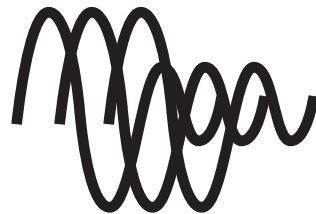




TESLA 3000

Disturbance Recorder



User Manual

Version 2.6 Rev 1

Preface

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Using This Guide

This User Manual describes the installation and operation of the TESLA disturbance 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
<i>Start>Settings>Control Panel</i>	Choose the Control Panel submenu in the Settings submenu on the Start menu.
Right-click	Click the right mouse button.
<i>Recordings</i>	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.

Version Compatibility

TESLA 3000 Version Compatibility		
TESLA 3000 Firmware	Setting Version	TESLA 3000/4000 Control Panel
v2.6	204	4000 v1.3 and greater
v2.5a	204	4000 v1.3 and greater
v2.5	204	4000 v1.2a and greater
v2.4	203	4000 v1.1 and greater
v2.3d	203	v2.3 and greater
v2.3c	203	v2.3 and greater
v2.3b Beta	203	v2.3b Beta
v2.3a	203	v2.3 or greater
v2.3	203	v2.3 or greater
v2.2a	202	v2.2 or greater
v2.2	202	v2.2 or greater
v2.1 Beta	202	v2.1
v2.0a	201	v2.0a or greater
v1.0e	201	v1.0a or greater
v2.0	201	v2.0
v1.0d	201	v1.0a or greater
v1.0c	201	v1.0a or greater
v1.0b	201	v1.0a or greater
v1.0a	201	v1.0a or greater
v1.0	201	v1.0a or greater

Please contact ERLPhase Customer Service for complete Revision History.

1 Overview

TESLA System Description

The TESLA Disturbance Recorder is a multi-time frame recording system used to monitor electrical power systems. It can record up to 36 analog channels and 64 digital (status) channels and store up to 1000 recordings. Up to four recorders can be operated as a cooperative group 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 trend (10 second to 1 hour intervals). A wide variety of triggers are available to initiate recording.

An optional PMU software module enables the TESLA to transmit Synchrophasors to a PDC as per IEEE C37.118 standards.

The TESLA system consists of a recorder, analog input isolation modules and the TESLA Control Panel user interface software. There are various analog input isolation modules available to interface to signal sources. Modules are available to connect to standard signals found in a typical electric power substation including secondary ac voltage and current and low level dc voltage and current signals. These modules can generally be installed up to 1120 meters from the recorder unit, allowing them to be located near the source of the signals being monitored.

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

An optional central station program - RecordBase - is available to automatically collect and store records from multiple recorders. RecordBase provides fast network-based access to collected records through distributed RecordBase View desktop clients.

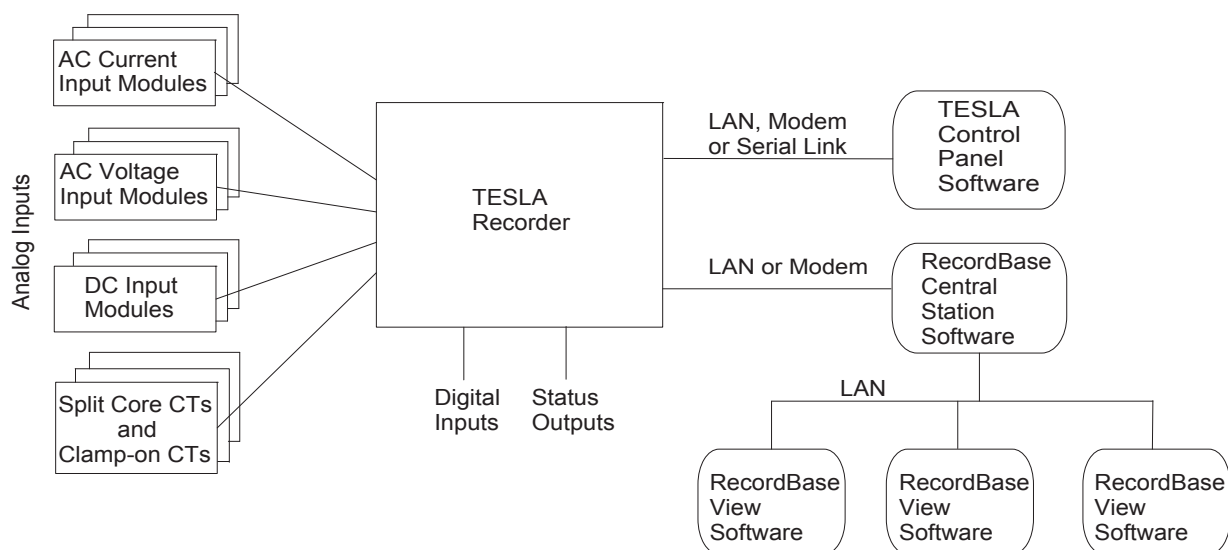


Figure 1.1: TESLA System Overview

TESLA 3000 Features

Installation

- 19" rack-mount format
- Small 3U footprint
- Analog input isolation modules for ac and dc input signals are DIN-rail mounted to minimize rack usage and can be located up to 300 meters from the main unit for flexible installation
- Analog input modules interface with standard signals: 1A/5A nominal ac currents, 69V (120/Root3) nominal ac voltages, dc current or voltage

Data Acquisition

- Up to 36 analog input channels, 16 bit resolution each channel
- Up to 64 external (digital) input channels
- Simultaneous operation in transient fault, dynamic swing and long term trend time frames
- User-selectable sample rates for transient fault recording: 32, 64, 96, 128, 256 and 384 samples per cycle
- 60 samples/second (1 sample/cycle) dynamic swing recordings
- 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
- Calculated channels: summations, watts, vars, power factor, positive, negative and zero sequence components, impedance, THD, frequency and harmonics

Optional PMU Module

- Transmits 12 user-selectable phasors as individual phase quantities or three-phase positive, negative or zero sequence phasors or summated phasors
- Transmits up to 12 analog quantities of Watts, VARS and VA

	<ul style="list-style-type: none">• Transmits up to 64 digital (Status) values
Triggers	<ul style="list-style-type: none">• Rates and level triggering on all input and calculated channels with individual controls for delay, logging, record initiation and alarm contact activation• Configurable logic can be applied to digital inputs and internal trigger states• User-assigned trigger priorities help identify critical events and records• Centralized cross-triggering of dynamic swing recordings through Record-Base Central Station
Records	<ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• Up to 4 recorders can be operated as a cooperative group• Automatic cross triggering over a LAN with IRIG-B synchronized time stamps• Automatic record retrieval with consolidation into a single group record
Logging	<ul style="list-style-type: none">• 250 day entry 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	<ul style="list-style-type: none">• Automatic fault location on up to 10 lines.• Fault location data available in the event log, in recordings and through SCADA
User Interface	<ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• Recorder configuration and relevant 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

- Up to 6 user-configurable output contacts can be activated by triggers
- Cross-trigger contact can activate other devices
- Failure / Service Required contact

Communication

- Integrated 10/100 BaseT
- Optional internal modem
- Standard TCP/IP communication protocol used to communicate with Control Panel and RecordBase software
- SCADA (Supervisory Control and Data Acquisition Systems) protocols. DNP3 and Modbus. DNP3 over Ethernet is supported

Time Coordination

- IRIG-B time code input - modulated or unmodulated. Supports IEEE 1344 extensions
- 1ms event timetagging of events and records
- Time synchronization indicator on front panel and in each record

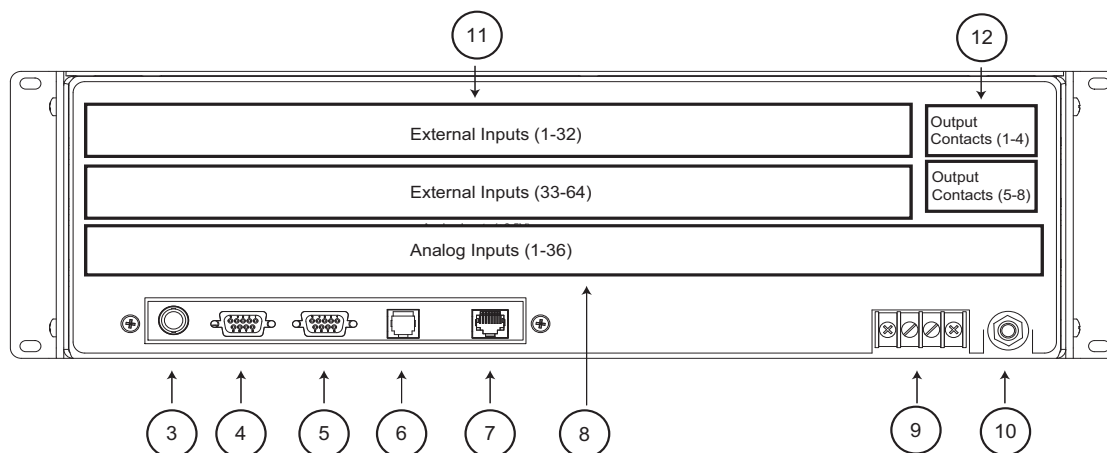
Reliability

- Self-monitoring supervisory software with hardware 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

Front Panel

Figure 1.2: Front Panel

Rear Connections



- 3. IRIG B External Clock, modulated or unmodulated
- 4. Port 2: EIA 232 Serial Connection for PC or an external modem
- 5. Port 3: EIA 232 SCADA Communication (DNP 3 and Modbus)
- 6. Internal Modem (option)
- 7. 10/100 Base T Ethernet Network
- 8. Analog Input Channels (18 or 36). Non-isolated
- 9. Power Supply (40-300Vdc). Handles 48, 125 or 250 Vdc or 120 Vac nominal
- 10. Chassis Ground
- 11. External (digital) Input Channels (32 or 64)
- 12. Output Contacts (4 or 8)

Figure 1.3: Rear Connections

2 Connection and Power Up

For drawings, see “TESLA 3000 Drawings” in Appendix I.

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 11.5 inches deep. An additional 3 inches of depth is required for rear connections and cables.

Case Grounding

WARNING!

To ensure safety and proper operation you must connect the recorder's grounding terminal to the station ground. Do not rely on the rack mounting screws to provide case grounding.

Ground the recorder even when testing.

Power Supply

ERLPhase recorders come with a wide range power supply (40-300 Vdc) that can be used with 48, 125 or 250 Vdc nominal systems or with standard 120 Vac power.

To protect against possible short circuit in the supply use an in-line fuse or circuit breaker with a 5 A rating. Make the chassis ground connection to ensure proper operation and safety.

The recorder does not have a power switch; the unit will start as soon as voltage is applied to the power supply input.

Signal Connections

Analog Input Channels and Input Modules

The recorder's 18 or 36 analog inputs are generic, low level (5.5 V pp) non-isolated signal inputs. They take their input from external interface modules that provide scaling, isolation and surge protection.

The external input modules accept conventional substation voltage and current signals and convert them into low level voltages that are fed into the recorder's analog inputs. The modules are mounted on DIN rails to make wiring easier and minimize rack space requirements.

Modules can be located up to 1220 meters (4000 feet) from the recorder. The wire used for the connection between the modules and the recorder can range in size from 16 to 20 AWG. It is highly recommended that twisted-shielded wire be used for cables that are run outside of the panel in which the TESLA is located, noting that the shield should be grounded only at the recorder. Belden 9388, or its equivalent, is an example of an acceptable cable that can be used.

Any of the recorder's analog input channels can be connected to any of the available input modules. The software configuration identifies the type of input module associated with each channel.

Input module channels can be connected to only one recorder input. Source and load impedance matching are used to minimize noise susceptibility; connecting to two channels will produce incorrect readings.

All input modules must be grounded via the ground stud on the module.

Re-calibration is required whenever an input module is replaced or moved to a different channel (see "Analog Input Calibration" on page 7-11)

Input Module Types

For further information on the input modules, see "Input Modules" in Appendix F.

AC Voltage Input Module

This 3 channel ac voltage input module (Model 401006) provides isolation and scaling for standard voltage signals. The nominal signal level is 69 V RMS (120/Root 3). The module has a dynamic range that can measure 2X nominal voltages.

AC Current Input Module

This 4 channel ac current input module provides isolation and scaling for standard current signals. The module's channels are connected in series with the current signal source. All models have a dynamic range that can pass 20x nom-

inal currents. The module can withstand 20x nominal for 1 second and has a maximum thermal rating of 400A for 1 second.

Model 401014 has a nominal signal level of 5 A RMS

Model 401020 has a nominal signal level of 1 A RMS

Split Core CT

The Split Core CT is designed to clamp around the secondary circuit wires of a primary current transformer. It is intended for situations where an outage is not possible to connect an in-line CT. The outputs from the CT are impedance matched to connect directly to the TESLA's analog input connectors. All models have a dynamic range that can pass 20x nominal currents continuously.

Model 401013 has a nominal signal level of 5 A RMS

Model 401017 has a nominal signal level of 1 A RMS

Clamp-on CT

The Clamp-on CT (Model 401012) is a clothespin style device designed to clamp around the secondary circuit wires of a primary current transformers. It is intended for quick, temporary connection to existing circuits. The outputs from the CT are impedance matched to connect directly to the TESLA's analog input connectors. The Clamp-on CT has a nominal signal level of 5A RMS and can pass 20x nominal currents continuously.

DC Module

The DC input module (Model 401016) provides dc-coupled isolation and scaling for four independent dc or ac voltage or current channels. DC module channels have a dc to 2 kHz bandwidth, but the bandwidth may be further limited by the recorder's input filters, depending on the sample rate. Externally mounted resistors set the input type and full scale range.

AC Low Voltage Input Module

This 4 channel isolated ac voltage input module (Model 401022) provides isolation and scaling for low level voltage. The nominal input voltage is 4 Vrms with a 7 Vrms full scale capability. Maximum input level is 12 Vrms continuous or 15 Vrms for 10 seconds.

External Input Channels

The recorder's external inputs are dry inputs intended for use with signals from a 48-250 Vdc station battery. The external inputs are isolated and protected against transient surges. They activate at approximately 32 Vdc.

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:

For 18/32 channel units:

- 1 Recorder fail. Closed on failure
- 2 User-configurable
- 3 User-configurable
- 4 Cross-trigger, Channel Group 1

Additional, for 36/64 channel units:

- 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.

IRIG-B Time Signal

The BNC connector on the rear of the unit accepts either modulated or unmodulated IRIG-B time signals, with or without the 1344 extensions.

Communication Ports

See "Communicating with the Recorder" on page 4-1.

Startup Sequence

On Power Up	Front panel Test Mode LED turns on to indicate the presence of power
~40 seconds after Power Up	Test Mode LED starts to blink at 2-3 second intervals
~90 seconds after Power Up	Test Mode LED stays on. The Records Stored LED turns on if records are present
~100 seconds after Power Up	Recorder Functional LED turns on The Test Mode LED remains on At this point, you can log into the recorder
~105 seconds after Power Up	Test Mode LED turns off Recorder Functional LED remains on

Front Panel LEDs

Front Panel LED	Indications
Recorder Functional	Normally active green LED that is turned on approximately 100 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 Failure Contact
IRIG-B Functional	Green LED that is active when a valid external time synchronizing signal is detected on the IRIG-B port
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

Front Panel LED	Indications
Test Mode	Normally inactive red LED that turns on immediately on power up and blinks during start-up until the self-test has been completed (approximately 105 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.

The TESLA 3000 CD-ROM contains the following:

- TESLA Control Panel: interface software
- Firmware update with installation instructions
- User Manual in PDF format
- Mechanical drawings in electronic format

PC System Requirements

The minimum hardware requirements are:

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

A serial port, modem or Ethernet LAN connection is required if communication with a TESLA recorder is desired.

Operating System

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

- Microsoft Windows XP Professional Service Pack 3 or
- Microsoft Windows 7 Professional Service Pack 1 32-bit or 64-bit

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. The exception to this is the ability to communicate with TESLA recorders through Modem-LAN Gateway (see "Modem-LAN Gateway" on page 4-8)

Overview

Instructions for installing TESLA Control Panel and configuring Windows for its use are covered in the following sections. Separate instructions for each version of Windows Operating System are provided for the above steps. Use the one that is appropriate for your computer.

The procedure has the following parts:

- 1 Install TESLA Control Panel.
- 2 Install the Null Modem driver.
- 3 Create Windows Dial-Up Network definitions for modem and direct serial connections.

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 3-11)

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.

Installation on Windows XP or Windows 7

Step 1: Install TESLA Control Panel Software from CD-ROM

- 1 Insert the TESLA CD-ROM in your drive.
- 2 The CD-ROM should start automatically. If it doesn't, go to Windows Explorer and run the "CD.exe" file at the root of the CD-ROM directory.
- 3 To install TESLA Control Panel software on your computer, select the *TESLA Disturbance Recorder* icon, then the *Install TESLA Control Panel*. The installation program starts automatically, but may take a few minutes to begin.
- 4 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 your desktop. Use the icon to launch Control Panel.
If you prefer, you can start Control Panel through Windows Start menu (*Start>Programs>NxtPhase/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 CD-ROM.

This section provides step by step instructions on how to install the Null Modem driver.

- 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

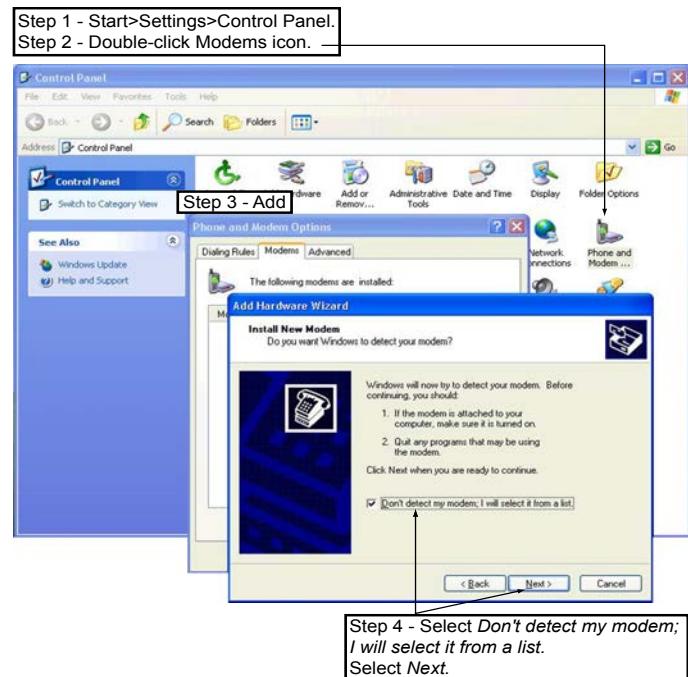


Figure 3.1: Null Modem Driver Installation

- 5 Select the *Have Disk* button, select *Browse*. To find the file go to *c:\Program Files\NxtPhase\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.

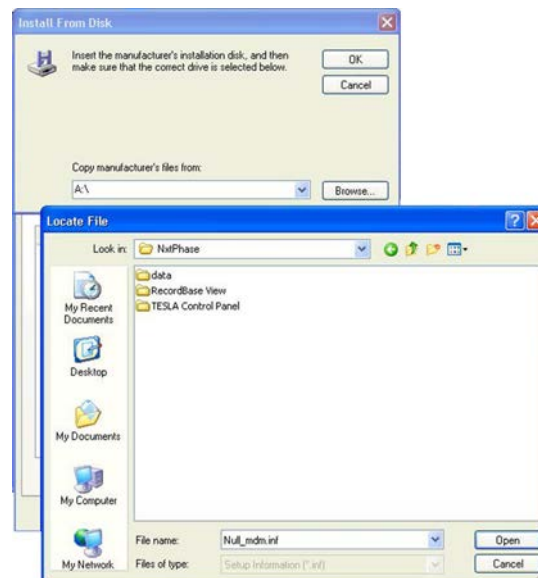


Figure 3.2: Browse for Null_Mdm.Inf

- 6 Select the *Generic Null Modem* driver and select *Next*. If you are given more than one option, select the one that has the most recent date associated with it.
- 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*.

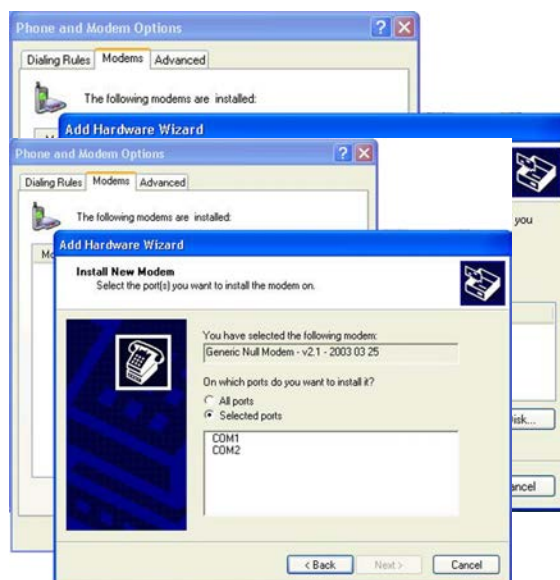


Figure 3.3: Select Serial Port

In Windows XP, you may get a message stating that the Null Modem “has not passed Windows Logo testing” and asking “Do you want to continue the installation?” Select *Continue Anyway* to continue.

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

Step 3: Dial-up Network Connections (DUN)

Windows’ Dial-Up Networks (DUN) are used to communicate with a recorder through your computer’s modem or serial port.

This section takes you through the steps required to create two Dial-Up configurations:

- APT_SERIAL for communication with a recorder via a serial cable (using the Null Modem installed in the previous section).
- APT_MODEM for communication with a recorder via your computer’s modem.

APT_SERIAL Dial-Up Network

To set up APT_SERIAL Dial-Up Networking:

- 1 Double-click the *My Computer* icon on your desktop, double-click the *Control Panel* icon, then double-click the *Network Connections* icon.
- 2 Double-click the *New Connection Wizard* icon to bring up the New Connection Wizard dialog box, click *Next*.

- 3 Select *Connect to the network at my workplace* and click *Next*.
- 4 Select *Dial-up Connection* and click *Next*.
- 5 Enter the name **APT_SERIAL** exactly, click *Next*.

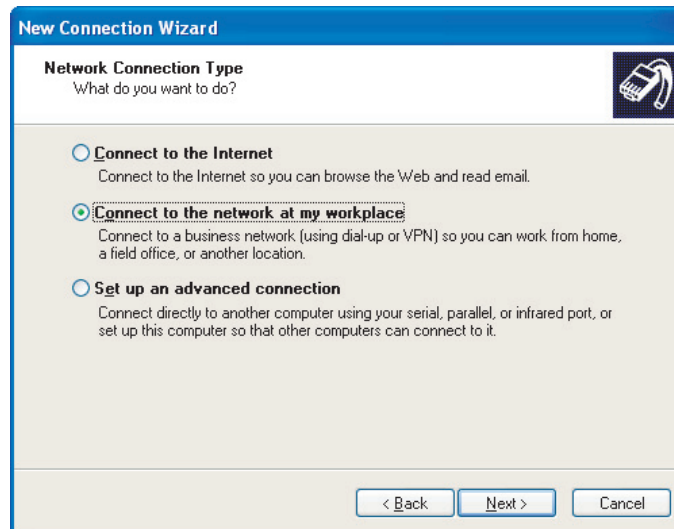


Figure 3.4: Windows XP Network Connection Type

- 6 When prompted for a phone number, enter **1** and click *Next*.
- 7 For Connection Availability select *Anyone's use* and click *Next*.

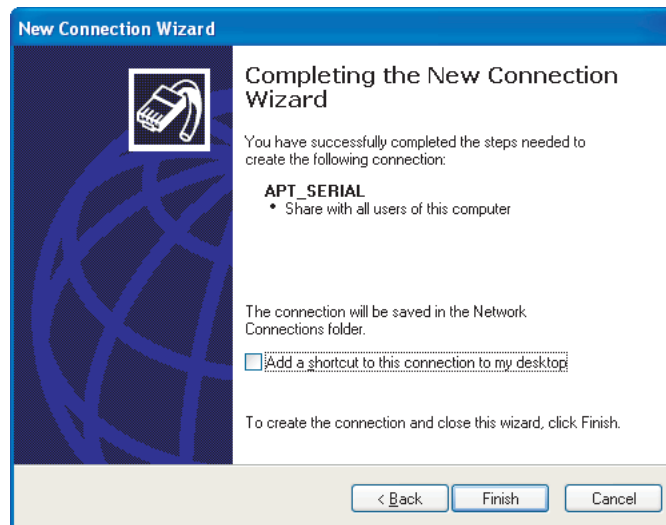


Figure 3.5: Windows XP Connection Availability

- 8 When the Completing the Network Connection Wizard dialog box appears, click *Finish*.

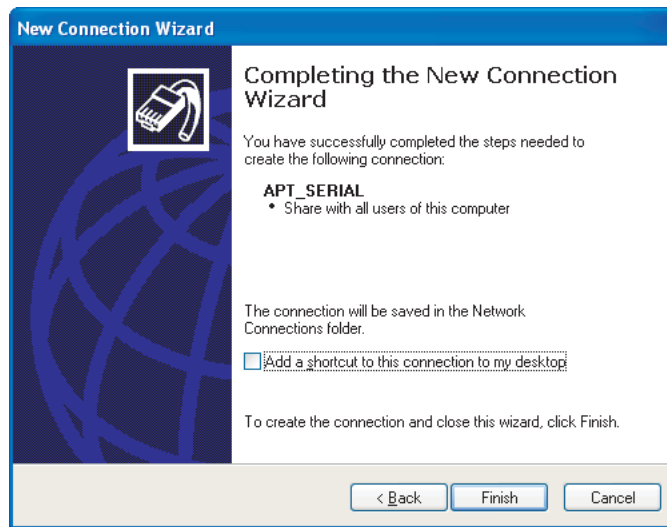


Figure 3.6: Windows XP Completing the New Connection Wizard

- 9 A Connect APT_SERIAL dialog box appears; select *Cancel* to close the box.



Figure 3.7: Windows XP Connect APT_SERIAL

- 10 In Network Connections>APT_SERIAL, right-click to bring up the Properties dialog box.

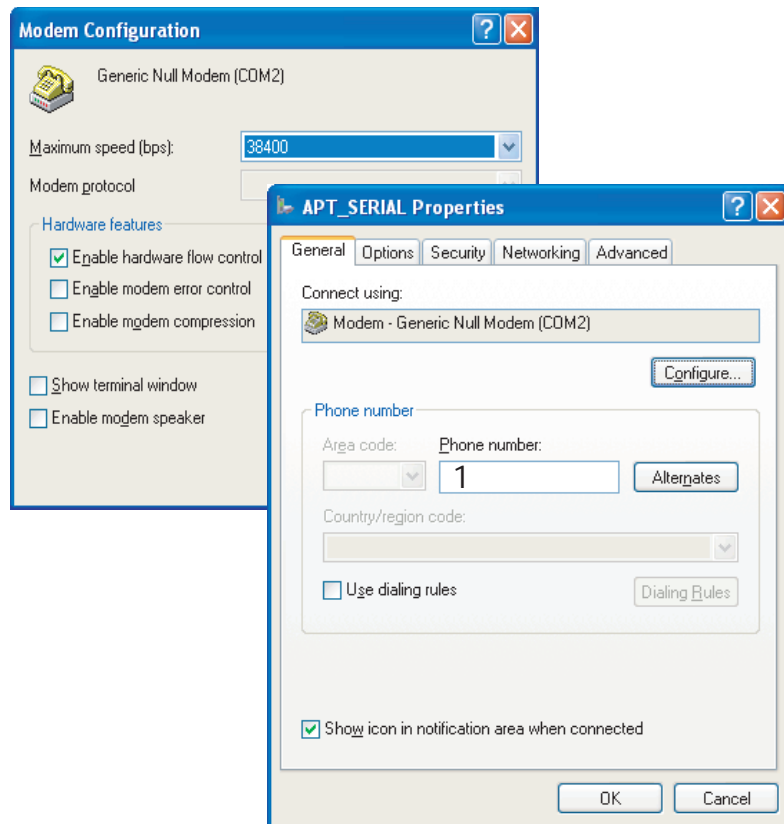


Figure 3.8: Windows XP Select Modem

- 11 With *Generic Null Modem* highlighted, select *Configure* to view the Generic Modem Configuration dialog box and set the maximum speed to 38,400. Select *OK*.

This sets up the baud rate for the null modem. The baud rate can be set at rates up to 115,200; 38,400 is the default baud rate of the recorder's front panel. If you wish to change baud rates in the future, both the baud rate specified here and that set on the recorder must be changed (see "Communication Port Settings" on page 7-3).

- 12 Select the *Options* tab of Figure 3.8..

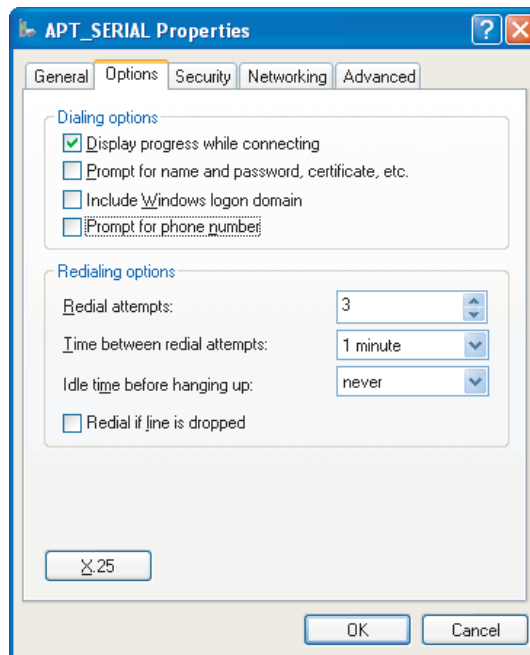


Figure 3.9: Windows XP Options

- 13 Select the *Security* tab, check the *Run Script* box; in the Run Script list select the file *tesla.scp*.

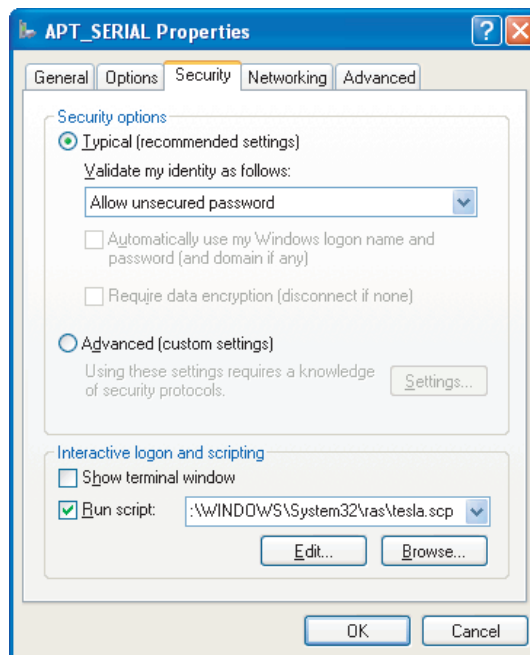


Figure 3.10: Windows XP Security

- 14 Select the *Networking* tab. Select *Internet Protocol (TCP/IP)* and press the *Properties* button. Configure the settings as shown in Figure 3.11.

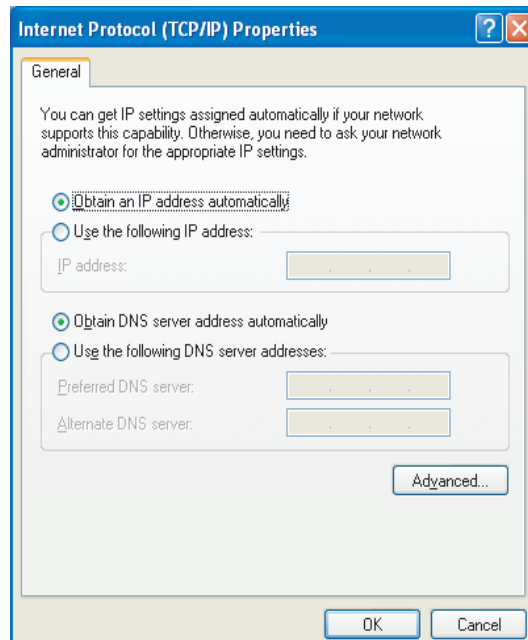


Figure 3.11: Windows XP Internet Protocol Settings

- 15 Press the *Advanced* button and configure the settings as shown in Figure 3.12 .

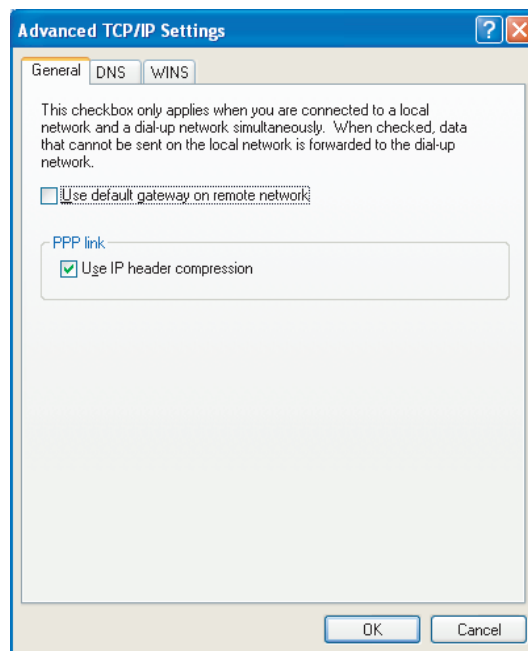


Figure 3.12: Windows XP Advanced TCP/IP Settings

- 16 Click *OK* to apply the setting to APT_SERIAL properties and close the APT_SERIAL dialog box.

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>NxtPhase>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\NxtPhase\Data, 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.

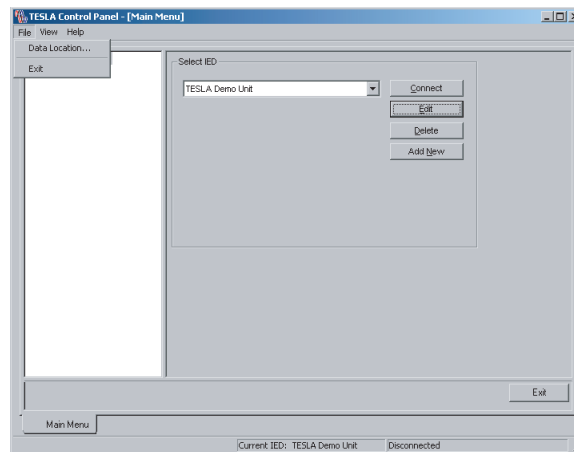


Figure 3.13: Data Location

4 Communicating with the Recorder

Communication Ports

The TESLA recorder has multiple communication ports for local and remote access to its user interface and SCADA services. For port pin-out and cabling information see “Communication Port Details” on page 4-13.

Port	Location	Description
Port 1	Front	RS-232 Data Communication Equipment (DCE) female DB9. Used for user interface access via a direct serial connection. Default Setting: 38,400 baud, 8 data bits, no parity, 1 stop bit.
Port 2	Rear	RS-232 DCE female DB9. Used for: <ul style="list-style-type: none">• User interface access via a direct serial connection.• User interface access via an external modem. The optional ERLPhase Modem Adapter converts this port to a Data Terminal Equipment (DTE) to simplify connection to an external modem. Default Setting: 38,400 baud, 8 data bits, no parity, 1 stop bit. N.B. Port 2 is disabled if the recorder is equipped with an internal modem.
Port 3	Rear	RS-232 DCE female DB9. Used for SCADA communication. Default Setting: 19,200 baud, 8 data bits, no parity, 1 stop bit.
Internal Modem Port	Rear	RJ-11 receptacle. Used for user interface access via the optional internal modem.
Network Port	Rear	RJ-45 receptacle for 10/100 Base-T Ethernet Default IP address: 192.168.1.100 Used for: <ul style="list-style-type: none">• User interface access.• DNP SCADA access.• Cooperative mode operations.

External converters may be used to convert communication ports and increase the options available for connection to devices and networks. (See Appendix G for optional devices available)

Ethernet LAN Link

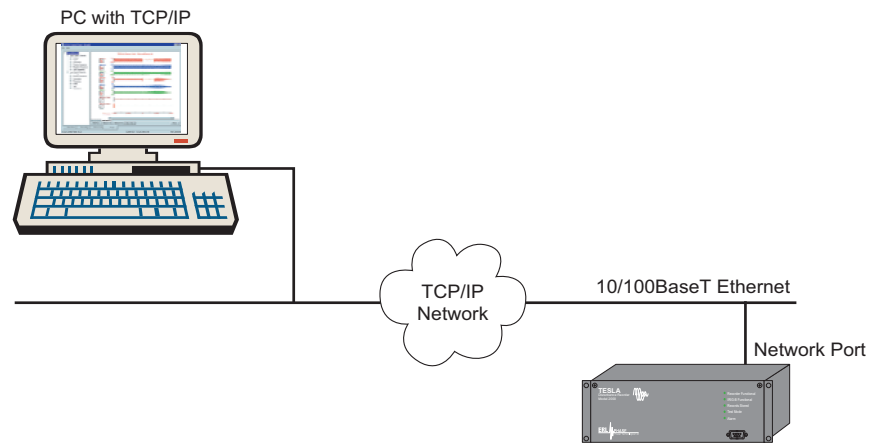


Figure 4.1: Ethernet LAN Link

Recorder Setup

- 1 Connect recorder's Ethernet port to the Ethernet LAN hub using an appropriate 10/100BaseT cable.
- 2 Modify the IP address, if necessary.
 - The default IP address is 192.168.1.100.
 - To modify or view the IP address, use the recorder's Maintenance menu, for details see 14 Maintenance Menu and Error Handling on page 1.
 - The IP address must not conflict with other devices on your network and must be accessible from the computer(s) on which run TESLA Control Panel and RecordBase Central Station. If you are unsure what IP address to use, consult your network administrator.
- 3 Modify the Default Gateway and Network Mask, if necessary.
 - The Default Gateway may need to be changed if the recorder and the central control station (Control Panel or RecordBase) are on different but connected networks. The default setting is No Default Gateway.
 - The Network Mask may need to be changed if the recorder and the central control station are on different subnets. The default setting is 255.255.255.0.
 - To modify the Default Gateway and/or Network mask, use the recorder's Maintenance Menu, command 1 - Modify IP Address.
 - If unsure of the use of these settings, consult your network administrator.

TESLA Control Panel Setup

- 1 Ensure that the computer running TESLA Control Panel has access to the Ethernet network 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

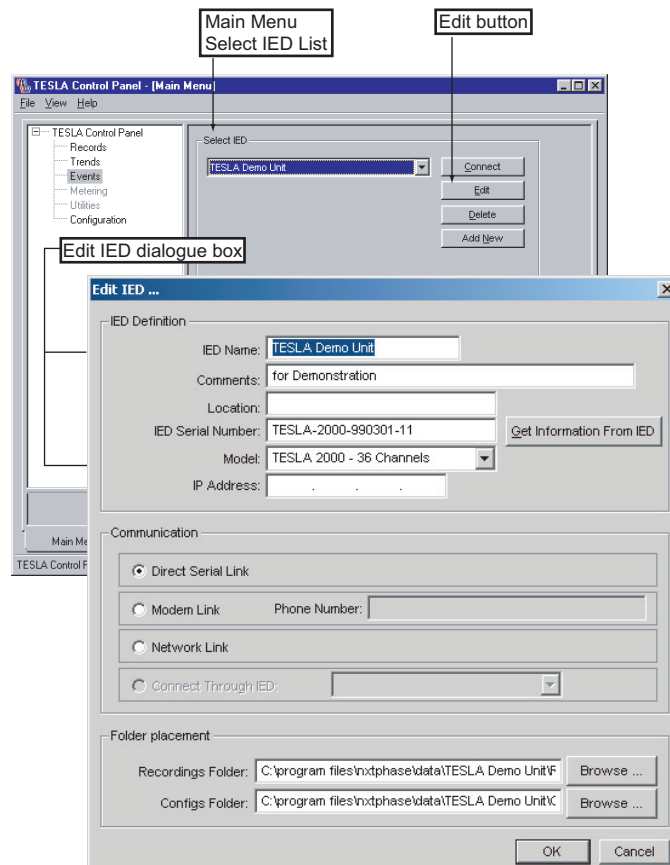


Figure 4.2: Edit IED

- 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 *Network Link* option is selected and the recorder's IP address is entered.
 - For details on IED definitions see “Working with TESLA Control Panel” on page 5-1.
- 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

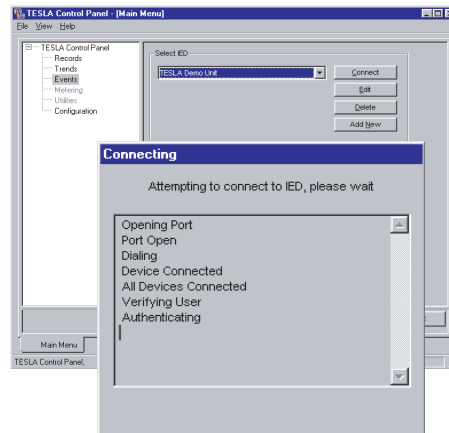


Figure 4.3: Connect Button Dialog Box

Direct Serial Link

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

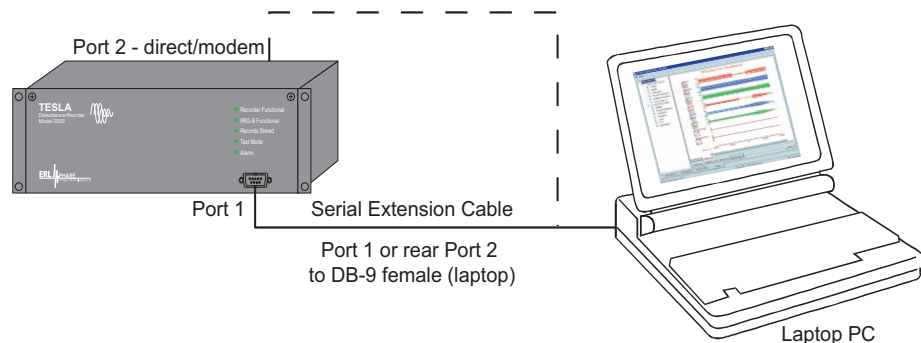


Figure 4.4: Direct Serial Link

- 1 Create a direct serial connection between the computer's serial port and the recorder's Port 1 or Port 2.
 - Use a standard straight through male-to-female serial cable (provided with the recorder). For port pin-out and cabling information see “Communication Port Details” on page 4-13.
 - Port 2 may not be used if the recorder has an internal modem installed unless the modem is disabled via the Maintenance Menu, for details see 14 Maintenance Menu and Error Handling on page 1.
- 2 **Ensure the recorder port and your PC's port have the same baud rate and communication parameters.**
 - The recorder's Port 1 and Port 2 serial ports are fixed at 8 data bits, no parity and 1 stop bit and have a default baud rate of 38,400.

- The baud rate and communication parameters of your computer's serial port is set through the APT_SERIAL Dial-Up Network (see "Setting Windows Serial Port Parameters" on page 4-12).
- 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.
 - 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 5-1.
 - 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 at the bottom of the screen.

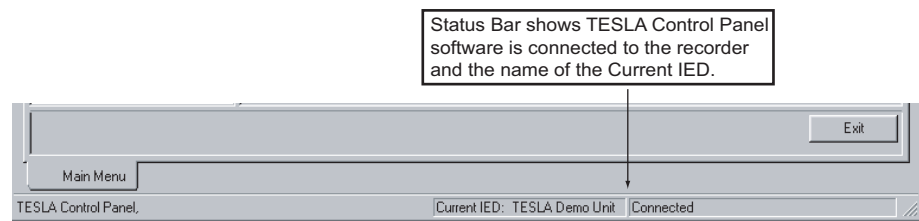


Figure 4.5: Status Bar

If the connection fails, check the following:

- The APT_SERIAL dial-up network has been created and has the correct settings (see "TESLA Control Panel Installation" on page 3-1).
- The communication parameters are the same on both ends (see Step 2 above).
- The correct serial port has been selected on your computer.

Some newer laptop 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. The Edgeport USB Serial Adapter, model # Edgeport/1, from B&B Electronics (www.bb-elec.com) is an example of such a device.

Modem Link

External Modem

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

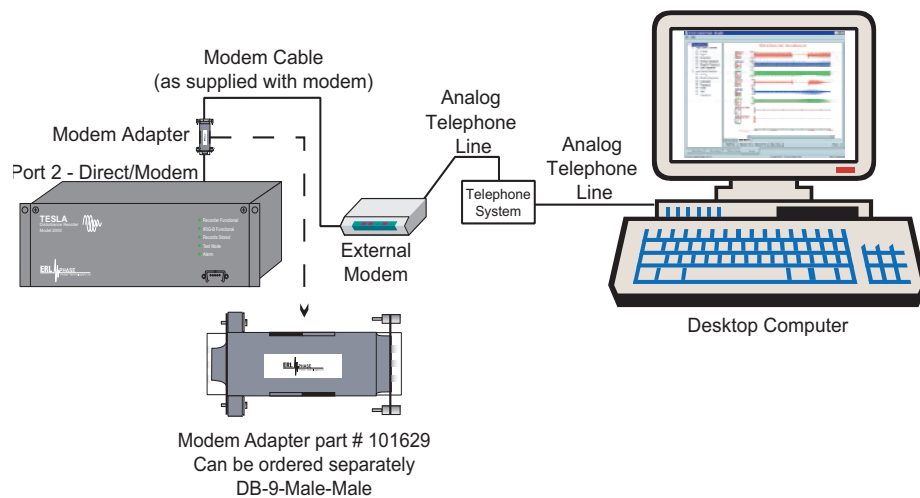


Figure 4.6: Modem Link - External

Recorder Setup

- 1 Connect a PC-compatible external serial modem to Port 2 on the rear of the recorder.
 - The cable between the recorder and the modem requires a crossover and a gender change as both devices are configured as RS-232 DCE ports.
 - You can use the ERLPhase Modem Port Adapter (part # 101629) to make the recorder's Port 2 appear as a DTE (like a PC serial port). A standard modem cable can then be used to connect to the recorder.
 - For port pin-out and cabling information see "Communication Port Details" on page 4-13.
 - If the unit has an internal modem, Port 2 will be disabled and an external modem will not work.
- 2 Connect the modem to an analog telephone line or switch and turn it on.
 - A standard telephone cable with an RJ-11 connector is used.
- 3 Configure the recorder's Port 2 to work with the modem.
 - Port 2 settings are accessed through the recorder's standard user interface.
 - a Establish a network or a direct serial connection between your computer and Port 1 on the recorder, run TESLA Control Panel software and initiate a connection to the unit.
 - b When connected, select *Utilities* in the Main Menu list, and go to the *Communication* tab to access the Port 2's settings.

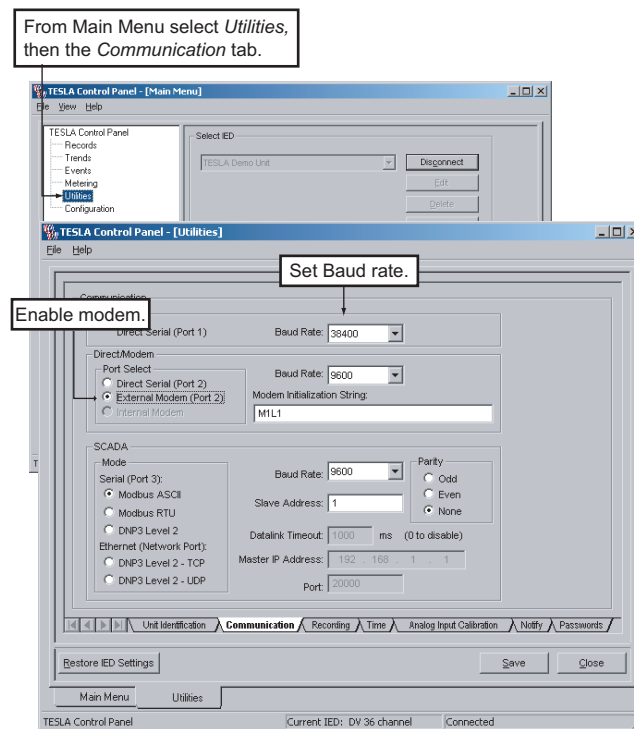


Figure 4.7: Communications Setup Utility

- c Set the Baud Rate. This will be the rate at which the recorder will communicate with the external modem. It does not control the rate at which the modems communicate with each other. Unlike a direct serial link, there is no need for this baud rate to match that of the remote computer. A rate faster than the modem's top speed is recommended to take full advantage of the modem's compression capabilities.
- d Select External Modem
- e The Modem Initialization String lets you set any special command codes required by your modem. The factory default for this field is "M1" for external modems. These default values are all that are required for most modems.
- f Save your changes, close the Utilities tab and disconnect.

TESLA Control Panel Setup

- 1 Configure your computer to work with its modem. Refer to your computer and modem documentation.
- 2 Ensure that an APT_MODEM dial-up network has been created on your computer (see "TESLA Control Panel Installation" on page 3-1).
- 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.

- The method of communication with the recorder is part of each IED's definition. Use the *Edit* button to view or change this information. Ensure the Modem Link option is selected and the telephone number of the recorder's modem is entered.
 - For details on IED definitions see "Working with TESLA Control Panel" on page 5-1.
- 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.

Internal Modem

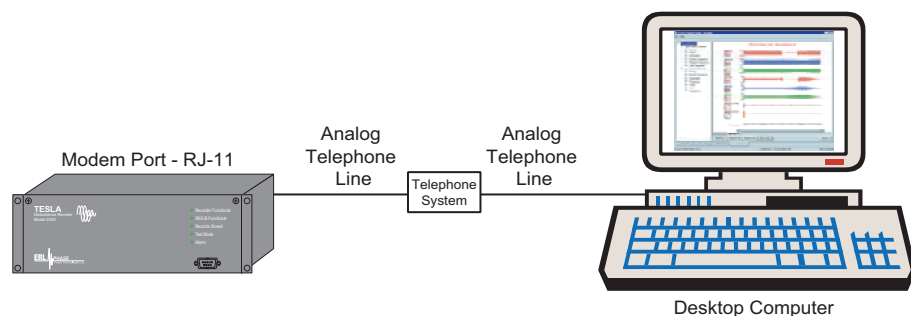


Figure 4.8: Modem Link - Internal

An optional internal modem is available for the TESLA recorder. Setup for the internal modem is the same as for an external modem (see previous section) with the following notes:

- The modem is internal to the recorder, so there is no external modem to connect to Port 2.
- Connect the telephone switch cable to the recorder's internal modem through the Modem Port.
- Internal modem configuration is done in the same way as for an external modem. Modem Initialization String which is "M1" for internal modems (see Figure 4.7: Communications Setup Utility on page 7).
- If the internal modem was installed at the factory, it will already be appropriately configured.

When an internal modem is installed, Port 2 is disabled

Modem LAN Gateway

Recorders on a LAN can be remotely accessed through a modem on a designed master recorder. The master acts as a gateway to the LAN, providing a route for IP communication between Control Panel or RecordBase and other TESLA 3000 recorders to the network. Although commonly used as a part of a cooperative group configuration, a gateway modem can also be used simply as a means to communicate with networked recorders.

- 1 Connect the recorders to the LAN and set their IP addressed. See "Setting Up a Recorder Network" on page 4-8.
- 2 Configure one of the recorders (now designated the master recorder) with an internal or external modem (see Modem Link - External or Modem Link - Internal).
- 3 Set up TESLA Control Panel to communicate with the master recorder via the PC's modem and create and configure an appropriate *IED Definition* for it (see Modem Link - External, TESLA Control Panel Setup).
- 4 Create an (or modify existing) *IED Definition* for each recorder to be accessed through the gateway (not including the master recorder). Under *Communication*, select *Connect Through IED* and pick the master IED created in the previous setup.
- 5 To initiate communication with any of the recorders, choose the target recorder from the Select IED list in TESLA Control Panel's Main Menu and use the *Connect* button.

