fault record assuming typical compression. Record size varies depending of number of channels configured. The Settings file is also included in the record and will therefore affect the size of the record.

The *Low Speed Recordings Sample Rate* is configurable with 1 or 2 samples/cycle.

Settings

The following table describes the recording control settings.

Table 9.3: Recording Control Settings

High Speed Recording	
Trigger Mode	Select Edge or Duration mode. See above for descriptions.
Sample Rate	Read-only display of the configured high speed sample rate. The sample rate is set in the configuration file downloaded to the recorder. (See “Sample Rate” on page 9-11).
Pre-trigger Time (Edge Mode)	The length of data that is recorded prior to the trigger time. At least 0.1 seconds of pre-trigger time is recommended to ensure the triggering event is included in the records.
Normal Record Length (Edge Mode)	Normal Record Length is the total length of the record, including pre-trigger data, without any record extension.
Post-Trigger Time (Duration Mode)	Post Trigger Time is the length of data that is captured after the falling edge of trigger event.
Maximum Record Length	Edge Mode: The maximum length of the record including pre-trigger, post-trigger and extensions. To enable record auto-extension for multiple triggers, the Maximum record Length must be larger than the Normal Record. Duration Mode: The maximum length of the record including pre-trigger, trigger and post-trigger. Longer records than the “Maximum Record Length” are possible using the Auto-Merge feature. See “Auto Merge Fault Records” on page 11-2.
Low Speed Recording	
Sample Rate	Samples at 1 or 2 samples/cycle producing record lengths of a few minutes to capture slower system dynamic swings. The sample rate for low speed recording is based on the recorder’s system frequency which is a factory setting.
Pre-trigger Time	The length of data prior to the trigger time included in the recording.
Normal Record Length	The total duration of each recording under single trigger conditions. Includes the pre-trigger time.
Max. Extended Record Length	The maximum length of the record including pre-trigger, post-trigger and extensions. To enable record auto-extension for multiple triggers, the Maximum Record Length must be larger than the Normal Record.
Storage (Requires connection to the IED Main Menu-> Records->Configuration)	
High/Low Speed Accumulation Mode	Select Recycle Mode to overwrite the oldest record with the latest record or Select Stop Mode to stop the recording when High/Low speed record storage is full.
High/Low Speed Storage Alarm Limits	When enabled, enter a limit giving the percentage of recording space that causes an alarm. Enter a number between 60 and 99. The storage alarm condition is indicated by flashing the front panel “Record Storage” LED and activating a selected alarm contact. Note: the alarm contact assigned to this is displayed as a read-only value. It’s set as part of the recorder’s configuration (see “TESLA Alarms” on page 9-7).

9.5 Channels and Triggers

The Channels and Triggers branch of the Navigation tree is where you define the recorder's input channels, calculated channels and triggers. It is significant tool with a variety of views and displays to help manage complex recorder's settings.

Channel Grouping and Naming

With the large number of input and calculated channels available, it is worthwhile to apply consistent channel organization and naming conventions in the settings. This section describes how the record handles channel names.

An effective way to organize the many channels available on the recorder is to group them by the power system element they are monitoring. With the Settings Editor, you can identify each monitored element and use its name to group and identify the analog, digital and calculated channels associated with it.

For example, if you have a transmission line named #1, you can define an element and name it "Line #1." The channels associated with that element might then be:

Line #1:Va	Line #1:Ia
Line #1:Vb	Line #1:Ib
Line #1:Vc	Line #1:Ic

External (digital) inputs can also be reasonably associated with the Line #1:

Line #1:EI:BRKR1_a
Line #1EI:21N_Trip

Calculated channels fit the model as well:

Line #1:W/V (watts and vars)
Line #1:Iseq (current channel sequence components)

Channel Types and Naming

Channel names consist of three parts: the Element Name, the Channel Type and an optional Descripton field. These fields are combined to produce the full channel name in the format:

Element:Type:Description
e.g. Line #1.EI.BRKR1_a

This is the name that will appear beside a channel when it is displayed in a graph or a log. For example the recorder's Event Log might contain this entry for a change in state of a external input:

Line	UTC Time	UTC Offset	Station Name	Unit ID	Event
1	2019-10-10 19:34:40.00	-05:00	Lab	TESLA 4000-SV Demo	Line #1.EI BRKR1_a open

Details on the channel name components are given in the following table

Table 9.4: Channel Name

Element Name (10 chars)	Free-form text describing the power system element associated with this channel (e.g. Line #1). Channels that are logically related can be grouped through the use of the same element name.	
Channel Type	Standardized channel type descriptors are automatically generated when you select the channel type.	
	Examples	
	Va	Phase A voltage
	Ic	Phase C current
	In	Neutral current
	Vac	Generic AC voltage
	EI	External inputs
	Vseq	Sequence component set (pos, neg, zero)
	VaSum	Summation of Phase A voltages
	W/V	Watts/vars set
	PF	Power factor
	Z1	Impedance
	Logic	Logic function
	FLoc	Fault locator
	Freq	Frequency
Description (optional) (12 chars)	Often the combination of the Element Name and the Channel Type is sufficient to fully identify a channel (e.g. Line #1:Va). In other cases, the Description is required to clarify the channel name. (e.g. You might name an external input channel as “Line #1:EI:BRKR1_a).	

Element and Channel Tree Views

The Config Editor can display recorder channels in two distinct views - Element View and Channel View. The title at the top of the tree pane indicates the present viewing mode. The button at the bottom of the tree pane lets you switch to the other viewing mode.

Element Tree

The Element Tree View organizes channels by the element names you create. In the following figure, Element “Line #1” has been expanded to show some of the channels associated with it, such as Va.

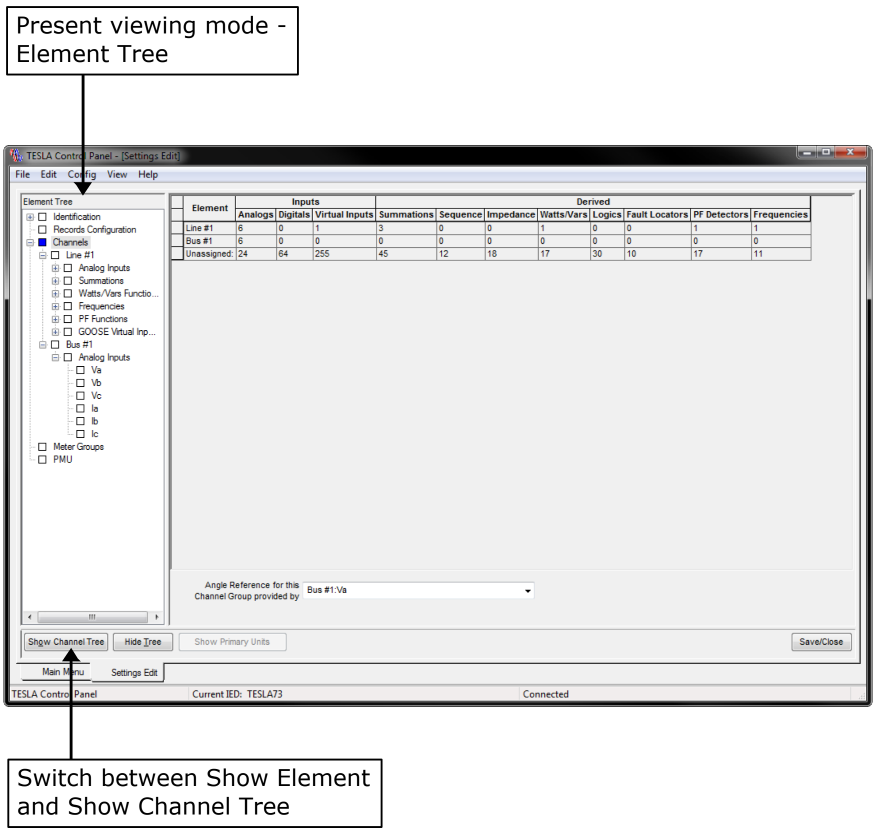


Figure 9.10: Element Tree View

Channel View

The Channel Tree View displays the same configuration organized by channel type. You can use this view to gain an overview of channel usage. Although you can chose to work in either view, the Element View is recommended for most operations as it provides an automatic way of grouping related channels.

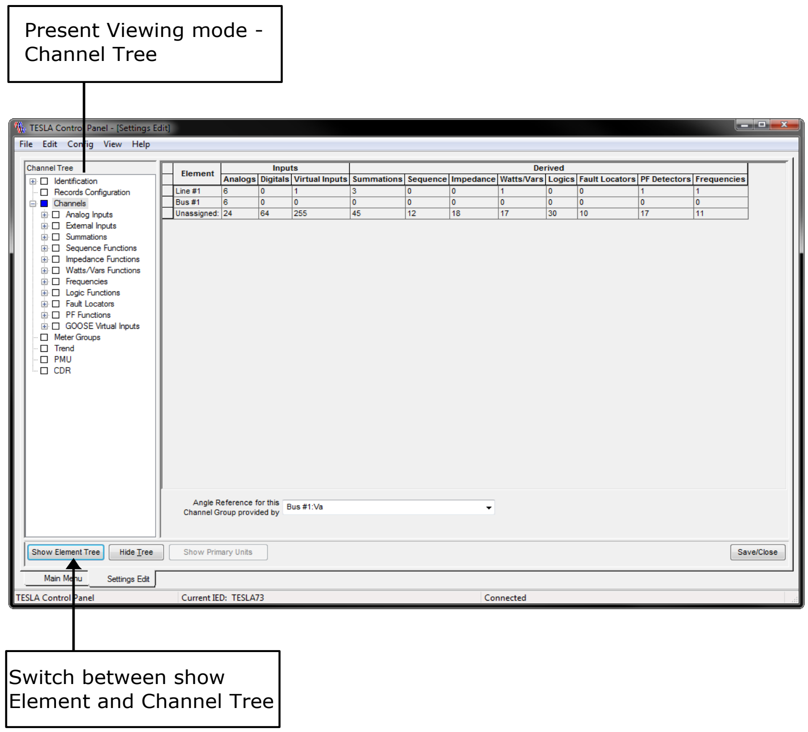


Figure 9.11: Channel Tree View

Element Overview

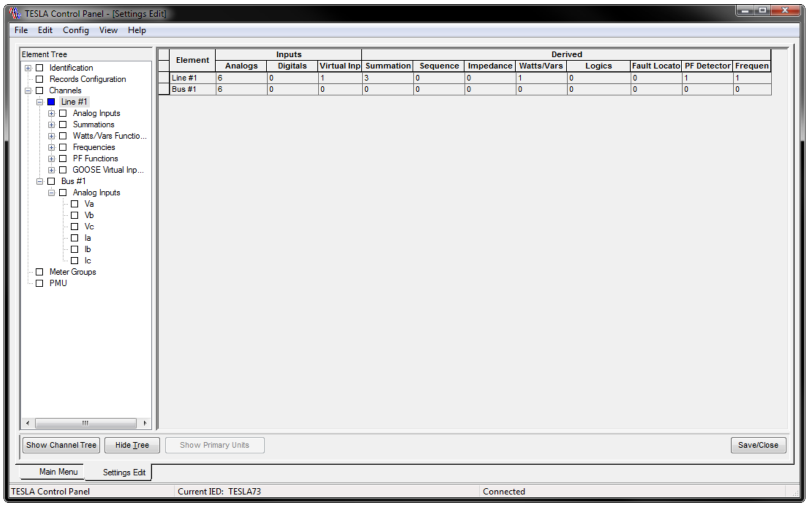


Figure 9.12: Element Overview Screen

An overview of the configured elements is available by selecting an element or the channel group heading in the Navigation tree. The last row of the display shows the channels and functions that are unassigned and available.

Phase Angle Reference Channel

The Element Overview screen, displayed by selecting Channels in the Navigation tree, is where you select the analog input channel to be used as the reference channel for angle measurements. All channels use the same reference to provide relative angle calculations. Typically, a phase A voltage channel is used as the reference. When PMU is enabled, PMU (GPS, 1PPS) must be selected as the angle reference.

Channel Overview

An overview of the configured channels is available by selecting the associated channel type heading from the Navigation tree. For example, selecting *Analog Inputs* displays a table of all defined analog channels.

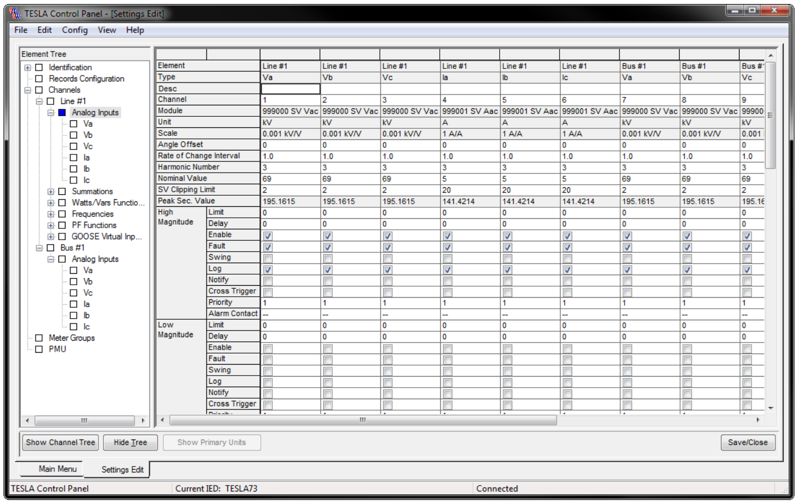


Figure 9.13: Channel Overview Screen

> Channel settings can be edited in the Channel Overview display, providing an alternate way to enter channel settings that helps maintain consistency between channels.

The column width can be adjusted on the overview tables to optimize the layout for the particular configuration.

Individual Channel Screens

Detailed channel configuration is displayed on an individual channel basis. The settings for each channel can be displayed in individual screens by selecting the specific channel in the Navigation. Each channel type has its own configuration screen with parameters appropriate for its type.

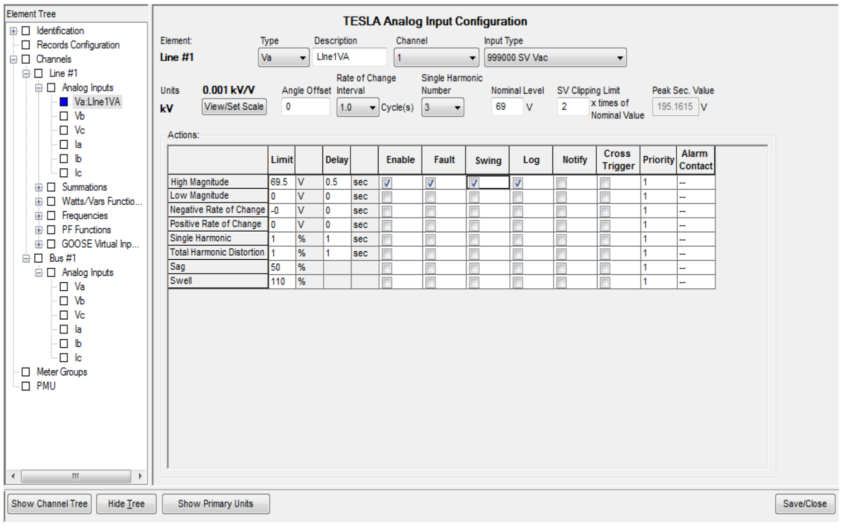


Figure 9.14: Individual Channel Configuration Screen

Adding an Element

To create a new element you must be in the Element Tree view (“Element and Channel Tree Views” on page 9-15):

1. Right-click and select *Add Element or Insert Element* from the shortcut menu. *Add Element* creates the new element at the end of the present Element list. *Insert Element* creates the new element above your current selection.
2. Type the element name and *Enter*. The typed text replaces the *New Element* text.

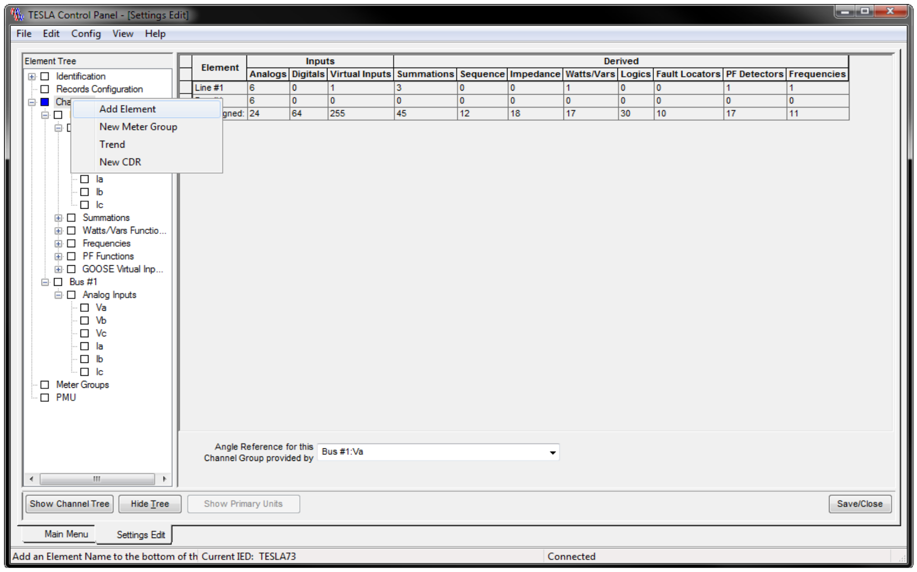


Figure 9.15: Add an Element

Deleting an Element

To remove an element from the tree, select it and press the <Del> key or right-click and select *Delete Element* from the shortcut menu.

Adding a Channel

Channels can be created in either the Element Tree view or the Channel Tree View (“Element and Channel Tree Views” on page 9-15).

To create a new channel in the Element Tree view

1. Select the desired element in the tree.
2. Right-click and select the desired channel type. If appropriate, choose the type that matches the input you are monitoring (e.g. Va). For an ac signal that has no specific phase designation you can select *New AC Voltage* or *New AC Current.* If you chose *New Ia, Ib, Ic* or *New Va, Vb, Vc*, three entries are created and the configuration screen for the first is displayed. The new channel(s) will be inserted automatically in the list.

To create a new channel in the Channel Tree view

1. Select the desired element in the tree.
2. Expand the branches in the tree to show the channels for each group.
3. Select the channel number and an input screen appears on the right side.
4. Type in the information required to configure the channel.
5. When you close the screen, you are asked to save the configuration to the recorder. Select *Save to Recorder.*

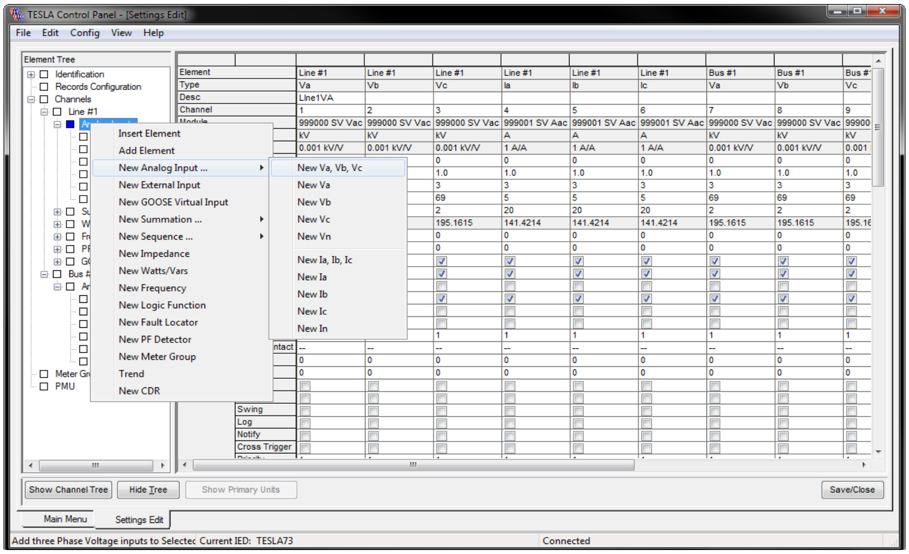


Figure 9.16: Adding Analog Input Channels from the Element Tree

Deleting a Channel

To remove an channel from the tree, select it and press the <Del> key or right-click and select the appropriate *Delete* entry from the shortcut menu.

Copying and Pasting Channel Configurations

A copy and paste function is provided for copying and pasting channel configuration data between channels of the channel same type. This feature aids in the efficiency of creating configurations with multiple similar channels. All of the channel configuration data, except for the channel name, will be copied.

To copy channel configuration data from one channel, simply right-click on the channel in the left-hand menu and select “Copy *Channel Type*” (where *Channel Type* is Analog Input, Summation, Sequence etc.). Then select the destination channel for pasting the data, right-click the channel in the left-hand menu and select Paste. *Ctrl-C* and *Ctrl-P* may also be used for copying and pasting channel configurations respectively.

Copying and pasting may only be performed on channels of the same type. For example, an Analog Voltage channel may be copied and pasted to another Analog Voltage channel, but it cannot be pasted to a Summation channel.

9.6 Analog Input Channels

Description

Basic recording channels for the recorder's Sampled Value inputs.

Input

The recorder's Sampled Value inputs.

> **Important Note:**
> Sampled Value Subscriptions must be configured via the ERL 61850 IED Configurator in order to acquire Analog Input data. Refer to "Sampled Value Setup Requirements" on page 19-18 for details.

Calculation

The rms amplitude of the fundamental is calculated using a DFT function. The resultant phasors are used for rate and level triggers, metering, low speed recording, trending and sag/swell detection. The single harmonic and THD detectors are calculated directly from the input samples.

Triggers

- High & low magnitude
- Negative and positive rate of change
- Single harmonic magnitude
- THD magnitude
- Sag and swell

To prevent multiple triggers on threshold conditions, an hysteresis of 2% of setting is applied to magnitude triggers.

Recording

High Speed**:** records the samples generated from the A/D converters at the selected sample rate.

Low Speed**:** records the calculated phasors at a rate of one phasor per cycle.

Number of Channels

Up to 36 Analog Input Channels can be defined.

Types

Va, Vb, Vc, Vn, Ia, Ib, Ic, In (use where appropriate)

Notes

The Analog Input Channel also produces THD and Single Harmonic readings that are available to the metering display, IEC 61850 and the long term trending function.

Settings

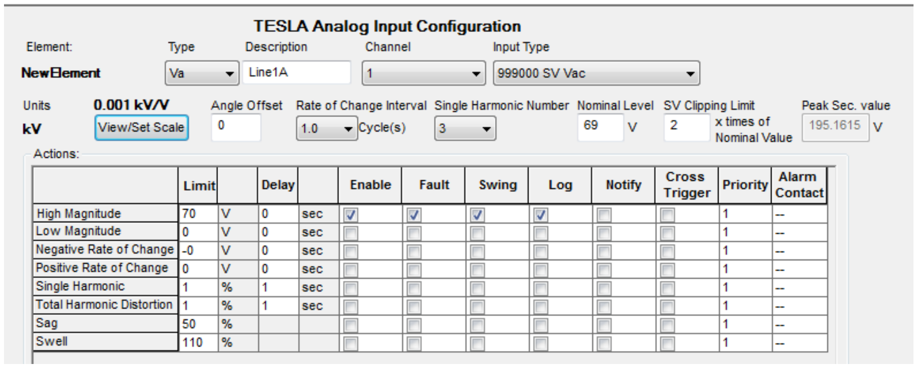


Figure 9.17: Analog Input Channel Configuration Screen - Sampled Value Measurement Type

Table 9.5: Analog Input Channel Settings	
Element	Identifies the group to which this channel belongs. The Element forms the first part of the channel name. The Element is selected when the channel is created and is fixed once assigned when you are working in the Element Tree view.
Type	Identifies the type of signal being applied to this input channel. The Type forms a part of the channel name (Element:Type:Description). Selecting the appropriate Type can simplify channel naming by eliminating the need for the optional Description field (e.g. Line #1:Va uniquely defines the channel). Initially set when the channel was created, the Type can be changed to refer to a different phase as needed.
Description	Optional field (12 characters). Provides an additional description of the channel that forms part of the channel name. Use if Element Name and channel Type do not sufficiently identify the channel. (“Channel Grouping and Naming” on page 9-13).
Channel	Identifies the Sampled Value input used by this channel. Refer to “SVI Logical Device” on page 19-17 for more details. To view an overview of channel assignments, switch to the Channel Tree view and look at the Analog Channel list.
Module Type	Two generic input types are used for the Sample Value Measurement Type, one for current (999000 SV Aac) and one for voltage (999000 SV Vac).
View/Set Scale	Sets the primary to secondary scale factor. See details below.

Table 9.5: Analog Input Channel Settings	
Angle Offset	Specifies a phase angle offset to be applied to the channel. The offset is included in: • Meter readings • Trigger calculations • Low speed recordings (phasors) • Trend channels • Output to calculated channels (watts, vars, Impedance, Summations, Sequence components, etc.) that use this channel as their input. High speed recordings of this channel will *not* have the phase angle applied as they are basic representations of the individual sampled points. When the Angle Offset is used on a channel that has been designated as the reference channel, it affects the angle measurement of all other channels. (See: "Phase Angle Reference Channel" on page 9-17).
Trigger Settings	
Rate of Change Interval	Specifies the period of time over which both positive and negative rate of change is measured. TESLA takes two samples per cycle, so setting is selectable in 0.5 cycle increments. For example, for a 1.5 ROC setting, TESLA compares previous 1.5 cycle window to the current 1.5 cycle window and checks if ROC condition is met. Setting range is 0.5 to 8.0 cycles.
Single Harmonic Number	Selects the harmonic of fundamental frequency that will be used by the Single Harmonic trigger. 2 to the highest harmonic allowed, which is defined in Table 9.1: High Speed Recordings Sample Rate (60 Hz System Frequency) on page 9-11 and Table 9.2: High Speed Recordings Sample Rate (50 Hz System Frequency) on page 9-11.
Nominal Level	Provides a nominal level for the channel. This must match with the Merging Unit Nominal Level setting/rating. The Nominal Level setting is also used as a threshold for frequency calculation. A minimum of 0.1 * Nominal Level must be present in order frequency to be calculated for the channel.
SV Clipping Limit	x times the Nominal Value. Determines the maximum magnitude at which the waveform is cut-off. This setting also should match with the Merging Unit analog full scale measurement value.
Limit	Specifies the trigger levels for the magnitude, single harmonic, THD, sag and swell triggers. Specifies the magnitude portion of the rate for rate of change triggers.
Delay	Specifies how long the trigger condition must be present before a trigger is declared. Magnitude and Rate of Change triggers: 0 to 1,200 seconds in half-cycle increments. Single harmonic and THD triggers: 0 to 10,000 seconds in half-cycle increments.
Trigger Actions	
Enable	Enables or disables the associated trigger. A trigger can be disabled without altering the rest of its settings.
Fault	Initiates a fault (high speed) recording when triggered.
Swing	Initiates a swing (low speed) recording when triggered. If both Fault and Swing are enabled, the recorder will attempt to create a combined record.

Table 9.5: Analog Input Channel Settings

Log	Logs a message in the Event Log when triggered.
Notify	Contacts the RecordBase Central Station when triggered. Can be used to initiate wide area swing recordings and/or automated record transfer.
Cross Trigger	Activates the cross-trigger contact (#4) to trigger another device.
Priority	Specifies the priority to be assigned to records created by this trigger. The priority is used to determine Central Station notification. 1 - 3 (3 is the highest priority).
Alarm Contact	Specifies a rear panel contact to be closed when triggered. Contacts are closed momentarily for one second. Contact assignment is not exclusive, allowing multiple triggers to activate the same contact. Available contacts: 2, 3, 5, 6, 7 or 8 on a 36 channel model. Contacts 1 and 4 are reserved for Recorder Functional and Cross-Trigger respectively. Contacts assigned for storage alarms ,Time Sync loss alarm or IEC 61850 communication failure alarm (“TESLA Alarms” on page 9-7) will not be available for use here.

AC Scaling - Sampled Value Measurement Type

When you select the *View/Set Scale* button on the Analog Input form for a Sample Value analog channel, TESLA Control Panel displays the Scaling dialog box.

The ratio of Equivalent Primary Value to Secondary Value represents the turns ratio of the primary transducer (CT or PT). Sampled Values are streamed as a primary quantity. The TESLA uses the ratio of Equivalent Primary Value to Secondary Value is used to scale the incoming primary measurements in the SV stream into secondary values. Note that if these settings do not match the settings on the Merging Unit producing the Sampled Value stream, the TESLA may display incorrect secondary values. Ensure that the ratio configured on the TESLA matches the Merging Unit's settings.

The SV Scale and SV Offset provides means to alter the incoming SV stream data. In general, the default Scale and Offset do not need to be modified.

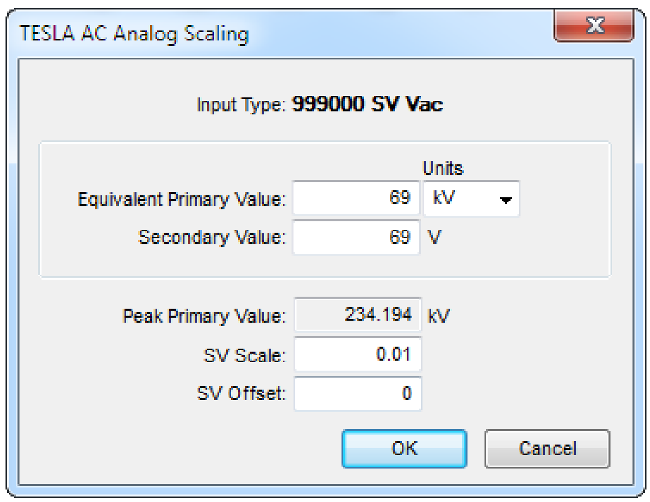


Figure 9.18: Sampled Value Scaling

Sag and Swell Detectors

Sag and Swell detectors are available on voltage channels. There are three related fields in the Configuration screen controlling Sag and Swell detectors. The definition of a Sag or Swell depends on a Nominal Level of voltage. The Sag and Swell thresholds are expressed as a percentage of the Nominal Level. The Sag upper limit is configurable between 50% and 90% of Nominal. The Sag lower limit is fixed at 10% of Nominal. The Swell lower limit is configurable between 110% and 150% of Nominal. The Swell level upper limit is fixed at 180% of Nominal. Sag or Swell is triggered when the input voltage is between the lower and upper limits.

The duration of a Sag or Swell is fixed at any value between 0.5 cycle and 1 minute.

9.7 External Input Channels

Description

Recording channels for the recorder's external (digital) input signals.

Input

The recorder's physical external input channels.

Calculation

The binary state of each external input is read at the selected high speed sample rate. A filter is applied to the samples to prevent triggering on spurious state changes, requiring that a state change be present continuously for a minimum of approximately 700 microseconds to be considered valid for triggering purposes.

Triggers

- Active state
- Inactive state

Recording

Records the state of all external input channels at the selected high speed sample rate. The input filter is not applied to the recorded data; all state changes are included in the records.

Number of Channels

Up to 64 External Input Channels can be defined, one for each physical input.

Types

EI

Settings

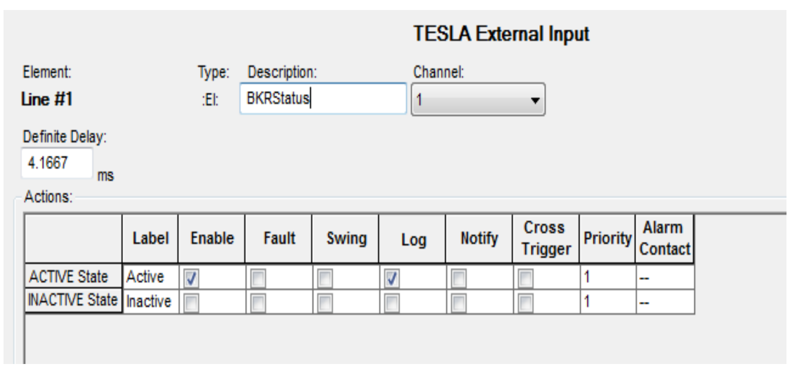


Figure 9.19: External Input Channel Configuration Screen

Table 9.6: External Input Channel Settings	
Element	Identifies the group to which this channel belongs. The Element forms the first part of the channel name. The Element is selected when the channel is created and is fixed once assigned when you are working in the Element Tree view.
Description	Optional field (12 characters). Provides an additional description of the channel that forms part of the channel name. Should always be used with External Input channels to uniquely name the channel. (“Channel Grouping and Naming” on page 9-13).
Channel	Identifies the physical External Input used by this channel. This number is identified on the rear of the TESLA chassis. The list only shows inputs which have not been assigned to other channels. To get an overview of channel assignments, switch to the Channel Tree view and look at the External Channel list.
Trigger Settings	
Definite Delay	Specifies how long the trigger condition must be present before a trigger is declared. Settable from 0 to 5,000 ms in eighth cycle increments. The delay setting is in addition to the pickup delay imposed by the input “glitch” filtering, which is approximately 700 microseconds.
Label	Text to designate the active and inactive states. Default is “on” and “off”. Maximum 8 characters.
Trigger Actions	
Enable	Enables or disables the associated trigger. A trigger can be disabled without altering the rest of its settings.
Fault	Initiates a fault (high speed) recording when triggered.
Swing	Initiates a swing (low speed) recording when triggered. If both Fault and Swing are enabled, the recorder will attempt to create a combined record.
Log	Logs a message in the Event Log when triggered.
Notify	Contacts the RecordBase Central Station when triggered. Can be used to initiate wide area swing recordings and/or automated record transfer.
Cross Trigger	Activates the cross-trigger contact (#4) to trigger another device.
Priority	Specifies the priority to be assigned to records created by this trigger. The priority is used to determine Central Station notification. 1 - 3 (3 is the highest priority).
Alarm Contact	Specifies a rear panel contact to be closed when triggered. Contacts are closed momentarily for one second. Contact assignment is not exclusive, allowing multiple triggers to activate the same contact. Available contacts: 2, 3, 5, 6, 7 or 8 on a 36 channel model. Contacts 1 and 4 are reserved for Recorder Functional and Cross-Trigger respectively. Contacts assigned for storage alarms, Time Sync loss alarm or IEC 61850 communication failure alarm (“TESLA Alarms” on page 9-7) will not be available for use here.

9.8 GOOSE Virtual Input Channels

Description

Recording channels for the recorder's GOOSE Virtual Input signals. The GOOSE Virtual Inputs are configured in the DVI Logical Device. Refer to "Logical Device: DVI" on page Appendix H-48 and to the ERL 61850 IED Configurator Manual for details on mapping.

Input

The recorder's digital subscription input channels via IEC 61850 GOOSE messages, with origin time stamping provided by the publishing IED.

Event Time Stamps

In the associated events for GOOSE Virtual Input channels, there are two events created, one is labeled "L" and one is labeled "G". The event labeled "G" contains the time stamp of the incoming GOOSE message which is set by the publishing IED (i.e. the origin time stamp). The event labeled "L" contains the time stamp of the instant that the TESLA 4000-SV received and processed the incoming GOOSE. It is normal to see a small discrepancy between the "G" and "L" timestamps due to the real-world transmission time of the GOOSE message (may vary depending on network conditions) and time synchronization differences between IEDs.

Calculation

When a GOOSE message is received by the TESLA 4000-SV it is processed and states are updated according to the data received in the GOOSE.

Triggers

- Active state (for Boolean data type)
- Inactive state (for Boolean data type)
- Change state (for types other than Boolean)

Recording

Records the state of all virtual input channels using the origin time stamp information included within the GOOSE message provided by the publishing IED.

Number of Channels

Up to 256 GOOSE Virtual Input Channels can be defined. There is no limit to how many channels may be used for each type (see Types below), as long as the total number of Virtual Input channels does not exceed 256.

Types

Boolean, Dbpos, Health, INT32, INT32U

> Currently, RecordGraph only supports graphing of Boolean digital channels. For all other types, the channels will not be available to add into digital graphs. However all data types are available for CSV export.

Settings

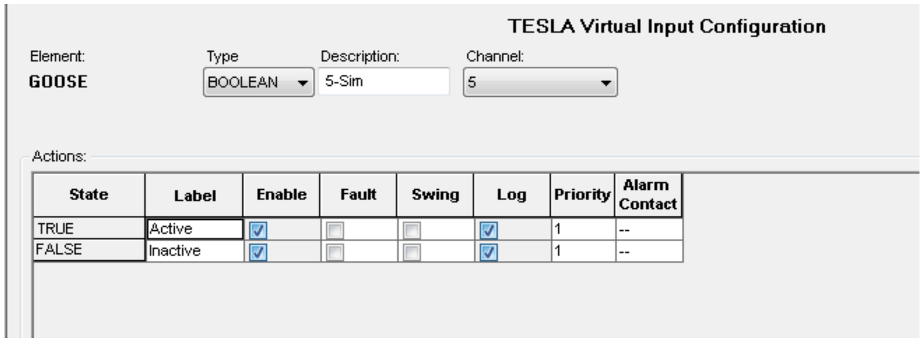


Figure 9.20: GOOSE Virtual Input Channel Configuration Screen

Table 9.7: GOOSE Virtual Input Channel Settings	
Element	Identifies the group to which this channel belongs. The Element forms the first part of the channel name. The Element is selected when the channel is created and is fixed once assigned when you are working in the Element Tree view.
Type	The type of data mapped into this GOOSE Virtual Input. Options are Boolean, Dbpos, Health, INT32, INT32U. Setting must match the type of data mapped in the CID file loaded to the IED. For Boolean type, “Active” and “Inactive” state triggers are available. For all other types, a “Change” state trigger is available.
Description	Optional field (12 characters). Provides an additional description of the channel that forms part of the channel name. Should always be used with GOOSE Virtual Input channels to uniquely name the channel.
Channel	Identifies the Virtual Input assigned to this channel. The list will only show inputs which have not already been assigned to other channels. To get an overview of channel assignments, switch to the Channel Tree view and look at the GOOSE Virtual Inputs list.
Trigger Settings	
Label	Text to designate the active and inactive states. Default is “Active” and “Inactive” for Boolean. Maximum 6 characters (excluding defaults). Label is only available for Boolean type.
Trigger Actions	
Enable	Enables or disables the associated trigger. For the GOOSE channels, True and False state are always forced to Enabled.
Fault	Initiates a fault (high speed) recording when triggered.
Swing	Initiates a swing (low speed) recording when triggered. If both Fault and Swing are enabled, the recorder will not attempt to create a combined record. Separate fault and swing records will be created.
Log	Logs a message in the Event Log when triggered.
Priority	Specifies the priority to be assigned to records created by this trigger. The priority is used to determine Central Station notification. 1 - 3 (3 is the highest priority).
Alarm Contact	Specifies a rear panel contact to be closed when triggered. Contacts are closed momentarily for one second. Contact assignment is not exclusive, allowing multiple triggers to activate the same contact. Available contacts: 2, 3, 5, 6, 7 or 8 on a 36 channel model. Contacts 1 and 4 are reserved for Recorder Functional and Cross-Trigger respectively. Contacts assigned for storage alarms ,Time Sync loss alarm or IEC 61850 communication failure alarm (“TESLA Alarms” on page 9-7) will not be available for use here.

9.9 Summation Channel

Description

Summation Channels combine up to three analog inputs to create a summed channel. Each input can be scaled and rotated before it is summed. Previously combined summation channels can be used as an input to a new summation channel.

> Note: Summation Channels are handled as phasor sums for triggering, metering, low speed recording and trending. Both the *Scale Factor* and *Angle Offset* settings are applied for these uses.

Input

Analog Input Channels or other Summation Channels can be used as inputs to a Summation Channel. The summation can have two or three inputs. If a Summation Channel is used as an input, it must have a lower *Summation Index.*

Calculation

Each input is converted to a phasor using a DFT function and is scaled and rotated using the *Scale Factor* and *Angle Offset* settings.The resulting phasors are added to form the summation.

The high speed recording of a Summation Channel is created by adding the individual data points from the input channels. The *Scale Factor* is applied to each channel before the addition.

Triggers

- High & low magnitude
- Negative and positive rate of change

To prevent multiple triggers on threshold conditions, an hysteresis of 2% of setting is applied to magnitude triggers.

Recording

High Speed**:** generates a channel that is the sum of the individual data samples with the *Scale Factor* applied.

Low Speed**:** generates a channel that is phasor sum of the input channels at a rate of one phasor per cycle.

Number of Channels

48 Summation Channels are available.

Types

Va, Vb, Vc, Vn, Ia, Ib, Ic, In (use where appropriate)

Notes

The primary to secondary scale factor used by the Summation Channel is the same as that of its first input channel.

Settings

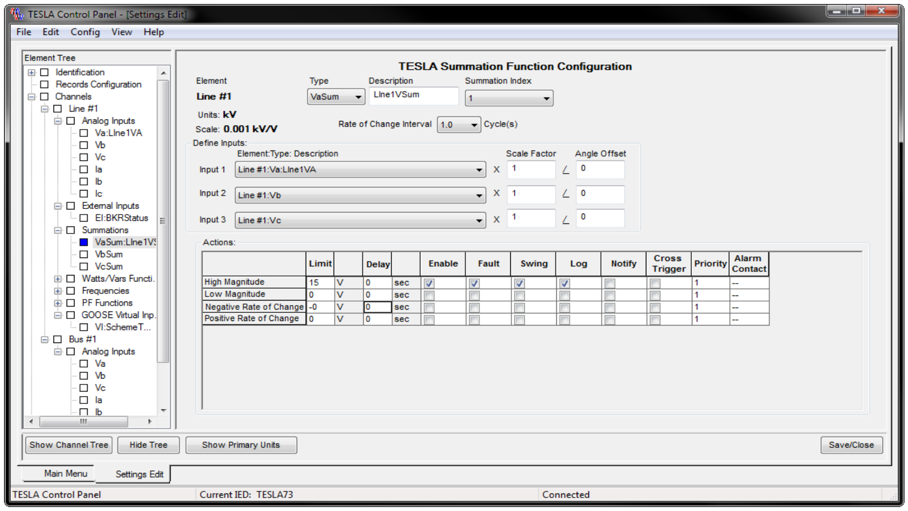


Figure 9.21: Summation Channel Configuration Screen

Table 9.8: Summation Channel Settings	
Element	Identifies the group to which this channel belongs. The Element forms the first part of the channel name. The Element is selected when the channel is created and is fixed once assigned when you are working in the Element Tree view.
Type	Identifies the type of signal being applied to this input channel. The Type forms a part of the channel name (Element:Type:Description). Selecting the appropriate Type can simplify channel naming by eliminating the need for the optional Description field (e.g. Line #1:IaSum uniquely defines the channel). Initially set when the channel was created, the Type can be changed to refer to a different phase as needed.
Description	Optional field (12 characters). Provides an additional description of the channel that forms part of the channel name. Use if Element Name and channel Type do not sufficiently identify the channel. (“Channel Grouping and Naming” on page 9-13).
Summation Index	Identifies the summation channel. Unlike the analog and external input channels, this is not associated with a hardware input, but simply identifies which of the internal virtual summation channels will be used. You can select any available channel; the only restriction is that nested summations require the input summation to have a lower Summation Index. If the only option is “undefined”, you have already used all available channels.
Input 1, Input 2, Input 3	Identifies the channels to be used in the summation. The available list includes all previously defined analog channels and any summation channel with a lower summation index number. The list grows automatically as you define new channels.
Scale Factor	Specifies a multiplier for each of the inputs. The scale factor is applied in the secondary domain.

Table 9.8: Summation Channel Settings

Angle Offset	Specifies a phase angle shift to be applied to each of the inputs. Note that when an offset is specified, a high speed summation recording - which uses sample by sample addition rather than phasor addition - is not generated. All other functions, including low speed recording, are available and will reflect the offset.
Trigger Settings	
Rate of Change Interval	Specifies the period of time over which both positive and negative rate of change is measured. TESLA takes two samples per cycle, so setting is selectable in 0.5 cycle increments. For example, for a 1.5 ROC setting, TESLA compares previous 1.5 cycle window to the current 1.5 cycle window and checks if ROC condition is met. Setting range is 0.5 to 8.0 cycles.
Limit	Specifies the trigger levels for the magnitude triggers and the magnitude portion of the rate for the rate of change triggers. The period portion of the rate is specified by the *Rate of Change Interval*.
Delay	Specifies how long the trigger condition must be present before a trigger is declared. 0 to 1,200 seconds in half-cycle increments.
Trigger Actions	
Enable	Enables or disables the associated trigger. A trigger can be disabled without altering the rest of its settings.
Fault	Initiates a fault (high speed) recording when triggered.
Swing	Initiates a swing (low speed) recording when triggered. If both Fault and Swing are enabled, the recorder will attempt to create a combined record.
Log	Logs a message in the Event Log when triggered.
Notify	Contacts the RecordBase Central Station when triggered. Can be used to initiate wide area swing recordings and/or automated record transfer.
Cross Trigger	Activates the cross-trigger contact (#4) to trigger another device.
Priority	Specifies the priority to be assigned to records created by this trigger. The priority is used to determine Central Station notification. 1 - 3 (3 is the highest priority).
Alarm Contact	Specifies a rear panel contact to be closed when triggered. Contacts are closed momentarily for one second. Contact assignment is not exclusive, allowing multiple triggers to activate the same contact. Available contacts: 2, 3, 5, 6, 7 or 8 on a 36 channel model. Contacts 1 and 4 are reserved for Recorder Functional and Cross-Trigger respectively. Contacts assigned for storage alarms, Time Sync loss alarm or IEC 61850 communication failure alarm (“TESLA Alarms” on page 9-7) will not be available for use here.

9.10 Sequence Component Channels

Description

Sequence Component Channels calculates positive, negative, and zero sequence components in one step. The positive sequence component may also be used as an input to a watts/vars or impedance function.

Input

Analog Input Channels or Summation Channels can be used as inputs to a Sequence Component Channel.

Calculation

The sequence component algorithm is applied to produce positive, negative and zero sequence components.

Triggers

- Positive sequence high and low magnitude
- Positive sequence negative and positive rate of change
- Negative sequence high magnitude
- Zero sequence high magnitude

To prevent multiple triggers on threshold conditions, an hysteresis of 2% of setting is applied to magnitude triggers.

Recording

High Speed**:** Positive, negative and zero sequence values at a rate of eight values per cycle (regardless of the system sample rate).

Low Speed**:** Positive, negative and zero sequence values at a rate of one value per cycle.

Number of Channels

24 Sequence Component Channels are available.

Types

Vseq, Iseq

Notes

The primary to secondary scale factor used by the Sequence Component Channel is the same as that of the selected Phase A channel.

Settings

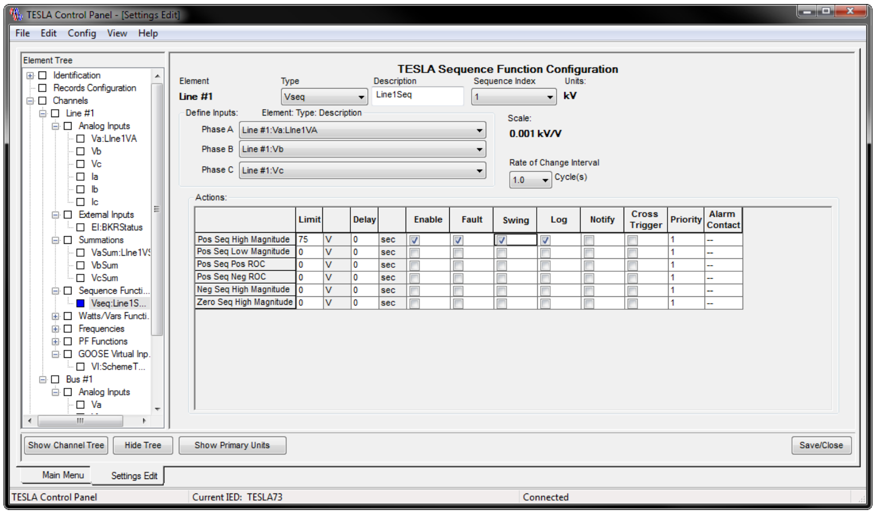


Figure 9.22: Sequence Channel Configuration Screen

Table 9.9: Sequence Component Channel Settings	
Element	Identifies the group to which this channel belongs. The Element forms the first part of the channel name. The Element is selected when the channel is created and is fixed once assigned when you are working in the Element Tree view.
Type	Identifies the type of signal being applied to this input channel. The Type forms a part of the channel name (Element:Type:Description). Selecting the appropriate Type can simplify channel naming by eliminating the need for the optional Description field (e.g. Line #1:VSeq uniquely defines the channel). Initially set when the channel was created, the Type can be changed to refer to a different phase as needed.
Description	Optional field (12 characters). Provides an additional description of the channel that forms part of the channel name. Use if Element Name and channel Type do not sufficiently identify the channel. (“Channel Grouping and Naming” on page 9-13).
Sequence Index	Identifies the Sequence Component channel. Unlike the analog and external input channels, this is not associated with a hardware input, but simply identifies which of the internal virtual summation channels will be used. You can select any available channel without restriction. If the only option is “undefined”, you have already used all available channels.
Phase A, Phase B, Phase C	Identifies the channels used to create the sequence set. The list is limited to channels of the correct type (voltage or current) and includes analog input or summation channels which have already been defined. The list grows automatically as you define new channels.
Trigger Settings	

Table 9.9: Sequence Component Channel Settings

Rate of Change Interval	Specifies the period of time over which both positive and negative rate of change is measured. TESLA takes two samples per cycle, so setting is selectable in 0.5 cycle increments. For example, for a 1.5 ROC setting, TESLA compares previous 1.5 cycle window to current 1.5 cycle window and checks if ROC condition is met. Setting range is 0.5 to 8.0 cycles.
Limit	Specifies the trigger levels for the magnitude triggers and the magnitude portion of the rate for the rate of change triggers. The period portion of the rate is specified by the *Rate of Change Interval*.
Delay	Specifies how long the trigger condition must be present before a trigger is declared. 0 to 1,200 seconds in half-cycle increments.
Trigger Actions	
Enable	Enables or disables the associated trigger. A trigger can be disabled without altering the rest of its settings.
Fault	Initiates a fault (high speed) recording when triggered.
Swing	Initiates a swing (low speed) recording when triggered. If both Fault and Swing are enabled, the recorder will attempt to create a combined record.
Log	Logs a message in the Event Log when triggered.
Notify	Contacts the RecordBase Central Station when triggered. Can be used to initiate wide area swing recordings and/or automated record transfer.
Cross Trigger	Activates the cross-trigger contact (#4) to trigger another device.
Priority	Specifies the priority to be assigned to records created by this trigger. The priority is used to determine Central Station notification. 1 - 3 (3 is the highest priority).
Alarm Contact	Specifies a rear panel contact to be closed when triggered. Contacts are closed momentarily for one second. Contact assignment is not exclusive, allowing multiple triggers to activate the same contact. Available contacts: 2, 3, 5, 6, 7 or 8 on a 36 channel model. Contacts 1 and 4 are reserved for Recorder Functional and Cross-Trigger respectively. Contacts assigned for storage alarms, Time Sync loss alarm or IEC 61850 communication failure alarm ("TESLA Alarms" on page 9-7) will not be available for use here.

9.11 Impedance Channels

Description

Impedance Channels calculate impedance from voltage and current inputs. The channel can produce either single phase or three phase values. Triggering is based on the rate of impedance within a defined impedance circle centered around the origin.

Input

Analog Input Channels, Summation Channels or Sequence Component channel can be used as inputs to an Impedance Channel. Using Sequence Component as an input results in a three-phase impedance.

Calculation

The impedance calculation continuously recalculates the apparent impedance from the selected voltage and current signals, then subtracts an earlier calculated value (determined by the “Rate of Change Interval” setting). The impedance trigger operates if the difference is between the “Minimum Change” and “Maximum Change” settings, and the calculated impedance is within “Circle Radius” of the origin.

Triggers

Rate of impedance within a defined impedance circle.

Recording

Low Speed: Impedance magnitude at a rate of one value per cycle.

Number of Channels

18 Impedance Channels are available.

Types

Z1 (impedance)

Notes

The impedance magnitude and angle readings are also available to the metering display, IEC 61850 and the long term trending function.

Settings

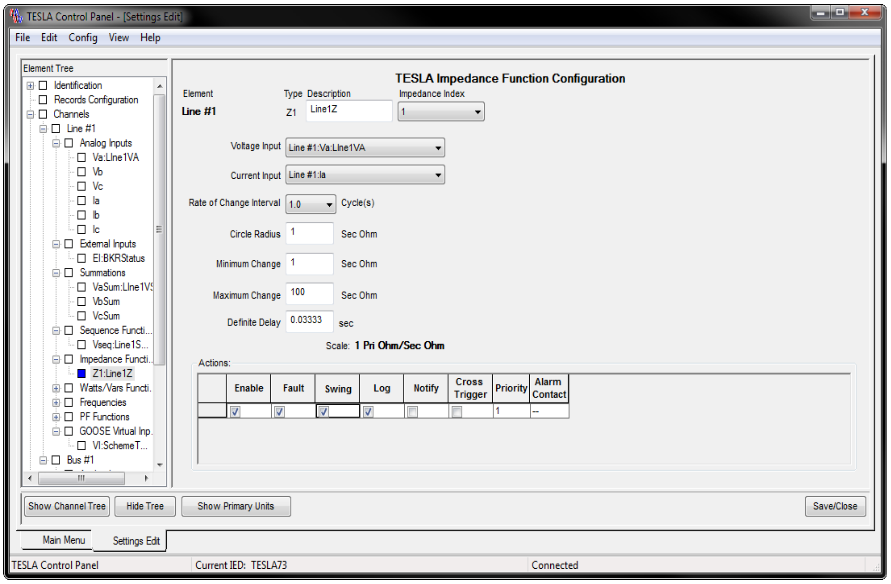


Figure 9.23: Impedance Channel Configuration Screen

Table 9.10: Impedance Channel Settings

Element	Identifies the group to which this channel belongs. The Element forms the first part of the channel name. The Element is selected when the channel is created and is fixed once assigned when you are working in the Element Tree view.
Description	Optional field (12 characters). Provides an additional description of the channel that forms part of the channel name. Use if Element Name and channel Type do not sufficiently identify the channel. (“Channel Grouping and Naming” on page 9-13).
Impedance Index	Identifies the Impedance channel. Unlike the analog and external input channels, this is not associated with a hardware input, but simply identifies which of the internal virtual impedance channels will be used. You can select any available channel without restriction. If the only option is “undefined”, you have already used all available channels.
Voltage Input, Current Input	Identifies the channels to be used to create the impedance. If you select analog or summation channels as inputs, the impedance channel calculates single-phase impedance; if you select sequence channels, it calculates three-phase impedance.The list is limited to channels of the correct type (voltage or current) and includes analog input or summation channels which have already been defined. The list grows automatically as you define new channels.

Table 9.10: Impedance Channel Settings	
Trigger Settings	
Rate of Change Interval	Specifies the period of time over which both positive and negative rate of change is measured. TESLA takes two samples per cycle, so setting is selectable in 0.5 cycle increments. For example, for a 1.5 ROC setting, TESLA compares previous 1.5 cycle window to the current 1.5 cycle window and checks if ROC condition is met. Setting range is 0.5 to 8.0 cycles.
Circle Radius	Specifies the radius of the impedance circle in secondary ohms.
Minimum Change	Specifies the minimum impedance change to be detected.
Maximum Change	Specifies the maximum impedance change to be detected.
Definite Delay	Requires the element to be energized before an active state is determined. Settable from 0 to 1,200 seconds in half-cycle increments.
Trigger Actions	
Enable	Enables or disables the associated trigger. A trigger can be disabled without altering the rest of its settings.
Fault	Initiates a fault (high speed) recording when triggered.
Swing	Initiates a swing (low speed) recording when triggered. If both Fault and Swing are enabled, the recorder will attempt to create a combined record.
Log	Logs a message in the Event Log when triggered.
Notify	Contacts the RecordBase Central Station when triggered. Can be used to initiate wide area swing recordings and/or automated record transfer.
Cross Trigger	Activates the cross-trigger contact (#4) to trigger another device.
Priority	Specifies the priority to be assigned to records created by this trigger. The priority is used to determine Central Station notification. 1 - 3 (3 is the highest priority).
Alarm Contact	Specifies a rear panel contact to be closed when triggered. Contacts are closed momentarily for one second. Contact assignment is not exclusive, allowing multiple triggers to activate the same contact. Available contacts: 2, 3, 5, 6, 7 or 8 on a 36 channel model. Contacts 1 and 4 are reserved for Recorder Functional and Cross-Trigger respectively. Contacts assigned for storage alarms ,Time Sync loss alarm or IEC 61850 communication failure alarm (“TESLA Alarms” on page 9-7) will not be available for use here.

9.12 Watts and Vars Channels

Description

The Watts/Vars Channels calculate apparent power (volt-amps), real power (watts) and reactive power (vars) from voltage input and current inputs. The channel can produce either single phase or three phase values.

Input

Analog Input Channels, Summation Channels or Sequence Component channel can be used as inputs to a Watts/Vars Channel. Using a Sequence Component as an input results in three-phase Watts and Vars.

Calculation

Voltage and current are multiplied to calculate apparent power, real power and reactive power.

Triggers

- Watts: high and low level (2)
- Watts: positive and negative rate of change (2)
- Vars: high and low level
- Vars: positive and negative rate of change
- Dual triggers for Watts allows fault and swing recordings to be triggered by different settings (e.g. Rate of Change Interval), if desired.

To prevent multiple triggers on threshold conditions, an hysteresis of 2% of setting is applied to magnitude triggers.

Recording

High Speed**:** Watt and Var values at a rate of eight values per cycle (regardless of the system sample rate).

Low Speed**:** Watt and Var values at a rate of one value per cycle.

Number of Channels

18 Watts/Vars Channels are available.

Types

W/V

Notes

The primary to secondary scale factor used by the Watts/Vars Channel is based on those of its voltage and current input channels.

Watts, Vars, and Volt-Amp magnitudes are also available to the metering display, IEC 61850 and the long term trending function.

Settings

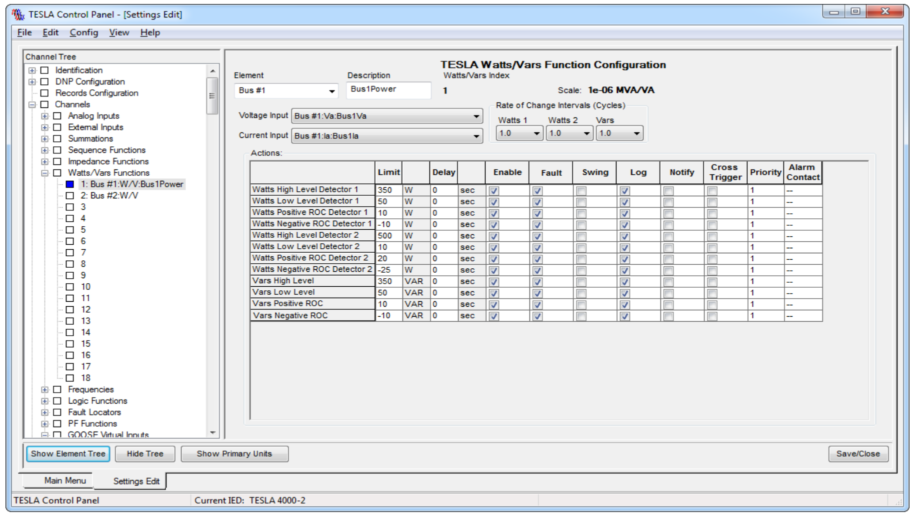


Figure 9.24: Watts/Vars Channel Configuration Screen

Table 9.11: Watts/Vars Channel Settings	
Element	Identifies the group to which this channel belongs. The Element forms the first part of the channel name. The Element is selected when the channel is created and is fixed once assigned when you are working in the Element Tree view.
Description	Optional field (12 characters). Provides an additional description of the channel that forms part of the channel name. Use if Element Name and channel Type do not sufficiently identify the channel. (“Channel Grouping and Naming” on page 9-13).
Watts/Vars Index	Identifies the watts/vars channel. Unlike the analog and external input channels, this is not associated with a hardware input, but simply identifies which of the internal virtual watts/vars channels will be used. You can select any available channel without restriction. If the only option is “undefined”, you have already used all available channels.
Voltage Input	Identifies the voltage channels to be used to create the watts and vars. These can be either analog input channels, summations or positive sequences. If you select analog or summation channels as inputs, single phase watts and vars will be calculated; if you select sequence channels, three-phase watts and vars will be calculated.
Current Input	Identifies the current channels to be used to create the watts and vars. These can be either analog input channels, summations or positive sequences. If you select analog or summation channels as inputs, single phase watts and vars will be calculated; if you select sequence channels, three-phase watts and vars will be calculated.
Trigger Settings	
Watts 1, Watts 2, Watts 3	Period of time over which both positive and negative rate of change for each Watts Detector is measured. 0.5 to 8.0 cycles.
Vars	Period of time over which both positive and negative rate of change for Var Detector is measured. 0.5 to 8.0 cycles.

Table 9.11: Watts/Vars Channel Settings

Limit	Specifies the trigger levels for the magnitude triggers and the magnitude portion of the rate for the rate of change triggers. The period portion of the rate is specified by the *Rate of Change Interval*.
Delay	Specifies how long the trigger condition must be present before a trigger is declared. 0 to 1,200 seconds in half-cycle increments.
Trigger Actions	
Enable	Enables or disables the associated trigger. A trigger can be disabled without altering the rest of its settings.
Fault	Initiates a fault (high speed) recording when triggered.
Swing	Initiates a swing (low speed) recording when triggered. If both Fault and Swing are enabled, the recorder will attempt to create a combined record.
Log	Logs a message in the Event Log when triggered.
Notify	Contacts the RecordBase Central Station when triggered. Can be used to initiate wide area swing recordings and/or automated record transfer.
Cross Trigger	Activates the cross-trigger contact (#4) to trigger another device.
Priority	Specifies the priority to be assigned to records created by this trigger. The priority is used to determine Central Station notification. 1 - 3 (3 is the highest priority).
Alarm Contact	Specifies a rear panel contact to be closed when triggered. Contacts are closed momentarily for one second. Contact assignment is not exclusive, allowing multiple triggers to activate the same contact. Available contacts: 2, 3, 5, 6, 7 or 8 on a 36 channel model. Contacts 1 and 4 are reserved for Recorder Functional and Cross-Trigger respectively. Contacts assigned for storage alarms ,Time Sync loss alarm or IEC 61850 communication failure alarm (“TESLA Alarms” on page 9-7) will not be available for use here.

9.13 Frequency Channels

Description

The Frequency Channels measure the frequency on their assigned input channel.

Input

Any Analog Input Channel. A voltage channel is recommended for best results.

Calculation

Frequency is measured over a multi-second time window to improve resolution and accuracy. The frequency measurement operates in a band that is approximately +/-15% of the nominal frequency. Noise observed in the frequency measurement can be reduced using the Frequency Filter.

Frequency measurement requires that the selected input channel has a signal present with a minimum magnitude of 0.1 * Nominal Level. For example, if a Va channel has a Nominal Level configured as 69V and is set as the input for a frequency channel, then a minimum of 6.9V must be present on the Va channel in order for frequency to be measured.

Triggers

- High & low magnitude
- Negative and positive rate of change

To prevent multiple triggers on threshold conditions, the frequency magnitude triggers have a fixed 0.02 Hz hysteresis.

Recording

Low Speed: Frequency measurements at a rate of one value per cycle.

Number of Channels

12 Frequency Channels are available.

Types

Freq

Settings

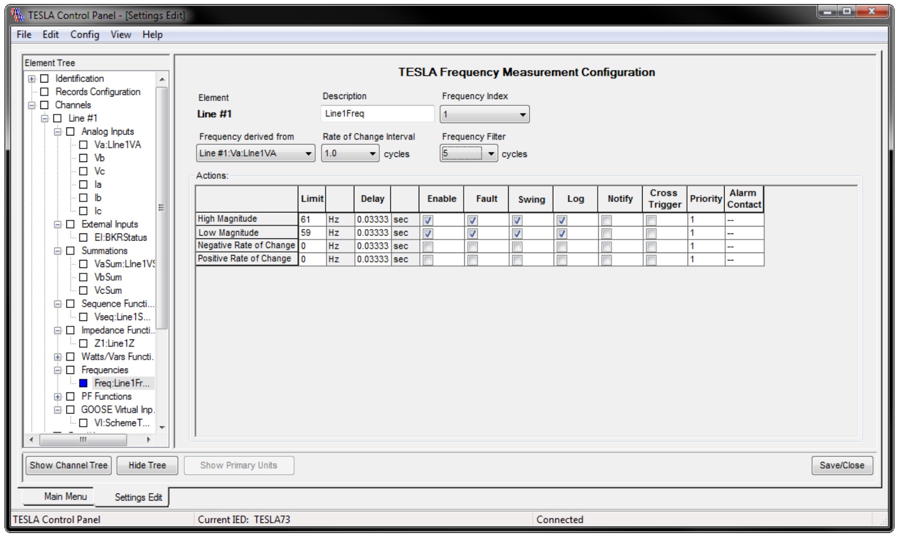


Figure 9.25: Frequency Channel Configuration Screen

Table 9.12: Frequency Channel Settings	
Frequency derived from	Identifies the analog input channel on which to measure frequency. A voltage channel is recommended for best results.
Frequency filter	Specifies the time constant of the low-pass filter which is applied for frequency measurements. 0 to 60 cycles in 5-cycle increments (for 60 Hz system frequency). 0 to 50 cycles in 5-cycle increments (for 50 Hz system frequency). Use of 0 cycles will disable the low-pass filter.
Trigger Settings	
Rate of Change Interval	Specifies the period of time over which both positive and negative rate of change is measured. TESLA takes two samples per cycle, so setting is selectable in 0.5 cycle increments. For example, for a 1.5 ROC setting, TESLA compares previous 1.5 cycle window to the current 1.5 cycle window and checks if ROC condition is met. Setting range is 0.5 to 8.0 cycles.
Limit	Specifies the trigger levels for the magnitude triggers and the magnitude portion of the rate for the rate of change triggers. The period portion of the rate is specified by the *Rate of Change Interval*. The high magnitude limit is 7/6 x nominal frequency, low magnitude limit is 5/6 x nominal frequency.
Delay	Specifies how long the trigger condition must be present before a trigger is declared. 0.0333 (2 cycles) to 1,200 seconds in half-cycle increments.
Trigger Actions	
Enable	Enables or disables the associated trigger. A trigger can be disabled without altering the rest of its settings.
Fault	Initiates a fault (high speed) recording when triggered.

Table 9.12: Frequency Channel Settings

Swing	Initiates a swing (low speed) recording when triggered. If both Fault and Swing are enabled, the recorder will attempt to create a combined record.
Log	Logs a message in the Event Log when triggered.
Notify	Contacts the RecordBase Central Station when triggered. Can be used to initiate wide area swing recordings and/or automated record transfer.
Cross Trigger	Activates the cross-trigger contact (#4) to trigger another device.
Priority	Specifies the priority to be assigned to records created by this trigger. The priority is used to determine Central Station notification. 1 - 3 (3 is the highest priority).
Alarm Contact	Specifies a rear panel contact to be closed when triggered. Contacts are closed momentarily for one second. Contact assignment is not exclusive, allowing multiple triggers to activate the same contact. Available contacts: 2, 3, 5, 6, 7 or 8 on a 36 channel model. Contacts 1 and 4 are reserved for Recorder Functional and Cross-Trigger respectively. Contacts assigned for storage alarms ,Time Sync loss alarm or IEC 61850 communication failure alarm (“TESLA Alarms” on page 9-7) will not be available for use here.

9.14 Logic Functions

Description

Logic Functions are boolean logic statements that can be applied to External Input Channels, GOOSE Virtual Input Channels (Boolean type only) and trigger detectors from other channels. You can choose up to 5 inputs, each of which may be inverted, and specify a chain of logic operations to be performed on each.

Input

Up to 5 inputs. Each can be an External Input Channel, GOOSE Virtual Input Channel or the output of a trigger detector from any channel, including other Logic Functions with lower Indexes.

Calculation

Boolean logic is applied to each input in succession.

Triggers

- Active state
- Inactive state

Recording

High Speed**:** Logic functions recorded at a rate of eight values per cycle (regardless of the system sample rate).

Low Speed**:** Logic functions recorded at a rate of one value per cycle.

Number of Channels

30 Logic Functions are available.

Types

Logic

Notes

The output of the Logic functions is available to the metering display, IEC 61850 and the long term trending function.

Settings

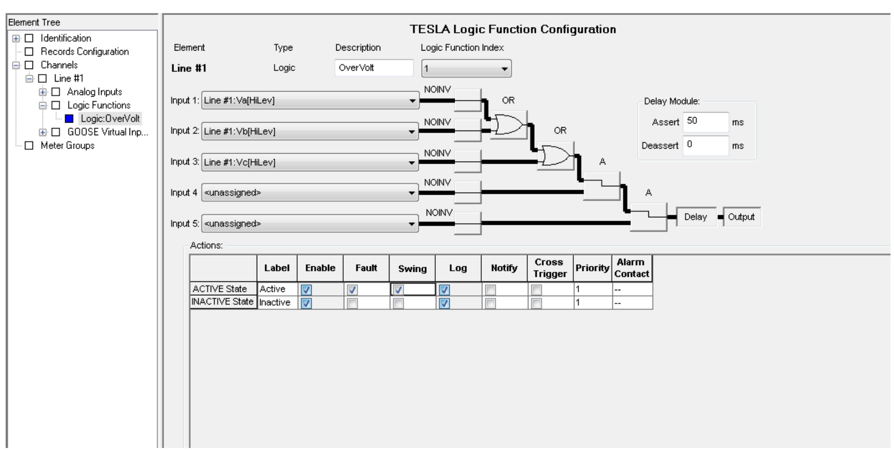


Figure 9.26: Logic Function Configuration

Table 9.13: Logic Function Settings	
Element	Identifies the group to which this channel belongs. The Element forms the first part of the channel name. The Element is selected when the channel is created and is fixed once assigned when you are working in the Element Tree view.
Description	Optional field (12 characters). Provides an additional description of the channel that forms part of the channel name. Use if Element Name and channel Type do not sufficiently identify the channel. (“Channel Grouping and Naming” on page 9-13).
Logic Function Index	Identifies the logic function. You can select any available function; the only restriction is that nested logic functions require the input logic to have a lower Logic Function Index. If the only option is “undefined”, you have already used all available channels.
Inputs 1–5	Selects the source of the input state for each stage of the boolean calculation. External Input Channels, GOOSE Virtual Input Channels, trigger detectors from other channels and previously-defined Logic Functions are available.
Inversion Blocks	Allows the input state to be inverted. Click to activate and move mouse to select option before releasing.
Logic Gates	NOT, AND, NAND, OR, NOR, Exclusive OR, and Exclusive NOR. Click to activate, scroll window to display, click icon to select
Delay Module	Assert: delays the output for the specified time. Deassert: locks in the output state for the specified time. 0 to 20 seconds in half-cycle increments.
Trigger Action	
Enable	Enables or disables the associated trigger. A trigger can be disabled without altering the rest of its settings.
Fault	Initiates a fault (high speed) recording when triggered.
Swing	Initiates a swing (low speed) recording when triggered. If both Fault and Swing are enabled, the recorder will attempt to create a combined record.
Log	Logs a message in the Event Log when triggered.
Notify	Contacts the RecordBase Central Station when triggered. Can be used to initiate wide area swing recordings and/or automated record transfer.
Cross Trigger	Activates the cross-trigger contact (#4) to trigger another device.
Priority	Specifies the priority to be assigned to records created by this trigger. The priority is used to determine Central Station notification. 1 - 3 (3 is the highest priority).
Alarm Contact	Specifies a rear panel contact to be closed when triggered. Contacts are closed momentarily for one second. Contact assignment is not exclusive, allowing multiple triggers to activate the same contact. Available contacts: 2, 3, 5, 6, 7 or 8 on a 36 channel model. Contacts 1 and 4 are reserved for Recorder Functional and Cross-Trigger respectively. Contacts assigned for storage alarms ,Time Sync loss alarm or IEC 61850 communication failure alarm (“TESLA Alarms” on page 9-7) will not be available for use here.

9.15 Fault Locator Functions

Description

Fault Locator Functions produce distance-to-fault informations based on the impedance measured on the specified voltage and current channels. The information is logged and available through IEC 61850.

Input

Initiating Event: any External Input Channel, GOOSE Virtual Input Channel or trigger detector from any other channel or function.

Voltage Channels: must be Analog Input Channels monitoring voltage.

Current Channels: can be Analog Input Channels or Summation Channels monitoring current.

The correct phases must be selected to achieve the desired results.

Calculation

When a user-configurable event occurs, the fault locator assesses the distance to fault using the user-supplied line parameters. If one or more of the impedances is consistent with a fault on the line, fault identification (e.g. B-G) and location information is generated in the form of an event message.

A fault location event will be calculated if the following conditions are met (as shown in “Fault Locator calculation” on page 9-49):

1. The initiating event goes high AND
2. The fault impedance is within the fault location pick-up zone. This zone is 0% to 120% forward reach of the circle and calculated distance is less than the line length.

The lowest impedance within the pick-up zone between Zan, Zbn, Zcn, Zab, Zbc and Zca is used to calculate the fault location.

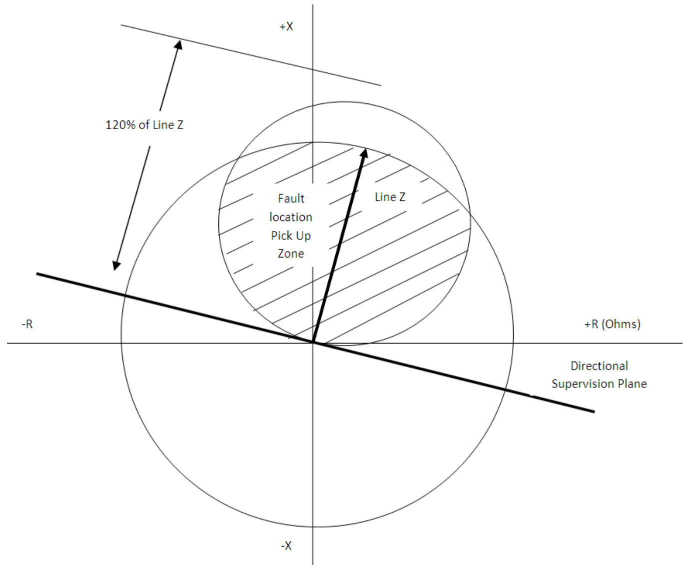


Figure 9.27: Fault Locator calculation

Triggers

N/A

Recording

Fault Locator Functions are not recorded.

Number of Channels

10 Fault Locator Functions are available.

Types

FLoc

Notes

When a Fault Locator Function is triggered, it writes a message into the Event Log identifying the time, the Element, the faulted type (e.g. A-B, B-G...) and the distance to fault.

The output of the Fault Locator Function is available through IEC 61850. It cannot be metered or trended.

Settings

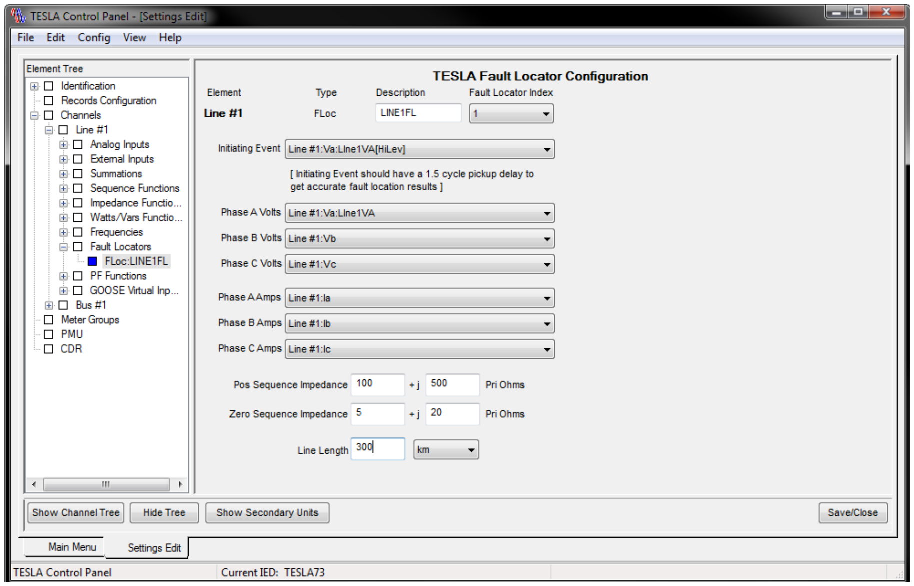


Figure 9.28: Fault Locator Function Configuration

Table 9.14: Fault Locator Function Settings	
Element	Identifies the group to which this channel belongs. The Element forms the first part of the channel name. The Element is selected when the channel is created and is fixed once assigned when you are working in the Element Tree view.
Description	Optional field (12 characters). Provides an additional description of the channel that forms part of the channel name. Use if Element Name and channel Type do not sufficiently identify the channel. (Ref: “Channel Grouping and Naming” on page 9-13).
Fault Locator Index	Identifies the Fault Location function. You can select any available function. If the only option is “undefined”, you have already used all available channels.
Initiating Event	Any External Input Channel, GOOSE Virtual Input Channel or trigger detector from any other channel or function. Note that the initiating Event typically requires a 1.5 cycle delay to obtain accurate fault location information.
Voltage and Current Inputs	Select the voltage and current inputs used for Fault Location calculation.
Line Impedance	The Positive and Zero sequence impedance of the line. You may enter in either Primary or Secondary Ohms by toggling the “Show Primary/Secondary Units” button.
Line Length	Length of the line in either kilometres or miles.

9.16 Power Factor Functions

Description

Power Factor Functions monitor the real and reactive power values calculated by a Watts/Vars Channel and trigger depending on total power level. Inductive power factor is defined as a situation where the calculated reactive power is positive. Capacitive power factor is defined as a situation where the reactive power is negative.

Input

A previously-defined Watts/Vars Channel.

Calculation

The Power Factor Detector monitors the watts, vars, and volt-amps values computed by its input channel and operates when the power factor is less than a user-specified threshold. Separate detectors allow separate thresholds for lagging (inductive) and leading (capacitive) power factors. To reduce the incidence of nuisance operations, you may specify a minimum volt-amps setting.

Triggers

Inductive power factor – Low magnitude

Capacitive power factor – Low magnitude

To prevent multiple triggers on threshold conditions, the power factor triggers have a fixed hysteresis of 0.05.

Recording

Power Factor Functions are recorded in the low-speed recordings.

Number of Channels

18 Power Factor Functions are available.

Types

PF

Notes

Power factor readings are available to the metering display, IEC 61850 and the long term trending function.

Settings

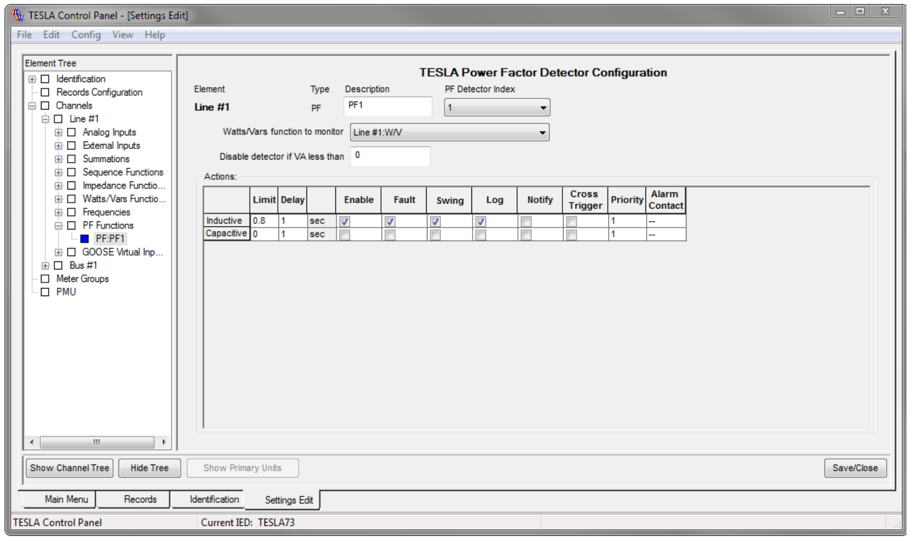


Figure 9.29: Power Factor Function Configuration

Table 9.15: Power Factor Function Settings	
Element	Identifies the group to which this channel belongs. The Element forms the first part of the channel name. The Element is selected when the channel is created and is fixed once assigned when you are working in the Element Tree view.
Description	Optional field (12 characters). Provides an additional description of the channel that forms part of the channel name. Use if Element Name and channel Type do not sufficiently identify the channel. (“Channel Grouping and Naming” on page 9-13).
PF Detector Index	Identifies the Power Factor function. You can select any available function. If the only option is “undefined”, you have already used all available channels.
Watts/Vars function to monitor	Specifies which Watts/Vars channel to use as input. Must be previ-ously defined.
Trigger Settings	
Disable detector if VA less than	Allows the trigger to be supervised by a minimum VA level. Can be set in primary or secondary units.
Limit	Power factor trigger level. 0 to 1 in 0.001 increments.
Delay	Requires the element to be energized before an active state is deter-mined. Settable from 1 to 10,000 seconds in 1 second increments.
Trigger Action	
Enable	Enables or disables the associated trigger. A trigger can be disabled without altering the rest of its settings.
Fault	Initiates a fault (high speed) recording when triggered.

Table 9.15: Power Factor Function Settings	
Swing	Initiates a swing (low speed) recording when triggered. If both Fault and Swing are enabled, the recorder will attempt to create a combined record.
Log	Logs a message in the Event Log when triggered.
Notify	Contacts the RecordBase Central Station when triggered. Can be used to initiate wide area swing recordings and/or automated record transfer.
Cross Trigger	Activates the cross-trigger contact (#4) to trigger another device.
Priority	Specifies the priority to be assigned to records created by this trigger. The priority is used to determine Central Station notification. 1 - 3 (3 is the highest priority).
Alarm Contact	Specifies a rear panel contact to be closed when triggered. Contacts are closed momentarily for one second. Contact assignment is not exclusive, allowing multiple triggers to activate the same contact. Available contacts: 2 or 3 on a 18 channel model and 2, 3, 5, 6, 7 or 8 on a 36 channel model. Contacts 1 and 4 are reserved for Recorder Functional and Cross-Trigger respectively. Contacts assigned for storage alarms or Time Sync loss alarm or IEC 61850 communication failure alarm (“TESLA Alarms” on page 9-7) will not be available for use here.

9.17 Meter Groups

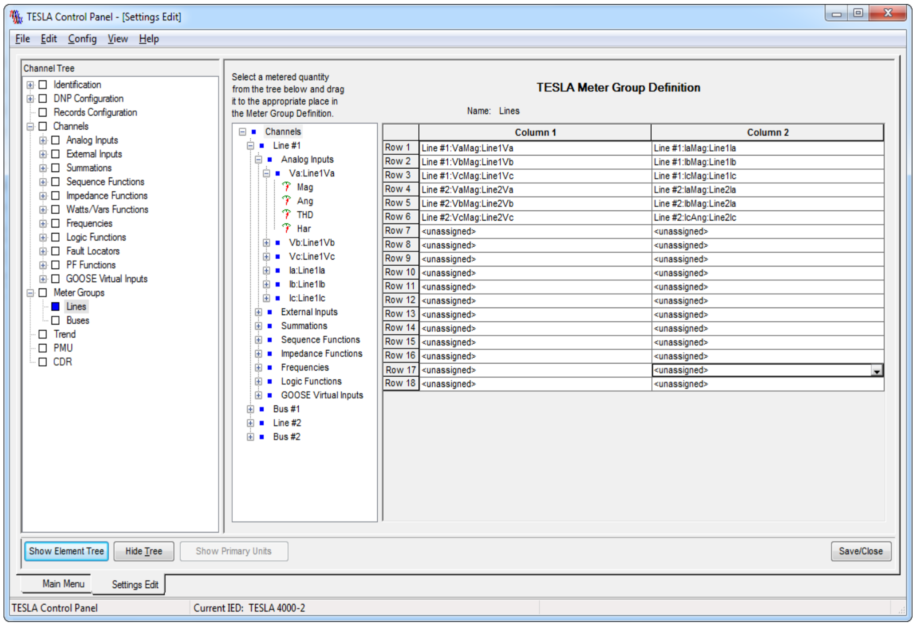


Figure 9.30: Meter Group Configuration Screen

A Meter Group is a collection of measured and calculated values that are presented as a group by the TESLA Control Panel's Metering function. Metering Groups are referred to by a user-specified name, and the name of the Metering Group appears on the tab in the Metering display.

There are two default metering groups and ten user-defined groups for a total of twelve metering groups.

The Metering display has fixed displays for analog and external input channels. You may add additional displays containing any set of channels, organized as you wish.

1. To create a meter group, right-click on the *Meter Groups* entry in the Configuration menu.
2. Select *Add Meter Group*. A New Meter Group line appears, and the New Meter Group text is selected.
3. Type the Meter Group name, then *Enter*. The text you type replaces the New Meter Group text.
4. In the meter group screen, you can place any defined channel in any cell. The resultant meter group display will show the desired channels in the specified place on the screen.

> Phase angle readings displayed in meter groups are based on the configured Phase Angle Reference Channel "Phase Angle Reference Channel" on page 9-17.

9.18 Trend Logging

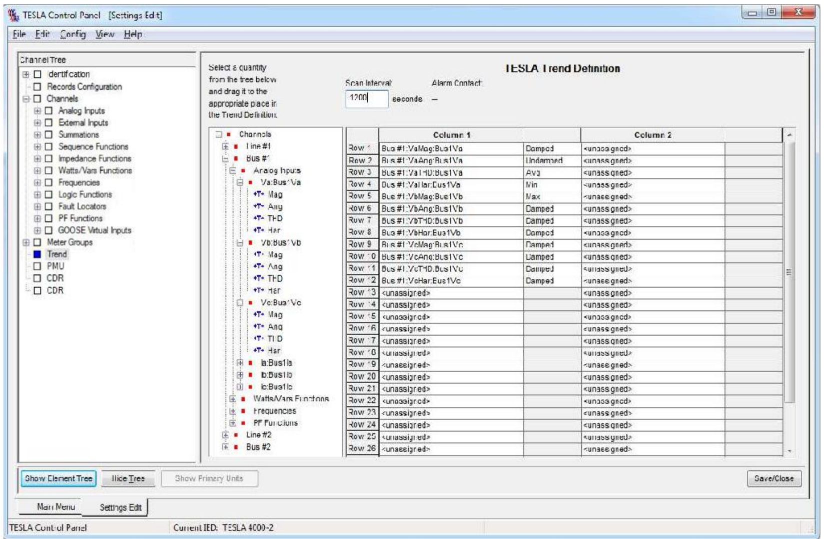


Figure 9.31: Trend Log Configuration

The TESLA recorder can log periodic measurements over an extended period of time. Up to 60 values can be logged at intervals ranging from 10 seconds to one hour.

All recorder channels and calculated values are available for trending. Event messages can also be stored in the trend log, allowing them to be saved from the normal circular overwrite of the Event Log.

The trend log accumulates data for up to 90 days. When it is full, it can either be set to automatically overwrite the oldest data or to stop logging. A “near full” alarm function is available. The accumulation settings are defined in the Trend Configuration menu (see “Network Redundancy Configuration” on page 8-11).

To configure trend logging select either *New Trend* from the Config menu or *New Trend* from the right-click context menu in either the Channel Tree or Element Tree.

The *Scan Interval* (see Scan Interval on page 9-57) determines the frequency of data logging. It can be set from 10 seconds to 3,600 seconds (one hour).

Choose channels to be trended by clicking on one of the (larger) spaces in the trend grid. Clicking on the arrow that appears, lists all the available channels in the list box that appears adjacent to the space you originally clicked. Alternatively, use the selection tree that appears to the immediate left of the trend grid. Use the tree’s expansion buttons to locate the desired channel, then drag and drop your selection on the grid.

You can control how the data is accumulated between logged values for each trended value. The *Accumulation Modes* are as follows:

Table 9.16: Trend Accumulation Modes:	
Damped (default)	Logs a value representative of the measurements during the interval.
Undamped	Logs the latest value measured during the interval.
Avg	Logs the average measured value over the interval.
Min	Logs the minimum measured value over the interval.
Max	Logs the maximum measured value over the interval.

For more details on trend accumulation modes, see “Trend Accumulation Mode Calculations” on page 9-56.

You can record the same channel with more than one accumulation mode, but you can not record the same channel with the same accumulation mode more than once.

When you have defined a trending process, a long-term event log is started automatically.

If you wish to have the long-term event log without trending any data, define a trend without any channels in it. A daily limit of 1000 events can be stored in the trend log.

Trend Accumulation Mode Calculations

There are five trend accumulation modes available for trend value calculation; Damped, Undamped, Avg, Min and Max. The following is a detailed description of how these five accumulation modes are used to calculate trend data.

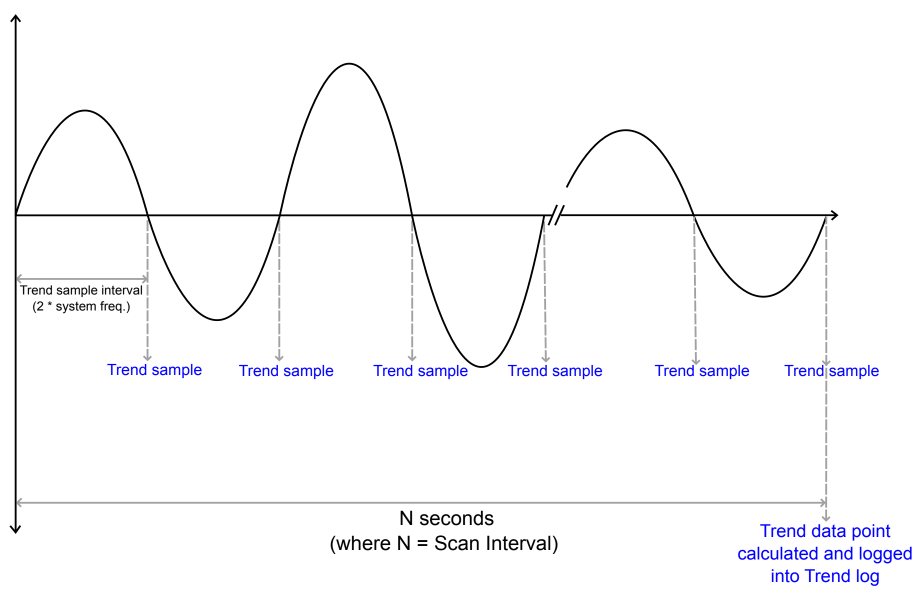


Figure 9.32: Trend calculation

In Figure 9.32, there are two important concepts related the trend calculation process:

- **Trend Sampling:**
  The trend sample is a measurement taken over the trend sample interval. The trend sampling occurs at the frequency of 2 * System Frequency (trend sample interval is 8.33ms for 60Hz or 10ms for 50Hz).
- **Scan Interval:**
  The scan interval determines how frequently one trend sample is logged into the trend log. For Damped and Undamped modes, the latest trend sample in the Scan Interval is directly logged into the trend log. For Avg, Min and Max modes an additional calculation is performed over the entire Scan Interval before a trend sample is logged into the trend log.

Damped

Damped mode uses the following formula for calculating trend samples. This calculation is performed by the TESLA after every trend sample interval.

$$NewDampedValue = PreviousDampedValue + \frac{2 \times (NewSample - PreviousDampedValue)}{SamplingRate}$$

Where,

SamplingRate = 120 for 60Hz or 100 for 50Hz

At the end of the Scan Interval, the latest damped value is logged into the trend log.

Undamped

In Undamped mode, at the end of the Scan Interval, the latest trend sample is directly logged into the trend log.

Avg

In Avg mode, at the end of the Scan Interval, the average value of all trend samples over the entire Scan Interval is calculated and logged into the trend log.

Min

In Min mode, at the end of the Scan Interval, the trend sample with the minimum value within the Scan Interval is logged into the trend log.

Max

In Max mode, at the end of the Scan Interval, the trend sample with the maximum value within the Scan Interval is logged into the trend log.

10 Setting Files Comparison Tool

Setting Files Comparison tool is used to compare two configuration setting files of TESLA and this tool is integrated with TESLA Control Panel (TCP) software itself.

This tool compares TESLA 4000 setting version 406 and up for Model 4000, and all setting versions of Model 4000-SV and Model 4000-A.

10.1 Launching the Tool

"Compare Settings" command button is available in Settings tab.

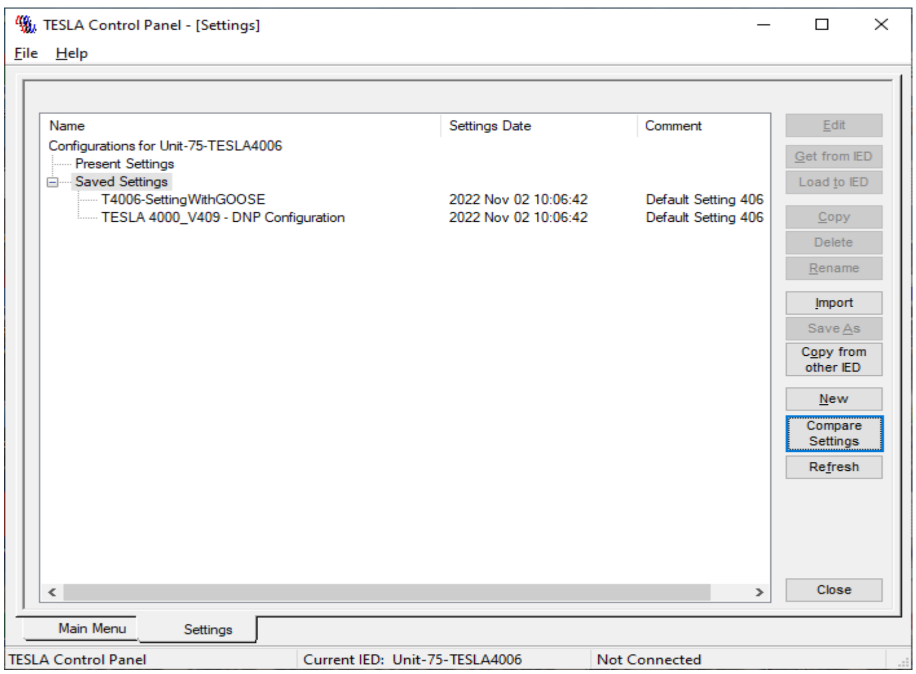


Figure 10.1: Button "Compare Settings" on TESLA Control Panel

By clicking this button will launch the "Tesla Settings File Comparison" tool in separate window.

Select *Import File 1* button to choose the first file to be compared, select *Import File 2* button to choose the second file and select *Compare* button to display the comparison.

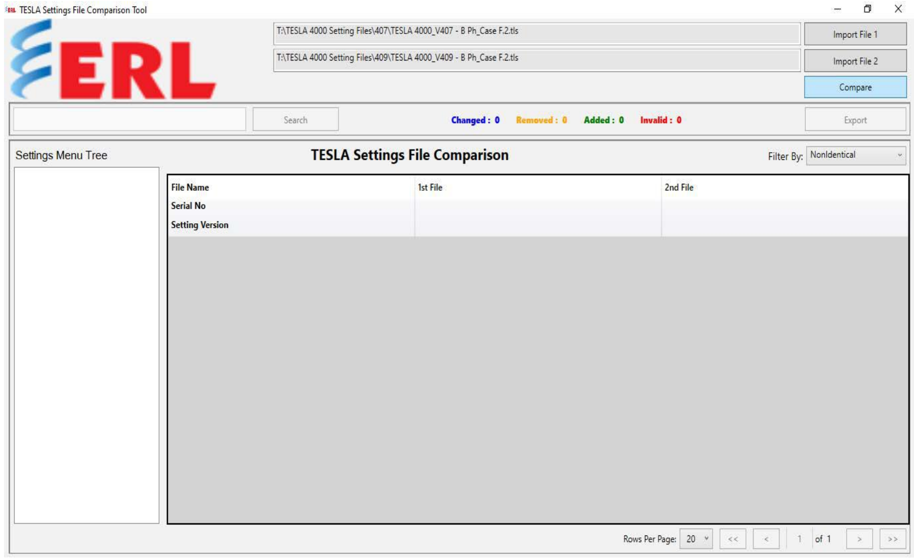


Figure 10.2: TESLA Settings Comparison Tool main screen

10.2 Understanding the TESLA Setting File Comparison Tool

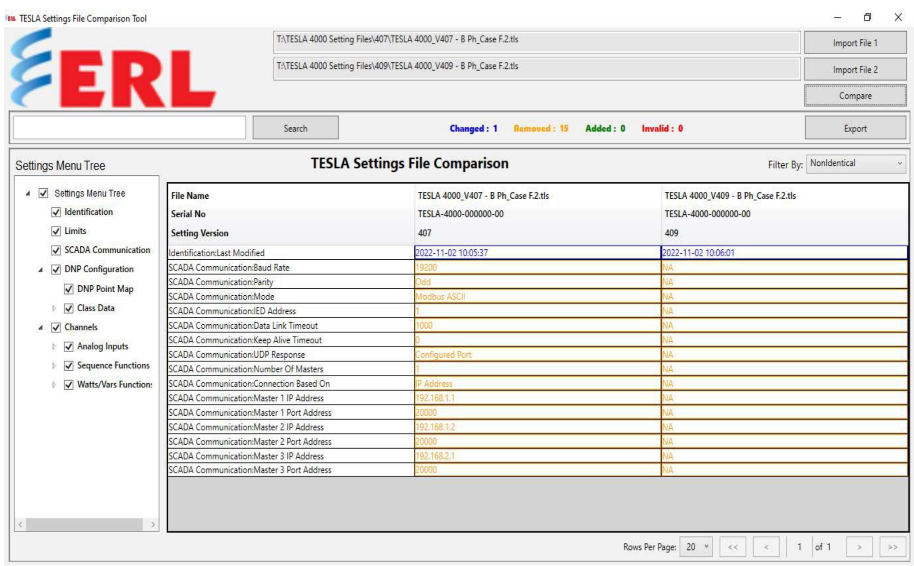


Figure 10.3: TESLA Settings Comparison information display

Settings Menu Tree - This box will display a tree of available channels according to the files selected for comparison. As default all check boxes are selected and “Filter By: Nonidentical” option is setup.

TESLA Settings File Comparison - TESLA Settings File Comparison table displays the setting parameters based on the settings selected under Settings Menu Tree and the filter by option.

This tool uses the setting file 1 as reference file and compare the setting file 2 to find the Nonidentical and Identical setting details.

Nonidentical setting has further categorized as “Changed”, “Removed”, “Added” and “Invalid” to give more distinguished information from the tool.

Filter By: - This is a filter that works along with the items selected on “Settings Menu Tree”. This will display the combination of the selected settings on “Settings Menu Tree” with one of the following options: All, Changed, Removed, Added, Invalid, Identical or Non-Identical.

- **Changed:**

Any setting value is changed in file 2 with reference to file 1 is listed under Changed category and the setting values are shown in Blue color.

- **Removed:**

Any setting parameter is removed in file 2 with reference to file 1 is listed under Removed category and the setting values are shown in Orange color.

- **Added:**

Any setting parameter is added in file 2 with reference to file 1 is listed under Added category and the setting values are shown in Green color.

- **Invalid:**

Any setting value is illegal in file 2 with reference to file 1 is listed under Invalid category and the setting values are shown in Red color.

- **Identical:**

Setting values are same in both the files are listed under Identical category and the setting values are shown in Black color.

Rows Per Page - This is to select the number of rows per page to display in the TESLA Settings File Comparison table.

Pagination - This is to navigate throughout the pages if more than one page is available. The page number is a editable field where user can type the page to be displayed in the TESLA Settings File Comparison table.

Search - This is to search the specific information available in any of the three columns of TESLA Settings File Comparison table. Search command will find the information and displays the setting parameters based on the selection in Settings Menu Tree and the filter by option.

Export - This feature is to provide the report based on the selections in Settings Menu Tree and Filter By option. This tool can export the report files in CSV, Excel, HTML, PDF and XML formats.

Important Note: This tool may compare configuration setting files from previous TESLA Models, however, the result may not be accurate.

11 Record and Log Management

11.1 Records

The Record management services are available from the *Records* tab, accessible from the *Main Menu*.

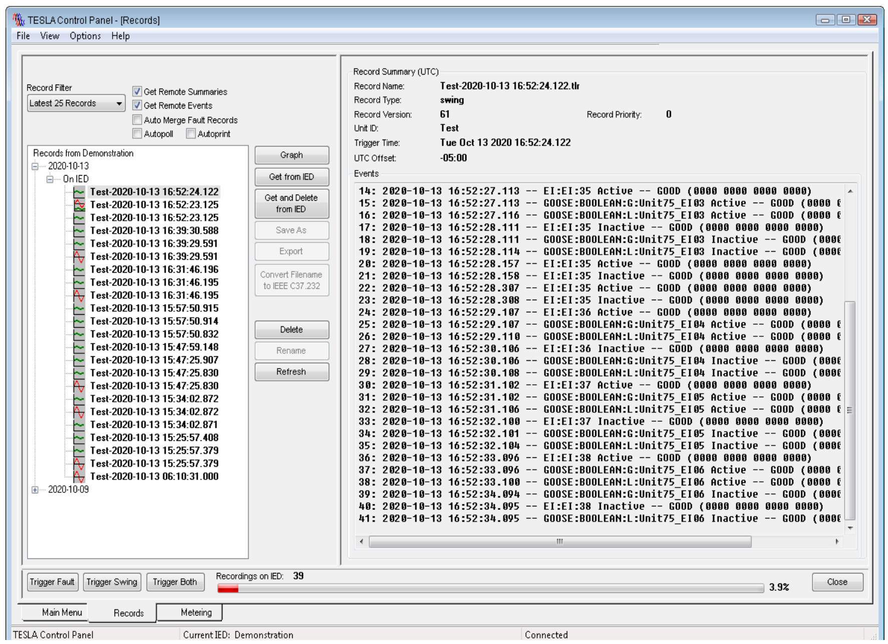


Figure 11.1: Record Listing

Record Lists

The left side of the *Records* tab shows lists of records for the current IED organized by date. Expanding a date entry shows *On IED* and *Local* headings. Records presently on the recorder are shown under the *On IED* heading. Records that have been previously transferred to TESLA Control Panel are shown under the *Local* heading. Records on the IED that have not been transferred to TESLA Control Panel are shown in bold-face. If working offline, only local records are shown.

Record Filter

The list of records displayed is controlled by the *Record Filter* control. The filter applies to both *On IED* and *Local* record lists. The time taken to access the directory can be controlled by selecting an appropriate number of records in the *Record Filter*.

Note that if additional recordings are created through the Trigger Fault, Trigger Swing or Trigger Both buttons, these new records do not displace the earliest fetch/displayed file records in the tree.

> Record timestamps are received from the recorder are in UTC. The record timestamp also displays a "UTC Offset" depending on the time-zone and DST setting on the time screen.

Record Summary

The right side of the *Records* tab shows summary information on the selected record. The summary includes the list of events which occurred during the time-span of the record from the recorder's event log.