Note: To connect to recorders through a modem gateway, you must be logged into Windows with local administrator privileges on the computer running Control Panel or RecordBase. Administrator privileges are required to handle updates to the network routing table.

Accessing SCADA Services

The recorder supports DNP3 (Level 2) and Modbus SCADA protocols as standard features. This section describes how to connect and configure the services. Protocol details, including point lists, are provided in the appendices.

Serial Port Connection

Both DNP3 and Modbus protocols are available on the recorder's serial Port 3, an RS-232 DCE port with a female DB9 connector. The port is wired to support a connection to a PC serial port (or equivalent) using a standard straight-through male to female serial cable. An external RS-232 to RS-485 converter can be used to connect to an RS-485 network. For port pin-out and cabling information see "Communication Port Details" on page 4-13.

Ethernet Connection

The DNP protocol can also be available over Ethernet using TCP or UDP. A standard 10/100BaseT Ethernet cable is required.

The Ethernet port can support DNP SCADA and user interface access via TESLA Control Panel at the same time.

For details on setting the recorder's IP address, for details see 14 Maintenance Menu and Error Handling on page 1.

Protocol Settings

Configuration of the SCADA protocol and communication parameters is done through the recorder user interface. Use TESLA Control Panel to connect to the recorder, then go to the SCADA section of the *Utilities>Communication* tab. Setting descriptions follow.

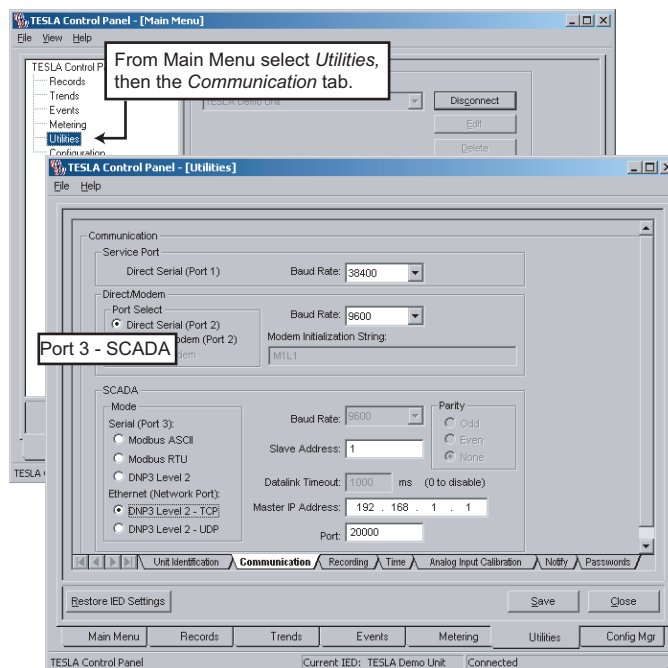


Figure 4.9: SCADA Protocol Settings

SCADA Protocol Settings	
Mode	Select one of the available SCADA modes.
Baud Rate	Port 3 serial baud rate. Default is 19,200.
Parity	Port 3 serial parity. Note: When parity is set to "None" and a Modbus protocol is selected, the number of stop bits automatically is set to 2, as per the Modbus standard.
Stop Bits	(Automatic setting). Always set to 1 stop bit except as noted in Parity setting above
Data Bits	(Automatic setting) The number of data bits is controlled by the selected protocol mode. Modbus ASCII: 7 data bits Modbus RTU: 8 data bits DNP 3: 8 data bits
Slave Address	Identifies the unit to the SCADA master.
Datalink Timeout	(DNP) Specifies the time in which the recorder expects a response from the SCADA master to primary frame messages. If a response is not received in this time, the recorder will re-transmit the message. The timeout is usually set to 0 milliseconds per DNP3 Technical Bulletin 9804-002. This document is available from the DNP3 User's Group (www.dnp.org) For UDP and TCP modes, the timeout is not settable and is automatically set to 0 milliseconds.

SCADA Protocol Settings	
Master IP Address	(DNP TCP or UDP) Defines the IP address of the master SCADA device that will be polling the TESLA. This prevents unauthorized master devices from communicating with the TESLA. Note: This setting does not control IP address of the TESLA's Ethernet card. That is done through the recorder's Maintenance Menu. Make sure the Master IP Address is different from the TESLA IP Address.
Port	DNP TCP or UDP) Defines the TCP or UDP port on which the DNP service may be accessed. Usually set to 20000.

Diagnostics

Protocol monitor utilities are available to assist in resolving SCADA communication difficulties such as incompatible baud rate or addressing. The utilities can be accessed through the Maintenance user interface, for details see 14 Maintenance Menu and Error Handling on page 1.

Setting Windows Serial Port Parameters

To achieve a direct serial link between a serial port on the recorder and one on your PC, both ports need to be running with the same communication parameters.

This section describes how to change the baud rate of your computer's serial port.

Direct Serial Link

The recorder's Port 1 and Port 2 communication parameters are:

- 8 bit data, no parity and 1 stop bit (non-configurable).
- Hardware or software flow control (automatically handles either).
- The default baud rate of Port 1 and Port 2 is 38,400. The baud rate for these ports is configured through the recorder's user interface via TESLA Control Panel software (see "" on page 4-4).

The computer's serial port communication parameters are set through the APT_SERIAL Dial-Up Network, which was created as part of the installation of Control Panel software.

Windows XP/7

Access the Network and Dial Up Connections function through Windows Control Panel.

- 1 Bring up the APT_SERIAL properties control by right-clicking on the *APT_SERIAL icon* and selecting *Properties*
- 2 Select *Modem - Generic Null Modem* from the *Connect using* modem list and select the *Configure* button.
- 3 Set the desired baud rate in the *Maximum Speed* field.
- 4 Select *OK* to save changes

NB. Other communication parameters such as the number of data bits cannot be set here. The recorder's communication parameters are standard (8, N, 1), so changes to these parameters on your computer's port are unlikely to be needed. If you do need to view or modify them, use the *Phone and Modem Options* function found in Windows Control Panel, and go to the *Modems* tab.

Communication Port Details

All recorder serial ports (Ports 1, 2 and 3) are configured as EIA RS-232 DCE devices with female DB9 connectors. This allows them to be connected directly to a PC serial port with a standard straight-through male-to-female serial cable.

A modem adapter (part #101629) is available to convert a port into a DTE device, equivalent to the serial port on a PC. The adapter allows you connect an external modem to the recorder's Port 2 using a standard modem cable.

The TESLA 3000 Power System Monitoring Recorder has been factory configured to communicate with peripheral software tools and devices using communications Port 2000. The TESLA 3000 Power System Monitoring Recorder (V2.6 or better) has provisions available to reconfigure this communication port to use the ERLPhase registered IANA Port 7631. This operation may be enabled through the TESLA 3000 Maintenance Menu ("Maintenance Menu and Error Handling" on page 14-1).

TESLA Recorder Serial Ports

Port	Location	Function
1	Front Panel	Serial port for direct connection to a computer. Default baud rate set at 38,400 baud.
2	Rear Panel	Serial port for connection to an external modem or for direct connection to a computer (configurable). Default baud rate set at 38,400 baud. This port is unused when the recorder is equipped with the optional internal modem unless the modem is disabled via the Maintenance Menu.
3	Rear Panel	Connection to SCADA (DNP3 or Modbus) interface. Default baud rate set at 19,200 baud.

Signal Name	Direction PC<->IED	Pin # on the IED Port
DCD	←	1
RxD	←	2
TxD	→	3
DTR	→	4
Common		5
DSR	←	6
RTS	→	7
CTS	←	8

Signal Name	Direction PC<->IED	Pin # on the IED Port
No connection		9

Notes:

- IED is DCE, PC is DTE.
- Pins 1 and 6 are tied together internal to the IED.

Male DB-9 Cable End for IED Port	Female DB-9 Cable End for Computer Port
Pin # on Cable	Pin # on Cable
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9

Signal Name	Direction Modem <-> IED	Pin # on the Modem Adapter
DCD	→	1
RxD	→	2
TxD	←	3
DTR	←	4
Common		5
DSR	→	6
RTS	←	7
CTS	→	8
No connection		9

Notes:

- IED (with modem adapter) is DTE, modem is DCE.
- Pins 1 and 6 are tied together internal to the IED.

5 Working with TESLA Control Panel

Recorder Workspace

TESLA Control Panel supports multiple recorders. Each recorder has its own workspace within Control Panel that stores its communications parameters, records and configuration files. Workspaces for both TESLA 2000 and TESLA 3000 recorders can be maintained.

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 3000 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.

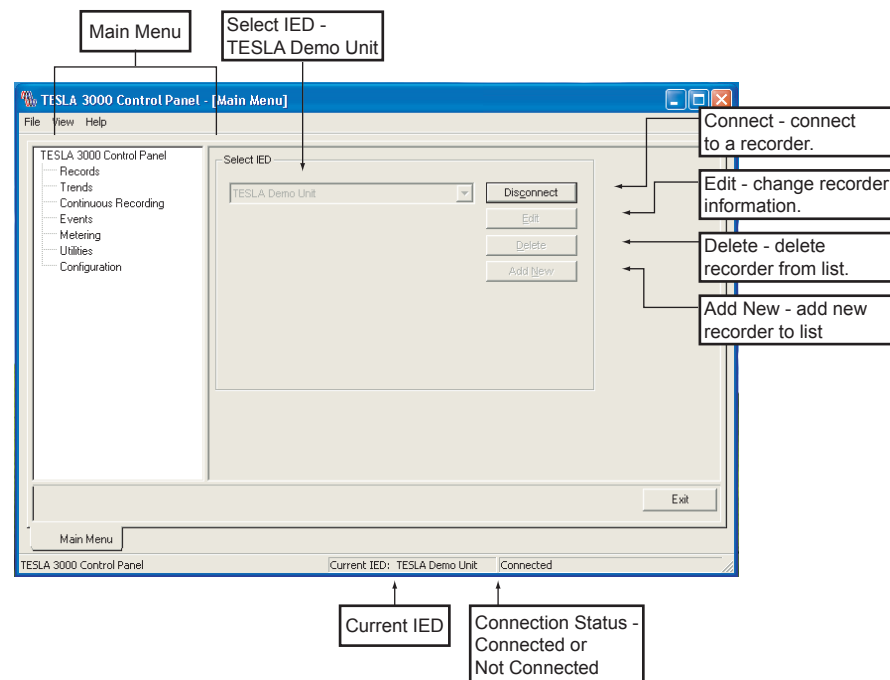


Figure 5.1: Selecting a Recorder Workspace

The 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 (see Figure 5.1).

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 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 (see Figure 5.1) 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 5.2 and the settings are described in the following table.

Edit IED ...

IED Definition

IED Name:

Comments:

Location:

IED Serial Number:

Model:

TESLA

Configuration:

TESLA 3000/4000 - 36 Channels

PMU Module:

Communication

Direct Serial Link

Serial Link:

COM1: ERLPhase Null Modem

Baud Rate:

115200

Modem Link

Modem:

COM9: Nokia C3-01 USB Modem

Phone Number:

Network Link

First IP Address

Second IP Address

Use SOCKS5 Proxy

Server IP:

Port Number:

0

Connect Through IED:

Add New Modem/Serial Link

Get Information From TESLA

Folder placement

Recordings Folder:

C:\Documents and Settings\ERLPHASE\My Docume

Browse ...

Configs Folder:

C:\Documents and Settings\ERLPHASE\My Docume

Browse ...

Save IED definition

Cancel

Figure 5.2: Recorder Workspace Definition

IED Workspace Settings
IED Definition

D01721R02.61

TESLA 3000 User Manual

5-3

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 7-2).
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.
Model	TESLA 2000 or 3000, 18 or 36 channel, or TESLA 3000 - Cooperative IED
IP Address	IP address of the recorder. The recorder's default factory IP address is 192.168.1.100. It is changed through the recorder's Maintenance Menu, "Maintenance Menu" on page 14-1.
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.
Communication	
Direct Serial Link	Connect to this recorder through a serial cable.
Modem Link	Connect to this recorder via a telephone link.
Phone Number	Recorder's telephone number. Can contain numbers plus standard modem dial characters (e.g. comma represents a pause).
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. For details on setting up a modem-Lan Gateway "Modem LAN Gateway" on page 4-8)
Folder Placement	The Default Folder directory applied to new IED definitions can be modified with the <i>File>Data Locations</i> 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 (realtime 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

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 in 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.

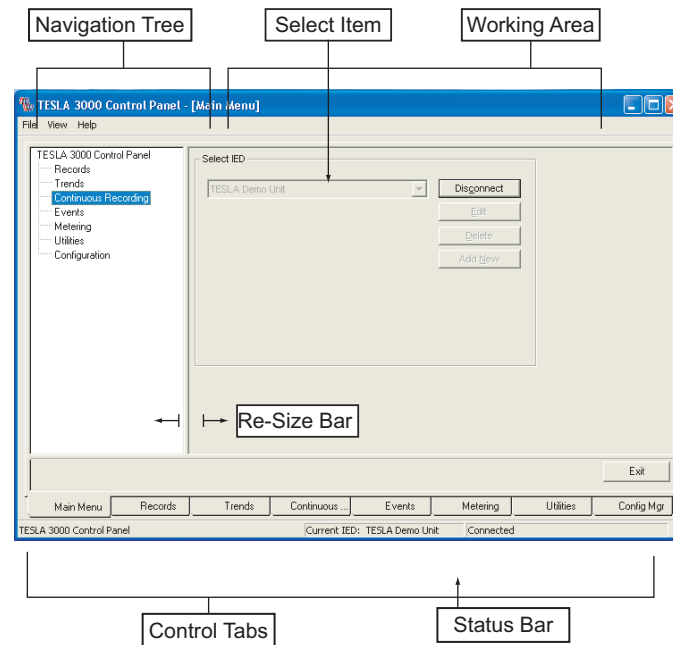


Figure 5.3: TESLA Control Panel Display Sections Navigation Tree

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.

6 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.

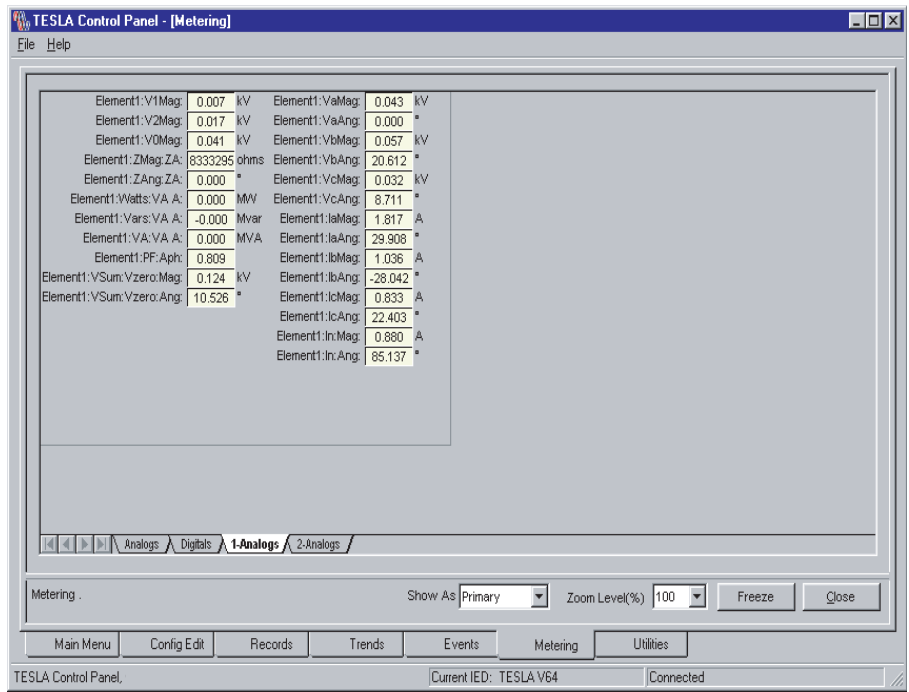


Figure 6.1: Metering Display

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 8-42).

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 8-11).

7 Recorder Setup Utilities

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

- Unit identification
- Communication port parameters
- Record length and mode settings
- Time display and settings
- Analog input calibration
- Central Station trigger and record notification
- Passwords

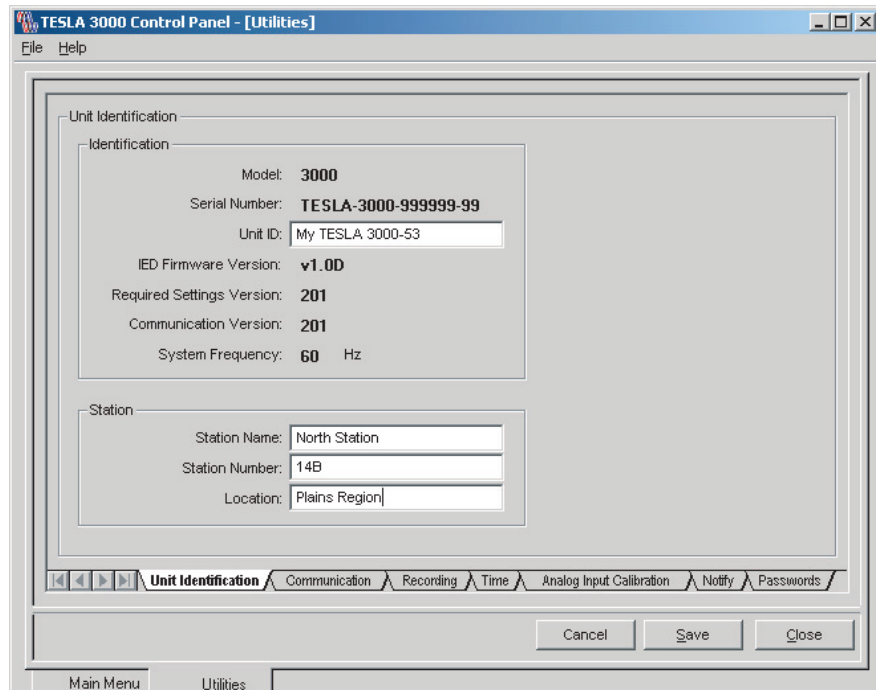


Figure 7.1: Recorder Setup Utilities

The setup parameters are accessed through the *Utilities* tab on TESLA Control Panel. You must be communicating with the IED for the *Utilities* tab to be available.

For details on connecting to the recorder using TESLA Control Panel software see "Communicating with the Recorder" on page 4-1.

Unit Identification

The Unit Identification tab identifies a particular recorder and its records. Double-click *Utilities* to bring up the tabs; select *Unit Identification*.

Figure 7.2: Recorder Setup Utilities - Unit Identification

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. Control Panel is capable of creating older versions of settings files for use with recorders whose firmware has not been updated (see "Managing Configuration Files" on page 8-1).
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	
Station Name	User-defined, for your reference only.
Station Number	User-defined, for your reference only.
Location	User-defined, for your reference only.

Communication Port Settings

The Communication settings control the modes and baud rates of the recorder’s three serial communication ports and defines the SCADA communication mode.

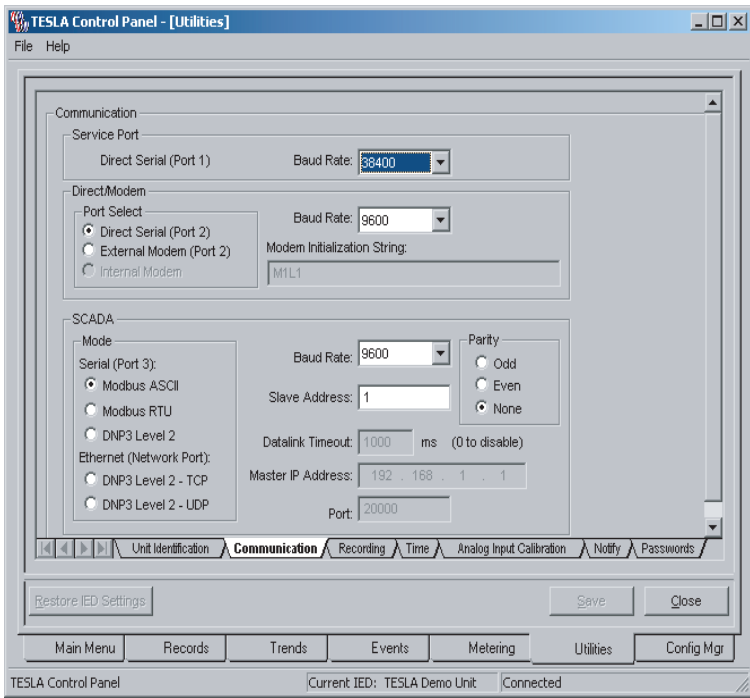


Figure 7.3: Recorder Setup Utilities - Communication Ports

Communication Settings	
Service Port	
The Service Port is Port 1 on the front of the recorder. It can be used for direct serial connection with TESLA Control Panel or a terminal program (to access the Maintenance Menu).	
Baud Rate	<p>Sets the baud rate of the recorder's serial port. The default baud rate is 38,400 baud.</p> <p>Note: The baud rate must match that of the serial port of the computer connected to this port. For details about changing the baud rate see “Setting Windows Serial Port Parameters” on page 4-12.</p> <p>For best results, use the maximum baud rate that your communication link and equipment can sustain.</p>

Direct/Modem Port	
The Direct/Modem Port refers to either the recorder's rear panel Port 2 or its (optional) Internal Modem port, depending on the Port Select setting.	
Port Select	<p>Direct Serial: Port 2 is enabled for a direct serial connection with TESLA Control Panel or a terminal program (to access the Maintenance Menu).</p> <p>External Modem: Port 2 can be used to connect to an external modem through a serial link.</p> <p>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. Port 2 is automatically disabled when the internal modem is installed and enabled. The internal modem can be disabled through the Maintenance Menu.</p>
Baud Rate	<p>Sets the baud rate of the recorder's port 2. The default baud rate is 38,400 baud.</p> <p>For a direct serial connection on Port 2, the baud rate must match that of the serial port of the computer connected to this port. For details about changing the baud rate see "Setting Windows Serial Port Parameters" on page 4-12.</p> <p>When configured for an internal or external modem, the baud rate specifies the rate at which the recorder communicates with the modem. The actual communication rate between modems is less than or equal to this setting, depending on what the modems can negotiate over the phone line.</p> <p>For best results, use the maximum baud rate that your communication link and equipment can sustain.</p>
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.
SCADA	
<p>The SCADA protocols can be accessed via either the serial Port 3 SCADA Port or the Network Port. Modbus ASCII, Modbus RTU or DNP3 Level 2 is selected, Port 3 is used. If DNP3 Level 2 - TCP or DNP3 Level 2 - UDP are selected, SCADA can be accessed via ethernet. The factory configuration for SCADA is 19,200 baud, no parity, Modbus ASCII mode, Slave Address 1.</p> <p>The number of data bits is determined by the protocol and mode: Modbus ASCII used 7 bits, Modbus Binary and DNP3 Level 2 use 8 bits. The number of stop bits is always 1 except when a Modbus protocol is selected. In that case, the number of stop bits is 2, as per the Modbus standard</p>	
Mode	<p>Serial (Port 3)</p> <p>Modbus ASCII: Modbus SCADA protocol, ASCII mode</p> <p>Modbus RTU: Modbus SCADA protocol, RTU mode</p> <p>DNP Level 3: DNP 3 SCADA protocol, Level 2, serial</p> <p>Ethernet (Network Port)</p> <p>DNP Level 3: DNP 3 SCADA protocol, Level 2, TCP</p> <p>DNP Level 3: DNP 3 SCADA protocol, Level 2, UDP</p>
Baud Rate and Parity	<p>Must be set the same as the master device on the SCADA network.</p> <p>The number of data bits is determined by the protocol and mode; Modbus ASCII uses 7 bits, Modbus Binary and DNP3 Level 2 use 8 bits.</p>
Slave Address	The slave address must be set to an unused address value on the SCADA network and is used by the master to communicate with the TESLA. The slave address range is automatically adjusted to the valid range for the protocol selected.

Datalink Timeout	Used only for DNP3 Level 2. This sets the timeout for the DataLink layer of the DNP protocol. Although configurable, the timeout should be disabled (set to 0 milliseconds) as per the DNP Users Group "Technical Bulletin 9804-002 DNP Confirmation and Retry Guidelines". The DataLink Timeout is automatically disabled when using either DNP3 Level 2 - TCP or UDP.
Master IP Address	For either DNP3 Level 2 - TCP or UDP, the Master IP Address must be set to the IP address of the master device that will be polling the TESLA. This prevents unauthorized master devices from communicating with the TESLA. Note: This setting does not control the IP address of the recorder's Ethernet port. That is done through the recorder's Maintenance Menu. Make sure the Master IP address is different from the recorder's IP address
Port	For either DNP3 Level 2 - TCP or UDP, the Port is the TCP or UDP port that the DNP service may be accessed at and is usually set to 20000.

For details regarding the data and functions available on the TESLA recorder's SCADA port see "Modbus Functions" in Appendix D and "DNP3 Reference" in Appendix E.

Recording Control Settings

The Recording Settings control the parameters of the High Speed Recording, Low Speed Recording and Trend Logging.

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.

In the TESLA 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

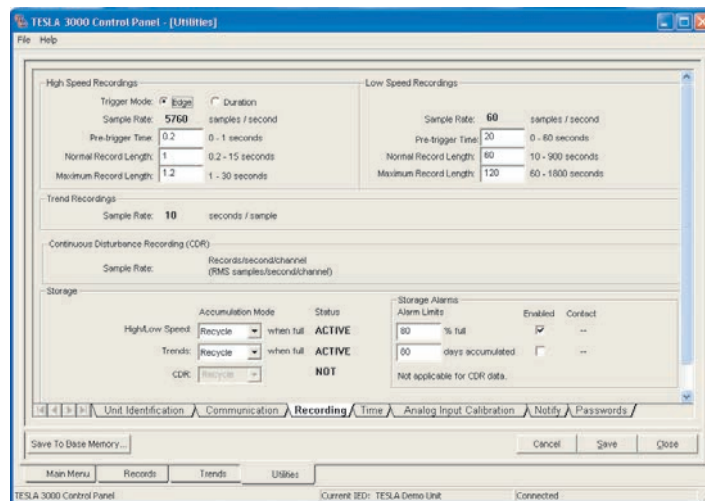


Figure 7.4: Recorder Setup Utilities - Edge Recording

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

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

Duration Mode

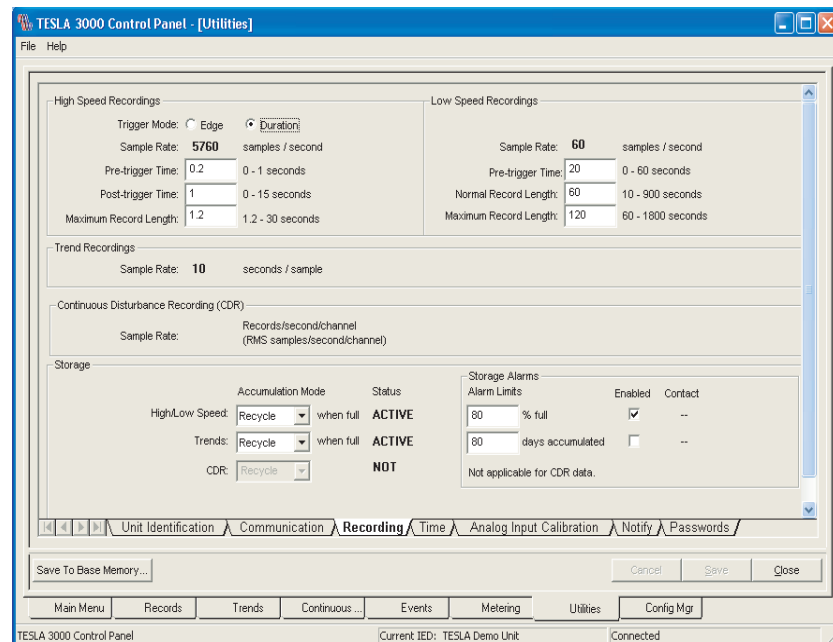


Figure 7.5: Recorder Setup Utilities - Duration Recording

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.

Recording Settings	
High Speed Recording	
Trigger Mode	Select Edge or Duration mode. See above for descriptions.
Sample Rate	Displays the configured high speed sample rate. The sample rate is set in the configuration file downloaded to the recorder. (See "Sample Rate" on page 8-5)
Pre-trigger Time	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	Normal Record Length (Edge Mode) is the total length of the record, including pre-trigger data, without any record extension

Recording Settings	
Post-Trigger Time	Post Trigger Time (Duration Mode) 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.
Low Speed Recording	
Sample Rate	Samples at 50 or 60 samples/second (1 sample/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 that is 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.
Trend 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 8-43).
Continuous Disturbance Recording (CDR)	
Sample Rate	Read-only display of the recording rate in RMS samples/second/channel. The rate is configured in the recorders setting file, for details see "Continuous Disturbance Recording" on page 10-1
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.
High/Low Speed Storage Alarm Limits	When enabled, you can enter a limit giving the percentage of recording space that causes an alarm. Enter a number between 60 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 "Storage Alarms" on page 8-7).
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.

Recording Settings	
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 "Storage Alarms" on page 8-7).
CDR Accumulation	This is a read-only indicator set to <i>Recycle</i> when Continuous Disturbance Recording is enabled.

Time Display and Settings

The Time Control tab displays the recorder's current time and provides controls to describe the IRIG-B time signal input. In the absence of an IRIG-B input there is a facility to set the time manually.

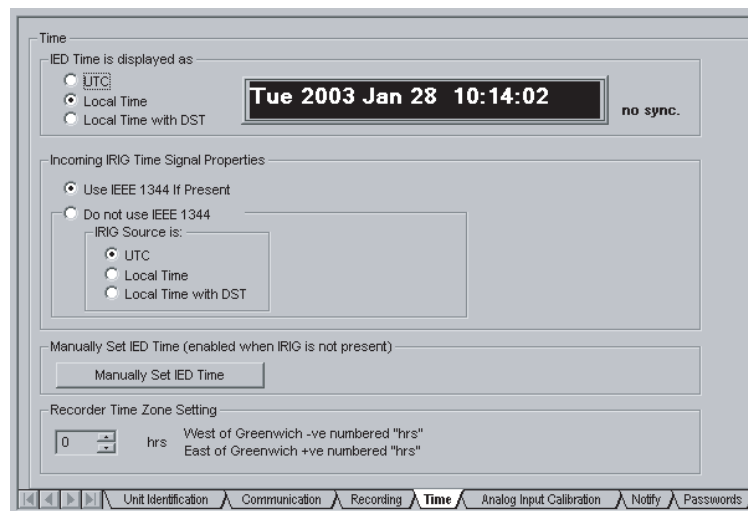


Figure 7.6: Recorder Setup Utilities - Time Control

When the time is changed manually or by the application of IRIG-B, any existing trend and continuous disturbance recording data will be compromised. You should erase this data after performing the time change.

Displayed Time

Time is maintained in UTC format on the recorder (i.e.: without a time zone offset or daylight savings time applied). If the clock feeding the IRIG-B time signal to the recorder is sending local time, the recorder converts it to UTC internally.

The time displayed in the Time Control screen above is determined by the adjacent time display settings. The recorder will automatically convert from its internal UTC time as required. The Recorder Time Zone Setting determines the offset between Local time and UTC. DST will automatically add 1 hour to the offset if appropriate.

Event and Record Timestamps

Event timestamps in the recorder's Event Log are also controlled by the above time display settings. They will be displayed as UTC or local times as configured here.

Record timestamps shown in Control Panel's Records tab are handled a bit differently. Record times are converted from UTC using the Windows Time and Date settings of the PC running Control Panel. This enables records from multiple time zones to be normalized to a common time zone and format.

Time Settings	
IED Time is displayed as	
UTC	Sets the time display and the Event Log timestamps to Universal Coordinated Time (UTC). Note that UTC time is not affected by the Recorder Time Zone setting or Daylight Savings Time.
Local Time	Sets the time display and the Event Log timestamps to Local Time. Local time is converted to UTC using the Recorder Time Zone setting.
Local Time with DST	Same as Local Time, except Daylight Savings Time (DST) is factored into the time conversion. Daylight Savings Time is assumed to be in effect from 2 AM on the first Sunday in April until 2 AM on the last Sunday in October.
Present Time Display	When connected to a recorder, the recorder's present time is shown and continually updated. The specified time settings (e.g. Local Time) are applied to the displayed time.
Sync/No Sync Display	Indicates that the recorder is synchronized to an IRIG-B time signal input.
Incoming IRIG Signal Properties	These settings determine how the recorder responds to IEEE 1344 information in the IRIG-B time signal and manually define the format of the incoming time if IEEE 1344 data is not available.
Use IEEE 1344 If Present	If Use IEEE 1344 if Present is checked and the source clock generates IEEE 1344 data, the recorder: <ul style="list-style-type: none"> • uses the time zone offset from the IEEE 1344 data embedded in the IRIG-B time signal • reads the IEEE 1344 data to determine the mode of the incoming IRIG signal (UTC, Local, Local with DST) Otherwise, the recorder uses the manually entered time zone offset and clock source mode settings.
Do not use IEEE 1344	If Do Not Use IEEE 1344 is selected, the recorder will ignore any IEEE 1344 data in the IRIG-B signal and use the manually entered time zone offset and clock source mode settings.
IRIG Source	Specifies the mode of the incoming clock signal. Ignored if IEEE 1344 data is present in the IRIG-B time signal and the Use IEEE 1344 If Present setting is enabled.
Manually Set IED Time	Allows the recorder's clock to be manually set if an IRIG-B signal is not present. If an IRIG-B signal is present, but does not contain IEEE 1344 data, the year can be set manually.
Recorder Time Zone Setting	Provides the offset from local time to UTC in hours. For example, Central Time has a +6 hour offset from UTC. This setting is ignored if IEEE 1344 data is present in the IRIG-B time signal and the Use IEEE 1344 If Present setting is enabled.

Changing time manually or IRIG-B re-synchronizing to the recorder compromises the trend and continuous disturbance recording data.

You should download all trend and continuous disturbance records before you change the time in the *Utilities, Time* tab.

Analog Input Calibration

The Calibration Utility provides a means of calibrating the recorder's analog input channels. It is accessed through the TESLA Control Panel's Utilities tab as Analog Input Calibration.

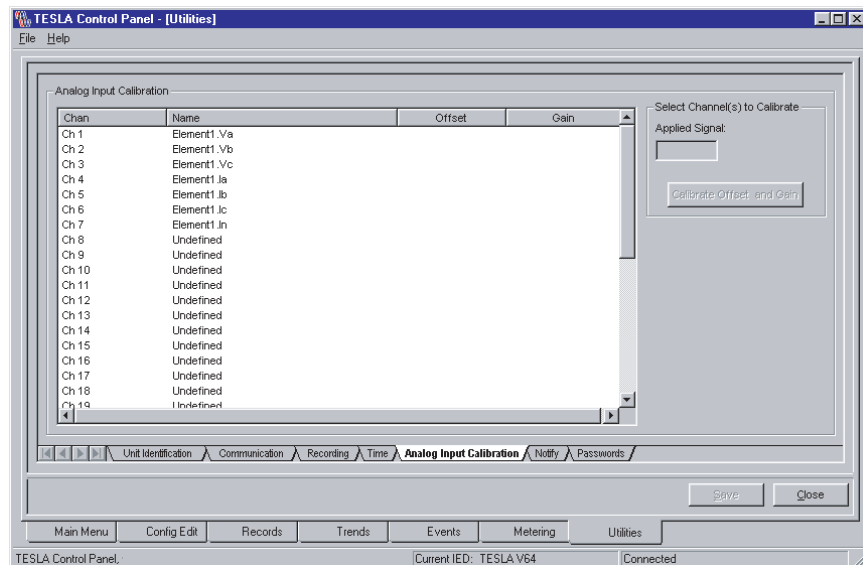


Figure 7.7: Analog Input Calibration

When To Calibrate

The recorder's analog input channels should be re-calibrated whenever an analog isolation module is changed.

If the type of isolation module is changed, for example from a voltage to a current the readings will be significantly wrong until calibration has been performed.

Only the channels associated with the altered module need be re-calibrated.

AC Channel Calibration Process

To calibrate a channel (*Main Menu > Utilities > Analog Input Calibration*):

- 1 Select the channel or channels from the list. More than one channel of voltage or current can be chosen using the *Control/Shift + left-click*.

It is possible to calibrate multiple channels simultaneously by using the mouse to select a set of channels from the list. Multiple channels can be selected using standard Windows selection methods.

All channels in the selected set must have the same type of input module.

- 2 Enter the voltage or current magnitude that is applied to the isolation module associated with the channel Applied Signal field. The signal magnitude level should be measured with a precision calibrated instrument.
- 3 Press the *Calibrate Offset* and *Gain* button. If a channel has not yet been configured, only *Calibrate Offset* will be displayed.
- 4 Under the *Offset* and *Gain* columns the line of the channel being calibrated *OK* or *No* will be displayed (see “Analog Input Calibration” on page 7-11).
- 5 Repeat for all other channels being used.
- 6 Use the *Save* button to load the new calibration to the recorder.

DC Channel Calibration Process

The dc calibration procedure is a two-step procedure. When one or more compatible dc channels are selected, two calibration areas appear on the screen. You may calibrate the points in either order as is convenient. DC calibration is not complete until both points have been calibrated, and the associated offset and gain values accepted.

Out of Range

An error message is displayed if the applied signal as seen by the recorder differs from the value entered in the Applied Signal field by more than 10%. This helps to prevent erroneous calibration.

If you change the type of isolation module associated with a channel, you must specify the new module type in the input channel's configuration before calibrating.

Notify

The TESLA recorder can call a ERLPhase RecordBase Central Station via modem or LAN to notify it of selected events.

Notification is used for two purposes:

- 1 To initiate cross-triggering of dynamic swing records on other recorders
- 2 To initiate record transfer to RecordBase when a new record is created

The Notify tab of the Utilities screen contains settings to control the dial-out process and the initiation of record transfers.

Automatic Record Transfer

You can control which records are automatically transferred to the RecordBase Central Station by specifying the required record priority. The setting ranges from 0 (all records) to 3 (highest priority only) and provides an option to disable automatic record transfers completely.

Record priority is determined by the highest priority trigger included in the record. Trigger priority is set as part of each channel's configuration.

Cross-Trigger Notification

A Notification call to RecordBase to trigger swing recordings on other recorders can be initiated by any of the recorder's triggers. Cross-trigger notification is selected as part of each channel's configuration.

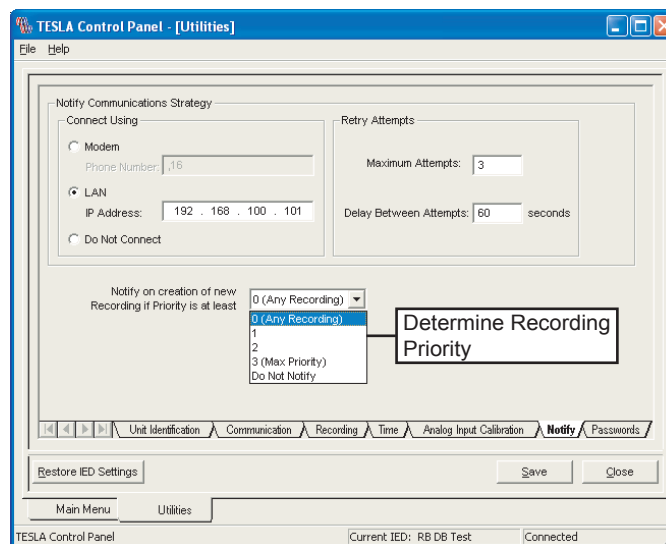
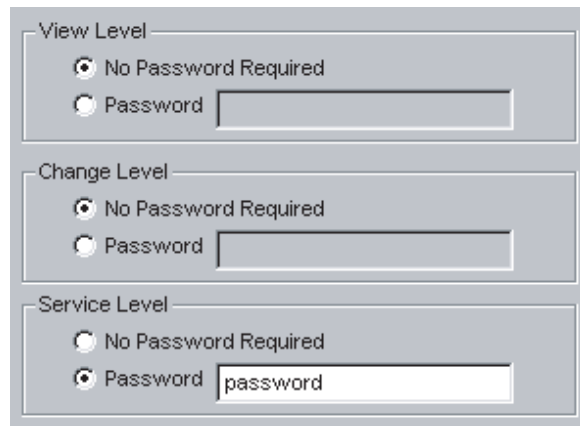


Figure 7.8: Notify Communication Strategy

Notify Settings	
Connect Using	The TESLA recorder can be set to notify a RecordBase Central Station via modem or LAN, or to not notify at all. These 3 options are mutually exclusive. Note that the availability of these controls is dependent on the hardware options and configuration of the recorder.
Modem	If <i>Modem</i> is selected, enter the telephone number of the RecordBase call-in modem. All standard modem dialing characters are supported (e.g. a comma is used to specify a pause in the dialing sequence).
LAN	If <i>LAN</i> is selected, enter the IP address of the computer running RecordBase Central Station.
Do Not Connect	If <i>Do Not Connect</i> is selected, the TESLA recorder will not notify RecordBase Central Station of new records or cross triggers. This is a global setting and can be used to temporarily disable notification.
Retry Attempts	These rules are applied when the TESLA recorder fails to establish communication with RecordBase Central Station (i.e. if the phone line is busy, or if the network is down).
Maximum Attempts	When the TESLA recorder fails to establish contact with RecordBase central station, this is the maximum number of attempts it will make before giving up.
Delay Between Attempts	Specifies the delay, in seconds, that the TESLA will wait before making another notification attempt.
Notify on creation of new Recording if Priority is at least	Controls which records, if any, are automatically transferred to the RecordBase Central Station. When a record is created with a priority equal to or greater than the specified value, the recorder sends a New Record Created notification message to RecordBase. The setting can range from 0 (all records) to 3 (highest priority only). Selecting Do Not Notify disables automatic record transfers completely. Record priority is determined by the highest priority trigger included in the record. Trigger priority is set as part of each channel's configuration.

Password Protection

Access to various TESLA functions can be protected through the use of passwords.



The screenshot shows a utility window with three sections, each with a title bar and a group box containing two radio buttons and a text field:

- View Level:** The 'No Password Required' radio button is selected. The 'Password' radio button is unselected, and its text field is empty.
- Change Level:** The 'No Password Required' radio button is selected. The 'Password' radio button is unselected, and its text field is empty.
- Service Level:** The 'No Password Required' radio button is unselected. The 'Password' radio button is selected, and its text field contains the word 'password'.

Figure 7.9: Passwords

There are three user access levels: VIEW, CHANGE and SERVICE.

Setting Passwords

Passwords can be viewed and set through the *Passwords* tab of TESLA Control Panel's Utilities screen.

You have the option of explicitly disabling the password protection for each access level. Leaving the VIEW access level password disabled, for example, will allow free use of the TESLA for read-only operation.

The Password tab can only be accessed when connected via direct serial link through the recorder's service port (Port 1). This provides protection from unauthorized remote access while ensuring that on-site staff can freely use the recorder.

	Function	Required Access Level
Records	Display Record List from IED	VIEW
	Delete Record from IED	CHANGE
	Create Fault or Swing Record	VIEW
	Rename Local Record	None
	Display Local Record List	None
	Delete Local Record	None
Trends	Delete Trends (local)	None
	Delete Trends on IED	CHANGE
	Download Trends	VIEW
	Display Trends	None
	Event Log	VIEW
Events	Display Event Log	VIEW
	Erase Event Log	CHANGE
Metering	Metering Display	VIEW
Utilities	Display Unit Identification	VIEW
	Set Unit Identification	CHANGE
	Display Communication Settings	VIEW
	Set Communication Settings	CHANGE
	Display Recording Settings	VIEW
	Set Recording Settings	CHANGE
	Display Time & Settings	VIEW
	Set Time & Settings	CHANGE
	Display Calibration	VIEW
	Save Calibration Changes	SERVICE
Configuration	Display Configurations (Online)	VIEW
	Display Configurations (Offline)	None
	Load Configuration to IED	CHANGE
	Save Local Configuration	None
	Delete Local Configuration	None

8 Configuring the Recorder

Where the Setup Utilities of the previous chapter specify the recorder's global characteristics, it is the recorder's Configuration File that defines its individual channels and recording triggers.

The configuration file identifies and adjusts the recorder's input channels, derived (calculated) channels, record triggers, metering displays and trend logs. It also specifies how the recorder handles record storage and excessive trigger conditions. Configuration files are created and managed by TESLA Control Panel and loaded into the recorder's non-volatile memory through the communications link.

Managing Configuration Files

TESLA Control Panel's *Configuration Manager* creates and manages configuration files and handles transfer to and from the recorder. To open the Configuration Manager screen, double-click the *Configuration* line in the left pane of the Main Menu screen.

The configurations shown in the Configuration Manager screen are specific to the selected Current IED. To work with configurations from another recorder, you must first select that unit as the Current IED (from the Main Menu).

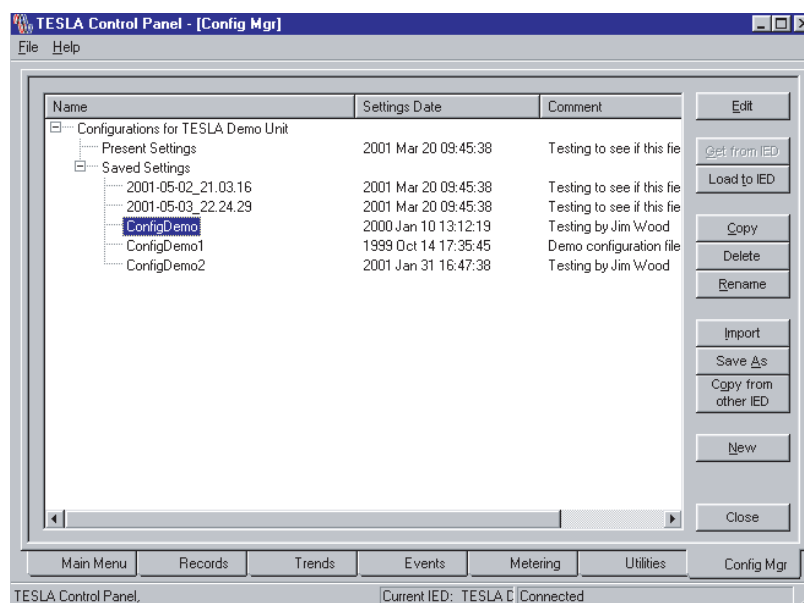


Figure 8.1: Configuration Manager

If a communication link to the Current IED is available, you can work directly with the recorder's configuration by either double-click on the *Present Settings* item in the list or by selecting *Present Settings* and using the *Edit* button. This will read the configuration from recorder and displays it in the Configuration Editor.

Editing a Recorder's Present Configuration

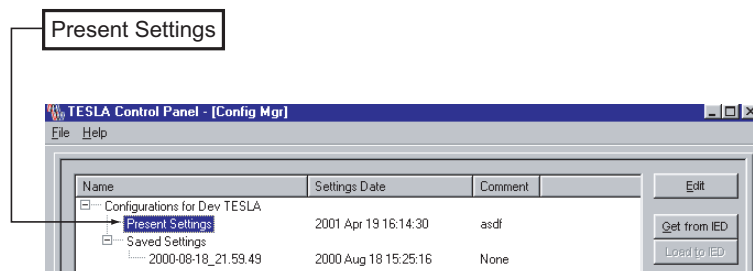


Figure 8.2: Present Configuration

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

You can also transfer the recorder's present configuration to a saved file in Control Panel using the *Get from IED* button. When transferred, the configuration appears in the *Saved Settings* list.

Saved Configuration Files

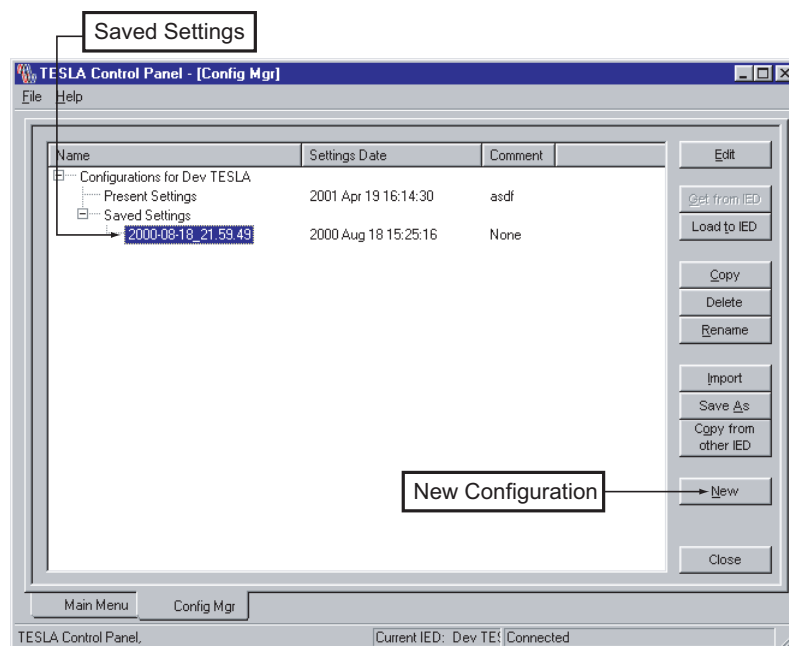


Figure 8.3: Saved Configurations

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

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

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

Loading a Saved Configuration

Note: A configuration file must be compatible with the firmware on the recorder in order to be loaded. Compatibility is defined by the *Settings Version*, a number which identifies the version of configuration file a given version of firmware requires.

Control Panel will either prevent incompatible configuration files from being loaded or will offer to make the configuration compatible before it loads it.

To load a configuration file from the Saved Settings list into the Current IED, you must be communicating with the recorder. Initiate the load by selecting the desired configuration file and clicking the *Load to IED* button. The recorder will immediately load and run the new configuration. Complex configurations can take a few minutes to transfer and load, depending in part on communications rate. The recorder will acknowledge the new settings back to Control Panel.

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

Creating a New Configuration

Use the *New* button to create a new configuration file. New configuration files are compatible with the latest Setting Version by default. The Setting Version can be changed if desired to create new configuration 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 5-3).

Using Another Recorder's Configuration as a Starting Point

You can use the *Copy from Other IED* button to create a configuration for the current recorder based on an existing one from another recorder. The configuration can be chosen from a list of the saved settings of the other IEDs defined in Control Panel.

Configuration Editor

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

The sample screens shown are from the TESLA 3000 Demo configuration.

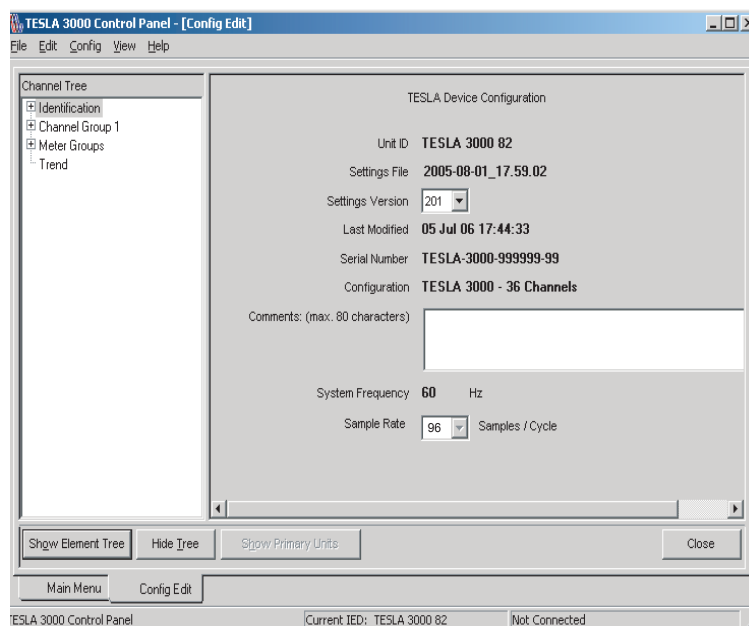


Figure 8.4: TESLA Configuration Editor

Navigation Tree

The right-side pane of the Configuration Editor window provides a navigation tree to access the various sections of the configuration. Selecting an item in the tree shifts the large right pane view to the appropriate topic. Double-clicking on a tree branch in the left pane that has a small “+” to its left or selecting on the “+” itself 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 Control Panel gives you an opportunity to save your changes to a file (or send them to the IED) before closing the Configuration Editor. To close without saving changes, use the *Save/Close* button and then select *Exit Without Saving* and *Discard* on the subsequent screens.

Identification

Device Configuration

The Device Configuration screen is displayed when you select the Identification item in the Navigation Tree (“TESLA Configuration Editor” on page 8-4). 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 5-3).

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

Settings Version

Recorders with older firmware may require older versions of configuration files. Compatibility between a configuration 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 7-2). You must be connected to the recorder to view this information. Settings Version requirements are also listed in the compatibility table at the front of this User Manual and are identified in each version’s Release Notes. TESLA 2000 recorders use Setting Versions 1 through 7. TESLA 3000 Setting Versions start at 201 to distinguish them from those used by TESLA 2000.

The version of a configuration file is controlled through the *Settings Version* field in the main identification screen (see: “TESLA Configuration Editor” on page 8-4). Changing the setting automatically converts the configuration 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 cancelling 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 configuration file without saving, the conversion is also abandoned.

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

TESLA Control Panel 3000 can work with configuration files of any Setting Version, including those for TESLA 2000 recorders, creating, editing, storing and transferring them to and from a recorder as needed.

Note: TESLA Control Panel should be updated as needed whenever you update the firmware on your recorders. This will ensure it can generate configuration files with the latest Settings Version.

Since Control Panel can work with back versions of configuration files and can communicate with recorders with older firmware, the newest version of Control Panel can always be safely installed.

Sample Rate

The *Sample Rate* setting controls the rate at which the TESLA 3000 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 calculat-

ed high speed channels. The sample rate does not affect the data rate of 'downstream' calculations that generate data for low speed swing recordings, low speed calculated channels, the metering display update rate or the trending rate.

The *Sample Rate* will also determine the number of channels the recorder can record. For sample rates up to 128 samples/cycle (7680 samples/second on a 60Hz system frequency), the recorder supports all its channels - 36 analog and 64 digital. For sample rates above 128 samples/cycle, the number of channels is reduced proportionally. Channel reductions always take place starting from the highest numbered channels. The numbers of available calculated channels (e.g. watts) is not affected by the sample rate.

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

Table 8.1: Sample Rates (60Hz System Frequency)

Samples / Second	Samples / Cycle	Analog Channels	External Channels	Highest Harmonic*	Approx. Record Size** (kbytes)
1,920	32	36	64	8	50
3,840	64	36	64	16	100
5,760	96	36	64	25	150
7,680	128	36	64	33	200
15,360	256	18	32	66	200
23,040	384	9	32	100	200

Table 8.2: Sample Rates (50Hz System Frequency)

Samples / Second	Samples / Cycle	Analog Channels	External Channels	Highest Harmonic*	Approx. Record Size** (kbytes)
1,600	32	36	64	8	50
3,200	64	36	64	16	100
4,800	96	36	64	25	150
6,400	128	36	64	33	200
12,800	256	18	32	66	200
19,200	384	9	32	100	200

*Limited by the anti-aliasing filters

**For a 1 second fault record assuming typical compression

Note: 18 channel models are limited to a maximum of 18 analog channels and 32 external channels

Comments

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

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 specify the time window (*Chatter Detection Window*) in which the chatter detector works. The detector limits the number of triggers that can occur - on the same channel and of the same trigger type - within the window. Four External Input triggers and two analog or calculated channel triggers are allowed in the window. If this number is exceeded, the trigger is automatically disabled until the trigger rate falls to less than that number for the specified number of seconds (*Recovery Time*). This prevents the recorder from being overloaded by nuisance triggers and automatically re-enables the trigger when conditions return to normal.

Note: Although an External Input triggers may be disabled by a chatter limit function, the recording will contain the original External Input data.

Storage Alarms

The *Storage Alarms* screen, accessed by expanding the *Identification* branch in the Navigation tree, lets you select the output contact to be closed when the memory for triggered records or long term trend logs is nearly full. The accumulation mode (recycle or stop-when-full) and the level at which to alarm are set in the *Recording* tab of the *Utilities* screen (“Recording Control Settings” on page 7-6).

The record and trend storage alarm condition can also be accessed via the SCADA protocols.

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 configurations.

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 your configuration. 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 Configuration 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:Vb
Line #1:Vc
Line #1:Ia
Line #1:Ib
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 Description 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:

2005 Jan 12 20:44:33.672 Line #1.EI.BRKR1_a open.

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

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
	DC	DC voltage or current
	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
	Frequency	Frequency (one per channel group)
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.

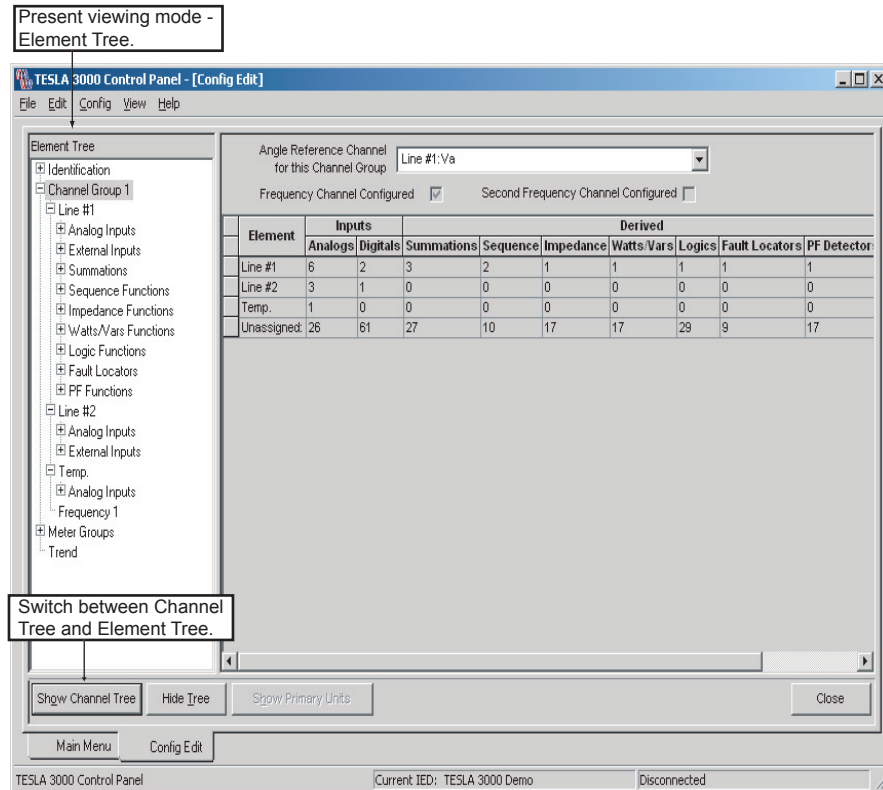


Figure 8.5: Element Tree View

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 choose to work in either view, the Element View is recommended for most operations as it provides an automatic way of grouping related channels.

Element Overview

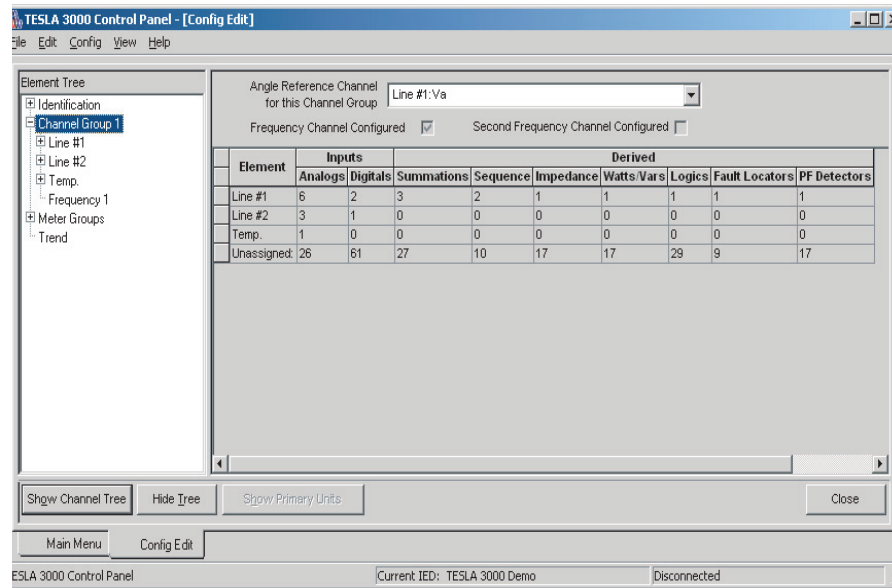


Figure 8.6: Element Overview Screen

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 Channel Group 1 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.

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.

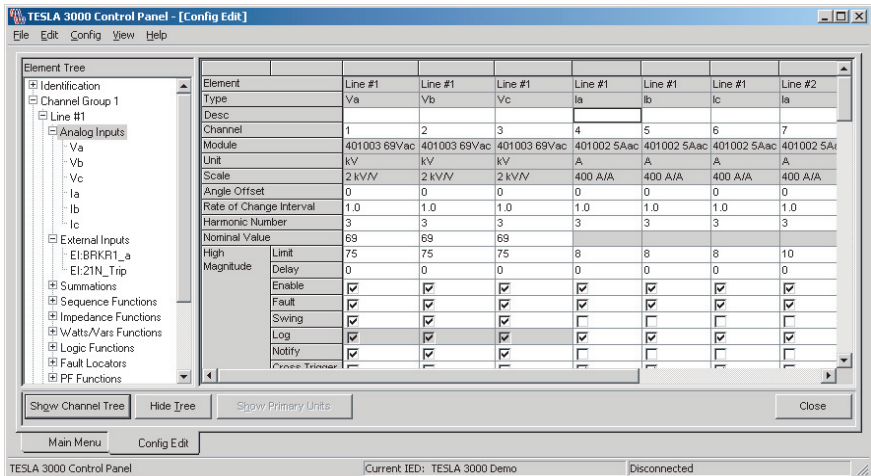


Figure 8.7: Channel Overview Screen

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.

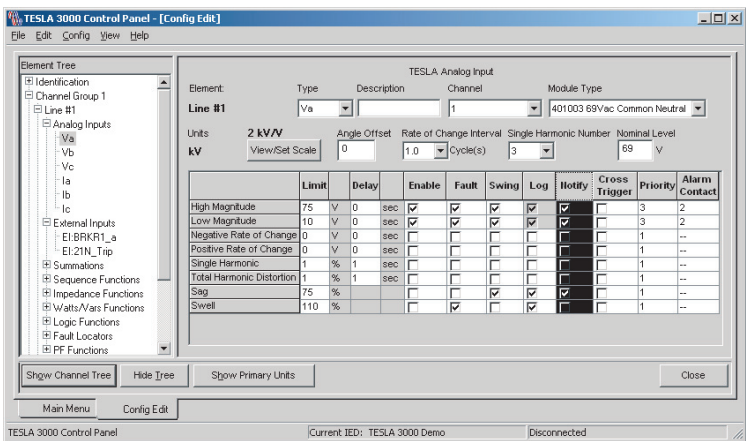


Figure 8.8: Individual Channel Configuration Screen

Adding an Element

To create a new element you must be in the Element Tree view (“Element and Channel Tree Views” on page 8-10):

- 1 Select the Channel Group heading or an existing element in the Element Tree.
- 2 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.
- 3 Type the element name and *Enter*. The typed text replaces the *New Element* text.

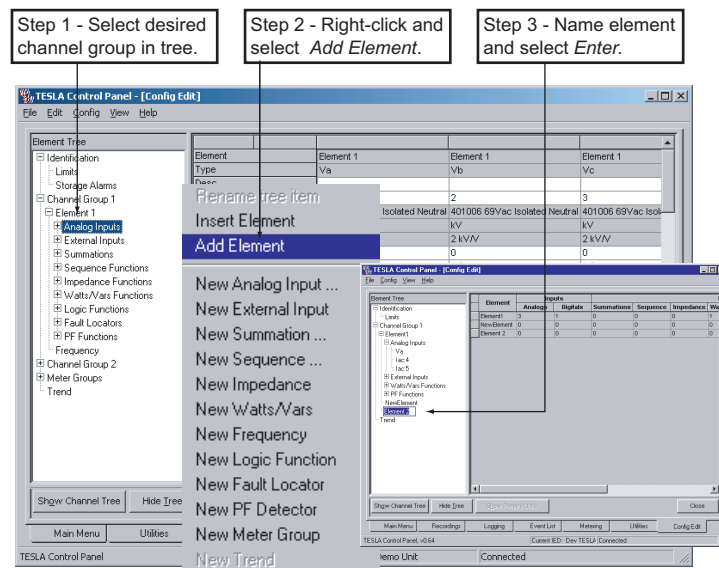


Figure 8.9: Add an Element

Deleting an Element

To remove an element from the tree, select it and press the 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 8-10).

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*.

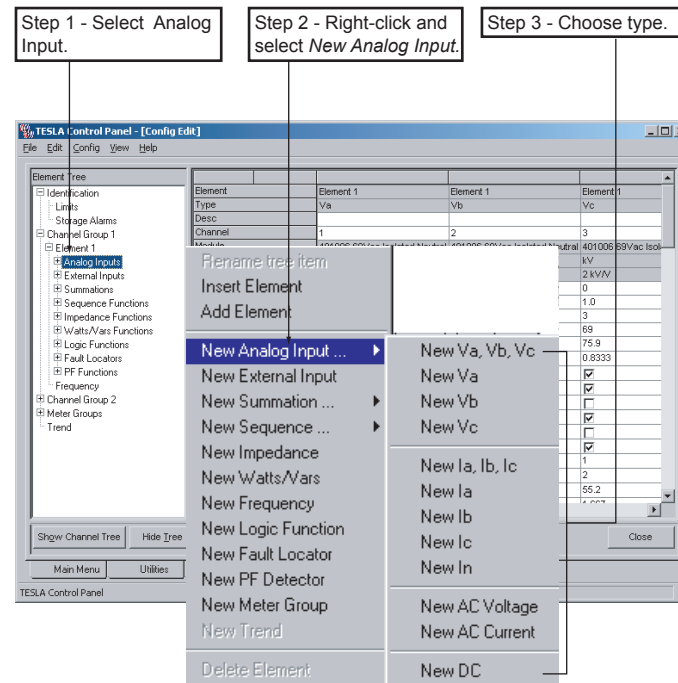


Figure 8.10: Adding Analog Input Channels from the Element Tree

Deleting a Channel

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

Analog Input Channels

Description	Basic recording channels for the recorder's analog input signals.
Input	The recorder's physical analog input channels.
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	<p>High & low magnitude</p> <p>Negative and positive rate of change</p> <p>Single harmonic magnitude</p> <p>THD magnitude</p> <p>Sag and swell</p> <p>To prevent multiple triggers on threshold conditions, an hysteresis of 2% of setting is applied to magnitude triggers.</p>
Recording	<p>High Speed: records the samples generated from the A / D converters at the selected sample rate.</p> <p>Low Speed: records the calculated phasors at a rate of one phasor per cycle.</p>
Number of Channels	<p>Up to 36 Analog Input Channels can be defined, one for each physical input (limited to 18 on an 18 channel model).</p> <p>The numbers of channels are reduced at high sample rates (see: Table 8.1 on page 6 and Table 8.2 on page 6)</p>
Types	<p>Specific: Va, Vb, Vc, Ia, Ib, Ic, In (use where appropriate)</p> <p>Generic: Vac, Iac, DC</p> <p>Note: the DC type indicates that a DC Input Isolation Module is used on this channel. This module can in fact be used with either ac or dc signals.</p>
Notes	The Analog Input Channel also produces THD and Single Harmonic readings that are available to the metering display, SCADA and the long term trending function.

Settings

TESLA Analog Input

Element: **Element1** Type: **Va** Description: Channel: **1** Module Type: **401003 69Vac Common Ne**

Units: **2 kV/V** Angle Offset: **0** Rate of Change Interval: **1.0** Cycle(s) Single Harmonic Number: **3** Nominal Level: **69** V

kV [View/Set Scale](#)

	Limit		Delay		Enable	Fault	Swing	Log	Notify	Cross Trigger	Priority	Alarm Contact
High Magnitude	75	V	1	sec	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	3	2
Low Magnitude	60	V	0	sec	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1	--
Negative Rate of Change	-10	V	0	sec	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1	--
Positive Rate of Change	10	V	0	sec	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1	--
Single Harmonic	1	%	1	sec	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1	--
Total Harmonic Distortion	1	%	1	sec	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1	--
Sag	85	%			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1	--
Swell	110	%			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1	--

Figure 8.11: Analog Input Channel Configuration Screen

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 8-8).
Channel	Identifies the physical input used by this channel. This number is identified on the rear of the TESLA chassis. The list shows only inputs not assigned to other channels. To get an overview of channel assignments, switch to the Channel Tree view and look at the Analog Channel list.
Module Type	Indicates the type of external input isolation module used with this channel. The list is limited to those modules appropriate for the selected channel type. The module defines input scaling information to the system.
View/Set Scale	Sets the primary to secondary scale factor. See details below.

Analog Input Channel Settings	
Angle Offset	<p>Specifies a phase angle offset to be applied to the channel. The offset is included in:</p> <ul style="list-style-type: none"> • 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. <p>High speed recordings of this channel will <i>not</i> have the phase angle applied as they are basic representations of the individual sampled points.</p> <p>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 8-11).</p>
Trigger Settings	
Rate of Change Interval	Specifies the period of time over which both positive and negative rate of change is measured. 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 8.1 and Table 8.2 on page 6.
Nominal Level	Provides a nominal level for the sag and swell detectors. Available on voltage channels only. See sag and swell detector details below.
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	<p>Specifies how long the trigger condition must be present before a trigger is declared.</p> <p>Magnitude and Rate of Change triggers: 0 to 1,200 seconds in half-cycle increments.</p> <p>Single harmonic and THD triggers: 1 to 10,000 seconds in 1 second increments.</p>
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	<p>Initiates a swing (low speed) recording when triggered.</p> <p>If both Fault and Swing are enabled, the recorder will attempt to create a combined record.</p>
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 ("Notify" on page 7-13)
Cross Trigger	Activates the cross-trigger contact (#4) to trigger another device.
Priority	<p>Specifies the priority to be assigned to records created by this trigger. The priority is used to determine Central Station notification.</p> <p>1 - 3 (3 is the highest priority). ("Notify" on page 7-13).</p>

Analog Input Channel Settings	
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 and 2 or 3 on an 18 channel model. Contacts 1 and 4 are reserved for Recorder Functional and Cross-Trigger respectively. Contacts assigned for storage alarms ("Storage Alarms" on page 8-7) will not be available for use here.

Scaling Input Channels

AC Scaling

When you select the *View/Set Scale* button on the Analog Input form for an ac channel, Control Panel displays the Scaling dialog box (Figure 6.12). The scaling factor represents the turns ratio of the primary transducer (CT or PT). The nominal secondary value is used as the default calibration level for the channel.

If you are using an ac module to measure the ac quantity, Control Panel sets the Full Scale quantity appropriately; if you are using the DC input module enter the Full Scale value associated with the values of the scaling resistors Rsh, Rin and Rfb as listed in "Input Modules" in Appendix F.

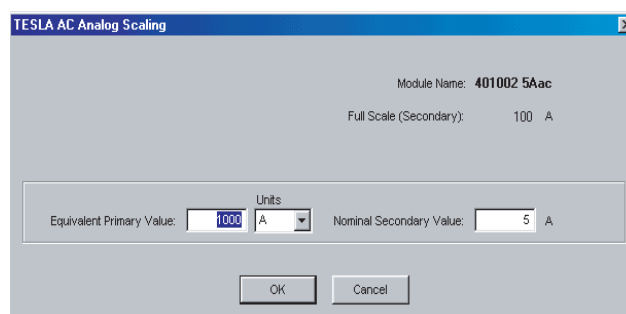


Figure 8.12: AC Scaling

DC Scaling

When you select the *View/Set Scale* button on the Analog Input form for a DC channel, Control Panel displays the DC Scaling dialog box. You must set the Full Scale value, which can be determined from the scaling resistors attached to the module. For DC channels, TESLA uses two-point scaling, whereby the conversion process performs a linear transformation between two points. The secondary values are the default calibration points for the channel.

The terms Primary and Secondary are used in the case where a measurement transducer is applied and the output of the transducer is routed to the input of the dc module. In this case, Secondary refers to the output of the transducer; Primary refers to the scale and units of the signal measured by the transducer. The "Scaling Resistors attached to the module" are the Rsh, Rin and Rfb values referred to in "DC Input Module" in Appendix F. Enter the associated Full Scale value from the table as the Full Scale (Secondary) value. If you are measuring a DC voltage or current directly, enter the same values as Primary and Secondary for each of Points 1 and 2. The specific values for Point 1 and 2, provided they are reasonably separated, are not significant, except that they are

used as default values for the calibration activity. For instance, if you are directly measuring a 48 Vdc input, you may wish to enter 0 V for Point 1 and 48 V for Point 2.

If you are monitoring an ac signal through a dc module, you must define the signal as an ac signal (see above).

Figure 8.13: DC 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 threshold is configurable between 50% and 90% of Nominal. The minimum Sag level is fixed at 10% of Nominal. The Swell threshold is configurable between 110% and 150% of Nominal. The maximum Swell level is fixed at 180% of Nominal.

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

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 (limited to 32 on an 18 channel model). The numbers of channels are reduced at high sample rates (Table 8.1 on page 6 and Table 8.2 on page 6)
Types	EI
Settings	

TESLA External Input Configuration

Element:

Description:

Channel: 9

Definite Delay: ms External Delay: ms

	Label	Enable	Fault	Swing	Log	Notify	Cross Trigger	Priority	Alarm Contact
ACTIVE State	Active	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	2	6
INACTIVE State	Inactive	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	1	3

Figure 8.14: External Input Channel Configuration Screen

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.

External Input Channel Settings	
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 8-8).
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 ("Notify" on page 7-13).
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). ("Notify" on page 7-13).
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 and 2 or 3 on an 18 channel model. Contacts 1 and 4 are reserved for Recorder Functional and Cross-Trigger respectively. Contacts assigned for storage alarms ("Storage Alarms" on page 8-7) will not be available for use here.

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.

For high speed recording, Summation Channels are displayed as the *sum of the individual data samples* with only the *Scale Factor* setting applied. High speed Summation channels are not recorded if a non-zero *Angle Offset* has been specified.

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. A high speed channel is not generated if a non-zero *Angle Offset* has been specified on any of the summation's input channels.

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

Number of Channels

30 Summation Channels are available.

Types

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

Generic: Vac, Iac

Notes

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

Settings

TESLA Summation Function Configuration

Element	Type	Description	Summation Index
Element1	VaSum	tst_Va1_2	1

Units: **V**
 Scale: **1 V/V** Rate of Change Interval: **1.0** Cycle(s)

Define Inputs:

Input	Element:Type:Description	Scale Factor	Angle Offset
Input 1	Element1:Va:tst_Va1_1	x 1	/ 0
Input 2	Element1:Vb:tst_Vb1_1	x 1	/ 0
Input 3	Element1:Vc:tst_Vc1_1	x 1	/ 0

	Limit		Delay		Enable	Fault	Swing	Log	Notify	Cross Trigger	Priority	Alarm Contact
High Magnitude	0	V	0	sec	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	2	3
Low Magnitude	0	V	0	sec	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	1	--
Negative Rate of Change	0	V	0	sec	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	3	6
Positive Rate of Change	0	V	0	sec	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	1	--

Figure 8.15: Summation Channel Configuration Screen

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:laSum 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 8-8).
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.
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.

Summation Channel Settings	
Trigger Settings	
Rate of Change Interval	Specifies the period of time over which both positive and negative rate of change is measured. 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 <i>Rate of Change Interval</i> .
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 ("Notify" on page 7-13)
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). ("Notify" on page 7-13).
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 and 2 or 3 on an 18 channel model. Contacts 1 and 4 are reserved for Recorder Functional and Cross-Trigger respectively. Contacts assigned for storage alarms ("Storage Alarms" on page 8-7) will not be available for use here.

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	<p>Positive sequence high and low magnitude</p> <p>Positive sequence negative and positive rate of change</p> <p>Negative sequence high magnitude</p> <p>Zero sequence high magnitude</p> <p>To prevent multiple triggers on threshold conditions, an hysteresis of 2% of setting is applied to magnitude triggers.</p>
Recording	<p>High Speed: Positive, negative and zero sequence values at a rate of eight values per cycle (regardless of the system sample rate).</p> <p>Low Speed: Positive, negative and zero sequence values at a rate of one value per cycle.</p>
Number of Channels	12 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

TESLA Sequence Function Configuration

Element: **Element2** Type: **Vseq** Description: **tst_Vs2_2** Sequence Index: **7** Units: **V**

Select Inputs: Element: Type: Description

Phase A: **Element2:Va:tst_Va2_1**

Phase B: **Element2:Vb:tst_2_1**

Phase C: **Element2:Vc:tst_Vc2_1**

Scale: **1 V/V**

Rate of Change Interval: **1.0** Cycle(s)

	Limit	Delay	Enable	Fault	Swing	Log	Notify	Cross Trigger	Priority	Alarm Contact
Pos Seq High Magnitude	0	V	0	sec	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	2	3
Pos Seq Low Magnitude	0	V	0	sec	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	1	5
Pos Seq Pos ROC	0	V	0	sec	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	1	6
Pos Seq Neg ROC	0	V	0	sec	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	1	7
Neg Seq High Magnitude	0	V	0	sec	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	3	3
Zero Seq High Magnitude	0	V	0	sec	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	1	3

Figure 8.16: Sequence Channel Configuration Screen

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 8-8).
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	
Rate of Change Interval	Specifies the period of time over which both positive and negative rate of change is measured. 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 <i>Rate of Change Interval</i> .
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 ("Notify" on page 7-13).
Cross Trigger	Activates the cross-trigger contact (#4) to trigger another device.

Sequence Component Channel Settings	
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). ("Notify" on page 7-13).
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 and 2 or 3 on an 18 channel model. Contacts 1 and 4 are reserved for Recorder Functional and Cross-Trigger respectively. Contacts assigned for storage alarms ("Storage Alarms" on page 8-7) will not be available for use here.

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, SCADA and the long term trending function.
Settings	

TESLA Impedance Function Configuration

Element	Type	Description	Impedance Index
Element1	:Z1:	tstZ1_1	1

Voltage Input

Element1:Va:tst_Va1_1

Current Input

Element1:Ia:tst_Ia1_1

Rate of Change Interval

1.0

Cycle(s)

Circle Radius

1

sec. ohms

Minimum Change

1

sec. ohms

Maximum Change

100

sec. ohms

Definite Delay

0.01667

sec

Detector Actions:

Scale: 1 Pri ohms/Sec ohms

	Enable	Fault	Swing	Log	Notify	Cross Trigger	Priority	Alarm Contact
	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	1	3

Figure 8.17: Impedance Channel Configuration Screen

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 8-8).
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.
Trigger Settings	
Rate of Change Interval	Specifies the period of time over which both positive and negative rate of change is measured. 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 ("Notify" on page 7-13)
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). ("Notify" on page 7-13).

Impedance Channel Settings	
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 and 2 or 3 on an 18 channel model. Contacts 1 and 4 are reserved for Recorder Functional and Cross-Trigger respectively. Contacts assigned for storage alarms ("Storage Alarms" on page 8-7) will not be available for use here.

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	<p>Watts: high and low level (2)</p> <p>Watts: positive and negative rate of change (2)</p> <p>Vars: high and low level</p> <p>Vars: positive and negative rate of change</p> <p>Dual triggers for Watts allows fault and swing recordings to be triggered by different settings (e.g. Rate of Change Interval), if desired.</p> <p>To prevent multiple triggers on threshold conditions, an hysteresis of 2% of setting is applied to magnitude triggers.</p>
Recording	<p>High Speed: Watt and VAR values at a rate of eight values per cycle (regardless of the system sample rate).</p> <p>Low Speed: Watt and VAR values at a rate of one value per cycle.</p>
Number of Channels	18 Watts/Vars Channels are available.
Types	W/V
Notes	<p>The primary to secondary scale factor used by the Watts/Vars Channel is based on those of its voltage and current input channels.</p> <p>Watts, VARs, and Volt-Amp magnitudes are also available to the metering display, SCADA and the long term trending function.</p>

Settings

TESLA Watts/Vars Function Configuration

Element: **Element2** Description: **tst_W2_1** Watts/Vars Index: **10** Scale: **1e-006 MVA/VA**

Voltage Input: **Element2:Va:tst_Va2_1** Current Input: **Element2:Ia:tst_Ia2_1**

Rate of Change Intervals (Cycles):
Watts 1: **1.0** Watts 2: **1.0** Vars: **1.0**

	Limit		Delay		Enable	Fault	Swing	Log	Notify	Cross Trigger	Priority	Alarm Contact
Watts High Level Detector 1	0	W	0	sec	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	2	3
Watts Low Level Detector 1	0	W	0	sec	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1	--
Watts Positive ROC Detector 1	0	W	0	sec	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	3	3
Watts Negative ROC Detector 1	0	W	0	sec	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1	--
Watts High Level Detector 2	0	W	0	sec	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1	--
Watts Low Level Detector 2	0	W	0	sec	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1	--
Watts Positive ROC Detector 2	0	W	0	sec	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	2	5
Watts Negative ROC Detector 2	0	W	0	sec	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	1	5
Vars High Level	0	VAR	0	sec	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1	--
Vars Low Level	0	VAR	0	sec	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1	--
Vars Positive ROC	0	VAR	0	sec	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1	--
Vars Negative ROC	0	VAR	0	sec	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	1	7

Figure 8.18: Watts/Vars Channel Configuration Screen

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 8-8).
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.
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 <i>Rate of Change Interval</i> .

Watts/Vars Channel Settings	
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 ("Notify" on page 7-13).
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). ("Notify" on page 7-13).
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 and 2 or 3 on an 18 channel model. Contacts 1 and 4 are reserved for Recorder Functional and Cross-Trigger respectively. Contacts assigned for storage alarms ("Storage Alarms" on page 8-7) will not be available for use here.

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.
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	2 Frequency Channels are available.
Types	Freq
Notes	Frequency channels are not associated with particular Elements. Their names are fixed as Frequency 1 and Frequency 2.
Settings	

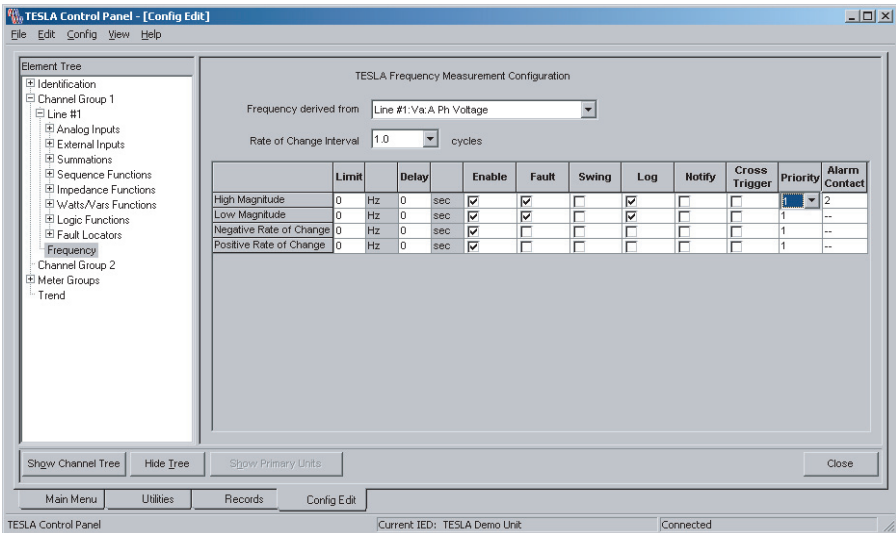


Figure 8.19: Frequency Channel Configuration Screen

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 Channel Settings	
Trigger Settings	
Rate of Change Interval	Specifies the period of time over which both positive and negative rate of change is measured. 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 <i>Rate of Change Interval</i> . 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 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 ("Notify" on page 7-13.)
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). ("Notify" on page 7-13).
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 and 2 or 3 on an 18 channel model. Contacts 1 and 4 are reserved for Recorder Functional and Cross-Trigger respectively. Contacts assigned for storage alarms ("Storage Alarms" on page 8-7) will not be available for use here.

Logic Functions

Description

Logic Functions are boolean logic statements that can be applied to External Input Channels 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 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

Logic Functions are not recorded.

Number of Channels

30 Logic Functions are available.

Types

Logic

Notes

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

Settings

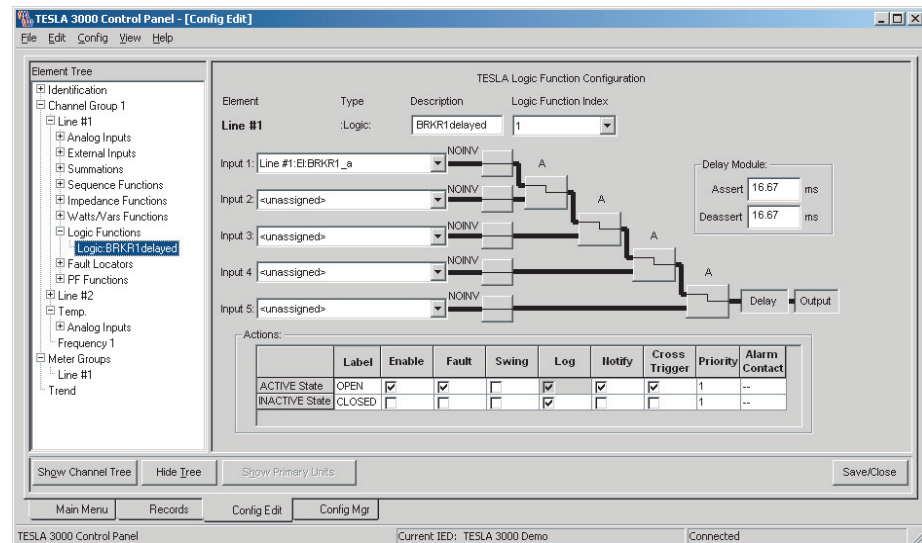


Figure 8.20: Logic Function Configuration

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 8-8).
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, 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 1,200 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 ("Notify" on page 7-13.)
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). ("Notify" on page 7-13).
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 and 2 or 3 on an 18 channel model. Contacts 1 and 4 are reserved for Recorder Functional and Cross-Trigger respectively. Contacts assigned for storage alarms ("Storage Alarms" on page 8-7) will not be available for use here.

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 SCADA.
Input	<p>Initiating Event: any External Input Channel or trigger detector from any other channel or function.</p> <p>Voltage Channels: must be Analog Input Channels monitoring voltage.</p> <p>Current Channels: can be Analog Input Channels or Summation Channels monitoring current.</p> <p>The correct phases must be selected to achieve the desired results.</p> <div style="border: 1px solid black; padding: 5px; margin-top: 10px;"> <p>In most cases, the Initiating Event input should be delayed by 1.5 cycles to obtain accurate fault location information. The delay can be set in the source detector or a Logic Function can be used as an intermediary to insert the delay.</p> </div>
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.
Triggers	N/A
Recording	Fault Locator Functions are not recorded.
Number of Channels	10 Fault Locator Functions are available.
Types	FLoc
Notes	<p>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.</p> <p>The output of the Fault Locator Function is available through SCADA. It cannot be metered or trended.</p>

Settings

TESLA Fault Locator Configuration

Element	Type	Description	Fault Locator Index
Element1	:FLoc:	<input type="text"/>	1 <input type="button" value="v"/>
Initiating Event	<input type="text" value="Element1:\b:tst_Vb1_1[Swell]"/> <input type="button" value="v"/>		
Phase A Volts	<input type="text" value="Element1:\a:tst_Va1_1"/> <input type="button" value="v"/>		
Phase B Volts	<input type="text" value="Element1:\b:tst_Vb1_1"/> <input type="button" value="v"/>		
Phase C Volts	<input type="text" value="Element1:\c:tst_Vc1_1"/> <input type="button" value="v"/>		
Phase A Amps	<unassigned> <input type="button" value="v"/>		
Phase B Amps	<unassigned> <input type="button" value="v"/>		
Phase C Amps	<unassigned> <input type="button" value="v"/>		
Pos Sequence Impedance	<input type="text" value="0"/> + j <input type="text" value="0"/> Pri. ohms		
Zero Sequence Impedance	<input type="text" value="0"/> + j <input type="text" value="0"/> Pri. ohms		
Line Length	<input type="text" value="0"/> <input type="button" value="km"/> <input type="button" value="v"/>		

Figure 8.21: Fault Locator Function Configuration

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 8-8).
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 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.

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 not recorded.

Number of Channels

18 Power Factor Functions are available.

Types

PF

Notes

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

Settings

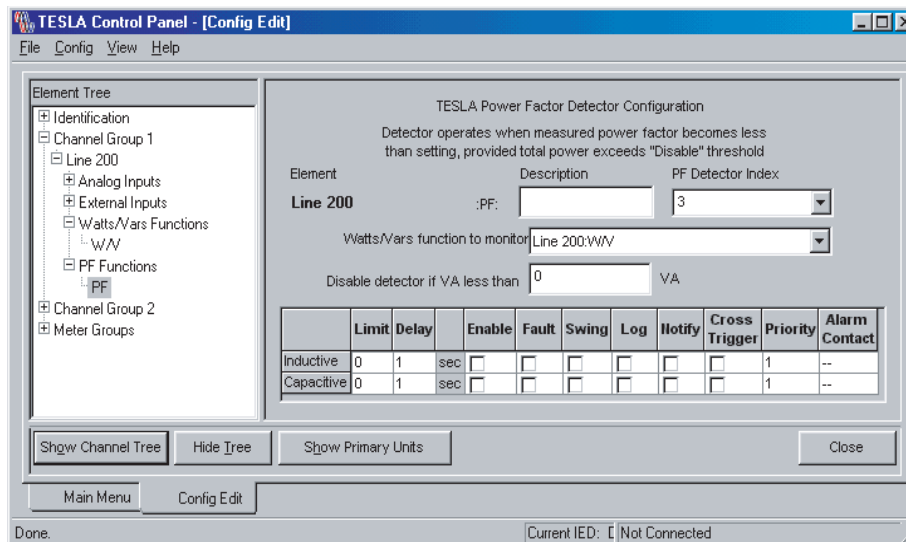


Figure 8.22: Power Factor Function Configuration

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 8-8).
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 previously 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 determined. 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.
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 ("Notify" on page 7-13).
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). ("Notify" on page 7-13).
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 and 2 or 3 on an 18 channel model. Contacts 1 and 4 are reserved for Recorder Functional and Cross-Trigger respectively. Contacts assigned for storage alarms ("Storage Alarms" on page 8-7) will not be available for use here.

Meter Groups

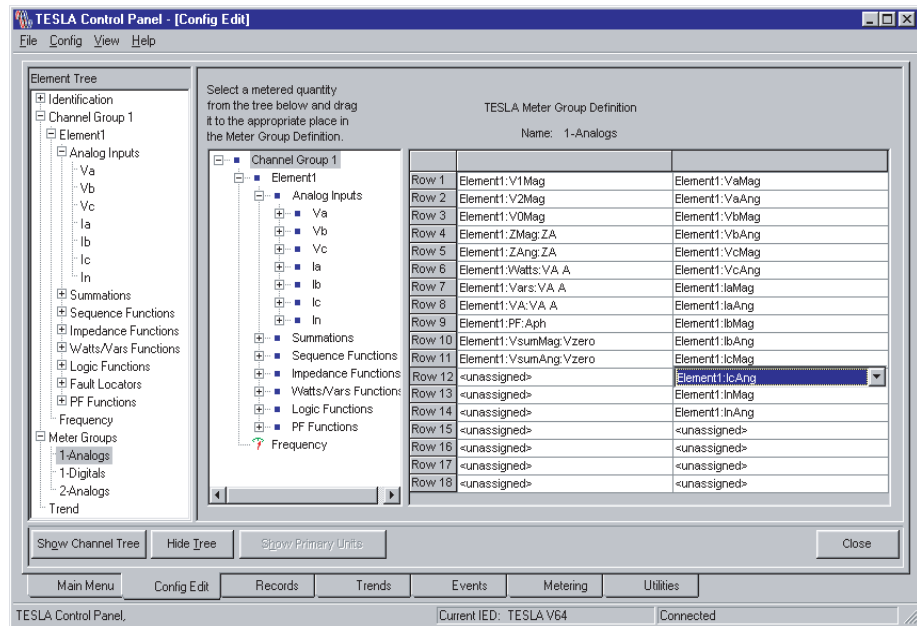


Figure 8.23: Meter Group Configuration Screen

A Meter Group is a collection of measured and calculated values that are presented as a group by the 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 8-11.

Trend Logging

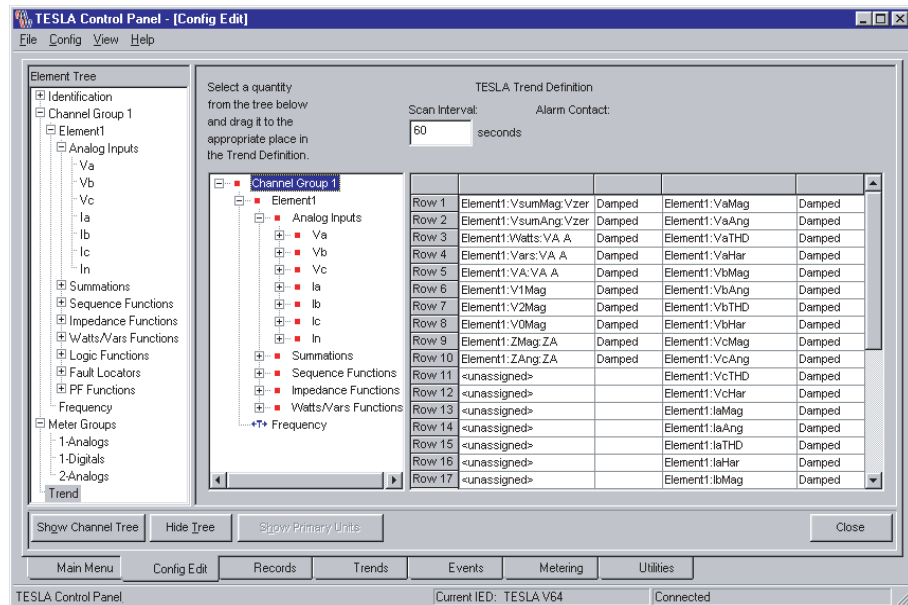


Figure 8.24: Trend Log Configuration

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 recorder's Utilities menu (see "Recording Control Settings" on page 7-6).

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* 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 *Process Options* are as follows:

Trend Accumulation Modes:	
Damped (default)	Logs a value representative of the measurements during the interval.
Undamped	Logs the last 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.

You can record the same channel with more than one Process Option, but you can not record the same channel with the same Process Option 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.

Printing

Printing a Configuration

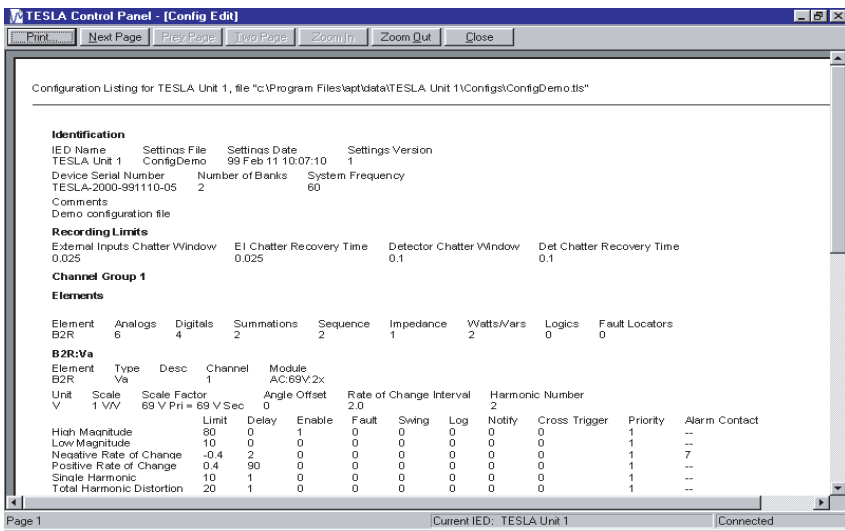


Figure 8.25: Print a Configuration

Generate a Configuration print at any time by selecting *Print Settings* from the *File* menu. The printed output follows the same general layout as the Element Tree. Where applicable, the settings are given in secondary units. The exception is the Fault Location parameters which are given in primary units.

You can preview the printed output by selecting *Print Preview* from the *File* menu.

Print Config function is also available under the *Config* menu.

Printing a SCADA Address List

MODBUS

The MODBUS address equivalents shows all of the functions defined in the TESLA recorder (see “Modbus Functions” in Appendix D). Selecting the *Print MODBUS* settings item from the *File* menu generates a listing that is configurable—listing the full function names in Element-Function-Description format along with the equivalent MODBUS addresses.

You can preview the printed output by selecting *Print MODBUS Preview* from the *File* menu.

Print MODBUS function is also available under the *Config* menu.

DNP

The DNP point list shows all of the functions defined in the TESLA recorder, (see “DNP3 Reference” in Appendix E) Selecting the *Print DNP* settings item from the *File* menu generates a listing that is configurable—listing the full function names in Element-Function-Description format along with the equivalent DNP points.

You can preview the printed output by selecting *Print DNP Preview* from the *File* menu.

Print DNP function is also available under the *Config* menu.

9 Record and Log Management

Records

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

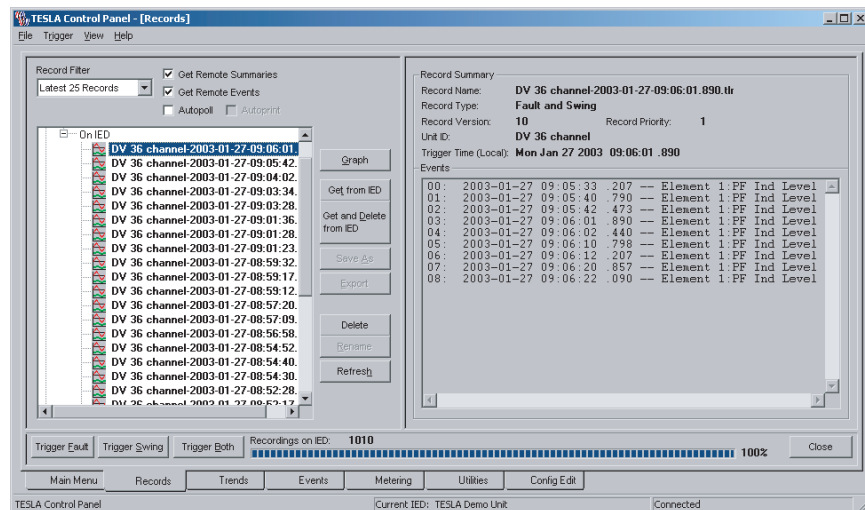


Figure 9.1: Record Listing

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 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 and are converted to local time using the *Time Zone and Daylight Saving* settings of the computer running TESLA Control Panel

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.

For cooperative group records, the event list cannot be displayed until the records have been transferred to TESLA Control Panel and combined.

Get Remote Summaries/Get Remote Events

When both *Get Remote Summaries* and *Get Remote Events* options are checked, 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.

Autopoll/Autoprint

When *Autopoll* is checked, Control Panel will periodically (default 60 seconds) poll the connected TESLA recorder for new record files and automatically transfer them to the local computer. Newest records will be transferred first, and only one new record will be transferred at each poll. Checking *Autoprint* will cause each transferred (via Autopoll) record file to be automatically printed on the default Windows printer using RecordGraph's default template.

Note that the *Autopoll* and *Autoprint* states are not persistent; if Control Panel is disconnected from the recorder, both *Autopoll* and *Autoprint* become unchecked.

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.

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 Control Panel and verified.

When connected to a cooperative group, *Get From IED* automatically transfers the corresponding record from each group member and combines them into a single group record ("Record Export Utility" on page 12-1).

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 12 Record Export Utility on page 1.

Delete

The *Delete* button can be used to delete records on the IED or locally. More than one file can be deleted at a time 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 <i>Refresh</i> updates the <i>Recordings</i> screen. It checks the local directory and the remote IED (if connected) for new and stored files, updates Control Panel's records database and refreshes the screen.
Trigger Fault/Swing/Both	<p>The recorder can be manually triggered to generate different types of records. <i>Trigger Fault</i> creates a high speed transient recording. <i>Trigger Swing</i> creates a low speed swing recording. <i>Trigger Both</i> creates a combined record.</p> <p>Note the Swing records may take up to 15 minutes to generate depending on the recorder's settings.</p>
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 <i>On IED</i> 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 <i>Get from IED</i> or a <i>Get and Delete from IED</i> Command.

Trend Log

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

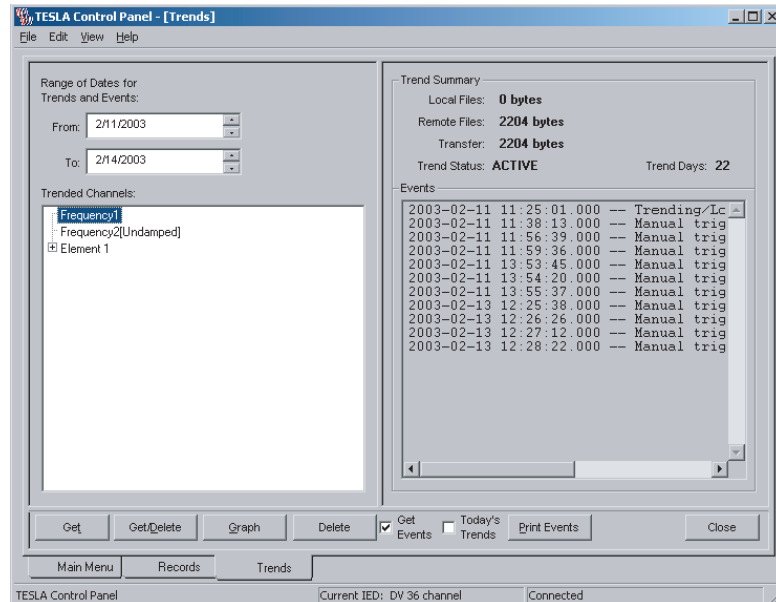


Figure 9.2: Trend Listing

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 files you have selected. *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

Get, Get/Delete	When you click <i>Get</i> all of the trends not previously transferred are transferred to your computer. If you select <i>Get/Delete</i> , 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 Record-Graph, ERLPhase's interactive graphing software, for details see 11 Graphing Records on page 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 Control Panel. If this checkbox is selected, 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 <i>Events</i> portion of your screen is printed.