Get Remote Summaries/Get Remote Events

When both *Get Remote Summaries* and *Get Remote Events* options are checked, TESLA Control Panel accesses and displays the corresponding recording information in the *Record Summary* and *Events* sections of the right-hand pane. You may eliminate the delay involved in accessing this information by disabling the corresponding check-boxes.

Auto Merge Fault Records

Enabling this feature allows for longer high speed records during conditions with many consecutive triggers. Depending on triggering conditions and configured record lengths, high speed records with durations greater than one minute are possible.

When *Auto Merge Fault Records* is enabled, TESLA Control Panel will merge records with overlapping time durations into a single record. Two or more consecutive records occurring on the same IED will be merged together, as long as the durations of the records overlap. The record merging is handled locally by the TESLA Control Panel software, the records stored on the IED are not affected by this setting. The merging process occurs during the retrieval process when multiple overlapping records are retrieved using the "Get *From IED"* or "*Graph*" buttons.

Autopoll/ Autoprint

When *Autopoll* is checked, TESLA Control Panel will poll the connected TESLA recorder for new record files every 60 seconds and automatically transfer them to the local computer. Only one new record will be transferred at each poll, starting with the newest record. The state of the *Autopoll* enable is persistent to the local computer and retained between TESLA Control Panel sessions and menu navigation. During periods of user inactivity, a count of *Autopoll* records transferred is indicated within the record tab when this feature is active.

Checking *Autoprint* will cause each transferred (via *Autopoll*) record file to be automatically printed on the default Windows printer using RecordGraph's default template. The state of the *Autoprint* enable is persistent to the local computer and retained between TESLA Control Panel sessions and menu navigation and only available when the *Autopoll* feature is enabled.

Graph

Records can be viewed with RecordGraph, ERLPhase's interactive graphing software. To launch RecordGraph, select one or more local records and select the *Graph* button. RecordGraph is also launched when double-clicking on a record.

Get from IED

Selecting a recorder file under *On IED* and then selecting the *Get from IED* button causes a record file on the IED to be transferred from the recorder to your local computer. More than one file can be transferred at the time using Windows file selection function (*Control*/*Shift* + *left*-click). This action will not delete the record on the IED.

Get from IED and Delete

The *Get From IED* and *Delete* button erases the records on the recorder after they have been transferred to TESLA Control Panel and verified.

Save As

Selecting a local record and selecting the *Save As* button copies a record to a specified file. The .tlr file suffix should be retained.

Export

Selecting a local record and selecting the *Export* button launches the Export Utility. Records can be exported in common formats such as COMTRADE for use in other software or playback, for details see 14 Record Export Utility on page 14-1.

Convert Filename to IEEE C37.232

The *Convert Filename to IEEE C37.232* button toggles the filename format between the IEEE C37.232 standard format and the ERLPhase proprietary format. User must enable this option via the *Tools* > *Options* menu. For more information, see “IEEE C37.232 TSD File Naming” on page 14-9.

Delete

The *Delete* button can be used to delete records on the IED or locally. Multiple files can be deleted simultaneously using Windows file selection functions (*Ctrl/Shift + left-click*).

Rename

Select *Rename* to allow a local record file to be renamed. Records on the recorder cannot be renamed.

Refresh

Selecting *Refresh* updates the *Recordings* screen. It checks the local directory and the remote IED (if connected) for new and stored files, updates TESLA Control Panel’s records database and refreshes the screen.

Trigger Fault/ Swing/Both

The recorder can be manually triggered to generate different types of records. *Trigger Fault* creates a high speed transient recording. *Trigger Swing* creates a low speed swing recording. *Trigger Both* creates a combined record.

Note the Swing records may take up to 15 minutes to generate depending on the recorder’s settings.

Recordings on IED

Shows the number of records stored on the recorder and percentage of recording space used.

File>Select Remote

This function is available through the *On IED* menu. If you are online with your TESLA, this function selects all of the recording files displayed in the record list that have not yet been transferred to your local Recordings directory. You may then perform whatever command is appropriate for the selection set, such as a *Get from IED* or a *Get and Delete from IED* Command.

11.2 Trend Log

The trend manager services are available from the *Trend* item, accessible from the *Main Menu*.

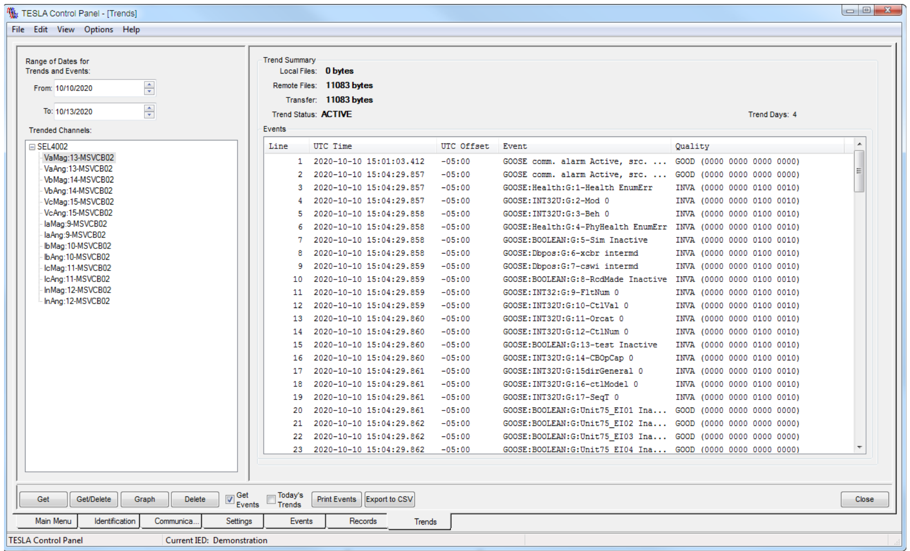


Figure 11.2: Trend Listing

Range of Dates

Set the time range using the two date control boxes, *From* and *To*. The initial setting is for the previous three days. When you change these settings, the remainder of the display updates to show data pertinent to your chosen period. If you are connected to a TESLA, both local and remote data are combined in the tree; otherwise, the display shows only data resident on your local computer.

Trended Channel

The tree on the left side of the screen shows the channel names of the trended data available for the period you have selected. You may select any number of channels from the tree for further operations.

Select more than one channel by using the Ctrl and Shift keys in conjunction with mouse clicks and arrow keys.

Trend Summary

The *Trend Summary* section of the screen shows statistical information about the selected files. *Local Files* indicates the amount of space used by the selected trend files on your local computer. *Remote Files* indicates the amount of space used by the selected trend files on the IED. *Transfer* refers to files that are on the IED, but not on your local computer, and represents the total amount of bytes in stored trend files that would be transferred before further processing takes place.

Events

The *Events* section of the display shows all the events recorded during the period of interest set with the range of dates. The Event log includes the associated Data Quality (see “Data Quality” on page 20-1).

Get, Get/Delete

When you click *Get* all of the trends not previously transferred are transferred to your computer. If you select *Get/Delete*, all files successfully transferred from the IED will also be deleted from the IED.

Graph

The trend data selected in the Trended Channels list is viewed with RecordGraph, ERLPhase's interactive graphing software, for details see 13 Graphing Records on page 13-1. Any selected trend data not already in your computer is transferred prior to graphing.

Delete

The trend data selected in the Trend Channel list is removed from your computer. If you are currently connected, you have the option of removing the data on the IED files as well.

Get Events

Each time you change the Range of Dates, the list of events on the right side of the screen is updated. If you are not interested in this action, remove the check mark from the checkbox.

Today's Trends

If the Range of Dates includes data that is currently being recorded, some of the data may not be in a form suitable for transfer to TESLA Control Panel. If this checkbox is selected, TESLA Control Panel will send a request to the IED to convert the most recent data so that it can be transferred. The time that this takes may be significant, and if you do not have a need for this data, the feature may be disabled by removing the check mark from the check box.

Print Events

The list of events in the *Events* portion of your screen is printed.

11.3 Event Log

The event log services are available from the *Events* tab, accessible from the *Main Menu*.

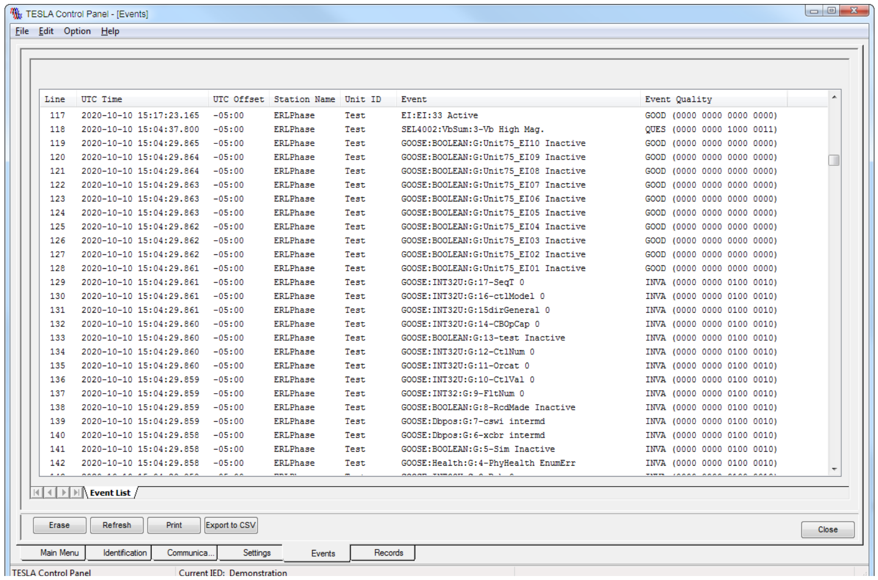


Figure 11.3: Event Log Display

The recorder maintains a log of time-stamped events. Event messages can be produced by any of the recorder’s detectors if configured to do so.

Event messages can also be viewed in the Record Summary and Trend Summary displays

Circular Storage

The Event Log stores up to 1000 events with automatic overwrite of the oldest event. For greater event storage, or to prevent automatic overwrite, the recorder’s trending function can also be used to store event messages.

Event Messages

The text of an event message is derived from the configuration of the detector that generates it.

The general format for event message is:

Line# Date/Time UTC Offset Station ID Unit ID Event Description Event Quality

Table 11.17: Event Log Message Details	
Line #	Index number for identifying events. Newest event is #1
Date/Time	Date and time of the event. Displayed according to time display setting (see “Time Display Settings” on page 8-26)
UTC Offset	The IED’s UTC Offset (see “Time Display Settings” on page 8-26)
Station ID	The Station ID, determined by the setting on the Identification screen (see “Unit Identification” on page 8-2)
Unit ID	The Unit ID, determined by the setting on the Identification screen (see “Unit Identification” on page 8-2)
Event Description	Description of the event which generated the event message
Event Quality	The data quality associated with the event. See “Data Quality” on page 20-1 for more details on the Data Quality implementation.

Examples of Event Messages can be seen above in Figure 11.3: Event Log Display.

Printing Event Log

The events in the Event Log are available for copying and printing while connected to the IED. To print the event log either press the *Print* button at the bottom of the screen, select *File > Print Events,* or press *Ctrl-P*.

Controls

The event display is a static snapshot of the contents of the event log. You can use the buttons at the bottom to access the Erase, Refresh, Print functions, and Export to CSV function. Users can copy selected events by selecting *Edit > Copy*, or by pressing *Ctrl-C*. Print commands are available under the File menu.

Table 11.18: Event Screen Functions	
Refresh	Updates Event List by getting a new list from remote IED and updates the Event List screen.
Erase	Removes all events from remote IED.
Print	Prints all the events to a local printer.
Export to CSV	Exports the event list to CSV format to a user-selected file location.

11.4 Audit Trail

The Audit Trail is accessed by selecting *Audit Trail* from the *Main Menu.* Audit Trail is only accessible to users with the “SECAUD” role assigned. The purpose of the Audit Trail is to display a log of sequential timestamped security notifications. For more information on the Security Notifications, see section 18.4 Security Notification System on page 18-10.

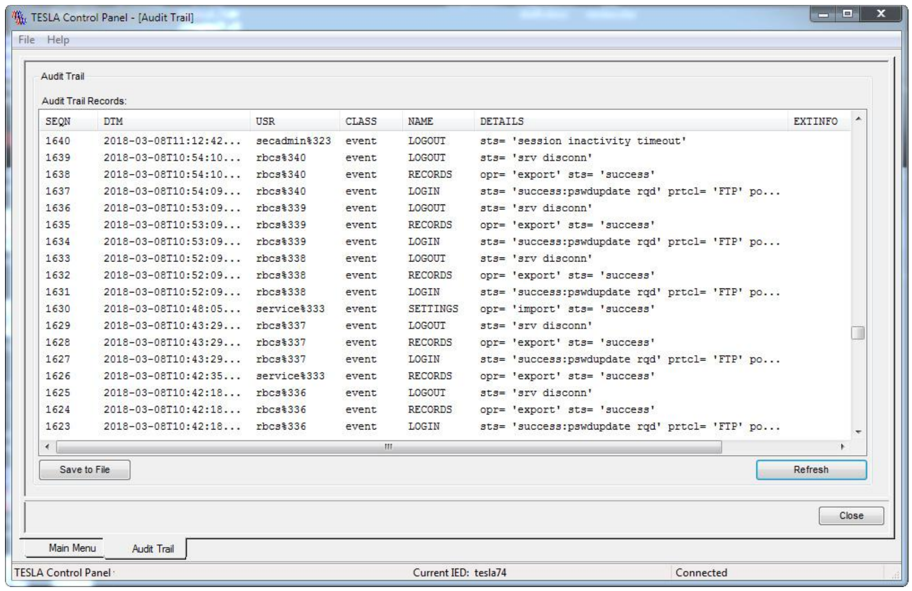


Figure 11.4: Audit Trail

Save to File

The *Save to File* option allows for saving of the current Audit Trail to csv format.

Refresh

The *Refresh* button updates the Audit Trail to display any new security alarms or events.

12 Continuous Disturbance Recording

Continuous Disturbance Recording (CDR) implemented in the TESLA 4000-SV recorder allows the gathering of power system disturbance data to review and analyze transmission and generation protection systems. The TESLA 4000-SV recording system incorporated CDR for NERC standards requirements, including user-selectable recording channels and user-selectable recording sample rate.

NERC Standards:

1. Standard PRC-002-5 – Disturbance Monitoring and Reporting Requirements
2. Standard PRC-028-1 – Disturbance Monitoring and Reporting Requirements for Inverter-Based Resources

The CDR feature incorporated in the TESLA 4000-SV Recording System meets and exceeds the requirements of NERC Standards as represented in the following table. As per the latest NERC standard PRC-028-1, TESLA 4000-SV with 64 GB or 1 TB flash memory option can store CDR data for more than 20 days with 60 samples per second rate with all the sampled value channels configured.

Table 12.1: NERC Standards

Continuous Recording Requirements	PRC-002	PRC-028	TESLA 4000-SV
Input sampling rate (samples per second)	At least 960	At least 960	1920 - 30960
Output recording rate (records per second per channel)	At least 30	At least 60	6 - 60
Data retention period (days)	10	20	At least 22 days with maximum reporting rate and maximum 36 number of channels configured for the 64GB storage. With 1TB storage, it can be extended up to 36 days.

The continuous disturbance recording data retention period depends on the number of selected channels, flash memory size ordered and on the selected sample rate. Estimated continuous disturbance recording data retention periods (in days) for various combinations of channel numbers, flash memory and the sampling rates are shown in Table 12.2.

Table 12.2: Estimated CDR retention period in days at 60Hz

	Number of channels	Sample Rate (RMS records per second per channel)						
		6	10	12	15	20	30	60
16GB (obso-lete)	8	183	110	91	73	55	36	18
	12	143	85	71	57	42	28	14
	18	107	64	53	42	32	21	10
	36	61	36	30	24	18	12	6
64GB	8	673	404	336	269	202	134	67
	12	523	314	261	209	157	104	52
	18	392	235	196	157	117	78	39
	36	224	134	112	89	67	44	22
1TB	8	1082	649	541	432	324	216	108
	12	841	505	420	336	252	168	84
	18	631	378	315	252	189	126	63
	36	360	216	180	144	108	72	36

The general configuration screen is reached by selecting *Settings* from the *Main Menu*; the main Continuous Recording screen is reached by selecting *Continuous Recording*. See Figure 12.1: Main Menu showing the Continuous Recording menu option.

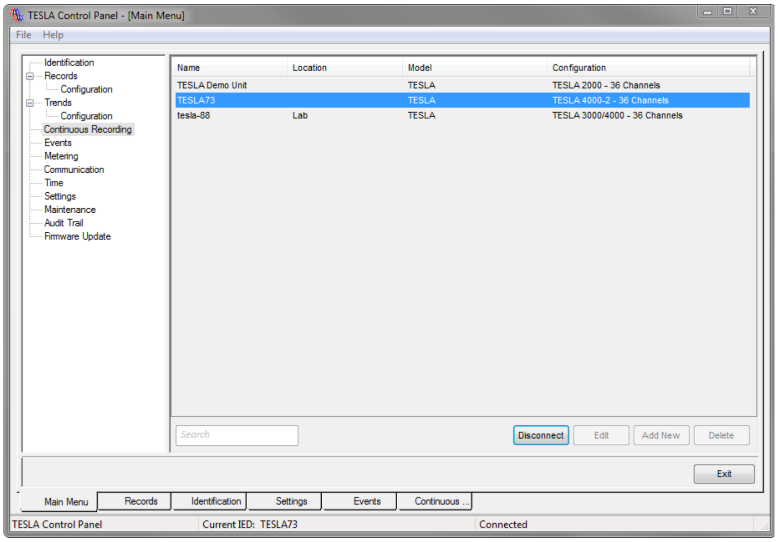


Figure 12.1: Main Menu showing the Continuous Recording menu option

Configuration

Selecting *Settings* from the main menu of the TESLA Control Panel shows a configuration view. If the Continuous Disturbance Recording is not configured, right-click and select New CDR to display the continuous disturbance recording channel configuration view.

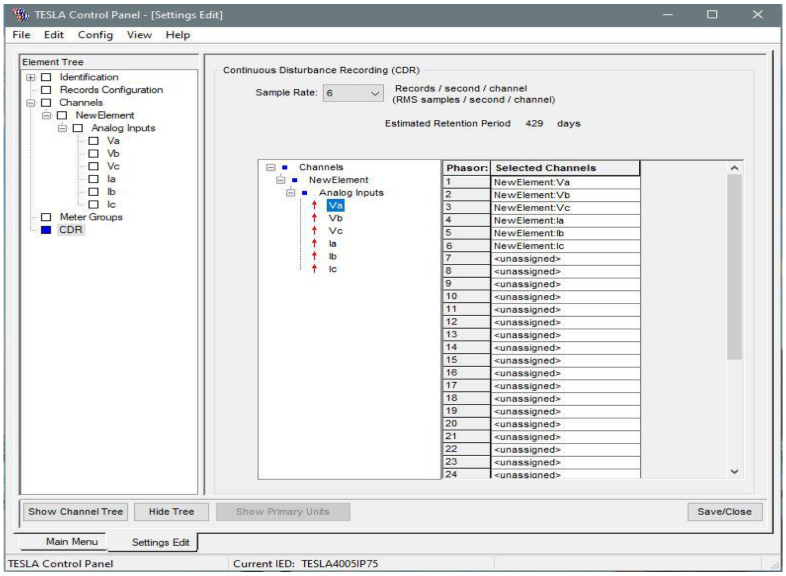


Figure 12.2: Configuring Continuous Disturbance Recording

Select channels from the tree view by dragging the channel name and dropping it on the selected channels grid view on the right hand side or by selecting a channel from the list in the grid view - a maximum of 36 channels can be selected.

Select the continuous disturbance recording rate from the *Sample Rate* list box. Depending on the system frequency, the list box is filled with available sample rates. Selecting channels based on the current Sample Rate, displays available data retention period in the read-only *Estimated retention period (days)* display box.

CDR Sampling Rates

The following table shows the available sampling rates at the corresponding system frequency.

Table 12.3: CDR Sampling Rates

System Frequency	Continuous disturbance recording sample rates (rms records/second/channel)						
60 Hz	6	10	12	15	20	30	60
50 Hz	5	-	10	-	-	25	50

Number of Continuous Disturbance Recording Channels

The number of continuous disturbance recording channels is user-configurable and limited only by the number of analog inputs available at any given time according to the analog input sampling rate as shown above. Only analog input data and frequency channels are stored; use RecordGraph software for derived channels, such as Watts, Vars, etc.

Data Storage and Retention Period

TESLA 4000-SV units come equipped with a 64GB flash drive for data storage suitably partitioned for continuous disturbance recording to function. Optional 1TB flash memory is available.

Continuous disturbance recording data retention period depends on the number of selected channels and on the selected sample rate. Estimated continuous disturbance recording data retention periods (in days) for various combinations of channel number and sampling rate are displayed in TESLA Control Panel's Configuration screen, for details see "Configuring Continuous Disturbance Recording" on page 12-3.

After all storage space designated for the continuous recording data is consumed, the oldest data is automatically deleted and released storage space is reused to store newly accumulated data. There is no indication about recycling of the continuous disturbance recording data storage space provided.

Continuous Disturbance Recording Status

The status of continuous disturbance recording and the time interval for each unit that has continuous recording data accumulated is displayed in TESLA Control Panel's *Continuous Recording* screen. The following Status types are possible:

- Not Supported: TESLA does not have enough storage to support CDR
- Not Connected: not connected to TESLA
- Active: CDR active, normal operation
- Disabled: CDR is not configured Alarm: CDR storage corruption

In the case of the Alarm status of continuous recording, an appropriate message is logged to the Event Log.

Continuous Recording Screen

Selecting the Continuous Recording branch in the left-hand side tree brings up the Continuous Recording Screen below:

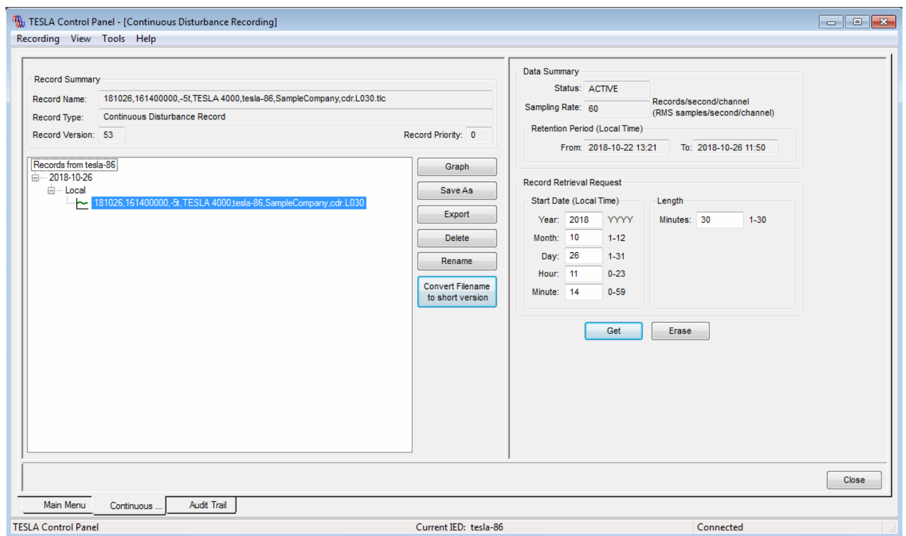


Figure 12.3: Continuous Disturbance Recording Screen

Table 12.4: CDR Screen controls

Get	Entering appropriate parameters in the Record Retrieval Request section and selecting the **Get** button retrieves and saves a CDR record to the local disk.
Erase	Selecting the **Erase** button erases all CDR data on the TESLA recorder. A confirmation dialog is displayed before this action is carried out.
Record Retrieval Request	Enter year, month, day, hour and minute information in the start date Section, and a Length for the requested record. These fields are pre-filled with a time that is computed from the To time minus the initial Length value.
Graph	Launch RecordGraph with the selected record or records.
Save as	Brings up a dialog to save the selected record with a new name and/or location.

Table 12.4: CDR Screen controls

Export	Brings up the Export utility to export the selected record in a different format.
Delete	Deletes the selected records from the local file system.
Rename	Allows the user to rename the record keeping the original file extension.
Convert Filename	Allows the user to toggle between the ERLPhase proprietary and IEEE C37.232 file naming structures. Note: The IEEE C37.232 Long Filenames setting must be enabled from the Options menu in order for this feature to feature to be available. See “IEEE C37.232 TSD File Naming” on page 14-9 for more details.

Safe Shutdown Mode

Since data is being continuously written to the storage device, it is important to follow a safe shutdown procedure. This will ensure data integrity.

Safe Shutdown Mode is available on the TESLA Control Panel Identification screen.

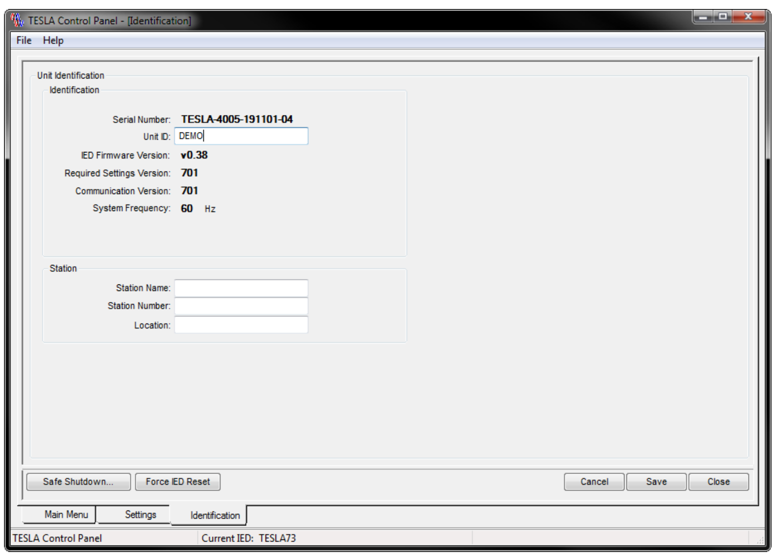


Figure 12.4: Unit Identification - Safe Shutdown

The command Safe Shutdown Mode is available only at the service access level for TESLA Control Panel or via Port 450 login for maintenance utilities. When the command Safe Shutdown Mode is used, all TESLA 4000-SV application tasks are stopped ensuring all accumulated data are written out to the flash drive, all open files are closed and the file system status is updated. The front panel Test Mode and Alarm LEDs start blinking indicating that it is safe to turn off the unit. The unit stays in the safe shutdown mode for 15 minutes and then is rebooted automatically. The Event Log will maintain a record of all received Safe Shutdown commands.

Note that the Safe Shutdown command operates differently than the "Force IED Reset" command. The "Force IED Reset" initiates an IED hardware reboot immediately after pressing the TESLA Control Panel button.

Handling Configuration Changes

All accumulated continuous disturbance recording data is discarded every time new settings with modified continuous recording configuration are loaded on TESLA 4000-SV. Continuous recording configuration includes sample rate, analog input configuration, continuous recording channel selection and order.

If changes to existing settings are made and user attempts to load them into the TESLA, the following dialog will appear:

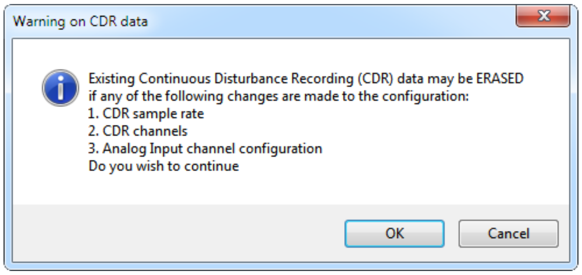


Figure 12.5: Warning on CDR Data

Time Synchronization

In order to accurately calculate the CDR date and time and to ensure data continuity, a valid IRIG-B or PTP sync is required. The use of any other synchronization method (RTC) may cause data continuity issues and for this reason only IRIG-B and PTP sync is supported for use with CDR.

13 Graphing Records

13.1 Getting Started

RecordGraph is a tool used to display and analyze records from ERLPhase relays and recorders. Use it to graphically view the data recorded during fault, swing and trend modes. RecordGraph is integrated with TESLA Control Panel. For more information on RecordGraph and working with records, see the RecordGraph user manual included with the RecordGraph software.

Launch RecordGraph from TESLA Control Panel

Method 1: Records

1. Open TESLA Control Panel.
2. If remote records are to be accessed, login to the recorder using a user-account that has access to remote records. If only locally stored records are to be retrieved, skip this step.
3. Open the *Records* screen from the *Main Menu*.
4. Select a local record from the tree list. If a remote record is to be graphed, select a record from the *On IED* list and press the *Get* button, or double-click on the record. Double-clicking on a remote record will also automatically launch RecordGraph.
5. Click the *Graph* button.

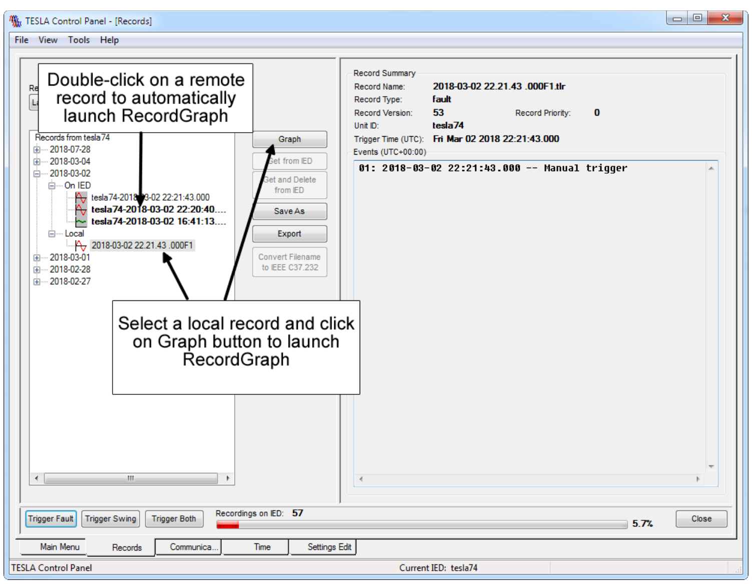


Figure 13.1: Launching RecordGraph from TESLA Control Panel

When the Graph button is clicked from the TESLA Control Panel, RecordGraph is launched with the selected record.

Method 2: Auto Print

If the Auto Print option is checked (enabled) in the Records list view, then RecordGraph will be automatically launched and prints the channels directly on to the Default printer. The layout and channel information is predefined in the <Default> or User-defined template.

Method 3: Trends

1. Double-click *Trends* from the Main Menu.
2. Select the record from the list. To select multiple records, press *Ctrl* key and click on the desired records.
3. Select the *Graph* button at bottom of screen.

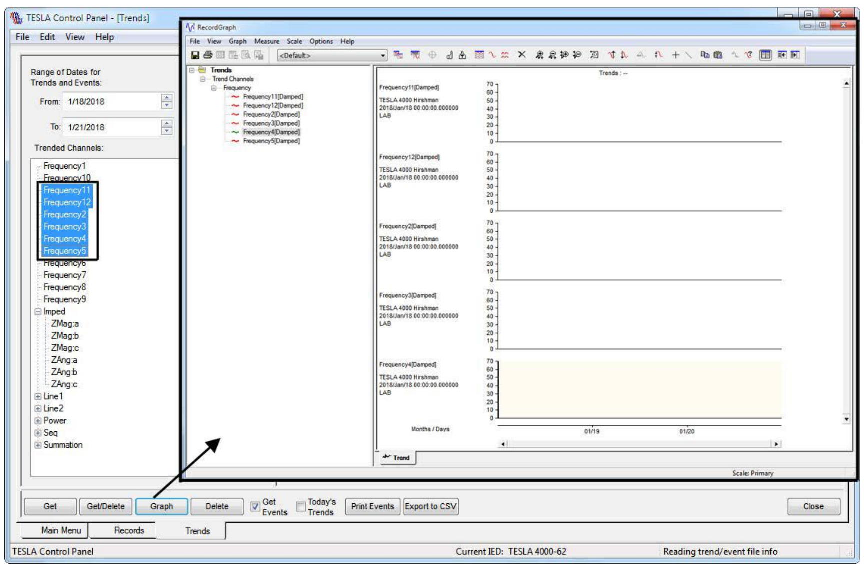


Figure 13.2: Display Trend Records

14 Record Export Utility

The record export utility lets you convert records into different formats for use with other software tools.

COMTRADE

Common Format for Transient Data Exchange (COMTRADE) is an industry standard record format used to share data between tools and to replay faults through a test set. The export utility supports both ASCII and binary COMTRADE formats and creates output that complies with the latest (2013) or older version (1999 and 1991) of the standard.

PTI

Power Technologies Incorporated (PTI) produces widely used power system modeling tools. TESLA records can be exported in a PTI-compliant format for import into PTI tools. The export utility supports ASCII format and creates output that complies with PTI version 1 or version 2 formats.

CSV

TESLA records can be exported in basic comma separated values (also known as comma-delimited) ASCII format suitable for importing into standard tools such as Microsoft Excel.

Launch the Export Utility

To launch the export utility:

1. Double-click *Records* from the *Main Menu*.
2. Select a local record from the record list.
3. Select the *Export* button to launch the Export window.
4. Select the desired export output format and select *OK*.

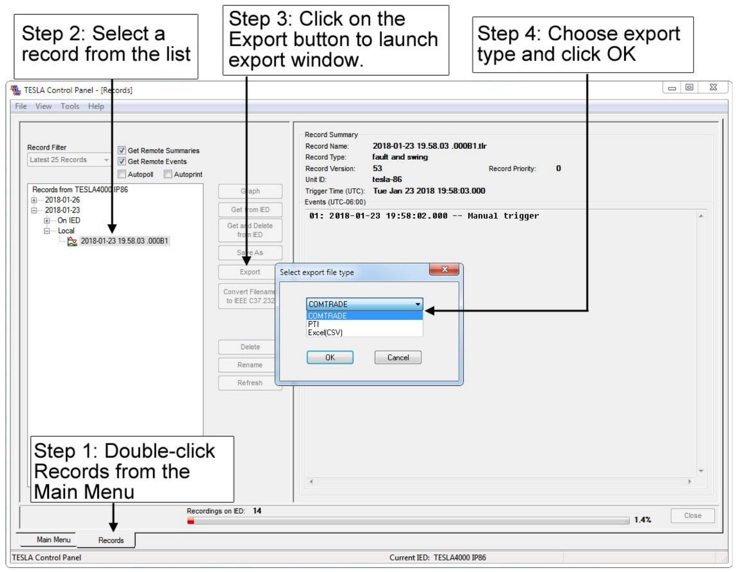


Figure 14.1: Select Export File Type

14.1 COMTRADE Format

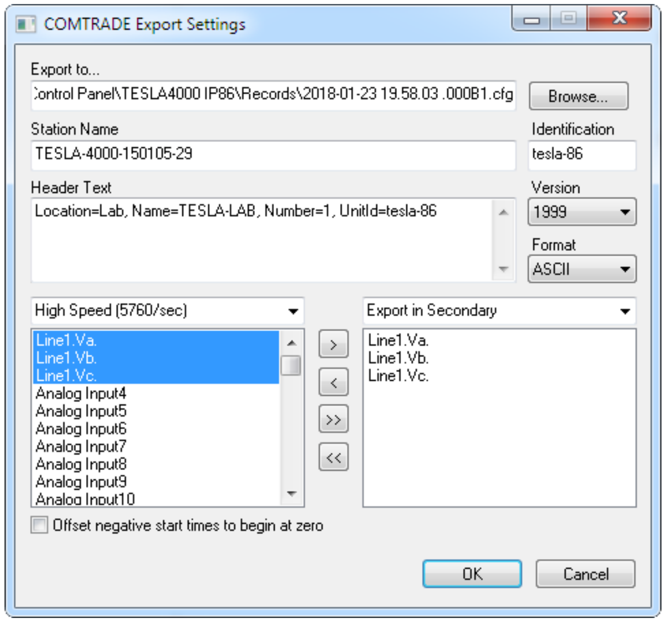


Figure 14.2: COMTRADE Settings

The COMTRADE format (IEEE C37.111) defines a common format for storing digital data records of transient and dynamic swing events. It consists of up to four output files with the same base name and different file extensions: configuration files (.cfg), header files (.hdr), data files (.dat) and optional information files (.inf). The COMTRADE Export Utility produces the configuration, header and data files.

With reference to Figure 14.2: COMTRADE Settings,

Table 14.1: COMTRADE Export Settings

Name	Function
Export to...	The base filename and directory of the output files are set using the Export to. option. By default the base filename is the same as the record you are exporting. You can edit this or use the Browse button to set a new directory and/or base filename.
Station Name and Identification	The Station Name and Identification fields are set by default using information from this recorder. They are written as the first line in the.cfg output file.
Header Text	The Header Text field contains the text written into the COMTRADE header (.hdr) file. By default, the field contains the Location, Name, Number and the Unit ID of the unit that produced the record. This text can be modified, deleted or extended as desired.

Table 14.1: COMTRADE Export Settings

Version	The Version field lets you select the revision of COMTRADE standard to produce. COMTRADE has been an evolving standard and a number of changes have been made over the years. 2013, 1991 and 1999 COMTRADE versions are supported.
Format	The Format field specifies that the data in the COMTRADE file (ASCII or BINARY format). ASCII data has the advantage of being usable by simple text editor and spreadsheet programs, but results in a significantly larger record relative to binary format. BINARY format is therefore recommended if the software package you will be using the data in supports binary format COMTRADE.
Selecting Channels (Exported Channels)	You must select the channels from the record that you want to include in the output file. For convenience, the digital data recorded is classified into: • High Speed: Analog and external digital input channels sampled at the high speed transient data rate. • Low Speed (60/sec): Analog input channels sampled at the low speed swing data rate. Select the desired channel from the list with a left-click. Multiple channels can be selected using standard Windows selection actions (click + Ctrl or Shift keys).
>	Place selected channels in the Exported Channels list box.
>>	Place all channels into the Exported Channels list box.
<	Delete a channel from the Exported Channel list box.
<<	Delete all channels from the Exported Channel list box.
Offset negative start times to begin at zero	When checked, this option shifts the negative time to start from zero.

See “Record Export Timestamps” on page 8-28 for details on the COMTRADE export timestamp format.

14.2 PTI Format

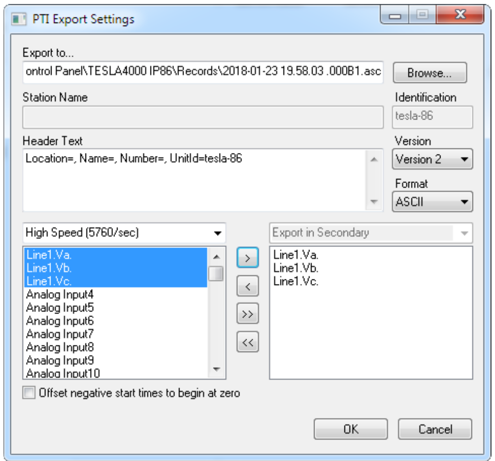


Figure 14.3: PTI Settings

The PTI file format is used to import records into the Power Technologies Incorporated system modeling software.

Output File PTI export produces a single output file with an .asc extension.

Table 14.2: PTI Settings

Name	Title
Export to...	The base filename and directory of the output files are set using the Export to. option. By default the base filename is the same as the record you are exporting. You can edit this or use the Browse button to set a new directory and/or base filename.
Station Name and Identification	The Station Name field is set by default using the unit's Station Name setting. It is written as the third line in the output file. If desired, you can edit this text. The Identification field is not written to the PTI output file.
Header Text	The Header Text field contains the text that is written as a single line in the fourth line in the output file. By default, the field contains the Location, Name, Number and Unit ID of the recorder that produced the record. This text can be modified, deleted or extended as desired.
Version	The Version field lets you select between PTI version 1 and version 2. Please refer to PTI documentation for details on the differences of these versions. Format Only ASCII format output files are available.
Format	ASCII is the only format option for PTI.

Table 14.2: PTI Settings	
Channel Selection	Use Channel Selection to select channels to export. You must select the channels from the record that you want to include in the output file. For convenience, the digital data recorded is classified into: • High Speed: Analog and external digital input channels sampled at the high speed transient data rate. • High Speed (480/sec): Analog and internal logic channels produced 8 times per cycle. • Low Speed (60/sec): Analog input channels sampled at the low speed swing data rate. • Low Speed (120/sec): Analog calculated channels sampled at the low speed data rate. Select the desired channel from the list with a left-click. Multiple channels can be selected using standard Windows selection actions (click + Ctrl or Shift keys).
>	Place selected channels in the Exported Channels list box.
>>	Place all channels into the Exported Channels list box.
<	Delete a channel from the Exported Channel list box.
<<	Delete all channels from the Exported Channel list box.
Offset negative start times to begin at zero	When checked, this option shifts the negative time to start from zero.

14.3 CSV Format

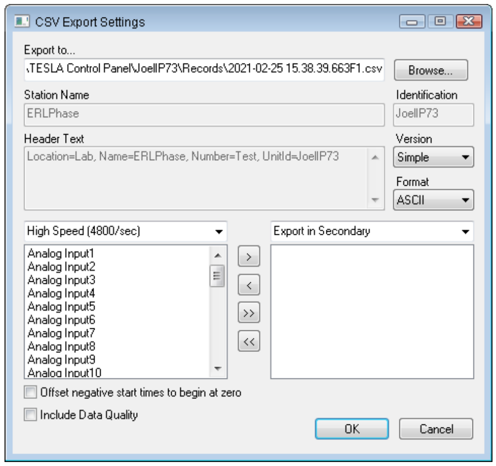


Figure 14.4: Excel (CSV) Settings

The CSV (Comma Separated Value) format is used to import records into a spreadsheet software, such as Microsoft Excel. This format is also known as comma delimited ASCII and can generally be used by most programs that import data arrays.

CSV export produces a single output file with a .csv extension, which is recognized by Microsoft Excel.

Table 14.3: CSV Export Settings

Name	Function
Export to...	The base filename and directory of the output files are set using the Export to... option. By default the base filename is the same as the record you are exporting. You can edit this or use the Browse button to set a new directory and/or base filename.
Station Name and Unit ID	The Station Name and Identification fields are not written to the CSV format output file.
Header Text	There is no header text written to the CSV format output file.
Version	There are no version options for the CSV output.
Format	ASCII is the only format options for the CSV output.

Table 14.3: CSV Export Settings

Channel Selection	You must select the channels from the record that you want to include in the output file. For convenience, the digital data recorded is classified into: • High Speed: Analog and external digital input channels sampled at the high speed transient data rate. • High Speed (480/sec): Analog and internal logic channels produced 8 times per cycle. • Low Speed (60/sec): Analog input channels sampled at the low speed swing data rate. • Low Speed (120/sec): Analog calculated channels sampled at the low speed data rate. Select the desired channel from the list with a left-click. Multiple channels can be selected using standard Windows selection actions (click + Ctrl or Shift keys).
>	Place selected channels in the Exported Channels list box.
>>	Place all channels into the Exported Channels list box.
<	Delete a channel from the Exported Channel list box.
<<	Delete all channels from the Exported Channel list box.
Offset negative start times to begin at zero	When checked, this option shifts the negative time to start from zero.
Include Data Quality	When checked, this option includes the data quality as a column for each channel

See “Record Export Timestamps” on page 8-28 for details on the CSV export timestamp format.

14.4 IEEE C37.232 TSD File Naming

TESLA Control Panel supports the use of the C37.232-2011 IEEE Standard for Common Format for Naming Time Sequence Data Files (COMNAME). Feature set-up is accessed by selecting *Tools > Options* in the Records and CDR menus, allowing the user to activate the C37.232 conversion capability at a workstation level. A company Name entry is required and used as a portion of the filename construction.

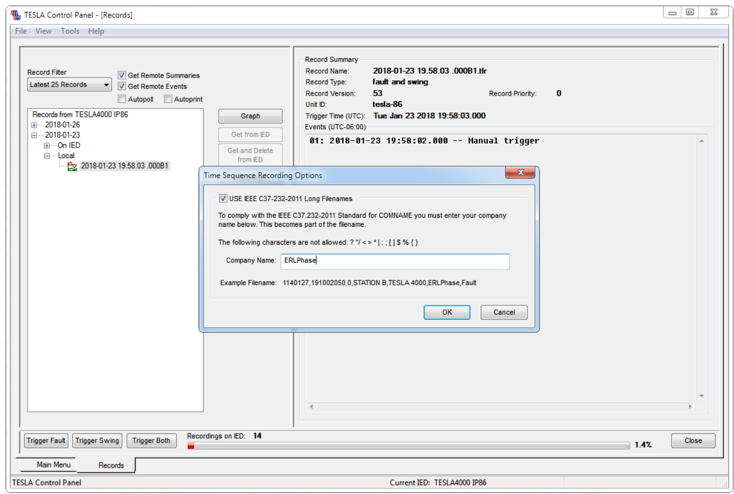


Figure 14.5: Time Sequence Data (TSD) Record Settings

Feature activation allows local TSD Record and CDR names to be toggled between ERLPhase proprietary and C37.232 file naming structures. This does not affect records currently stored on the IED.

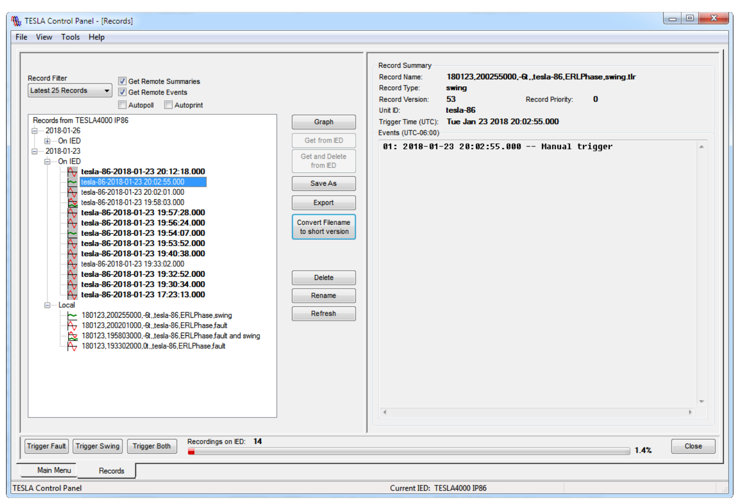


Figure 14.6: IEEE C37.232 Filename Conversion Feature - Records Screen

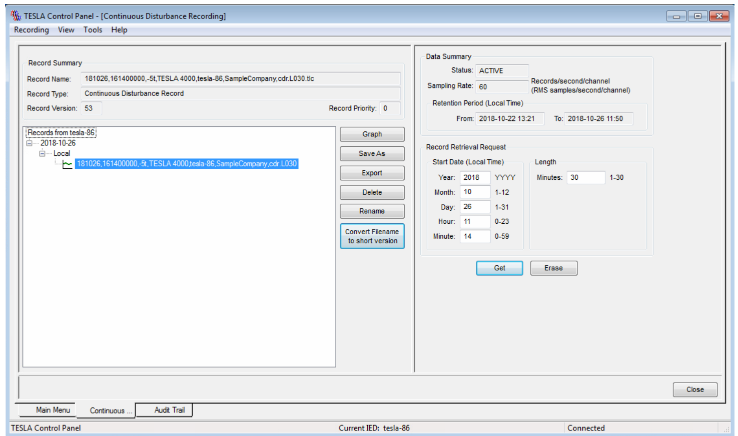


Figure 14.7: IEEE C37.232 Filename Conversion Feature - CDR Screen

15 Cooperative Recorder Group and Group Record Trigger (GRT)

15.1 Overview

A cooperative recorder group combines the easy-to-use interface of a single TESLA 4000-SV recorder with the recording capabilities of up to four recorders. A cooperative recorder group consists of two to four TESLA 4000-SV recorders working together to form a larger virtual recorder. This virtual recorder has one assigned “master” unit acting as the primary recorder for the group. An Ethernet LAN connects the group of recorders and TESLA Control Panel provides the user interface. Each recorder continues to function as a stand-alone unit independent of its involvement in a cooperative group.

A cooperative recorder group provides the following functions:

- Automatic triggering of synchronous recordings on all group members whenever any member is triggered.
- Transfer and combination of the synchronized records from all group members to TESLA Control Panel into a single record.

Starting with firmware version 1.5, the TESLA 4000-SV introduces a Group Trigger and Record Combine system, in addition to the conventional cooperative mode. This feature serves as an alternative to the cooperative mode, particularly when configuring a Group Record Trigger (GRT) across different types of recorders. The GRT mode allows users to group up to eight IEDs within the same network. Unlike the cooperative mode setup, establishing communication between different recorders requires creating Group Record Trigger (GRT) mappings using the ERL 61850 IED Configurator.

15.2 Cooperative Recorder Group Details

Local Network

A cooperative recorder group is comprised of two to four TESLA 4000-SV recorders, typically located in one location (ie. the same substation control house). The recorders communicate with each other through an Ethernet LAN which allows cross-triggering between recorders along with the normal record transfer and user interface functions. The cooperative recorder group can have its own network or can be connected to a larger network.

Remote Access

Remotely access a cooperative recorder group over a wide area network via the Ethernet ports. Serial/Modem connection is not supported for the TESLA 4000-SV Cooperative Mode.

Master Recorder

One member of the cooperative recorder group is designated as the Master Recorder. The Master Recorder is the primary interface between the cooperative recorder group and TESLA Control Panel. In addition to its normal recording role, the Master Recorder:

- Maintains the list of group recordings.
- Provides IP address information about the other group members.
- Acts as the communication gateway for remote access when a modem link is used.

Cooperative Group IED

Within TESLA Control Panel a virtual Cooperative Group IED is created to work with the cooperative recording group. When connected to the Cooperative Group IED, TESLA Control Panel functions are applied to the group of recorders rather than an individual one. Records from the cooperative recorder group are transferred, combined and viewed in this way.

Triggering and Recording

In a cooperative recorder group a trigger detected by any recorder results in time-synchronized recordings on all group members. These records are retrieved and combined into a single record by TESLA Control Panel.

Cross-triggering between group members takes place over the LAN. The trigger message includes the timestamp of the initiating trigger to allow each recorder to capture data from the same time period. Sample clock coordination among the group recorders, derived from the source clock signal, ensures that the data points from all the recorders are synchronous.

The trigger message also specifies the type of recording to be created. If the initiating trigger was configured to produce a transient recording, a swing recording, or both, the receiving units will create the same type of record or records. If multiple recorders detect a trigger during the same disturbance, each will send a trigger message to the others. A trigger buffer is used by each recorder to sequence overlapping triggers and produce a single record whose trigger time is that of the first detected event.

Time Synchronization

All cooperative group recorders must be synchronized from a common external IRIG-B or PTP time source. Operating without any synchronization source is not recommended in cooperative mode.

Record Collection and Consolidation

Records are retrieved from cooperative group members and combined into a single group record by TESLA Control Panel. When you initiate a record transfer from the group's Master recorder, TESLA Control Panel automatically transfers the corresponding records from the other group members and combines them into a single record. Within TESLA Control Panel, the resultant record is stored under group's Cooperative Group IED record list.

In some circumstances a record from a group member may be omitted from the combined record. This could be caused by a settings mismatch, network communication problem or loss of time signal synchronization. If the record was captured by the recorder it can still be retrieved and viewed as a single record from the individual recorder using standard (i.e. non-cooperative mode) methods.

For further details on cooperative group records, see “Records” on page 15-12.

RecordBase Central Station

RecordBase Central Station v5.2 and above can work with a TESLA 4000-SV cooperative recording group. RecordBase can:

- Collect records from group members and combine them into a single record.
- Issue swing record cross-trigger commands to the group.
- Communicate with individual group members via WAN.