Event Log

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

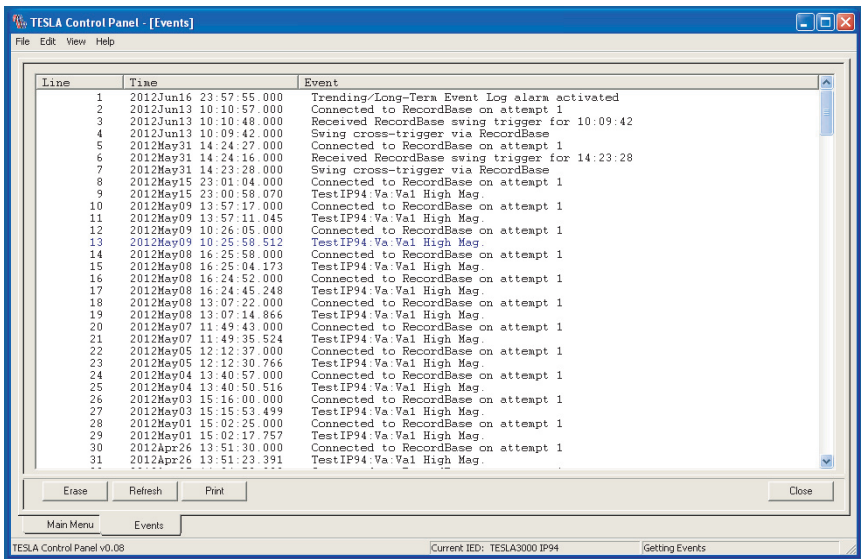


Figure 9.3: Event Log Display

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 250 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:

Date Time ElementName.Type.Description Detector State

where:

- *ElementName* is the user-assigned name of the element associated with this channel
- *ChannelType* describes the member of the element or the type of channel which the detector is monitoring
- *Description* is user-assigned text available to further identify the detector
- *Detector* is the type of detector
- *State* indicates whether the detector is picking up or dropping out. In the case of external inputs this text is user-assigned to accommodate different external devices.

Example of an event message from an External Input detector

2005 Jan 12 20:44:33.672 Line #1.EI.BRKRI-a open

Example of an event message from a high analog level detector:

2005 Jan 12 20:44:33.650 Line #1.Va.High Mag active

Printing Event Log

You may print or copy to clipboard all the events that are in the Event Log. Right-click or choose from the menu bar to print event logs while connected to the IED.

Controls

The event display is a static snapshot of the contents of the event log.

You can use the buttons at the bottom or a right-click to access these functions. In addition, print commands are available under the File menu, a copy command is available under the Edit menu, and a refresh command is available under the View menu.

Copy	Copies the event list to clipboard for pasting to other programs,
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	(bottom button only) Prints all the events (up to 250 events) to a local printer.

10 Continuous Disturbance Recording

Continuous Disturbance Recording (CDR) implemented in the TESLA 3000 recording system allows you to gather power system disturbance data to review and analyze transmission and generation protection systems. The TESLA 3000 recording system incorporated CDR for NERC standards requirements, including user-selectable recording channels and user-selectable recording sample rate.

NERC Standards:

- 1 Standard PRC-018-1 – Disturbance Monitoring Equipment Installation and Data Reporting
- 2 Standard PRC-002-1 – Define Regional Disturbance Monitoring and Reporting Requirements

The CDR feature incorporated in the TESLA 3000 Recording System meets and exceeds the requirements of NERC Standards as represented in the following table.

The 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 numbers and the sampling rates are shown in for details see Figure 10.2: Configuring Continuous Disturbance Recording on page 2.

The general configuration screen is reached from the Configuration branch in the main screen; the main Continuous Recording screen is reached from the Continuous Recording branch, see for details see Figure 10.1: Main Screen showing the Continuous Recording Branch on page 1.

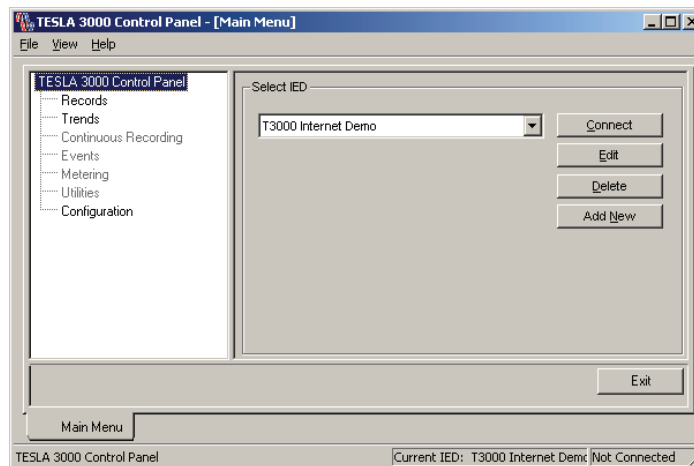


Figure 10.1: Main Screen showing the Continuous Recording Branch

Configuration

Selecting *Configuration* 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.

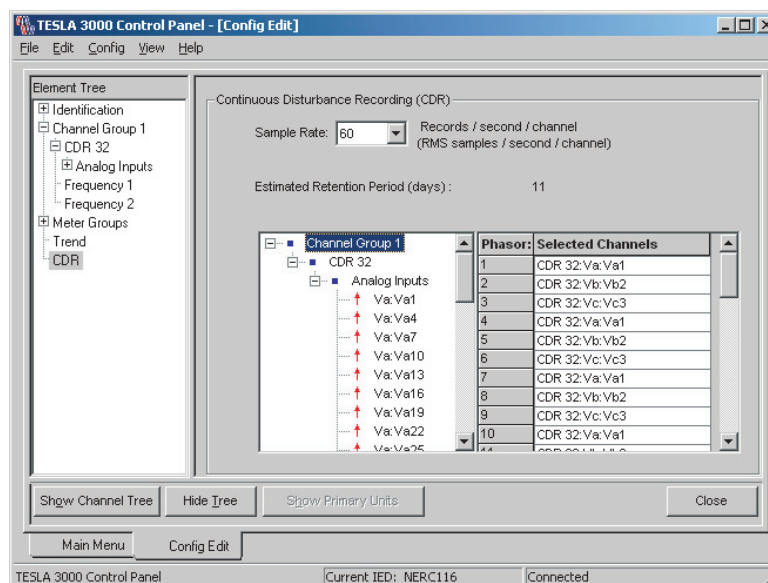


Figure 10.2: Configuring Continuous Disturbance Recording

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.

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

A 4-gigabyte flash drive is required for continuous disturbance recording to work. If TESLA 3000 firmware with continuous disturbance recording support

Continuous Disturbance Recording Status

is installed on a unit without the designated continuous disturbance recording partition, continuous disturbance recording will be disabled.

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 Figure 10.2: Configuring Continuous Disturbance Recording.

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

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* and *Utilities>Recording* screens. 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:

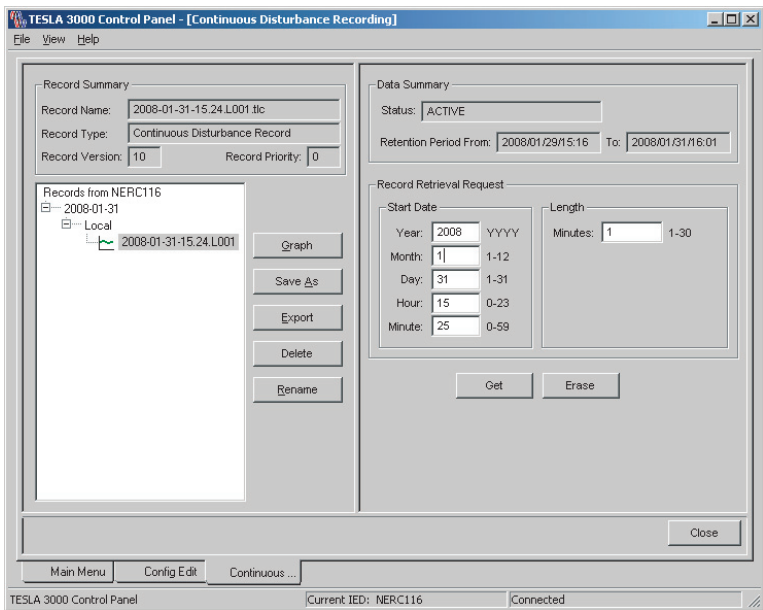


Figure 10.3: Continuous Disturbance Recording Screen

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.
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.

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. A new command Safe Shutdown Mode is added to the maintenance menu and to the TESLA Control Panel Utilities screen.

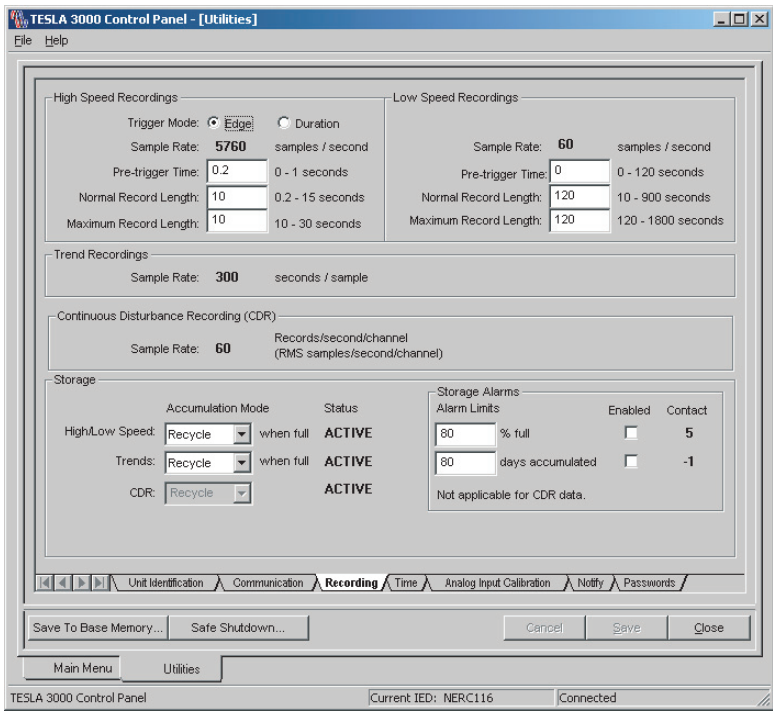


Figure 10.4: Utilities

The command Safe Shutdown Mode is available only at the service access level for TESLA Control Panel or via Port 1 login for maintenance utilities. When the command Safe Shutdown Mode is used, all TESLA 3000 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 re-booted automatically. The Event Log will maintain a record of all received Safe Shutdown commands.

Handling Configuration Changes

All accumulated continuous disturbance recording data is discarded every time new settings with modified continuous recording configuration are loaded on TESLA 3000. 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:

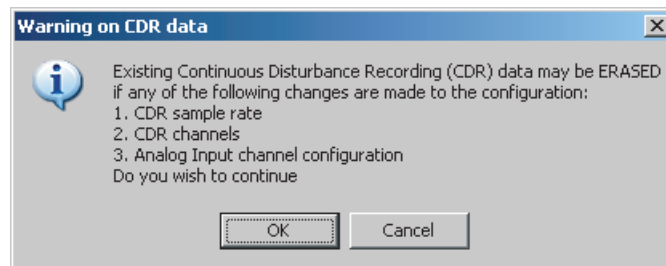


Figure 10.5: Utilities Screen showing Safe Shutdown button

11 Graphing Records

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.

Launch RecordGraph from TESLA Control Panel

Method 1: Records

- 1 Open TESLA Control Panel by double-clicking on the *TESLA* icon on your desktop. If the application is not installed, install the application and then proceed.
- 2 Double-click on the *Records* item in the tree list or select *Records* and use the *Enter* key.
- 3 Using the *Records* tab, select a local record from the tree list.
- 4 Click the *Graph* button.

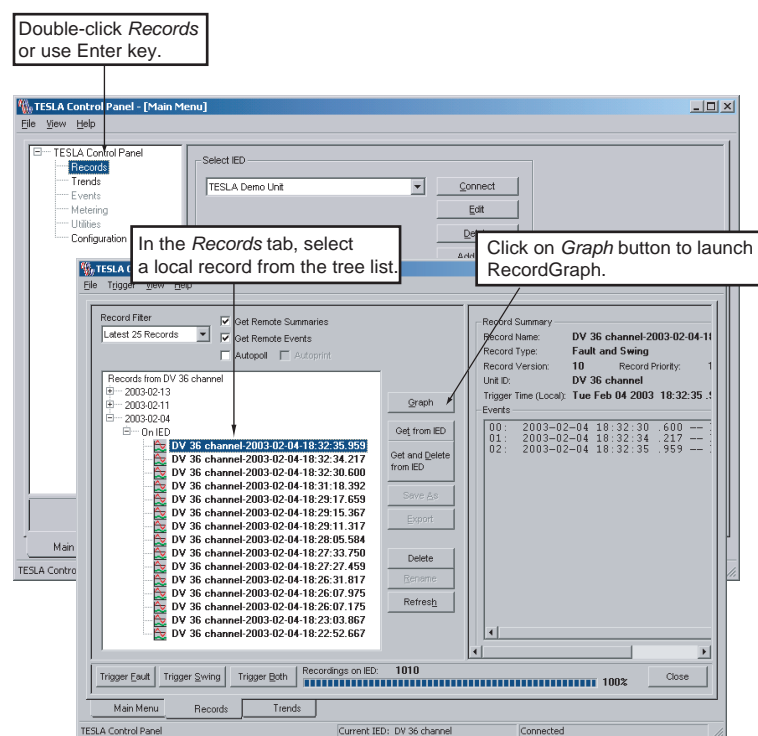


Figure 11.1: Launching RecordGraph from TESLA Control Panel

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.

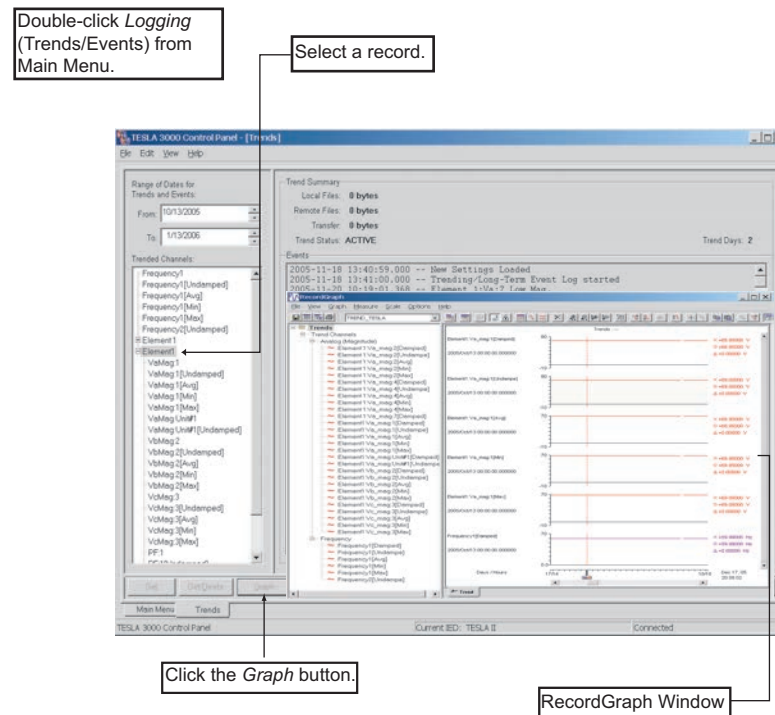


Figure 11.2: Launch from Logging (Trends/Events)

Launch RecordGraph from Windows Explorer

- 1 Open Windows Explorer.
- 2 Select a record. (It should have valid extensions, *.lpr, *.lpl, *.tpr, *.tpt, *.tlr, *.bpr, *.bpl, *.fpr.)
- 3 Right-click the selected record.
- 4 Choose, the *RecordBaseView>Launch Graph* option.

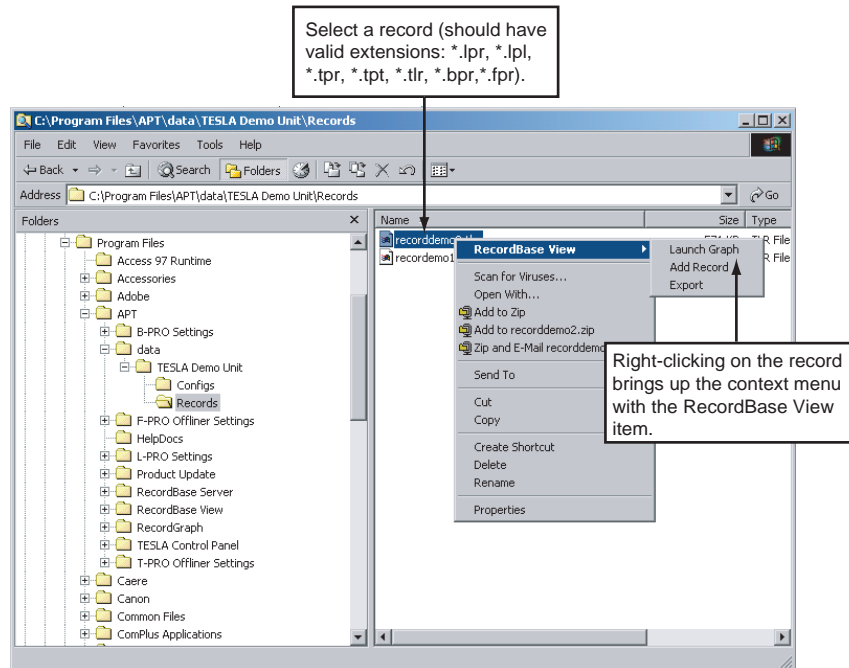


Figure 11.3: Launching RecordGraph from Windows Explorer

RecordGraph Components

- Main menu items
- Tool bar buttons
- A drop-down box lists the templates associated with the current record's IED
- A left-hand side pane (LHS) or tree view lists the names of records to be displayed or analysed
- A right-hand side pane (RHS) displays the graphs in various views. Initially a single blank screen appears.
- A right-click context menu on both the LHS and RHS pane.
- RecordGraph version is displayed in the *Help>About RecordGraph*.

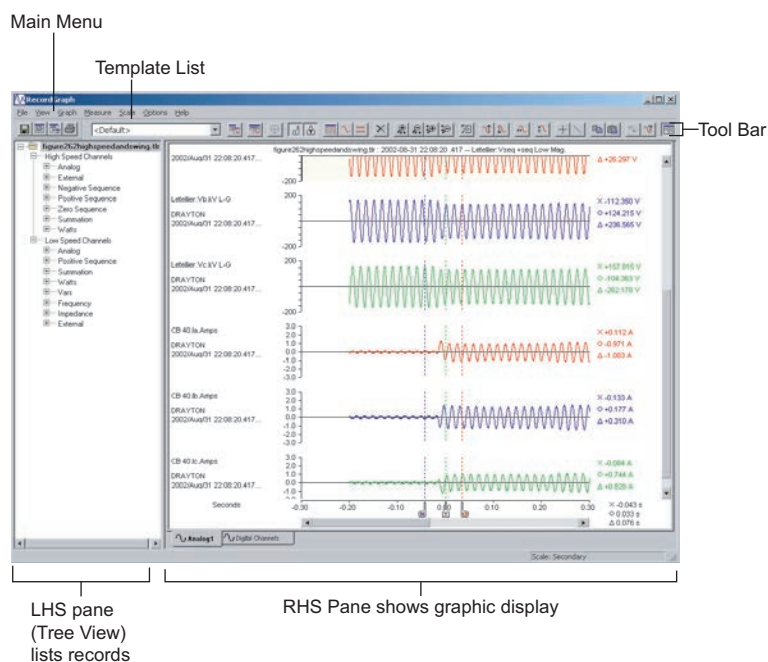


Figure 11.4: Components of RecordGraph Window

Menus

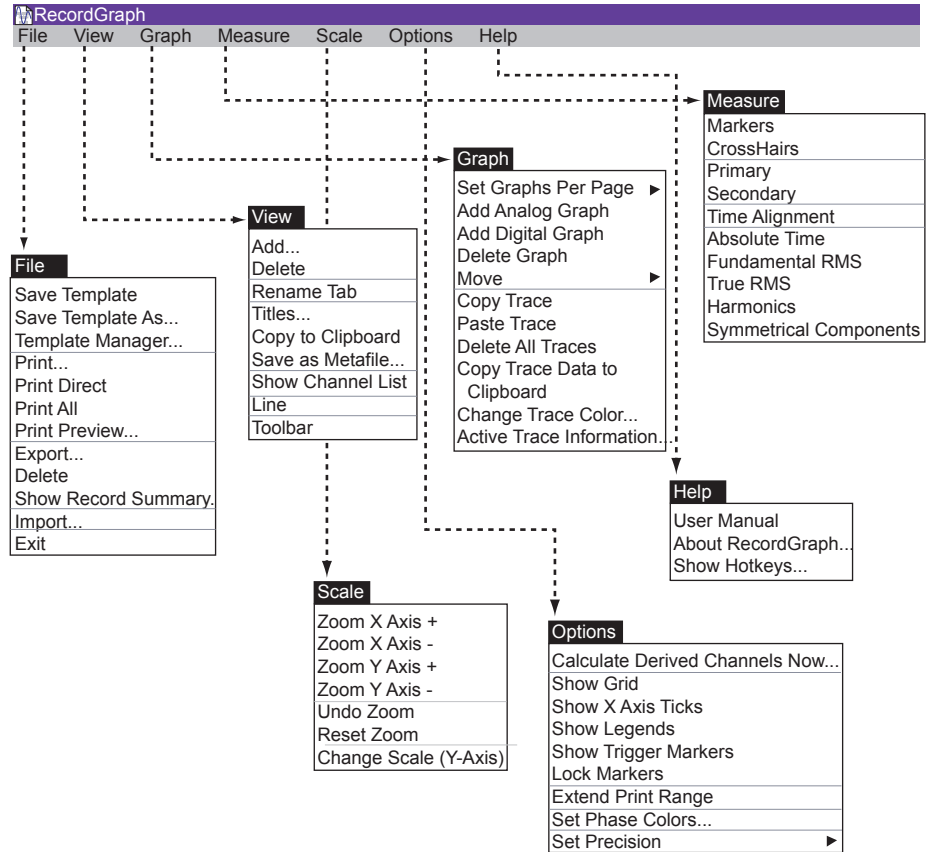


Figure 11.5: Menus

RecordGraph Menu Items

File Menus

File>Save Template

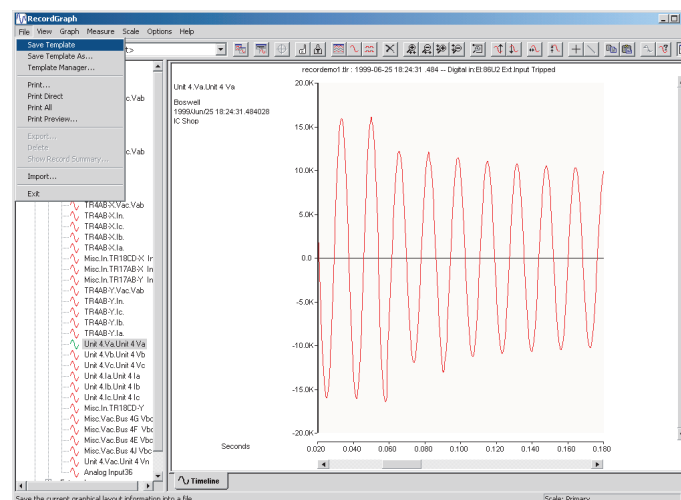


Figure 11.6: Save Template

Use this option to save the current graphical layout information to a file (see “Templates” on page 11-56 for further explanations on templates and their role in graphical analysis).

When this option is chosen and if there are no templates in the template list, then a *Save As Template* dialog box is displayed. Otherwise, the current layout information is saved in a file as shown in the template list box.

File>Save Template As...

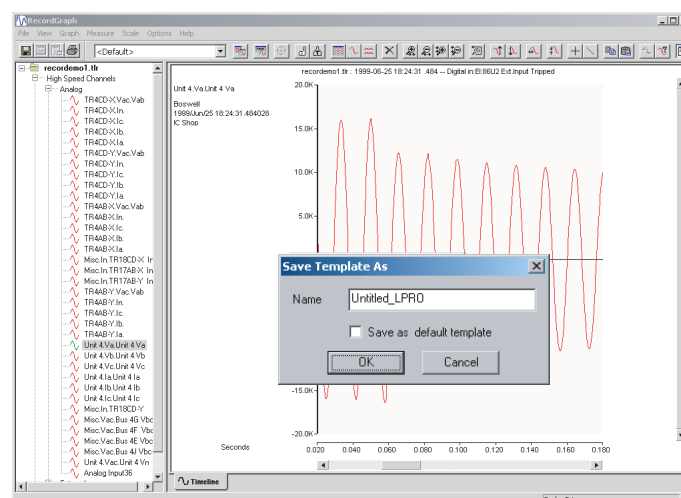


Figure 11.7: Save Template As

Save the current graphical layout information in a different file. A dialog box is displayed to choose the template file name. The check box, save as default

template, if checked, saves the current template as a user-defined default template (see “Templates” on page 11-56).

File>Template Manager

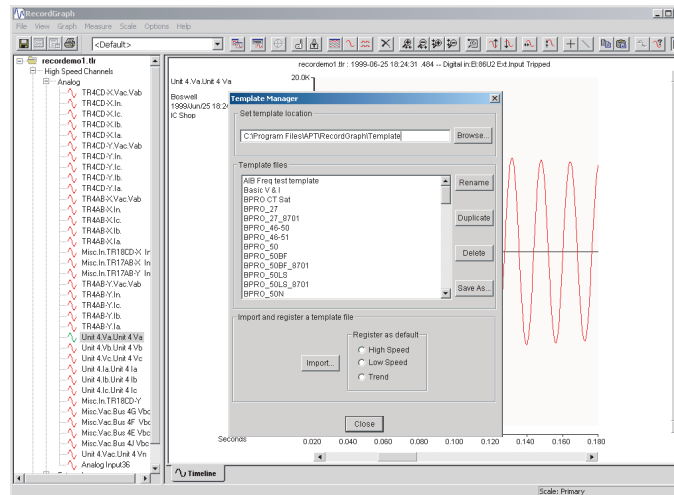


Figure 11.8: Template Manager

Rename, duplicate, save as, import or delete template files. A dialog box is displayed to manage the template files (see “Templates” on page 11-56).

File>Print

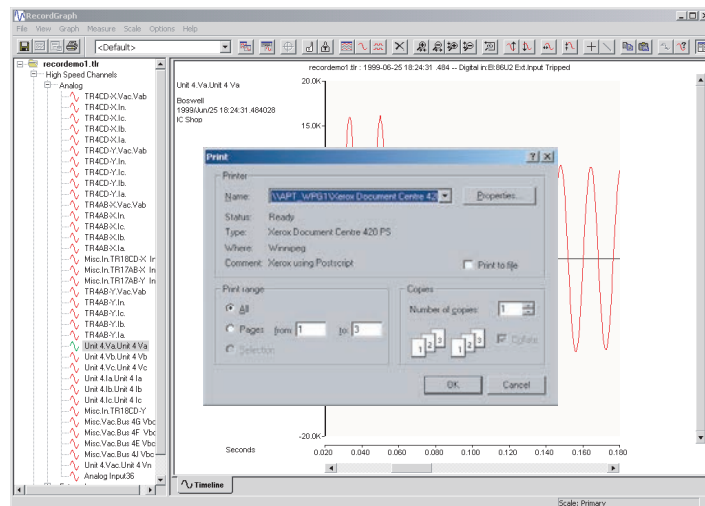


Figure 11.9: Print

Print the active (visible) view. Use this option to select the type of the printer and other configurations associated with it through the standard print dialog box options.

File>Print Direct

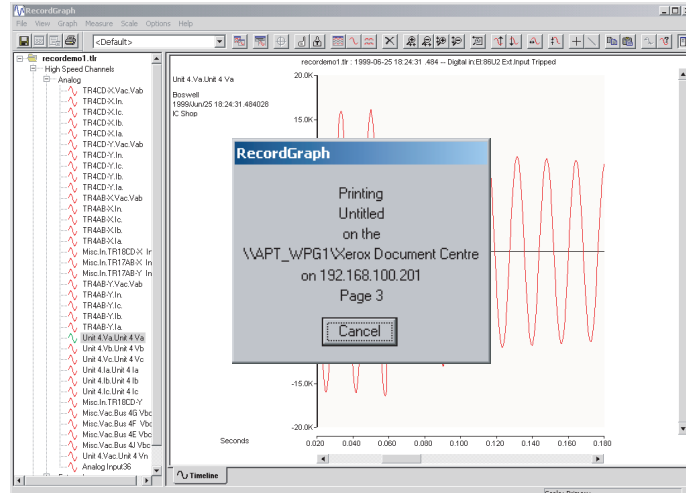


Figure 11.10: Print Direct

Send the active view directly to the default printer. When this option is chosen, the standard print dialog box is not displayed. The active view is sent directly to the default printer for printing, but you can cancel the printing if the print status dialog box is displayed.

File>Print All

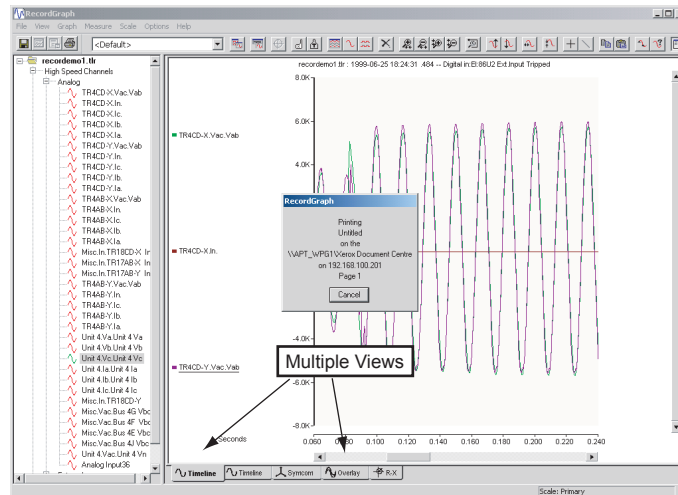


Figure 11.11: Print All

Send all the pages of all the views to the default printer. Select this option to print multiple views (visible and invisible) to the default printer.

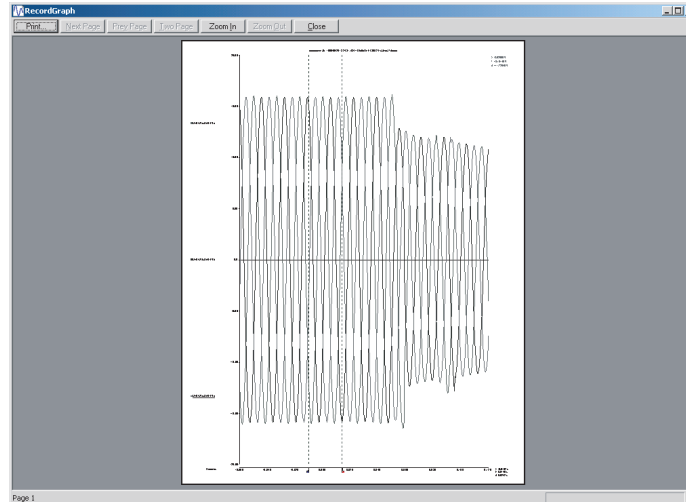
File>Print Preview

Figure 11.12: Print Preview

Display the print preview window of the active view page.

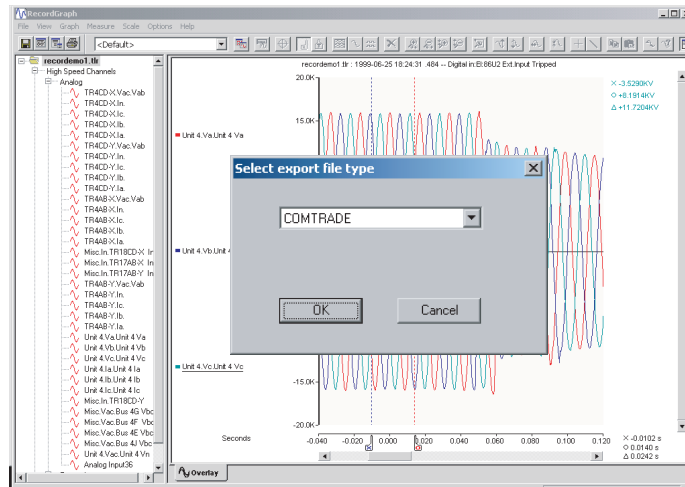
File>Export

Figure 11.13: Export

Export the selected record to a user-defined format, for details see 12 Record Export Utility on page 1.

File>Delete

Delete the currently selected record from the tree view. This option does not clear the view associated with the record.

File>Show Record Summary

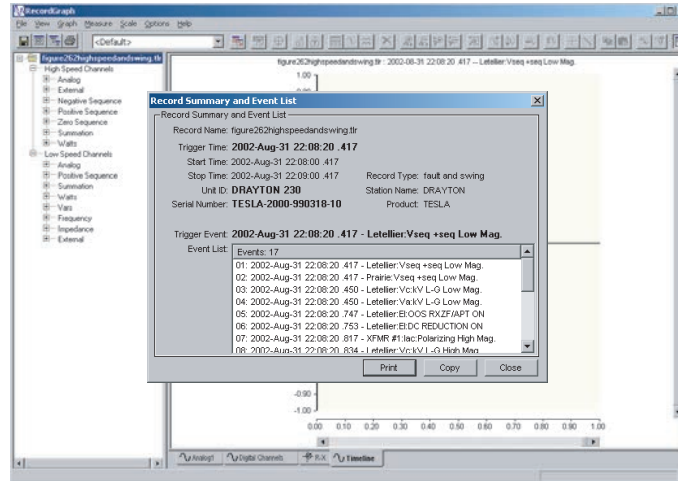


Figure 11.14: Show Record Summary

Display the record summary and the event list of the active record in a dialog box.

File>Import

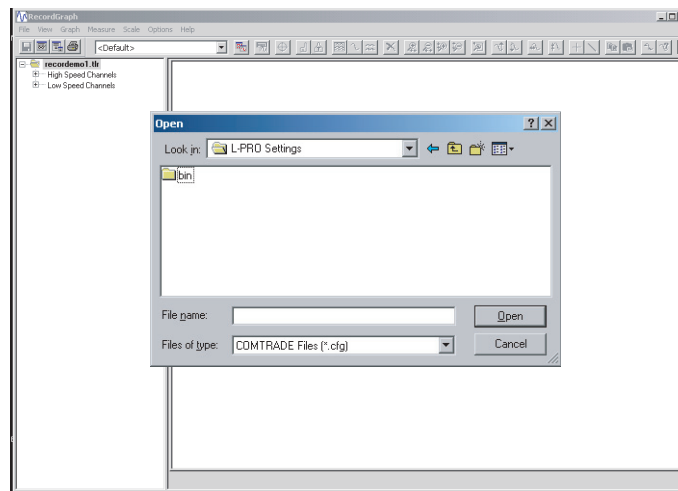


Figure 11.15: Import

Choose this option to import a COMTRADE file and display a standard open file dialog box to select *.cfg COMTRADE files.

File>Exit

Exit the RecordGraph application. Save your graphical layout information before selecting this option.

View Menus

View>Add

Create a new view and add it to the existing layout (see “Views” on page 11-32).

View>Delete

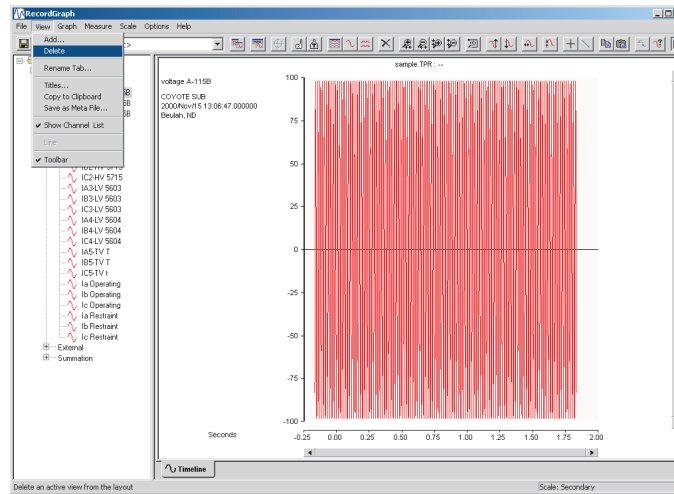


Figure 11.16: Delete

Delete an active view from the layout. When you select this option, a dialog box appears to confirm the deletion of the view. If accepted, the current view is deleted from the layout.

View>Rename Tab

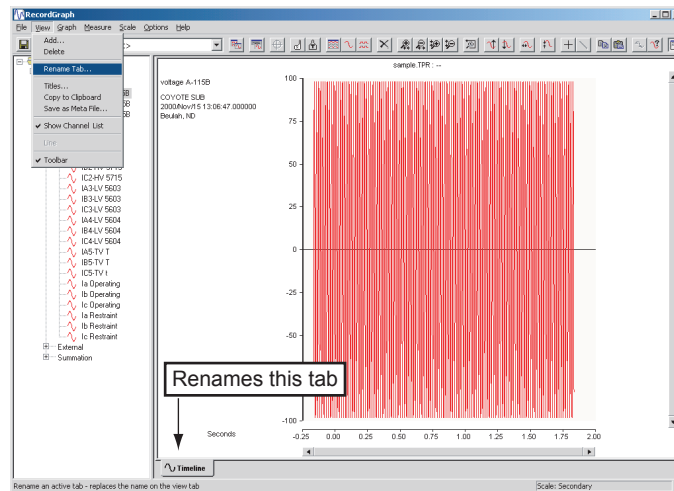


Figure 11.17: Rename Tab

Replaces the name on the active view tab with one of your choice. A dialog box appears to enter the name.

View>Titles

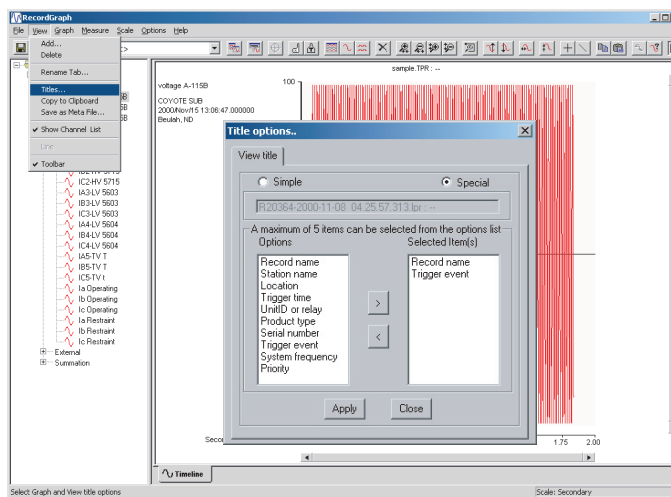


Figure 11.18: Titles

Select graph and view titles options to compile titles and various options (see “View and Graph Titles” on page 11-62).

View>Copy to Clipboard

Copy an active view to the clipboard for import to another program such as MS Word or Excel, for details see 12 Record Export Utility on page 1.

View>Save As Metafile

Save an active view page as a Windows metafile, for details see 12 Record Export Utility on page 1.

View>Show Channel List

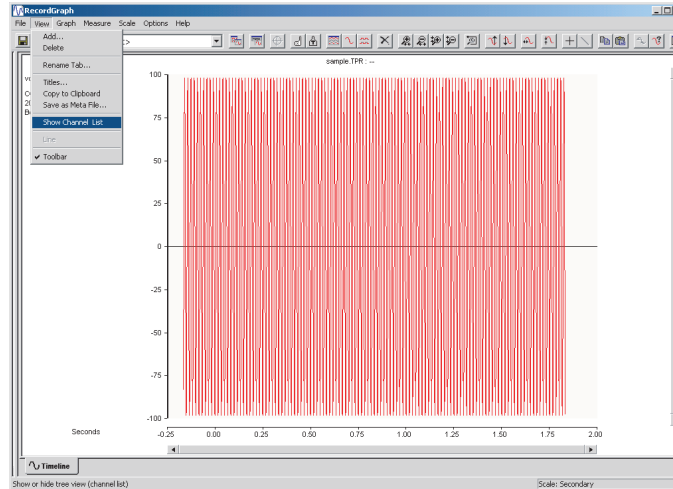


Figure 11.19: Show Channel List

Hide or show the channel list displayed in the tree view.

View>Line

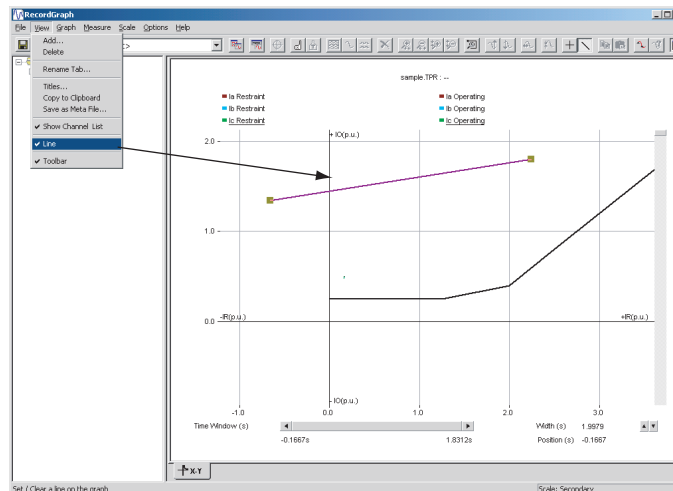


Figure 11.20: Line

Place a reference line on the graph (for Impedance and Differential views only). Use Line in conjunction with the CrossHair measurement for quick read-outs. When you choose this option free form zooming is disabled. Clear the line to enable free form zooming.

View > Tool Bar

Show or hide tool bar from the main window.

Graph Menus

Graph>Set Graphs Per Page

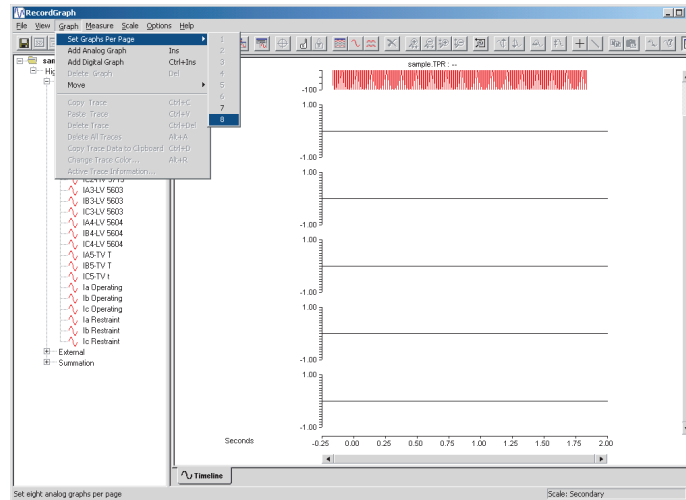


Figure 11.21: Set Graphs Per Page

Set up the number of graphs per view; up to eight graphs are allowed using the Set Graphs Per Page option. Timeline, Overlay and Trend Views allow a maximum of 36 graphs. Use *Add Analog Graph* or the *Insert* key to add one graph at a time.

Graph>Add Analog Graph

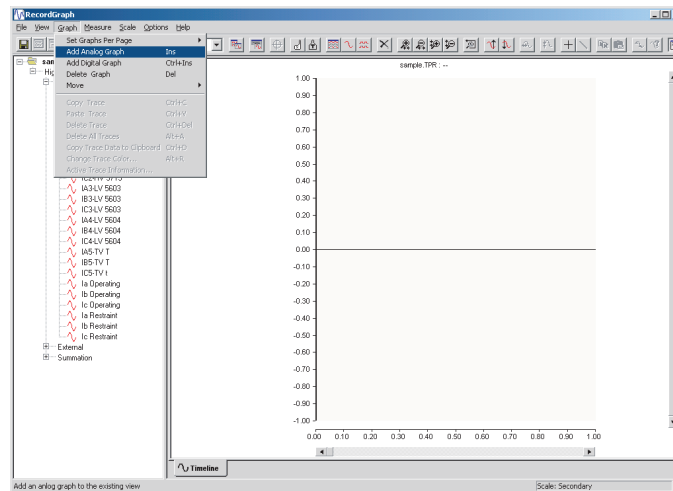


Figure 11.22: Add Analog Graph

Add an analog graph to the existing view or use the *Insert* key.

Graph>Add Digital Graph

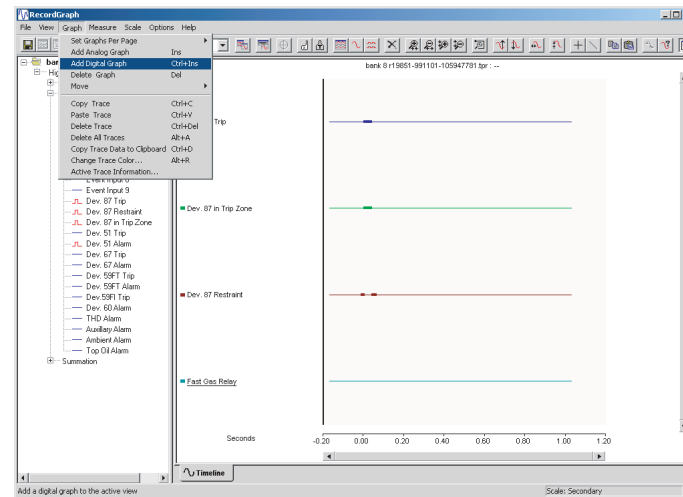


Figure 11.23: Add Digital Graph

Add a digital graph to the existing view. This graph shows the digital status information in the form of thick or thin stacked traces. You can plot up to 32 traces in a single graph.

Graph>Delete Graph

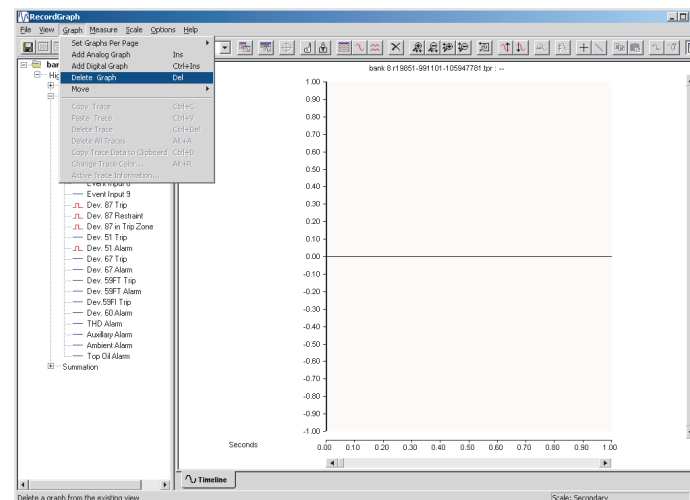


Figure 11.24: Delete Graph

Delete an active graph (click any graph to make it active) from the existing view or use the *Delete* key.

Graph>Move

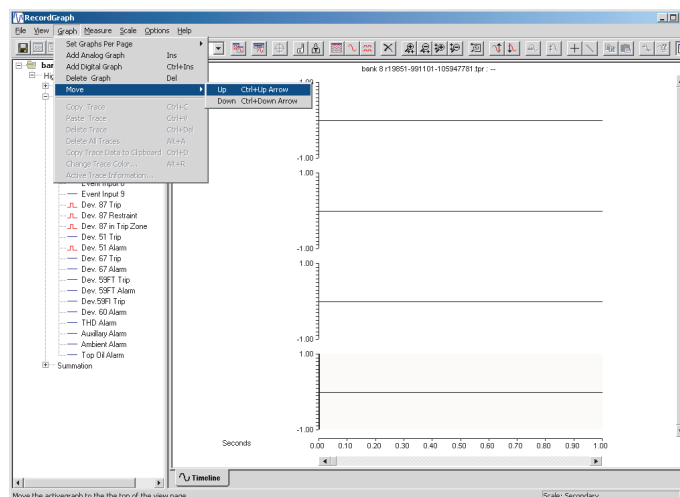


Figure 11.25: Move

Rearrange the relative position of the graphs in the active view page. First select the graph and use either the *Move>Up* or *Move>Down* option to change the position of the graph.

Graph>Copy Trace

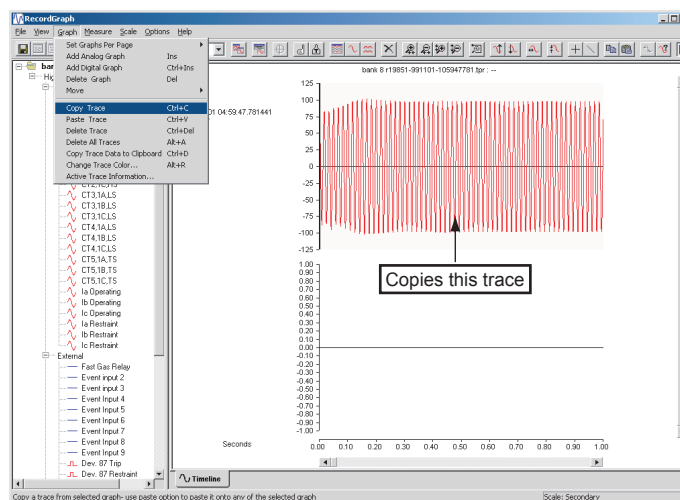


Figure 11.26: Copy Trace

Copy an active trace from the selected graph. Use this option in conjunction with the paste trace option. You need at least one channel on a graph to use the copy operation.

Graph>Paste Trace

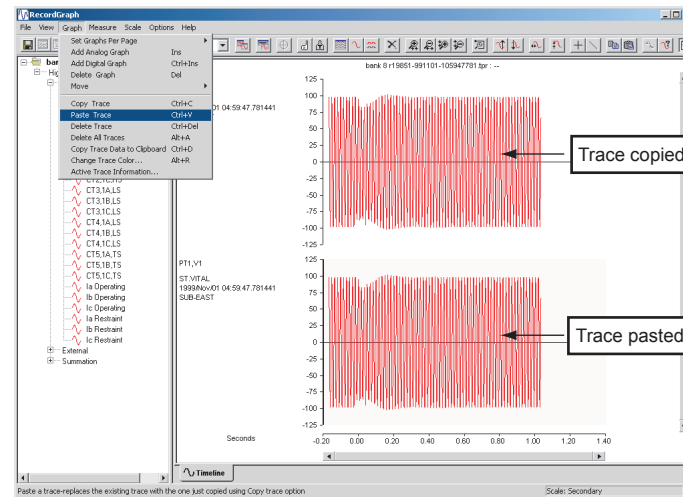


Figure 11.27: Paste Trace

Add or replace an existing trace in the selected graph. In Timeline View an analog graph supports one trace per graph. In an Overlay View you can select up to 32 traces per graph. If you use the paste operation in Timeline View, and if the graph has a trace, it is replaced with the one just copied or adds the trace if there is no trace. In Overlay View it adds the trace to the existing graph.