15.3 Cooperative Recorder Group Assembly

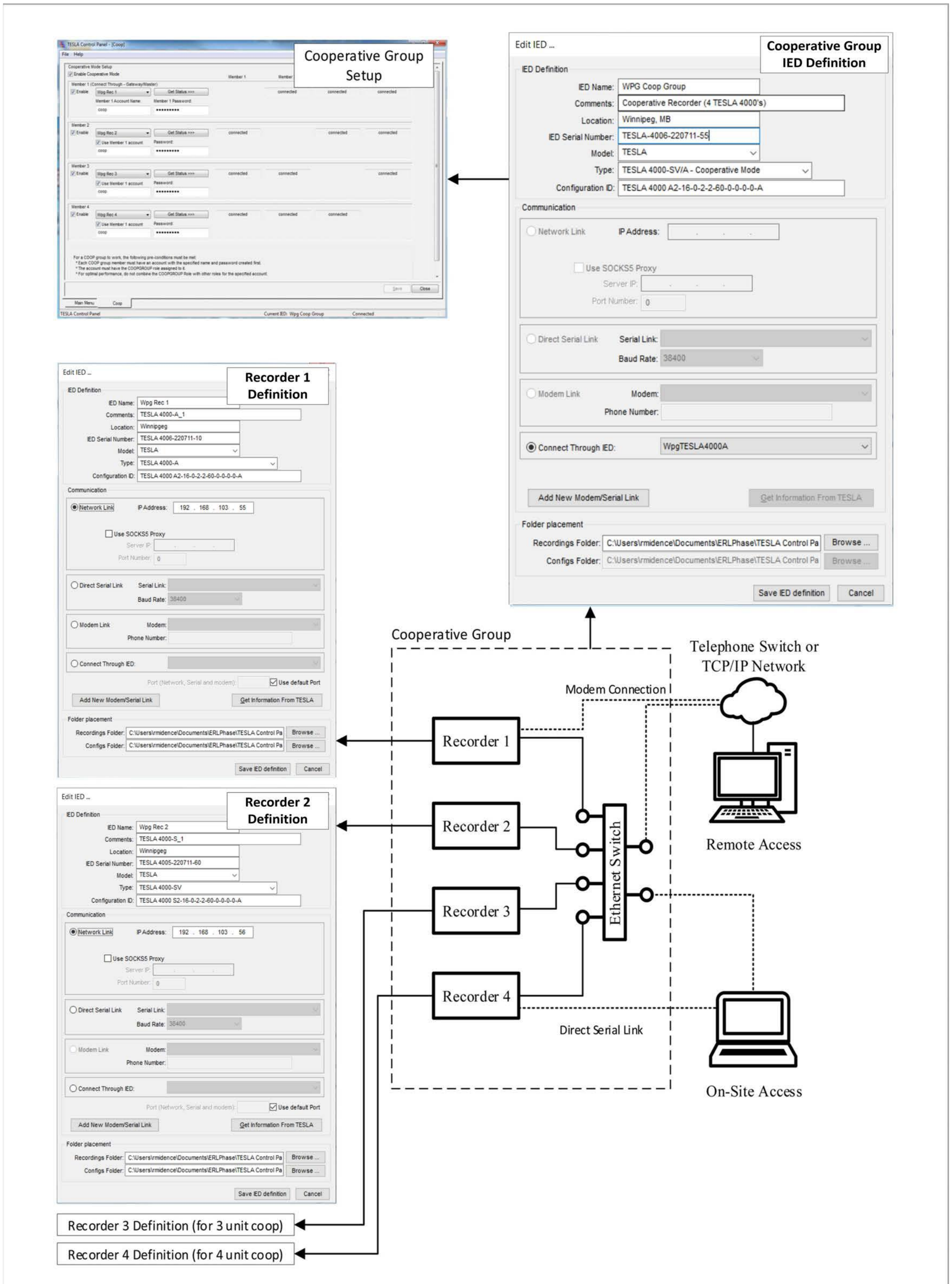


Figure 15.1: Cooperative Recording Group with Remote Access

There are three main steps to setting up a cooperative recording group:

- Step 1: Set up the network in the substation.
- Step 2: Configure the individual recorders.
- Step 3: Configure the Cooperative Recording Group.

> A cooperative group must only include recorders from the same generation (4000-SV, 4000, 4003, 3000). The TESLA 4000-A and TESLA 4000-SV are the exception and they can be combined into the same coop group as shown in Figure 15.1.

Step 1: Set up the Network

1. Create IED definitions for each recorder.

   This step is shown in Figure 15.1. See “Adding/Editing a Recorder Workspace Definition” on page 6-9 for how to create IED definitions.

2. Connect the LAN ports on each recorder to the Ethernet switch (see “Cooperative Recorder Group Assembly without External Ethernet Switch” on page 15-11 for an alternative method).

   Use an industrial-quality 100BASE-T Ethernet Switch for best performance. The rear Ethernet ports are either 100BASE-T copper interface or a 100BASE-FX optical interface. Connect the recorders using either a CAT5 cable with an RJ-45 connector or 100BASE-FX 1300 nm multimode optical fiber with an ST style connector. For a group of only two recorders, a cross-over Ethernet network cable can be used instead of an Ethernet switch.

   When connected to a larger network, consideration should be given to network load. The recorders can tolerate considerable delay in the delivery of inter-recorder trigger messages. The network load resulting from the transfer of large records may impact other devices on the network.

3. Configure Ethernet Communication settings.

   The Ethernet Communication settings are configured on the *Communication > Ethernet* screen in TESLA Control Panel (see “Ethernet Configuration” on page 8-6).

   - Assign unique IP addresses to each recorder.
   - Ensure IP addresses for all recorders belong to the same local network.
   - Ensure TCP/IP Port setting is the same for all recorders.

Step 2: Set Up the Individual Recorders

1. Create/edit an IED Definition for the Master Recorder.

   The Master Recorder is the recorder designated as the primary interface between the recorder group and TESLA Control Panel. The Master is the recorder that is used to “Connect Through” to access the other members in the cooperative group. Communication between members is done on a peer-to-peer basis.

   The following table provides a setting guide for the Master Recorder’s IED definition:

Table 15.4: IED Definitions for the Master Recorder

IED Name	• Should identify both the recorder and its cooperative group. • Should have the same name as the recorder’s *Unit ID*. (The *Unit ID* is configured in the recorder through the *Identification* menu in TESLA Control Panel. See “Unit Identification” on page 8-2).
Comment	Should indicate that the IED is the Master Recorder for the group.
Location	Should be the name and/or location of the Substation.
IED Serial Number	Can be left blank if the unit’s serial number is not known. The serial number can also be automatically obtained from the recorder later using the *Get Information from IED* button (see below).
Model	Select TESLA.
Configuration	Select TESLA 4000-SV 36 Channels
Communication	Select *Network Link* and enter IP address
Get Information from IED	(optional): If a communications link is available to the recorder, this button can be used to retrieve the recorder’s name, location and serial number information. Any information in the corresponding fields of the IED Definition will be overwritten and saved if you exit with *OK*. These values are configured on the recorder as part of its Unit Identification.

2. Create/edit IED definitions for the remaining group members.

   The group can have up to four recorders. The following table provides a setting guide for the IED definitions of group members.:

Table 15.5: IED Definitions for the Other Group Recorders

IED Name	• Should identify both the recorder and its cooperative group. • Should have the same name as the recorder’s *Unit ID*. (The *Unit ID* is configured on the recorder through the *Identification* menu in TESLA Control Panel. See “Unit Identification” on page 8-2).
Comment	Should indicate that the IED is a group member.
Location	Should be the name and/or location of the Substation.

Table 15.5: IED Definitions for the Other Group Recorders

IED Serial Number	Can be left blank if the unit’s serial number is not known. The serial number can also be automatically obtained from the recorder later using the *Get Information from IED* button (see below).
Model	Select *TESLA*
Communication	Use *Network Link* and enter the IP address of the IED.
Get Information from IED	(Optional): If a communications link is available to the recorder, this button can be used to retrieve the recorder’s name, location and serial number information. Any information in the corresponding fields of the IED Definition will be overwritten and saved if you exit with *OK*. These values are configured on the recorder as part of its Unit Identification.

3. Configure the individual recorders.

Each recorder must be configured as a stand-alone unit with its channels and triggers defined. Chapter 8: Recorder Setup and Chapter 9: Recorder Settings cover this in detail.

Important:
Certain settings must be the same on all recorders for cooperative mode to function correctly. See “Required Settings” on page 15-13 for the list.

4. Configure the security accounts for the individual recorders.

In cooperative mode there are two connection types that occur:

- TCP-Member connection
- Inter-Member connection

These connection types require different security roles and require careful consideration by the security administrator to ensure that cooperative communication will work as expected. See “Security Setup” on page 8-32 and “Authentication and Authorization System” on page 18-5 for further details on security configuration.

The TCP-Member connection is established via TESLA Control Panel for the purposes of configuration and record management. When the user logs into the Cooperative Group IED they are prompted to provide login credentials. TESLA Control Panel uses these login credentials to login to each of the group’s recorders through the Master recorder. To access and configure the cooperative configuration on the *Coop* screen, adequate security roles must be assigned to the login account. See Table 15.6 for more details.

The Inter-Member connection is established between members of the cooperative group for cross-triggering records. The Inter-Member communication requires each member to login to all other members in the group using a valid login account. This login account is configured on the *Coop* screen in TESLA Control Panel. See Table 15.6 for more details.

Table 15.6: Cooperative Group Security Setup Summary

Connection Type	Where to Enter Credentials	Requirements	Recommended Default Accounts
TCP-Member	When connecting to the Cooperative Group IED via TESLA Control Panel. TCP connects through the Master IED to all of the other group members.	• Same user account must exist on all IEDs in the group, with the same password • User account must contain ENGINEER or UPDATE role to configure cooperative mode	change service update
Inter-Member	On the *Coop* screen in TESLA Control Panel. Enter credentials for each member in the group.	• User accounts must contain COOPGROUP role. • A different login account may be used for each member, but it is recommended to use the same account for each member to simplify setup procedure • Login Failure Handling Maximum Retries should be set to value greater than 3 to avoid a lockout condition if invalid credentials are accidentally entered	coop

Step 3: Configure the Cooperative Recording Group

1. Create a Cooperative Group IED Definition in TESLA Control Panel.

   The Cooperative Group IED is a virtual TESLA recorder which combines up to four recorders into one. The Cooperative Group IED is used to configure the group of recorders and for retrieving and managing the combined records. The following table provides a setting guide for the Cooperative Group IED definition:

Table 15.7: IED Definitions for the Cooperative Group IED

IED Name	Should identify this as the Cooperative Group IED
Comment	Should indicate that this IED represents the whole group
Location	Should be the name and/or location of the Substation
IED Serial Number	blank
Model	Must be TESLA 4000-SV Cooperative Mode
IP Address	Blank
Communication	Must be *Connect Through IED* with the Master Recorder selected

2. Select the cooperative recording group members.

   A Cooperative Mode Setup screen (called *Coop*) is available when connected to the Cooperative Group IED. This screen allows the user to specify which recorders are part of the cooperative group. It also provides connection status information about the group of recorders. To access the *Coop* screen and configure the group:

   a. Connect to the Cooperative Group IED by selecting the it from the IED list on the Main Menu tab and pressing *Connect*. Login to the Cooperative Group IED by using valid login credentials (see Table 15.6 for details).

   b. Select the *Coop* screen by double-clicking on *Coop* in the *Main Menu* tree. See the *Coop* screen in Figure 15.2.

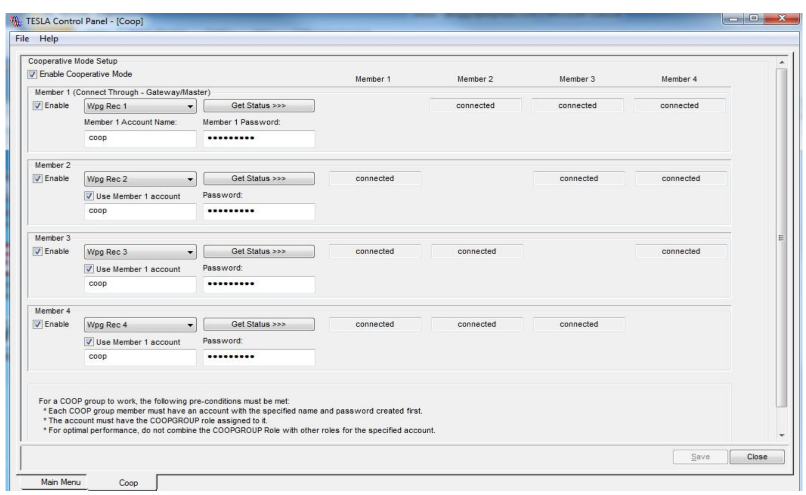


Figure 15.2: Cooperative Mode Setup Screen

Select the recorders that are to be part of the cooperative group using the pick-lists. Enable each member by using the "Enable" check-box. The master recorder is automatically assigned as Member 1. Once two or more recorders are enabled, then the global "Enable Cooperative Mode" option can be enabled. If an expected recorder does not appear in the Member pick list, check the recorder's IED Definition for errors.

> The Member Number (Member 1, Member 2 etc.) determines the numbering used in the combined records. The channels in the combined recorder are labelled with a number before the channel name. This identifies which IED the channel is from.

c. Enter valid login credentials for each IED (see Table 15.6 for details). Figure 15.2 shows an example with each member using the default account. If all members are to use the same login credentials select the "Use Member 1 Account" check-box.

3. Enable cooperative recording group operation.

a. Save the configuration.

TESLA Control Panel will connect to each member recorder to provide member IP addresses and enable cross-triggering. The connection status of each member is displayed after approximately 75 seconds. Figure 14.2 shows all members are connected to each other. If a proper connection is not established, then useful status messages are displayed in the connection matrix. For a full list of status messages, and how to troubleshoot connection issues, see "Maintenance Functions and Diagnostic Tools" on page 16-5.

> The *Get Status* button beside the member recorder names in Figure 15.2 initiates a status check of the communications between the member recorders. It can be used at any time.

b. Click *Close.*

The cooperative recording group configuration is now complete and cross-triggering, record collection and combining of member records are enabled.

c. Verify that all members are successfully added to the group.

The *Identification* screen in TESLA Control Panel displays a cooperative group status message for each IED in the group. Login to each individual IED in the group and ensure the *Identification* screen displays "coop member". If at any point a communication or setup error occurs, the *Identification* screen will display "coop comm error" in red flashing text. A pop-up message will also be displayed in TESLA Control Panel upon connecting to an IED with a "coop comm. error". Login to the Cooperative Group IED and begin the troubleshooting process as described in "Maintenance Functions and Diagnostic Tools" on page 16-5.

15.4 Cooperative Recorder Group Assembly without External Ethernet Switch

A TESLA Cooperative Recorder Group may also be assembled without the use of an external Ethernet switch. Instead, the recorders may be connected in such a way that utilizes the internal Ethernet switches provided inside the TESLA.

In order to assemble a Cooperative Recorder Group without an External Ethernet switch, follow the same steps outlined in “Cooperative Recorder Group Assembly” on page 15-4, except at Step 1: Set up the Network, do the following.

Connect each TESLA in a “daisy-chain” method, as shown in Figure 15.3. This requires connecting the rear port 401 of Recorder 1 to the front port 401 of Recorder 2. Connect the rear port of Recorder 2 to the front port 401 of Recorder 3. Connect the rear port 401 of Recorder 3 to the rear port 401 of Recorder 4.

This will create a closed LAN within the Cooperative Group. This Cooperative Group may then be accessed via a PC connection to the front port 401 or USB port of Recorder 1.

After connecting the recorders in this manner, follow all of the same steps outlined in “Cooperative Recorder Group Assembly” on page 15-4 to complete the Cooperative Recorder Group assembly.

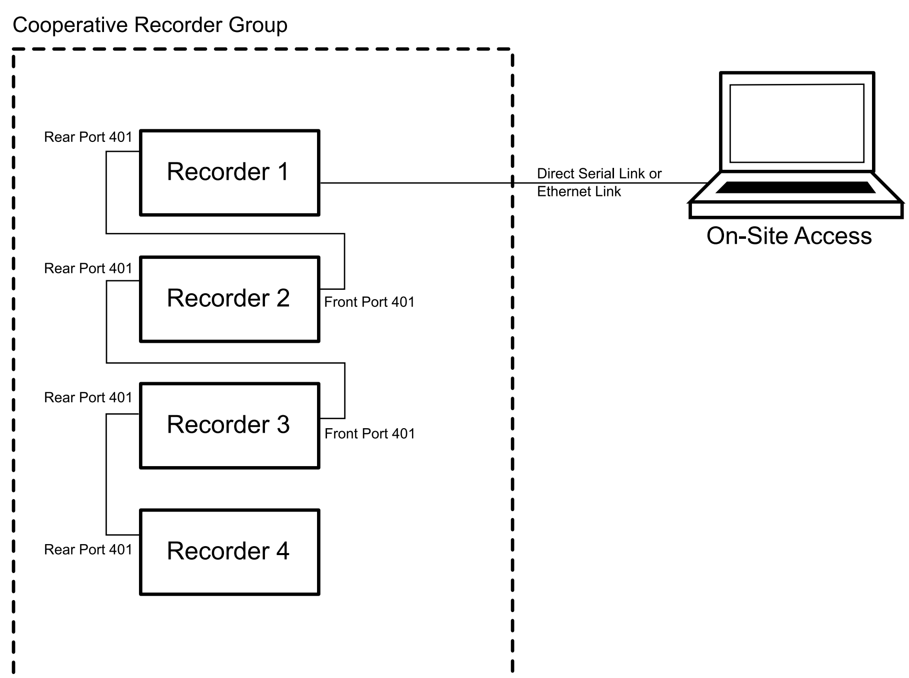


Figure 15.3: Cooperative Recorder Group Assembly without External Ethernet Switch

15.5 Records

Cooperative recording group records are managed in TESLA Control Panel in the same way as records from individual recorders (see Chapter 10: Setting Files Comparison Tool).

To access a group's records, connect to the Cooperative Group IED using valid credentials. Once connected, double-click Records in the menu tree to open the Records screen. Local records which have already been retrieved can be accessed by navigating to the Records screen without logging in.

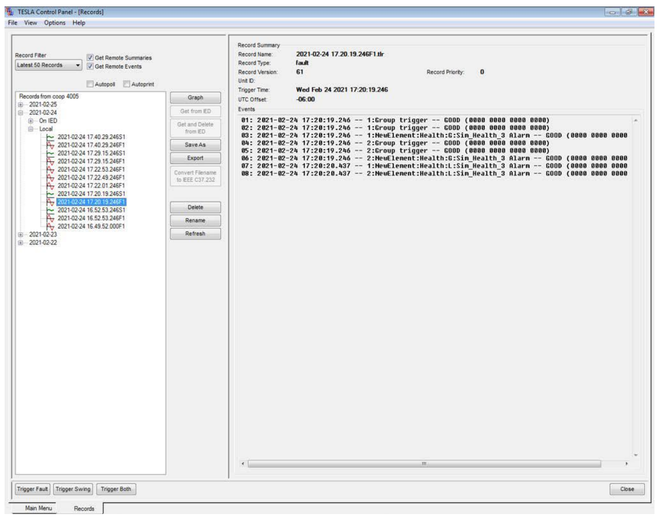


Figure 15.4: Records display

Records shown as “On IED” are on the Master Recorder. When initiating record retrieval (“Get from IED”), TESLA Control Panel retrieves records with the same timestamp from all group members and combines them into a single record. The record also combines event data from all recorders in the group, chronologically sorted. Records listed under the Local branch have already been retrieved and combined.

Each recorder’s channel names and event entries in the combined record are labeled with “1:”, “2:”, “3:”, and “4:” to avoid ambiguity. These prefixes correspond to the member number defined in the *Coop* screen.

Calculated channels are automatically generated when the records are retrieved to TESLA Control Panel. This differs from individual recorder records where calculated channels are generated when the record is first displayed by RecordGraph.

The displayed record summary information is derived from the Master Recorder. The preview of events cannot be shown until the combined record has been generated. The event list is only displayed for locally stored records.

Delete remote records by selecting records from the “On IED” list. Record deletion for a Cooperative Group IED deletes the associated record from each group member.

15.6 Required Settings

Cooperative mode operation requires some key settings to be consistent on all recorders in the group. Table 15.8 identifies those settings and guidelines for selecting appropriate values.

Table 15.8: Cooperative Mode Settings

Setting	Effect on Cooperative Operation	Guideline
Firmware Version	May cause compatibility issues between group members.	All group members must be operating with same firmware version. Members can be either 18 channel or 36 channel configurations. Mixing of 18 channel and 36 channel configurations in the coop group is also allowed.
Incoming IRIG Time Signal Properties	May cause a UTC time mismatch between recorders that results in trigger messages being rejected.	Setting should be the same on all group members. All IEDs must be synchronized to the same IRIG time source.
Recorder Time Zone Setting	May cause a UTC time mismatch between recorders that results in trigger messages being rejected.	Setting should be the same on all group members.
TCP/IP Port Number	Allows TESLA Control Panel to establish communication.	Setting must be the same on all group members.
Recording Control Settings *(Main Menu/Records/Configuration)*		
Trigger Mode	In *Duration* mode, triggers from other recorders result in a record of *Maximum Record Length* as their duration is not evident to the receiving recorder.	Setting should be *Edge* on all group members.
Pre-Trigger Mode	Records with a pretrigger time different from that of the Master Recorder's record will be left out of the combined group record.	Setting must be the same on all group members.
Normal Record Length	Records of different duration can be combined into a group record. The group record can be displayed.	Settings should be the same if COMTRADE export of the combined record is desired.
Maximum Record Length	Controls the capability of each recorder to automatically extend a recording to include subsequent triggers.	A minimum of 3.0 seconds of auto-extension *(Maximum Record Length > Normal Record Length)* is automatically added to avoid multiple overlapping records in the case of near-coincident triggers.
TESLA Device Configuration *(Identification screen in the Configuration editor)*		
Setting	**Effect on Cooperative Operation**	**Guideline**

Table 15.8: Cooperative Mode Settings		
Sample Rate	Records with a sample rate different from that of the Master Recorder's record will be left out of the combined record group.	Setting must be the same on all group members.

15.7 Disassembly

It is important that cooperative mode is disabled correctly before removing group members for maintenance. The TESLA is designed to handle cooperative mode configuration issues, however unexpected behaviors may be observed on group member IEDs if the proper disabling procedure is not followed. This procedure should be followed when performing firmware updates on cooperative group members.

To properly disable the cooperative mode, perform the following steps:

1. Connect to the Cooperative Group IED.

   In TESLA Control Panel on the Main screen, select the Cooperative Group IED from the IED list, and press *Connect.* Login to the Cooperative Group IED using valid login credentials.

2. Navigate to the *Coop* screen to begin disabling the Cooperative mode.

   To disable the cooperative mode on one or all of the group members, uncheck the "Enable" check-box for each group member that is to be removed. If the entire Cooperative Group is to be dismantled, un-check the "Enable" check-box for each member and the global "Enable Cooperative Mode" check-box.

3. Save the changes.

   Wait for approximately 75 seconds while the changes are saved. After the saving process is complete, the members which have been removed should display "not connected".

4. Verify that members have been removed from the Cooperative Group.

   Login to each of the individual members and check the *Identification* screen. There should be no Cooperative status message displayed on the screen. If "coop member" or "coop comm. error" is displayed on the screen, then the member has not been removed from the group correctly. Ensure steps 1-3 have been followed correctly. Consult "Maintenance Functions and Diagnostic Tools" on page 16-5 if further troubleshooting is required.

15.8 Group Record Trigger Mode

In addition to the conventional cooperative mode, starting from firmware 1.5, TESLA 4000-SV allows to setup a group trigger and records combine system between TESLA4000 IEDs. This feature serves as an alternative to the cooperative mode, especially when the user wants to configure a Group Record Trigger (GRT) Mode across different types of recorders. The GRT mode enables users to add up to eight IEDs into the same group within the same network. Unlike the cooperative mode setup procedure, establishing communication between different types of recorders requires creating Group Record Trigger (GRT) mappings between GRT members using the ERL 61850 IED Configurator as well. When an IED is configured in the cooperative mode setup, its GRT trigger functionality will be automatically disabled if the trigger is initiated within the coop member. Below is an overview of the setup requirements and procedure for configuring the Record Trigger Group.

Setup Requirements:

- **Firmware:**
  - TESLA4000 firmware ≥ v2.4
  - TESLA4000-A firmware ≥ v1.2
  - TESLA 4000-SV firmware ≥ v1.5
- **Communication:** All members must be in the same Ethernet network.
- **Time Synchronization:** All members should be time-synchronized.
- **System Frequency:** All members should operate on the same system frequency.
- **Sample Rate:** All members must use the same sample rate.
- **Record Length:** All members must have the same record length configuration.

Configuration Procedure:

Step 1: Create GRT Mapping Using IED Configurator

1. For the GRT initiator (publisher), create a dataset with the GRT output attributes (stVal, q, t) from the Records.GRTGGIO1.ISCSO1 data object (Figure 15.5).

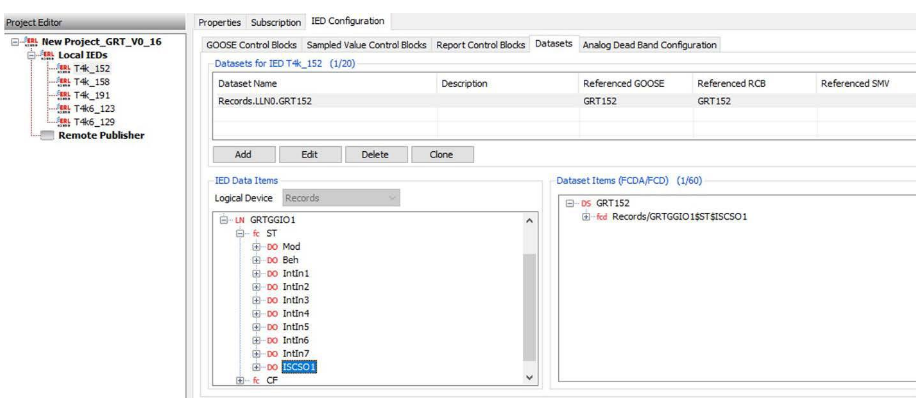


Figure 15.5: Create Dataset to include GRT output

2. Create a GOOSE Control Block to include this dataset, publishing a GOOSE message for the Group Record Trigger (Figure 15.6).

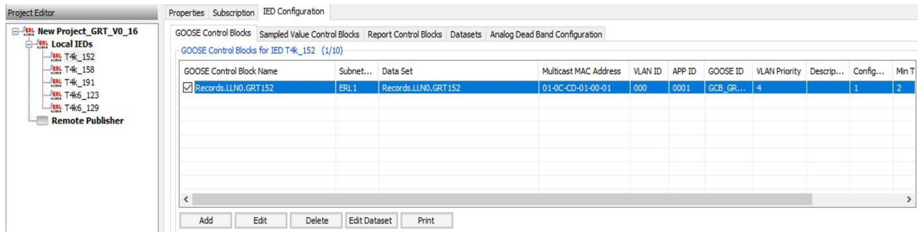


Figure 15.6: Create GOOSE Control Block for Group Record Trigger

3. Repeat these steps for all members associated with the GRT mapping.
4. Go to **Subscription -> GOOSE Mapping**, select the **Group Record Trigger** tab, and map each member's GRT output to its GRT inputs (Figure 15.7).

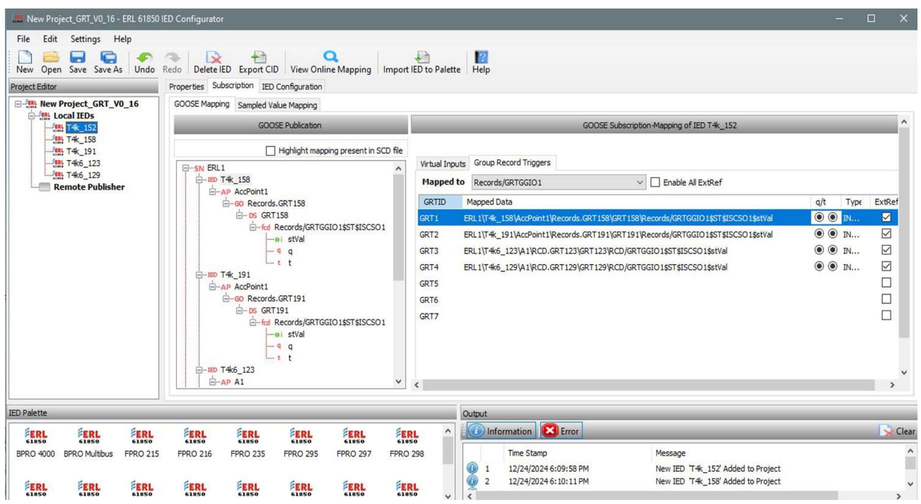


Figure 15.7: GRT Mapping

5. Send the CID file to each member and reboot the unit after successfully uploading the file.

Testing the Group Record Trigger

1. Manually trigger a record from any member. This action should initiate a group record trigger with a unique ID reflecting its IED identity and record type. Example:
   - 01: 2025-01-06 17:39:06.000 -- Initiating Group Record Trg. ID 0x01187a19
   - 02: 2025-01-06 17:39:06.000 -- Manual trigger
2. Verify that other members received this trigger with the same trigger time and GRT ID. Example:

- 01: 2025-01-06 17:39:06.000 -- Received Group Record Trg. ID 0x01187a19 -- GOOD (0000 0000 0000 0000)

Step 2: Configure Group Record Trigger Mode in TESLA Control Panel

1. Add a new group IED entry by selecting **TESLA4000/SV/A Group Record Trigger Mode** under the Type pick-list (Figure 15.8).

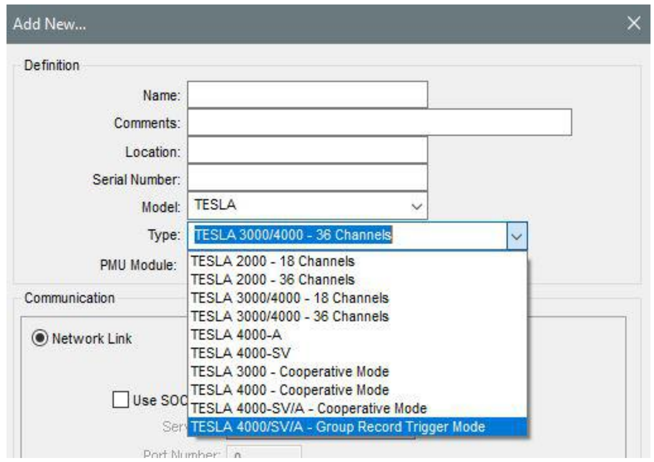


Figure 15.8: Add New Group Record Trigger Mode in TESLA Control Panel

2. After adding the group IED, two menu items, **Records** and **Setup**, will appear in the left-hand tree view (Figure 15.9).

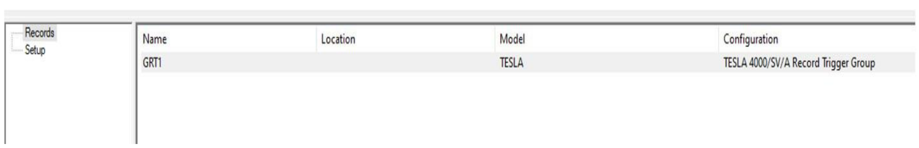


Figure 15.9: Group Record Trigger Mode IED entry shown in main menu

3. Select **Setup** to configure members. Example:

- Select the correct IED members and credentials.
- Click the
- **Check** button to verify member connectivity and communication requirements.
- Save the configuration once all members indicate an “OK” status.

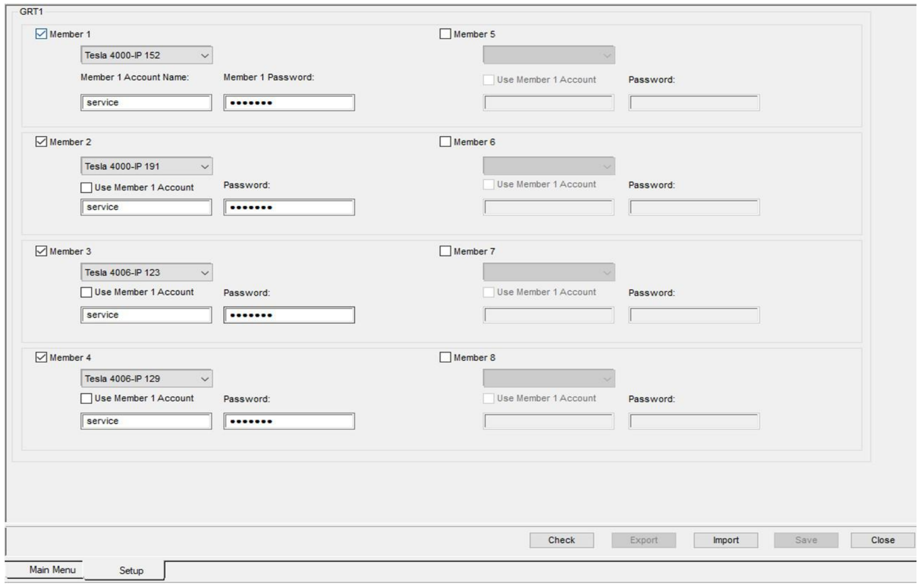


Figure 15.10: GRT member configuration

4. Export the configuration as a .xml file by selecting the **Export** button. The file can be imported later into the TESLA Control Panel or RecordBase Collector to replicate the configuration.

Step 3: Test the Group Record Combination

1. Select the previously configured GRT entry in the main menu and click **Connect** to establish a connection to the first member IED.
2. Select **Records** in the left-hand tree view to open the Records screen.
3. Manually trigger a fault record by clicking the **Trigger Fault** button at the bottom.
4. Select the newly triggered record from the record list and click the **Graph** button. The TESLA Control Panel will:
   - Collect records from each member based on the configuration.
   - Process the record combination.
5. Verify that the opened record includes member indices matching the Record Trigger Group configuration (Figure 15.11).

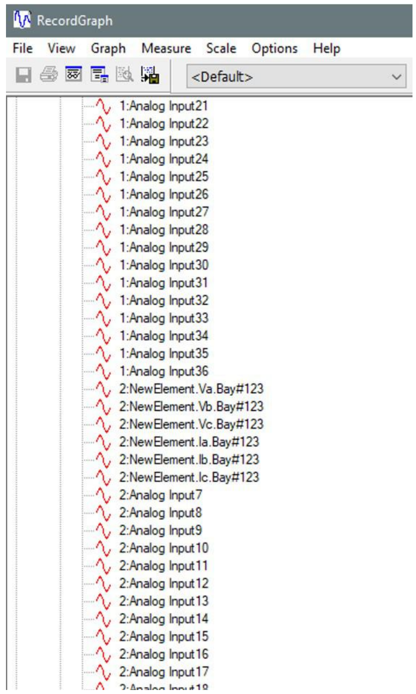


Figure 15.11: Combined record member indices

16 Recorder Health Monitoring and Maintenance

The TESLA 4000-SV has a built-in health monitoring system. This system is comprised of two sets of features:

1. Self-checking for continuous IED health monitoring.
2. Maintenance tools for diagnosing and recovering from issues detected by the self-check features.

16.1 Health monitoring and self-recovery features

Health Monitoring

The TESLA 4000-SV has the following features for continuous IED health monitoring:

- Supervisory software to monitor IED operations
- Watchdog to monitor operations of the supervisory software

The supervisory software continuously monitors the TESLA 4000-SV's operations. It detects and provides indication for the following conditions:

- Storage failure
- Incomplete firmware update [1]
- Compromised system security
- Abnormal TESLA 4000-SV software behaviour patterns
- Post-failure recovery

The hardware watchdog continuously monitors the behavior pattern of the supervisory software.

Self-Recovery Procedure

The TESLA 4000-SV, when not in its normal operating state, can be in one of the following states:

- Software restart
- Hardware restart
- Persistent Error state
- Post-failure recovery (after software restart, hardware restart or Persistent Error state)

If an issue is detected, the supervisory software handles the recovery process and the recorder's transitions between states. The basic flow of the TESLA 4000-SV's state transitions is shown in Figure 16.1: Error Handling. For a

1. Refer to the firmware update instructions to recover IED reporting incomplete firmware update.

more detailed flowchart and description of the TESLA 4000-SV's self-check and recovery process, see Appendix I TESLA Self-Check and Recovery.

If a failure is detected, the Supervisory software attempts to resolve the problem with a software restart. The software restart occurs quickly with no external indication given.

If the failure persists after multiple software restarts, the unit will initiate a hardware restart. The hardware restart takes approximately 1.5 minutes to complete. If the problem is not cleared after four consecutive restarts, the unit enters the Persistent Error State. In this state, the recorder activates its failure indicators and stops initiating resets to avoid interfering with any diagnostic investigation.

If the Supervisory software determines that the problem has been cleared, it automatically returns the unit to its normal operating state, clearing the failure indicators.

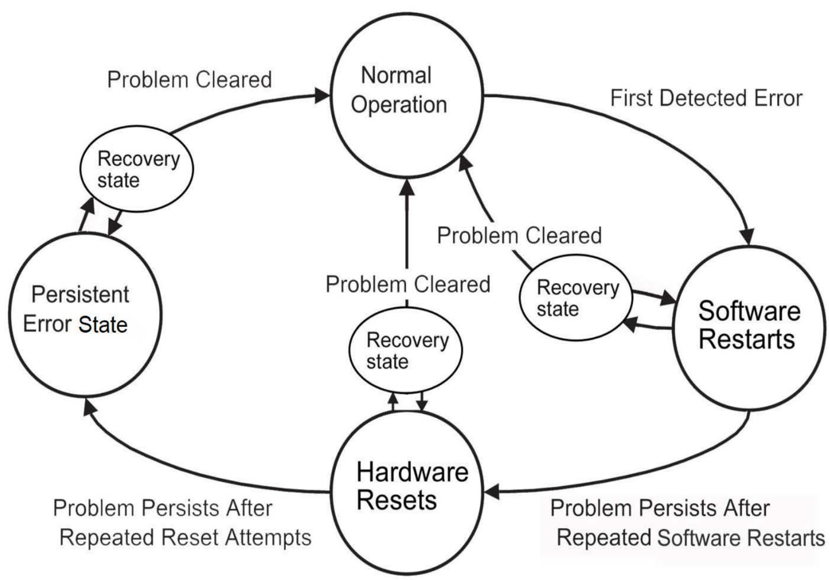


Figure 16.1: Error Handling

Recorder's State Indication

The recorder states are listed in the section Self-Recovery Procedure list above.

The TESLA 4000-SV recorder has the following features to indicate its state and to deliver IED status warnings:

- Recorder Inoperative output contact
- Front Panel Recorder Functional LED
- Front Panel Alarm LED
- Front Panel Test Mode LED
- TESLA Control Panel warnings displayed upon reconnection to recorder

Table 16.1: Recorder States and State Indicators

Recorder State	Recorder Inoperative Output Contact	Front Panel LED			TESLA Control Panel Warnings	Actions and Maintenance
		Recorder Functional	Alarm	Test Mode		
Normal Operation	Open	On	Off	Off	None	None
Software Restarts	Open	On	Off	Off	Self-check state	None
Hardware Restarts	Closed	Off	Off	Changes between On and Off	Self-check state	Wait 3-15 minutes to let IED recover or enter the Persistent Error State
Persistent Error	Closed	Off	Permanently On or Off depending on the type of failure	Permanently On or Off depending on the type of failure	List of the IED health conditions detected by the supervisory software	Refer to Maintenance section for diagnostics tools and recovery options

Table 16.1: Recorder States and State Indicators

Recovery	Retains Persistent Error / Software / Hardware restart state during the recovery	Retains Persistent Error / Software / Hardware restart state during the recovery	Retains Persistent Error / Software / Hardware restart state during the recovery	Off	Self-check state	Wait 3-15 minutes to let IED recover or re-enter the Persistent Error State

16.2 Maintenance Functions and Diagnostic Tools

Access to Maintenance Functions and Diagnostic Tools

TESLA Control Panel provides access to the recorder's diagnostic tools and maintenance functions. Refer to the section "Ports" on page 4-1 for the information on how to connect the TESLA Control Panel software to a recorder. It may take TESLA Control Panel longer to establish connection to a recorder in the Persistent Error (inoperative) state.

To log in to the IED, use the default maintenance account provided with the TESLA firmware or use any customized user account with the "MAINTENANCE" role.

On successful login, TESLA Control Panel software will display IED Status Warning if the supervisory software has detected any issues.

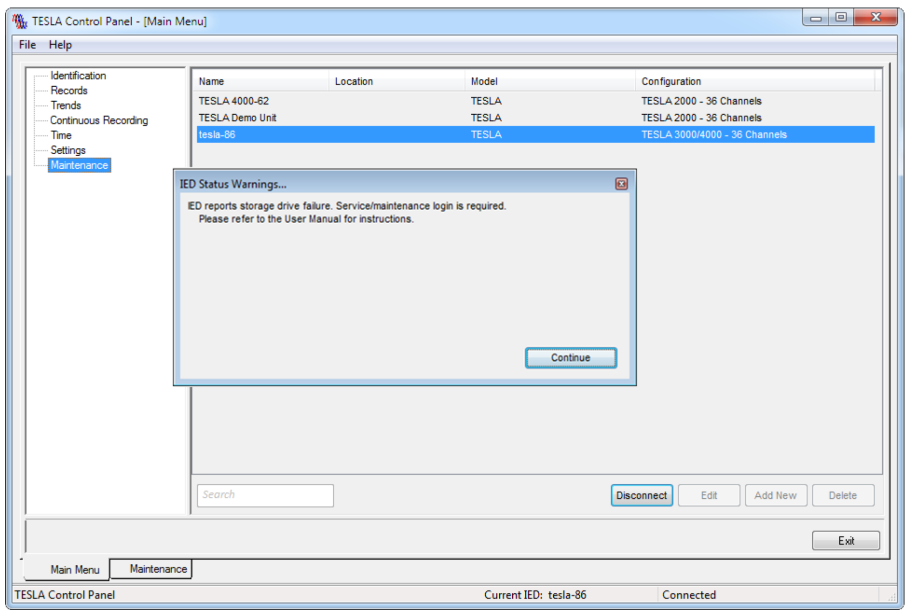


Figure 16.2: Example of IED Status Warning

If the IED Status Warning message pops up, review the warnings and press the *Continue* button to proceed to the Maintenance Menu.

Access the Maintenance menu by selecting *Maintenance* from the *Main Menu*. Access to the recorder's diagnostic tools and maintenance functions is restricted and is granted only to the users assigned the "MAINTENANCE" Role. Please contact your system administrator and request maintenance access if the Maintenance entry does not appear on the Main Menu after successful login. See "Authentication and Authorization System" on page 18-5 for information on user accounts and Roles. An example of TESLA Control Panel Main Menu with Maintenance access is shown in Figure 16.3: Main Menu with Maintenance access.

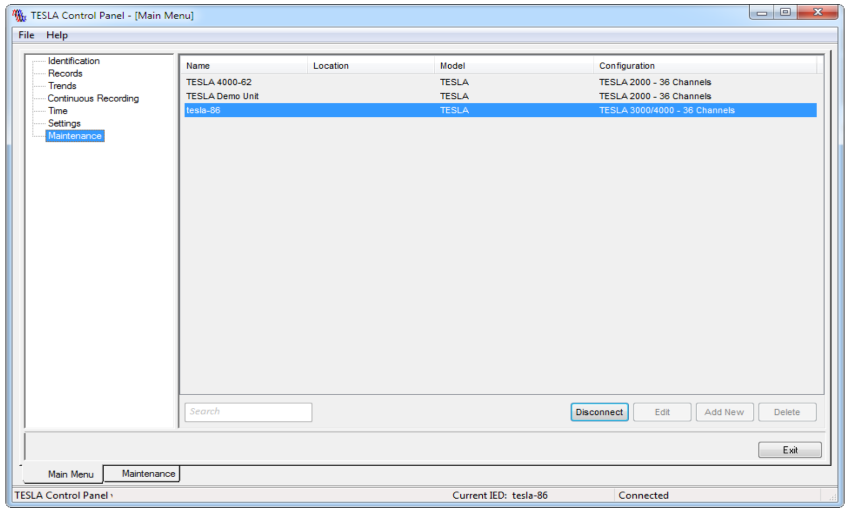


Figure 16.3: Main Menu with Maintenance access

Maintenance Functions Overview

An overview of the Maintenance Menu function groups and their intended use is provided in Table 16.2: TESLA Maintenance Functions Overview.

Table 16.2: TESLA Maintenance Functions Overview

Tab	Functions	Use	
		Normal Operational State	**Persistent Error (inoperative) state**
System Diagnostics tab	Access to the system diagnostics	View system diagnostics to check for: •Time sync issues; •Communication configuration issues •Soft restart reports	Retrieve system diagnostics file to submit to the ERLPhase customer support along with a support request.
Restore Defaults tab	Restoration of default unit setup and channel configuration	Clean up recorder's customized configuration	Recover IED that entered the Persistent Error state after loading new settings, calibration or set-up modification.
Storage Memory tab	Storage memory maintenance tools	Check IED storage memory status.	Check IED storage memory status. Recover IED that reports Storage Memory issue.
IED Network Utilities tab	Network diagnostic tools	Troubleshoot network communication issues.	Troubleshoot network communication issues. Assess network traffic going through recorder.

Table 16.2: TESLA Maintenance Functions Overview

PPP IP Addresses tab	Network over serial diagnostics and configuration tools	Troubleshoot PPP related TESLA Control Panel and RBCS communication issues over serial connection. PPP IP addresses configuration.	No usage
PTP Status	Check status of PTP Global, Clock and Port	Check PTP related status	Troubleshoot PTP synchronization issues

System Diagnostics

The System Diagnostics tab displays the IED's internal system diagnostics data and provides controls to retrieve system diagnostics file to a PC.

To view recorder's system diagnostics report, scroll the “System Diagnostics” view.

The purpose of the system diagnostics file is to send to ERLPhase Customer Support for issue investigation purposes. To retrieve system diagnostics file to PC, press the *Get Diagnostics* button. A “Save As” dialog with a recommended diagnostics file name will be displayed when the diagnostics are collected and ready to be saved on PC. The recommended system diagnostics file name includes configurable unit identifier (or unit serial number if unit identifier is not available), and date and time of the diagnostics file creation. The recommended diagnostics file name is unique for each new diagnostics file created by IED and does not need to be modified. The “Save As” dialog provides interface to modify the diagnostics file name if desired, though it is preferable to keep the date and time sections of the diagnostics file name as created by IED.

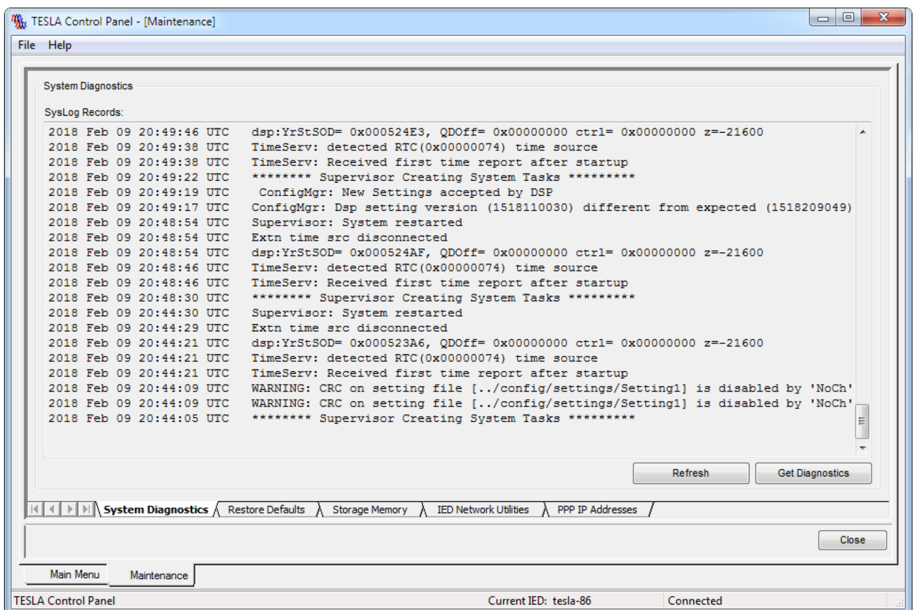


Figure 16.4: System Diagnostics tab.

Restore Defaults

The Restore Defaults tab provides controls to restore recorder's default set-up and/or channel configuration.

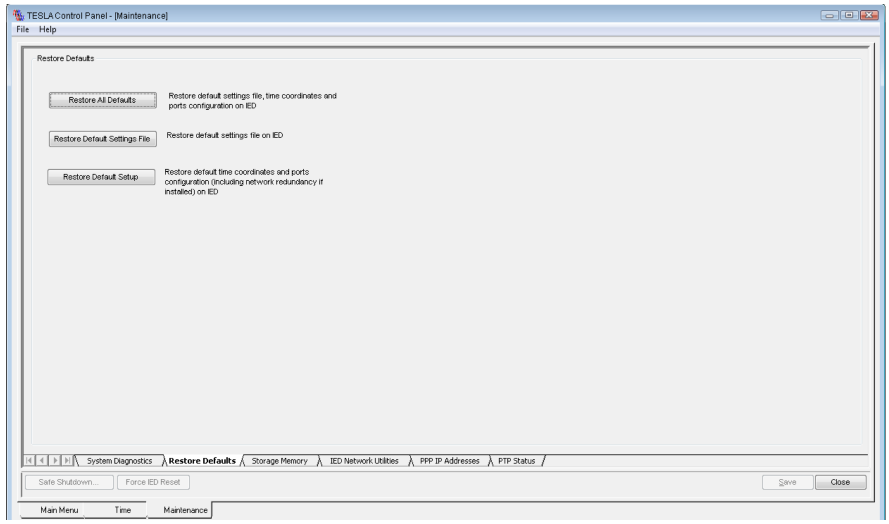


Figure 16.5: Restore Defaults tab

The recorder's Restore Defaults maintenance commands are described in Table 16.3:

Table 16.3: Restore Defaults Maintenance Commands

Command	Description
Restore Default Setting File	This command replaces recorder’s current setting file with the default setting file. All recorder channel configuration will be lost after command execution.
Restore Default Setup	This command restores recorder’s default configuration of Unit Identification, time coordinates, serial and modem ports, High and Low Speed recording, Trend recording, DSP clock calibration and PMU communication.
Restore All Defaults	This command restores Default Setting File, and recorder’s Default Setup, as described above, plus recorder’s default calibration.

Storage Memory

The Storage Memory tab provides controls to select and execute a storage memory maintenance command and displays IED's report after the execution of selected command.

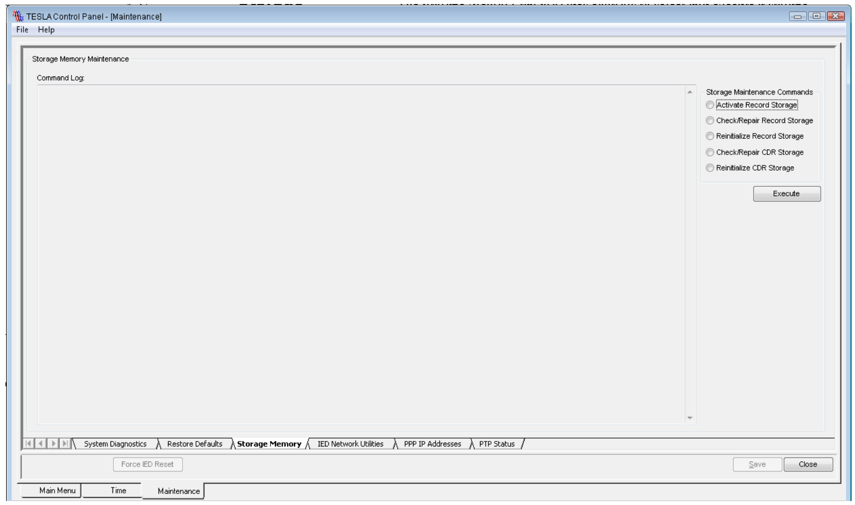


Figure 16.6: Storage Memory tab

The recorder's Storage Memory maintenance commands are described in Table 16.4:

Table 16.4: Storage Memory Maintenance Commands

Command	Description
Check/Repair Record Storage	This command checks the file system of the Record Storage and corrects fixable file system issues. Some transient, swing or trend records may be lost after command execution as a result of the file system repair.
Reinitialize Record Storage	This command reinitializes the file system of the Record Storage. All transient, swing and trend records will be lost after command execution.
Check/Repair CDR Storage	This command checks the file system of the CDR data Storage and corrects fixable file system issues. Some CDR data may be lost after command execution as a result of the file system repair.
Reinitialize CDR Storage	This command reinitializes the file system of the CDR data Storage. All CDR data will be lost after command execution.
Activate Record storage	This command verifies new record storage replacement device and ensures its compatibility with the current recorder's firmware.

> **Warning:**
>
> Improper power-off of TESLA recorder may damage its Storage Memory. Please put recorder in the Safe Shutdown state before turning off or disconnecting its power supply. Refer to “Safe Shutdown Mode” on page 12-6 for information on the recorder’s safe shutdown procedure.

IED Network Utilities

The IED Network Utilities tab displays the recorder’s network status and provides controls to issue ping requests to other network devices.

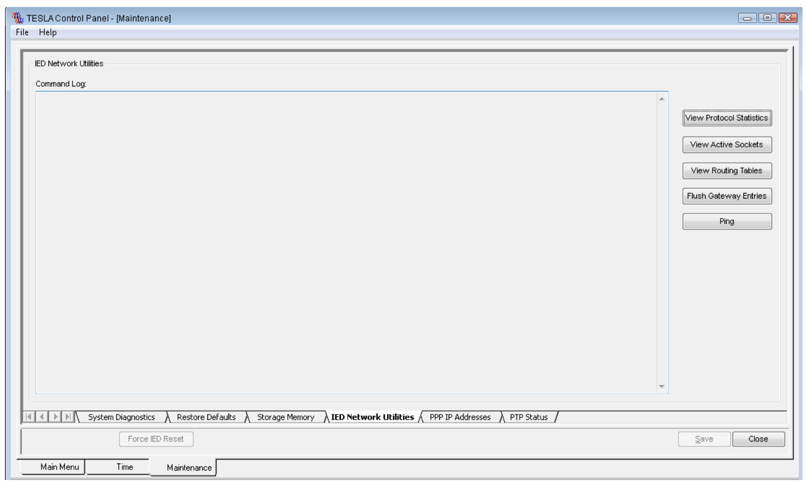


Figure 16.7: IED Network Utilities tab

The recorder’s Network Utilities maintenance commands are described in Table 16.5:

Table 16.5: IED Network Commands

Command	Description
View Protocol Statistics	This command retrieves network protocol statistics from IED and displays them in the Command Log view.
View Active Sockets	This command retrieves active socket information from IED and displays it in the Command Log view.
View Routing Table	This command retrieves network routing table from IED and displays it in the Command Log view.
Flush Gateway Entries	This command flushes recorder’s routing table including the default gateway if used. Unit reboot will be required to reinstate default gateway functionality.
Ping	This command provides user interface to enter an IP address and initiates 3 ping requests to the provided IP address. Ping execution report is displayed in the Command Log view.

Serial Access Issues troubleshooting

The PPP protocol is used to establish TCP/IP communication over serial connection. Normally the default PPP IP addresses do not have to be modified. Modification of the PPP IP addresses may be required only when the recorder's default PPP IP addresses conflict with the actual LAN IP addresses in use.

The PPP IP Addresses tab allows for viewing and modification of the recorder's PPP configuration.

The following conditions must be met for configuring the PPP addresses:

- The local-remote IP addresses for each port must be on the same network.
- Each pair of local-remote IP addresses must be on a different network.
- All PPP IP addresses must be on a different network than the recorder's LAN/WAN.

TESLA Control Panel enforces these three conditions and will not allow the user to save an invalid configuration.

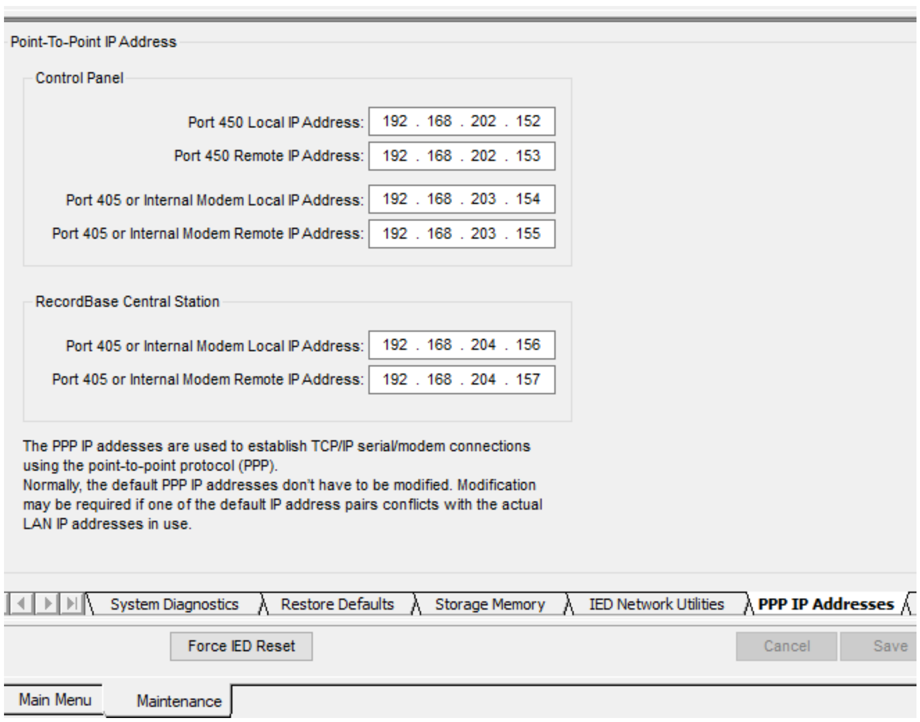


Figure 16.8: PPP IP Addresses tab

PTP Status

The PTP Status tab of the Maintenance screen provides status information for the PTP sync at a Global, Clock and Port level. This tab is provided when the unit is ordered with a redundant configuration, and PTP time sync mode is enabled.

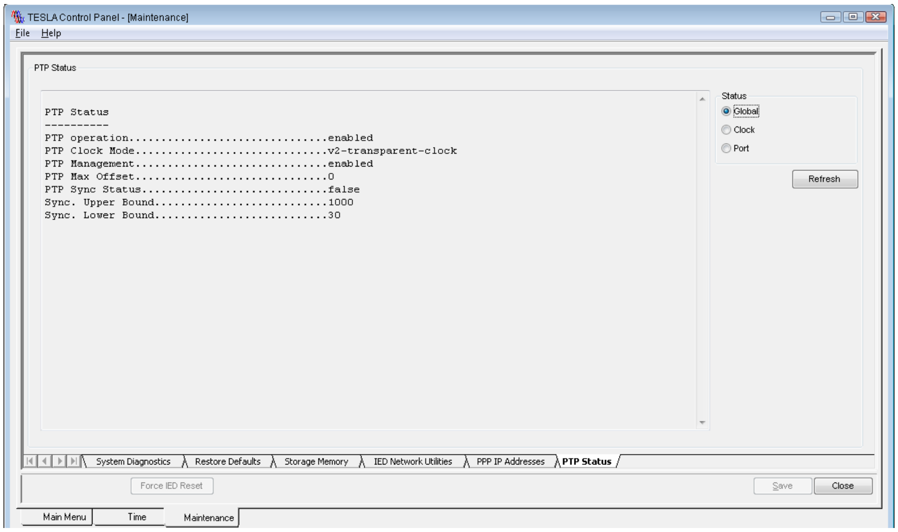


Figure 16.9: PTP Status Tab in Single redundancy hardware

Table 16.6: PTP Status

Status Level	Description
Global	Provides global PTP status information such as if PTP is enabled, clock mode, sync status and sync upper and lower bounds.
Clock	Provides PTP transparent clock status and sync information such as the local and master clock identities, network protocol, delay mechanism, domain, VLAD ID and priority, offset from master and end-to-end delay
Port	Provides PTP port status information such as the delay interval, delay and asymmetry, for each interface

17 PMU Functionality

This chapter describes the operation of the TESLA 4000-SV PMU functionality.

17.1 Overview

Phasor Measurement Unit (PMU) Description

Synchrophasors, phasor measurements with angles referenced to a global time standard, have been used in limited scope by electric power utilities for well over a decade for measuring and predicting dynamic stability of the power grid.

To transmit the PMU data reliably, you must connect the IRIG-B signal from a Global Positioning System (GPS) clock or receiver to the TESLA 4000-SV. The GPS signal must comply with the specification as mentioned in the IEEE C37.118 standard. An SNTP time synchronization source is not recommended for PMU applications.

The PMU module is a standard feature on the TESLA 4000. The PMU functionality complies/supports standards for Synchrophasors for Power Systems as described below:

- Complies with IEEE C37.118 – 2005
- Complies with IEEE C37.118.1a – 2014 and IEEE/IEC 60255-118-1-2018 for P-class application
- Supports IEEE C37.118.1a – 2014 and IEEE/IEC 60255-118-1-2018 for M-class application

The TESLA 4000-SV can transmit up to 36 user-selectable phasors as:

- individual phase quantities
- three-phase positive, negative or zero sequence phasors
- summated phasors

The phasor information is available via the Ethernet port at rates up to 60 frames each second.

The TESLA 4000-SV can also transmit 24 Analog quantities consisting of any combination of Watts, VARS, VA, DC, frequency and THD and 320 digital quantities which includes 64 External Inputs status and 256 Boolean Virtual Inputs status. The PMU functionality does not affect the existing TESLA features; it is designed to work simultaneously with the existing features such as triggering, recording, and trending.

17.2 TESLA 4000-SV PMU Features

Phasor Estimation

The PMU functional module estimates the phasor using the DFT algorithm, assuming the IED is receiving an IRIG-B signal from a reliable GPS receiver as per the C37.118 standard. The phasor magnitude and phase angle, once estimated, is compensated for the frequency variation over a wide range, covering the requirements specified in the C37.118 standards.

Phasor Reporting

Phasor data is transmitted in polar form (magnitude and phase angle) and is configurable to provide information in either Integer or Floating-Point format. Phasor data is transmitted using Ethernet (TCP/IP or UDP) communication. The phase angle is referenced to the absolute time of the GPS (IRIG-B signal) as per the C37.118 standard. The time stamp is based on the UTC time.

Number of Synchrophasors

Up to 36 user-selectable phasors, a combination of any of 36 discrete phasors (any analog channel input) and/or any of 12 sequence phasor channels and/or 48 summation channels.

Phasors selection is user-configurable via TESLA Control Panel software.

Number of Frequency Channels

One frequency channel (Frequency-1) per recorder. Inputs to the “Frequency-1” is user configurable using TESLA Control Panel software. Rate of change of frequency information (ROCOF) reported will be based on the frequency channel as configured by the user. Frequency channel data may be configured to provide information in either Integer or Floating-Point format.

Analog Data

There are 24 PMU Analog channels per TESLA 4000-SV recorder that can be streamed to a remote PDC (Phasor Data Concentrator). The quantities available are MW, MVAR, MVA, frequency, THD and DC. Analog data channels may be configured to provide information in either Integer or Floating Point format.

When the reporting format is integer, analog measurements are calculated as follows:

Analog measurement = analog value * PDC_SCALE * scale per bit

where, scale per bit= 10^-5

Unit corresponding to each 'Code' provided in configuration data frame are given in Table 17.1: Unit Codes for Analog Data on page 17-3

Table 17.1: Unit Codes for Analog Data

Code	Unit
65	V
66	kV
67	MV
68	A
69	mA
70	kA
71	W
72	kW
73	MW
74	VAR
75	kVar
76	MVar
77	VA
78	kVA
79	MVA
80	mV
81	Hz
82	ohms
83	degrees
84	PU
85	%
86	ºC
87	ºF
88	kWh
89	MWh

Digital Status Data

There are up to 320 PMU digital channels per TESLA 4000-SV recorder that can be streamed to a remote PDC (Phasor Data Concentrator).

PMU Reporting Rate

Table 17.2: PMU Reporting Rate

System Frequency	60 Hz						50 Hz			
Reporting rate - frames per second	10	12	15	20	30	60	5	10	25	50

PMU Reporting Times

For a reporting rate of N frames per second, the reporting times are evenly spaced through each second with frame number 0 (numbered 0 through N-1) coincident with UTC second rollover (usually the 1 second PPS provided by GPS). These reporting times (time-tags) are to be used for determining the instantaneous values of the synchrophasor. This is illustrated below in Figure 1, where the reporting times are a 0, T_0, $2T_0$, $3T_0$, $4T_0$, etc (as per IEEE C37.118 standard).

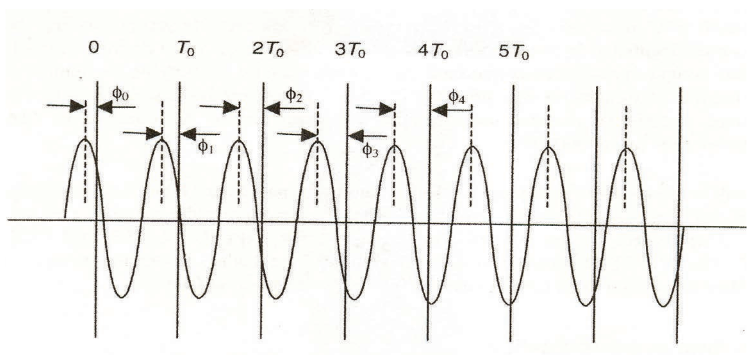


Figure 17.1: A sinusoid with a period of *T* observed at instants that are multiples of the T_O apart. T_O is not an integer multiple of *T*.

PMU Standards Options

In PMU definition, from the PMU standards option, the standard by which the data should be streamed can be selected. The following three options are available in the drop down selection:

1. C37.118 - 2005
2. C37.118.1 - 2011/ 60255-118-1:2018 (P - Class)
3. C37.118.1 - 2011/ 60255-118-1:2018 (M- Class)

PMU Response Time

The response time is the interval of time between the instant the step change is applied and the time-tag of the first phasor measurement for which the TVE (total vector error) enters and stays in the specified accuracy zone corresponding to the compliance level (as per the standard selected).

PMU Accuracy

Total Vector Error: (TVE) according to the standard selected.

Signal Frequency Variation

According to the standard selected.

Signal Magnitude

According to the standard selected.

Phase Angle

According to the standard selected.

Total Harmonic Distortion

According to the standard selected.

GPS Clock Signal Requirements

A reliable GPS clock signal (IRIG-B) as per the IEEE C37.118 specification.

The PMU module uses a GPS signal (IRIG-B) connected on the rear of the IED as global reference for reporting the phasors.

Angle Calibration

Phase angle calibration is achieved by comparing the known applied phase angle from the test set and the phase angle reported in the TESLA PMU module metering screen. For example, if the test set is applying a sinusoidal signal at nominal voltage of 69 Vrms at 0 degree phase angle at nominal system frequency, its cosine referenced signal will be 69 Vrms at -90 degrees. The PMU should report 69 Vrms at -90 degrees. If the PMU reports -89.5 degrees, there is a difference of -0.5 degrees with respect to the applied signal (assuming that the test set phase angle is accurate within tolerable limits as per IEEE C37.118). This phase angle offset can be introduced in the analog channel configuration as shown, “Setting up angle calibration offset through analog channel configuration” on page 17-6.

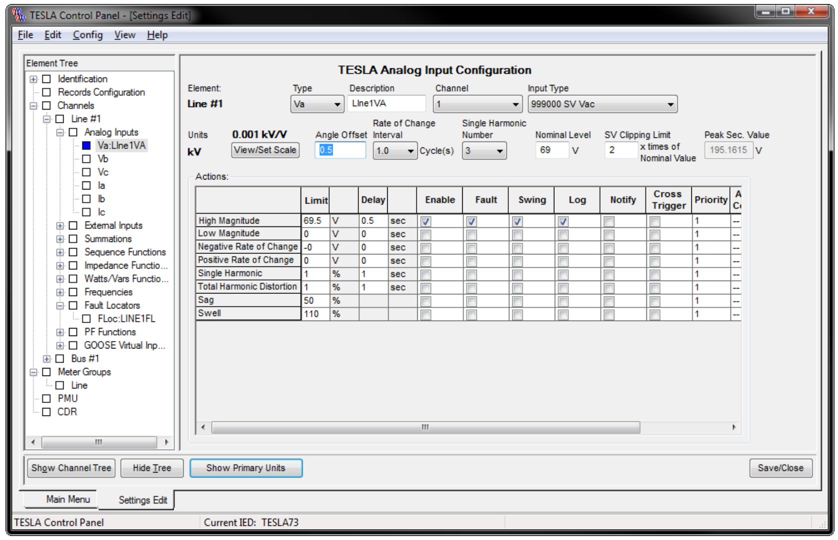


Figure 17.2: Setting up angle calibration offset through analog channel configuration

Once this phase angle offset is incorporated in the configuration, reload the configuration back to the TESLA recorder. Apply the known signal at any phase angle, and PMU should report the phase angle with the accuracy to meet the TVE as per the C37.118 standard selected. Phase angle calibration is required for all analog channels used in the PMU phasor configuration. Phase angle calibration is required when ever the TESLA recorder sample rate are changed and also recommended when the PMU standard selected is changed.

17.3 Communication with the PMU

PMU communication setup is done through TESLA Control Panel software. For the PMU, you must set the rate at which the data needs to be transferred, and the communication mode such as TCP/IP, UDP. You must also setup the Phasor Data Concentrator (PDC or DC as mentioned here and in TESLA Control Panel) information to transfer the data.

17.4 Setting up PMU Communication Mode

PMU data is transmitted via Ethernet. TCP and UDP are available for Ethernet communication. Connect to a TESLA unit and click on the *Communication > PMU* tab to modify the PMU Communication setup.

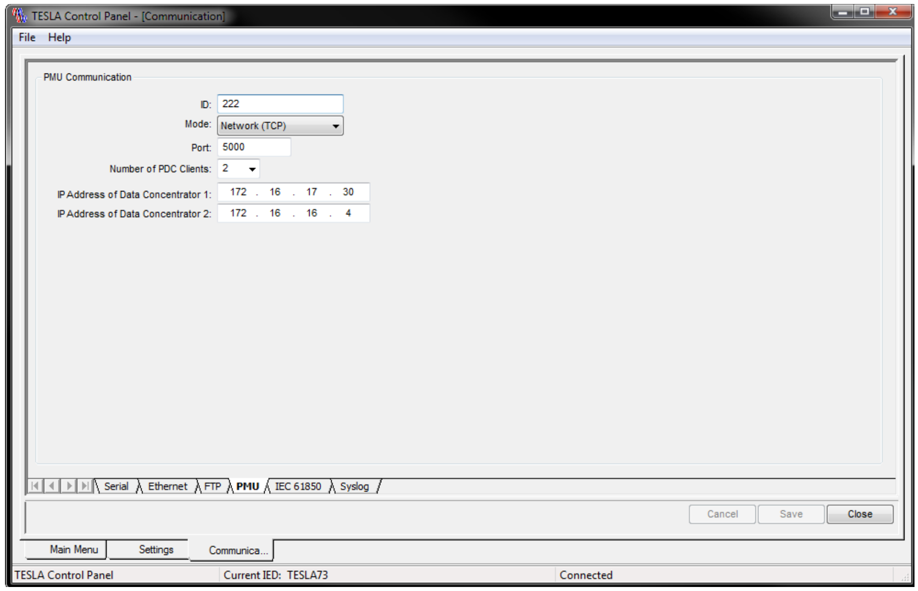


Figure 17.3: PMU communication setup screen

Settings

ID control of the PMU group allows setting PMU identification number (16-bit integer).

Mode control of the PMU group allows selecting communication mode for the real-time transfer of the PMU data. The following commutation options are available for the selection via the Mode control:

- Do Not Transmit: With this choice, no PMU data is reported to the DC (Data Concentrator). Useful for maintenance purposes.
- Network (TCP): This choice transmits the PMU data using network communication link (as set by the user in the IED settings) and using TCP protocol. The port number of the DC is required to set this communication choice.
- Network (UDP): This choice transmits the PMU data using network communication link (as set by the user in the IED settings) and using UDP protocol. IP address and the port number of the PDC are required to set this communication choice.

The PDC options are:

- IP Address of Data Concentrator 1, IP Address of Data Concentrator 2: This option is enabled only if the Mode is either Network (TCP) or Network (UDP) otherwise it is disabled. The table below describes the cases where IP Address of Data Concentrator is enabled or disabled.

- Port: This option allows user to configure the listening port number of the recorder to which a PDC client will connect via the network link.
- Number of PDC Clients: This option allows user to set the number of PDC clients that can connect to the recorder simultaneously. The TESLA 4000-SV supports up to two PDC clients.

Table 17.3: Data Concentrator IP Address State

Mode	Network (UDP)	Network (TCP)	
Number of PDC Clients	1 (fixed)	1	2
IP Address of Data Concentrator 1	Enabled	Enabled	Enabled
IP Address of Data Concentrator 2	Disabled	Disabled	Enabled

17.5 PMU Configuration

Configuring PMU Phasors with Existing Settings

Select an existing configuration file by double-clicking on the file and the following screen appears.

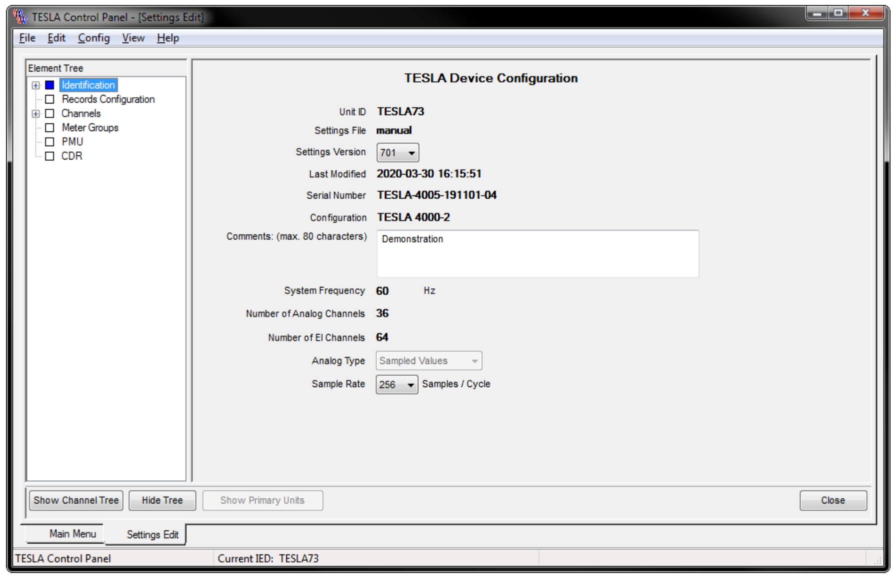


Figure 17.4: Setting version conversion view

Right-click on the Channel Group1 to display the choice to add a PMU as shown below.

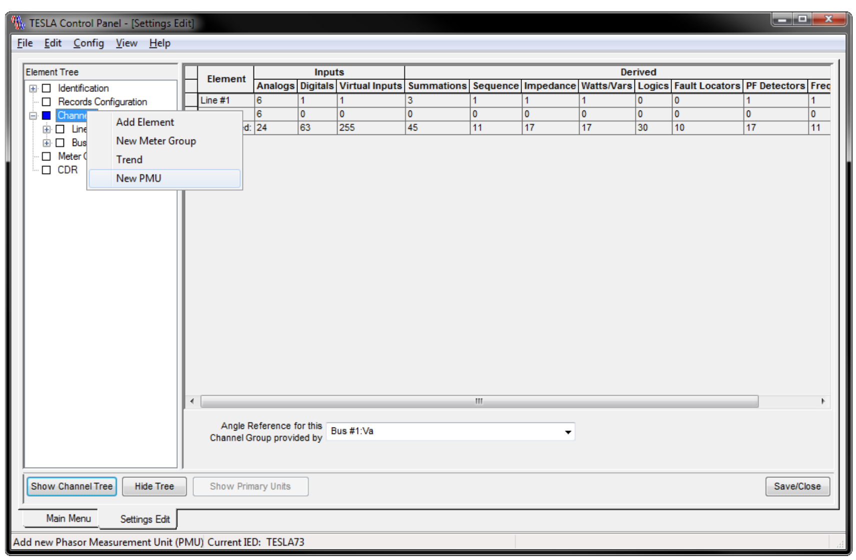


Figure 17.5: Invoking PMU configuration through right-click menu

Select the PMU choice and the following screen appears allowing you to select the Phasors.

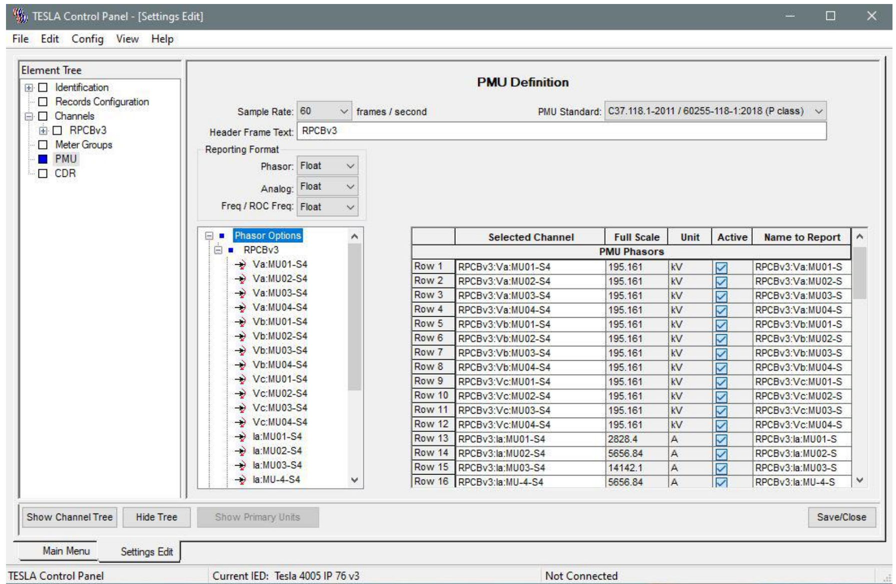


Figure 17.6: PMU configuration screen

In the PMU Definition Screen, Analog Inputs (voltage & currents), Summations and Sequence Functions channels are available for PMU Phasors reporting. You can select up to 36 phasors by dragging and dropping the channels on the Selected Channels list or by selecting the phasors from the Combo Box as shown below. In addition up to 24 analog quantities (Watt, Vars, VA, frequency and THD) and 320 digital quantities (breaker contacts) can be selected in the PMU definition screen for streaming to the PDC. Analog, PMU and Frequency data formats may be user configured to provide information in Integer or Floating-Point form.

The following features can be observed with the PMU Definition configuration screen:

A PMU item appears on the left-hand side tree view.

On the right-hand side the PMU Definition Configuration screen displays the following configuration items:

- Sample Rate - sample rate for the PMU to report. The default setting is set to 10 frames per second. Different samples rates can be chosen: 10, 12, 15, 30 or 60 frames per second for the 60 Hz power system. For the 50 Hz power system the sample rates are 10, 25, 50 frames per second. Selection is by drop down selection.
- Header Frame Text - You can enter comments up to 80 characters using this option by default the value is blank.

The lower part of the PMU Definition screen is made up of two sections. To the left is the selection tree. To the right are the placement columns where the quantities are dragged to from the left selection tree or selection can be done by the drop-down columns in each of the right-hand columns.

The right-hand PMU Definition screen is made up of three sections, Selected Channels: PMU Phasors, PMU Analogs, PMU Digitals

Selection Channel Column

PMU Phasor section allows 36 PMU Phasors to be selected from the Phasor Options left hand tree by selecting from the tree, drag and drop into one of the up to 36 rows under PMU Phasor column. The user can also use the row drop down selection tool. A PMU Phasor can be; an analog voltage or current phasor, a summated voltage or current phasor or a voltage/current sequence component (Pos., Neg., or a Zero sequence) phasor.

PMU Analog allows 24 PMU Analogs to be selected from the Analog Options left hand tree by selecting from the tree, drag and drop into one of the 24 rows under PMU Analog column. User can also use the row drop down selection tool. A PMU Analog can be MWatts, MVars, MVA, DC, frequency and/or THD values.

PMU Digital allows up to 320 digital inputs per TESLA recorder. When a digital channel is configured it will be automatically placed in the PMU Digital section of the screen.

As soon as the phasor, analog value or digital channel is selected, corresponding channel name will be displayed in the Name to Report column with the default name as depicted under Selected Channels. If the name as appearing in the Selected Channels is greater than 16 characters, it will be truncated to 16 characters before it is displayed

If no phasors are selected (no discrete phasor channels and no positive sequence phasor channels) then the real time PMU data will not be transmitted, even though the other parameters are available. You must select at least one phasor channel in order for the PMU to report the phasor information in real time.

Full Scale Column (PMU Phasor and Analog sections)

For PMU Phasors, this column's values are automatically calculated and inserted. These values are derived by the full scale of the input device (voltage or current modules) times the PT or CT ratio. The voltage module's full scale is 138 volts. The current module's full scale is 20 x In -1 amp module = 20 amps, 5 amps module = 100 amps. These are multiplied by the PT / CT ratios to get the full scale value in this column

For the PMU Analog section, this column's value have a default value which is calculated by multiplying the full scale values of the voltage and current from the PMU Phasors' section.

Unit Column (PMU Phasors and Analog sections)

This column will automatically place the primary unit scale of the voltage and current phasors in the PMU Phasors Section

In the PMU Analog section column will automatically place the primary unit scale of the Watts (MW), Vars (MVAR), VoltAmps (MVA), Frequency (Hz) and THD (%).

Active Column (Digitals)

This column shows check boxes, where you can enable or disable the PMU streaming of these PMU quantities to the Data Concentrator. A check will enable this PMU channel.

Name to Report (PMU Phasors, Analog and Digitals)

This column allows the user to re-name the streaming PMU channel that will be reported to the remote Data Concentrator.

Note that the saved PMU configuration is automatically used in the PMU metering display, when this file is loaded on the TESLA 4000-SV.

Use Save/Close option to save the PMU information in the setting file for later retrieval and/or loading into TESLA 4000-SV.

Configuring PMU from a New Setting File

Before setting up PMU configuration, you must set up the desired analog and/or summation and/or sequence channels as explained in the Configuring the Recorder section of the TESLA User Manual. Once the channels are defined, the procedure as explained in “PMU Configuration” can be followed to define PMU phasors.

17.6 PMU Metering

PMU metering does not require any special configuration settings. Once the PMU phasors are defined as explained in the previous section, the PMU metering automatically displays the metering screen through a separate PMU tab. Phasor magnitude and respective phase angles are displayed in primary or secondary units. All the user interface and update features available for the normal metering are also available for the PMU metering. In addition to the phasor channels configured in the PMU configuration, a frequency channel will also be displayed, if one is already configured. A typical PMU metering screen is as shown below.

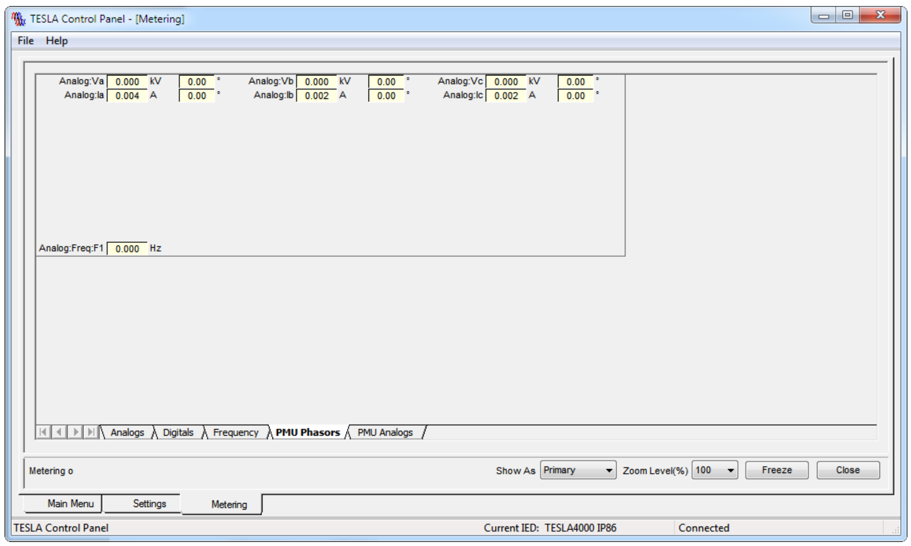


Figure 17.7: Typical PMU metering screen

17.7 PMU Stream Quality on Time Synchronization Loss

The TESLA 4000-SV meets all of the IEEE C37.118.2 requirements, including time-quality reporting, when synchronized with an IRIG or PTP source that is complaint with the standard. However, in the event of the loss of the required high accuracy timing signal, the following summarizes the expected response/behavior of the recorder during this type of condition.

Internal Clock Drift

The biggest factor in the internal clock drift is whether or not the TESLA 4000-SV has been connected to a C37.118 compliant timing source during the current power cycle.

When the TESLA 4000-SV is synchronized to a highly accurate external time reference, it counts the number of internal oscillator clock cycles between consecutive starts of each second (consecutive PPS - Pulse Per Second), and stores this count value as PPS_COUNT. PPS_COUNT remains stable because the time source is stable and the oscillator frequency is stable. It is within +/- one count value of the actual PPS when synchronized to an external reference. The TESLA 4000-SV internal oscillator is 133MHz therefore one count value is 7.5ns.

If external time synchronization is lost, the TESLA 4000-SV continues to operate using the PPS_COUNT captured prior to losing sync. Each future PPS is assumed to occur PPS_COUNT clock cycles after the previous PPS, and this is used to maintain internal time in the absence of an external time reference. Since the PPS_COUNT value was within +/- one count of the true PPS prior to sync loss, and the TESLA 4000-SV internal oscillator is 133MHz where one count is 7.5ns, the time drift could be as high as 7.5ns per second (I.E. per PPS), or 648us per day (7.5ns/s x 86,400 s/day).

If the TESLA 4000-SV is powered up without ever connecting to a valid external time reference, PPS_COUNT accuracy is based on the accuracy of the internal clock oscillator which is 50ppm. 50ppm results in a time drift of 50/1,000,000 x 86,400 s/day = 4.32 s/day. This is unacceptable for PMU applications.

It is worth noting that the front panel “Time Sync” LED is not a Time Sync Loss indication, but is actually an indication that a good Time Signal is available and the recorder has synchronized to it. The loss of time sync source is reported via the various supported communication protocols and in the case of PMU streaming, it is handled as explained above, and specified in C37.118.2, Section 6 “Synchrophasor Message Format”, specifically in subsections 6.1 - 6.2.

18 Cyber Security

The TESLA Cyber Security System is designed to address cyber security requirements specified by NERC-CIP ([1], [2]) and IEEE ([3]) standards.

The IEEE Std 1686-2013 Table of Compliance is shown in Appendix J IEEE 1686-2013 Table of Compliance on page J-1.

For remote access protection the TESLA 4000-SV relies on the Electronic Security Perimeter concept ([1]).

> For references indicated in square parentheses [#], see 18.5 Cyber Security Reference Documents on page 18-12.

18.1 Ports and Services

Table 5.1 on page 5-1 shows a list of Services supported by the TESLA 4000-SV. This table also shows which services can be enabled or disabled. There are two groups of services:

- Data communication services
- Interactive User services

System access control for the data communication group of services relies on specific protection mechanisms defined by corresponding service protocol.

System access control for the Interactive User group of services is described in "System Access Control" on page 18-2.

18.2 System Access Control

The TESLA 4000-SV enforces interactive user (User) authentication. The User must provide valid Credentials to get access to IED. Credentials include the User Name and Password.

The User provides Credentials during the login procedure. Each login starts a User Access Session (User Session). The User Session ends, when the User logs out or is forced to logout.

All User Sessions share a common set of properties that define session lifetime. These properties are called Access Polices (see "Access Rules" on page 18-3).

IED continuously monitors User activity. Each logged in User is assigned a unique id (User ID) and their activity is being tracked separately (for details see "Security Notification System" on page 18-10). The User ID consist of two parts

- User Name
- Session ID

The Session ID is a unique programmatically generated number used to differentiate User Sessions, in case several Users with the same credentials are logged into the system simultaneously. The Session ID is reset to 1 on system start-up.

The User credentials are also used for authorization purposes (for details see 18.3 Authentication and Authorization System on page 18-5). If the User authentication (login) is successful, then the User is assigned a set of privileges (Rights). This set of Rights is used to authorize the User activity. Any attempt to perform non-authorized actions will fail.

User Rights are configurable. Rights assigned to a User at login time are valid until the end of the User Session. If User Rights change, they will affect only new sessions.

An Account is associated with each User. User Credentials and Rights information is stored on the Account (for details see User Accounts on page 18-5).

IED limits the total number of simultaneously logged-in interactive Users to 7.

Credentials

User Credentials include User Name and Password. The User Name and Password are ASCII strings.

The maximum length of User Name and Password is 23 characters. Character set includes:

- Upper case and lower case characters
- Numerical characters
- Special characters

Appendix K Credential Character List on page K-1 contains a complete list of characters allowed for User Name and Password.

Password Complexity Rules

The IED enforces Password Complexity Rules for all User constructed passwords. Password Complexity Rules are configurable and include the following Password properties:

- Contain at least one upper-case character;
- Contain at least one lower-case character;
- Contain at least one numerical character;
- Contain at least one special character;
- Enforce minimum Password length (8 to 20 characters).

See “Password Complexity” on page 8-36 for details on configuring the Password Complexity Rules.

Access Rules

The Access Rules are listed in Table 17.1 below.

Table 18.1: Access Rules

Policy	**Units**	**Min**	**Max**
Session Duration Timeout	Hours	1	8760
Session Inactivity Timeout	Minutes	1	120
Failed Login Handling:			
Maximum Retries		1	30
Lockout Timeout	Minutes	3	60
Password Change Period:			
Enable		OFF	ON
Change Period	days	1	3650

Session Duration Timeout

The “Session Duration Timeout” defines the maximum duration of the User Session. The IED forcefully logs the User out and closes the session after the timeout expires.

Session Inactivity Timeout

The “Session Inactivity Timeout” defines the maximum time the User can remain inactive during a session. Inactivity is defined as the absence of user communication with the IED. The IED forcefully logs the User out and closes the session if user is inactive for a period exceeding the timeout setting.

> The minimum inactivity timeout should not be set to less than 3 minutes on an IED that is used as the gateway for connect-through sessions (including for Cooperative Mode Master Recorder)

Failed Login Handling

“Failed login handling” defines the IED behavior in the case of failed login attempts. The IED allows for a number of failed login attempts for the same User. The IED locks the User out after the number of consecutive failed login attempts reaches a configurable maximum. This maximum value is defined by the “Maximum retries” setting. The User is locked out for the period of time defined by the “Lockout timeout” setting. Any login attempts (with or without correct Credentials) are invalidated (failed) until lockout timeout expires. User is allowed to login after lockout timeout expires.

The IED keeps track of failed logins by associating a failed logins counter with each User. The User is locked out when counter reaches the “Maximum retries” value. The counter is cleared and the User is allowed to login after the lockout timeout expires.

The failed logins counter is cleared, when outside of the lockout period, under these conditions:

- On a successful login
- If there are no login attempts within a period of time defined by “Lockout timeout” setting (prevents accumulation of failed login attempts over long period of time).

> Failed logins counters are not persistent across system start-ups. All counters are cleared on start-up.

Password Change Period

The “Password change period” setting is used to support the NERC CIP requirement to periodically update User passwords. If the “Password change period” setting is enabled, the IED compares the current date against the date Password was last updated on User login. If the difference exceeds “Change period” setting value, then the User gets a Password change notification. The IED doesn’t enforce Password change, but rather informs the User that update is required. The User is still granted access and allowed using all services assigned to them.

> TESLA Control Panel prompts the User to enter a new password, if password change period has expired. The User can discard the prompt and continue using services.

Refer to “Access Policies” on page 8-36 for details on how to configure Access Policies.

18.3 Authentication and Authorization System

TESLA uses an accounts system for User authentication and authorization. The Account system is used for all types of interactive User services. The Account system is stored locally on IED.

There are two types of accounts:

- Multi-purpose User Accounts
- Contingency Account for Security Configuration recovery to factory defaults.

Authentication Defeat Mechanism

There are no means to defeat or circumvent the IED Authentication System. A Role Based Access Control (RBAC) model is used for User authorization.

User Accounts

Number of User Accounts

The TESLA 4000-SV supports up to 32 User Accounts.

Account Properties

The properties associated with the User Accounts are shown in Table 18.2 Account Properties:

Table 18.2: Account Properties

Property	Value	Notes
User Name	Text string	User name used at login time
Password	Text string	Password used at login time
Account enabled	ON/OFF	Used to enable/disable account
Password change on the next login	ON/OFF	Advises user to change password on login
Active date	Date	Date when user account becomes active
Expiration date	Date	Date when user account expires
Roles		A list of Roles (privileges) assigned to the user
Comments	Text	General purpose notes describing the user account

The “User Name” and “Password” are used for authentication purposes.

The IED stores a password signature instead of a clear text password. The clear text password is converted into a signature when an account is created or updated. The User entered password is converted into a signature at login time and the result is compared against the signature stored on the account.

The “account enabled” property allows to manually disable the account. If the account is disabled, it is not used for User authentication purposes.

The “password change on the next login” property advises the User to change the password. This property allows the security administrator to manually initiate individual password updates. If enabled, this property remains enabled until the User updates their password. The property is set automatically when time period defined by “Password change period” setting expires (see “Password Complexity Rules” on page 18-3). The password change is not enforced.

If the “Active period validation” property is enabled, it instructs the IED to validate the date at the time of login. The “Active date” and “Expiration date” settings are used for validation. User authentication fails if the login date is outside of the period defined by “Active date” (lower bound) and “Expiration date” (upper bound).

> The “Active period validation” is disabled for users with the SECADM role. This guarantees continuous control over system accessibility.

The “Roles” property is used for authorization purposes. It contains a list of Roles assigned to the User. Refer to “Authentication and Authorization System” on page 18-5 for more details.

The “Comments” property is a general purpose text describing the account. The maximum text length is 79 characters. This property is not used by the IED and is for displaying purposes only.

Refer to “User Account Management” on page 8-33 for how to create and manage User Accounts.

Contingency Account

The Contingency Account is used for authorization of Security Configuration restoration to Factory Defaults operation.

Challenge-Response protocol

The IED uses a Challenge-Response protocol to Restore Security Configuration to Factory Defaults.

The IED programmatically generates a Challenge Authorization String (Challenge) based on a randomly generated number. The Challenge is a 24-character ASCII string. The character “-” is used as a separator for readability purpose and is not part of the Challenge. The Challenge is presented to a user in a format as follows

XXXX-XXXX-XXXX-XXXX-XXXX-XXXX

The User provides the IED with a Response Authorization String (Response). The IED validates this Response and restores Security Configuration to factory defaults, if the Response is valid. The Response format is also a 24-character ASCII string, similar to the Challenge.

Challenges and Responses are unique to the IED they are generated by/for. The Responses generated for one IED are invalid for all others.

Challenge lifetime

A Challenge never expires. It is updated programmatically after the Security Configuration restoration operation. Alternatively, the User can trigger a Challenge update manually at any time. Challenge update is available in the Security Configuration “Contingency Account” dialog or Terminal UI dialog (see “Default Security Configuration Settings” on page 8-38 for more details).

> Please contact ERLPhase customer support to generate a Response. A request for Response should include the Challenge.

Responses are specific to Challenges. A new Response is required every time the Challenge is updated.

Authorization System

The TESLA authorization system complies with RBAC model specified in [4]. Table 18.3 TESLA Role List lists supported User Roles.

Table 18.3: TESLA Role List

Role Name	Comment
Pre-defined User Roles defined in IEC 62351-8	
VIEWER	Can view parameters and browse menus
OPERATOR	Can read parameters and perform control operations
ENGINEER	Can read and change parameters, change configuration (other than security) and settings, full access to files
INSTALLER	Can view parameters, change configuration (other than security) and settings
SECADM	Can read and change security configuration
SECAUD	Can read and download audit trail log
TESLA 4000-SV default User Roles	
MAINTENANCE	Can perform TESLA 4000-SV maintenance functions
UPDATE	Can perform TESLA 4000-SV firmware update
RCDREADER	Can access TESLA 4000-SV record storage
COOPGROUP	Role is designated for the inter-TESLA COOP mode communication.
RBCS	Role is designated for RecordBase Central Station access to the TESLA 4000-SV record storage and RBCS related communication configuration.

> RBACMNT Role defined in the IEC 62351-8 standard is not supported.

Roles assigned to a User define user privileges. See Table 18.4 Privilege to Roles Assignment.

Table 18.4: Privilege to Roles Assignment

Privilege	Roles										
	VIEWER	OPERATOR	ENGINEER	INSTALLER	SECADM	SECAUD	RCDREADER	COOPGROUP	MAINTENANCE	UPDATE	RBCS
View unit identification information	X	X	X	X	X	X	X	X	X	X	X
Change unit identification information			X	X	X						
View IED’s cooperative mode status	X	X	X					X		X	X
View record list	X	X	X				X			X	X
Read records		X	X				X			X	X
Delete records			X								X
Manually trigger recording		X						X			X
Read recording configuration		X	X				X			X	X
Change recording configuration			X								
View trend channel list	X	X	X							X	
Read trend data		X	X							X	
Delete trend data			X								
Read trend configuration		X	X							X	
Change trend configuration			X								
View Continuous Disturbance Recording summary	X	X	X								X
Read Continuous Disturbance Recording data		X	X								X
Erase Continuous Disturbance Recording data			X								
View events	X	X	X								X
Erase events			X								
View metering data	X	X	X	X							
Read cooperative group configuration		X	X					X		X	X
Change cooperative group configuration			X							X	
Trigger cooperative group recording		X						X			X
View IED setting file description	X	X	X	X						X	
Read IED settings file		X	X	X						X	
Load settings file to IED			X							X	
Read communication configuration		X	X	X	X						X[1]
Change communication configuration			X	X	X						
View IED time	X	X	X	X	X	X			X	X	
Read time configuration		X	X	X	X				X	X	
Change time and time configuration			X	X	X				X		
Calibrate			X	X							
Update firmware										X	
Read/download system diagnostics									X	X	
Restore default configuration									X	X	

Table 18.4: Privilege to Roles Assignment

Privilege	Roles										
	VIEWER	OPERATOR	ENGINEER	INSTALLER	SECADM	SECAUD	RCDREADER	COOPGROUP	MAINTENANCE	UPDATE	RBCS
Activate safe shutdown mode		X							X		
Force restart									X		
Access network utilities									X		
Activate new storage device									X		
Repair storage device									X	X	
Manage security configuration					X						
Read/download Audit Trail						X					

1. RBCS role has a privilege to read FTP communication configuration.

TESLA RBAC model maps IED privileges to mandatory pre-defined Rights defined in [4]. Mapping is not shown in Table 18.4 Privilege to Roles Assignment.

Separation of Duties

Users may be assigned any combination of Roles except for the “SECADM” Role. “SECADM” cannot be combined with any other Role.

18.4 Security Notification System

The TESLA implements a Security Notification System to monitor cyber security related User activity. A Security Notification is an alert generated if User actions compromise or may compromise IED Cyber Security.

Security Notifications are categorized by class and type. There are two Security Notification classes, Security Events and Security Alarms:

- A Security Event is an alert related to an authorized activity.
- A Security Alarm is an alert related to an unauthorized activity or an activity critical to the operation of the IED

The Security Notification types are shown in Table 18.5 Security Notification Types.

Table 18.5: Security Notification Types

Name	Description
AUTH	Security Notifications related to Authentication and Authorization activity.
ACCS	Security Notifications related to access to IED Data and Control.
SECU	Security Notifications related to access to IED Security Data and Control.
SYST	Security Notifications related to IED System state change

The Security Notification contains information necessary to identify a nature of the alert, whose actions triggered it and when it happened. The Security Notification structure is shown in Table 18.6 Security Notification Structure.

Table 18.6: Security Notification Structure

Field	Description
Sequence Number	Automatically incremented sequence number
Time and Date	Time and date stamp
User ID	User ID includes User Name and Session ID
Notification ID	A number that uniquely identifies name, class, and type of Security Notification
Details	Security Notification specific details

Refer to [5] for Security Notification System detailed description.

Audit Trail

The TESLA records Security Notifications into a local security log called the Audit Trail. The Audit Trail size is limited to 2048 records (one Security Notification per record).

Records are handled in First-In-First-Out (FIFO) manner where the newest record overwrites the oldest one, if Audit Trail is full.

Audit Trail cannot be reset or erased and individual records cannot be deleted.

The validity of each record is protected by a signature.

Access to Audit Trail is available via TESLA Control Panel (see "Audit Trail" on page 11-8).

Syslog

The TESLA provides Cyber Security Notification messages to an external (relative to the TESLA) Syslog server. The Syslog server interface complies with RFC5424 ("The Syslog protocol") and RFC5426 ("Transmission of Syslog messages over UDP") standards.

The Syslog server settings are available on the *Syslog* tab in the *Communication* menu in TESLA Control Panel (see "Syslog Communication Settings" on page 8-31).

18.5 Cyber Security Reference Documents

[1] CIP-005-5 Cyber Security – Electronic Security Perimeter

[2] CIP-007-6 Cyber Security – System Security Management

[3] IEEE Std 1686-2013 IEEE Standard for Intelligent Electronic Devices Cyber Security Capabilities

[4] IEC/TS 62351-8 Power systems management and associated exchange – Data and communications security – Part 8: Role-based access control

[5] TESLA 4000-SV Security Notification System User Guide v1.01

19 IEC 61850 Implementation Overview

19.1 Introduction

The IEC 61850 standard defines a suite of protocols that permit substation equipment from different manufacturers to communicate with each other. ERL is dedicated to developing IEC 61850-based devices that can be used as part of an open and versatile communications network for power system automation.

The IEC 61850 defines an Ethernet-based protocol used in power systems for data communication. Power systems implement a number of devices for protection, measurement, detection, alarms, and monitoring. System implementation is often slowed down by the fact that the devices produced by different manufacturers are incompatible, since they do not support the same communication protocols. The problems associated with this incompatibility are quite serious, and result in increased costs for protocol integration and system maintenance.

The IEC 61850 is a broad ranging standard which encompasses the entire scope of power system automation, from the highest level of substation design to the lowest level of the communication protocol implementation on IEDs. The IEC 61850 Standard also defines a standard Engineering Process which is an iterative process which allows for the implementation and management of power system automation.