Graph>Delete Trace

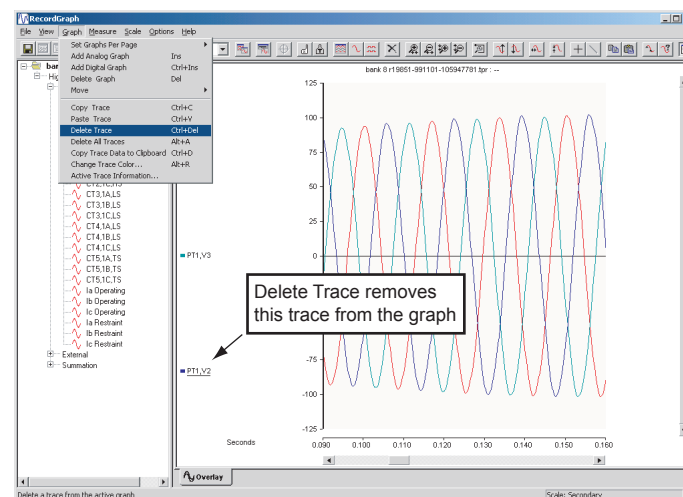


Figure 11.28: Delete Trace

Select a graph and the trace to be deleted and use *Delete Trace* to delete from the active graph. In the case of Overlay View a graph can have multiple traces. You can select a trace by clicking on the channel name and use delete trace option to delete the selected trace.

Graph>Delete All Traces

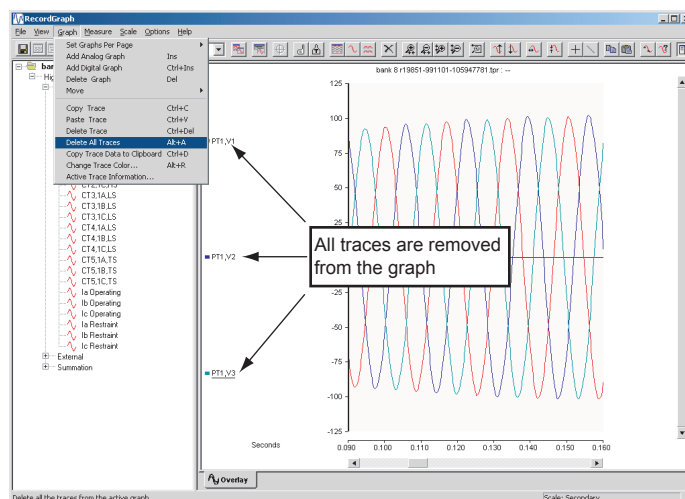


Figure 11.29: Delete All Traces

Deletes all the traces from the active graph. In an Overlay view this action removes all the traces.

Graph>Copy Trace Data to Clipboard

Copy trace data from the active graph to the clipboard (see “Exporting Channel Data” on page 11-73).

Graph>Change Trace Color

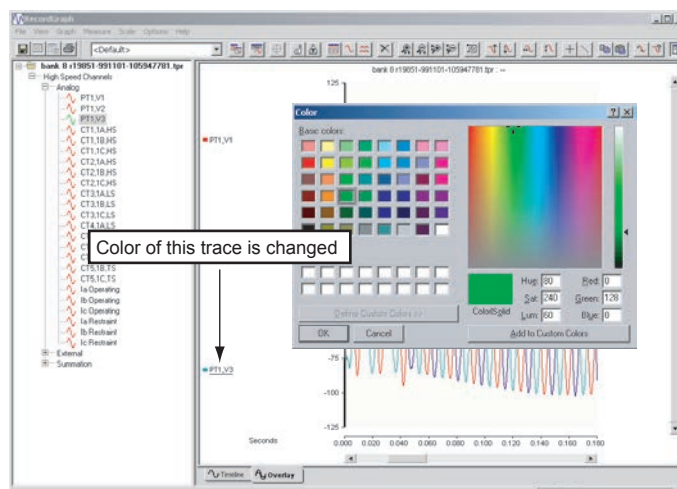


Figure 11.30: Change Trace Color

Change the trace color of the selected trace. In the Overlay View this option only changes the color of the active trace.

Graph>Active Trace Information

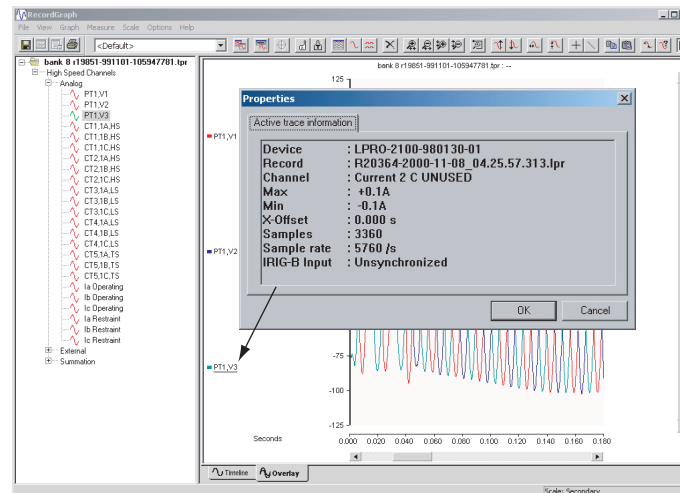


Figure 11.31: Active Trace Information

Display the trace information of the active graph.

Measure Menus

Measure>Markers

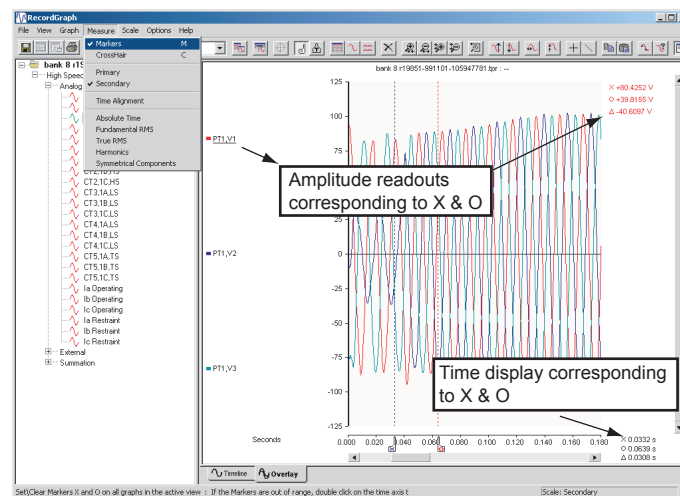


Figure 11.32: Markers

Set or clear markers X and O on all graphs in the active view. If the markers are out of range, double-click the time axis to bring them back into the view. When markers are placed, depending on the type of measurements option, readouts appear on the right hand side as shown corresponding to the positions of X and O marker. In case of multiple traces, the readout refers to the currently active (selected) trace.

Measure>CrossHair

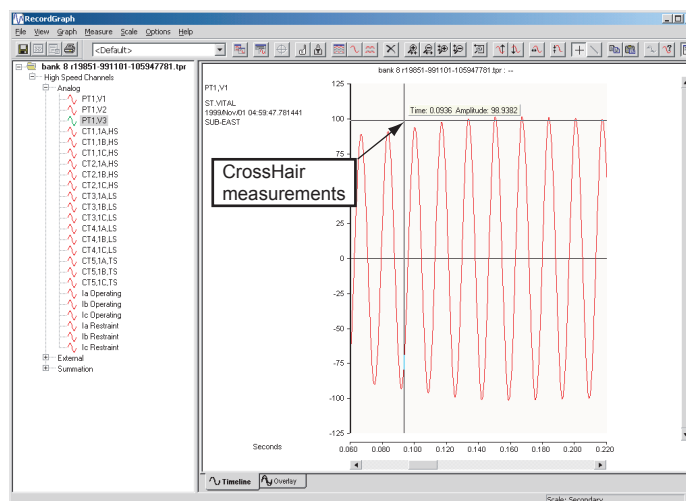


Figure 11.33: CrossHair

Set or clear crosshair cursor measurement by dragging the mouse (left-click and move) anywhere on the graph to display the readout. The difference between the marker and crosshair readout is that the marker values correspond to the data values, whereas the crosshair measurement corresponds to the x and y coordinates. When this option is selected, you can measure coordinates of any graph in the active view.

Measure>Primary

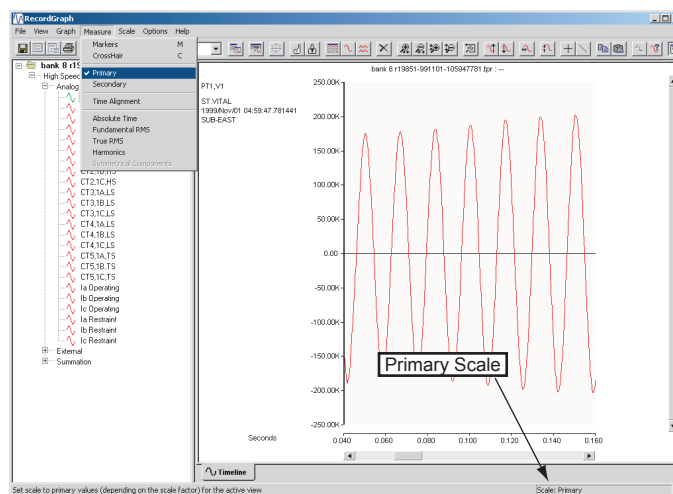


Figure 11.34: Primary

Set scale to primary values (depending on the scale factors CT/PT ratios) on all the graphs in the currently active view. The current choice (primary or secondary) is displayed on the status bar.

Measure>Secondary

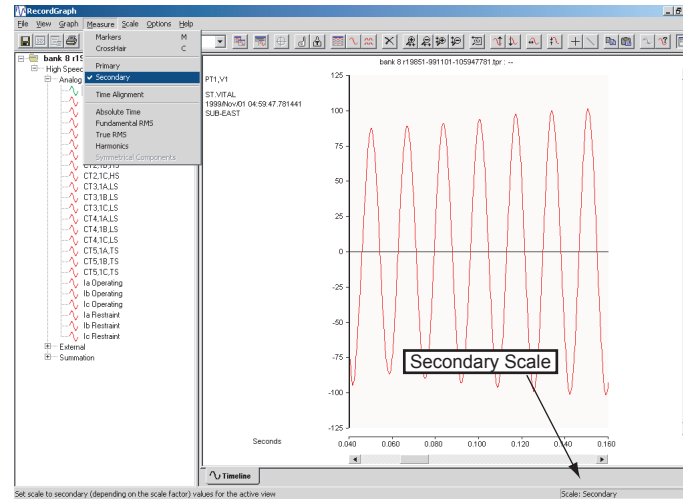


Figure 11.35: Secondary

Set scale to secondary values (depending on the scale factor of CT/PT ratios) on all the graphs in the currently active view. The current choice (primary or secondary) is displayed on the status bar.

Measure>Time Alignment

Offset X axis (trigger time alignment) for the currently active trace on the graph (see “Readouts and Measurements” on page 11-64).

Measure>Absolute Time

Display absolute time (actual recorded time) measurements for the active trace of the graph (see “Readouts and Measurements” on page 11-64).

Measure>Fundamental RMS

Display fundamental RMS measurement for the active trace of the graph (see “Readouts and Measurements” on page 11-64).

Measure>True RMS

Display true RMS measurement for the active trace of the graph (see “Readouts and Measurements” on page 11-64).

Measure>Harmonics

Display harmonics measurement – up to 5th order and THD expressed in percent with reference to the fundamental (the highest order harmonic included in THD depends on the sample rate). See table 7.1 and 7.2 on page 7-6) for the active trace of the graph (see “Readouts and Measurements” on page 11-64).

Measure>Symmetrical Components

Display symmetrical components measurement for the active graph. You must select a, b and c phase quantities in Overlay View to enable this option (see “Readouts and Measurements” on page 11-64).

Scale Menus

Scale>Zoom X Axis +

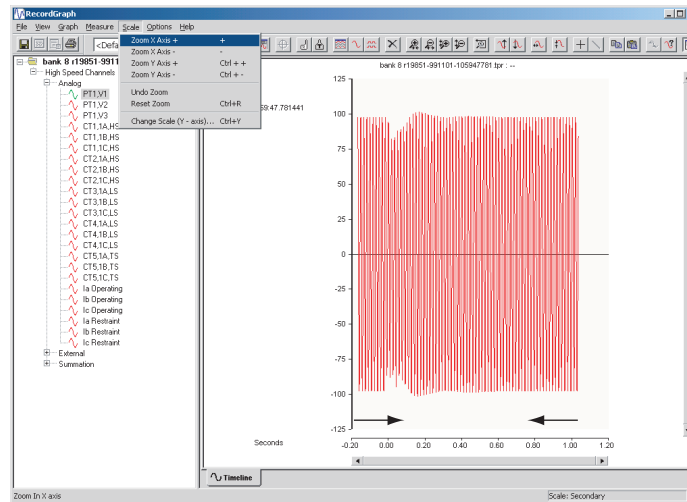


Figure 11.36: Zoom X Axis +

Select this option to decrease the x axis range by 25% of the current zoom range.

Scale>Zoom X Axis -

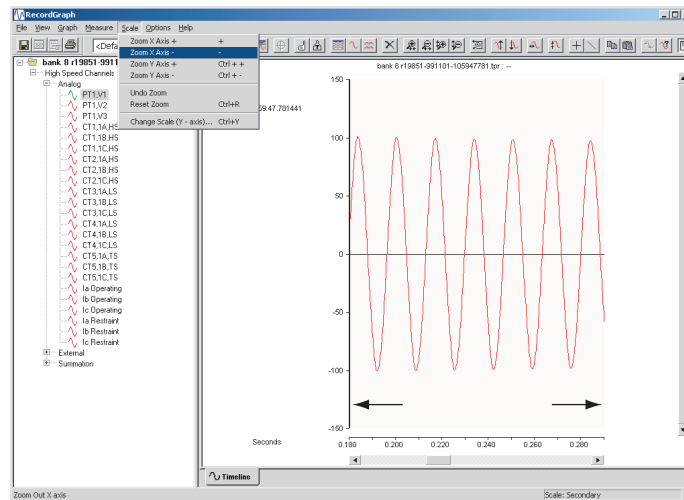


Figure 11.37: Zoom X Axis -

Select this option to decrease the x axis range by 25% of the current zoom range.

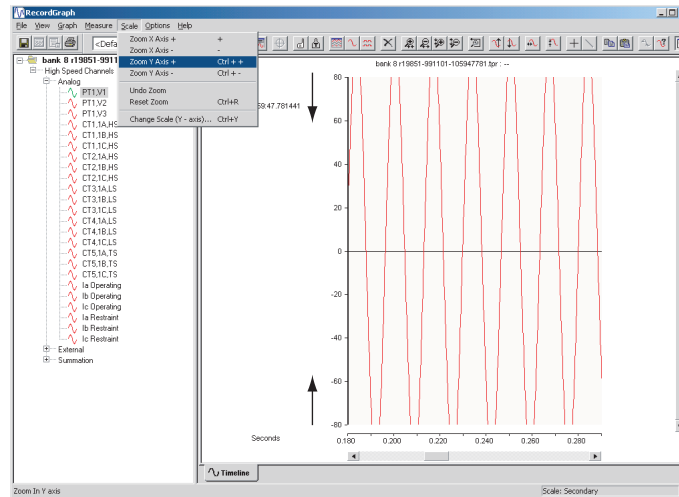
Scale>Zoom Y Axis +

Figure 11.38: Zoom Y Axis +

Select this option to decrease the y axis range by 25% of the current zoom range.

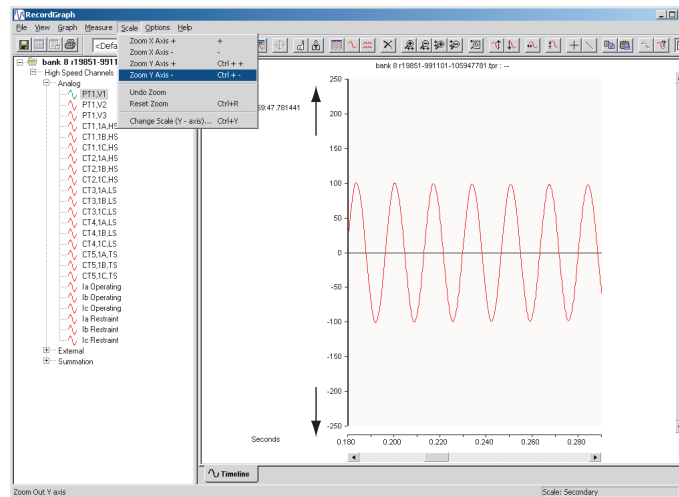
Scale>Zoom Y Axis -

Figure 11.39: Zoom Y Axis -

Select this option to increase the y axis range by 25% of the current zoom range.

Scale>Undo Zoom

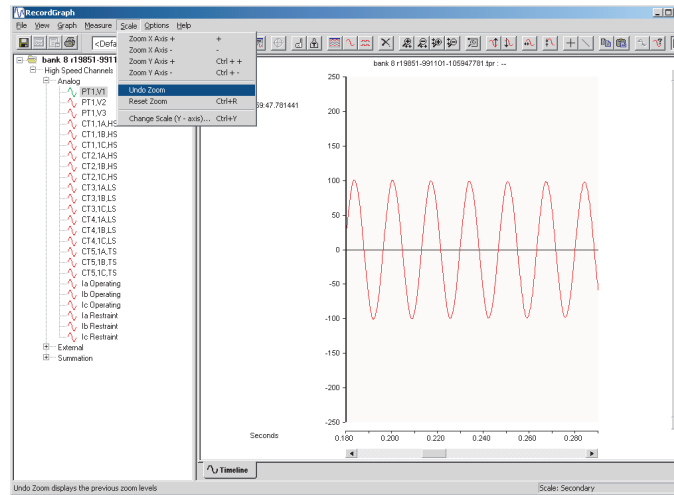


Figure 11.40: Undo Zoom

Display the previous zoom level.

Scale>Reset Zoom

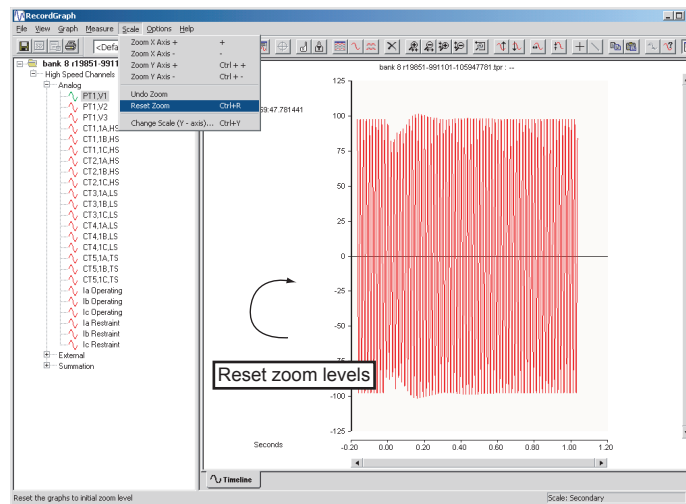


Figure 11.41: Reset Zoom

Reset the graphs to the initial zoom level.

Scale>Change Scale (Y Axis)

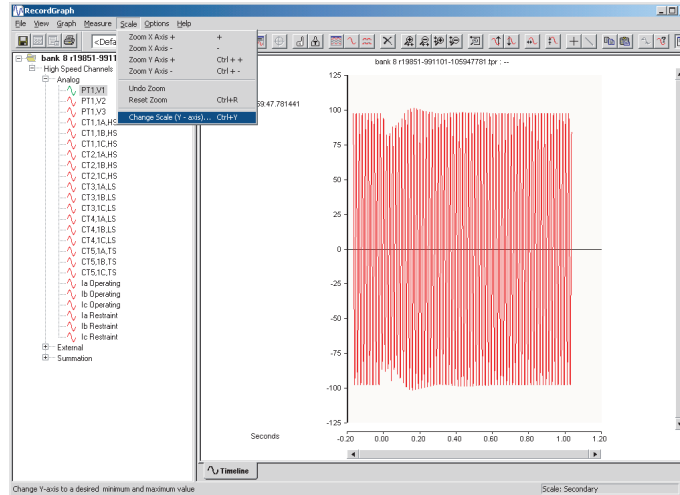


Figure 11.42: Change Scale (Y Axis)

Change Y axis to a desired minimum and maximum value using the dialog box to set the new values. If the manual scale option is checked, the y axis is not rescaled to new data values; the trace is displayed within the selected range. You can set the desired scaling, save the options in the template and recall the template for other recordings (see “Templates” on page 11-56).

Options Menus

Options>Calculate Derived Channels Now

Use this option to calculate the derived channels and append to the record as virtual channels. For TESLA records the data is written back to the original record so that the next time the record is viewed all the derived channel information is readily available (see “Calculated Channels” on page 11-71).

Options>Show Grid

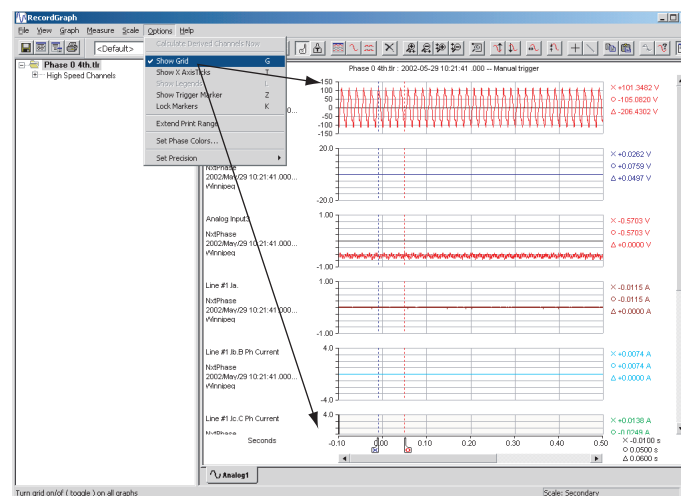


Figure 11.43: Show Grid

Turn grid on or off on all graphs.

Options>Show X Axis Ticks

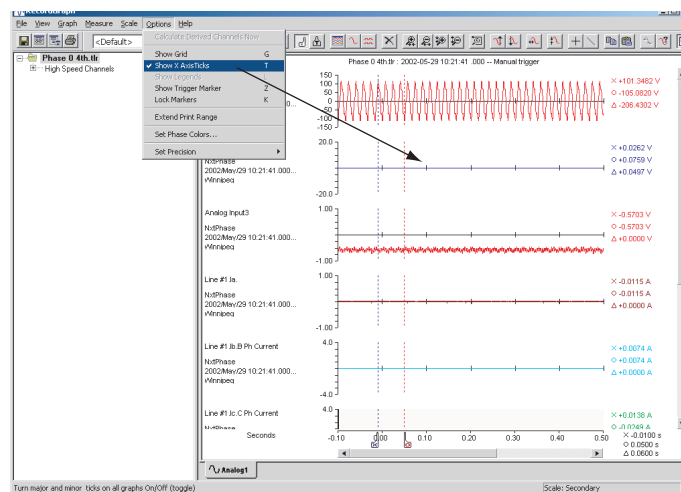


Figure 11.44: Show X Axis Ticks

Show X axis ticks on all graphs.

Options>Show Legends

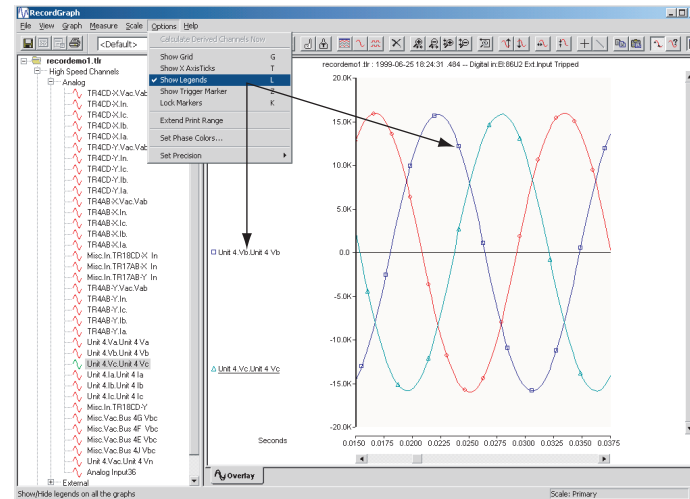


Figure 11.45: Show Legends

Show or hide legends on all the graphs.

Options>Show Trigger Marker

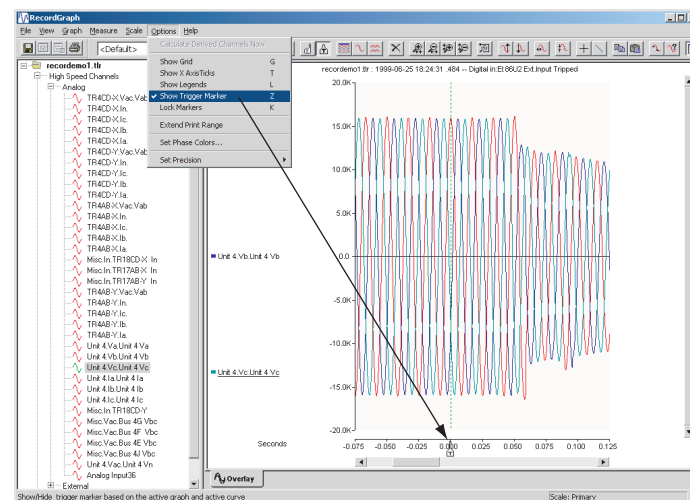


Figure 11.46: Show Trigger Marker

Show or hide trigger marker on the active graph and active curve.

Options>Lock Markers

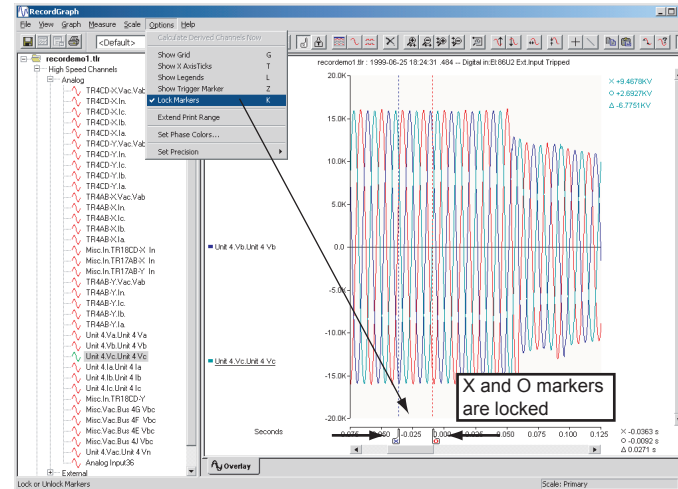


Figure 11.47: Lock Markers

Lock or unlock X and O markers.

Options>Extend Print Range

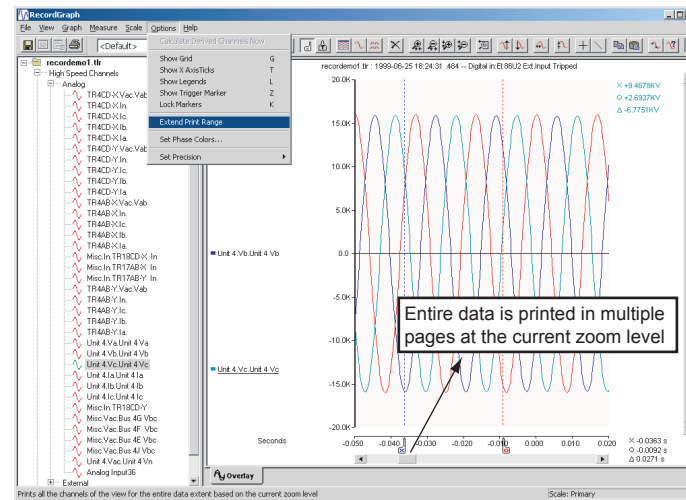


Figure 11.48: Extend Print Range

Print all the channels of the view for the entire data range in the current zoom level.

Options>Set Phase Colors

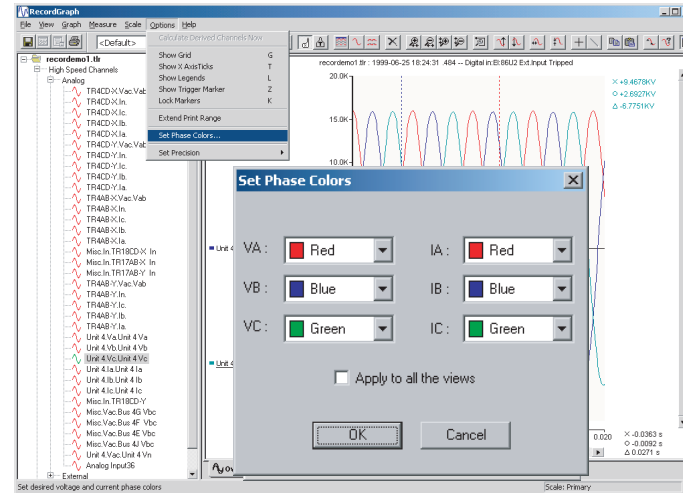


Figure 11.49: Set Phase Colors

Use this option to select user-defined colors for A, B and C phase voltages and currents. When the colors are selected, the channels are automatically identified based on the color. The default values for A, B and C phase quantities are red, blue and green respectively.

Options>Set Precision

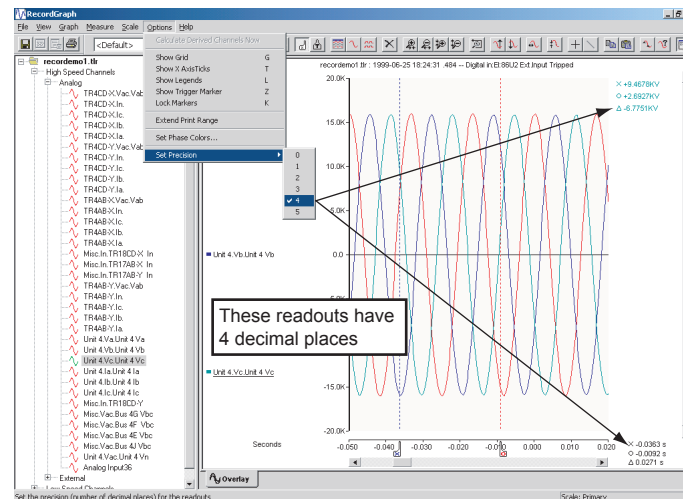


Figure 11.50: Set Precision

Set the precision (number of decimal places) for the readouts. In Symmetrical Component and Harmonic Views, the phase angle readout precision is always zero (no decimal places are used).

Help Menus

Help>User Manual

Select to display an electronic version of the user manual.

Help>About RecordGraph

Display program information, version number and copyright.

Help>Show Hot Keys

Lists the available hot keys or short cuts.

Tool Bar Buttons

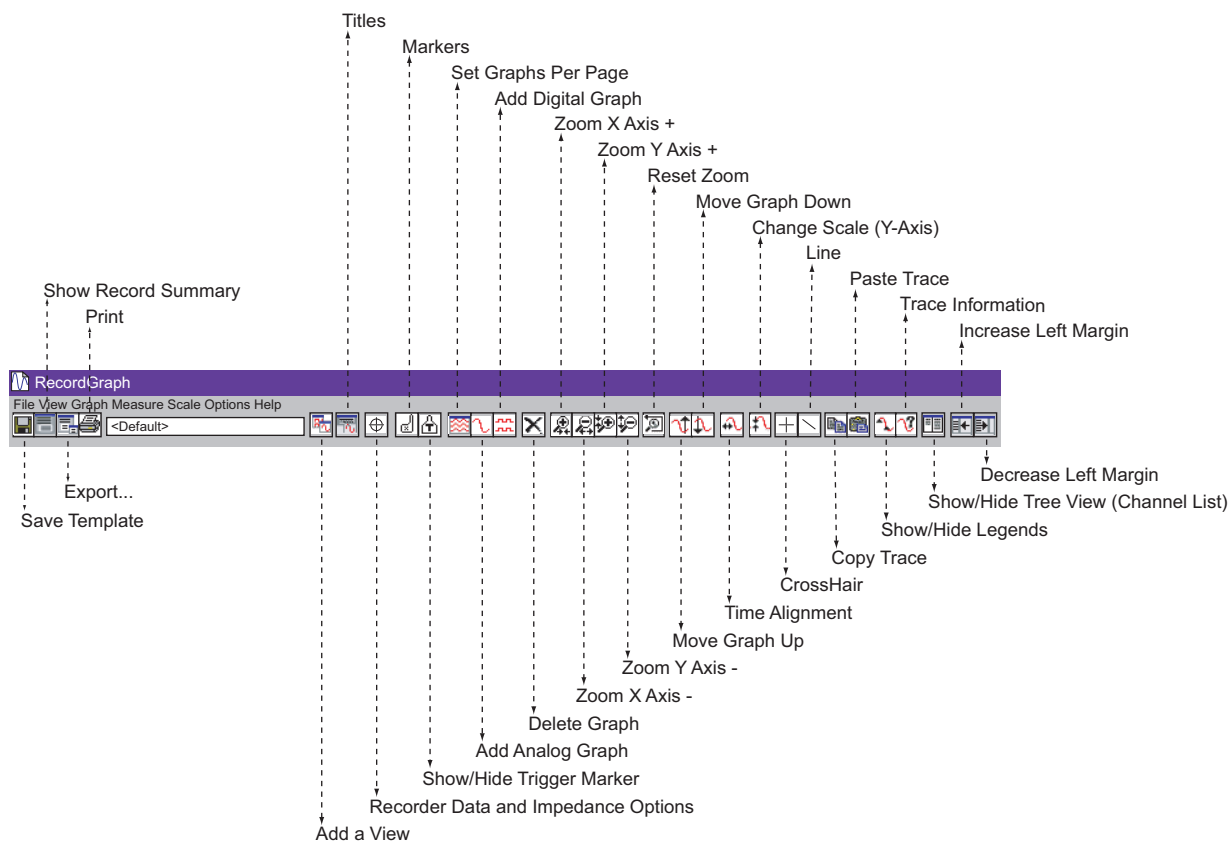


Figure 11.51: Tool Bar Buttons

In the Tree View, you can expand a loaded record to identify the recorded and calculated channels (if configured). A right-click menu is available to manipulate the tree items. Most of the tool bar buttons work in a similar way to that of the menu items explained in the previous sections.

Tool Bar Buttons	
Save Template	Save template file on the disk.
Show Record Summary	Displays record summary (events, trigger time, etc.)
Export	Brings up export module.

Print	Prints record.
Add a View	Adds a graph view that displays the fault information.
Titles	Places a title above graph for all views (see Figure 11.88: View Title Options).
Impedance	Creates an R-X plot before, during and after fault.
Markers	Displays vertical lines "x" and "o" to find the coordinate values on the graph.
Show/Hide Trigger Marker	Displays/hides zero trigger marker.
Set Graphs Per Page	Sets number of graphs per page.
Add Analog Graph	Add an analog graph.
Add Digital Graph	Add a digital graph.
Delete	Delete a graph.
Zoom X Axis +	Enlarges the trace range on X axis.
Zoom X Axis -	Reduces the trace range on X axis.
Zoom Y Axis +	Enlarges the trace range on Y axis.
Zoom Y Axis -	Reduces the trace range on Y axis.
Reset Zoom	Resets zoom control.
Move Graph Up	Vertically moves graph upwards.
Move Graph Down	Vertically moves graph downwards.
Time Alignment	Offset X axis time value.
Change Scale (Y Axis)	Scale Y axis minimum and maximum range.
CrossHair	Displays X and Y coordinate values.
Line	Available only for impedance view, draws a reference line.
Copy Trace	Copies a trace to another location.
Paste Trace	Pastes a trace.
Show/Hide Legends	Displays/hides legends the traces.
Trace Information	Displays/hides channel information: Date, Station Name, RecordName, Channel Name.
Show/Hide Tree View Channel List	Expands and minimizes RHS of the screen.
Decrease Left Margin	Decreases left margin.
Decrease Right Margin	Decreases right margin.

Views

The view screen graphically displays information from the record. A view is associated with a tab at the bottom of the screen which can be renamed using the Rename tab. You can create a maximum of 30 view tabs.

Add a View

Add new view to layout.

- 1 Select the *View>Add...* from the top menu bar or the *Add...* button from the tool bar.
- 2 Select the desired view from the shortcut menu.
- 3 Click *OK*.

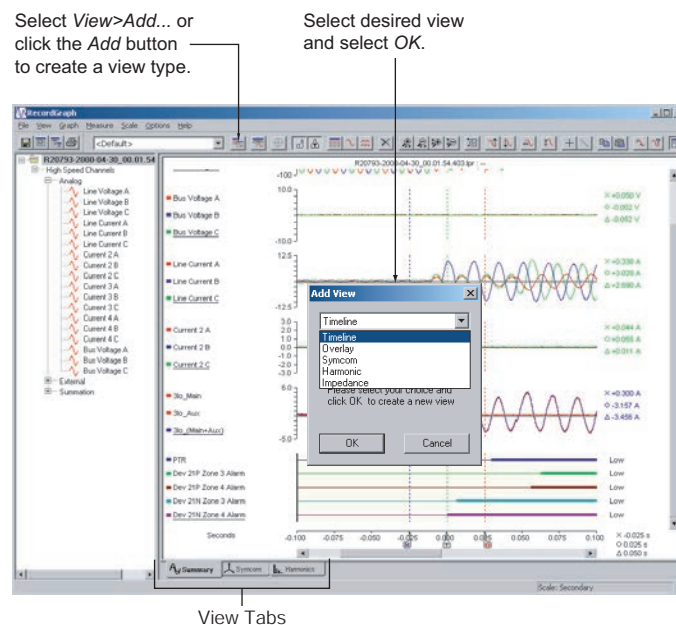


Figure 11.52: Add a View

The *Add View...* option lists Impedance View only if the selected record is from an L-PRO, TESLA or COMTRADE record.

Delete a View

Clears active view from layout.

- 1 Select the *View>Delete* from top menu bar. A shortcut menu asks you to confirm the deletion.
- 2 Click *OK* to confirm. Click *Cancel* to stop deletion.

Rename a View

Use this option to rename the active tab which is displayed at the bottom of the view.

- 1 Select the *View>Rename Tab* from top menu bar or right-click on the graph to bring up the context menu and select *Rename Tab*.
- 2 A dialog box appears with the old name. Modify and click *OK* to rename the view.

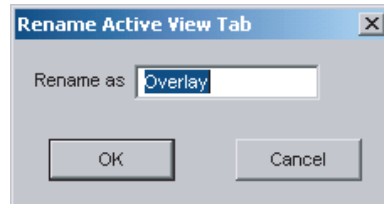


Figure 11.53: Rename Dialog Box

Show Channel List

Displays or hides the channel list on the left-hand side of the screen to allow more space for the graphs.

Toolbar

Displays or hides the toolbar on the left-hand side of the screen to allow more space for the graphs.

Graphs

The graph is an area or space in a view where each channel of analog or digital information is shown. The information is shown as X-Y data with X = time and Y = magnitude.

Adding Graphs

- 1 Select *Graph>Set Graphs Per Page* or right-click on the graph to bring up the context menu and select *Set Graphs Per Page* to add selected number of graphs to the Timeline View.
- 2 Select *Graph>Add Analog Graph* or right-click on the graph to bring up the context menu and select *Add Analog Graph* to add an analog graph to the Timeline View.
- 3 Select *Graph>Add Digital Graph* or right-click on the graph to bring up the context menu and select *Add Digital Graph* to add a digital graph to the Timeline View.

Adding Channels

- 1 Click the desired channel to be displayed on the graph.
OR
- 2 Drag a channel and drop it onto the desired graph.
- 3 Depending on the view type following action takes place:
 - In a Timeline View the existing channel is replaced and only one channel is allowed per graph.
 - In an Overlay View up to 32 traces can be placed per graph.
 - In a Trend View the existing channel is replaced and only one channel is allowed per graph.
 - External or digital channel should be placed on a digital graph to stack the traces. A maximum of 32 traces can be specified per graph.

Channel Tool-tip

When the cursor is moved over the channel name, following information is displayed in the tool-tip window.

- Device – name of the device (example, TESLA)
- Record – name of the record
- Channel – name of the channel
- Max – channel maximum value along with the unit
- Min – channel minimum value along with the unit
- X – Offset-whether the x-axis has offset (time alignment)
- Samples – number of samples
- Sample rate –samples /second
- IRIG-B status indicator

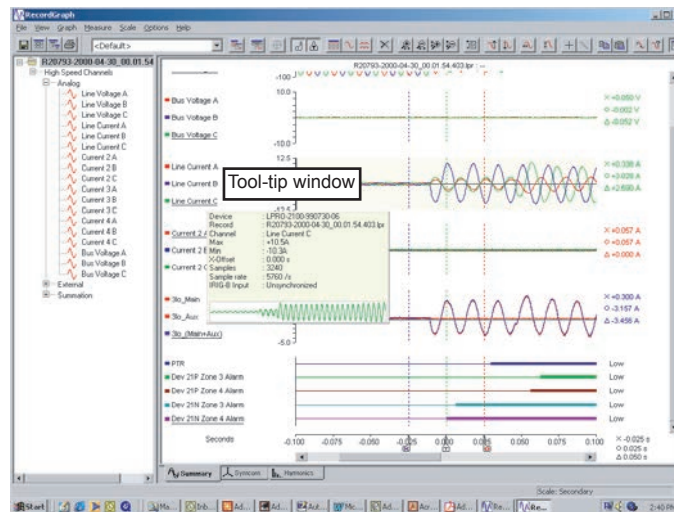


Figure 11.54: Tool-Tip

Zoom Using the Mouse

- 1 Left-click on any graph and drag to form a small box around the graph area.
- 2 When you release the mouse, the trace assumes new zoom position determined by the area of the zoom coordinates.

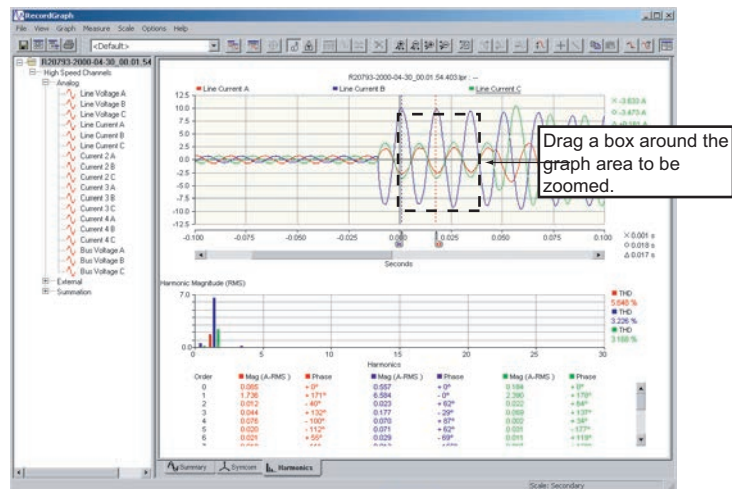


Figure 11.55: Select a Section of the Graph to Zoom

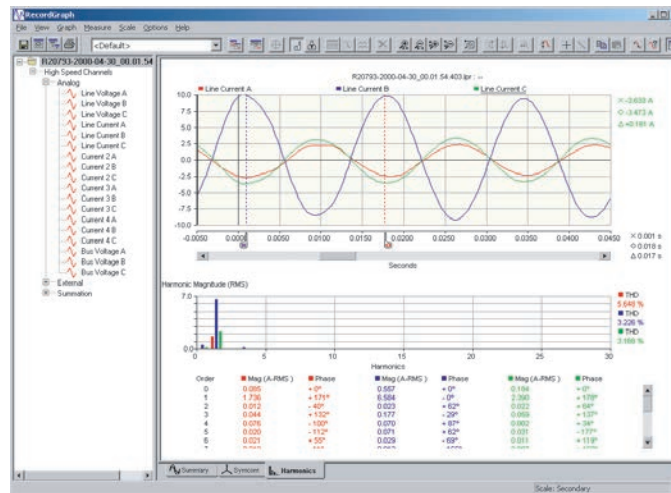


Figure 11.56: Portion of Zoomed Graph

Follow the procedure 1 and 2 for further zooming.

Zoom Using the Tool Buttons

You can also use Zoom X axis +, Zoom X axis -, Zoom Y axis + and Zoom Y axis - on the tool bar buttons to quick zoom in and zoom out (25%).

Repeat step 1 to zoom further.

Zoom only X or Y Axis

To zoom only the X axis, select *Ctrl* key and use the mouse to draw a box on the graph.

To zoom only the Y axis, select shift key down and use mouse to draw a box on the graph.

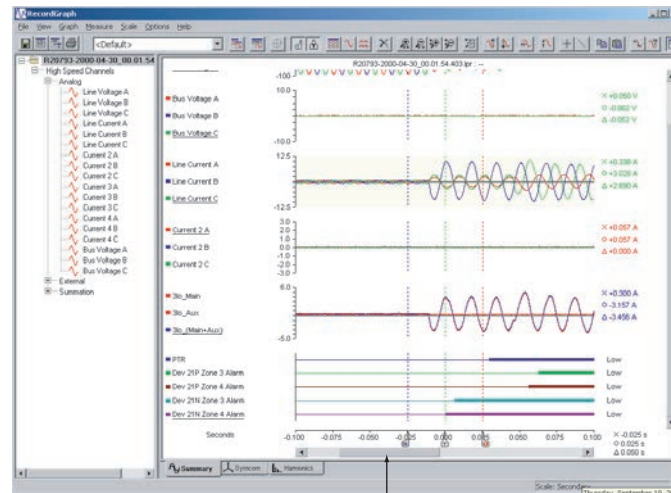
Undo Zoom on Graphs

- 1 Right-click on the graph to the context menu.
- 2 Select the *UndoZoom* option.
- 3 Graphs are redrawn to the previous zoom level.
- 4 Select *Reset Zoom* option to reset the graphs to the initial zoom level. This can be chosen at any stage.

Pan Graph

Zoom the graph (if not zoomed) to a required zoom level.

You should hold the “Thumb track” and move it along the scroll bar. To have fine control click on the right arrow scroll bar button or press *Shift* and click on the right arrow scroll button.



Thumb Track - move right/left to pan graph

Figure 11.57: Thumb Track

Keyboard Functions

The keyboard is also available for zooming, setting markers and positioning graphs. To display the keyboard hot key menu right-click on the graph and bring up the context menu, select *Show Hotkeys* option.

Hotkeys.....		
	Key	Function
1	Up Arrow	Select Graph Up
2	Down Arrow	Select Graph Down
3	Right Arrow	Move Marker 'X' Right
4	Left Arrow	Move Marker 'X' Left
5	Ctl+Right Arrow	Move Marker 'O' Right
6	Ctl+Left Arrow	Move Marker 'O' Left
7	Ctl+Left Mouse Drag	Zoom X - axis only
8	Shift+Left Mouse Drag	Zoom Y - axis only
9	+	ZoominX - (25%)
10	-	ZoomoutX - (25%)
11	Ctl+ +	ZoominY - (25%)
12	Ctl+ -	ZoomoutY - (25%)
13	Ctl+Up Arrow	Move active graph up
14	Ctl+Down Arrow	Move active graph down
16	Shift+RightArrow	Pan right by 10%
17	Shift+LeftArrow	Pan left by 10%

Figure 11.58: Hot Keys

Right-click Context Menu

✓ Markers	M
Undo Zoom	Ctrl+Z
Reset Zoom	Ctrl+R
Zoom	▶
Delete View	Alt+Del
Titles...	Ctrl+T
Rename Tab	F2
Set Graphs Per Page	▶
Add Analog Graph	Ins
Add Digital Graph	Ctrl+Ins
Delete Graph	Del
Move Graph	▶
Change Scale (Y - Axis)...	Ctrl+Y
Copy Trace	Ctrl+C
Paste Trace	Ctrl+V
Delete Trace	Ctrl+Del
Delete All Traces	Alt+A
Copy Trace Data to Clipboard	Ctrl+D
Change Trace Color...	Alt+R
Active Trace Information...	
Copy to Clipboard	Ctrl+B
Save as Meta File...	Ctrl+M
Print Graphs	Ctrl+P
Show Hotkeys...	

Figure 11.59: Right-Click Context Menu

Timeline View

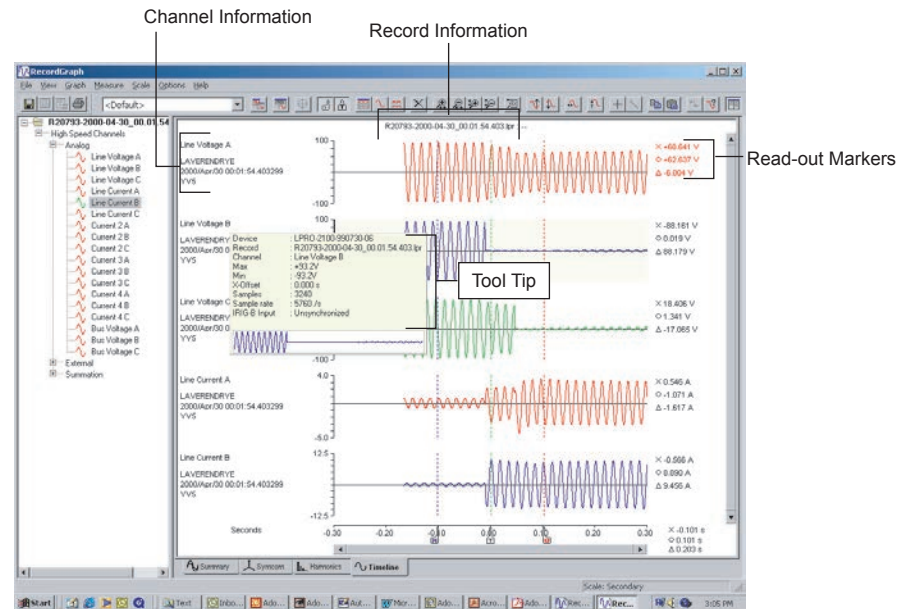


Figure 11.60: Timeline View

- Timeline View is designed to “stack” channels and has single time line axis common for all the graphs.
- Each analog graph in this view can hold only one trace.
- Each digital graph in this view can hold 32 traces (8 traces are preferred).
- Selecting a channel from the LHS tree view while the same graph is active replaces the existing channel with the currently selected one.
- A maximum of 32 graphs (analog and digital) can be added per view.
- You can mix and match channels from different records and/or IEDs.
- Time line view displays read-out (if markers are on) on the RHS and channel information on its LHS.
- Read-out corresponds to the currently selected channel type and the scale (primary/secondary) which is displayed on the status bar.

Overlay View

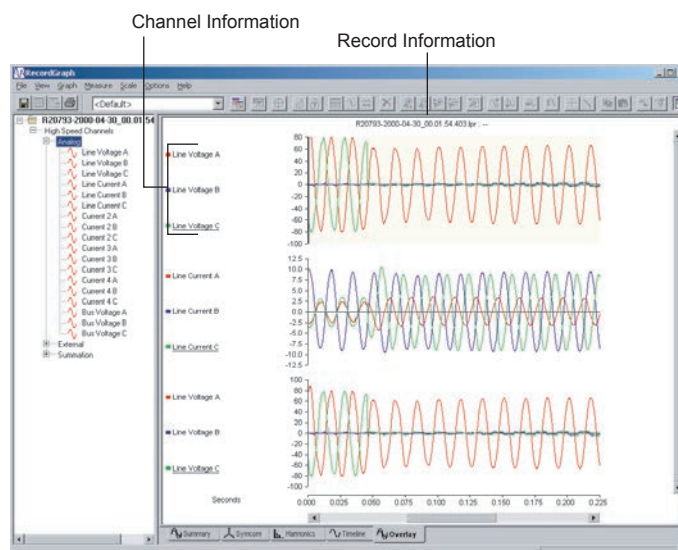


Figure 11.61: Overlay View

- Overlay View is designed to “overlay” channels and has single time line common axis for all the graphs.
- Each analog graph in a overlay view can hold 32 traces (3 traces are preferred).
- Each digital graph in this view can hold 32 traces (8 traces are preferred).
- Selecting a channel from the LHS tree view while the same graph is active overlays the channel on the selected graph.
- A maximum of 32 graphs can be added per view.
- You can mix and match channels from different records and/or IEDs. Time line view displays read-out (if markers are on) on the RHS and channel information on its LHS.
- Read-out corresponds to the currently selected channel type and the scale (primary/secondary) which is displayed on the status bar.