Some key concepts which are discussed further in the following sections are:

- Substation Configuration Language (see Section 19.2)
- The Engineering Process (see Section 19.3)
- Edition 2.0 Implementation (see Section 19.4)
- Sampled Value Subscription (see Section 19.11)

Parts of the Standard

The IEC 61850 Standard is comprised of many parts. The parts of the standard which are most relevant to the implementation in this device are:

- IEC 61850-6:2010 Edition 2.0: Configuration description language for communication in electrical substations related to IEDs
- IEC 61850-7-2:2010 Edition 2.0: Basic information and communication structure – Abstract communication service interface (ACSI)
- IEC 61850-7-3:2010 Edition 2.0: Basic communication structure – Common data classes
- IEC 61850 -7-4:2010 Edition 2.0: Basic communication structure – Compatible logical node classes and data object classes
- IEC 61850-8-1:2010 Edition 2.0: Specific communication service mapping (SCSM) – Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3
- Implementation Guideline for Digital Interface to Instrument Transformers using IEC 61850-9-2:2010 (also known as IEC 61850 9-2LE)

19.2 The Substation Configuration Language (SCL)

The Substation Configuration Language (SCL) is an XML based language which provides the basis for interoperable data exchange between IEDs from different vendors and between configuration tools. The SCL file structure is comprised of five main parts:

- Header - defines file information history
- Communication - defines access points and network configurations
- Substation - defines the substation equipment and provides coordinates for locating equipment on a Single Line Diagram
- IED - provides the definition of the IED(s) including the Services, Logical Devices, Logical Nodes, DataSets, Report Control Blocks, GOOSE Control Blocks and Sampled Value Control Blocks
- DataType Templates - contains the templates which define common data used within the data model

There are multiple types of SCL files which are used for different applications within the Engineering Process. Each type of SCL file is constructed using the sections defined above, but not all SCL file types contain all five sections (for example, the CID file type does not include a Substation section).

The SCL File types are:

- SSD - System Specification Description.
  Data exchange from a system specification tool to the system configuration tool.
- SED - System Exchange Description.
  Data exchange between system configuration tools of different projects.
- SCD - System Configuration Description.
  Data exchange from the system configuration tool to IED configuration tools.
- ICD - IED Configuration Description.
  Data exchange from the IED configuration tool to the system configuration tool. Defines the IEDs capabilities and Data Model.
- IID - Instantiated IED Description.
  Data exchange from the IED configuration tool to the system configuration tool which contains add-on and/or modified values.
- CID - Configured IED Description.
  Data exchange from the IED configuration tool to the IED.

ERL 61850 IED Configurator supports all of the SCL File types which are directly related to IED configuration (SCD, ICD, IID and CID).

19.3 The Engineering Process

The IEC 61850 standard defines an Engineering Process which is used to manage and implement substation automation. The basic Engineering Process is shown in the diagrams below. For further details, refer to IEC 61850-6 Edition 2.0.

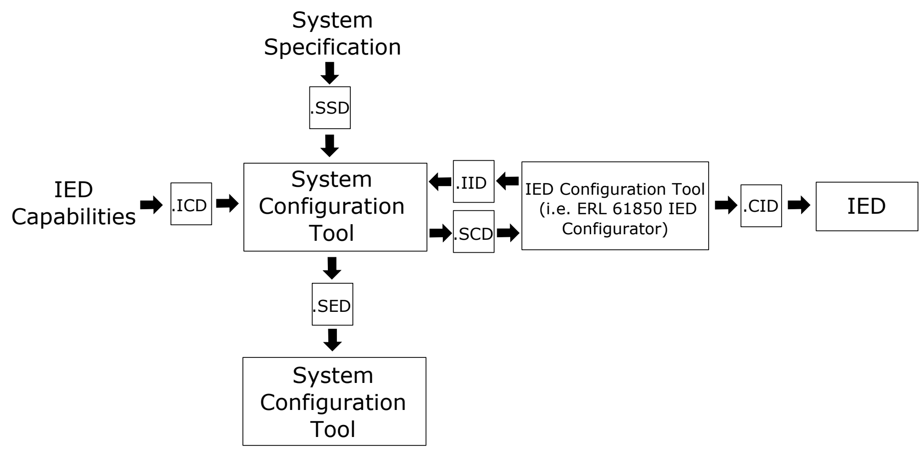


Figure 19.1: The Engineering Process

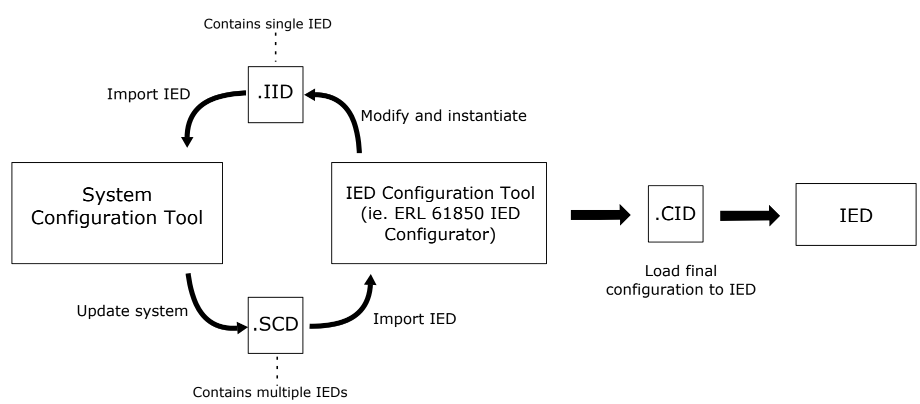


Figure 19.2: Iterations between IED Configuration Tool and System Configuration tool

ERL 61850 IED Configurator supports import and export of CID, ICD, IID and SCD, thus making it compatible with the Engineering Process. Refer to the ERL 61850 IED Configurator user manual for more details.

Note: Importing SCD files which contain mapping to ERL Devices which use IEC 61850 Edition 1.0 is not fully supported and is not recommended. ERL devices which support IEC 61850 Edition 2.0 fully support the SCD import feature and thus are compatible with System Configuration Tools as part of the Engineering Process.

19.4 IEC 61850 Edition 2.0 Implementation

The TESLA 4000-SV uses the second edition of the 61850 Standard. Edition 2.0 of the standard provides many new functionalities. The major changes which have been implemented in the TESLA 4000-SV from Edition 2.0 of the standard are described below.

Subscription Supervision via LGOS and LSVS

Two new logical nodes, LGOS and LSVS, have been added in Edition 2.0 to provide the ability to supervise GOOSE and SMV subscription statuses. The LGOS LN is used to monitor GOOSE subscriptions and LSVS LN is used to monitor SMV subscriptions.

One LGOS LN is created for each GOOSE Control Block which the IED subscribes to. One LSVS LN is created for each SMV Control Block (Sampled Value Stream) which the IED subscribes to.

The data objects of the LGOS LN are described in the table below:

Table 19.7: LGOS LN (based on IEC 61850 7-4:2010 5.3.6 (Edition 2.0))

Attribute	Description
NdsCom	Subscription needs commissioning
St	Status of the subscription (True = active, False = not active). If LGOS.St = False, this means that this GOOSE has not been received for 2x Time Allowed to Live.
SimSt	Status showing if simulated messages are received and accepted
LastStNum	Last state number received
ConfRevNum	Expected configuration revision number
GoCBRef	Reference to the subscribed GOOSE control block

The data objects of the LSVS LN are described in the table below:

Table 19.8: LSVS LN (based on IEC 61850 7-4:2010 5.3.7 (Edition 2.0))

Object	Description
NdsCom	Subscription needs commissioning
St	Status of the subscription (True = active, False = not active). If LSVS.St = False, this means that this SMV has not been received for 1 second.
SimSt	Status showing if simulated messages are received and accepted
LastStNum	Last state number received
ConfRevNum	Expected configuration revision number
SvCBRef	Reference to the subscribed SV control block

Use of Subscription Supervision in the TESLA Event Log

The LGOS and LSVS logical nodes are used to indicate GOOSE and SMV Communication Alarms in the Event Log. When the LGOS.St or LSVS.St attributes transition states, an event is logged into the TESLA event log with the indexed logical node name. This indexed logical node may be used to troubleshoot communication issues.

Note that these messages are only logged into the Event Log if the “GOOSE Subscription Supervision” and/or the “SMV Subscription Supervision” checkboxes are enabled in IEC 61850 IED Configurator.

Line	Local Time	UTC Offset	Station Name	Unit ID	Event
9	2019-11-15 13:32:39.000	-06:00		TESLA4005IP73	GOOSE comm. alarm Inactive, src. LGOS6
10	2019-11-15 13:32:39.000	-06:00		TESLA4005IP73	GOOSE comm. alarm Inactive, src. LGOS2
11	2019-11-15 13:32:38.000	-06:00		TESLA4005IP73	GOOSE comm. alarm Active, src. LGOS2
12	2019-11-15 13:32:37.000	-06:00		TESLA4005IP73	GOOSE comm. alarm Active, src. LGOS6
13	2019-11-15 13:31:50.000	-06:00		TESLA4005IP73	SMV comm. alarm Inactive, src. LSVS5

Figure 19.3: LGOS and LSVS shown in the Event Log

Subscription to *ldname*

There are two Logical Device naming methods (LDName), used for object references, described in IEC 61850-6:2010 Edition 2.0. These methods are:

- Product-related naming
- Function-related naming

In product-related naming, the LDName is comprised of the IED name and the LDevice inst attribute. ERL IEDs only use product-related naming for Logical Device naming. For example, for a TESLA 4000-SV with the IED name “MyTESLA”, the LDName for the Recorder LD would be:

LDName = IED name/LDevice inst = **MyTESLA/RCD**

In function-related naming, the LDName is derived from the LDevice *ldName* attribute. For IEDs to support the use of *ldName*, they must support the free setting of the Logical Device names. ERL IEDs do not support free setting of the Logical Device names, and so do not use the *ldName* attribute. However, Edition 2.0 ERL IEDs do support subscribing to data from other vendor's IEDs which use the function-related naming via the *ldName* attribute.

Data from an IED which uses the *ldName* attribute may be mapped to the ERL Edition 2.0 IED for subscription.

Subscription to Fixed-Length GOOSE

In IEC 61850 Edition 2.0, fixed-length encoded GOOSE messages were introduced. This is an optimized version of GOOSE encoding which uses a fixed length offset for each field of the GOOSE packet. If a GOOSE Control Block has the fixedOffs attribute set to True, this indicates that the GOOSE message uses fixed-length encoding.

ERL IEDs do not support publishing the fixed-length encoded GOOSE messages (fixedOffs attribute is always set to False). However, ERL IEDs can subscribe to GOOSE messages from other vendors which use fixed-length encoded GOOSE messages.

The fixed-length GOOSE subscription is backwards compatible, meaning that even ERL devices which use Edition 1.0 of the standard can subscribe to fixed-length GOOSE messages.

GOOSE Publishing

TESLA 4000-SV can publish GOOSE on different SubNetworks (network ports). A GOOSE message can be published on one Subnetwork only. GOOSE message Subnetwork is selected in ERL 61850 Configurator, when configuring GOOSE message.

Simulation Mode

TESLA 4000-SV supports simulation mode for GOOSE and SMV subscriptions. Simulation Mode is set (on/off) for the entire IED. Simulation mode is controlled via LD0.LPHD1.Sim data object.

LD Mode control hierarchy

LDs are organized in a hierarchy, where LD0 is a parent to all other LDs. Behavior of LNs of all LDs can be controlled by setting appropriately LD0/LLN0.Mod DataObject (Global Mode Control).
In addition to Global Mode Control, SVI (SMV subscription) and DVI (Virtual Inputs subscription) LDs each have a separate Mode Control.
SVI/LLN0.Mod is used to control Mode of all LNs in the SVI LD.
DVI/LLN0.Mod is used to control Mode of all LNs in the DVI LD.

All Mode Controls are implemented as “direct with normal security” controls. A new Mode takes effect immediately upon control command completion.

Multiple Subnetworks

TESLA 4000-SV supports GOOSE and SMV subscription in 4 different Ethernet ports, which refers to port 401, 402, 410/412 as well as port 411. Each physical Ethernet port has its associated subnetwork name. By default, this subnetwork name is defined as ERL1, ERL2, ERL3, ERL4 respectively in the ICD file. In order to properly subscribe to the expected GOOSE/SMV from the publisher, subnetwork name matching is required so that TESLA4000-SV will understand at which Ethernet port the GOOSE/SMV will be processed. The following GOOSE subscription mapping configuration shows an example where the publisher TESLA4000_SV_1 has configured 3 different GOOSE Control Blocks onto 3 different Ethernet ports 401 (ERL1), 402 (ERL2) and 410/412 (ERL3). The subscriber TESLA4000_SV_2 will process the GOOSE message destinated to the corresponding Ethernet port if the matched subnetwork name is found on the associated port. If the subnetwork name does not match between publisher and subscriber, mapping will be prevented by the ERL 61850 IED Configuration Tool. If the mapping was done using the System Configuration Tool by not considering the subnetwork matching, then the subscriber will not proceed the incoming GOOSE message. In that case, subnetwork name correction is needed with either SCT or ERL 61850 IED Configuration Tool. For the detail procedure of configuring the subnetwork name in ICT, please refer to the user manual of ERL 61850 IED Configuration Tool.

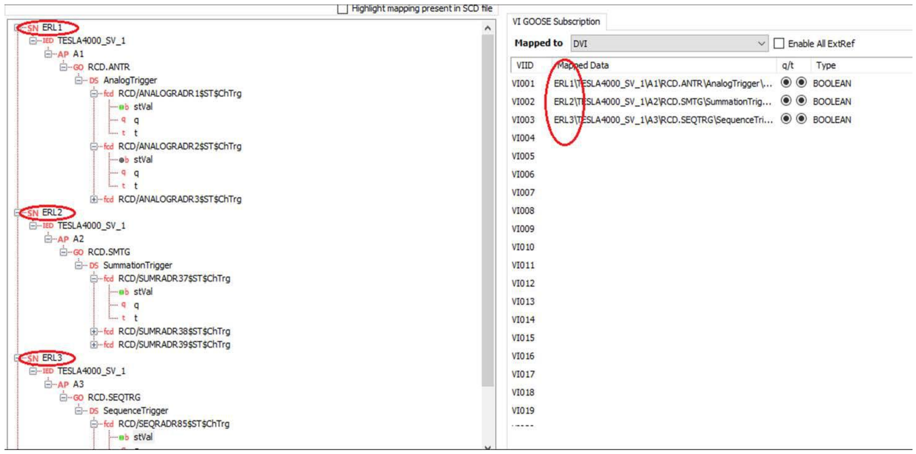


Figure 19.4: Multiple Subnetworks

SMV subscription

TESLA invalidates incoming SMV data, when SVI LD is in “on” Mode and incoming data quality test bit is set to true. The entire message is discarded, if at least one SMV data value is invalid.
SMV data is always processed in “test”/”test/blocked” Mode regardless of the state of data quality test bit.

GOOSE subscription

TESLA invalidates incoming GOOSE data, when DVI LD is in “on” Mode and incoming data quality test bit is set to true. IED allows for incoming messages to contain a mix of valid and invalid data. The invalid data is discarded. The valid is processed.

GOOSE data is always processed in “test”/”test/blocked” Mode regardless of the state of data quality test bit.

Once the incoming GOOSE message is successfully subscribed, the corresponding GOOSE Virtual Input associated events will be shown in the Event log with two designated letter 'L' and 'G' which refers to 'Local' and 'GOOSE' correspondingly. These two events refer to the same subscribed GOOSE operation however indicate with different time stamps. 'G' refers to the remote GOOSE message's time stamp, which came from either the remote publisher GOOSE data item's 't' attributes, or from the GOOSE header time stamp if 't' attribute is not defined in the dataset. 'L' refers to the local subscriber's incoming GOOSE message's local arrived and processed time stamp. In theory, if publisher and subscriber are precisely time synchronized, 'G' time stamp is always earlier than 'L' time stamp to accommodate the signal propagation delay as well as process time. Typically, time difference between 'L' and 'G' for the same operation event is around 2-4ms. If the time difference between the two events are noticeable large or 'L' time stamp is earlier than 'G' time stamp, then publisher and subscribe may face time synchronization issue, this issue may affect proper record trigger in some case.

IED Name Length

Edition 2.0 of the IEC 61850 standard allows for longer IED names. The maximum *IED name* length allowed according to the standard is 64 characters. However, this is limited by the total maximum allowed length for LDName references which is also limited 64 characters. The LDName is defined as *IED name/LDevice inst*. The total *IED name + LDevice inst* character count may not exceed 64 characters. This is handled automatically in ERL 61850 IED Configurator. The software ensures that *IED name* length does cause the maximum length for the LDName to be exceeded. For example, if the longest *LDevice inst* name is 10 characters long, then *IED name* length is limited to 54 characters, so that *IED name + LDevice inst* does not exceed 64 characters.

Common Data Classes

In Edition 2.0 of the IEC 61850 Standard some new Common Data Classes (CDC) were added and others were updated. The only CDC change in Edition 2.0 which affects the TESLA 4000-SV implementation is the LLN0.Beh data object uses CDC Type ENS.

Edition 1.0 Compatibility

In general, Edition 1.0 and Edition 2.0 devices are compatible with each other for GOOSE and SMV mapping. However, there are some backward compatibility issues which the user should be aware of before attempting mapping between Edition 1.0 and Edition 2.0 devices.

Mapping Edition 1.0 Data to an Edition 2.0 IED

There are no compatibility issues when mapping data from an Edition 1.0 ERL IED to an Edition 2.0 ERL IED. The Edition 2.0 of the IEC 61850 Standard is designed to handle this forward-compatibility case.

Mapping Edition 2.0 Data to an Edition 1.0 IED

Edition 2.0 of the IEC 61850 introduced some backward-compatibility limitations when mapping to an Edition 1.0 IED. The user should be aware of these limitations before configuring mapping Edition 2.0 data to an Edition 1.0 IED.

In order to map data from an Edition 2.0 IED to an Edition 1 IED, the following restrictions must be followed:

- The IED Name on the Edition 2.0 IED (publisher) must be limited such that *IED Name + Longest LD Inst* does not exceed 32 characters. This restriction is not enforced by ERL IEC 61850 Configurator, it is the responsibility of the user to ensure name length on the Edition 2.0 IED is not too long.
- The Edition 2.0 publisher cannot use function-related naming (i.e. *ldName* attribute). Edition 1.0 does not support the *ldName* attribute. If the Edition 2.0 publisher uses the *ldName* attribute, then its data may not be mapped to an Edition 1.0 ERL IED. ERL 61850 IED Configurator prevents this mapping when attempted by the user. The TESLA 4000-SV does not support publishing the *ldName* attribute, so this condition only applies when mapping with third party vendors who support the *ldName* attribute.
- In Edition 2.0 of the standard, new CDCs were introduced which may cause backward-compatibility issues. These new CDCs do not apply to the implementation in the TESLA 4000-SV and therefore this should not cause

any issues when mapping between ERL Edition 1.0 and 2.0 devices. However, the user should be aware when mapping from other vendor's IEDs that there may be issues if using data from CDCs which are newly introduced in Edition 2.0.

IEC 61869-9 Support

Starting from firmware v1.5, TESLA 4000-SV brings the support for IEC 61869-9.

IEC 61869-9 is the official IEC standard that replaces the earlier IEC 61850-9-2LE guideline.

It adds support for multiple sampling rates and introduces flexible, configurable datasets (up to 24 data items), where each dataset can include any combination of current and voltage channels.

The following sample rates is supported for 50Hz and 60Hz configuration.

Table 19.9: TESLA 4000-SV supported sample rate

System Frequency (Hz)	Samples/Cycle	Hz
50	80	4000
	96	4800
	256	12800
	288	14000
60	80	4800
	240	14400
	256	15360

Ed 2.1 SV Stream Support

Starting from firmware v1.5, TESLA 4000-SV brings the support for Ed 2.1 sampled value stream, where a new optional attribute *gmIdentity* is introduced. In the previous version of firmware, TESLA 4000-SV discards the entire SV packet when SV stream contains this optional new attribute. From firmware v1.5, TESLA 4000-SV will still subscribe to the other information in the packet, but not use the value of this attribute for further processing.

19.5 LD0 Logical Device

LD0 is the Root Logical Device of the TESLA 4000-SV data model. The Root Logical Device contains the Physical Device information and it acts as the parent Logical Device of all other Logical Devices.

The LD0 contains the Unit Identification information in the LPHD and LLN0 Logical Nodes (LPHD.PhyNam and LLN0.NamPlt). The table below shows how the Physical Device information stored in the LPHD LN relates to the Unit Identification information displayed in TCP (see “Unit Identification” on page 8-2).

Table 19.10: LD0 and TESLA Control Panel Unit Identification

LD0 Unit Identification	TESLA Control Panel Unit Identification
LPHD.PhyNam.Vendor	*ERLPhase*
LPHD.PhyNam.swRev	IED Firmware Version
LPHD.PhyNam.serNum	Serial Number
LPHD.PhyNam.model	*TESLA 4000-SV*
LPHD.PhyNam.location	Location
LPHD.PhyNam.ePSName	Station Name
LPHD.PhyNam.mRID	Unit ID
LLN0.NamPlt.Vendor	*ERLPhase*
LLN0.NamPlt.swRev	IED Firmware Version
LLN0.NamPlt.ConfigRev	Configuration ID

The LD0 LD will serve an increasingly role in future development of the TESLA 4000-SV.

19.6 SYS Logical Device

The SYS Logical Device is the System Logical Device of the TESLA 4000-SV data model. The SYS LD contains the following information:

- Output Contact status information (OCGGIO LNs)
- Time Synchronization status information (TMSRCLTMS LN)
- Subscription Supervision information (LGOS and LSVS)
- Physical communication channel supervision (P401LCCH1 to P412LCCH5)

There is one Output Contact LN per Output Contact on the TESLA.

The Time Synchronization LN contains information regarding the active time source on the TESLA.

For more information regarding the Subscription Supervision LNs, refer to "Subscription Supervision via LGOS and LSVS" on page 19-4.

Each Ethernet Port communication status is supervised by the LN LCCH, its prefix refers to the physical port number. For instance, in Single Redundancy hardware P401LCCH1 refers to the communication status on the front and rear Port 401, when the data packet is not received within a predefined time interval, its corresponding data attribute ChLiv status will change from true to false. For the IED that supports network redundancy, redundant port 412's status will be shown under P410LCCH3.RedChLiv when the Active Mode is set to PRP profile. When the Active Mode is set to RSTP profile, Port 412's status will be shown under P412LCCH5.ChLiv. The response time of the status change will vary depends on the port as well as received data packet condition. For details, refer to Appendix H

The data contained within the Logical Nodes in the SYS LD may be added to Datasets for use in Report Control Blocks or GOOSE Control Blocks or may monitored directly via a 61850 client. Refer to the ERL 61850 IED Configurator User Manual for more information regarding configuration of the 61850 services. Refer to "Data Mapping Specifications" in Appendix H for more details regarding the SYS LD and it's associated LNs.

19.7 RCD Logical Device

The RCD Logical Device is the Records Logical Device of the TESLA 4000-SV data model. The RCD LD contains all of the information regarding trigger statuses for each of the possible channels in the TESLA setting file:

- Analog channel triggers (ANALOGRADR LNs)
- Sequence channel triggers (SEQRADR LNs)
- Summation channel triggers (SUMRADR LNs)
- Frequency channel triggers (FREQRADR LNs)
- Impedance channel triggers (IMPRADR LNs)
- External input channel triggers (EIRBDR LNs)
- Logic channel triggers (LOGICRBDR LNs)
- Power function channel triggers (PFRADR LNs)
- Watt/Var channel triggers (WVARRADR LNs)
- Fault Recorder status (DFRRDRE LN)
- Group Record Trigger (GRTGGIO LN)

For each possible channel in the TESLA setting file there is one associated LN. Note that this LN always exists in the data model but will only be applicable if there is an associated channel configured in the setting file.

The Fault Recorder status LN (DFRRDRE) contains information about the recording status of the IED including number of records stored, percent of memory used and whether recording is currently in progress.

The data contained within the Logical Nodes in the RCD LD may be added to Datasets for use in Report Control Blocks or GOOSE Control Blocks or may be monitored directly via a 61850 client. Refer to the ERL 61850 IED Configurator User Manual for more information regarding configuration of the 61850 services. Refer to “Data Mapping Specifications” in Appendix H for more details regarding the RCD LD and it’s associated LNs.

19.8 MEAS Logical Device

The MEAS Logical Device is the Measurements Logical Device of the TESLA 4000-SV data model. The MEAS LD contains all of the information regarding measurement data for each of the possible channels in the TESLA setting file:

- Analog measurement data (ANLMAGMMXN, ANLANGGIO LNs)
- Sequence measurement data (SEQMSQI LNs)
- Summation measurement data (SUMMAGMMXN, SUMANGGIO LNs)
- Frequency measurement data (FREQMMXN LNs)
- Impedance measurement data (IMPMMXN LNs)
- Power factor measurement data (PFMMXN LNs)
- Watt/Var measurement data (WVARMMXN LNs)

For each analog (direct measurement or calculated) channel in the TESLA setting file there is one associated LN. Note that this LN always exists in the data model but will only be applicable if there is an associated channel configured in the setting file. For phasor data (direct analog channels and summation channels) there are two LNs per channel, one for magnitude values and one for angle values.

The data contained within the Logical Nodes in the MEAS LD may be added to Datasets for use in Report Control Blocks or may be monitored directly via a 61850 Client to obtain metered values. Refer to the ERL 61850 IED Configurator User Manual for more information regarding configuration of the 61850 services. Refer to “Data Mapping Specifications” in Appendix H for more details regarding the MEAS LD and it’s associated LNs.

19.9 FLTL Logical Device

The FLTL Logical Device is the Fault Locator Logical Device of the TESLA 4000-SV data model. The FLTL LD contains all of the information regarding the Fault Locator functions in the TESLA setting file. There is one Fault Locator logical node (FLTLOCRFLO LN) per available Fault Locator function.

The Fault Distance and Fault Impedance data is available for each Fault Locator. Note that this LN always exists in the data model but will only be applicable if there is an associated channel configured in the setting file.

The data contained within the Logical Nodes in the FLTL LD may be added to Datasets for use in Report Control Blocks or may be monitored directly via a 61850 Client. Refer to the ERL 61850 IED Configurator User Manual for more information regarding configuration of the 61850 services. Refer to “Data Mapping Specifications” in Appendix H for more details regarding the FLTL LD and it’s associated LNs.

19.10 DVI Logical Device

The DVI Logical Device is the GOOSE Digital Value Input Logical Device of the TESLA 4000-SV data model. The DVI LD is used for subscription to GOOSE data. There is one GOOSE virtual input receptor logical node (VIGGIO LN) per available GOOSE virtual input channel on the TESLA (256). Each LN in the DVI LD acts as an a receiver of a specific data attribute/object contained in a dataset within a GOOSE message. Each of these VIGGIO LNs corresponds to a GOOSE Virtual Input Channel in the TESLA Setting File.

Refer to the ERL 61850 IED Configurator User Manual for more information regarding configuration of the 61850 services and to “Data Mapping Specifications” in Appendix H for more details regarding the DVI LD and it’s associated LNs.

GOOSE Mapping

In ERL 61850 IED Configurator, data from GOOSE publishers (other IEDs) are mapped to the VIGGIO LNs. There are 256 inputs provided with the TESLA 4000-SV. These GOOSE inputs are labeled VI001 - VI256 in the ERL 61850 IED Configurator. See ERL 61850 IED Configurator User Manual for more details on how to perform mapping.

The GOOSE subscription inputs VI001-VI256 correlate to the GOOSE Virtual Input channels 1 to 256 in the Setting File. For example, if GOOSE data is mapped from another IED to input VI004, then in the TESLA’s settings, GOOSE Virtual Input channel 4 is configured as the associated channel for this mapping.

The TESLA 4000-SV can subscribe to GOOSE data of the following data types:

- Boolean
- Dpos
- Health
- Int32
- Int32u

The data type mapped must match with the Type setting on the GOOSE Virtual Input channel configuration in the TESLA setting file (see “GOOSE Mapping and Channel Assignment” on page 19-16).

> Currently, RecordGraph only supports graphing of Boolean digital channels. For all other types, the channels will not be available to add into digital graphs. However all data types are available for CSV export.

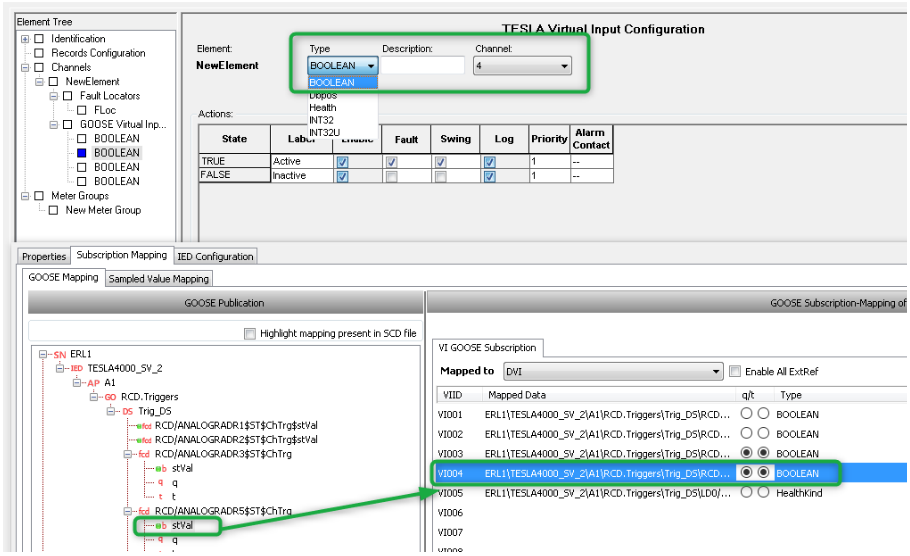


Figure 19.5: GOOSE Mapping and Channel Assignment

19.11 SVI Logical Device

The SVI Logical Device is the Sampled Value Input Logical Device of the TESLA 4000-SV data model. The SVI LD is used for subscription to Sampled Value data for analog signal acquisition. There is one Sampled Value input receptor logical node (CHTSGN LN) per available analog channel on the TESLA (36).

Each LN in the SVI LD acts as an a receiver of a specific Sampled Value quantity. For more details regarding how this subscription process works, see " Sampled Value Subscription Mapping" below. Note that no data may be viewed via the CHTGSN LNs or used in Report Control Blocks. These LNs only act as a receiver of data. The associated values are to be viewed using the corresponding measurement logical nodes (see “MEAS Logical Device” on page 19-13).

Also refer to the ERL 61850 IED Configurator User Manual for more information regarding configuration of the 61850 services and to “Data Mapping Specifications” in Appendix H for more details regarding the SVI LD and it’s associated LNs.

Sampled Value Subscription Mapping

The TESLA 4000-SV uses Sampled Value (IEC 61850 9-2LE) subscription as the method of acquiring Analog signals.

In ERL 61850 IED Configurator, data from Sample Value publishers (merging units) are mapped to the CHTGSN LN inputs. There are 36 inputs provided with the TESLA 4000-SV. The Sampled Value inputs are labeled C01 - C36 in the ERL 61850 IED Configurator. See ERL 61850 IED Configurator User Manual for more details on how to perform mapping.

The Sampled Value subscription inputs C01-C36 correlate to the Analog Input channels 1 to 36 in the Setting File. For example, if voltage “Va” is mapped from a merging unit to input C04, then in the TESLA’s settings, Analog Input Channel 4 must be configured accordingly as a SV Vac Input Type (as shown in Figure 19.6: SV Mapping and Channel Assignment).

Sampled Value mapping is supported for 80 and 256 samples per cycle (may only map either 80 or 256 samples per cycle, not a combination of both). The TESLA 4000-SV may subscribe to Sampled Value data from up to 8 different Sampled Value Control Blocks (Sampled Value Streams).

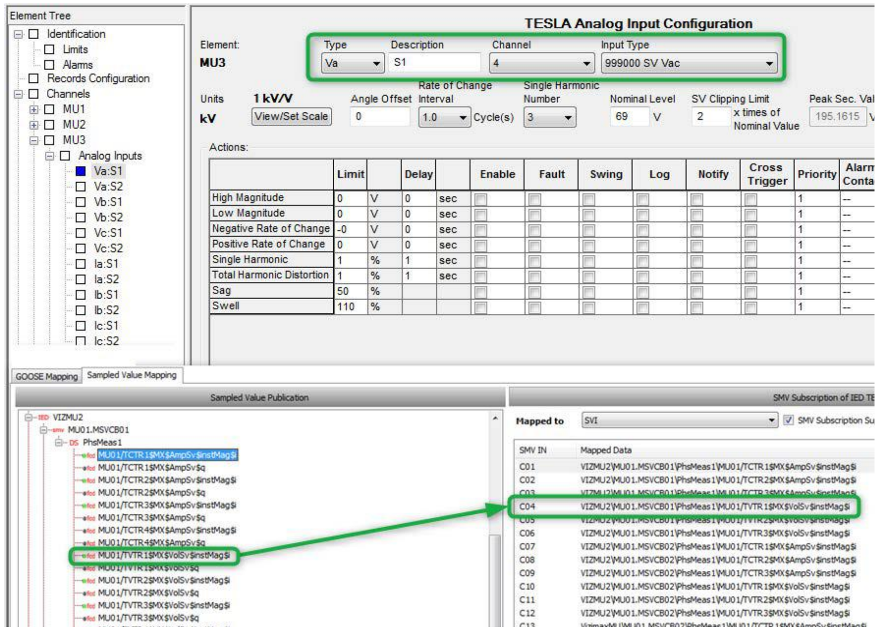


Figure 19.6: SV Mapping and Channel Assignment

Sampled Value Setup Requirements

The following requirements must be met to ensure that the TESLA 4000-SV can acquire the Analog Input data via Sampled Values from a Merging Unit (MU):

- The TESLA 4000-SV and the MU must both use the same system frequency (must both be 50Hz or 60Hz)
- The sample rate of the MU must match the sample rate specified in the TESLA setting file
- The maximum number of Sampled Value streams on the link cannot exceed 8 streams. Ensure that there are not more than 8 Sampled Value streams present on the network connection coming in to Port 402, even if the TESLA 4000-SV does not subscribe to the streams.
- Port 401,410/412 and 411 are not designed for sampled value processing, ensure that there is no sample value present on those ports.

> These requirements must be met or the TESLA 4000-SV will not be able to acquire Analog Input data via Sampled Values and will prevent the recorder from triggering and capturing any data and may put the unit into a service condition.

Additionally, the TESLA 4000-SV and the MU should be time synchronized for accurate recording and triggering. PTP is the best option for Sampled Value applications as it has the highest accuracy. If there is not a time synchronization on the TESLA 4000-SVand the MU, recording and triggering will continue although the data may be unreliable.

20 Data Quality

The TESLA 4000-SV receives data from various sources, for example IEC 61850 SMV and GOOSE, and it produces and records useful data for user analysis such as records, events and metering. As the TESLA 4000-SV is only as reliable as the data it receives and produces, the concept of "data quality" is very important. Data quality allows the user to know if the incoming or outgoing data is trustworthy and aids in troubleshooting of issues. Data quality is a concept introduced in the IEC 61850 standard (refer to IEC61850 standards 61850-7-3 Section 6.2 and 61850-8-1 Section 8.2).

The factors which affect the quality of data produced by the TESLA 4000-SV are:

- The quality of the incoming IEC 61850 Sampled Value data
- The quality of the incoming IEC 61850 GOOSE data
- User operations (i.e. putting the unit into test mode)

The data quality information is displayed to the user clearly in the events, recording (high speed, low speed, trend, CDR), CSV export and metering.

20.1 Data Quality Sources

The factors which affect the quality of data produced by the TESLA 4000-SV are:

- The quality of the incoming IEC 61850 Sampled Value data
- The quality of the incoming IEC 61850 GOOSE data
- User operations (i.e. putting the unit into test mode)

IEC 61850 Sampled Value

The TESLA 4000-SV uses IEC 61850 Sampled Value subscription to acquire its analog data. The incoming Sampled Value streams contain 16-bits of quality information (if the Sampled Value publisher is configured to publish the quality). The data quality of the incoming Sampled Value stream will be reflected in all associated metering channels and all associated events and recording.

If the subscribed Sampled Value stream does not include data quality information, the validity of data is handled as "Good". If derived channels (i.e. Watts/Vars) contains multiple SMV sources with different data quality, the combination of quality details and worst case validity will be selected. If the combination of the quality details conflict with the associated selected validity, then the conflicting quality identifiers are unconditionally set to zero.

IEC 61850 GOOSE

The TESLA 4000-SV uses IEC 61850 GOOSE subscription to acquire status messages from other IEDs. The incoming GOOSE messages contain 16-bits of quality information (if the GOOSE publisher is configured to publish the quality). The data quality of the incoming GOOSE message will be reflected in all associated metering channels and all associated events and recording.

If the subscribed GOOSE message does not include data quality information, the validity of data is handled as “Good”.

External Inputs

The External Inputs data quality validity is normally set to “Good”, however in cases where grounding issues are present and the External Input is repeatedly changing states (i.e. chattering), the detailed quality bit “oscillatory” will be set to true and the validity will be set to “Invalid”.

20.2 Data Quality Display

Data quality is comprised of a 16-bit string which indicates various conditions. The 16 bits are outlined in the table below:

Table 20.11: Data Quality Bits

Bits	Identifier	Value Description
0-1	Validity	00 (GOOD), 01 or 10 (INVALID), 11 (QUESTIONABLE)
2	Overflow	Possible associated validity: Invalid
3	OutofRange	Possible associated validity: Invalid, Questionable
4	BadReference	Possible associated validity: Invalid, Questionable
5	Oscillatory	Possible associated validity: Invalid, Questionable
6	Failure	Possible associated validity: Invalid
7	OldData	Possible associated validity: Questionable
8	Inconsistent	Possible associated validity: Questionable
9	Inaccurate	Possible associated validity: Questionable
10	Substitued	
11	Test	
12	OperatorBlocked	
13	Unused	
14	Unused	
15	Unused	

For example if the following data quality may be observed:

(QUES) 0000 0000 1000 0011

This data quality would refer to data with Questionable validity due to OldData (bits 0,1,7 are high).

This 16 bit string is displayed in the event log, record event summary, trend event summary and CSV exports. It is also available in the CDR records via CSV export.

Appendix A Specifications

TESLA 4000-SV Power System Recorder		
Item	**Quantity/Specs**	**Notes**
General		
Overvoltage Category	Overvoltage Category III	
Pollution Degree	Pollution Degree 2	
Insulation Class	Class I	
Ingress Protection	IP30 standard	
Nominal Frequency	50 or 60 Hz	
Power Supply	Nominal Voltage: 48 - 250 Vdc, 100 – 240 Vac Voltage tolerance: AC = +/- 10% DC =+20%/-10% Maximum current: 0.7 A Power Consumption: 20-36 W	
Memory	Settings and records are stored in non-volatile memory	Records are stored in a circular buffer
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, please refer to Table 9.1 and Table 9.2 for details.
Temperature	-10°C to 55°C Operating -40°C to 85°C Storage	
Operating Humidity	Up to 95% without condensation	
Channels and Triggers		
Analog Inputs	High and low threshold, positive and negative rate of change, harmonic level, THD level, sags, swells. Either Analog Measurement Type or Sampled Value Measurement Type, order configurable.	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	1 or 2 or 3 input 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	

TESLA 4000-SV Power System Recorder

Item	Quantity/Specs	Notes
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 Boolean, Health, Int32, Int32u, Dpos data types supported
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	
Recording and Logging		
Transient Fault	Record Length 0.2 to 15 seconds, 30 second extended	80 or 256 samples/cycle. 400, 4800, 14400 Hz 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.
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
Record Capacity	16GB (obsolete) flash up to 1000 5-second fault records with all 36 channels sampled at 80 or 256 samples/cycle or a combination of fault and swing records.	64 GB, 1TB storage supports up to 2500 5-second fault records with all 36 channels sampled at 80 or 256 samples/cycle or a combination of fault and swing records.
Continuous Disturbance Recording (CDR)		
Continuous Disturbance Recording (CDR)	6 to 60 RMS samples/second at 60Hz or 5 to 50 samples/second at 50Hz for up to 36 selectable Analog Input channels in the CDR configuration, all the calculated channels including summation channel, sequence channel, watt/var channel, etc. will be derived from the channel settings if available.	Retention period calculation is estimated in CDR configuration, the number of retention days depends on the sample rate, flash memory size and number of channel selection. Please refer to Table 12.2 for calculation example.

TESLA 4000-SV Power System Recorder

Item	Quantity/Specs	Notes
Phasor Measurement Unit (PMU)		
Phasor Measurement Unit (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 MVA, DC and frequency.
	64 External Inputs and 256 GOOSE Boolean Virtual Input Status data	Status data reported as 16 bit digital words
Inputs and Outputs		
Sampled Value Inputs	36 Sampled Value inputs (IEC 61850 9-2 LE) and IEC 61869-9.	May subscribe to up to 8 Sampled Value streams.
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	8 contacts per unit 300 Vdc max 150 Vdc max, for CE compliance 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, 4 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 when enabled in channel trigger setting; when enabled in Alarms setting, the duration of the latch follows the status of the alarm initiator, the selected Alarm contact will become exclusive when used to any of this settings. All contacts can be active simultaneously.

TESLA 4000-SV Power System Recorder

Item	Quantity/Specs	Notes
Virtual Inputs	256 GOOSE Virtual Inputs	
Interface & 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: 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 ports to 115 kbd	10m Maximum cable length
Internal Modem *Currently Not Used*	38.4 Kbps, V.32 bis	Optional
Configurable Alarms	6 contacts /unit	Normally open
Cross-trigger	1 contact/unit	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) IEEE Std C37.118-2005 (IRIG Standard 200-04 B004/B005) [1]IEEE Std 1344-1995 (IRIG Standard 200-04 B004/ B005) [1]IRIG Standard 200-04 B000/B001/B002/B003/ B006/B007 [1]May require use of Manual mode to manually set time configuration. See “IRIG-B Signal Interpretation” on page 8-19.	Unmodulated Input impedance = 680 ohms
Physical		
Weight	24lbs	
Dimensions	3U high (5.25"), 19" wide, 12.725" deep	
Mounting	Horizontal rack mount	
Time Synchronization		

TESLA 4000-SV Power System Recorder		
Item	**Quantity/Specs**	**Notes**
External Time Source	Synchronized using IRIG-B input (Unmodulated) or PTP (IEEE 1588)	Upon the loss of an external time source, the recorder maintains time with a maximum 640 seconds drift per year at a constant temperature of 25C. The recorder can detect loss or re-establishment of external time source and automatically switch between internal and external time.

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

Type Tests

Test	Description		Test Level
	Type Test	Test Points	
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)
Environmental Tests			
IEC 60068-2-1	Cold (operating and storage)	Enclosure	-40°C, 16Hrs
IEC 60068-2-2	Hot (operating and storage)	Enclosure	+85°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

Appendix B TESLA Hardware Description

Main Processor Board

The Main Processor Board consists of a DSP, a power PC processor, serial ports, Ethernet ports, an IRIG-B processor, a watchdog and a power supply that supplies the other boards. All other boards are connected to the MPB as I/O. The MPB has a socket for an optional internal modem.

External Input Boards #1 and #2

The TESLA has 32 external inputs and 4 contact outputs provided by each External Input Board. Inputs are optically isolated and accept up to 300 Vdc.

Two external input boards combine for a total of 64 external inputs and 8 outputs. Rear panel connection to the board is provided by removable screw terminal strips. Terminal strips are keyed to ensure that the correct terminal strip is installed into the correct bank.

Comm Board

The standard (non-redundant) Comm Board provides the TESLA with two RS-232 ports, IRIG-B time synchronization input, four network ports and a modem port. The RS-232 port is female DB-9 connectors, IRIG-B is a male BNC, the modem jack is an RJ-11 and the network ports are either RJ-45 or ST optical connectors depending on the unit configuration.

Single Network Redundancy Comm Board provides the TESLA with one RS-232 port, 8 network ports and an IRIG-B pluggable terminal block. The network ports are a combination of RJ-45 and LC optical connectors. Refer to “Ordering Options and Product Configuration ID” on page 1-5 and “Communication Ports - Single Redundant Configuration” on page 4-4 for more details. The Comm Board contains the Network Redundancy Module and runs the Network Redundancy Module Firmware.

Multiple Network Redundancy Comm Board provides the TESLA with 1 IRIG-B input with male BNC connector, 1 non-redundancy maintenance RJ45 port, 3 network redundancy pairs with SFPs. Cooper or Fiber SFP needs to be ordered separately. Refer to “Ordering Options and Product Configuration ID” on page 1-5 and “Communication Ports - Multiple Redundant Configuration” on page 4-5 for more details.

Power Supply

The Power Supply conditions and converts the input power for use by the internal electronics. The wide input voltage provides the TESLA with the ability to operate from 48 to 250 Vdc +20%/-10% or 100-240 Vac +/-10%.

Storage

Data storage capacity options for the TESLA recorder is a 16GB (obsolete), 64GB, 1TB (order configurable) solid state Flash. If the recorder needs to comply NERC PRC-028-1 requirement then the user shall select 64 GB or 1 TB flash memory option to store more than 20 days of CDR data on to the unit.

Front Panel Board

The Front Panel Board provides visual indication of the status of the TESLA recorder and USB and network ports.

Appendix C Glossary

AC Analog Input	An ac current or voltage that is obtained from a current transformer or a voltage transformer connected to an element on the power system.
AC Analog Summation	Configuration of TESLA allows two AC analog quantities to be summed. For example, currents from two parallel lines can be summed to produce a set of combined currents.
AC Input Module	This device takes in the voltage or current quantities (4 currents or 3 voltages, dependent on model), modifies these input quantities into low level signals that are suitable for input into the TESLA recorder back panel. The conversion ratio is stated on the module. Outputs from these modules can be connected to any of the Analog Input terminals on TESLA
COMTRADE	Common Format for Transient Data Exchange. IEEE standard C37.111-2013/1999/1991, IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems, which describes a common format for exchange of recorded power systems data between different manufacturers' recorders.
DC Input Module	An external input module that can be scaled to accept a wide range of voltage or current signals. The model provides galvanic isolation and accepts DC signals or AC signals up to 2 kHz.
DCE	Data Communications Equipment, an RS-232 term for modems and similar equipment. DCEs generally have a female DB connector.
DFT	Discrete Fourier Transform. A mathematical function used in signal processing to transform an input signal in a frequency domain representation.
DST	Daylight Savings Time. A seasonal adjustment of time applied in many jurisdictions to compensate for varying day lengths. Most often, an hour is added to the system time to begin on the second Sunday in March and end the first Sunday in November.
DTE	Data Terminal Equipment, an RS-232 term for a terminal or computer. DTEs generally have a male DB connector.
EIA RS-232C	Electronics Industries Association recommended standard 232, revision C, Interface between Data Terminal Equipment and Data Communication Equipment Employing Serial Binary Data Interchange. Defines the most popular electrical connection for serial binary data interchange, available on almost all computer systems.
Element	A component in the power system that conveys bulk power within the power system. TESLA Control Panel provides for a naming convention that groups real and calculated channels with a given element name. Has three voltages and three currents associated with it. For example, a transmission line, or a transformer.
External Input	A contact status brought into TESLA from the outside world. This contact must be externally wetted with a voltage from 30 to 150 Vdc. Correct polarity must be observed.
GOOSE	Generic Object Oriented Substation Events. A protocol contained within the IEC 61850 standard for communication in substation automation applications.
IEC 61850	A standard developed through the International Electrotechnical Commission related to the architecture of electric power systems, specifically the design of electrical substation automation.
IED	Intelligent Electronic Device, referring to a power system substation device which communications on a substation network, such as Modbus.

IEEE 1344	IEEE 1344 is an enhancement to the basic IRIG-B time code that embeds information such as the year, the UTC/local offset (under certain conditions only) and daylight savings time into the time stream. IEEE standard 1344-95, IEEE Standard for Synchrophasors for Power Systems, outlines the implementation and use of accurate time standards for power systems relaying and recording. Annex F describes an IRIG-B extension (using previously unused control bits in the signal) which provides extensive information beyond that of standard IRIG-B.
IEEE 1588	IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems.
IEEE C37.232	An IEEE standard related to the procedure for the naming of Time Sequence Data (TSD) files produced by digital fault recorders in power systems applications.
IEEE C37.238	IEEE Standard Profile for Use of IEEE 1588 Precision Time Protocol in Power System Applications
IRIG-B	Inter-Range Instrumentation Group time code format type B, see Range Commanders Council Telecommunications and Timing Group, IRIG standard 200-95, IRIG Serial Time Code Formats. Describes an implementation for distribution of precise timing information, especially to power systems relays and recorders. IRIG-B is typically provided by a satellite clock (e.g. GPS or GOES).
Modbus	Modbus is a network using a master/slave protocol often used in power system substations. Its function was developed and is defined by Modicon, Inc., North Andover, MA, USA. Refer to Modbus Protocol Reference Guide, Modicon document PI-MBUS-300.
PRP	Parallel Redundancy Protocol. A data communications network which allows the system to overcome any single network failure without impacting data transmission through the use of parallel and similar network topologies connected to each node.
PTI	Power Technologies Incorporated
PTP	Precision Time Protocol. A network protocol used for high-accuracy synchronization of devices and equipment to a common, network based time source
RSTP	Rapid Spanning Tree Protocol. A network protocol design to eliminate the negative effect of network loops and introduce redundancy in link connections.
SFP	The small form-factor pluggable (SFP) is a compact, pluggable optical transceiver used for networking applications.
SNTP	Simple Network Time Protocol. A simplified version of Network Time Protocol (NTP) use for synchronizing devices and equipment to a common, network based time source in the form of an SNTP server. SNTP time synchronization is not recommended in application where time accuracy is required.
Trigger	A situation that can initiate a recording.
UTC	Universally Coordinated Time. Approximately equivalent to Greenwich Mean Time (GMT). A universal time maintained by time standards bodies worldwide. All local times are expressed as an offset from UTC.

Appendix D PMU Standards

The PMU functionality in TESLA 4000-SV complies with the IEEE C37.118-2005, IEEE C37.118.1a – 2014 and IEEE/IEC 60255-118-1:2018 standards for Synchrophasor for Power Systems Measurements. Internal RTDS PMU compliance test was carried out to determine how close the TESLA 4000-SV is with the standard requirements according to IEC/IEEE 60255-118-1:2018 (both P - Class and M – Class). According to IEC/IEEE 60255-118-1:2018 standard Appendix E, when using SV inputs, compliance testing only includes the algorithm portion of the PMU since the front end has been moved to the EIT(Electronic Instrument Transformers)/SAMU(Stand-Alone Merging Units).

The following tables show the compliance of the TESLA 4000-SV with the sample rate at 256 samples/cycle with 60 fps reporting rate.