Symcom View

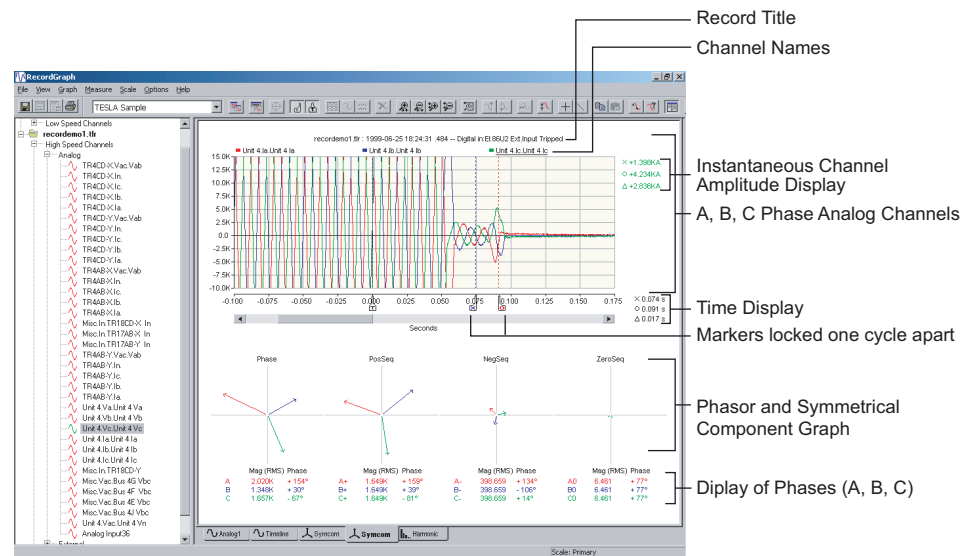


Figure 11.62: Symcom View

- Symcom View is designed to analyse symmetrical components of voltage or current channels.
- You must load 3 voltage or current channels to view the components and associated phasor plots from the same record.
- The view displays: analog channels, positive, negative, zero sequence phasors and corresponding table which contains numerical values of these components and phase angle.
- All the components are calculated in RMS values.
- Channel instantaneous values are displayed on the RHS of the analog graph.
- Markers are permanently set on the graph one-cycle apart.
- Grab the marker and move (on the time line axis) to display new set of components and phasor values.

Harmonic View

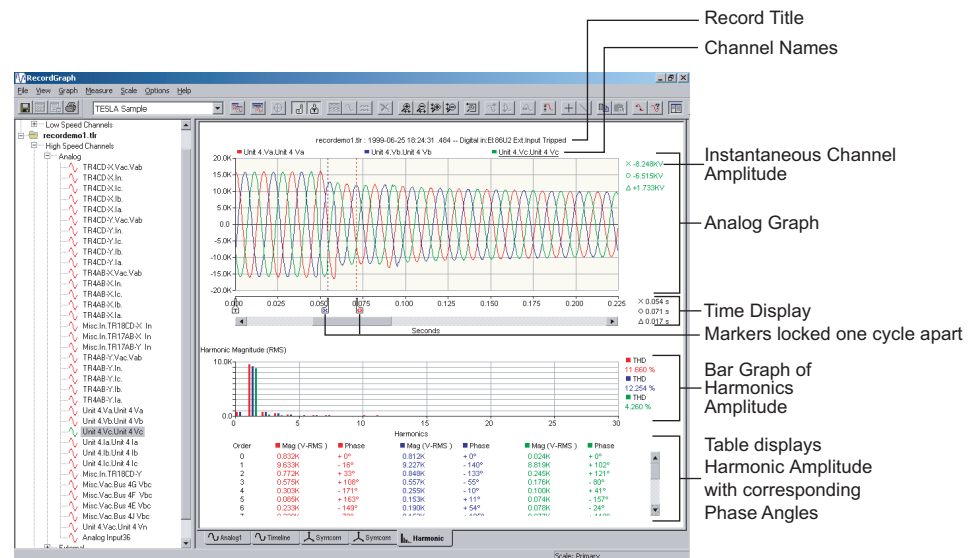


Figure 11.63: Harmonic View

- Harmonic View is designed to analyse harmonics associated with analog channels. In order to view harmonics, markers should be enabled by selecting Measure>Markers.
- A maximum of 3 traces can be analysed per view.
- The view displays: analog channels, a bar graph of harmonics and a table which contains RMS values of the harmonics with phase angle.
- The maximum number of 25 harmonics (order) displayed is based on the sample rate. See Table 7.1 and 7.2 on page 7-6.
- Channel instantaneous values are displayed on the RHS of the analog graph.
- Markers are permanently set on the graph one-cycle apart.
- Grab the marker and move (on the time line axis) to display a new set of harmonics.

All harmonic phase angles are referenced with respect to A-phase voltage in a configured channel in TESLA recorder. For COMTRADE records the first A-phase voltage is considered as the reference phase.

Impedance View

Impedance View is an R-X plot. The R-X quantities are calculated over the entire data range from the recorded analog voltage and current channels. R-X plot is useful in analyzing the performance of L-PRO relays and swing disturbances from the TESLA recorders. Since the information to be displayed involves time as a third dimension, this view provides meticulous cursor and zoom control over the data points being viewed. Optionally it supports superposition of the relay characteristics (Zone 1, Zone 2, Line, Blinders, etc.) from L-PRO records or files generated from any L-PRO *Offliner* settings program.

The following table summarizes the types of channels from which impedance (R and X values) is derived along with the supported product. RecordGraph displays these channels on the left hand side in the tree view. Depending on the product, the following basic quantities are used the respective impedance channels.

In an impedance calculation, a threshold limit is used based on the fundamental RMS value of the current to include or exclude the R and X values for plotting. This limit depends on the CT module used for the relay or recorder application. For 1A CT module, 0.02 A is the limit whereas for a 5A CT module, 0.1 A is used as the limit. When the data is copied to the clipboard, the discarded values of R and X values are not exported.

Sl. No.	Channel Types	Quantities	Supported Products
1	High Speed (HS)	Voltage and Current	L-PRO, TESLA, COMTRADE
2	High Speed (HS)	Positive Sequence Voltage and Current	TESLA
3	Low Speed (LS)	Voltage and Current	TESLA
4	Low Speed (LS)	Watts, Vars and Voltage (Phase and Sequence)	L-PRO, TESLA
5	Low Speed (LS)	Positive Sequence Voltage and Current	L-PRO, TESLA
6	Low Speed (LS)	Impedance (Phase and Sequence)	L-PRO, TESLA

To add an Impedance view select *View>Add.* or the Add a View tool bar button. From the dialog box select Impedance View.

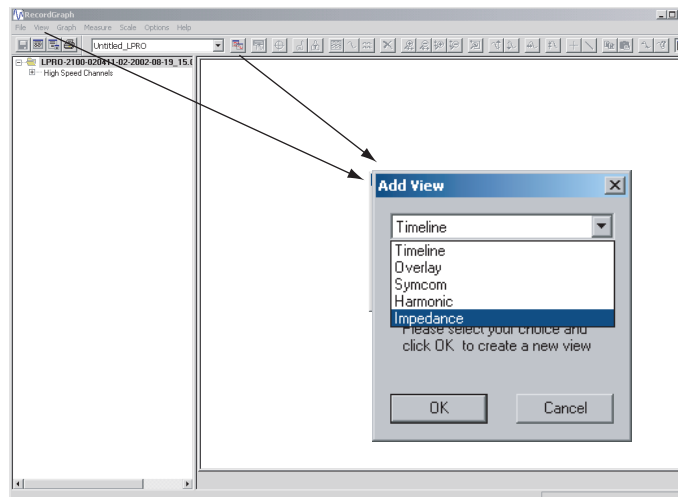


Figure 11.64: View>Add> Impedance

The Add View... dialog box lists the Impedance View only if the selected record is from L-PRO or TESLA or COMTRADE records depending on the record type.

When the Impedance View option is selected, the Impedance screen is displayed. The components and controls associated with this screen are described below.

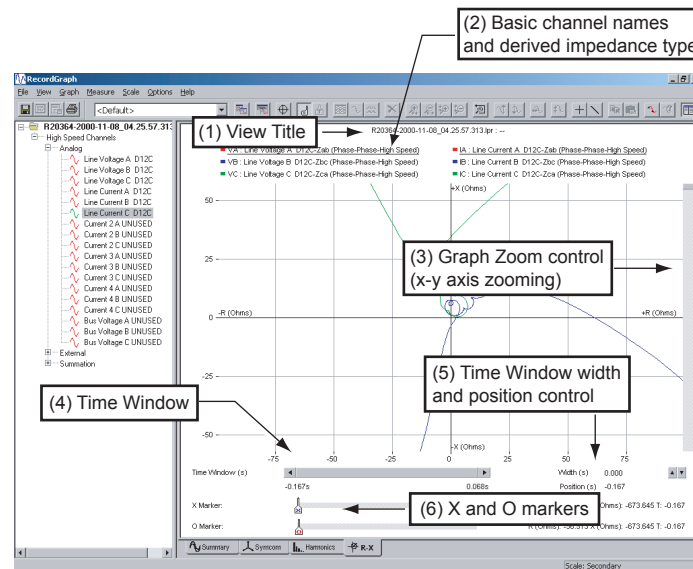


Figure 11.65: Opening Impedance Screen

Components and Controls

- (1) A text component displays the title at the top of the Impedance View shown in Figure 11.65: Opening Impedance Screen. The title is compiled from items in the Title Options dialog box. Default title is the file name and trigger event.
- (2) The basic channel names are displayed below the title.
- (3) The graph zoom is controlled using the sliding control on the right side of the window. The R-X plot aspect ratio is maintained under all zooming tools. The graph zoom control offers a 10x zoom factor between minimum and maximum amplitude of the data (R and X coordinates).
- (4) The Time Window control provides a means to select the range of data for better presentation of R-X values. For example, if the voltage and current channels are recorded from 0.0 to 0.2 seconds with 1000 data points, using this control, you can choose to view only 0.1 second data (500 points).
- (5) Time window width and position control can be used for the precise data analysis.
- (6) Control the X and O markers.

Create Impedance View with an TESLA Record

- 1 Launch RecordGraph with an TESLA high speed (fault) record and expand the channels in the tree view.
- 2 Create an Impedance View using *View>Add...* or use the tool bar option.
- 3 Select line voltages A, B and C, and corresponding line currents A, B and C from the tree view. Impedance (R and X) corresponding to Zab, Zbc and Zca phase-phase are calculated internally and displayed.

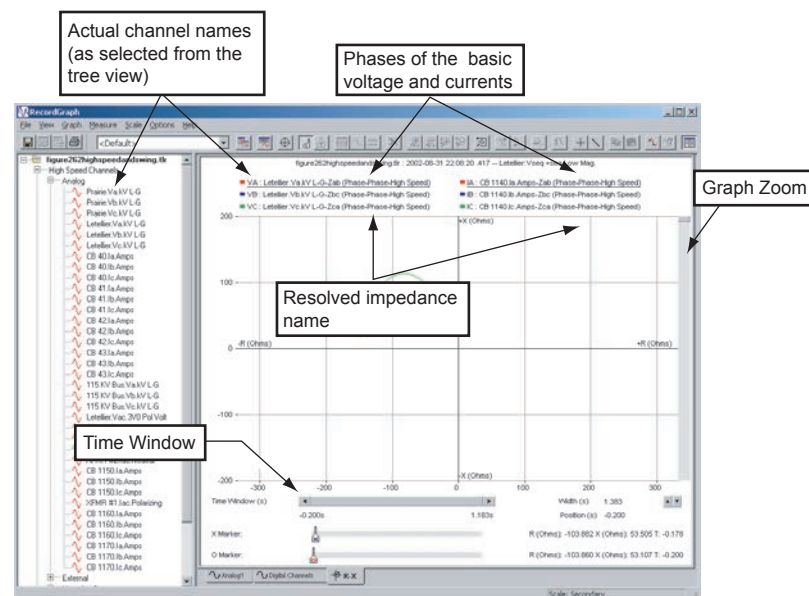


Figure 11.66: Create Impedance View with a TESLA Record

Each channel name is divided into three parts:

- the basic quantity (voltage or current) used in the calculation of the impedance.
- the name of the actual channel selected.
- the resolved impedance name with the configuration (phase-phase or phase-ground).

The Time Window control shows the minimum and maximum time of the data viewed. In the above example, the full range data is viewed.

Use the graph zoom control to zoom the x and y axis.

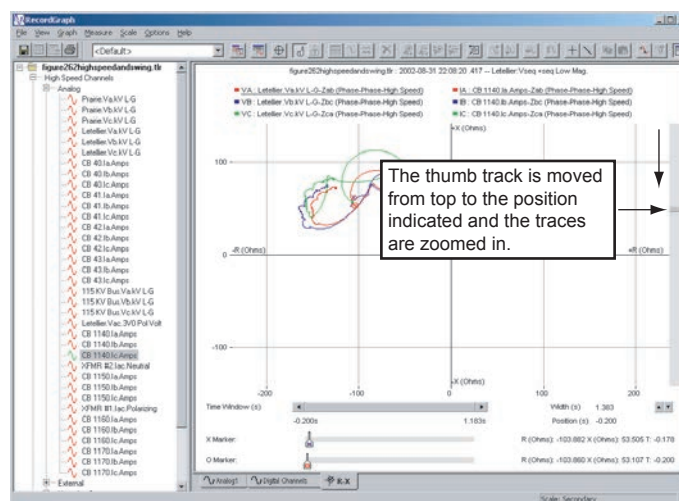


Figure 11.67: Example of Graph Zoom Control

When you move the mouse near the edge of the Time Window control, the cursor shape changes from normal arrow to two headed arrow as shown in the diagram. Now you can resize the thumb track to a desired level of data range. In the example, the data starts at position -0.200 and ends at $(-0.200 + 1.383)$, where 1.383 is the width (total data range). Therefore, only small portion of the data can be viewed.

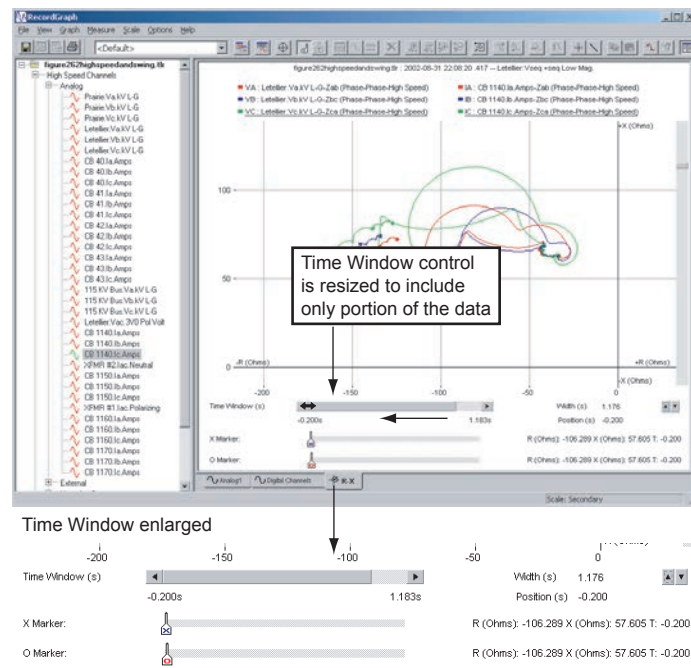


Figure 11.68: Example of Using Time Window Control

If you move the thumb track (not resize) to the extreme end, then the traces are rendered in the new data range.

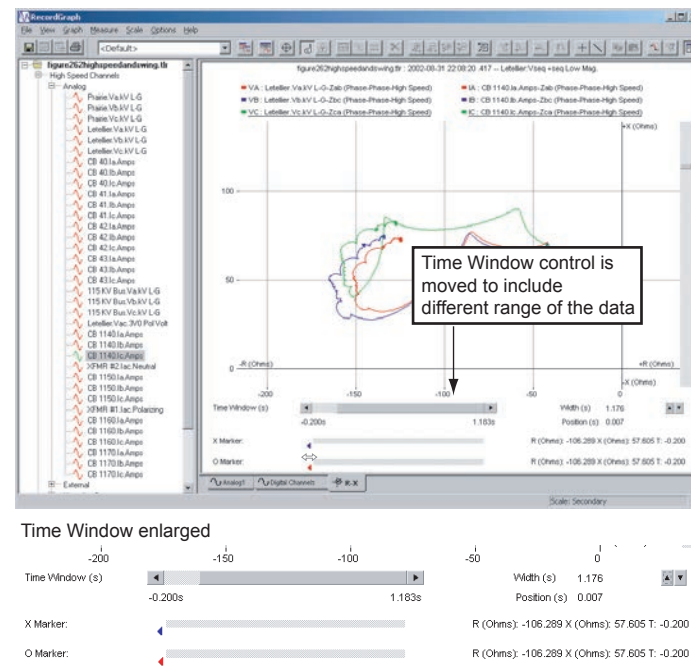


Figure 11.69: Time Window Control Moved to New Location

In the above case, the data is included from range 0.007 to $0.007 + 1.176$, where 1.176 is the data width. The 1.176 width remains same. If you resize the

thumb track, then the width can be controlled; or you can double-click near the number 1.176 to get a dialog box to enter the data range precisely.

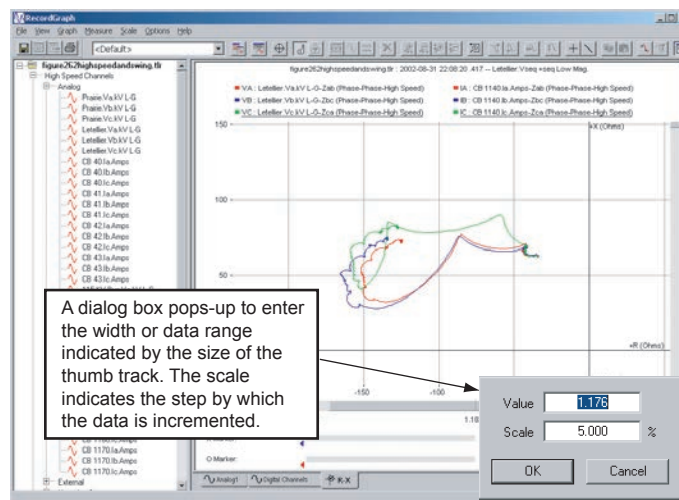


Figure 11.70: Indicate Data Range

A dialog box appears to enter the width or data range, which is indicated by the size of the thumb track. The scale indicates the step by which the data is incremental. For example, when the spin control arrow is clicked (after closing the dialog box), if an up arrow is clicked, the data is incremental from present position to present position + 5%. On the other hand, if the down arrow is clicked, the data is decremented by 5%.

Example to Superimpose the L-PRO Relay Characteristics

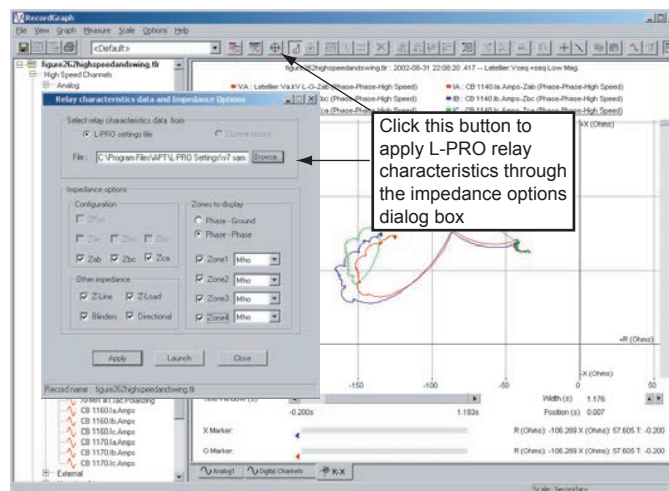


Figure 11.71: Superimpose the L-PRO Relay Characteristics

When you select the *Relay data & impedance options* button, a dialog box appears. The parameter required, such as k_0 factor, the line sequence impedance values, the system voltage data and the other required information is initialized through this dialog box initialization. All these values are read from the settings file opened through the impedance option dialog box.

Relay data and impedance options	
L-PRO settings file	Radio button to select relay characteristics from the current record. If an L-PRO record is selected, this button is enabled.
Current record	If a TESLA or COMTRADE record is selected, this button is enabled.
File	Displays the settings file (full path name) from which the relay data is extracted to plot the impedance characteristics.
Browse	Gives an option to select the settings file from any other location. The file type filter reads or selects only *.lps file type, if L-PRO setting file is selected.
Impedance Options	Impedance configuration option includes a number of other options, such as, Phase-Phase, Phase-Neutral, radio button. Depending on this option and the type of channel, different impedance options (check buttons) are enabled.
Configuration	Zpos (positive sequence impedance 3 phase basis).
	Zan, Zbn or Zcn.
	Zab, Zbc, or Zca.
Other Impedance	
Z-Line	Displays the line angle (can be checked or unchecked).
Z-Load	Displays the coordinate of the load impedance (can be checked or unchecked).
Blinders	Available only if the Phase-Phase option is chosen.
Directional	Displays the directional characteristics.
Zones to display	Phase-Ground or Phase-Phase.
Zone 1 to 4	Zone1-Zone4 displays the respective zones impedance characteristics (can be checked or unchecked).
Apply	Redraws the display with the currently selected options.
Launch	Launches the setting file through the <i>Offliner</i> settings program. Note that the L-PRO <i>Offliner</i> setting program should be installed for this to work successfully.
Close	Closes the dialog box.

In the *Relay data and impedance options* dialog box check the Zone 1 to Zone 4 boxes and select the *Apply* button. All the four zone characteristics are superimposed on the calculated phase impedances (note that the characteristics are zoomed using free-form zoom to get a better resolution).

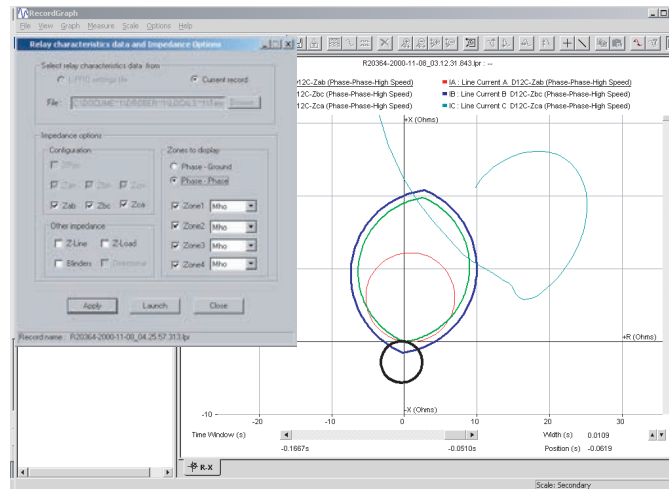


Figure 11.72: Example Superimposing the Zone Characteristics

In the above example phase-phase impedances Z_{ab} , Z_{bc} and Z_{ca} are selected, indicated by a check mark, but only Z_{ca} is in the zoom range.

All the four zones mho characteristics are superimposed. You can see that the Z_{ca} impedance has entered the Zone 2 and Zone 3. You can use a combination of zoom and time window control to analyze the precise time at which the impedance enters the zones.

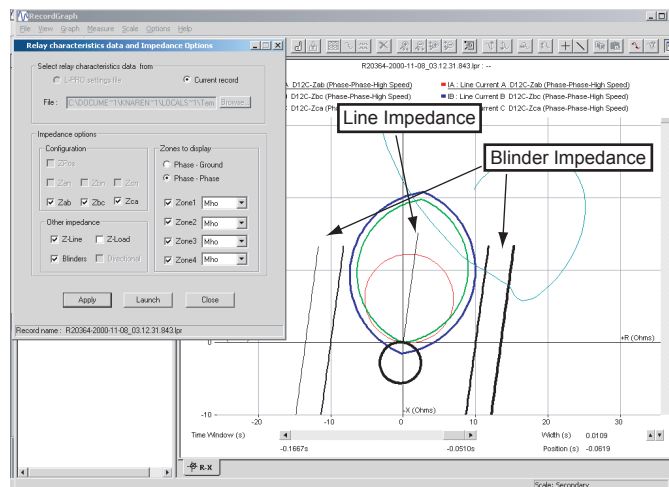


Figure 11.73: Example Showing the Line and Blinder Impedances

Check the **Z-Line** and **Blinder** boxes; then select the *Apply* button to superimpose the line and blinder impedances.

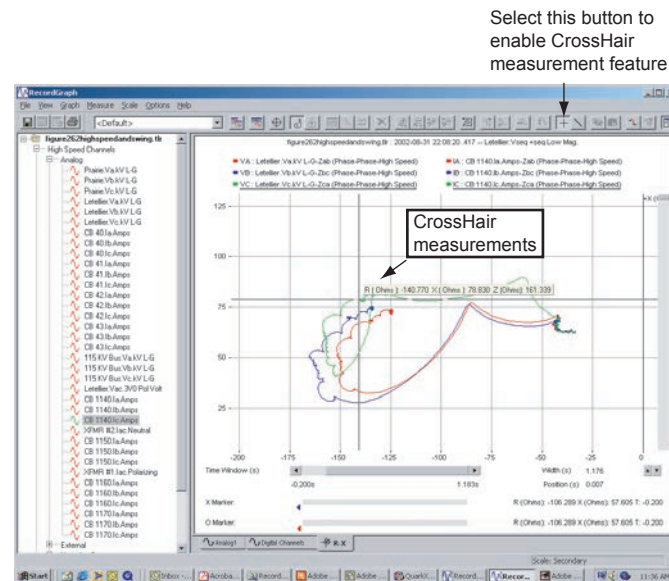


Figure 11.74: Example Illustrating the Use of the CrossHair Measurement

Select the *CrossHair* button. When you drag the mouse (left button down and move) on any point on the trace, the R, X and the Z corresponding values are displayed.

You can move the cursor anywhere on the graph to get the measurement. When this feature is enabled, free form zooming is disabled; but you can use the graph zoom control to get a closer look at the trace.

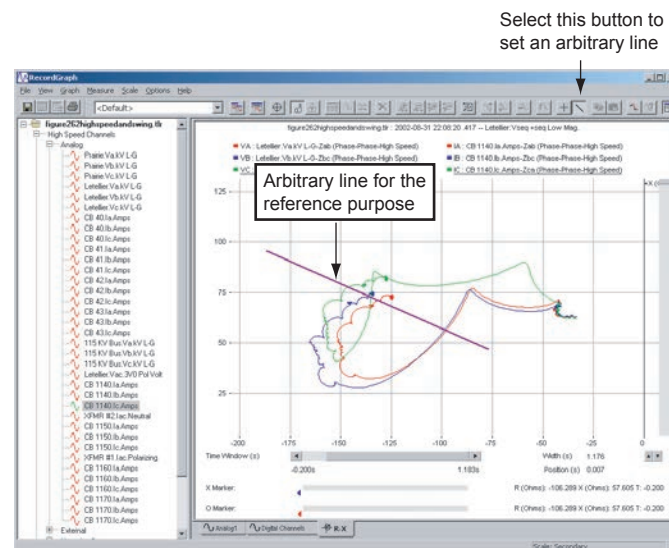


Figure 11.75: Example of the Line Feature

Set a reference line to measure the data using the *Line* feature. This line is a reference line and not associated with the data values.

When the line option is enabled, the free form box zooming is disabled. Disable the CrossHair measurement to resize and move the reference line; then en-

able the CrossHair option to measure the values. Select the line option again to remove the line from the graph.

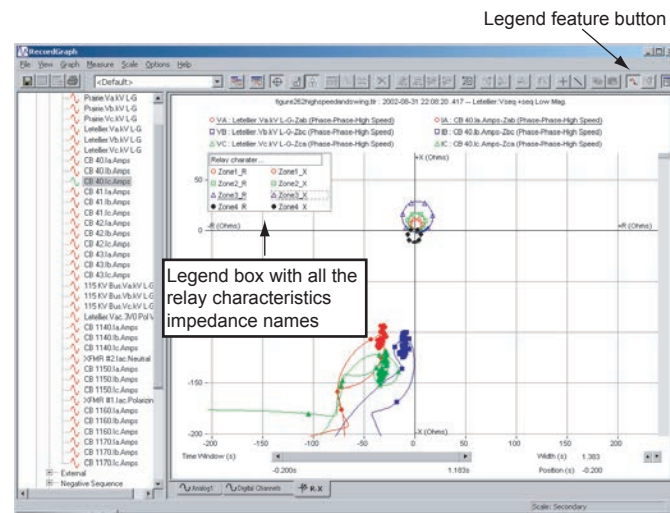


Figure 11.76: Example of the Legends Feature

Use the legend feature to distinguish relay characteristics from the calculated impedances. You can move the legend box and resize to the desired level. You can hide the legend box by re-selecting the legend option again.

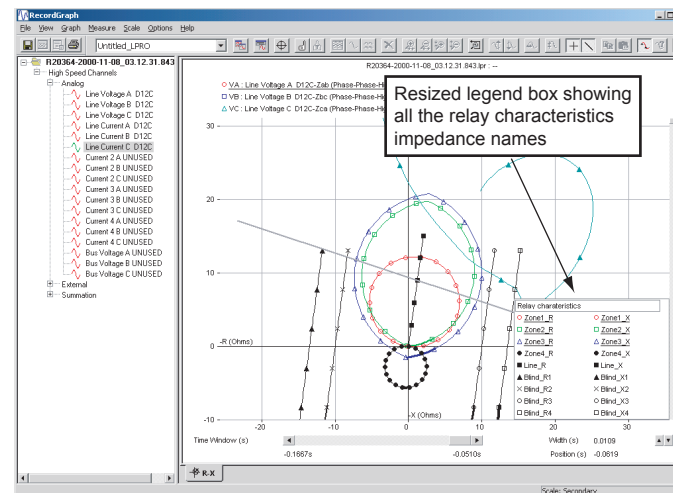


Figure 11.77: Legends Features Moved and Enlarged

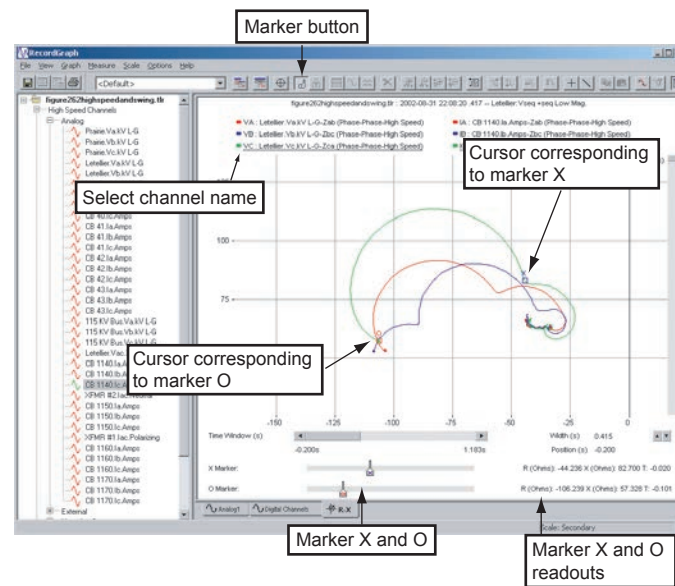


Figure 11.78: Example Illustrating the Use of Data Markers

Select the marker option to set the markers. Select the desired channel name for the required measurement. For example, the channel associated with Zca is chosen (click this channel name for the selection). Move the marker by sliding it to the desired location. When you change the data range (using Time Window control), the cursors may disappear from the traces indicating that the markers are always associated with the data.

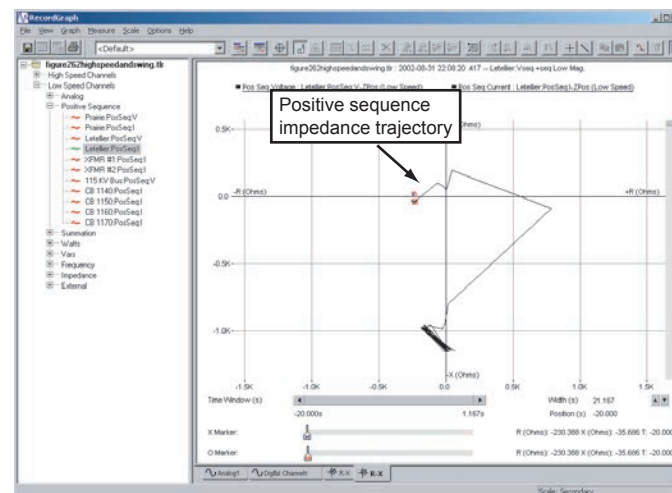


Figure 11.79: Example of TESLA Swing Record Choosing Positive Sequence Voltage and Current

Select a TESLA swing record and expand the channels. Click the positive sequence voltage and current; RecordGraph automatically calculates and displays the positive sequence impedance.

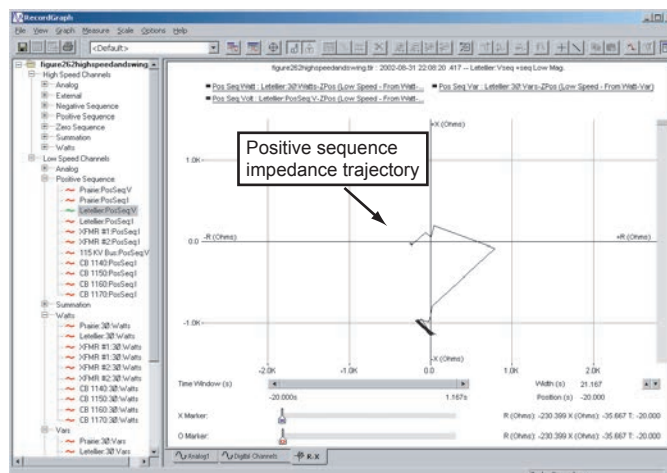


Figure 11.80: Example of TESLA Swing Record Choosing Watt, Var and Positive Sequence Voltage Channels

Select an TESLA swing record and expand the channels as shown. Click the watt, var and positive sequence voltage; RecordGraph automatically evaluates and displays the positive sequence impedance.

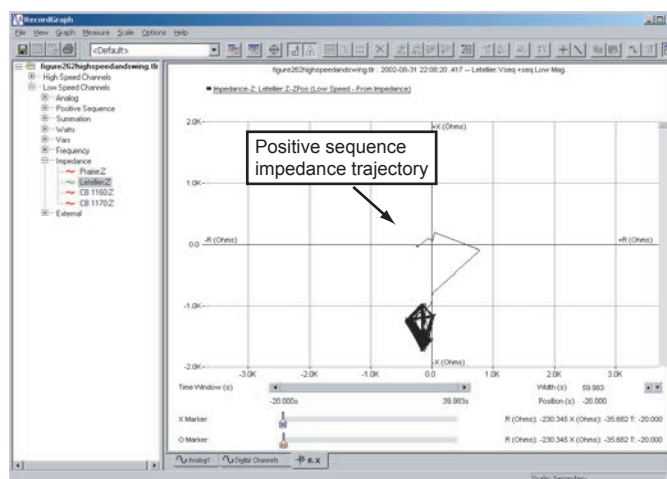


Figure 11.81: Example of TESLA Swing Record Choosing Impedance Channel

Select an TESLA swing record and expand the channels as shown. Click the impedance channel; RecordGraph automatically displays the positive sequence impedance trajectory.

As you select the desired channels, the impedance (R-X characteristics) are superimposed on the existing relay characteristics. To select new set of voltage and current channels use the *Delete trace(s)* option from the right-click context menu and select new channels. If desired, you can modify or re-apply the impedance options.

Drag the thumb track on the scroll bar to zoom in or zoom out the axis range. In the Time Window control + click the arrow buttons or drag the thumb track to scroll the window of visible data in the time domain.

To place the X and O markers use the tool bar or the right-click context menu or the *View>Markers* option, dragging a marker to the right or left moves corresponding marker. If the Time Window control does not show the data, then the markers are shown as small triangles on the left or right sides. If you click the triangle, corresponding data cursor is displayed and the time range is automatically adjusted.

You can save all the impedance display options to a template file (*File> Save template*)

Trend View

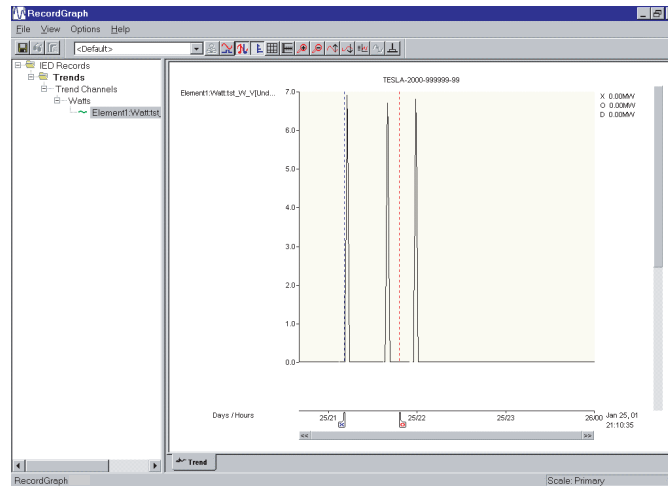


Figure 11.82: Trend View

- Trend View is designed to display “trend” data.
- It has a special x-axis, common to all the graphs to display the data in the “date” format. When zoomed, the scale automatically changes depending on the date range. (For example: years/months or months/days or days/hours or hours/minutes or minutes/seconds).
- Each analog graph in a trend view can display one trace.
- A maximum of 32 graphs can be added per view.

Templates

Templates associated with a record.

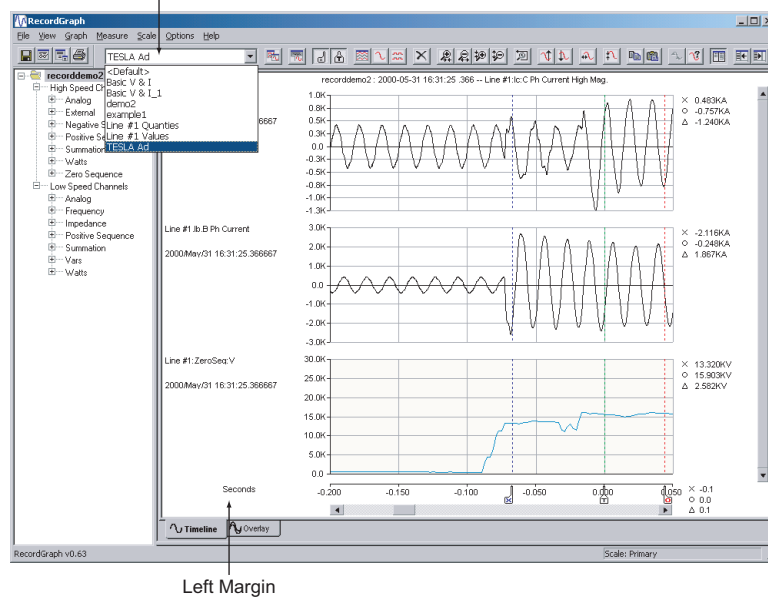


Figure 11.83: Template List

Template contains user-defined layout information including:

- Views – graphs and their location along with the traces (channels)
- Markers position (X, O and trigger marker, T)
- Views and graphs title options
- X axis scaling (zooming information)
- Y axis scaling (zooming information)
- X axis shift (time alignment) of each channel
- Measurement (readout) options
- Left Margin

Template stores the easy-to-manage layout information in a file based on product type (B-PRO, F-PRO, L-PRO, T-PRO, TESLA, COMTRADE).

When the template information is stored, it can be applied to any recording (normally from same IED or product) for which the template is valid. For example, if a template has 3 views with 3 graphs per view, and has 1, 2 and 3 analog channels displayed with various options, this information can be applied to any record with that common framework. The concept is to re-use the common layout information and update the data information with the new recorded channels thus reducing the graph re-creation processing time.

These flexible and user-defined templates can be shared among different users. Normally (under default installation options), templates are stored on the local hard disk in a sub-folder where the RecordGraph application resides, for example, c:\Program Files\NxtPhase\RecordGraph\template

The template graphical layout file contains information about fixed views, graphs, traces, marker positions, read-out, scaling and zoom range. You can analyze a system disturbance recorded at different times and at different locations using the template.

When a template is opened, the predefined layout information is automatically applied based on the new record (or set of records). You can save time by viewing the data recorded without manually loading the traces again. Templates are the first step in generating a visual report.

You automatically form a template when you create views and graphs. To re-apply the template to a different recording from the same or different recorder, you must save this layout information in a file. You can extend or alter templates by manipulating views, graphs and traces.

Templates are not saved automatically, but must be saved using the *File>Save Template* option. Template files can be shared and customized. The list of templates is dynamically created and displayed in the tool bar. When a record is added to RecordGraph, an automatic scan search is done to list the templates corresponding to the record loaded. This list may have both single or multi-record templates, if the record loaded is a part of multi-recorder template. If no match is found, a <Default> template is loaded. You can define any number of templates based on a single recorder or multiple recorders.

Default Templates

Hard coded, static default templates are created whenever you open the RecordGraph application. These are not stored in the file, but are dynamically created and displayed as <Default> in the list box.

You can override this <Default> template by saving any other template as a default template.

The user-defined default template path is stored in the registry key based on the product and the type of recording (applicable for all products).

For example:

- TESLA/HS - high speed
- TESLA/LS - low speed
- TESLA/Trend - slow recordings

Managing Template Files

Whenever a new record file is loaded into the RecordGraph, it automatically loads the relevant template file names in a list box attached to the main tool bar. The template files are filled or updated based on certain rules:

- Templates are stored based on product type.
- If a user-defined default template is available, it is loaded as the first item in the list box, otherwise, a static <Default> template is listed as the first item.
- Template files are matched based on IED (serial number) in the case of TESLA recorders and are common in case of relay products (B-PRO, F-PRO, L-PRO, T-PRO).

If template files for a TESLA recorder are created and stored (for example, with serial number TESLA-2000-981103-07), these template files can not be applied to another recorder with different serial number such as TESLA-2000-981103-08. On the other hand, if template files are created for relay products such as L-PRO, this template can be applied to any relay IED B-PRO, F-PRO, L-PRO or T-PRO). Hence, templates are IED-based (serial number-based) in case of recorders and product-based in case of relays.

Double-click (or use the Enter key) on the currently active record in the RecordGraph tree list (displayed in bold) to apply the template or pick any desired template from the template list box.

Templates can be renamed, duplicated or deleted using template manager from within the RecordGraph.

There is no limitation on the number of template files used (as long as the hard disk space is available).

Create New Template File

- 1 Modify the existing template layout information and save the modified template into a new file.
- 2 Create new views and graphs by deleting the views from the existing layout and saving new ones into a new the template file.

If the template file is created from multiple records, all the records should be pre-loaded into RecordGraph to successfully apply the layout information.

Layout information is applied one at a time. If the template involves more than one record, apply template (double-click on each record) to fill respective channels. The name of the recorder IED in the template file are displayed in the tool-tip list box window when the mouse cursor is moved over it. The tool-tip also displays the product name and the user-defined default template file name, if one exists.

Templates Menus

Save Template

Displays a dialog box only if <Default> template is currently displayed in the template list box. Since <Default> template name is reserved for hard coded templates, you must save the template information with a new name. If any other template file name is displayed, other than <Default>, the layout information is updated without the dialog box being displayed.

Save Template As...

Displays a dialog box to save the template. The option *Save as default template*, if checked, saves the template as user-defined default template. Refer previous section for more explanation on the user defined default template.

Template Manager...

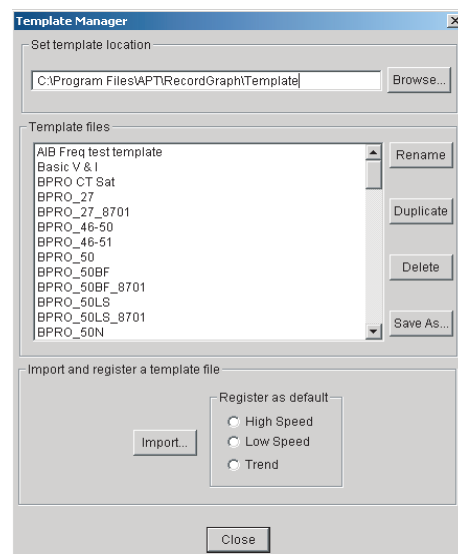


Figure 11.84: Template Manager

Brings up the template manager dialog box which lists all the templates currently available.

Rename

Renames the currently selected template.

Duplicate

Copies the contents of the selected template into another file.

Delete

Deletes currently selected template.

Save As...

Saves the selected template file from the template files list to the desired location.

Import...

Imports a file from any location to the current template location and registers the template as a high, low speed or trend default template (if one of the option is chosen).

Browse...

Sets the new template location. This folder stores all the template files available for the analysis based on the recorder (refer Templates section under Graphing Records for detailed explanations).

Close

Saves the current information of the template manager, refresh the template list box and exit the session.

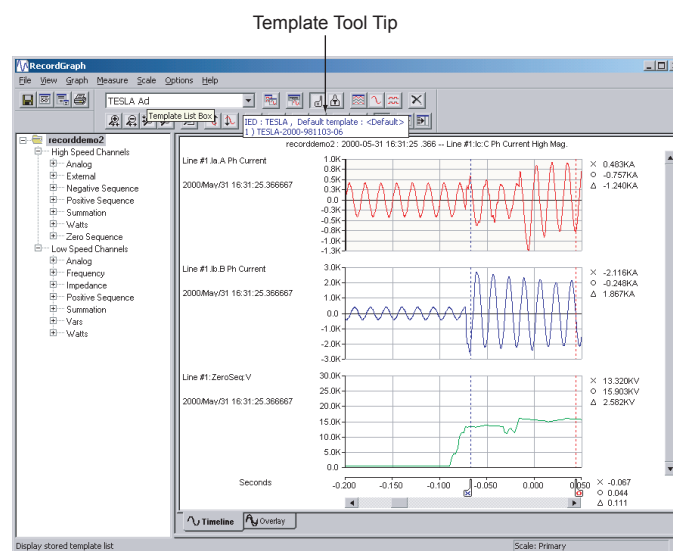
Template - Tool Tip

Figure 11.85: Template Tool Tip Information Displays:

- IED name
- User-defined default template associated with that IED
- Serial number of the IED which is used as the unique feature to match the templates.

Template - Single IED

- 1 Open a record from the desired IED (B-PRO, F-PRO, L-PRO, T-PRO or TESLA).
- 2 Create or modify the existing layout information.
- 3 Use Save Template as... option to save the new layout information with a desired template name.

A single IED Template is saved/matched based on its serial number. Any record from the IED with the same serial number can use or share the template (layout) information. A single IED template is saved/matched based on the product (not on the serial number) and hence once the template file is created for one of the IED, it can be shared by all the IEDs irrespective of whether they have the same or different serial number or from different recordings.

Template - Multiple IED

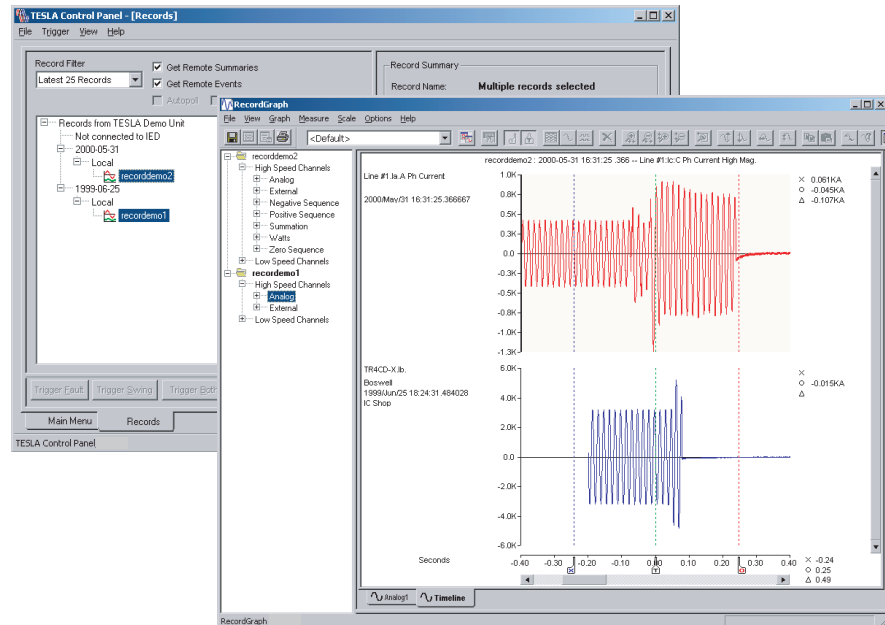


Figure 11.86: Multiple IEDs

- 1 Open records from two or more desired IEDs (different TESLAs or different relays).
- 2 Create or modify the existing layout information (create graphs by selecting channels from different IEDs).
- 3 Use Save Template as... option to save the new layout information with a desired template name.

When all IED records are pre-loaded into the RecordGraph, multiple IED templates are saved/matched based on serial number. If the record is loaded one at a time, then double-clicking on each record reappplies the template filling the respective channels.

View and Graph Titles

When a new record is loaded, the information corresponding to the options selected is compiled and the updated information is displayed in the View Title.

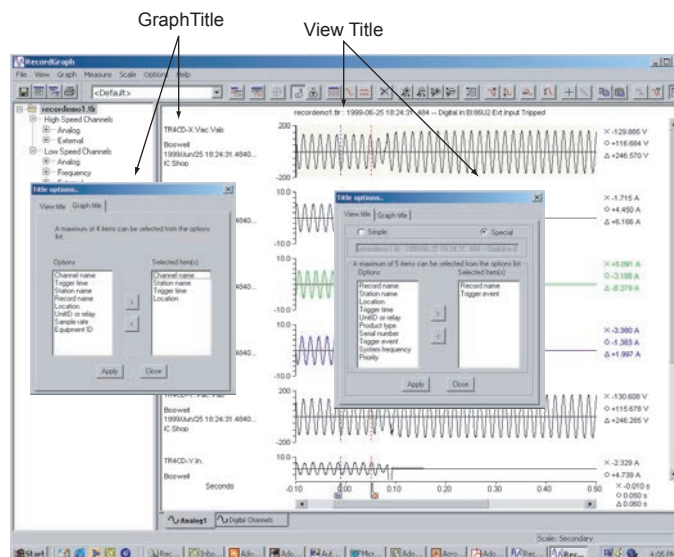


Figure 11.87: View and Graph Titles

View Title

View Title is the title on the top of each record view. When a new record is loaded, the information corresponding to the options selected is compiled and the updated information is displayed in the View Title. You can choose any of four options by clicking the arrows to move the items in the list. The option is saved into the template. This option is not available for the Symcom or Harmonic Views.

The option choices are:

- Record Name
- Station Name
- Location
- Trigger Time
- UnitID or Recorder
- Product Type
- Serial Number
- Trigger Event
- System Frequency
- Priority

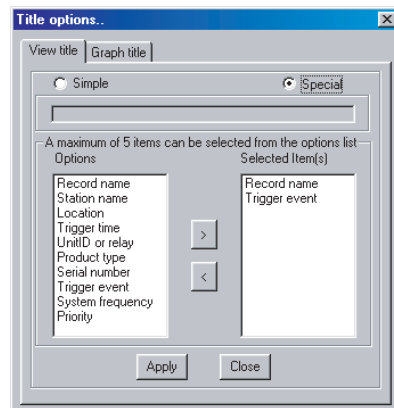


Figure 11.88: View Title Options

Graph Title

Graph Title is the information that appears on the left margin of each graph. Graph Title is a combination of various options. When a new record is loaded, the information corresponding to the options selected is compiled and the updated information is displayed in the Graph Title dialog box. You can choose any four options by clicking the arrows to move the items in the list. The option is saved into the template. This option is not available for the Overlay View.