D.1 IEC/IEEE 60255-11-1: 2018 (Superseded IEEE C37.118.1-2011 and IEEE C37.118.1a-2014)

Table D.1 Steady-state synchrophasor measurement standard requirements and test results

Influence quantity	**Reference condition**	**Minimum range of influence quantity over which PMU shall be within given TVE limit**					
		Performance – P class			**Performance – M class**		
		Range	**Max. TVE %**		**Range**	**Max. TVE %**	
			Std. Requirements	Results 50/60Hz		Std. Requirements	Results 50/60Hz
Signal Frequency	Frequency = f_0 ($f_{nominal}$)	±2.0 Hz	**1**	**0.172/0.147**	±2.0 Hz for F_s< 10 $\pm F_s/5$ for $10 \le F_s < 25$ ± 5.0 Hz for $F_s \ge 25$	**1**	**0.392/0.334**
Voltage signal magnitude	100% rated	80 % – 120 % rated	**1**	**0.01/0.01**	10 % – 120 % rated	**1**	**0.071/0.079**
Current signal magnitude	100% rated	10 % – 200 % rated	**1**	**0.429/0.429**	10 % – 200 % rated	**1**	**0.428/0.436**
Harmonic distortion (single harmonic)	< 0.2% (THD)	1 %. each harmonic up to 50th	**1**	**0.048/0.048**	10% each harmonic up to 50th	**1**	**0.082/0.081**
Out of band interference	< 0.2% of input signal magnitude		**None**	**None**	10% of input signal magnitude for F_s ≥ 10. No requirement for F_s < 10.	**1.3**	**0.225/0.229**

Table D.2: Steady-state frequency and ROCOF measurement requirements and test results

Influence quantity	Reference condition	Error requirements for compliance							
		P class				M class			
Signal frequency	Frequency = $f0$ ($f$nominal) Phase angle constant	Range: $f0$ ± 2.0 Hz				Range: $f0$ ± 2.0 Hz for $Fs \le 10$ ± $Fs/5$ for $10 \le Fs < 25$ ± 5.0 Hz for $Fs \ge 25$			
		Max. |FE|		**Max. |RFE|**		**Max. |FE|**		**Max. |RFE|**	
		Std. requirements	Results 50/60Hz	Std. requirements	Results 50/60Hz	Std. requirements	Results 50/60Hz	Std. requirements	Results 50/60Hz
		0.005 Hz	**0.0018/ 0.0013**	**0.4 Hz/s**	**0.0484/ 0.0329**	**0.005 Hz**	**0.0039/ 0.0037**	**0.1 Hz/s**	**0.0356/ 0.0363**
Harmonic distortion (single harmonic)	< 0.2 % THD	Range:1 %. each harmonic up to 50th				Range:10 %. each harmonic up to 50th			
	$Fs > 20$	**0.005 Hz**	**0/ 5.34e-05**	**0.4 Hz/s**	**0/0.01**	**0.025 Hz**	**6.48e-05/ 8.77e-05**	**Not required**	**-**
	$Fs \le 20$	**0.005 Hz**	**-**	**0.4 Hz/s**	**-**	**0.005 Hz**	**-**	**Not required**	**-**
Out-of-band interference	< 0.2 % of input signal magnitude	Range: No requirements				Range: Interfering signal 10 % of signal magnitude			
		Not required	**-**	**Not required**	**-**	**0.01 Hz**	**0.00939/ 0.00922**	**Not required**	**-**

Table D.3: Synchrophasor measurement bandwidth requirements and test results using modulated test signals							
Modulation level	Reference condition	Minimum range of influence quantity over which PMU shall be within given TVE limit					
		P class			M class		
		Range	Max. TVE		Range	Max. TVE	
			Std. requirements	Results 50/60Hz		Std. requirements	Results 50/60Hz
*k*x = 0.1. *k*a = 0	100 % rated signal magnitude. *f*nominal	Modulation frequency 0.1 to lesser of *F*s/10 or 2 Hz	**3 %**	**0.09/0.073**	Modulation frequency 0.1 to lesser of *F*s/ 5 or 5 Hz	**3 %**	**0.0828/ 0.0865**
*k*x = 0. *k*a = 0.1	100 % rated signal magnitude. *f*nominal		**3 %**	**0.07/0.06**		**3 %**	**0.0895/ 0.0955**

Table D.4: Frequency and ROCOF performance requirements and test results under modulation tests										
Frequency and ROCOF performance limits	Error requirements for compliance									
	P class					M class				
Reporting rate *F*s Hz	Fr Hz	Max. |FE|		Max. |RFE|		*Fr* Hz	Max. |FE|		Max. |RFE|	
		Std. requirements	Results 50/60Hz	Std. requirements	Results 50/60Hz		Std. requirements	Results 50/60Hz	Std. require ments	Results 50/ 60Hz
50	2	**0.06**	**0.0127**	**2.3**	**0.315**	5	**0.30**	**0.0784**	**14**	**4.873**
60	2	**0.06**	**0.0105**	**2.3**	**0.263**	5	**0.30**	**0.0655**	**14**	**4.045**
Formulas	min (*F*s/ 10.2)	0.03 × *F*r		0.18 × π × *F*r2		min (*F*s/ 5.5)	0.06 × *F*r		0.18 × π × *F*r2	

Table D.5: Synchrophasor performance requirements and test results under frequency ramp tests							
Test signal	**Reference condition**	**Influence quantity test limits over which PMU shall be within given TVE limit**					
		Ramp rate (Rf) (positive and negative ramp)	**Performance class**	**Exclusion interval**	**Ramp range**	**Max. TVE**	
						Std. requirem ents	**Results 50/60Hz**
Linear frequency ramp	100 % rated signal magnitude, and fnominal at a non-excluded point during the test	±1.0 Hz/s	P class	Larger of 2/ Fs or 2/f0	±2 Hz	**1 %**	**0.206/ 0.176**
			M class	Larger of 7/ Fs or 7/f0	Lesser of ±(Fs / 5) Hz or ±5 Hzb	**1 %**	**0.385/ 0.345**

Table D.6: Frequency and ROCOF performance requirements and test results under frequency ramp tests										
Signal specifica- tion	**Reference condition**	**Exclu- sion interval**	**Error requirements for compliance**							
Ramp tests – Linear frequency ramp	100 % rated signal magni- tude and 0 radian base angle	Same as speci- fied in Table 6	**P class**				**M class**			
			Max. |FE|		**Max. |RFE|**		**Max. |FE|**		**Max. |RFE|**	
			Std. require ments	Results 50/60Hz	Std. require ments	Results 50/60Hz	Std. require ments	Results 50/60Hz	Std. require ments	Results 50/60Hz
			0.01 Hz	**0.0065/ 0.0052**	**0.4 Hz/ s**	**0.04/ 0.029**	**0.01 Hz**	**0.0089/ 0.0078**	**0.2 Hz/ s**	**0.033/ 0.036**

Table D.7: Phasor performance requirements and test results for input step change													
Step change spec.	**Ref. condi-tion**	**Maximum response time. delay time. and overshoot**											
		P class						**M class**					
		Response time s		**|Delay time|**		**Max. Overshoot/ undershoot**		**Response time** s		**|Delay time|**		**Max. overshoot/ undershoot**	
		Std. require ments	Results 50/ 60Hz	Std. require ments	Results 50/ 60Hz	Std. require ments	Results 50/ 60Hz	Std. require ments	Results 50/ 60Hz	Std. require ments	Results 50/ 60Hz	Std. require ments	Results 50/ 60Hz
Magni-tude = ±10%. kx = ±0.1. ka = 0	All test condi-tions nomi-nal at start or end of step	**2/*f*0**	**0.0259/ 0.0216**	**1/(4 × Fs)**	**0.0008/ 0.0007**	**5 % of step magni tude**	**0.45/ 0.45**	**Larger of 7/ Fs or 7/*f*0**	**0.0305/ 0.0303**	**1/(4 × Fs)**	**0.001/ 0.0011**	**10 % of step magni tude**	**6.75/ 6.72**
Angle ±10°. kx = 0. ka = ±π/18	All test condi-tions nomi-nal at start or end of step	**2/*f*0**	**0.0287/ 0.0239**	**1/(4 × Fs)**	**0.0014/ 0.0012**	**5 % of step magni tude**	**0.34/ 0.37**	**Larger of 7/ Fs or 7/*f*0**	**0.0742/ 0.0694**	**1/(4 × Fs)**	**0.0014/ 0.0012**	**10 % of step magni tude**	**6.39/ 6.28**

Table D.8: Frequency and ROCOF performance requirements and test results for input step change									
Signal specification	**Reference condition**	**Maximum susceptibility response time**							
		P class				**M class**			
		Frequency response time		**ROCOF response time**		**Frequency response time**		**ROCOF response time**	
		Std. require ments	Results 50/60Hz	Std. require ments	Results 50/ 60Hz	Std. requirem ents	Results 50/60Hz	Std. require ments	Results 50/60Hz
Magnitude test as in Table D.8	Same as in Table D.8	**4.5/*f*0**	**0.0471/ 0.0396**	**6/*f*0**	**0.0577/ 0.0486**	**Greater of 14/Fs or 14/*f*0**	**0.111/ 0.1087**	**Greater of 14/ Fs or 14/*f*0**	**0.1726/ 0.1641**
Phase test as in Table D.8	Same as in Table D.8	**4.5/*f*0**	**0.049/ 0.041**	**6/*f*0**	**0.0592/ 0.0496**	**Greater of 14/Fs or 14/f0**	**0.175/ 0.172**	**Greater of 14/ Fs or 14/*f*0**	**0.2/ 0.1865**

Table D.9: PMU reporting latency and test requirements		
Performance class	**Maximum PMU reporting latency (s)**	
	Std. requirements	Results 50/60Hz
P class	**Greater of 2/F_S or 2/f_0**	34 ms (for 50 Hz, 50 fps) 19 ms (for 60 Hz, 60 fps)
M class	**Greater of 7/F_S or 7/f_0**	103 ms (for 50 Hz, 50 fps) 114 ms (for 60 Hz, 60 fps)
Note: Latency is limited by the need to include at least one cycle of the power system waveform for synchrophasor calculation.		

Appendix E Recommended Spare Parts List

Table E.1: TESLA 4000-SV Recommended Spare Parts List		
Part Number	**Part Description**	**Quantity**
101850	Digital Input Shorting Bar, 8 inputs	*

Note: * = One of each component used

Appendix F TESLA Handling and Disposition

Unpacking

To unpack a TESLA System Unit

- Open the bottom of the box.
- Place the box on the floor or a secure table.
- Lift the box off of the unit leaving the TESLA and packing material standing intact.
- Remove the packing material from the TESLA.
- Dispose of the packing materials and box in a manner consistent with local waste disposal procedures and regulations. We recommend recycling the box.

Long Term Storage

For long term storage:

- Store the TESLA system unit in original packing container.
- Protect any of the components not in original packing from dust accumulation and moisture.
- Store all components indoors and protect from moisture accumulation.

Final Disposition

Regulations governing disposal of electronics are rapidly being adopted and are constantly changing. We recommend that local electronics disposal regulations be reviewed prior to disposal of a TESLA system when it has reached the end of its useful life. The TESLA system unit contains a battery that should be disposed of separately and may contain other electronic components that are potentially subject to specific disposal instructions. Use a local electronics recycler who is familiar with local regulations.

Appendix G TESLA 4000-SV Drawings

This appendix contains the mechanical drawings for the TESLA 4000-SV.

TESLA 4000-SV Mechanical Overview

TESLA 4000-SV Rear Panel View

Electronic versions of the drawings in both PDF and DWG formats are available. Contact ERLPhase Customer Support to request the drawings. The PDF documents are scaled for 11" x 17" printing for improved readability.

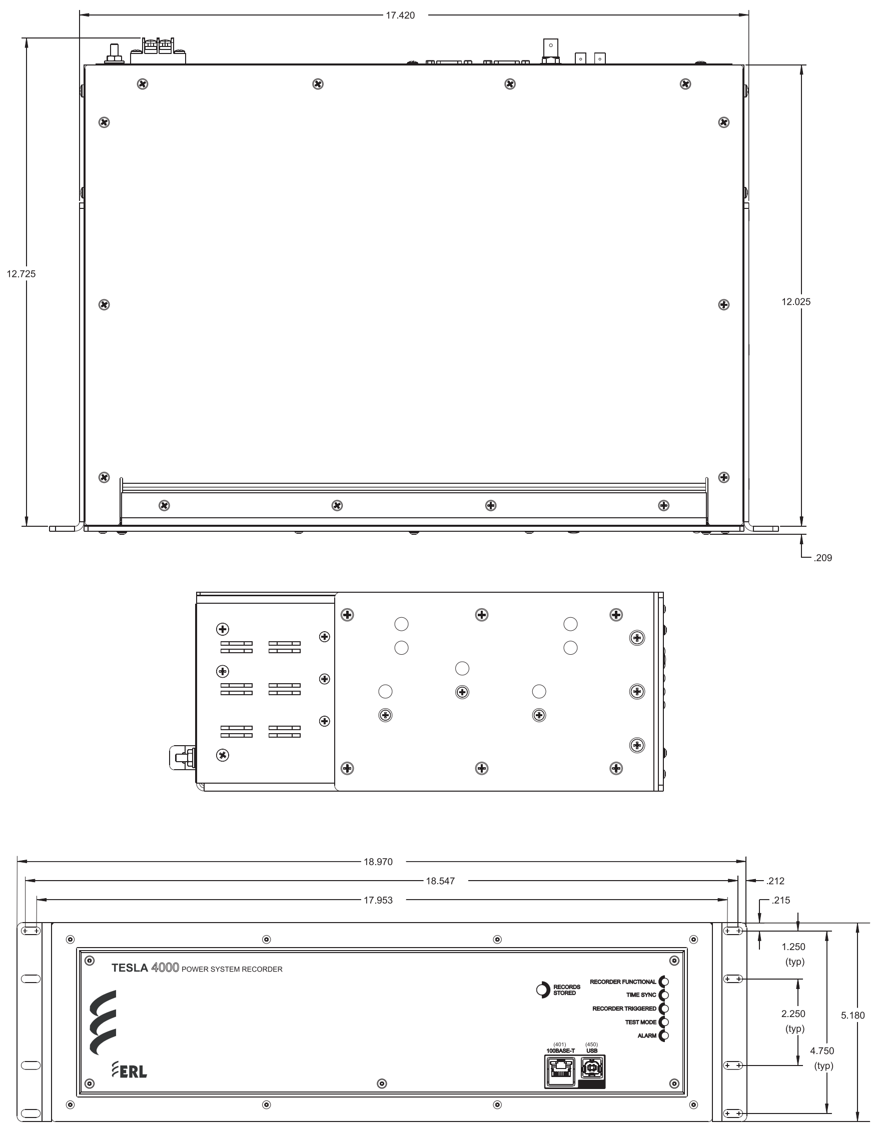


Figure G.1: Mechanical Drawings

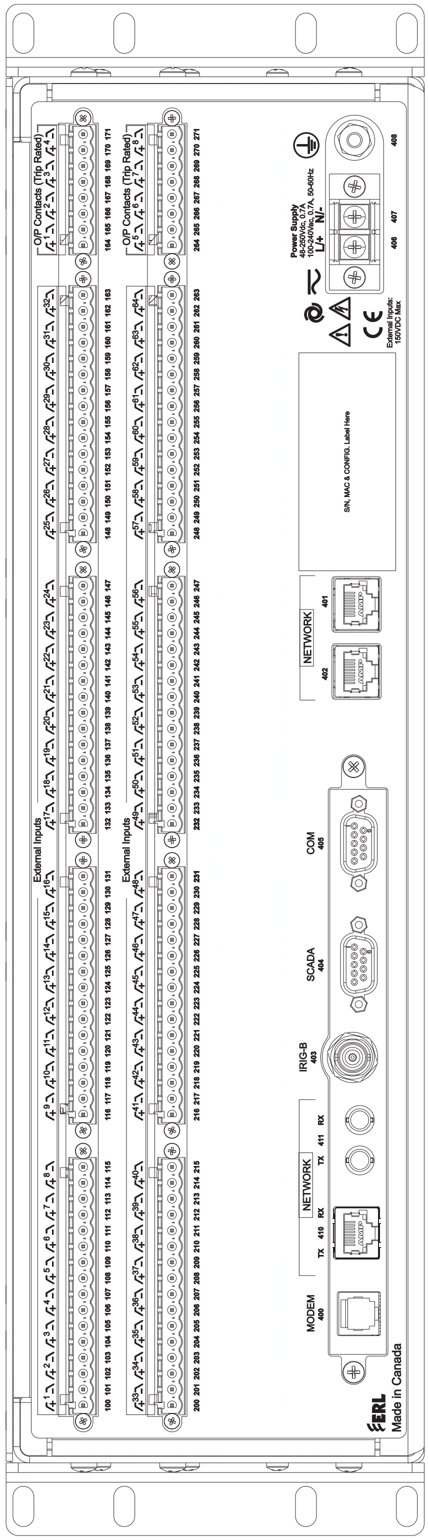


Figure G.2: Rear View - Non-redundant configuration

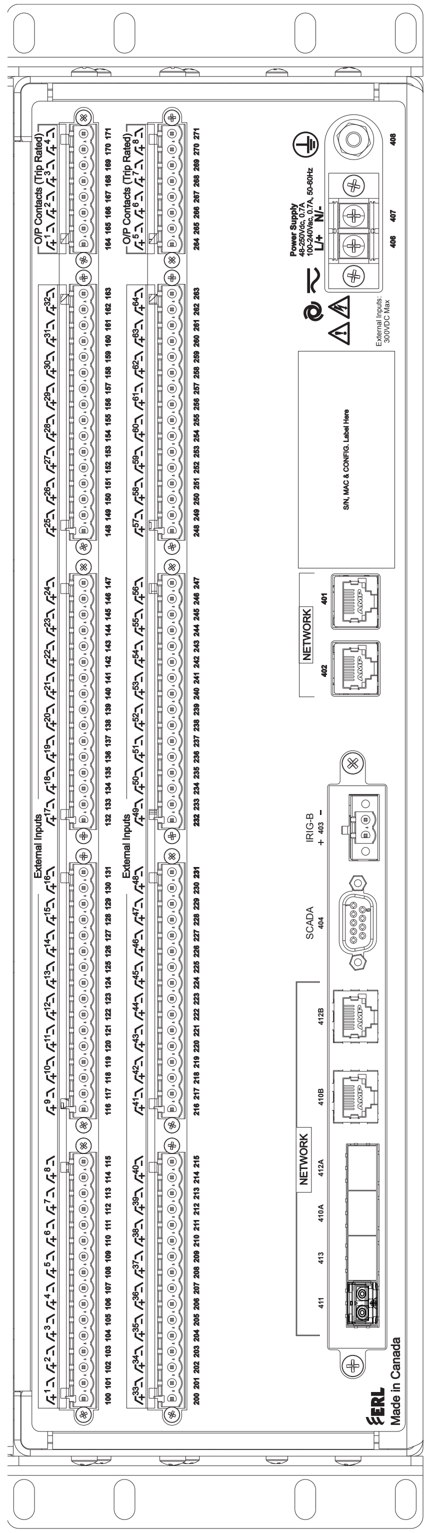


Figure G.3: Rear View - Single Redundant configuration

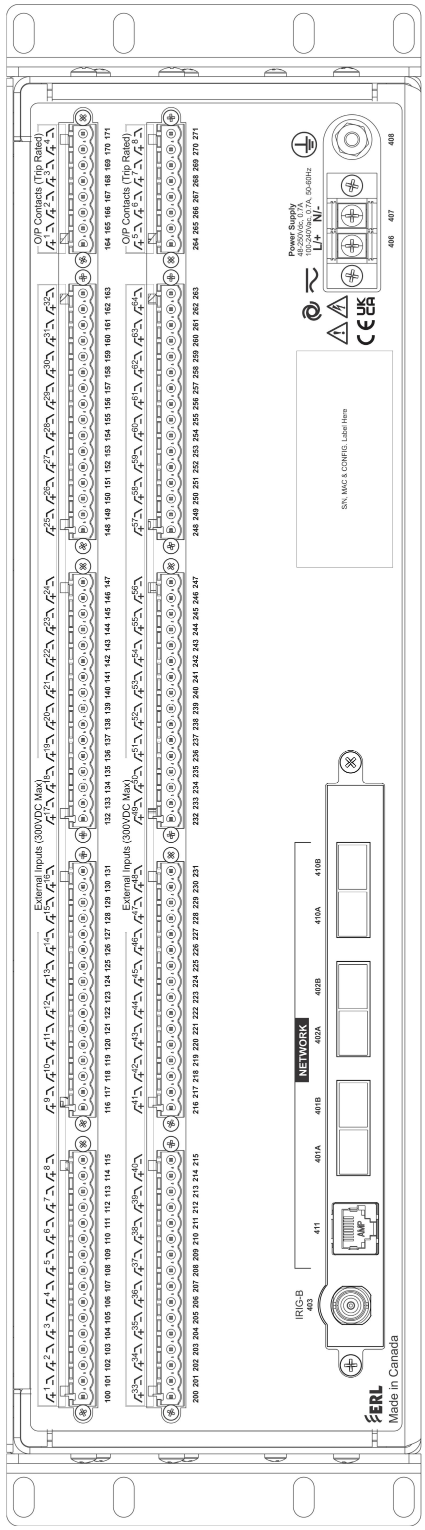


Figure G.4: Rear View - Multiple Redundancy Configuration

Not all ordering configurations shown in the Rear View drawings.

Appendix H IEC 61850 Conformance Statements and Data Mapping Specification

H.1 Protocol Implementation Conformance Statement (PICS)

Protocol Implementation Conformance Statement
for the IEC 61850 interface in TESLA 4000-SV

Document Version[1]: D04831R01.30
Date: 2021-11-30

Based upon UCAIUG PICS Template version 2.3

UCA International Users Group
Testing Sub Committee

1. The version shown in the user manual differs slightly in formatting to the official released version.

General

The following ACSI conformance statements are used to provide an overview and details about TESLA 4000-SV, with firmware v1.3:

- ACSI basic conformance statement
- ACSI models conformance statement
- ACSI service conformance statement

The statements specify the communication features mapped to IEC 61850-8-1 and IEC 61850-9-2.

ACSI basic conformance statement

The basic conformance statement is defined in Table H.1, “Basic conformance statement”.

Table H.1: Basic conformance statement

		Client/ Subscriber	Server/ Publisher	Value/ Comments
Client-Server roles				
B11	**Server** side (of TWO-PARTY-APPLICATION-ASSOCIATION)	-	YES	
B12	**Client** side of (TWO-PARTY-APPLICATION-ASSOCIATION)		-	
SCSMs supported				
B21	**SCSM**: IEC 61850-8-1 used		YES	
B22	**SCSM**: IEC 61850-9-1 used	-	-	Deprecated Ed2
B23	**SCSM**: IEC 61850-9-2 used	YES		
B24	**SCSM**: other		NO	
Generic substation event model (GSE)				
B31	**Publisher** side	-	YES	
B32	**Subscriber** side	YES	-	
Transmission of sampled value model (SVC)				
B41	**Publisher** side	-		
B42	**Subscriber** side	YES	-	

– = not applicable
YES = supported
NO or empty = not supported

ACSI Models Conformance Statement

The ACSI models conformance statement is defined in Table H.2, “ACSI models conformance statement”.

Table H.2: ACSI models conformance statement

		Client/ Subscriber	Server/ Publisher	Value/ Comments
If **Server** side (B11) and/or **Client** side (B12) supported				
M1	Logical device		YES	c1
M2	Logical node		YES	c1
M3	Data		YES	c1
M4	Data set		YES	c2
M5	Substitution		NO	
M6	Setting group control		NO	
	Reporting			
M7	Buffered report control		YES	
M7-1	sequence-number		YES	
M7-2	report-time-stamp		YES	
M7-3	reason-for-inclusion		YES	
M7-4	data-set-name		YES	
M7-5	data-reference		YES	
M7-6	buffer-overflow		YES	
M7-7	entryID		YES	
M7-8	BufTm		YES	
M7-9	IntgPd		YES	
M7-10	GI		YES	
M7-11	conf-revision		YES	
M8	Unbuffered report control		YES	
M8-1	sequence-number		YES	
M8-2	report-time-stamp		YES	
M8-3	reason-for-inclusion		YES	
M8-4	data-set-name		YES	
M8-5	data-reference		YES	
M8-6	BufTm		YES	
M8-7	IntgPd		YES	
M8-8	GI		YES	

Table H.2: ACSI models conformance statement				
		Client/ Subscriber	**Server/ Publisher**	**Value/ Comments**
M8-9	conf-revision		YES	
	Logging		NO	
M9	Log control		NO	
M9-1	IntgPd		NO	
M10	Log		NO	
M11	Control		YES	
M17	File Transfer		YES	
M18	Application association		YES	c1
M19	GOOSE Control Block	YES	YES	
M20	Sampled Value Control Block	YES		
c1 Server must be Y if B11=Yes; Client must be Y if B12=Y c2 Server must be Y if M7-Y or M8=Y or M9=Y or M19=Y or M20=Y				
If **GSE** (B31/32) is supported				
M12	GOOSE	YES	YES	
M13	GSSE			Deprecated Ed2
If **SVC** (B41/42) is supported				
M14	Multicast SVC	YES		
M15	Unicast SVC			
For all IEDs				
M16	Time		YES	
YES = service is supported NO or empty = service is not supported				

ACSI Service Conformance Statement

The ACSI service conformance statement is defined in ACSI service Conformance statement (depending on the statements in Table H.1, “Basic conformance statement” and Table H.2, “ACSI models conformance statement”).

Table H.3: ACSI service Conformance statement

	Ed.	Services	AA: TP/MC	Client (C)	Server (S)	Comments
Server: if B11=Y or B12=Y						
S1	1,2	GetServerDirectory (LOGICAL-DEVICE)	TP		YES	
Application association: if B11=Y or B12=Y						
S2	1,2	Associate			YES	
S3	1,2	Abort			YES	
S4	1,2	Release			YES	
Logical device: if M1=Y						
S5	1,2	GetLogicalDeviceDirectory	TP		YES	
Logical node: if M2=Y						
S6	1,2	GetLogicalNodeDirectory	TP		YES	
S7	1,2	GetAllDataValues	TP		YES	
Data: if M3=Y						
S8	1,2	GetDataValues	TP		YES	
S9	1,2	SetDataValues	TP		NO	
S10	1,2	GetDataDirectory	TP		YES	
S11	1,2	GetDataDefinition	TP		YES	
Data set: if M4=Y						
S12	1,2	GetDataSetValues	TP		YES	
S13	1,2	SetDataSetValues	TP		NO	Deprecated in Ed2
S14	1,2	CreateDataSet	TP		NO	
S15	1,2	DeleteDataSet	TP		NO	
S16	1,2	GetDataSetDirectory	TP		YES	

Table H.3: ACSI service Conformance statement						
	Ed.	**Services**	**AA: TP/MC**	**Client (C)**	**Server (S)**	**Comments**
Substitution: if M5=Y						
S17	1,2	SetDataValues	TP		NO	
Setting group control: if M6=Y						
S18	1,2	SelectActiveSG	TP		NO	
S19	1,2	SelectEditSG	TP		NO	
S20	1,2	SetEditSGValues	TP		NO	
S21	1,2	ConfirmEditSGValues	TP		NO	
S22	1,2	GetEditSGValues	TP		NO	
S23	1,2	GetSGCBValues	TP		NO	
Reporting: If M7=Y or M8=Y						
Buffered report control block (BRCB); If M7=Y						
S24	1,2	Report	TP		YES	
S24-1	1,2	data-change (dchg)			YES	
S24-2	1,2	quality-change (qchg)			YES	
S24-3	1,2	data-update (dupd)			YES	
S25	1,2	GetBRCBValues	TP		YES	
S26	1,2	SetBRCBValues	TP		YES	
Unbuffered report control block (URCB) If M8=Y						
S27	1,2	Report	TP		YES	
S27-1	1,2	data-change (dchg)			YES	
S27-2	1,2	quality-change (qchg)			YES	
S27-3	1,2	data-update (dupd)			YES	
S28	1,2	GetURCBValues	TP		YES	
S29	1,2	SetURCBValues	TP		YES	
Logging: If M9=Y or M10=Y						
Log control block; If M9=Y						
S30	1,2	GetLCBValues	TP		NO	
S31	1,2	SetLCBValues	TP		NO	

Table H.3: ACSI service Conformance statement						
	Ed.	**Services**	**AA: TP/MC**	**Client (C)**	**Server (S)**	**Comments**
Log; If M10=Y						
S32	1,2	QueryLogByTime	TP		NO	
S33	1,2	QueryLogAfter	TP		NO	
S34	1,2	GetLogStatusValues	TP		NO	

Generic substation event model (GSE): If M19=Y						
GOOSE						
S35	1,2	SendGOOSEMessage	MC		YES	
GOOSE-CONTROL-BLOCK						
S36	1,2	GetGoReference	TP		NO	
S37	1,2	GetGOOSEElementNumber	TP		NO	
S38	1,2	GetGoCBValues	TP		YES	
S39	1,2	SetGoCBValues	TP		YES	
GSSE						
S40	1	SendGSSEMessage	MC	-	-	Deprecated in Edition 2
GSSE-CONTROL-BLOCK						
S41	1	GetReference	TP	-	-	Deprecated in Edition 2
S42	1	GetGSSEElementNumber	TP	-	-	Deprecated in Edition 2
S43	1	GetGsCBValues	TP	-	-	Deprecated in Edition 2
S44	1	SetGsCBValues	TP	-	-	Deprecated in Edition 2

Transmission of sampled value model (SVC): If M20=Y						
Multicast SV						
S45	1,2	SendMSVMessage	MC		NO	
Multicast Sampled Value Control Block						
S46	1,2	GetMSVCBValues	TP		NO	
S47	1,2	SetMSVCBValues	TP		NO	
Unicast SV						
S48	1,2	SendUSVMessage	TP		NO	
Unicast Sampled Value Control Block						
S49	1,2	GetUSVCBValues	TP		NO	

Table H.3: ACSI service Conformance statement

	Ed.	Services	AA: TP/MC	Client (C)	Server (S)	Comments
S50	1,2	SetUSVCBValues	TP		NO	
Control: If M11=Y						
S51	1,2	Select			NO	
S52	1,2	SelectWithValue	TP		NO	
S53	1,2	Cancel	TP		NO	
S54	1,2	Operate	TP		YES	
S55	1,2	CommandTermination	TP		NO	
S56	1,2	TimeActivatedOperate	TP		NO	
File transfer: If M17=Y						
S57	1,2	GetFile	TP		YES	
S58	1,2	SetFile	TP		NO	
S59	1,2	DeleteFile	TP		NO	
S60	1,2	GetFileAttributeValues	TP		YES	
S61	1,2	GetServerDirectory (FILE-SYSTEM)	TP		YES	
Time						
T1	1,2	Time resolution of internal clock			24 (60ns)	Nearest negative power of 2^{-n} in seconds (number 0..24)
T2	1,2	Time accuracy of internal clock			T1	TL (ms)(low accuracy), T3 <7 (c1) T0 (ms)(<=10ms), 7 <= T3 < 10 (c1) T1 (µs)(<=1ms), 10<= T3 < 13 T2 (µs)(<=100µs), 13 <= T3 < 15 T3 (µs)(<=25µs), 15 <= T3 < 18 T4 (µs)(<=4µs), 18 <= T3 < 20 T5 (µs)(<=1µs), 20 <= T3 < 25

Table H.3: ACSI service Conformance statement						
	Ed.	**Services**	**AA: TP/MC**	**Client (C)**	**Server (S)**	**Comments**
T3	1,2	Supported TimeStamp resolution	-		10 (1 ms)	Nearest value of 2^{-n} in seconds (number 0...24)
c1 TL may only be specified for Ed2. If Ed1 has accuracy which is better than 1 second but is not T1 then declare T0.						

H.2 Model Implementation Conformance Statement (MICS)

Model Implementation Conformance Statement (MICS)
for the IEC 61850 Edition 2 server interface in TESLA 4000-SV

Document Version[1]: D04833R01.40
Date: 2023-10-30

Based upon
UCA International Users Group
Testing Sub Committee

MICS template for Server Test Procedures First edition and Edition 2 servers
Template version 1.2

1. The formatting of the official version of this document differs slightly from the version shown here in the user manual, but the content is the same.

Introduction

This model implementation conformance statement is applicable for TESLA 4000-SV, with firmware v1.4:

This MICS document specifies the modeling extensions compared to IEC 61850 Edition 2. For the exact details on the standardized model please compare the ICD substation configuration file: “ERLPhaseTESLA4005v1.03.02”, version 1.03 revision 2.

Clause 2 contains the list of implemented logical nodes.

Logical Nodes List

The following table contains the list of logical nodes implemented in the device:

Table H.4: Logical Nodes List
L: System Logical Nodes
LPHD (Physical device information)
LLN0 (Logical node zero)
LGOS (GOOSE Subscription)
LSVS (SMV Subscription Supervision)
LTMS (Time Master Supervision)
LCCH (Physical communication channel supervision)
R: Logical nodes for protection related functions
RDRE (Disturbance recorder function)
RADR (Disturbance recorder channel analog)
RBDR (Disturbance recorder channel binary)
RFLO (Fault Locator)
G: Logical Nodes for generic references
GGIO (Generic process I/O)
M: Logical Nodes for metering and measurement
MSQI (Sequence and Imbalance)
MMXN (Non-phase-related measurement)
T: Logical Nodes for instrument transformers and sensors
TGSN (Generic Sensor)

Logical Node Extensions

The following table uses:

- M: Data is mandatory in the IEC 61850-7-4 Ed.2.
- O: Data is optional in the IEC 61850-7-4 Ed.2 and is used in the device.
- E: Data is an extension to the IEC 61850-7-4 Ed.2.

Extended Logical Nodes

The following logical nodes have been extended with extra data. All extra data has been highlighted in the tables and marked as “E” (Extended).

VIGGIO – Virtual Input LN

GGIO class				
Name	**Description**			
VIGGIO	Virtual Input LN for GOOSE subscription. 256 LNs provided, indexed VIGGIO1 – VIGGIO256.			
Data object name	**Common data class**	**Explanation**	**M/O/C/E**	**Remarks**
Data objects				
Common Logical Node Information				
Beh	ENS	Behaviour	M	
Status Information				
Ind1	SPS	General indication (binary input)	O	
IntIn1	INS	Integer status input	O	
PosMir	DPS	Double-point status input	E	

H.3 TISSUES Implementation Conformance Statement (TICS)

Introduction

This document provides a template for the Tissues conformance statement. According to the UCA IUG QAP the Tissue conformance statement is required to perform a conformance test and is referenced on the certificate.

This document is applicable for TESLA 4000-SV with firmware v1.3.

Document Version[1]: D04832R01.30
Date: 2021-11-30

Mandatory Edition 2 Tissues

Below tables give an overview of the applicable mandatory Tissues. Items in *italic* are brief interpretations provided by the UCA International Users Group to aid in interpretation and is not normative. The original TISSUE should consulted for details of changes.

Table H.5: Mandatory Edition 2 Tissues

Tissue	Description	Implemented Y/na
Part 6		
658	Tracking related features *EntryID and CST missing, these are checked by schema*	na
663	FCDA element cannot be a “functionally constrained logical node” *doName now mandatory in FCDA element,* *SCT: refuse to make empty doName? ICT: Refuse SCD*	Y
668	Autotransformer modeling *Autotransformer model in substation section has changed*	na
687	SGCB ResvTms *SettingControl has added attribute resvTms* *see also TISSUE 845*	na
719	ConfDataSet - maxAttributes definition is confusing *maxAttributes now means max count of FCDA in dataset*	Y
721	Log element name *LN0/Log now has optional attribute “name”*	na
768	bType VisString65 is missing *VisString65 added as SCL BasicType*	na
779	object references *“@” as first character in object references now allowed*	na
788	SICS S56 from optional to mandatory *SICS S56=”Interpret IED capabilities and prohibit unsupported usage”*	na

1. The formatting of the official version of this document differs slightly from the version shown here in the user manual, but the content is the same.

Table H.5: Mandatory Edition 2 Tissues

Tissue	Description	Implemented Y/na
789	ConfLdName as services applies to both server and client *Many changes made to Services section*	na
804	valKind and IED versus System configuration *valImport missing/false DAI means ICT shall ignore value in SCD and SCT shall not change from ICD/IID value. Instance section inherits from DA/BDA element.*	na
806	Max length of log name inconsistent between -6 and -7-2 *LogControl.logName and Log.name restricted to 32 chars*	na
807	Need a way to indicate if “Owner” present in RCB *Services/ReportSettings@owner added*	Y
823	ValKind for structured data attributes *valKind is prohibited on structured attributes*	Y
824	Short addresses on structured data attributes *sAddr is now allowed for structured attributes*	na
825	Floating point value *Server shall support <Val> with exponential notation*	na
845	SGCB ResvTms *Services/SettingGroups/SGEdit added attribute resvTms* *Services/SettingGroups/ConfSG added attribute resvTms* *See also TISSUE 687*	na
853	SBO and ProtNs *DA[@name=SBO] element shall have ProtNS element*	na
855	Recursive SubFunction *Substation section extension must be tolerated*	na
856	VoltageLevel frequency and phases *Substation section extension must be tolerated*	na
857	Function/SubFunction for ConductingEquipment *Substation section extension must be tolerated*	na
886	Missing 8-1 P-types *“tP_IP_UDP_PORT” and “tP_IP_TCP_PORT” added*	na
901	tServices as AP or as IED element *Rules for contents of AP/Server/Services are now defined*	Y
936	SupSubscription parameter usage is difficult *SupSubscription “max” replaced by “maxGo” and “maxSv”*	Y
1147	tServices - FileHandling not consistent with -7-2 *Services/FileHandling now means only support for GetFile and GetFileAttributeValues and NOT SetFile/DeleteFile*	Y
1185	Valkind value Conf for EX FC data *valKind=Conf is allowed for dataNs*	na
1284	SCSM mapping may require a communication section in an ICD file *Server IEDs supporting client/server associations to 61850-8-1 shall include a <Communication> section*	Y

Table H.5: Mandatory Edition 2 Tissues

Tissue	Description	Implemented Y/na
1328	Limitation on the size of data type templates identifiers *Identifer now limited to 255 characters*	Y
1395	Client LN attributes *ReportControl/RptEnabled/ClientLN@ldInst shall be “LD0” for pure clients (without any Logical Devices)*	na
1402	ExtRef during engineering *an ExtRef.intAddr attribute value unequal to empty string (pre-scribed or filled by the IED tool) is the flag indicating that the ExtRef shall not be deleted by the system tool. The system tool can however remove the link to the source IED* <<applicable for SCL tool test>>	na
1415	SICS-S110 IID import mandatory for Edition2 *only the import of data model modifications and CF value changes is mandatory for system tool* <<applicable for SCL tool test>>	na
1419	Support of ldName on other IEDs *SICS I212 is now mandatory*	Y
1444	Need to support fixed and SCT controlled Datasets *Services/xxxSetttings@datSet=fix now means “data set pointed by Control Block cannot be altered from ICD/IID* value <<appli-cable for SCL tool test>>	na
1445	ConfReportControl and a fixed ReportSettings *Control block capabilities must be consistent* *<<applicable for SCL tool test>>*	na
1450	originalSclXxx computation rules *Ed2 ICD/IID files specifying SCL@version=2007 SHALL include originalSCLVersion=2007 and originalSCLRevision as attributes of the <IED>element*	Y
1485	Need to supercede Tissue 1398 to clarify SCT behavior *Same as TISSUE 1450 <<applicable for SCL tool test>>*	na
Part 7-1		
828	Data model namespace revision IEC 61850-7-4:2007[A] *Both 2007 and 2007A are allowed for namespace name*	Y
948	Enumeration (string) values format *Enums are limited to 127 characters from Basic-Latin and Latin-1 character sets*	Y
1151	simulated GOOSE disappears after 1st appearance when LPHD.Sim = TRUE *New LGOS state machine defined, but TISSUE is not IntOp2, therefore TISSUE is optional if LGOS is used*	Y
1396	The use and configuration flow of LGOS and LSVS is unclear *If Services/SupSubscription@maxGo > 1 then at least 1 LGOS must exist. Same for maxSv/LSVS.* *If maxGo > count(LGOS) then SCT can create additional LGOS. Same for maxSv/LSVS*	Y

Table H.5: Mandatory Edition 2 Tissues

Tissue	Description	Implemented Y/na
1447	Restriction on ENUMtypes in SCL *If a ENUM DA limits write or configuration to a subset, then that subset must be declared*	na
1457	Multiple DOI nodes with the same name *LN can have no more than one DOI with same name*	Y
1468	Re-use DO from other LN *allow standard or private dataNs*	na
1491	CmdBlk blocks itself? *The data CmdBlk shall have no effect on the controllable data Mod or CmdBlk*	na
1495	GetVariableAccessAttributes error code *Return MMS error access/object-non-existent if the object does not exist*	Y
Part 7-2		
728	BRCB: could PurgeBuf be set when RptEna=TRUE? *PurgeBuf while RptEna=true is prohibited*	Y
778	AddCause values – add value not-supported *Align 7-2 with 8-1 (nothing new to 8-1)*	na
780	What are unsupported trigger option at a control block? *All control blocks must support all trigger options*	Y
783	TimOper Resp- ; add Authorization check *Clarifies Time-Operated Controls*	na
786	AddCause values 26 and 27 are switched *Annex B.2 has wrong AddCause values*	na
820	Mandatory ACSI services (use for PICS template) *Model entries M18 (Application Association), M19 (GCB), M20 (SVCB) are new. Services S17 (Substitution) and S61 (Get-ServerDirectory) are new. Services S1, S3, S4, S5, S6, S8, S16, S18, S23, S36, S37, S41, S42 are changed.*	Y
858	typo in enumeration ServiceType *Tracking serviceType now has GetLogicalNodeDirectory*	na
861	dchg of ConfRev attribute *Clarifies (tracking) BTS.confRev is AFTER BRCB change*	na
1050	GTS Phycomaddr definition in SCL *(Tracking) GTS needs a special structure for SCL*	na
1071	Length of DO name *Private DO name length shall be <=12 including instance*	Y
1127	Missing owner attribute in BTS and UTS *NSD files for 61850-7-3 show owner in (tracking) BTS/UTS*	na
1202	GI not optional *GI support is mandatory for both URCB and BRCB*	Y
1232	EntryID needs clarification *Segments of a report shall have same identifiers*	Y

Table H.5: Mandatory Edition 2 Tissues		
Tissue	**Description**	**Implemented Y/na**
1242	NTS definition *NTS.resv have been added*	na
1307	Segmented report with Buffer overflow *Segments of a report shall have identical buf-overflow value*	Y
1428	MTS and NTS should use svOptFlds *MTS.optFlds and NTS.optFlds now have bType=SvOptFlds*	na
1630	Attributes in CDC=LTS do not match 8-1 definition *Order of attributes in LTS changed to:* *logEna, logRef, datSet, oldEntrTm, newEntrTm, oldEnt, newEnt, trgOps, intgPd*	na
Part 7-3		
697	persistent command / PulseConfig *PulseConfig adds enum “persistent-feedback”* *DPC.cmdQual==”persistent” is conditionally allowed*	na
698	Wrong case is BAC.dB attribute *attribute renamed from “dB” to “db”*	na
711	blkEna freeze data update while setting its quality to operater-Blocked *Mode=Blocked shall not cause q.operatorBlocked*	na
722	Units for 'h' and 'min' not in UnitKind enumeration. *New unit enums 84=hours, 85=minutes*	na
919	Presence Condition for sVC *svC may be valKind=Conf in ICD file*	na
925	Presence of i or f attribute - Problem with writing *New constructed attribute class "AnalogueValueCtl"*	na
926	Presence Conditions within RangeConfig *All or none of hhLim+hLim+lLim+llLim shall be present*	Y
954	Data attributes with FC=CF should have trgOp=dchg *Some INS and HST and CSG attributes missing dchg*	Y
1078	CMV.t update if rangeAng changed *Add rangeAng to“reasons-to-update-timestamp-of-CMV”*	na
1565	db = 0 behaviour *db=0 not longer suppresses reporting*	Y
1578	dataAttribute NameSpace content *Attributes with FC=EX must be initialized in ICD/IID file*	Y
Part 7-4		
671	mistake in definition of Mod & Beh *Beh=on, q=test should be “Processed as valid”*	Y
674	CDC of ZRRC.LocSta is wrong *ZRRC LocSta should be CDC=SPC*	na
676	Same data object name used with different CDC *LCCH.Fer renamed to FerCh, LCCH.RedFer to RedFerCh*	na

Table H.5: Mandatory Edition 2 Tissues		
Tissue	**Description**	**Implemented Y/na**
677	MotStr is used with different CDC in PMMS and SOPM LN classes *Rename SOPM.MotStr to MotStrNum*	na
679	Remove CycTrMod Enum *Enum is no longer used, use TrMod instead*	na
680	SI unit for MHYD.Cndct *Change unit from S/cm^2 to S/m*	na
681	Enum PIDAlg *Typographical error, invalid XML syntax*	na
682	ANCR.ParColMod *ParColMod enum values text have changed*	na
683	Enum QVVR.IntrDetMth *IntrDetMth enum values text have changed*	na
685	Enum ParTraMod *ParTraMod enum values text have changed*	na
686	New annex H - enums types in XML *Many changes have been made to enumeration names*	Y
694	Data object CmdBlk *CmdBlk semantics have changed*	na
696	LSVS.St (Status of subscription) *LSVS.St is now mandatory*	Y
712	interpretation of quality operatorBlocked *Mode and Behavior semantics have changed*	na
713	DO Naming of time constants in FFIL *Many DO names in FFIL have changed*	na
714	Enums for ShOpCap and SwOpCap *Type for YPSH.ShOpCap and XSWI.SwOpCap have changed*	na
715	RBDR.ChNum1 *RBDR.ChNum1 changes from optional to conditional*	na
716	TAXD text for condition *TAXD.SmRte condition for inclusion has changed*	na
724	ANCR.Auto *ANCR.Auto changes from mandatory to optional*	na
725	Loc in LN A-group *Loc changes to optional, LocKey/LocSta conditions change*	na
734	LLN0.OpTmh vs. LPHD.OpTmh *LLN0.OpTmh deleted, LPHD.OpTmH added as conditional*	na
736	PFSign *MMXU.PFSign enum is extended with 3=Excitation*	na
742	GAPC.Str, GAPC.Op and GAPC.StrVal *Objects have instance indicator removed (ex, Str1 to Str)*	na

Table H.5: Mandatory Edition 2 Tissues

Tissue	Description	Implemented Y/na
743	CCGR.PmpCtl and CCGR.FanCtl *Object have instance indicator added (ex:PmpCtl to PmpCtl1)*	na
744	LN STMP, EEHealth and EEName *Removed STMP.EEHealth and STMP.EEName*	na
772	LPHD.PwrUp/PwrDn should be transient *These objects are now transient*	na
773	Loc, LocKey and LocSta YPSH and YLTC *Add Loc, LocKey and LocSta in YLTC and YPSH (optional)*	na
774	ITCI.LocKey *Add ITCI.LocKey as optional*	na
776	LPHD.OutOv/InOv and LCCH.OutOv/InOv *Clarified: stays true until buffer space again available*	na
800	Misspelling in CSYN *CSYN.VInvTmms renamed to CSYN.VIntvTmms*	na
802	CCGR and Harmonized control authority *Add Loc, LocKSta to every controllable LN (e.g. FSPT)*	na
808	Presence condition of ZMoT.DExt and new DOs *Change ZMOT.DExt to optional; add TotThmSt and MotSt*	na
831	Setting of ConfRevNum in LGOS *Add RxConfRevNum to LGOS and LSVS*	na
838	Testing in Beh=Blocked *Change sematic of Beh=Blocked to allow controls to be acknowledged even when LN is blocked.*	na
844	MFLK.PhPiMax, MFLK.PhPiLoFil, MFLK.PhPiRoot DEL->WYE *Change these NFLK objects from cdc=DEL to cdc=WYE*	na
877	QVUB -settings should be optional *Change QVUB.UnbDetMth and QVUB.StrVal to optional*	na
908	ARIS.StrSeq – transient *Change ARIS.StrSeq to transient*	na
909	Remove ANCR.ColOpR and ColOpL *Replace ANCR.ColOpR and ANCR.ColOpL with ANCR.Col-Chg. Add YEFN.ColChg*	na
912	Clarification of PwrRtg/VARtg *Change many DOs in YPTR, and ZGEN, see name space 2007A2.nsd for final result*	na
920	Resetable Counter is NOT resetable *Change GGIO.CntRs to CntVal; Same for FCNT*	na
932	Rename AVCO.SptVol to AVCO.VolSpt	na
933	Presence of LCCH.RedFerCh and RedRxCnt *Change the presence condition of LCCH.RedChLiv*	na
939	Change CDC for ANCR.FixCol *Change ANCR.FixCol from APC to ASG*	na

Table H.5: Mandatory Edition 2 Tissues		
Tissue	**Description**	**Implemented Y/na**
991	LGOS: GoCBRef (as well as LSVS.SvCBRanre ef) should be mandatory *LGOS.GoCBRef and LSVS.SvCBRef are now both mandatory*	Y
1007	PTRC as fault indicator - Update of description required *PTRC.Tr and Op and Str conditional (at least 1 of group)*	na
1044	TapChg in AVCO *AVCO.TapChg is now optional*	na
1077	Rename DOnames within LTIM *LTIM.TmChgDayTm, changed to TmChgDay;* *LTIM.TmChgStdTm changed to TmChgStd*	na
1256	New DO for LTIM to set time “manually” *Add LTIM.TmSet*	na
1331	Mod, Beh and Health with q=TEST, client can't receive their states *Mod while in Blocked will always be processed*	Y
1426	Add two DO for leap seconds in LTIM *LTIM.Leap added,*	na
1456	Annex A and Mod/Beh/Health *Mod.stVal writes always igore test bits in controls*	Y
1568	ISAF.AlmReset ->transient *Change ISAF.AmlReset to transient*	na
Part 8-1		
770	GoID type mitmatch 18.1.1 and 18.1.2.5.2 *GoID string length is now 129*	Y
784	Tracking of control (CTS) *Tracking CTS has been added*	na
817	Fixed-length GOOSE float encoding *GOOSE float is encoded Tag-0x87, length=5, first octet=8*	na
827	Mandatory ACSI services (Part of 7-2 TISSUE resolution) *Change Table 111 (ServicesSupported): Add initiate, abort, and release. Change conditions for defineNamedVariables.*	Y
834	File dir name length 64 *Filename length changed from 32 to 64*	na
951	Encoding of Owner attribute *xRCB.owner is encoded as 4 octets(IPv4) or 16 octets(IPv6)*	na
1040	More associate error codes *3 additional associate error codes added*	Y
1178	Select Response+ is non-null value *Response to SBO read should be <CO_CtrlObjectRef>*	na
1324	The response- for DeleteNamedVariableList is not defined *numDeleted=0; error=service/object-constraint-conflict*	na
1345	Fixed-length GOOSE ASN.1 length encoding *GOOSE publisher shall always encode minimum size legth field*	na

Table H.5: Mandatory Edition 2 Tissues		
Tissue	**Description**	**Implemented Y/na**
1441	Optonal fields in buffered reports *Writing BRCB.optFld shall not cause a purgeBuf operation*	Y
1442	Journal variableTag for ReasonCode *Example in the standard is incorrect*	na
1453	Purge buffer on write to BRCB *PurgeBuf only occurs if different value is written*	Y
1454	Reports can be transmitted before write (RptEna=true) is confirmed	na
1495	GetVariableAccessAttributes error code *Return MMS error access/object-non-existent if the object does not exist*	Y
1500	the response for DeleteNamedVariableList with a non-existent LN is not specified *CreateDataSet/DefineNamedVariableList specifying a non-existing LD/LN shall fail with access/object-non-existent*	na
1626	PICS for Information Report is incorrect *MMS ServicesSupported "informationReport" should be optional for servers because they never receive InformationReport requests. It is only required for clients which process reports or control command-termination*	Y

H.4 Protocol Implementation eXtra Information for Testing (PIXIT)

Protocol Implementation eXtra Information for Testing (PIXIT) for the IEC 61850 Edition 2 server interface in
TESLA 4000-SV

Document Version[1]: D04834R01.30
Date: 2021-11-30

Based Upon UCAIug Server PIXIT
Template version 20

1. The formatting of the official version of this document differs slightly from the version shown here in the user manual, but the content is the same.

PIXIT for Server

Introduction

This document specifies the protocol implementation extra information for testing (PIXIT) of the IEC 61850 interface in TESLA 4000-SV with firmware version v1.3.

Together with the PICS and the MICS the PIXIT forms the basis for a conformance test according to IEC 61850-10. The PIXIT entries contain information which is not available in the PICS, MICS, TICS documents or SCL file.

Each table specifies the PIXIT for applicable ACSI service model as structured in IEC 61850-10. The “Ed” column indicates if the entry is applicable for IEC 61850 Edition 1 and/or Edition 2. A hyphen (“-”) in the Ed column indicates the PIXIT entry is not applicable for any version.

PIXIT for DOCUMENTATION

ID	Ed	Description	Value / Clarification
Do1	2	How to expose required firmware versions not present in the datamodel	Firmware version and ICD file compatibility listed in the firmware release notes.

PIXIT for ASSOCIATION MODEL

ID	Ed	Description	Value / Clarification
As1	1	Maximum number of clients that can set-up an association simultaneously	4
As2	1,2	TCP_KEEPALIVE value. The recommended range is 1...20s	5 seconds
As3	1,2	Lost connection detection time	20 seconds
As4	-	Authentication is not supported yet	
As5	1,2	What association parameters are necessary for successful association: Called value: Calling values:	Transport selector Y Session selector Y Presentation selector Y AP Title N AE Qualifier N other Transport selector Y Session selector Y Presentation selector Y AP Title N AE Qualifier N other
As6	1,2	If association parameters are necessary for association, describe the correct Called values: e.g. Calling parameters: e.g.	Transport selector 0001 Session selector 0001 Presentation selector 00000001 other Transport selector 0001 Session selector 0001 Presentation selector 00000001 other
As7	1,2	What is the maximum and minimum MMS PDU size	Max MMS PDU size: 32,000 Min MMS PDU size: 1300
As8	1,2	What is the maximum start up time after a power supply interrupt	180 seconds
As9	1,2	Does this device function only as test equipment? (test equipment need not have a non-volatile configuration; but it cannot be part of the substation automation system)	N

PIXIT for SERVER MODEL

ID	Ed	Description	Value / Clarification
Sr1	1,2	Which analogue value (MX) quality bits are supported (can be set by server)	Validity: Y Good, Y Invalid, Y Reserved, Y Questionable Detail Quality: Y Overflow Y OutofRange Y BadReference Y Oscillatory Y Failure Y OldData Y Inconsistent Y Inaccurate Miscellaneous: Y Source Y Test N OperatorBlocked Reserved is treated as Invalid
Sr2	1,2	Which status value (ST) quality bits are supported (can be set by server)	Validity: Y Good, Y Invalid, Y Reserved, Y Questionable Detail Quality: Y BadReference Y Oscillatory Y Failure Y OldData Y Inconsistent Y Inaccurate Miscellaneous: Y Source Y Test N OperatorBlocked Reserved is treated as Invalid
Sr3	-	What is the maximum number of data object references in one GetDataValues request	Deprecated
Sr4	-	What is the maximum number of data object references in one SetDataValues request	Deprecated
Sr5	1	Which Mode values are supported [a]	On Y [On-Blocked] N Test Y Test/Blocked N Off N

a. IEC 61850-6:2009 clause 9.5.6 states that if only a subrange of the enumeration value set is supported, this shall be indicated within an ICD file by an enumeration type, where the unsupported values are missing

PIXIT for DATA SET MODEL

ID	Ed	Description	Value / Clarification
Ds1	1	What is the maximum number of data elements in one data set (compare ICD setting)	128
Ds2	1	How many persistent data sets can be created by one or more clients (this number includes predefined datasets)	CreateDataSet not supported.
Ds3	1	How many non-persistent data sets can be created by one or more clients	CreateDataSet not supported.

PIXIT for SUBSTITUTION MODEL

ID	Ed	Description	Value / Clarification
Sb1	1	Are substituted values stored in volatile memory	Not Supported

PIXIT for SETTING GROUP CONTROL MODEL

ID	Ed	Description	Value / Clarification
Sg1	1	What is the number of supported setting groups for each logical device	Not Supported
Sg2	1,2	What is the effect of when and how the non-volatile storage is updated (compare IEC 61850-8-1 §16.2.4)	Not Supported
Sg3	1	Can multiple clients edit the same setting group	Not Supported
Sg4	1	What happens if the association is lost while editing a setting group	Not Supported
Sg5	1	Is EditSG value 0 allowed	Not Supported
Sg6	2	When ResvTms is not present how long is an edit setting group locked	Not Supported

PIXIT for REPORTING MODEL

ID	Ed	Description	Value / Clarification
Rp1	1	The supported trigger conditions are (compare PICS)	integrity Y data change Y quality change Y data update Y general interrogation Y Trigger option Data Update (dupd) is supported by the IED. However data model doesn't contain any CDC DA with trigger dupd=true. Therefore, such an event will not be possible to generate
Rp2	1	The supported optional fields are	sequence-number Y report-time-stamp Y reason-for-inclusion Y data-set-name Y data-reference Y buffer-overflow Y entryID Y conf-rev Y segmentation Y
Rp3	1,2	Can the server send segmented reports (when not supported the device shall refuse an association request with a smaller than minimum PDU size)	Y
Rp4	1,2	Mechanism on second internal data change notification of the same analogue data value within buffer period (Compare IEC 61850-7-2 §17.2.2.9)	Send report immediately
Rp5	1	Multi client URCB approach (compare IEC 61850-7-2:2003 §14.2.1)	Each URCB is visible to all clients
Rp6	-	What is the format of EntryID	Deprecated
Rp7	1,2	What is the buffer size for each BRCB or how many reports can be buffered	Buffer size is 50,000 bytes for each BRCB
Rp8	-	Pre-configured RCB attributes that are dynamic, compare SCL report settings	Deprecated
Rp9	1	May the reported data set contain: - structured data objects - data attributes	 Y Y
Rp10	1,2	What is the scan cycle for binary events. Is this fixed, configurable?	3 ms Fixed
Rp11	1	Does the device support to pre-assign a RCB to a specific client in the SCL	N

ID	Ed	Description	Value / Clarification
Rp12	2	After restart of the server is the value of ConfRev restored from the original configuration or retained prior to restart	Restored from original configuration
Rp13	1,2	Does the server accept any client to configure / enable a BRCB with ResvTms=-1? What fields are used to do the identification?	N
Rp14	1,2	When BRCB.ResvTms is exposed, what is the default value for BRCB.ResvTms if client does not write (must be > 0) When BRCB.ResvTms is not exposed, what is the internal reservation time-(must be >= 0)	N/A 0 seconds
Rp15	2	Is data model db=0 supported	Y

PIXIT for LOGGING MODEL

ID	Ed	Description	Value / Clarification
Lg1	1,2	What is the default value of LogEna (Compare IEC 61850-8-1 §17.3.3.2.1, the default value should be FALSE)	Not Supported
Lg2	-	What is the format of EntryID	Deprecated
Lg3	1,2	Are there multiple Log Control Blocks that specify the Journaling of the same MMS NamedVariable and TrgOps and the Event Condition (Compare IEC 61850-8-1 §17.3.3.3.2)	Not Supported
Lg4	-	Pre-configured LCB attributes that cannot be changed online	Deprecated, the information is already available in SCL
Lg5	1	Which TrgOps are supported for logging (note Ed2 and up requires support for all TrgOps)	Not Supported

PIXIT for GOOSE PUBLISH MODEL

ID	Ed	Description	Value / Clarification
Gp1	1,2	Can the test (Ed1) / simulation (Ed2) flag in the published GOOSE be set	N
Gp2	1	What is the behaviour when the GOOSE publish configuration is incorrect	NdsCom=T DUT keeps GoEna=F
Gp3	1,2	Published FCD supported common data classes are	SPS, ENS, ACD, LPL, DPS, ACT, INS, SPC Arrays are not supported
Gp4	1,2	What is the maximum value of TAL (maxTime) Is it fixed or configurable	Configured by ICT MaxTime 120,000ms
Gp5	1,2	What is the fastest retransmission time	2 ms
Gp6	-	Can the GOOSE publish be turned on / off by using SetGoCBValues(GoEna)	Deprecated See PICS - SetGoCBValues
Gp7	1,2	What is the initial GOOSE sqNum after restart	sqNum = 0
Gp8	1	May the GOOSE data set contain: - structured data objects (FCD) - timestamp data attributes	 Y Y
Gp9	1,2	Does Server or ICT refuse GOOSE payload dataset length greater than SCSM supports?	Y – ICT refuses

PIXIT for GOOSE SUBSCRIBE MODEL

ID	Ed	Description	Value / Clarification
Gs1	1,2	What elements of a subscribed GOOSE message are checked to decide the message is valid and the allData values are accepted? If yes, describe the conditions. Notes: • the VLAN tag may be removed by an Ethernet switch and shall not be checked • the simulation flag shall always be checked (Ed2)	Y destination MAC address Y APPID Y gocbRef Y timeAllowedtoLive N datSet N goID N T Y stNum N sqNum Y simulation / test Y confRev Y ndsCom Y numDatSetEntries Yout-of-order dataset members
Gs2	1,2	When is a subscribed GOOSE marked as lost (TAL = time allowed to live value from the last received GOOSE message)	message does not arrive by 2x TAL
Gs3	1,2	What is the behaviour when one or more subscribed GOOSE messages is not received or syntactically incorrect (missing GOOSE)	Syntactically incorrect messages (incorrect stNum increment) received within the TAL are discarded, message will be processed after TAL expires and syntactically correct message is not received.
Gs4	1,2	What is the behaviour when a subscribed GOOSE message is out-of-order	Older messages are discarded
Gs5	1,2	What is the behaviour when a subscribed GOOSE message is duplicated	First message will process and second message will discard.
Gs6	1	Does the device subscribe to GOOSE messages with/without the VLAN tag	Y, with the VLAN tag Y, without the VLAN tag
Gs7	1	May the GOOSE data set contain: - structured data objects (FCD) - timestamp data attributes	 Y Y
Gs8	1,2	Subscribed FCD supported common data classes are	SPS, ENS, DPS, INT, ACD, ACT, SEC Arrays are not supported
Gs9	1,2	Are subscribed GOOSE with test=T (Ed1) / simulation=T (Ed2) accepted in test/simulation mode	Y
Gs10	1,2	Max number of dataset members	Fixed at 128
Gs11	1	Is Fixed-length encoded GOOSE supported	Y
Gs12	2	Is IEC 62351-6 security supported	N

PIXIT for GOOSE PERFORMANCE

ID	Ed	Description	Value / Clarification	
Gf1	1,2	Performance class	P2 = 10ms P3 = 20ms	
Gf2	1,2	GOOSE ping-pong processing method	Scan cycle based	
Gf3	1,2	Application logic scan cycle (ms)	Max.	4ms (GOOSE PUB) 100us (GOOSE SUBS)
			Min.	100us (GOOSE PUB) 100us (GOOSE PUB)
Gf4	1	Maximum number of data attributes in GOOSE dataset (value and quality has to be counted as separate attributes)	Such that dataset does not exceed GOOSE: 1000 Bytes	

PIXIT for CONTROL MODEL

ID	Ed	Description	Value / Clarification
Ct1	1	What control models are supported (compare ICD file enums for Ed2)	Dons: Y SBOns: N DOes: N SBOes: N
Ct2	1,2	Is the control model fixed, configurable and/or dynamic	Fixed
Ct3	-	Is TimeActivatedOperate supported (compare PICS or SCL)	Deprecated
Ct4	-	Is “operate-many” supported (compare sboClass)	Deprecated, see sboClass in datamodel (ICD)
Ct5	1	Will the DUT activate the control output when the test attribute is set in the SelectWithValue and/or Operate request (when N test procedure Ctl2 is applicable)	Yes only for Mode control
Ct6	-	What are the conditions for the time (T) attribute in the SelectWithValue and/or Operate request	Deprecated
Ct7	-	Is pulse configuration supported (compare pulseConfig)	Deprecated
Ct8	1	What is the behaviour of the DUT when the check conditions are not set Is this behaviour fixed, configurable, online changeable	Check conditions are not checked.

ID	Ed	Description	Value / Clarification
Ct9	1,2	Which additional cause diagnosis are supported	N Unknown N Not-supported N Blocked-by-switching-hierarchy N Select-failed N Invalid-position N Position-reached N Step-limit N Blocked-by-Mode N Blocked-by-process N Blocked-by-interlocking N Blocked-by-synchrocheck N Command-already-in-execution N Blocked-by-health N 1-of-n-control N Abortion-by-cancel N Time-limit-over N Abortion-by-trip N Object-not-selected **Edition 1 specific values:** N Parameter-change-in-execution (Ed1 semantics) **Edition 2 specific values:** N Object-already-selected N No-access-authority N Ended-with-overshoot N Abortion-due-to-deviation N Abortion-by-communication-loss N Blocked-by-command N None N Locked-by-other-client N Parameter-change-in-execution (Ed2 semantics)
Ct10	1,2	How to force a “test-not-ok” respond with SelectWithValue request	Not Supported
Ct11	1,2	How to force a “test-not-ok” respond with Select request	Not Supported
Ct12	1,2	How to force a “test-not-ok” respond with Operate request	Not supported
Ct13	1,2	Which origin categories are supported / accepted	Y bay-control Y station-control Y remote-control Y automatic-bay Y automatic-station Y automatic-remote Y maintenance Y process
Ct14	1,2	What happens if the orCat value is not supported or invalid	DOns: Operate response-

ID	Ed	Description	Value / Clarification
Ct15	1,2	Does the IED accept a SelectWithValue / Operate with the same control value as the current status value Is this behaviour configurable	DOns: N Configurable: N
Ct16	1	Does the IED accept a select/operate on the same control object from 2 different clients at the same time	DOns: N
Ct17	1	Does the IED accept a Select/SelectWithValue from the same client when the control object is already selected (Tissue #334)	Not Suported
Ct18	1	Deprecated	
Ct19	-	Can a control operation be blocked by Mod=Off or [On-] Blocked (Compare PIXIT-Sr5)	Deprecated
Ct20	1,2	Does the IED support local / remote operation	N
Ct21	1,2	Does the IED send an InformationReport with LastApplError as part of the Operate response- for control with normal security	DOns: N
Ct22	2	How to force a “parameter-change-in-execution”	Not Supported
Ct23	1,2	How many SBOns/SBOes control objects can be selected at the same time?	Not Supported
Ct24	1,2	Can a controllable object be forced to keep its old state e.g. Internal Controllable Objects may not be accessible to force this, whereas a switch like Circuit Breaker outside the DUT can?	N
Ct25	1,2	When CDC=DPC is supported, is it possible to have DPC (Controllable Double Point) go to the intermediate state? (00)	N
Ct26	1,2	Name an enhanced securitycontrol point (if any) with a finite operate timeout specify the operate timeout (in milliseconds)	Ld/Ln.DataObject, xxx or No DOes points have timeout DOes: No SBOes: No
Ct27	2	Does the IED support control objects with external signals?	DOns: N SBOns: N DOes: N SBOes: N
Ct28		Deprecated, kept as placeholder	

PIXIT for TIME SYNCHRONIZATION MODEL

ID	Ed	Description	Value / Clarification
Tm1	1	What time quality bits are supported (may be set by the IED)	Y LeapSecondsKnown Y ClockFailure Y ClockNotSynchronized
Tm2	1,2	Describe the behaviour when all time server(s) cease to respond What is the time server lost detection time	Assert CNS after lost detection time SNTP: Configurable “Poll Interval” + 5*”Timeout Interval”
Tm3	1,2	How long does it take to take over the new time from time server	From ‘no sync’ to ‘SNTP sync’: it takes approximately 5 seconds For the same SNTP time master time adjustment: it takes “Poll Interval” + 5*”Timeout Interval” to get the new time from the same time server.
Tm4	1,2	When is the time quality bit “Clock-Failure” set	Bit is set, when no IRIG-B, SNTP or PTP is detected
Tm5	1	When is the time quality bit “Clock not Synchronized” set	Bit is set, when No IRIG-B, SNTP or PTP is detected Unlocked IRIG-B is detected Note: For Ed2 and up, CNS is set according to PIXIT Tm2
Tm6	-	Is the timestamp of a binary event adjusted to the configured scan cycle	Deprecated
Tm7	1	Does the device support time zone and daylight saving	Y
Tm8	1,2	Which attributes of the SNTP response packet are validated	N Leap indicator not equal to 3 N Mode is equal to SERVER N OriginateTimestamp is equal to value sent by the SNTP client as Transmit Timestamp N RX/TX timestamp fields are checked for reasonableness Y SNTP version 3 and/or 4 N other (describe)
Tm9	1,2	Do the COMTRADE files have local time or UTC time and is this configur-able	COMTRADE files are not supported on the IED. Native Records may be converted to COMTRADE via soft-ware tools. Converted COMTRADE file has the UTC time values.

PIXIT for FILE TRANSFER MODEL

ID	Ed	Description	Value / Clarification
Ft1	1	What is the structure of files and directories Where are the COMTRADE files stored Are COMTRADE files zipped and what files are included in each zip file	Flat file system with pseudo folders (Ed2) COMTRADE files are not stored on the IED
Ft2	1,2	Directory names are separated from the file name by	"/"
Ft3	1	The maximum file name size including path (recommended 64 chars)	64 chars
Ft4	1,2	Are directory/file name case sensitive	Y
Ft5	1,2	Maximum file size for SetFile	SetFile Not Supported
Ft6	1	Is the requested file path included in the MMS fileDirectory respond file name	Y But client is not allowed to use any path names that contain anything other than “/”. In that case Server will return response with zero files. (Ed2: always complete path)
Ft7	1	Is the wild card supported in the MMS fileDirectory request	Yes, wild card = *
Ft8	1,2	Is it allowed that 2 clients get a file at the same time	Y same file Y different files
Ft9	1,2	Which files can be deleted	Delete files not supported

PIXIT for SERVICE TRACKING MODEL

ID	Ed	Description	Value / Clarification
Tr1	2	Which ACSI services are tracked by LTRK.GenTrk	Not Supported

H.5 Data Mapping Specifications

TESLA 4000-SV Logical Devices

The TESLA 4000-SV Recorder has the following IEC 61850 logical devices defined in its ICD file:

- LD0 - Root Logical Device
- RCD - Recorder Triggers
- MEAS- Measurements
- SYS - System Info
- FLTL - Fault Locators
- DVI - Digital Virtual Inputs
- SVI - Sampled Value Inputs

TESLA 4000-SV Logical Nodes

The following table, Table H.6: TESLA 4000-SV Logical Nodes, defines the list of logical nodes (LN) which belong to the TESLA 4000-SV logical devices.

Table H.6: TESLA 4000-SV Logical Nodes

LD Name	LN Name	LN Description	Comments
LD0	LLN0	Common LN	
LD0	LPHD	Physical Device LN	
RCD	DFRRDRE	Digital Fault Record Status	
RCD	GRTGGIO1	Group Record Trigger Channel	Group Record Trigger Inputs and Output
RCD	ANALOGRADR1 . . . ANALOGRADR36	Disturbance Recorder Channel Analog	Trigger Status of Analog Channels 1 to 36
RCD	SUMRADR37 . . . SUMRADR84	Disturbance Recorder Channel Analog	Trigger Status of Summation Channels 1 to 48
RCD	SEQRADR85 . . . SEQRADR108	Disturbance Recorder Channel Analog	Trigger Status of Sequence Channels 1 to 24
RCD	WVARRADR109 . . . WVARRADR126	Disturbance Recorder Channel Analog	Trigger Status of Watt/Var Channels 1 to 18

Table H.6: TESLA 4000-SV Logical Nodes

LD Name	LN Name	LN Description	Comments
RCD	IMPRADR127 . . . IMPRADR144	Disturbance Recorder Channel Analog	Trigger Status of Impedance Channels 1 to 18
RCD	FREQRADR133 . . . FREQRADR144	Disturbance Recorder Channel Analog	Trigger Status of Frequency Channels 1 to 12
RCD	PFRADR145 . . . PFRADR162	Disturbance Recorder Channel Analog	Trigger Status of PF Detectors 1 to 18
RCD	LOGICRBDR1 . . . LOGICRBDR30	Disturbance Recorder Channel Binary	Trigger Status of Logic Channels 1 to 30
RCD	DIGRBDR31 . . . DIGRBDR94	Disturbance Recorder Channel Binary	Trigger Status of Digital (External Input) Channels 1 to 64
MEAS	ANLMAGMMXN1 . . . ANLMAGMMXN36	Non phase related measurement	Magnitude of Analog Channels 1 to 18 /36
MEAS	SUMMAGMMXN37 . . . SUMMAGMMXN84	Non phase related measurement	Magnitude of Summation Channels 1 to 48
MEAS	WVARMMXN85 . . . WVARMMXN102	Non phase related measurement	Watt/Var Channels 1 to 18
MEAS	IMPMMXN103 . . . IMPMMXN120	Non phase related measurement	Impedance Channels 1 to 18
MEAS	FREQMMXN121 . . . FREQMMXN132	Non phase related measurement	Frequency Channels 1 to 12

Table H.6: TESLA 4000-SV Logical Nodes

LD Name	LN Name	LN Description	Comments
MEAS	PFMMXN133 . . . PFMMXN150	Non phase related measurement	Power Factor Channels 1 to 18
MEAS	SEQMSQI1 . . . SEQMSQ24	Sequence and imbalance	Sequence Channels 1 to 12
MEAS	ANLANGGGIO1 . . . ANLANGGGIO36	Generic process I/O	Angle of Analog Channels 1 to 36
MEAS	SUMANGGGIO37 . . . SUMANGGGIO84	Generic process I/O	Angle of Summation Channels 1 to 48
SYS	OCGGIO1	Generic process I/O	Output contact status
SYS	TMSRCLTMS1	Time Master Supervision	Time Source status
SYS	LGOS1 . . . LGOS32	GOOSE Subscription Supervision	One LGOS LN is included per GOOSE Control Block which is subscribed to. See “Subscription Supervision via LGOS and LSVS” on page 19-4.
SYS	LSVS1 . . . LSVS8	Sampled Value Subscription Supervision	One LSVS LN is included per Sample Value stream which is subscribed to. See “Subscription Supervision via LGOS and LSVS” on page 19-4.
SYS	P401LCCH1, P402LCCH2, P410LCCH3, P411LCCH4, P412LCCH5, P413LCCH6	Physical communication channel supervision	Physical port communication status P413LCCH6 is currently unused
FLTL	RFLO1 . . . RFLO10	Fault locator	Fault Locators 1 to 10
DVI	VIGGIO001 . . . VIGGIO256	Generic process I/O	Multi-purpose external GOOSE Virtual Inputs. Total of 256 GOOSE Virtual Inputs
SVI	CHTGSN01 . . . CHTGSN32	Sampled Value Channel Input	SV Channel Input 1-32 used for Sample Value Subscription. See “SVI Logical Device” on page 19-17 for more details.

Logical Node Specifications

The following tables provide information on each of the TESLA 4000-SV logical nodes.

Note:

Common Logical Node information is not shown in the following Logical Node descriptions. Only the data provided from the TESLA 4000-SV application to the IEC 61850 stack are described

Logical Device: RCD

DFRRDRE1			
Logical Node	**Description**	**Data Name**	**Comments**
DFRRDRE1	Recorder status information	ST$RcdMade$stVal ST$FltNum$stVal ST$RcdStr$stVal ST$MemUsed$stVal	Indicates Records stored on IED Number of Records stored on IED Indicates that Recording is in progress Indicates percentage of memory used

GRTGGIO1			
Logical Node	**Description**	**Data Name**	**Comments**
GRTGGIO1	Group Record Trigger Inputs and output	ST$IntIn1$stVal ..... ST$IntIn7$stVal ST$ISCSO1$stVal	GRT input 1 to 7, GRT output 1

ANALOGRADR1 … ANALOGRADR36			
Logical Nodes	**Description**	**Data Attribute**	**Comments**
ANALOGRADR1 . . . ANALOGRADR36	Trigger status of analog channel 1 . . . Trigger status of analog channel 36	ST$ChTrg$stVal	

SUMRADR37 … SUMRADR84			
Logical Nodes	**Description**	**Data Attribute**	**Comments**
SUMRADR37 . . . SUMRADR84	Trigger status of summation channel 1 . . . Trigger status of summation channel 48	ST$ChTrg$stVal	

SEQRADR85 … SEQRADR96			
Logical Nodes	**Description**	**Data Attribute**	**Comments**
SEQRADR85 . . . SEQRADR96	Trigger status of sequence channel 1 . . . Trigger status of sequence channel 12	ST$ChTrg$stVal	

WVARRADR97 … WVARRADR114			
Logical Nodes	**Description**	**Data Attribute**	**Comments**
WVARRADR97 . . . WVARRADR114	Trigger status of watt/var channel 1 . . . Trigger status of watt/var channel 18	ST$ChTrg$stVal	

IMPRADR115 … IMPRADR132			
Logical Nodes	**Description**	**Data Attribute**	**Comments**
IMPRADR115 . . . IMPRADR132	Trigger status of impedance channel 1 . . . Trigger status of impedance channel 18	ST$ChTrg$stVal	

FREQRADR133 ... FREQRADR144			
Logical Nodes	**Description**	**Data Attribute**	**Comments**
FREQRADR133 . . . FREQRADR144	Trigger status of frequency channel 1 . . . Trigger status of frequency channel 2	ST$ChTrg$stVal	

PFRADR145 … PFRADR162			
Logical Nodes	**Description**	**Data Attribute**	**Comments**
PFRADR145 . . . PFRADR162	Trigger status of PF detector 1 . . . Trigger status of PF detector 18	ST$ChTrg$stVal	

LOGICRBDR1 … LOGICRBDR30			
Logical Nodes	**Description**	**Data Attribute**	**Comments**
LOGICRBDR1 . . . LOGICRBDR30	Trigger status of logic channel 1 . . . Trigger status of logic channel 30	ST$ChTrg$stVal	

DIGRBDR31 … DIGRBDR94			
Logical Nodes	**Description**	**Data Attribute**	**Comments**
DIGRBDR31 . . . DIGRBDR94	Trigger status of External Input channel 1 . . . Trigger status of External Input channel 64	ST$ChTrg$stVal	

Logical Device MEAS

ANLMAGMMXN1 … ANLMAGMMXN36			
Logical Node	**Description**	**Data Attributes**	**Comments**
ANLMAGMMXN1 . . . ANLMAGMMXN36	Magnitude of analog channel 1 . . . Magnitude of analog channel 36	MXAmpmag MX$Volt$mag	Current input magnitude in A, Voltage input magnitude in V **Note:** Logical node will only use one of the two data attribute types, depending on channel configuration.

SUMMAGMMXN37 … SUMMAGMMXN84			
Logical Node	**Description**	**Data Attributes**	**Comments**
SUMMAGMMXN37 . . . SUMMAGMMXN84	Magnitude of summation channel 1 . . . Magnitude of summation channel 48	MXAmpmag MX$Volt$mag	Current input magnitude in A, Voltage input magnitude in V

WVARMMXN85 … WVARMMXN102			
Logical Node	**Description**	**Data Attributes**	**Comments**
WVARMMXN85 . . . WVARMMXN102	Watt/Var channel 1 . . . Watt/Var channel 18	MX$Watt$mag, MX$VolAmpr$mag MX$VolAmp$mag	Magnitude in W, Magnitude in VAR Magnitude in VA **Note:** Logical node will only use one of the three data attribute types, depending on channel configuration.

IMPMMXN103 … IMPMMXN120			
Logical Node	**Description**	**Data Attributes**	**Comments**
IMPMMXN103 . . . IMPMMXN120	Impedance channel 1 . . . Impedance channel 18	MXImpcVal$mag MX$Imp$cVal$ang	Impedance in polar form.

FREQMMXN121... FREQMMXN132			
Logical Node	**Description**	**Data Attribute**	**Comments**
FREQMMXN121 . . . FREQMMXN132	Frequency channel 1 . . . Frequency channel 2	MXHzmag	In Hz

PFMMXN133 … PFMMXN150			
Logical Node	**Description**	**Data Attribute**	**Comments**
PFMMXN105 . . . PFMMXN122	Power factor channel 1 . . . Power factor channel 18	MX$PwrFact$mag	0 < PF < 1

SEQMSQ1 … SEQMSQ24			
Logical Node	**Description**	**Data Attributes**	**Comments**
SEQMSQ1 . . . . SEQMSQ24	Sequence channel 1 . . . . Sequence channel 24	MX$SeqA$c1$cVal$mag MX$SeqA$c1$cVal$ang MX$SeqA$c2$cVal$mag MX$SeqA$c2$cVal$ang MX$SeqA$c3$cVal$mag MX$SeqA$c3$cVal$ang MX$SeqV$c1$cVal$mag MX$SeqV$c1$cVal$ang MX$SeqV$c2$cVal$mag MX$SeqV$c2$cVal$ang MX$SeqV$c3$cVal$mag MX$SeqV$c3$cVal$ang	Current positive sequence magnitude Current positive sequence angle Current negative sequence magnitude Current negative sequence angle Current zero sequence magnitude Current zero sequence angle Voltage positive sequence magnitude Voltage positive sequence angle Voltage negative sequence magnitude Voltage negative sequence angle Voltage zero sequence magnitude Voltage zero sequence angle

ANLANGGGIO1 … ANLANGGGIO36			
Logical Node	**Description**	**Data Attribute**	**Comments**
ANLANGGGIO1 . . . ANLANGGGIO36	Angle of analog channel 1 . . . Angle of analog channel 36	MX$AnIn1$mag	In degrees

SUMANGGGIO37 … SUMANGGGIO84			
Logical Node	**Description**	**Data Attribute**	**Comments**
SUMANGGGIO37 . . . SUMANGGGIO84	Angle of summation channel 1 . . . Angle of summation channel 48	MX$AnIn1$mag	In degrees

Logical Device: SYS

OCGGIO1			
Logical Node	**Description**	**Data Attributes**	**Comments**
OCGGIO1	Output Contacts	ST$Ind1$stVal . . . ST$Ind8$stVal	Output contact 1 . . . Output contact 8

TMSRCLTMS1			
Logical Node	**Description**	**Data Attribute**	**Comments**
TMSRCLTMS1	Time Source Status	ST$TmSrc$stVal ST$TmSyn$stVal	Time source type (RTC or IRIG-B) Synchronization status

LGOS1...LGOS32			
Logical Nodes	**Description**	**Data Attributes**	**Comments**
LGOS1 . . . LGOS32	GOOSE Subscription Supervision	ST$NdsCom$stVal STStstVal ST$SimSt$stVal ST$LastStNum$stVal ST$ConfRevNum$stVal SP$GoCBRef$setSrcRef	Subscription needs commissioning Status of the subscription Status showing if simulated GOOSE are accepted Last state number received Expected configuration revision number Reference to the subscribed GOOSE control block **Note:** One LGOS LN is included per GOOSE Control Block which is subscribed to. See “Subscription Supervision via LGOS and LSVS” on page 19-4

LSVS1...LSVS8			
Logical Nodes	**Description**	**Data Attributes**	**Comments**
LSVS1 . . . LSVS8	Sampled Value Subscription Supervision	ST$NdsCom$stVal STStstVal ST$SimSt$stVal ST$LastStNum$stVal ST$ConfRevNum$stVal SP$GoCBRef$setSrcRef	Subscription needs commissioning Status of the subscription Status showing if simulated SV are accepted Last state number received Expected configuration revision number Reference to the subscribed SV control block **Note:** One LSVS LN is included per Sampled Value Control Block which is subscribed to. See “Subscription Supervision via LGOS and LSVS” on page 19-4.

P401LCCH1... P413LCCH6			
Logical Node	**Description**	**Data Attribute**	**Comments**
P401LCCH1	Port 401 communication status	ST$ChLiv$stVal ST$RedChLiv$stVal	Response Time: True to false (up to 61 seconds); Fault to True (up to 3 seconds)
P402LCCH2	Port 402 communication status	ST$ChLiv$stVal ST$RedChLiv$stVal	Response Time: True to false (up to 61 seconds); Fault to True (up to 3 seconds)
P410LCCH3	Port 410 communication status/PRP redundancy port 412 communication status	ST$ChLiv$stVal / ST$RedChLiv$stVal	Response Time: True to false (up to 130 seconds); Fault to True (up to 60 seconds)
P411LCCH4	Port 411 communication status	ST$ChLiv$stVal	Response Time: True to false (up to 130 seconds); Fault to True (up to 60 seconds)
P412LCCH5	RSTP redundancy port 412 communication status	ST$ChLiv$stVal	Response Time: True to false (up to 130 seconds); Fault to True (up to 60 seconds)

Logical Device: FLTL

FLTLOCRFLO1...FLTLOCRFLO10			
Logical Nodes	**Description**	**Data Attribute**	**Comments**
RFLO1 . . . RFLO10	Fault locator 1 . . . Fault locator 10	MX$FltZ$cVal$mag MX$FltZ$cVal$ang MX$FltDiskm	Fault impedance magnitude Fault impedance angle Fault location

Logical Device: DVI

VIGGIO001...VIGGIO256			
Logical Nodes	**Description**	**Data Attributes**	**Comments**
VIGGIO001 . . . VIGGIO256	Multi-purpose external GOOSE Virtual Inputs for high/low speed recording triggers, Logic inputs and Digital recording channels	ST$Ind1$stVal	

Logical Device: SVI

CHTGSN01...CHTGSN36			
Logical Nodes	**Description**	**Data Attribute**	**Comments**
CHTGSN01 . . . CHTGSN36	Sampled Value Subscription Channel Input	MX$GenSV$InstMag	The Sampled Value magnitude is not available for viewing via the InstMag attribute. This is only used as an input. See “Logical Device MEAS ” on page Appendix H-42 for Logical Nodes which contain the measurements.

H.6 61850 Conformance Certificate

No.: CPRIBLRMUADSASL21TC0003

Applicable Test Procedures from the UCA International Users Group Edition 2 Server Test Procedures version 2.0.5

Conformance Block	Mandatory	Conditional
1: Basic Exchange	sAss1, sAss2, sAss3, sAss4, sAssN2, sAssN3, sAssN4, sAssN5, sSrv1, sSrv2, sSrv3, sSrv4, sSrv5, sSrv8, sSrvN1abcdf, sSrvN4	sAssN6, sSrv9, sSrv10
2: Data Sets	sDs1, sDs10a, sDsN1ae	sDs15
5: Unbuffered Reporting	sRp1, sRp2, sRp3, sRp4, sRp5, sRp9, sRp14, sRp16, sRpN1, sRpN2, sRpN3, sRpN4, sRpN8	sRp8, sRp10, sRp11, sRp12, sRp15, sRp17, sRpN5
6: Buffered Reporting	sBr1, sBr2, sBr3, sBr4, sBr5, sBr9, sBr14, sBr16, sBr20, sBr21, sBr22, sBr25, sBr26, sBr27, sBr28, sBr29, sBrN1, sBrN2, sBrN3, sBrN4, sBrN5, sBrN8	sBr8, sBr10, sBr11, sBr12, sBr15, sBr17
9a: GOOSE publish	sGop2a, sGop3, sGop4, sGop9, sGop10, sGop11, sGop12	sGop1, sGop6, sGopN1, sGopN2
9b: GOOSE subscribe	sGos1, sGos2, sGos3, sGos5, sGos6a, sGos7, sGos8, sGos9, sGos10, sGos11, sGos12, sGosN1, sGosN2, sGosN3, sGosN4, sGosN5, sGosN6	sGos4
13: Time sync	sTm1, sTm2, sTmN1	sTmN2
14: File Transfer	sFt1, sFt2ab, sFt4, sFt5, sFtN1ab	---

(Harinath Babu P V)
Joint Director

(Pradish M)
Test Engineer

Page **2** of **2**

CENTRAL POWER RESEARCH INSTITUTE

Prof. Sir C V Raman Road, PO Box 8066, Sadashivanagar PO,
BANGALORE 560 080. I N D I A

UCA International Users Group

IEC 61850 Certificate Level A[1]

No.: CPRIBLRMUADSASL21TC0003

Issued to:
M/s. Phase Power Protection Private Limited
(A Subsidiary of ERLPhase Power Technologies Limited, Winnipeg, Canada)
No.235-O/2, Second Floor, Bommasandra Industrial Area,
Phase III, Hosur Road,
Bangalore – 560099 INDIA

For the server product:
POWER SYSTEM RECORDER
Model No.: TESLA 4000
Serial No.: TESLA-4005-191101-05
Hardware Version: V2.0
Software Version: V1.2A

Issued by: CENTRAL POWER RESEARCH INSTITUTE, India

The server product has not been shown to be non-conforming to:

IEC 61850 Edition 2 Parts 6, 7-1, 7-2, 7-3, 7-4 and 8-1

Communication networks and systems for power utility automation

The conformance test has been performed according to IEC 61850-10 Edition 2, the UCA International Users Group Edition 2 Server Test Procedures version 2.0.5 with product's protocol, model and technical issue implementation conformance statements: "PICS version D04831R01.21, dated 07 September, 2021", "MICS version D04833R01.21, dated 07 September, 2021", "TICS version D04832R01.21, dated 07 September, 2021" and product's extra information for testing: "PIXIT version D04834R01.21, dated 07 September, 2021".

The following IEC 61850 conformance blocks have been tested with a positive result (number of relevant and executed test cases / total number of test):

1	Basic Exchange (19/26)	9a	GOOSE Publish (11/13)
2	Data Sets (4/7)	9b	GOOSE Subscribe (18/20)
5	Unbuffered Reporting (20/23)	13	Time Synchronization (4/7)
6	Buffered Reporting (28/33)	14	File Transfer (5/8)

This Certificate includes a summary of the test results as carried out at Central Power Research Institute (CPRI), Bangalore in India with Client Simulator UniGrid SA Simulator version 1.8.0 with test suit version Ed2_Server_TP_2.0_20211006.3 and UniCA 61850 analyzer version 6.40.01.0. This document has been issued for information purposes only, and the original paper copy of the CPRI report No.: CPRIBLRMUADSASL21T0003; dated 01 November, 2021 will prevail.

The test has been carried out on one single specimen of the product as referred above and submitted to CPRI by M/s. Phase Power Protection Private Limited, (A Subsidiary of ERLPhase Power Technologies Limited, Winnipeg, Canada), No.235-O/2, Second Floor, Bommasandra Industrial Area, Phase III, Hosur Road, Bangalore – 560099, INDIA. The manufacturer's production process has not been assessed. This certificate does not imply that CPRI has certified or approved any product other than the specimen tested.

Bangalore; 01 November, 2021

(Harinath Babu P V)
Joint Director

(Pradish M)
Test Engineer

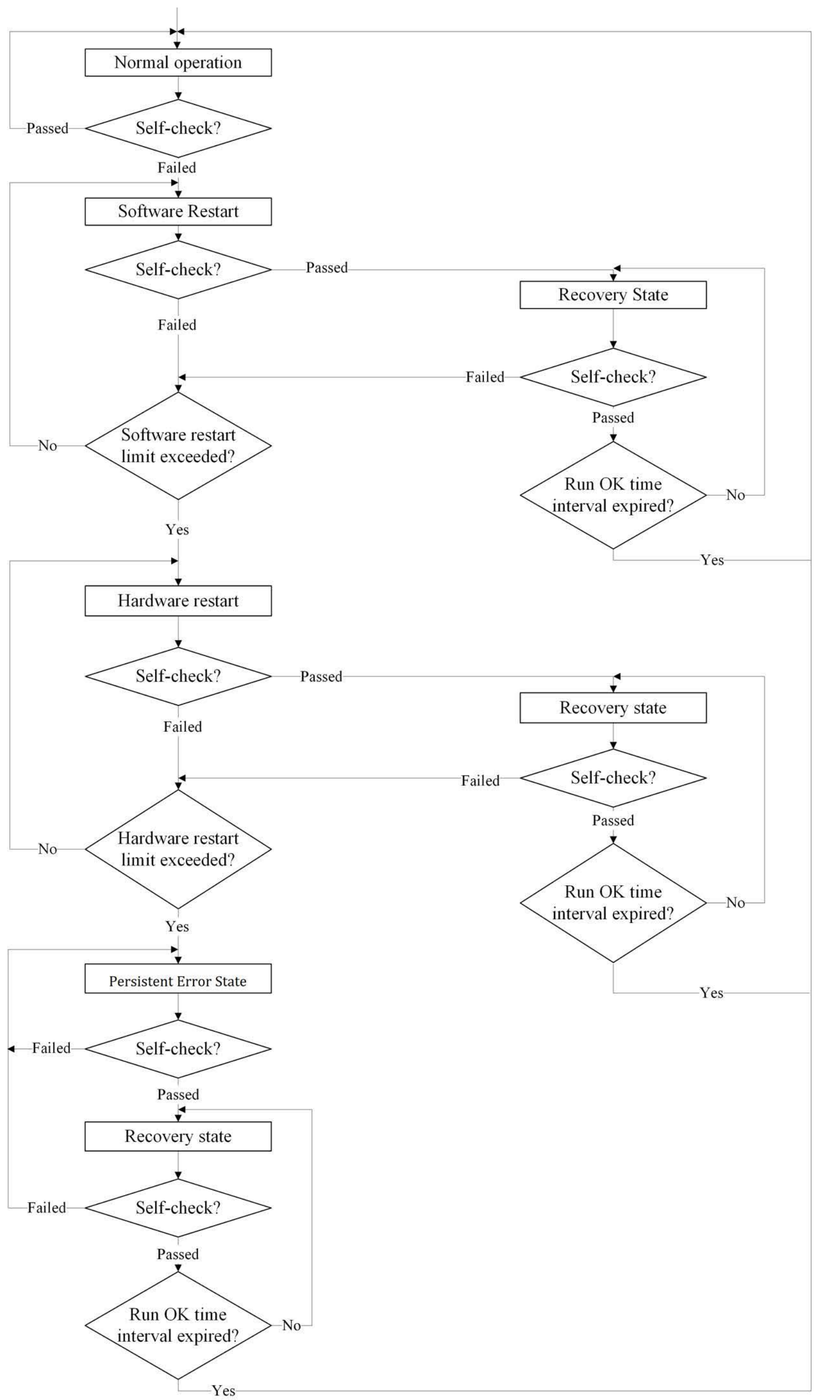
1 Level A – Independent Test lab with certified ISO/IEC 17025 Quality System.

Page **1** of **2**

Appendix I TESLA Self-Check and Recovery

The purpose of this Appendix is to provide a detailed description of the TESLA Self-Check and Recovery process.

Self-check and Recovery Flowchart



Self-Check and Recovery Description

When the supervisory software detects an issue for a first time, it makes an attempt to correct the issue through a software restart. The software restart takes place quickly and does not activate any external indications. If the issue persists after the first software restart, the supervisory software initiates two more software restarts in attempt to correct the issue.

If the issue persists after three software restarts, the supervisory software initiates a hardware reset in an attempt to correct the issue. A hardware reset takes approximately a minute and a half to complete. Refer to the Table 16.1:Recorder States and State Indicators for the hardware reset indications and guidance on maintenance actions to take.

If the problem is not cleared after four consecutive hardware resets initiated by the supervisory software, the unit enters the Persistent Error state. In this state, the recorder activates its Persistent Error state indication and stops initiating hardware resets to avoid interfering with issue investigation. Refer to the Table 16.1:Recorder States and State Indicators for the Persistent Error state indication and guidance on maintenance actions to take.

If the Supervisory software subsequently determines that the problem has been cleared, it automatically returns the unit to its normal operating state and clears the failure indication.

If the supervisory software is not able to function properly, the hardware watchdog initiates unit reboot. If the supervisory software issue is not corrected after the first watchdog initiated reboot, the watchdog initiates four more unit reboots and then activates Persistent Error state indication. Refer to the Table 16.1:Recorder States and State Indicators for the Persistent Error state indications and guidance on maintenance actions to take.

Appendix J IEEE 1686-2013 Table of Compliance

Clause Number	Clause/Subclause Title	Status	Comment
5	IED cyber security features	Acknowledge	
5.1	Electronic access control	Acknowledge	
5.1.2	Password defeat mechanisms	Comply	
5.1.3	Number of individual users	Exceed	Number of individual users is 32
5.1.4	Password construction	Comply	
5.1.5	IED access control	Acknowledge	
5.1.5.1	Authorization levels by password	Comply	
5.1.5.2	Authorization using role-based access control (RBAC)	Exception	IED doesn’t allow for user-defined roles. IED complies with IEC 62351-8 RBAC model. 6 pre-defined and 4 default roles are supported. See User Manual for details.
5.1.6	IED main security functions	Comply	
5.1.6 a)	View data	Comply	
5.1.6 b)	View configuration settings	Comply	
5.1.6 c)	Force values	Comply	
5.1.6 d)	Configuration change	Comply	
5.1.6 e)	Firmware change	Comply	
5.1.6 f)	ID/password or RBAC management	Comply	User-defined roles are not supported.
5.1.6 g)	Audit trail	Comply	
5.1.7	Password display	Comply	
5.1.8	Access timeout	Exceed	Inactivity timeout range is between 1min to 120min.
5.2	Audit trail	Acknowledge	
5.2.2	Storage capability	Comply	
5.2.3	Storage record	Comply	
5.2.3 a)	Event record number	Comply	
5.2.3 b)	Time and date	Comply	
5.2.3 c)	User identification	Comply	

Clause Number	Clause/Subclause Title	Status	Comment
5.2.3 d)	Event type	Comply	
5.2.4	Audit trail	Exception	
5.2.4 a)	Log in	Comply	
5.2.4 b)	Manual log out	Comply	
5.2.4 c)	Timed log out	Comply	
5.2.4 d)	Value forcing	Comply	
5.2.4 e)	Configuration access	Comply	
5.2.4 f)	Configuration change	Comply	
5.2.4 g)	Firmware change	Comply	
5.2.4 h)	ID/password creation or modification	Comply	
5.2.4 i)	Password deletion	Comply	
5.2.4 j)	Audit log access	Comply	
5.2.4 k)	Time/date change	Exception	Time/date changes are not captured in audit trail
5.2.4 l)	Alarm incident	Comply	
5.3	Supervisory monitoring and control	Acknowledge	
5.3.2	Events	Comply	
5.3.3	Alarms	Exception	
5.3.3 a)	Unsuccessful login attempt	Comply	
5.3.3 b)	Reboot	Comply	
5.3.3 d)	Attempted use of unauthor-ized configuration software	Comply	
5.3.3 d)	Invalid configuration or firm-ware download	Comply	
5.3.3 e)	Unauthorized configuration or firmware file	Comply	
5.3.3 f)	Time signal out of tolerance	Exception	Out of tolerance time signal alarms are not captured in audit trail
5.3.3 g)	Invalid field hardware changes	Comply	Feature not offered in this product
5.3.4	Alarm point change detect	Comply	
5.3.5	Event and alarm grouping	Comply	Supervisory system upon the occurrence of events and alarms is not supported

Clause Number	Clause/Subclause Title	Status	Comment
5.3.6	Supervisory permissive control	Exception	Feature is implemented for Remote Firmware Update only
5.4	IED cyber security features	Acknowledge	
5.4.1	IED functionality compromise	Comply	Ports and services are listed in User Manual
5.4.2	Specific cryptographic features	Exception	
5.4.2 a)	Web-server functionality	Comply	Feature not offered in this product
5.4.2 b)	File transfer functionality	Exception	FTP protocol is used for file transfer
5.4.2 c)	Text-oriented terminal connections	Comply	Feature not offered in this product
5.4.2 d)	SNMP network management	Comply	Feature not offered in this product
5.4.2 e)	Network time synchronization	Exception	SNTP protocol is used
5.4.2 f)	Secure tunnel functionality	Comply	Feature not offered in this product
5.4.3	Cryptographic techniques	Comply	Implemented cryptographic techniques are based on NIST Computer Security Division recommendations.
5.4.4	Encrypting serial communications	Exception	Data encryption for remote serial communication is not supported
5.4.5	Protocol-specific security features	Comply	
5.5	IED configuration software	Acknowledge	
5.5.1	Authentication	Exception	Feature is not supported
5.5.2	Digital signature	Comply	Digital signatures are used in the configuration and firmware download files
5.5.3	ID/password control	Exception	Feature is not supported
5.5.4	ID/password controlled features	Exception	
5.5.4.1	View configuration data	Exception	Feature is not supported
5.5.4.2	Change configuration data	Exception	Feature is not supported
5.5.4.2 a)	Full access	Exception	Feature is not supported
5.5.4.2 b)	Change tracking	Exception	Feature is not supported
5.5.4.2 c)	Use monitoring	Exception	Feature is not supported
5.5.4.2 d)	Download to IED	Exception	Feature is not supported

Clause Number	Clause/Subclause Title	Status	Comment
5.6	Communications port access	Exception	Not all ports and services can be disabled
5.7	Firmware quality control	Comply	

Appendix K Credential Character List

Table K.7: Alphabetic Characters

Character	ASCII Decimal	Description	Character	ASCII Decimal	Description
A	65	Uppercase A	a	97	Lowercase a
B	66	Uppercase B	b	98	Lowercase b
C	67	Uppercase C	c	99	Lowercase c
D	68	Uppercase D	d	100	Lowercase d
E	69	Uppercase E	e	101	Lowercase e
F	70	Uppercase F	f	102	Lowercase f
G	71	Uppercase G	g	103	Lowercase g
H	72	Uppercase H	h	104	Lowercase h
I	73	Uppercase I	i	105	Lowercase i
J	74	Uppercase J	j	106	Lowercase j
K	75	Uppercase K	k	107	Lowercase k
L	76	Uppercase L	l	108	Lowercase l
M	77	Uppercase M	m	109	Lowercase m
N	78	Uppercase N	n	110	Lowercase n
O	79	Uppercase O	o	111	Lowercase o
P	80	Uppercase P	p	112	Lowercase p
Q	81	Uppercase Q	q	113	Lowercase q
R	82	Uppercase R	r	114	Lowercase r
S	83	Uppercase S	s	115	Lowercase s
T	84	Uppercase T	t	116	Lowercase t
U	85	Uppercase U	u	117	Lowercase u
V	86	Uppercase V	v	118	Lowercase v
W	87	Uppercase W	w	119	Lowercase w
X	88	Uppercase X	x	120	Lowercase x
Y	89	Uppercase Y	y	121	Lowercase y
Z	90	Uppercase Z	z	122	Lowercase z

Table K.8: Numeric Characters		
Character	**ASCII Decimal**	**Description**
0	48	Zero
1	49	One
2	50	Two
3	51	Three
4	52	Four
5	53	Five
6	54	Six
7	55	Seven
8	56	Eight
9	57	Nine

Table K.9: Special Characters		
Character	**ASCII Decimal**	**Description**
!	33	Exclamation mark
“	34	Quotation mark
#	35	Number sign
$	36	Dollar sign
&	38	Ampersand
‘	39	Apostrophe
(	40	Left parenthesis
)	41	Right parenthesis
*	42	Asterisk
+	43	Plus sign
,	44	Comma
-	45	Hyphen-minus
.	46	Full stop
/	47	Slash (Solidus)
:	58	Colon
;	59	Semicolon
<	60	Left-than sign

Table K.9: Special Characters

=	61	Equal sign
>	62	Greater-than sign
?	63	Question mark
@	64	At sign
[	91	Left Square Bracket
]	93	Right Square Bracket
^	94	Circumflex accent
_	95	Underscore
|	124	Vertical bar
{	123	Left Curly Bracket
}	125	Right Curly Bracket
~	126	Tilde

Appendix L CE Declaration of Conformity

DECLARATION OF CONFORMITY

We,

ERLPhase Power Technologies Ltd.
74 Scurfield Blvd.
Winnipeg, Manitoba, Canada
R3Y 1G4
Ph: 204-477-0591
Fax: 204-478-1697

declare under our sole responsibility that the product

TESLA 4000 Power System Recorder

is in conformity with the applicable requirements of the following documents

2014/35/EU **SI 2016/1101**	**Low Voltage Directive** IEC 60255-27:2013 Measuring relays and protection equipment - Part 27: Product safety requirements
2014/30/EU **SI 2016/1091**	**Electromagnetic Compatibility Directive** **EMC Regulations 2016** IEC 60255-26:2013 Measuring relays and protection equipment - Part 26: Electromagnetic compatibility requirements
2015/863/EU **SI 2012/3032**	**Restriction of Hazardous Substances in Electrical and Electronic Equipment Directive** BS EN IEC 63000:2018

I hereby declare that the equipment named above has been designed to comply with the relevant sections of the above referenced specifications. The unit complies with all applicable essential requirements of the directives.

Signed by:____________________

Name: Andy Perreault
Position: Research and Development Manager
Signed at: Winnipeg, Manitoba, Canada
Date: March 4, 2024

ERLPhase Document Number: D04050R03.00

Index