The option choices are:

- Channel name
- Trigger time
- Station name
- Record name
- Location
- UnitID or recorder
- Sample rate
- Equipment ID

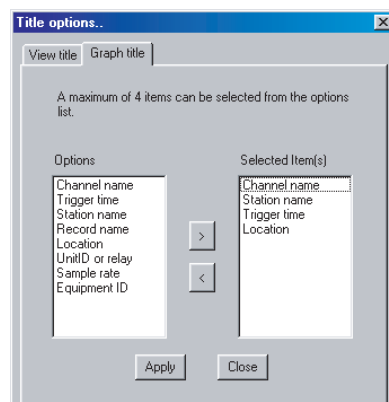


Figure 11.89: Graph Title Options

Readouts and Measurements

The Measure menu consists of the following:

- Markers
- Primary/Secondary
- Time Alignment
- Absolute Time
- Fundamental RMS
- True RMS
- Harmonics
- Symmetrical Components

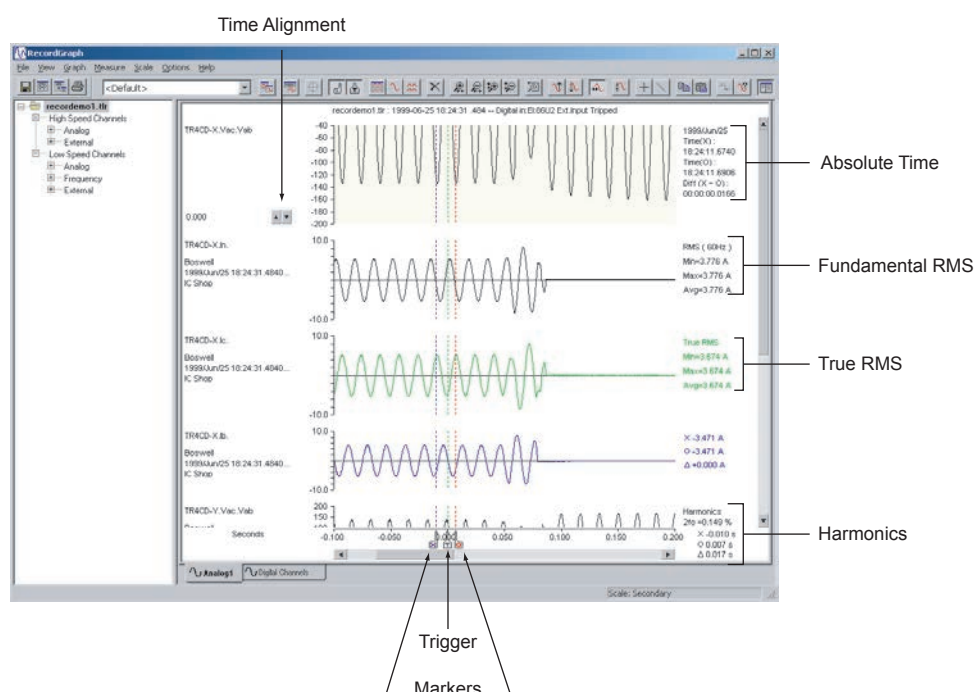


Figure 11.90: Readouts and Measurements

Markers

Selecting *Measure>Markers* or using the tool bar button places the “X” and “O” markers on the graph, as well as, automatically placing markers on all new graphs. If the markers are out of view range, double-click on the timeline graph to bring back the markers to the desired location. Marker positions are saved into the template. Readout corresponding to the option chosen is displayed on the right side of the graph. Selecting trigger marker, T, displays the trigger time of the record.

Primary

Selecting *Measure>Primary* multiplies the channel data by the primary scaling factor and redraws the y-axis for all graphs.

Secondary

Selecting *Measure>Secondary* multiplies the channel data by the secondary scaling factor and redraws the y-axis of all graphs.

Time Alignment

Use this option to offset or align the trigger time of channels (normally from different locations) or shift the x-axis time. This feature offsets the x-axis time data by a precise value as desired.

- 1 A trace (channel) must first exist on the graph. Click the graph that you want to show time alignment.
- 2 Select the *Measure>Time Alignment* menu option or the *Time Alignment* button on the tool bar.
- 3 Use the “spin” control (up and down arrows) to increase or decrease the offset.
- 4 Double-click the value to bring up a dialog box to enter the new offset value and offset scale. Offset scale is the percent by which the increment is required.
- 5 Clear this option, by a second click on the *Time Alignment* button on the tool bar or by selecting the *Graph>Time Alignment* menu option a second time.

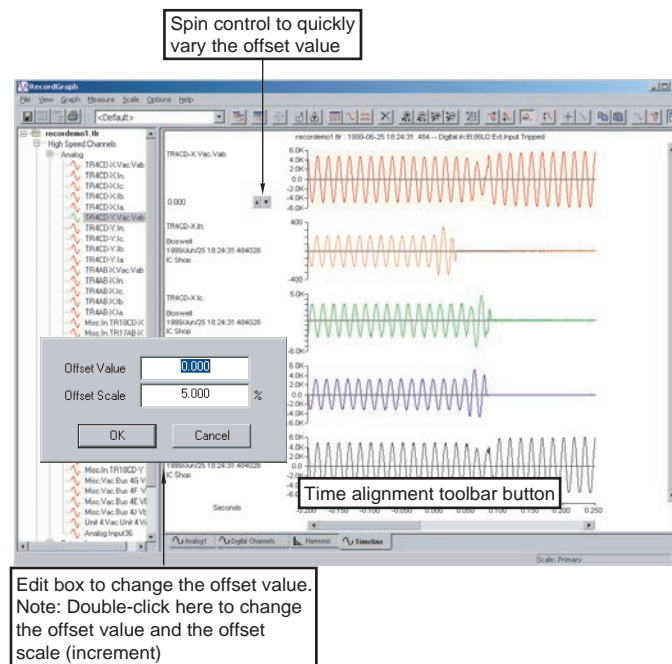


Figure 11.91: Time Alignment

Absolute Time

This option displays the absolute time—the actual time of the recorded channels.

- 1 A trace (channel) must first exist on the graph. Click the graph that you want to show absolute time measurement.
- 2 Select the *Measure>Markers* menu option or the *Markers* button on the tool bar to place the markers on the graph. Markers are automatically placed if not selected.
- 3 Select *Measure>Absolute Time* menu option.
- 4 Readout corresponding to the markers is displayed on the right-hand side of the graph including:
 - Year, Month, Day of the recording (yyyy/mm/dd)
 - Absolute Time corresponding to marker X
 - Absolute Time corresponding to markers O
 - Difference in the Absolute Time between marker X and marker O

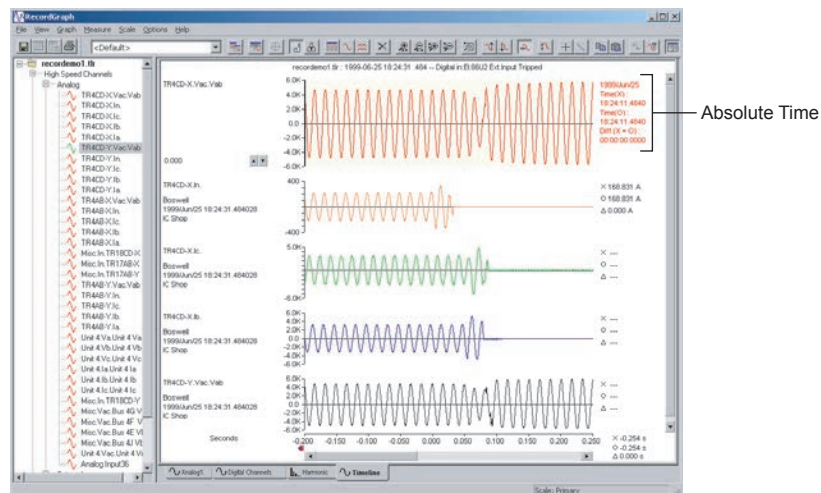


Figure 11.92: Absolute Time

Fundamental RMS

This option displays the RMS measurement of the fundamental (60 or 50 Hz) between the two markers (X and O) of the selected channel.

- 1 A trace (channel) must first exist on the graph. Click the graph that you want to show absolute time measurement.
- 2 Select the *Measure>Markers* menu option or the Markers button on the tool bar to place the markers on the graph. Markers are automatically placed if not selected.
- 3 Select *Measure>Fundamental RMS* menu option.
- 4 Readout corresponding to the markers is displayed on the right-hand side of the graph including:
 - RMS (fundamental frequency) Title
 - Minimum RMS
 - Maximum RMS
 - Average RMS

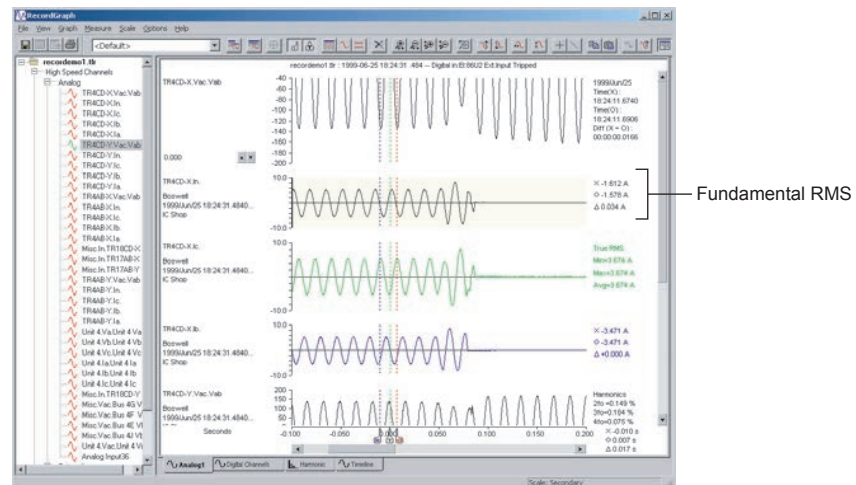


Figure 11.93: Fundamental RMS

True RMS

This option displays true RMS measurement values of all the harmonics (up to 25 order—including the fundamental), depending on the sample rate of the recorded channel.

- 1 A trace (channel) must first exist on the graph. Click the graph that you want to show absolute time measurement.
- 2 Select the *Measure>Markers* menu option or the *Markers* button on the tool bar to place the markers on the graph. Markers are automatically placed if not selected.
- 3 Select *Measure>True RMS* menu option.

Readout corresponding to the markers is displayed on the right-hand side of the graph including:

- True RMS Title
- Minimum True RMS
- Maximum True RMS
- Average True RMS

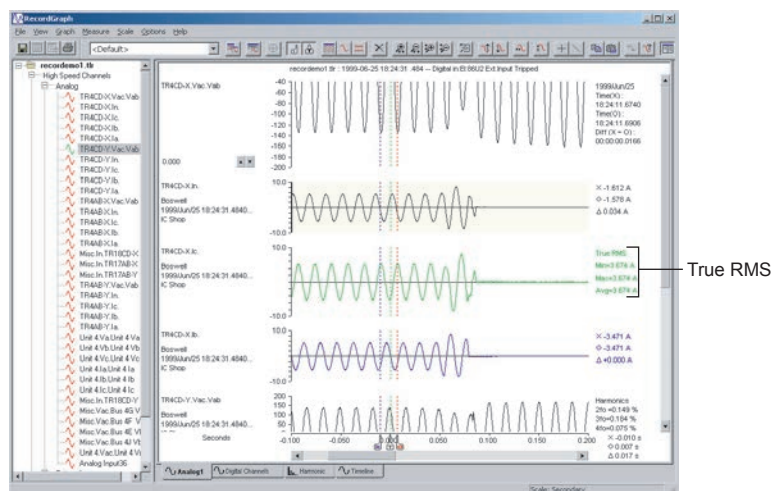


Figure 11.94: True RMS

Harmonics

This option displays the harmonic contents (magnitude) of the desired channel along with the Total Harmonic Distortion (THD) in percentage.

- 1 A trace (channel) must first exist on the graph. Click the graph that you want to show absolute time measurement.
- 2 Select the *Measure>Markers* menu option or the *Markers* button on the tool bar to place the markers on the graph. Markers are automatically placed if not selected.
- 3 Select *Measure>Harmonics* menu option.
- 4 Readout corresponding to the markers is displayed on the right-hand side of the graph including:
 - Harmonics Title
 - 2nd Harmonic
 - 3rd Harmonic
 - 4th Harmonic
 - 5th Harmonic
 - THD% of fundamental (the number of harmonics included in THD) depends on the sample rate. See Table 7.1 and 7.2 on page 7-6.



Figure 11.95: Harmonics

Symmetrical Components

This measurement option displays the magnitudes of the positive, negative and zero sequence components of 3-phase voltage or current channel.

- 1 Create an Overlay View—you must have a 3-phase voltage or current channel.
- 2 Place three phase voltage or current channels on the graph.
- 3 Select the *Measure>Symmetrical Components* menu option.
- 4 Readout corresponding to the markers is displayed on the right-hand side of the graph including:
 - SymCom Title
 - Positive sequence component magnitude
 - Negative sequence magnitude
 - Zero sequence magnitude

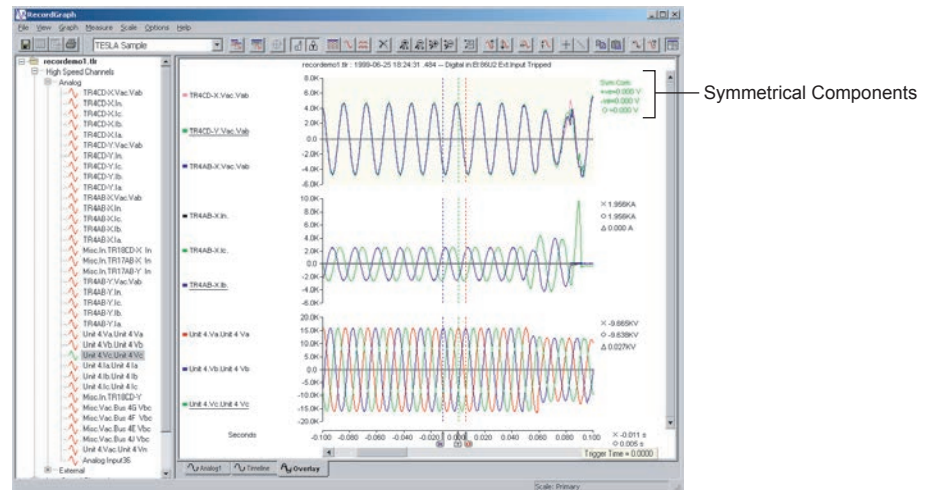


Figure 11.96: Symmetrical Components

Calculated Channels

Calculated channels are virtual channels derived from the original recorded channels. They are calculated based on the configuration information. In the TESLA recorder, all the calculated channels are added to the original record only once, but are available any time to view with the RecordGraph application. Calculated channels differ widely depending on the product. They are classified under high and low speed categories.

High Speed Calculated channels

- Summation
- Positive sequence
- Negative sequence
- Zero sequence
- Watts (single and three phase)

Low Speed Calculated channels

- Summation
- Positive sequence
- Watts (single or three phase)
- Vars (single or three phase)
- Impedance
- External

Type and number of channels available for the view depends on the configuration information.

Choose *Options>Calculate Derived Channels Now* to add the calculated channels. If this option is disabled, then the calculated channels are already available.

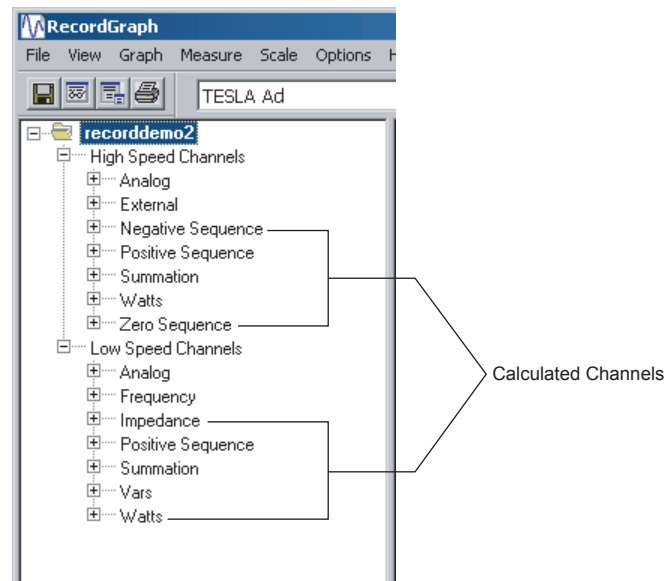


Figure 11.97: Calculated Channels

Exporting Views

Export active visible views to windows standard clipboard or to an enhanced metafile. Following options are available:

- Copy To ClipBoard
- Save As MetaFile

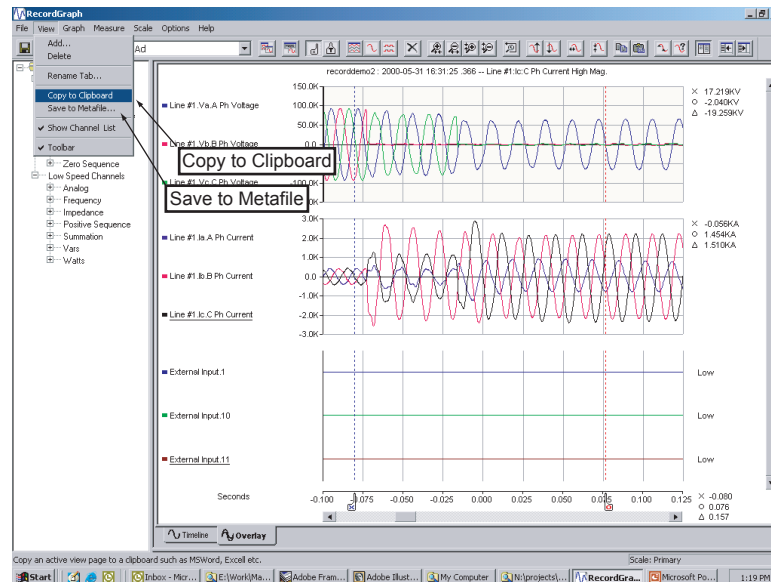


Figure 11.98: Export Views

Copy to Clipboard

Copies view to the clipboard in order to copy into another document, for example Microsoft Word.

- 1 To copy to clipboard select *View>Copy to Clipboard* or right-click on the graph to bring up the context menu and select *Copy to Clipboard*.
- 2 Open any other software package, which supports the “pasting” facility from the clipboard (for example Excel or Microsoft Word) and paste the view.

Save View as Metafile

Saves the view to a Metafile format *.emf.

- 1 To save to as a Metafile select *View>Save to Metafile...* or right-click on the graph to bring up the context menu and select *Save to Metafile*.
- 2 A dialog box appears prompting you to save the file in a selected folder.

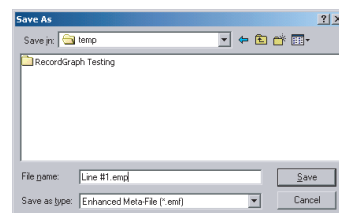


Figure 11.99: Save to Metafile

Exporting Channel Data

Any channel data can be exported to the clipboard from the active view. If a graph has multiple channels, all the channel data is exported to the clipboard. This option copies the trace data to the clipboard and using *Edit>Paste* to paste into other applications like Microsoft Word or Excel.

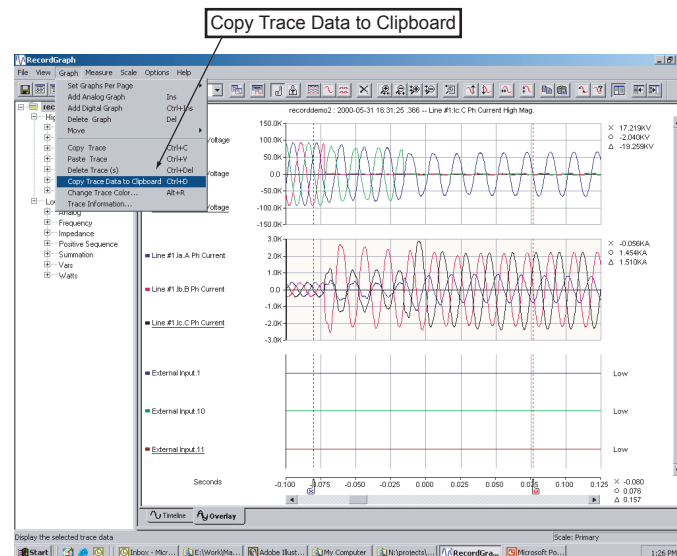


Figure 11.100: Copy Trace to Clipboard

Pasting exported data using Microsoft Excel

- 1 Open Microsoft Excel.
- 2 Choose *Edit>Paste Special*.

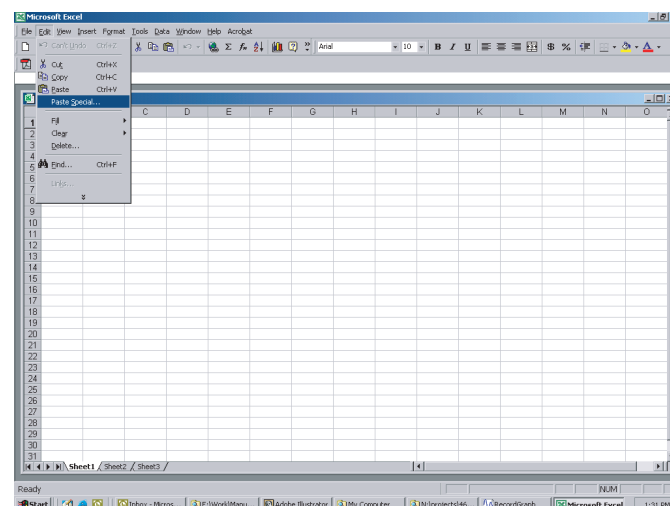


Figure 11.101: Paste Special Using Excel

Pasting exported data using Microsoft Excel

Choose *CSV* (comma separated variable) format and click *OK*.

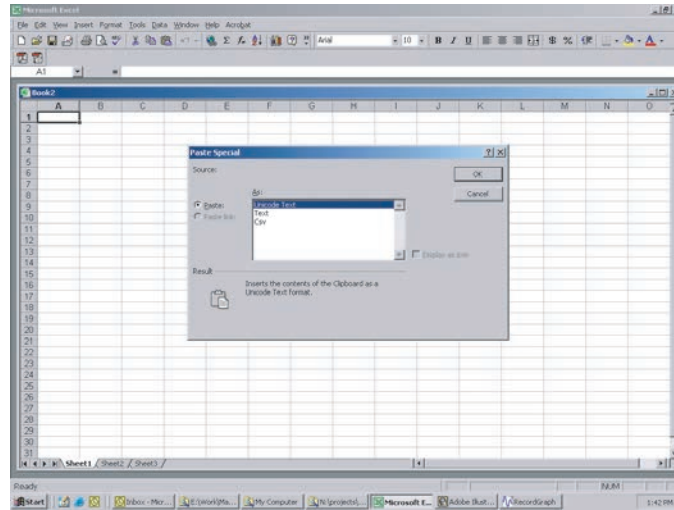


Figure 11.102: Choose CSV

Pasting exported data using Microsoft Excel

Domain: normally time data, it can be date YYYY/mm/dd in case of trend data.

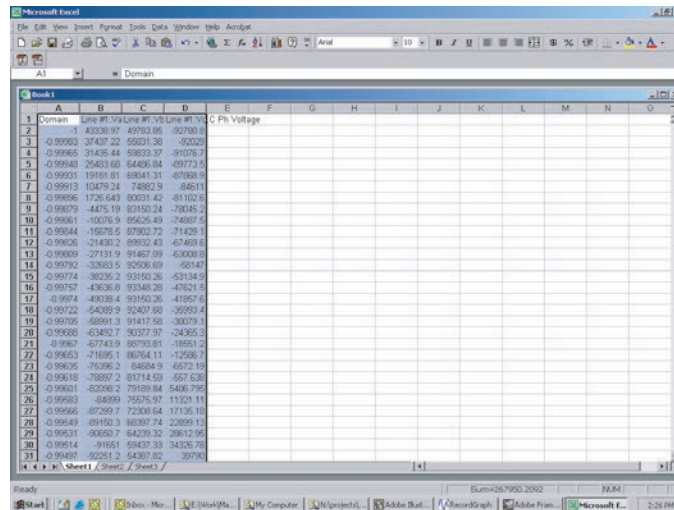


Figure 11.103: Paste to Excel

Record Summary

- 1 Click the record name to enable this feature.
- 2 Choose *File>Show Record Summary...* to display the record summary.

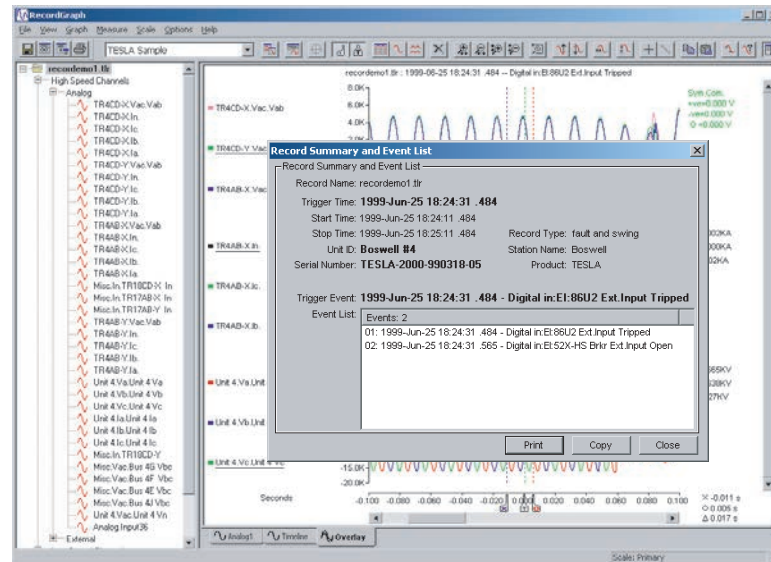


Figure 11.104: Show Record Summary

Digital Channel Status Indicator

Highlight digital channel which change state (with different icons), and list only configured channels in the tree view. A mimic screen shot of the icons is shown below. The <default> template automatically displays the digital channels which changes the state.

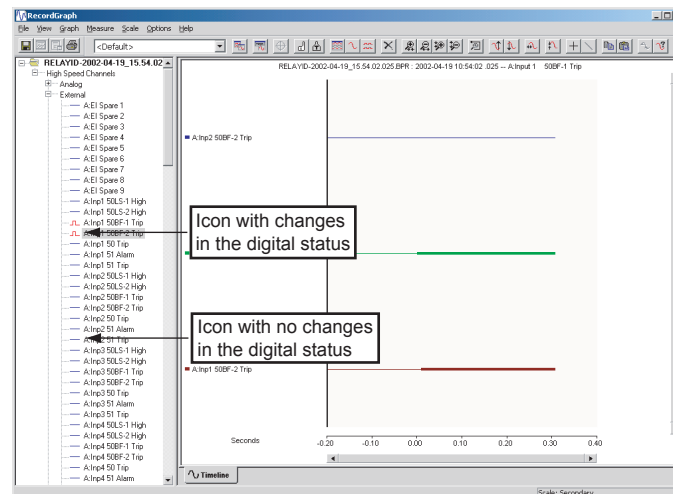


Figure 11.105: Digital Channel Status Indicator

IRIG-B Input Status Display

IRIG-B input status (synchronized, unsynchronized or not available) is displayed in the tool tip window when you place the mouse on the channel name or use Active Trace Information.

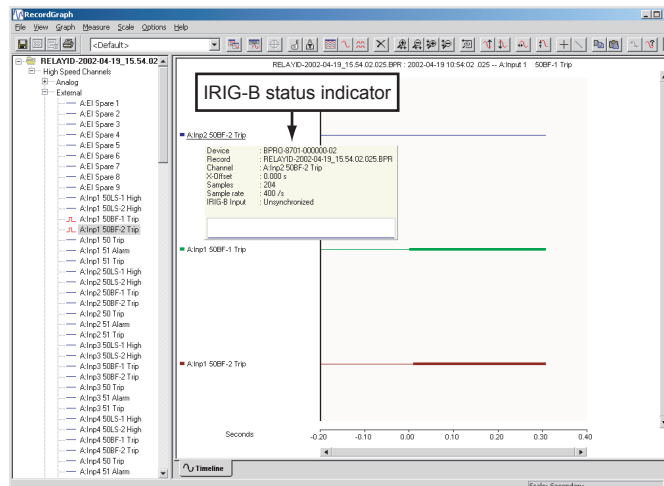


Figure 11.106: IRIG-B Input Status Indicator

Derived Digital Swing Channels for TESLA Swing Recordings

TESLA recordings do not record External Input channels for the swing records. A facility to view these channels in the RecordGraph is provided. RecordGraph automatically displays these channels (if configured) under low speed channel group. Events with the same element are grouped together to form a channel. This facility is backward compatible.

Derived Channels for L-PRO, F-PRO High Speed Recordings

For L-PRO and F-PRO high-speed records, Main and Aux individual phase summation channels are added to the existing derived summation channels. This facility is backward compatible.

COMTRADE Import

COMTRADE (Common Format for Transient Data Exchange) is an industry standard record format used to share data between tools and to replay faults through a test set. The import utility supports viewing of both ASCII and binary COMTRADE formats (1991, 1999 and 2000). When the COMTRADE file is imported into the RecordGraph, all its functionality can be seamlessly used to analyze the record.

- 1 RecordGraph application must be running to access this facility. If not, launch RecordGraph via TESLA Control Panel, RecordBase View or Windows Explorer.
- 2 Choose *File>Import*.
- 3 Browse to select desired file.
- 4 Double-click on the COMTRADE record to apply <Default> template or select it from the templates list box.

Import file

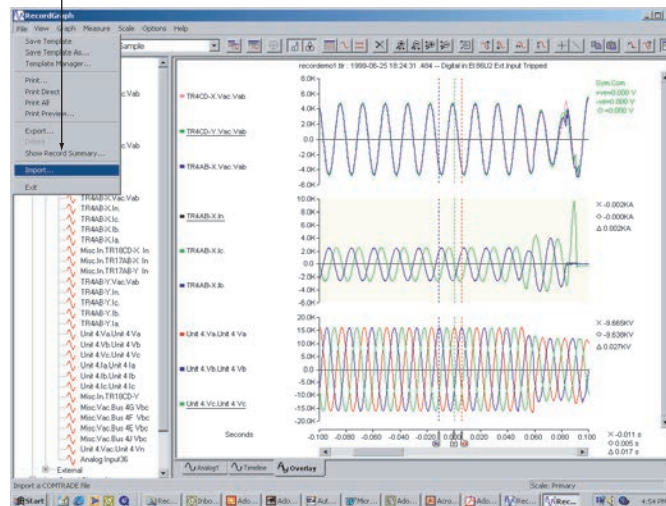


Figure 11.107: Import COMTRADE File

Choose COMTRADE File

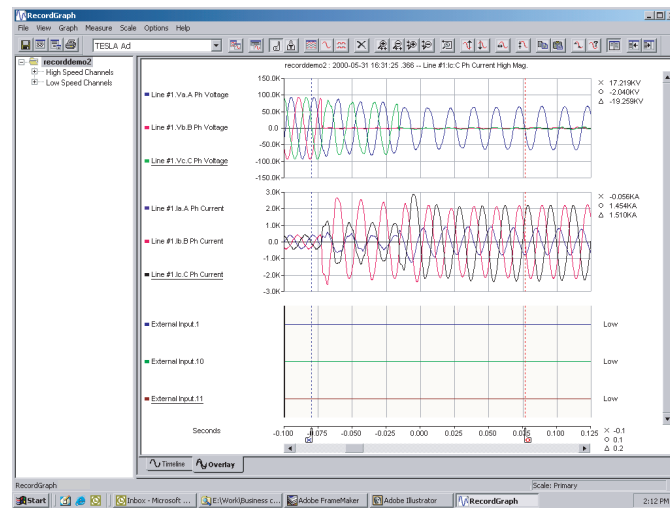


Figure 11.108: Select COMTRADE File

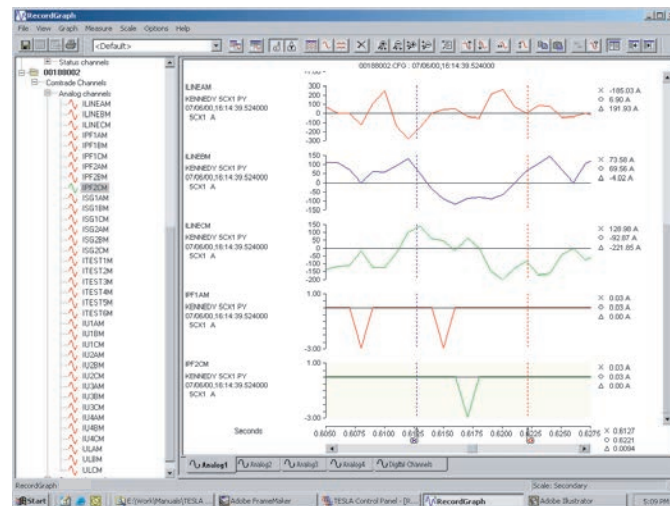


Figure 11.109: Apply <Default> Template

Print Options

The following options are available:

- Print... – pops-up a print option dialog box to select paper size, orientation and other options.
- PrintDirect – sends active view directly to the default printer.
- PrintAll – sends all the views directly to the default printer.
- Print Preview... – displays standard preview window.

12 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 (1999) or older version (1991) of the standard.

PTI

Power Technologies Incorporated (PTI) produces widely used power system modelling 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.

Excel (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*.

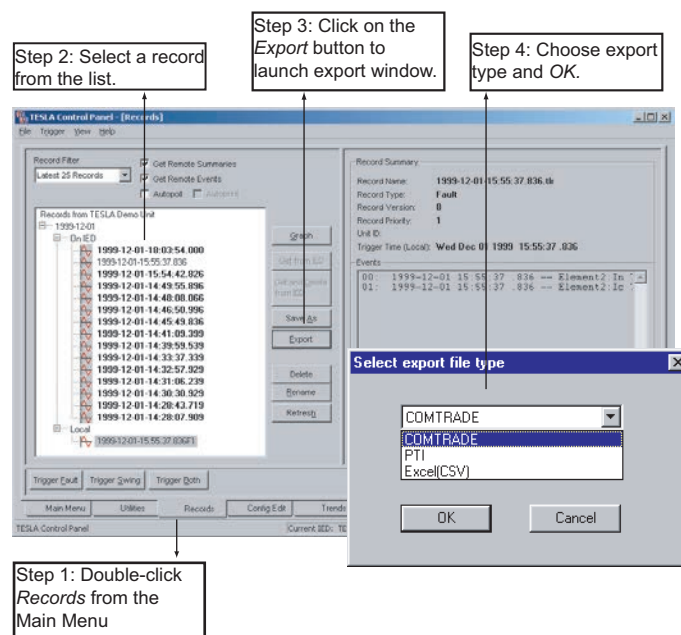


Figure 12.1: Select Export File Type

COMTRADE Format

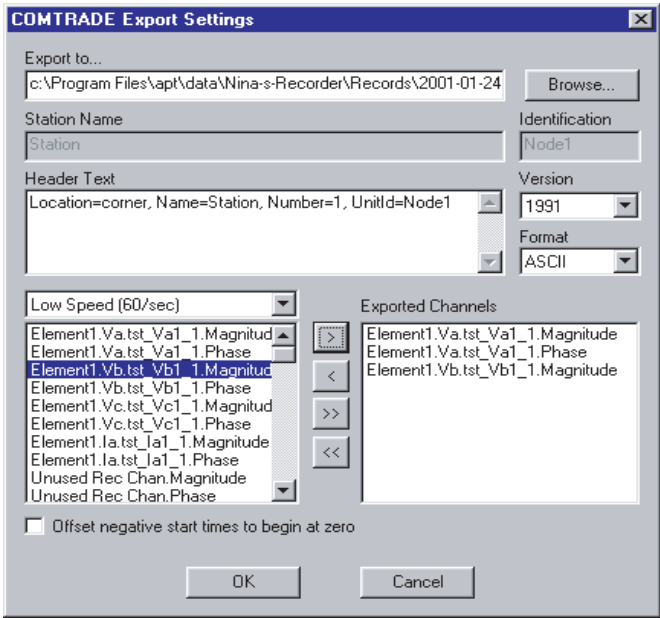


Figure 12.2: COMTRADE Settings

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 12.2: COMTRADE Settings,

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.

COMTRADE Export Settings	
Name	Function
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. 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: <ul style="list-style-type: none"> • 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. 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.

PTI Format

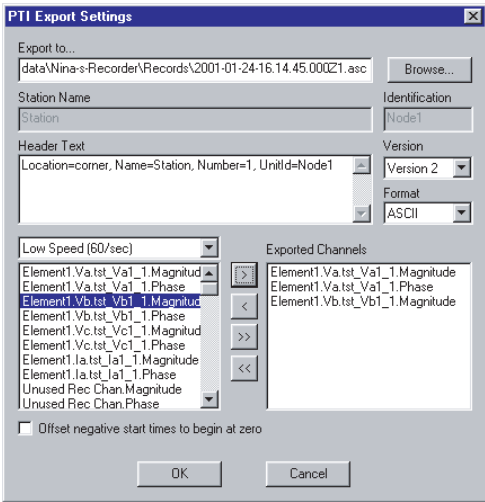


Figure 12.3: PTI Settings

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

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

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.

PTI Settings	
Name	Title
Channel Selection	<p>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.</p> <p>For convenience, the digital data recorded is classified into:</p> <ul style="list-style-type: none">• 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. <p>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).</p>
>	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.

Excel (CSV) Format

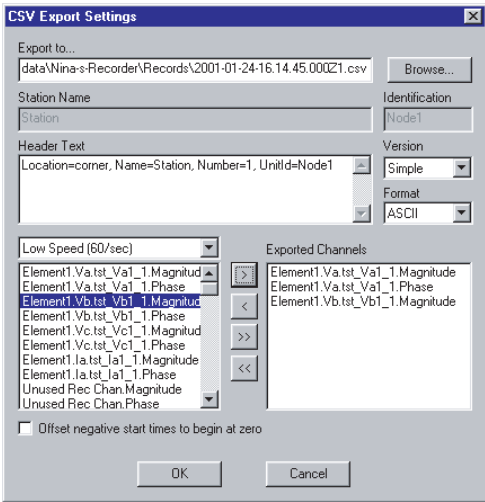


Figure 12.4: Excel (CSV) Settings

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

Excel CSV export produces a single output file with a .csv extension, which is recognized by Excel. Excel is automatically launched when you double-click on file.

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 Excel CSV format output file.
Header Text	There is no header text written to the Excel CSV format output file.
Version	There are no version options for the Excel CSV output.
Format	ASCII is the only format options for the Excel CSV output.

CSV Export Settings	
Name	Function
Channel Selection	<p>You must select the channels from the record that you want to include in the output file.</p> <p>For convenience, the digital data recorded is classified into:</p> <ul style="list-style-type: none">• 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. <p>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).</p>
>	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.

13 Cooperative Recorder Group

A cooperative recorder group consists of up to four TESLA 3000 recorders working together to form a larger virtual recorder. The recorders are connected through an Ethernet LAN and are accessed as a single "Cooperative Group " from Control Panel.

With a cooperative recorder group you can:

- Automatically trigger synchronous recordings on all group members whenever any member recorder is triggered.
- Transfer the resulting records from all group members to Control Panel and combine them into a single record.

Recorder group members also function as individual recorders. They are configured as stand-alone units and retain their normal recording capabilities.

Instructions for setting up recorders to operate in a cooperative recording group are provided later in this chapter.

How A Cooperative Recorder Group Works

Local Network

A cooperative recorder group is comprised of two to four TESLA 3000 recorders, typically located in a 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, user interface and SCADA functions. The cooperative recorder group can have its own network or can be connected to a larger network in the substation.

Remote Access

There are two ways to remotely access a cooperative recorder group:

- 1 Over a wide area network, if a network link to the substation is available.
- 2 Via a modem connected to one of the group recorders.

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 Control Panel a special Cooperative Group IED is created to work with the cooperative recording group. When the Cooperative Group IED is set as the Current IED, 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 IRIG-B clock signal, ensures that the data points from all the recorders are synchronous.

All cooperative group recorders must be synchronized from a common external IRIG-B time source.

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.

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, Control Panel automatically transfers the corresponding records from the other group members and combines them into a single record. Within Control Panel, the resultant record is stored under group's Cooperative Group IED record list.

It is possible in some circumstances for a record from a group member to be omitted from the combined record. This could be caused by a settings mismatch, network communication problem or loss of the IRIG B time signal. 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.

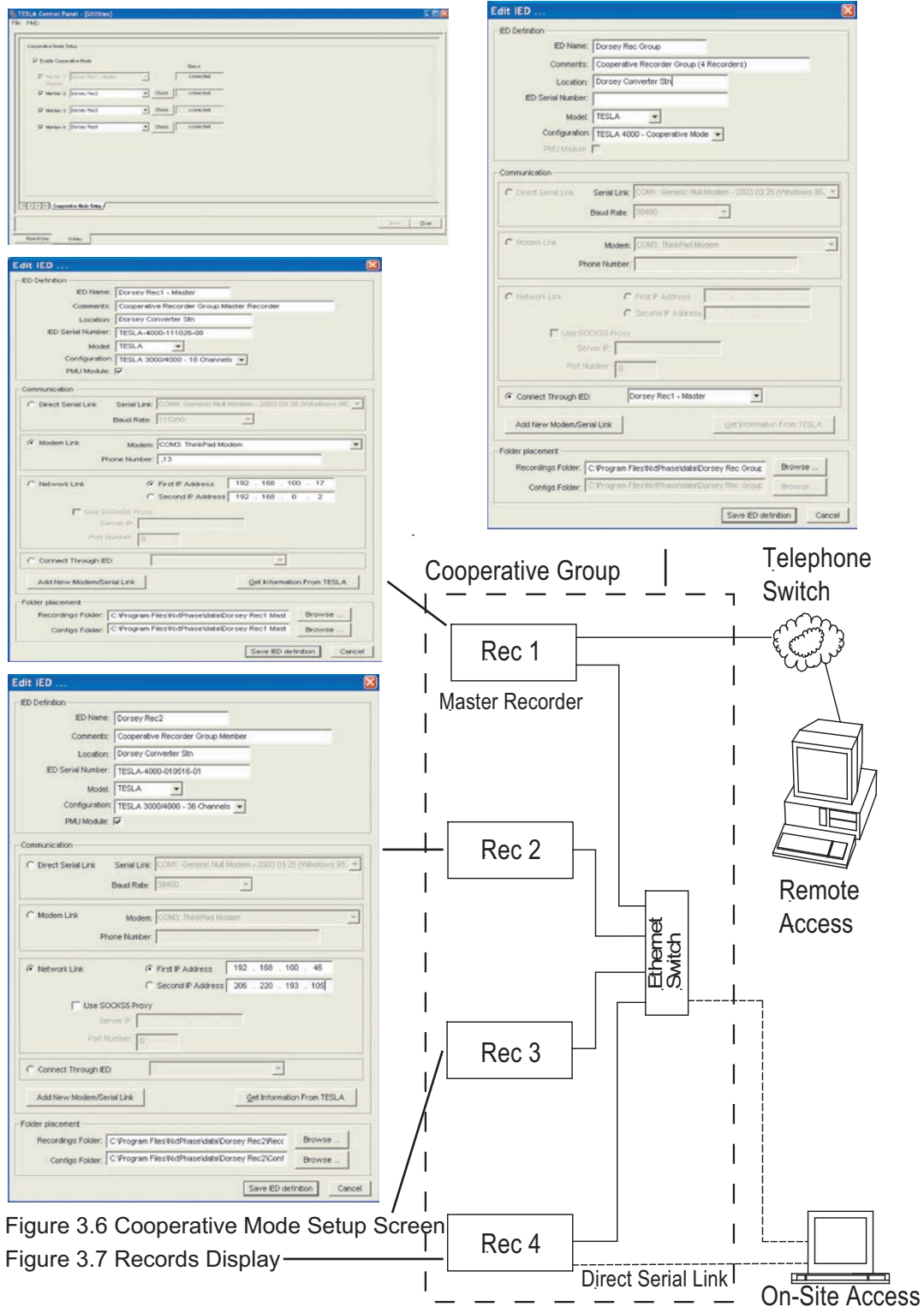
For further details on cooperative group records, see “Working With Records From a Cooperative Recording Group” on page 13-10.

RecordBase Central Station

RecordBase Central Station v2.0 and above can work with a TESLA 3000 cooperative recording group. RecordBase can:

- Automatically 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 or a modem on the Master recorder.

Setting Up a Cooperative Recording Group



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

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

These steps are covered in detail in the following sections.

Step 1: Set up the Network

You will need to create IED definitions for each of the group recorders, and a special one for the cooperative group itself. Example IED definitions are shown in Figure 13.1 on page 13-3; general instructions on how to create IED definitions are available in “Adding/Editing a Recorder Workspace Definition” on page 5-3

1 Connect the LAN port on each recorder to the Ethernet switch.

An industrial-quality 100Base-T Ethernet Switch is recommended for best performance, although a standard IEEE 802.3 10Base-T Ethernet hub can be used. Cable should be Type CAT 5 with maximum segment lengths of 100 meters as per the standard. Where a group consists 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 overall network load. Although the recorders are designed to tolerate considerable delay in the delivery of inter-recorder trigger messages (up to 4 seconds for transient recording triggers and 25 minutes for swing triggers), connection to a network segment with heavy traffic may result in missed triggers. Conversely, the network load resulting from the transfer of possibly large records may impact other devices on the network.

2 Assign IP addresses.

Each recorder must be assigned a unique IP address. The IP address is viewed and modified through the recorder's Maintenance Menu, for details see 14 Maintenance Menu and Error Handling on page 1. The factory default IP address is 192.168.1.100.

All recorders in the group must be assigned IP addresses that belong to the same local network. The permissible address range of a local network depends on the value of the first term of the IP address as shown in the following table.

IP address range (first term)	IP addresses on the same local network
1-126	---.xxx.xxx.xxx
128-191	---.---.xxx.xxx
192-223	---.---.---.xxx
0, 127, 224, 255	Reserved

If network access to the recorder from a different network or subnet is intended, it may be necessary to change the recorder's default gateway and/or its network mask. By default the recorder has no default gateway and a network mask of 255.255.255.0. These settings can be changed through the recorder's Maintenance Menu.

A note on PPP addresses: TESLA uses 3 pairs of IP addresses for its serial PPP (point to point protocol) communication; one for the front serial port, one for the rear serial / modem port, and one for communication with RecordBase Central Station. These IP addresses can be viewed and changed through the recorder's Maintenance Menu.

To assist in verifying and troubleshooting network connections, an IP "Ping" function is available through the recorder's Maintenance Menu. In addition, a communications status indicator is available in Control Panel (see the Check button on the Cooperative Mode Setup screen, Figure 13.2 on page 13-8).

3 Configure the Master Recorder's modem and connect to the telephone switch

This step is only required if remote access to the recorders will take place through modem rather than a wide area network.

The set-up of both internal and external modems is described in "Communicating with the Recorder" on page 4-1.

To make use of a modem link connection to multiple recorders, the Control Panel user must be logged into Windows with local administrator privileges. This is required to permit temporary access to the computer's network routing table.

Step 2: Set Up the Individual Recorders

1 Create an IED Definition in TESLA 3000 Control Panel for the Master Recorder

The Master Recorder is a recorder in the group designated as the primary interface between the recorder group and Control Panel. In addition to its role as a recorder, the Master Recorder maintains the list of group records and provides the IP addresses of the other group members to Control Panel. If remote access to the recorder group will be through a modem, the Master Recorder must be the recorder with the modem.

The following table provides a setting guide for the Master Recorder's IED definition.

IED Definitions for the Master Recorder	
IED Name	<ul style="list-style-type: none"> • Should identify both the recorder and its cooperative group. • Should have the same name as the recorder's <i>Unit ID</i>. (The <i>Unit ID</i> is configured in the recorder through the <i>Utilities</i> menu. See "Unit Identification" on page 7-2).
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 <i>Get Information from IED</i> button (see below).
Model	Select <i>TESLA 3000 – 36 Channels</i> or <i>TESLA 3000 – 18 Channels</i> as appropriate to the hardware model.
IP Address	Must be the same IP address configured in the recorder in Step 1.
Communication	Must reflect the method of remote access to the cooperative recording group. <ul style="list-style-type: none"> • Select <i>Modem Link</i> if a modem is used. Specify the appropriate telephone number. • Select <i>Network Link</i> if the group will be accessed through a network.
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 IED Definitions for each of the other group recorders

Once an IED definition for the Master Recorder has been created, you can create 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..

IED Definitions for the Other Group Recorders	
IED Name	<ul style="list-style-type: none"> • Should identify both the recorder and its cooperative group. • Should have the same name as the recorder's <i>Unit ID</i>. (The <i>Unit ID</i> is configured on the recorder through the <i>Utilities</i> menu. See "Unit Identification" on page 7-2).
Comment	Should indicate that the IED is a group member.
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 <i>Get Information from IED</i> button (see below).
Model	Select <i>TESLA 3000 – 36 Channels</i> or <i>TESLA 3000 – 18 Channels</i> as appropriate to the hardware model.
IP Address	Must be the same IP address configured on the recorder in Step 1. The IP address is required regardless of the <i>Communications</i> mode.
Communication	Indicates how to communicate with the IED as an individual recorder. <ul style="list-style-type: none"> • Use <i>Network Link</i> if the recorder can be directly reached over the network. • Use <i>Connect Through IED</i> and select the Master Recorder from the pick list to allow a telephone connection to the recorder (through the Master Recorder). • Use <i>Direct Serial Link</i> if you are working in the substation and intend to connect directly to the recorder through a serial cable.
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 7: Recorder Setup Utilities and Chapter 8: Configuring the Recorder cover this in detail.

Important

Certain settings must be the same on all recorders for cooperative mode to function correctly. See “Required Cooperative Mode Settings” on page 13-11 for the list.

Step 3: Configure the Cooperative Recording Group

1 Create a Cooperative Group IED Definition in TESLA 3000 Control Panel

Within Control Panel, a special Cooperative Group IED is created to work with the cooperative recording group. When the Cooperative Group IED is selected, 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

The following table provides a setting guide for the Cooperative Group IED definition..

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 <i>TESLA 3000 – Cooperative</i> .
IP Address	Blank
Communication	Must be <i>Connect Through IED</i> with the Master Recorder specified.

2 Select the cooperative recording group members

A setup screen associated with the Cooperative Group IED lets you specify which recorders are part of the cooperative group and provides group control and status information. To access the Cooperative Mode Setup screen:

- a Connect to the Cooperative Group IED by selecting the it from the IED list on the *Main Menu* tab and pressing *Connect*.
- b Select the Utilities screens by double-clicking on *Utilities* in the *Main Menu* tree.
- c You are now in the *Utilities – Cooperative Mode Setup* screen as shown in Figure 13.2.

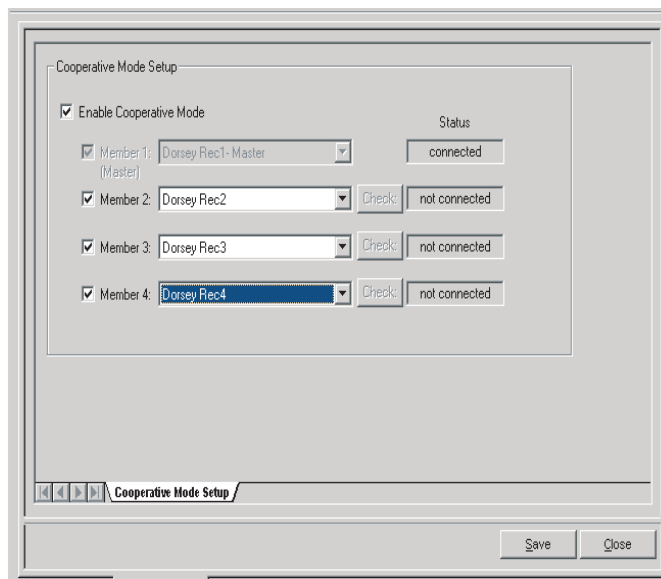


Figure 13.2: Cooperative Mode Setup Screen

- d Check the *Enable Cooperative Mode* box. Note: To exit Cooperative Mode, this box must be unchecked, and the chosen recorders (in part e) must also be unselected. User must choose Save to complete disabling Cooperative Mode.
- e Select the recorders you want to be part of the cooperative group using the pick lists. The Master recorder is automatically assigned as Member 1.

Note: If an expected recorder does not appear in the Member pick list, check the recorder's IED Definition for errors.

This list also determines the order in which records are combined. The member number shown here is pre-pended onto each analog and digital channel in the combined record to identify which recorder it came from.

3 Enable cooperative recording group operation

- a Click *Save*. TESLA Control Panel will connect to each member recorder to provide member IP addresses and enable cross-triggering. Progress information is displayed as each member recorder is updated. When the update is finished the status of each Member recorder should say *Connected*.
- b Click *Close*. The cooperative recording group configuration is now complete and cross-triggering, record collection and combining of member records are enabled.

The *Check* button beside the member recorder names in Figure 13.2 initiates a status check of the communications between the member recorders. It can be used at any time.

Working with Control Panel in the Substation

In the substation you can connect to the recorders through the LAN if a spare port is available on the Ethernet switch. Alternatively, a direct serial connection with each recorder can be used. (You may need to alter the Communication mode settings in a recorder's IED Definition).

Working With Records From a Cooperative Recording Group

Records from a cooperative recording group are managed in TESLA 3000 Control Panel in the same manner as records from individual recorders (see Chapter 9: Record and Log Management).

To access a group's records, select its Cooperative Group IED (*Select IED* on the *Main Menu* tab) and use the *Connect* button to establish a link with the group's Master recorder. Once connected, double-click *Records* in the menu tree to open the Records screen. If you only want to access previously downloaded records, the connection to the Master Recorder is not necessary.

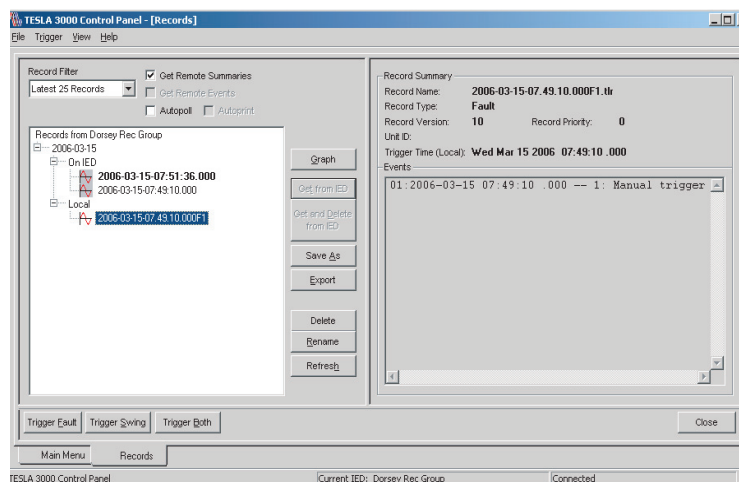


Figure 13.3: Records display

Records shown as being on the recorder (*On IED* branch) are on the Master Recorder. When you initiate record transfer, Control Panel automatically retrieves records with the same timestamp from all group members and combines them into a single group record. The record also combines event data from all recorders in the group, chronologically sorted. Records listed under the *Local* branch have already been transferred and combined.

To eliminate naming ambiguity and identify the data associated with each recorder, channel names and event entries in the combined record are prefixed with "1: ", "2: ", "3: ", and "4: ". These prefixes correspond to the member number defined in the Cooperative Mode Setup screen.

Calculated channels are automatically generated when the records are transferred to Control Panel. This differs from individual recorder records where calculated channels are generated when the record is first displayed by Record-Graph.

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, so the event list is only displayed for records that have already been transferred.

Record deletion for a Cooperative Group IED is handled the same way as record transfer. Deleting a record from the *On IED* branch of a Cooperative Group IED automatically deletes the associated record from each group member. If the group record is not deleted, the individual records can be retrieved

and viewed from a group member using standard (i.e. non-cooperative mode) methods

Required Cooperative Mode Settings

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

Time Control Settings <i>(Utilities->Time setup screen)</i>		
Setting	Effect on Cooperative Operation	Guideline
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
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
Recording Control Settings <i>(Utilities->Recording)</i>		
Trigger Mode	In <i>Duration</i> mode, triggers from other recorders result in a record of <i>Maximum Record Length</i> as their duration is not evident to the receiving recorder	Setting should be <i>Edge</i> 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. At least 0.1 seconds of pre-trigger is recommended
Normal Record Length	Records of different duration can be combined into a group record. The group record can be displayed, but not exported in COMTRADE format	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 0.1 second of auto-extension (<i>Maximum Record Length</i> > <i>Normal Record Length</i>) is recommended to avoid multiple overlapping records in the case of near-coincident triggers.

TESLA Device Configuration <i>(Identification screen in the Configuration editor)</i>		
Setting	Effect on Cooperative Operation	Guideline
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

14 Maintenance Menu and Error Handling

Maintenance Menu

TESLA has a set of utilities that provide diagnostic, recovery and TCP/IP services. These utilities are available through the Maintenance Menu accessed with a VT-100 terminal connection to the recorder's serial ports, modem or Ethernet LAN. For security purposes any utilities that can modify the TESLA are disabled when connecting remotely. To access these utilities you must connect to the recorder using Port 1 on the unit's front panel.

Any terminal program that fully supports VT-100 emulation and provides z-modem file transfer services can be used. HyperTerminal, which is included in Windows XP and is also available separately as HyperTerminal PE, is used here as an example.

- 1 Determine how you want to connect to the recorder.
 - A direct serial link connects your computer's serial port to the recorder's front panel Port 1. Port 1 is set up so that a standard, straight-through, male-to-female serial cable can be used.
 - If both the recorder and your computer have modems, you can access the Maintenance Menu through the telephone system.
 - If both the recorder and your computer are on the same LAN or WAN, you can access the Maintenance Menu through your network.
- 2 Configure your terminal program as described in the table below.
 - For a direct serial link, the baud rate must be same as that of the recorder's serial port. The default baud rate for Port 1 is 38,400. The baud rate can be viewed and changed in the *Utilities>Communication* tab of TESLA Control Panel.
 - For a modem link, the baud rate and other communication parameters only determine how your computer talks to your modem. Usually, the fastest possible baud rate is chosen to maximize your modem's compression capabilities.
 - For a network link, only the Emulation and Font settings from the table are relevant.

Terminal Program Setup	
Baud rate	For a direct serial link, the baud rate must match that of the recorder serial port. Port 1 default baud rate is 38,400. For a modem link, the baud rate refers only to the link between your computer and its own modem.
Data bits	8
Parity	None
Stop bits	1

Terminal Program Setup	
Flow control	Hardware or Software. Hardware flow control is recommended. The recorder automatically supports both on all its serial ports.
Function, arrow and control keys	Terminal keys
Emulation	VT100
Font	A font that supports line drawing (e.g. Terminal or MS Line Draw). If the menu appears outlined in odd characters, the font you have selected is not supporting line drawing characters.

- 3 Select the device on your PC you will communicate through. In HyperTerminal, this is done in the Connect Using field of its Properties control.
 - For a direct serial link, select an available serial port
 - For a modem link, select the appropriate modem
 - For a network link, select “TCP/IP (Winsock)” (available with HyperTerminal v1.2 or greater)
- 4 Initiate the connection. The TESLA will respond with a login prompt
 - In HyperTerminal, use the Call button or menu command to initiate the connection.
- 5 At the login prompt, log in as “maintenance”
 - Lower case
 - No password is required. If you are asked for one, there is a mistake in the login name. Press Enter to get another Login prompt and try again.

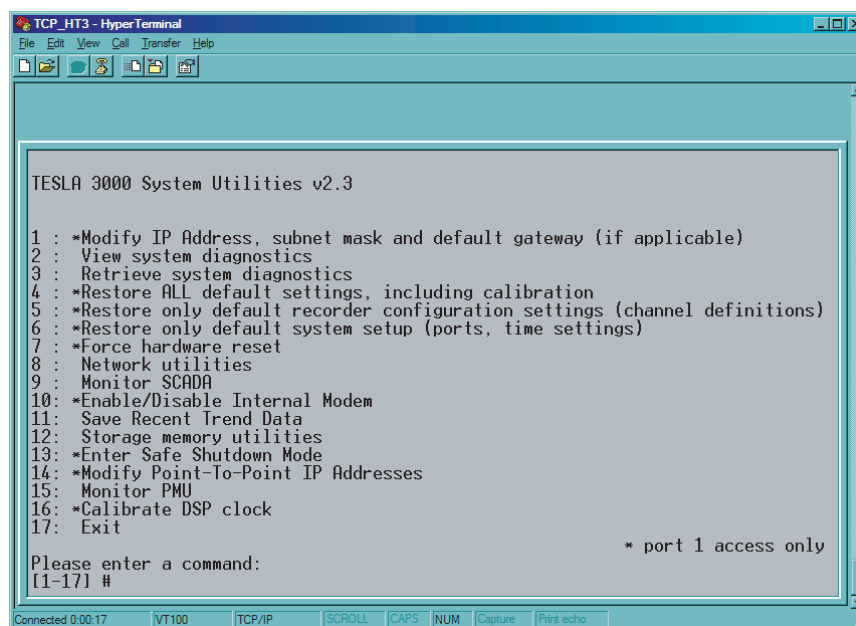


Figure 14.1: Maintenance Menu

Maintenance Menu Commands

1 Modify IP Address, subnet mask and default gateway	Modify the LAN IP address, default subnet mask and default gateway.
2 View system diagnostic	Displays the TESLA's internal status log.
3 Retrieve system diagnostics	Automatically packages up the internal status log plus setting and setup information and downloads it in compressed form to your computer. This file can then be sent to ERL-Phase customer support to help diagnose a problem.
4 Restore ALL default settings	Restores ALL factory defaults including settings, calibration and setup parameters.
5 Restore only default recorder configuration settings	Restores the default settings that define channels, sample rates and triggers.
6 Restore only default system setup	Restores the default values for the setup parameters including communication settings, record controls and time controls.
7 Force hardware reset	Manually initiates a hardware reset. Note that the communication link is immediately lost and cannot be re-established until the unit completes its start-up.
8 Network utilities	Enter network utilities sub-menu.
9 Monitor SCADA	Shows real time display of Modbus or DNP 3 data.
10 Enable/Disable internal modem	Enables or disables the optional internal modem. Allows an internal modem to be disabled so that an external modem can be used.
11 Save recent trend data	Saves any accumulated Trend Data that hasn't yet been saved to disk. This should be executed prior to [7] Force Hardware Reset if trend logging is enabled.
12 Storage memory utilities	Enter storage memory utilities sub-menu.
13 Enter safe shutdown mode	Suspends TESLA application and stops FLASH Drive operations. This should be executed prior to cycling power to the unit to prevent accidental FLASH Drive corruption.
14 Modify point-to-point IP addresses	Modify point-to-point addresses used for TCP/IP communication over serial or modem connection.
15 Monitor PMU	Displays outgoing PMU data frames in real time.
16 Calibrate DSP clock	Performs DSP clock calibration.
17 Exit	Logs off as Maintenance user.

Network Utilities Menu Commands	
1 View protocol statistics	View IP, TCP and UDP statistics.
2 View active socket states	View current states of active sockets.
3 View routing tables	View routing tables.
4 View MAC address	View MAC address.
5 Flush gateway entries	Flush the routing tables of all gateway entries.
6 Ping	Check network connection to given point.
7 Enable or disable port 2000	Toggle port 2000/port 7631 configuration.
8 Exit network utilities	Exit network utilities menu and return to maintenance menu commands.

Storage Memory Utilities	
1 Repair record storage	Attempts to repair a corrupted FLASH or Hard Drive partition used to store transient and swing records, trend data, event log, etc.
2 Repair CDR data storage	Attempts to repair a corrupted FLASH or Hard Drive partition used to store Continuous Recording Data.
3 Activate storage memory	Activates newly installed pre-formatted FLASH or Hard Drive to be used on the unit. Any pre-existing data are deleted.
Exit storage memory utilities	Exit storage memory utilities and return to maintenance menu commands.

Error Handling

The recorder has hardware and software self-check capabilities that work to keep it operational and provide an indication if a failure occurs.

Failure Contact

Output Contact #1 on the rear panel is a normally open contact that closes to indicate a problem with the device. The contact is controlled by a hardware watchdog circuit, ensuring a failure is reported even if the unit's processors are not functional. The state of the Failure Contract is mirrored by the front panel Recorder Functional LED.

Failure Handling

Supervisory software continually checks all system processes. If a failure is detected an attempt is made to correct the problem through a software restart. A

software restart takes place quickly and does not activate any external indicators.

If the failure persists, the unit will initiate a hardware reset to attempt to clear the problem. A hardware reset takes approximately a minute and half to complete. If the problem is not cleared after four consecutive reset attempts, 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 subsequently determines that the problem has been cleared, it automatically returns the unit to its normal operating state, clearing the failure indicators.

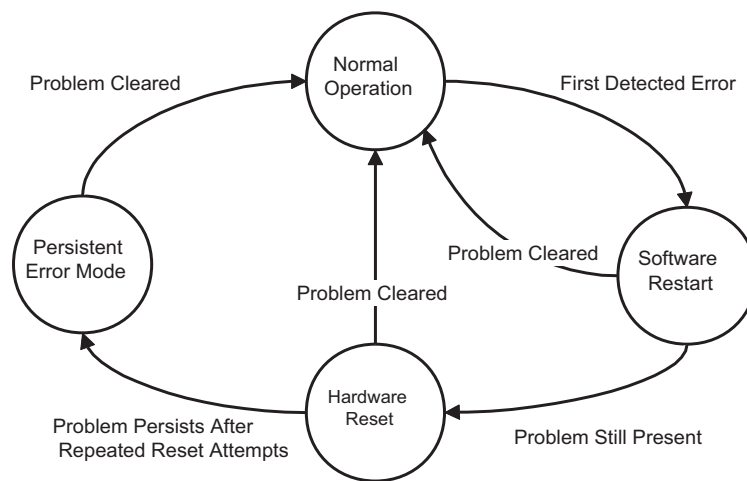


Figure 14.2: Error Handling

State Indicators

Recorder State	Indicators
Normal	Recorder Functional LED ON Failure Contact OPEN
Software Reset	Recorder Functional LED ON Failure Contact OPEN
Hardware Reset	Recorder Functional LED ON Test Mode LED ON Failure Contact OPEN
Persistent Error	Recorder Functional LED OFF Alarm LED ON Failure Contact CLOSED

Diagnostic Tools

The recorder has an internal log file to aid in problem diagnosis. The log can be viewed from the Maintenance Menu (see below). As well, a full diagnostic information package can be generated and uploaded to your PC, where it can be e-mailed to ERLPhase customer support for analysis.

The Maintenance menu also has tools to help diagnose SCADA problems and network communication problems.

15 PMU - Optional Software Module

This chapter describes the installation and operation of the TESLA 3000 PMU module. It supports the first time user and clarifies details of the equipment.

Overview

Phasor Measurement Unit (PMU) Description

PMU functionality is an optional software product feature on the TESLA Disturbance Recorder Model 3000. The PMU module can be installed as a field upgrade. The PMU functionality complies with the IEEE C37.118 - 2005 standard Synchrophasors for Power Systems. You can transmit up to 12 user selectable phasors as individual phase quantities or three-phase positive, negative or zero sequence phasors or summated phasors, via Ethernet, serial port or modem at rates up to 60 frames each second. You can also transmit to the PDC 12 Analog quantities of Watts, VARS, and VA and all 64 digital (status) quantities available from a 36/64 channel TESLA recorder. The PMU functionality does not affect the existing TESLA 3000 features; it is designed to work simultaneously with the existing features such as triggering, recording, and trending.

Synchrophasors - phasor measurements with angles referenced to a global time standard have been used in limited scope by electric power utilities in North America for well over a decade as a means of measuring and predicting dynamic stability of the power grid. Recently, a growing concern about the stability of the power system has increased interest in the use of synchrophasors on a broader scale. The formulation of a new standard to define the calculation and transmission of synchrophasors (IEEE C37.118 - 2005) and the launch of a major synchrophasor project on the eastern north American power grid (North American Synchro Phasor Initiative (NASPI) - formerly EIPP) have solidified the requirement for devices which can provide synchrophasor measurements in real time.

To transmit the PMU data reliably, you must connect to the IRIG-B signal from a Global Positioning System (GPS) clock or receiver to the TESLA Disturbance Recorder Model 3000 as described in the TESLA User Manual. The GPS signal must comply with the specification as mentioned in the IEEE C37.118 standard.

TESLA 3000 PMU Features

Phasor Estimation	Assuming IRIG-B signal from a reliable GPS receiver as per C37.118 standard Annex E section E1, the PMU functional module estimates the phasor using the DFT algorithm. The phasor magnitude and phase angle, once estimated, is compensated for the frequency variation over a wide range (+ / -60% of the nominal system frequency).
Phasor Reporting	Phasor data is transmitted in polar form (magnitude and phase angle) using Ethernet (TCP/IP or UDP), modem or serial communication. The phase angle is referenced to the absolute time of the GPS (IRIG-B signal) as per C37.118. The time stamp is based on the UTC time.
Number of Synchrophasors	<p>For a 36 channel TESLA recorder, up to 12 phasors (combination of any of 36 discrete phasors (any analog channel input) and/or any of 12 sequence phasor channels and/or summation channels).</p> <p>For 18 channel TESLA recorder, 12 phasors (combination of any of 18 discrete phasors (any analog channel) and/or any of 12 sequence phasor channels and/or summation channels).</p> <p>Phasors selection is user configurable via TESLA 3000 Control Panel software.</p>
Number of Frequency Channels	One frequency channel (user configurable using TESLA 3000 Control Panel software) per recorder. Rate of change of frequency information (DFREQ) reported will be based on the frequency channel as configured by the user. The frequency estimation is accurate over +/- 60% of nominal system frequency.
Analog Data	There are 12 PMU Analog channels per TESLA 36 analog channel recorder that can be streamed to a remote PDC (PMU Data Concentrator). The quantities are MWatts, MVars and MVA.
Digital Status data	There are 64 digital (contact) channels or statuses per TESLA 3000 recorder that can be streamed to a remote PDC (PMU Data Concentrator).
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 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).

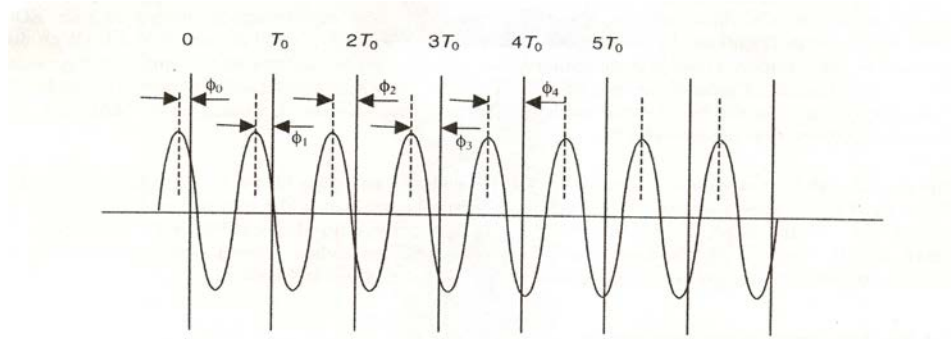


Figure 1—A sinusoid with a period of T observed at instants that are multiples of T_0 apart. T_0 is not an integer multiple of T .

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 (1%) - (as per IEEE C37.118 standard).

PMU Accuracy Signal Frequency Variation

Total Vector Error: (TVE) < 1% (as per C37.118 standard).

As per IEEE C37.118 standard - Level 1, for details see Table 15.1: PMU Standard - Level 1 on page 15-4.

Signal Magnitude

As per IEEE C37.118 standard - Level 1, for details see Table 15.1: PMU Standard - Level 1 on page 15-4.

Phase Angle

As per IEEE C37.118 standard - Level 1, for details see Table 15.1: PMU Standard - Level 1 on page 15-4.

Total Harmonic Distortion (<0.2%)

(<0.2%): As per IEEE C37.118 standard - Level 1, for details see Table 15.1: PMU Standard - Level 1 on page 15-4.

Out-Of-Band Frequency Deviation

As per IEEE C37.118 standard - Level 1, for details see Table 15.1: PMU Standard - Level 1 on page 15-4.

Influence Quality	Reference Conditions	Range of influence quantity change with respect to reference and maximum allowable TVE in percent (%) for each compliance Level	
		Level 1	
		Range	TVE (%)
Signal Frequency	F_{nominal}	± 0.5 Hz	1.0
Signal magnitude	100% rated	10.0% to 120% rated	1.0
Phase angle	0 radians	$\pm \pi$ radians	1.0
Harmonic distortion	<0.2% of (THD)	10.0%%, any harmonic up to 50th	1.0
Out-of - Band interfering signal, at frequency f_i where $ f_i - f_0 > F_s / 2$, F_s = phasor reporting rate $F_0 = F_{\text{nominal}}$	<0.2% of input signal magnitude	10.0% of input signal magnitude	1.0

Table 15.1: PMU Standard - Level 1**PMU Module Requirements**

PMU module functionality is an optional feature available with the TESLA Disturbance Recorder Model 3000. In order to have PMU module on an existing TESLA the following firmware revisions are necessary.

Firmware Release vX.XX

The firmware is available through the accompanying CD titled TESLA 3000 Disturbance Fault Recorder vX.XX and the corresponding TESLA 3000 Disturbance Fault Recorder User Manual. The instructions to update to the latest version of the firmware are found in the TESLA 3000 Firmware Update Instructions document.

Firmware Versions

To install the PMU module The TESLA 3000 Disturbance Fault Recorder unit must have a firmware version 2.1 or later.

Please refer to the website for the latest versions of the TESLA 3000 Disturbance Fault Recorder firmware and the TESLA 3000 PMU Module firmware.

Calibration

TESLA Disturbance Recorder Model 3000 voltage and/or current input modules are optional and a variety of input modules for voltage and current inputs are available, therefore, you must calibrate the input modules. The PMU calibration requires both the magnitude and phase angle calibration at nominal signal level. This is very important in order to meet the TVE < 1% as per C37.118.

Test Set Requirements

You must have an accurate calibration test set to achieve high accuracy. Any calibration test set which generates GPS controlled signal with the accuracy as specified in the standard C37.118 is a good candidate. ERLPhase recommends Doble test set F6150 with the associated GPS equipment.

Magnitude Calibration

This process is similar to that as described in the TESLA User Manual. Magnitude calibration is required whenever the input module and /or the TESLA recorder sample rate are changed.

Angle Calibration

You must carry out the magnitude calibration as explained in the previous section before the phase 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 see “Metering Display” on page 6-1. 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 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 15-5.

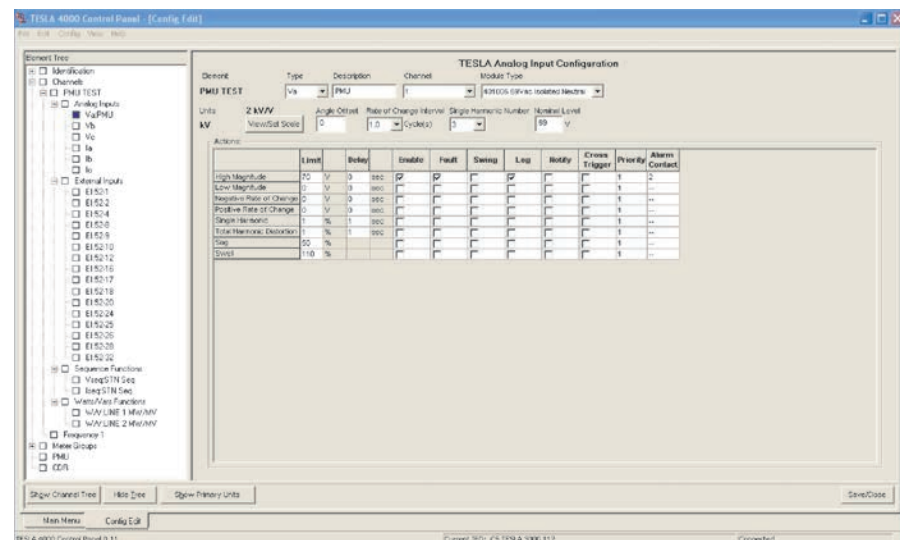


Figure 15.2: Setting up angle calibration offset through analog channel configuration

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 < 1% as per C37.118 standard. Phase angle calibration is required for all analog channels used in the PMU phasor configuration. Phase angle calibration is required whenever the input module and / or the TESLA recorder sample rate are changed.

Communication with the PMU

PMU data can be transmitted via serial port, modem or Ethernet. Serial communications will be available on the TESLA's rear panel Port 2. When in use for synchrophasor transmission, Port 2 is not be available for any other TESLA function. However, it is possible to use an internal modem to provide normal user interface access when Port 2 is in use for synchrophasor transmission. It is possible to transmit synchrophasors via one modem and have another modem provide normal user interface access. In such a situation, one modem is internal and the other is external and connected to Port 2. Either modem is usable for either role. TCP and UDP options are available for Ethernet communication. PMU communication is initiated by the receiver.

PMU communication setup is done through TESLA 3000 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, modem or serial communication. You must also setup the Phasor Data Concentrator (PDC) information to transfer the data. First connect to the TESLA 3000 DFR and check whether it has PMU capabilities.

Identifying the PMU Module Support

Open TESLA 3000 Control panel software. Connect to the TESLA 3000 DFR unit. Double-click on the *Utilities* item in the tree view. Select the *Unit Identification* tab - the PMU information is displayed as shown below.

If the unit has PMU capability, the PMU version information will be displayed.

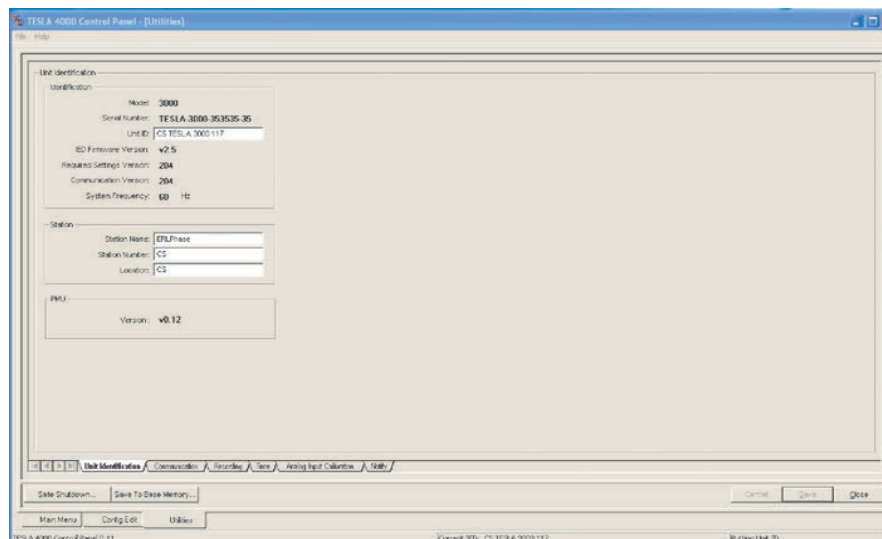


Figure 15.3: PMU Module feature identification on the TESLA unit using Unit Identification screen

If the unit does not have the PMU capability, it displays *PMU Not Installed*.

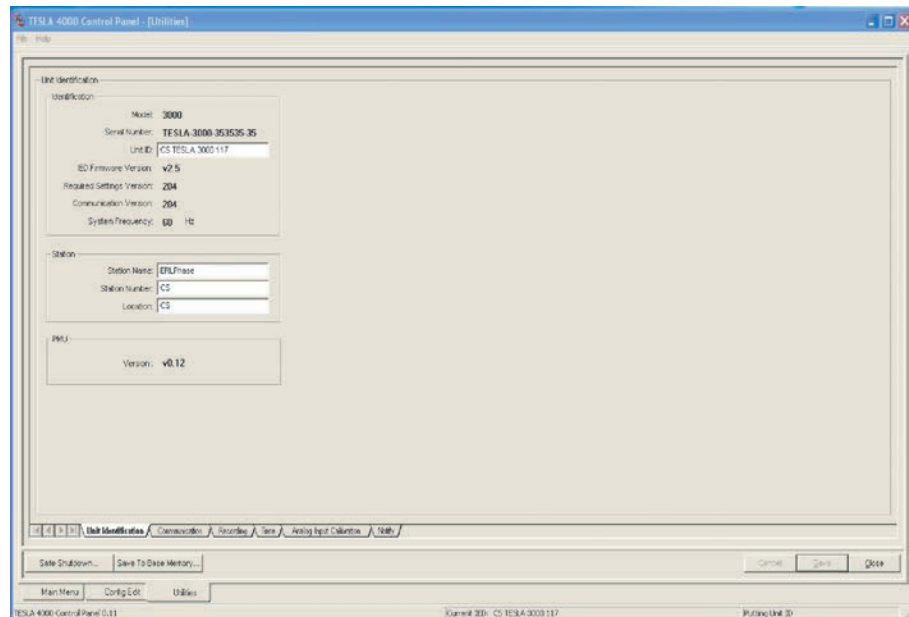


Figure 15.4: Example of Unit Identification display when PMU Module feature is not installed

Setting up PMU Communication Mode

Connect to a TESLA unit that has PMU features. Click on the *Communication* tab.

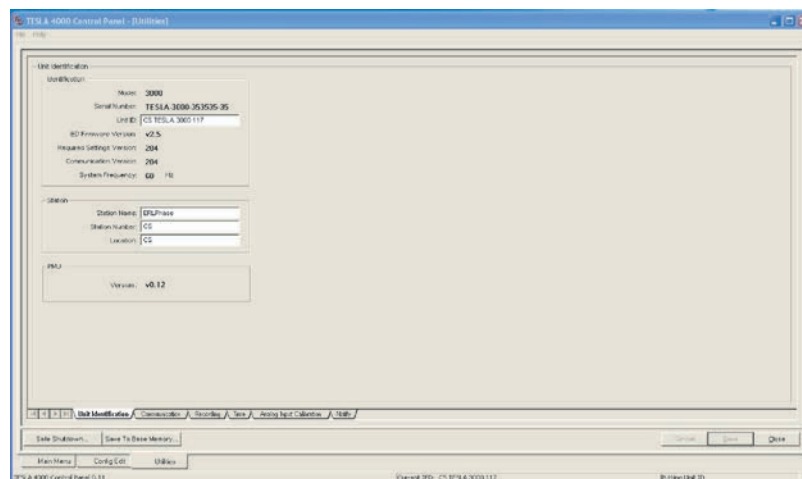


Figure 15.5: PMU communication setup screen

Use this view to set up the TESLA and PMU communication.

- Service Port (Port 1) settings do not change with the PMU functionality as Port 1 is not available for PMU reporting. Setting of this parameter is similar to the existing TESLA unit.
- Port 2 is a new group available for Direct Serial or External Modem communication. Port 2 can be selected for PMU reporting. Port 2 Baud rates

available are 1200, 2400, 9600, 19200, 38400, and 57600. The initial value is set based on the information available from the TESLA unit current setting information.

- Internal Modem group is a new group available for modem communication using a TESLA unit in which the internal modem is installed. If the internal modem is not available, then this group will be disabled.
- If the internal modem is available, then the Baud rate and the modem initialization string can be set for this group. The Baud rates available are, 1200, 2400, 9600, 19200, 38400, and 57600. The initial value will be set based on the information available from the TESLA unit current setting information.
- PMU group is a new group available to set the PMU identification and communication.

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 communication options are available for the selection via the Mode control:

- Do Not Transmit: With this choice, no PMU data is reported to the DC. Useful for maintenance purposes.
- Internal Modem: PMU data reporting is done using Internal Modem. Baud rate and the modem configuration are obtained from the Internal Modem group settings.
- Port 2: PMU data reporting is done using Port 2 parameter setting information. The settings information is obtained from the Port 2 group settings
- 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 DC are required to set this communication choice.

The initial values of the above controls are based on the data received from the unit on connect.

The *Notify* screen is affected based on the Internal Modem or Port 2 choice, which will be explained later in the Notify view user interface descriptions.

Figure 15.6: Setting up PDC communication information

PDC options under PMU are:

- **IP Address of DC:** This option is enabled only if the Mode is either Network (TCP) or Network (UDP) otherwise it is disabled. This choice allows you to configure the IP address of the DC (required for the Network (UDP) only).
- **Port of DC:** This option is enabled only if the Mode is either Network (TCP) or Network (UDP) otherwise it is disabled. This choice allows you to configure the port number of the DC to connect via the network link.

If the TESLA unit does not support the PMU functionality, then the following screen will be presented with all PMU controls disabled.

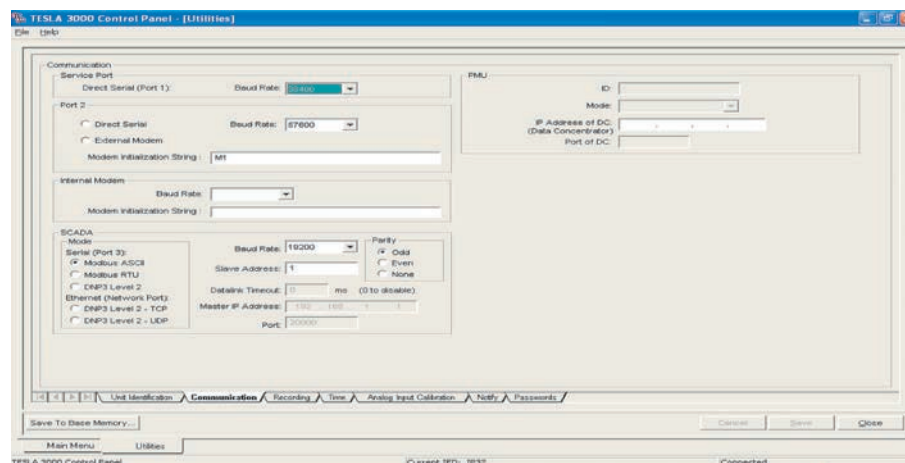


Figure 15.7: Disabled PMU communication controls when PMU feature is not installed

PMU Configuration

Configuration settings specific to PMU takes place in a single PMU configuration view. PMU settings utilize the existing TESLA configuration. For example, a positive sequence synchrophasor is selected from the list of configured Sequence Component calculated channels rather than re-specified based on individual input channels. Default names for the PMU channels are those of the underlying selected TESLA channel in the element: type: description format, truncated if necessary to meet the 16 character limit defined in the C37.118 standard. you can enter a user specified name to over-ride the default. For offline use, the *Edit IED* option in the main menu provides means to configure PMU configuration settings from TESLA Control Panel.

Downloading a setting file that contains PMU settings to a recorder that does not have the PMU option installed will be prevented and a warning/explanation message displayed.

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” on page 15-10 can be followed to define PMU phasors.

Configuring PMU Phasors with Existing Settings

To configure PMU phasors offline, the following check must be performed in the Main Menu's Select IED view. Open TESLA Control Panel software and click on the *Edit* option to open the following screen.

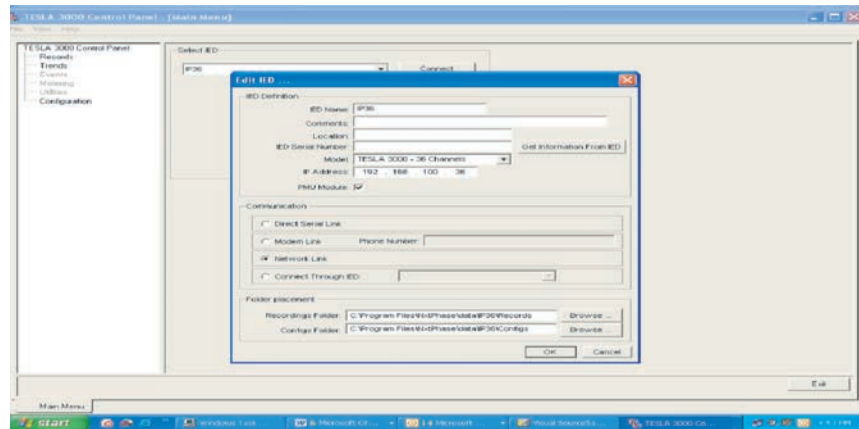


Figure 15.8: Enabling PMU Module configuration support through Edit IED dialogue

To allow PMU configuration you must check the *PMU Module* in the Edit IED dialog box enabling the TESLA Control Panel configurator. If the *PMU Module* option is unchecked, the configurator will not allow PMU configuration. After you check the PMU Module, select *Save IED definition* to accept the changes, then select the *Configuration* option to open the configuration view. Select an existing configuration file by double-clicking on the file and the following screen appears.

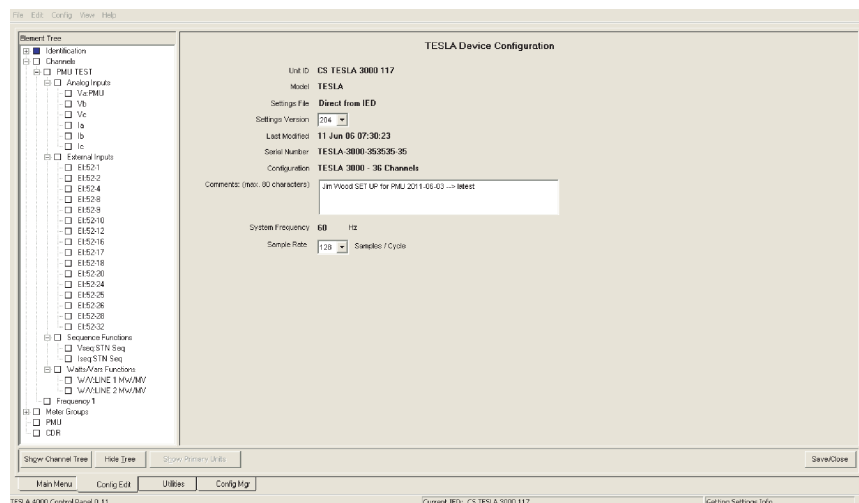


Figure 15.9: Setting version conversion view

If the Setting Version is older than setting version 202 the PMU feature will not be available. Therefore the current setting file must be converted to setting version 202. This is done by selecting the Setting Version to 202. You must do this to add the PMU configuration to the existing setting file. when the setting file is converted to the latest setting version, right-click on the *Channel Group 1* to display the choice to add a PMU as shown below.

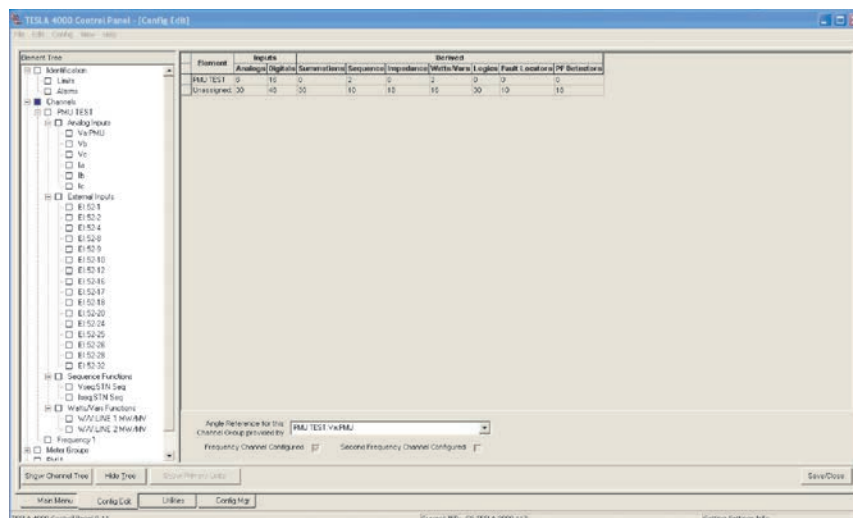


Figure 15.10: Invoking PMU configuration through right-click menu

Select the *PMU* choice and the following screen appears allowing you to select the Phasors.

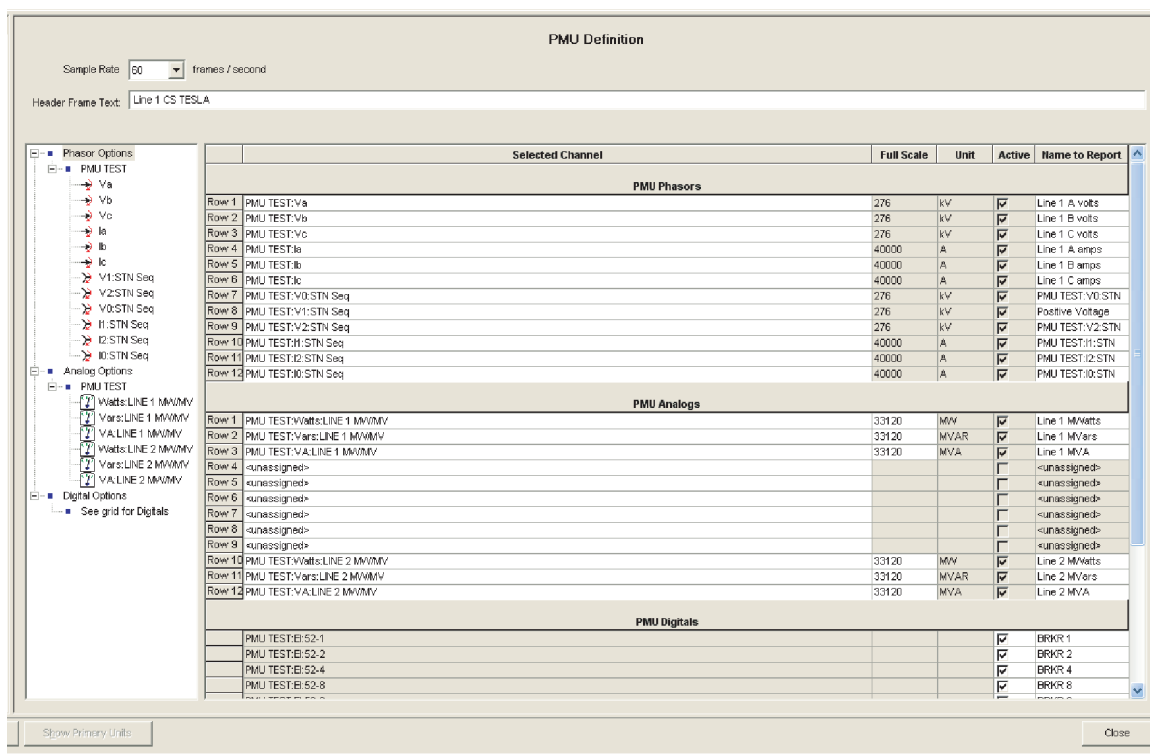


Figure 15.11: PMU configuration screen with preconfigured analog, sequence and summation channels

In the above PMU Definition Screen, Analog Inputs (voltage & currents), Summations and Sequence Functions channels are available for PMU Phasors reporting. You can select up to 12 phasors by dragging and dropping the chan-

nels on the Selected Channels list or by selecting the phasors from the Combo Box as shown below. In addition 12 PMU Analogs, which are the Watt, Var and VA quantities to be also, streamed with the PMU phasors at the same time to the Phasor Data Concentrator (PDC). You can also stream with the PMU phasors and the PMU analogs, the 64 PMU Digitals (breaker contacts) to the PDC from a single TESLA 36/64.

	Selected Channel	Full Scale	Unit	Active	Name to Report
PMU Phasors					
Row 1	PMU TEST:Va	276	kV	<input checked="" type="checkbox"/>	Line 1 A volts
Row 2	PMU TEST:Vb	276	kV	<input checked="" type="checkbox"/>	Line 1 B volts
Row 3	PMU TEST:Vc	276	kV	<input checked="" type="checkbox"/>	Line 1 C volts
Row 4	PMU TEST:Ia	40000	A	<input checked="" type="checkbox"/>	Line 1 A amps
Row 5	PMU TEST:Ib	40000	A	<input checked="" type="checkbox"/>	Line 1 B amps
Row 6	PMU TEST:Ic	40000	A	<input checked="" type="checkbox"/>	Line 1 C amps
Row 7	PMU TEST:V0:STN Seq	276	kV	<input checked="" type="checkbox"/>	PMU TEST:V0:STN
Row 8	PMU TEST:V1:STN Seq	276	kV	<input checked="" type="checkbox"/>	Positive Voltage
Row 9	PMU TEST:V2:STN Seq	276	kV	<input checked="" type="checkbox"/>	PMU TEST:V2:STN
Row 10	PMU TEST:I1:STN Seq	40000	A	<input checked="" type="checkbox"/>	PMU TEST:I1:STN
Row 11	PMU TEST:I2:STN Seq	40000	A	<input checked="" type="checkbox"/>	PMU TEST:I2:STN
Row 12	PMU TEST:I0:STN Seq	40000	A	<input checked="" type="checkbox"/>	PMU TEST:I0:STN
PMU Analogs					
Row 1	PMU TEST:Watts:LINE 1 MVMV	33120	MW	<input checked="" type="checkbox"/>	Line 1 MWatts
Row 2	PMU TEST:Vars:LINE 1 MVMV	33120	MVAR	<input checked="" type="checkbox"/>	Line 1 MVars
Row 3	PMU TEST:VA:LINE 1 MVMV	33120	MVA	<input checked="" type="checkbox"/>	Line 1 MVA
Row 4	<unassigned>			<input type="checkbox"/>	<unassigned>
Row 5	<unassigned>			<input type="checkbox"/>	<unassigned>
Row 6	<unassigned>			<input type="checkbox"/>	<unassigned>
Row 7	<unassigned>			<input type="checkbox"/>	<unassigned>
Row 8	<unassigned>			<input type="checkbox"/>	<unassigned>
Row 9	<unassigned>			<input type="checkbox"/>	<unassigned>
Row 10	PMU TEST:Watts:LINE 2 MVMV	33120	MW	<input checked="" type="checkbox"/>	Line 2 MWatts
Row 11	PMU TEST:Vars:LINE 2 MVMV	33120	MVAR	<input checked="" type="checkbox"/>	Line 2 MVars
Row 12	PMU TEST:VA:LINE 2 MVMV	33120	MVA	<input checked="" type="checkbox"/>	Line 2 MVA
PMU Digitals					
	PMU TEST:BI:52-1			<input checked="" type="checkbox"/>	BRKR 1
	PMU TEST:BI:52-2			<input checked="" type="checkbox"/>	BRKR 2
	PMU TEST:BI:52-4			<input checked="" type="checkbox"/>	BRKR 4
	PMU TEST:BI:52-8			<input checked="" type="checkbox"/>	BRKR 8
	PMU TEST:BI:52-9			<input checked="" type="checkbox"/>	BRKR 9
	PMU TEST:BI:52-10			<input checked="" type="checkbox"/>	BRKR 10
	PMU TEST:BI:52-12			<input checked="" type="checkbox"/>	BRKR 12

Figure 15.12: Phasor selection for PMU reporting

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.

PMU Phasors Section (Selection Channel Column)

- PMU Phasor section allows 12 PMU Phasors to be selected from the Phasor Options left hand tree by selecting from the tree, drag and drop into one of the 12 rows under PMU Phasor column. 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 12 PMU Analogs to be selected from the Analog Options left hand tree by selecting from the tree, drag and drop into one of the 12 rows under PMU Analog column. User can also use the row drop down selection tool. A PMU Analog can be MWatts, MVars and/or MVA values.
- PMU Digital allows up to 64 Digital (contacts) inputs per TESLA recorder. When you configure a digital channel it will be automatically placed in the PMU Digital section of the PMU Definition.

Full Scale Column (PMU Phasor section)

- 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, split core CTs) times the PT or CT ratio.
 - Voltage module's full scale is 138 volts
 - Current module's full scale is 1 amp module/split core = 20 amps. 5 amp module/split core = 100 amps.

Example: voltage Full scale = PT ratio = 2000:1, full scale of voltage module is 138 - CT ratio = 2000:1 (1.0 amp module), therefore the full scale in the PMU Definition screen:

Full Scale = PTratio x PT module full scale

$Fs = 2000 \times 138 = 276,000$

Full Scale = CTratio x CT module full scale

$Fs = 2000 \times 20 = 40,000$

Full Scale Column (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.
 - Full Scale watts = Full scale volts = 276,000, Full scale amps = 40,000. Therefore the full scale watts; $Fs \text{ volts} \times Fs \text{ amps} = 276,000 \times 40,000 = 33,120,000,000 \text{ Watts}$ or 33,120 MW. This number is large but the user can edit this column to put a more practical scale (use nominal values).

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) and VoltAmps (MVA)

Active Column (PMU Phasors, Analog and 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 allow the user to re-name the streaming PMU channel that will be reported to the remote Data Concentrator

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.

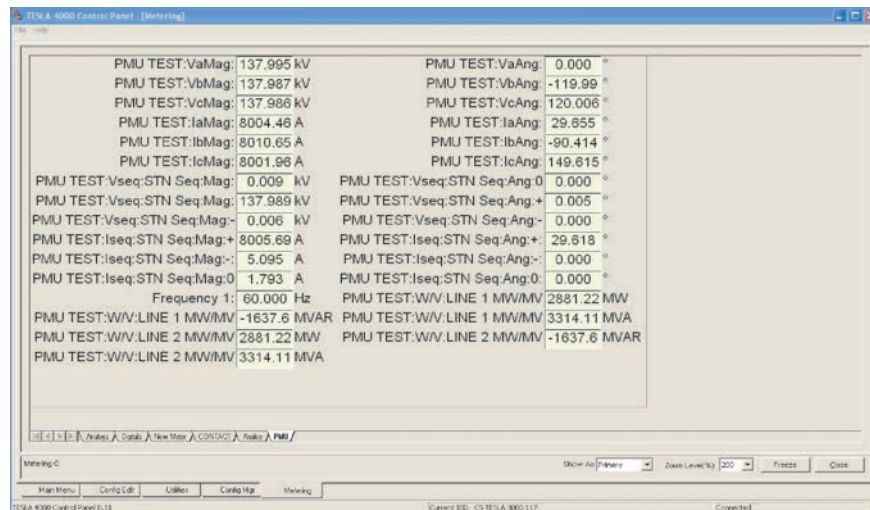


Figure 15.13: Typical PMU metering screen

Note that the PMU metering is a default metering view, and is considered the 10th user defined metering group. This means, if the setting file already has 10 user defined Metering groups, the PMU metering replaces the last (10th) metering group. Hence the total number of user defined Metering groups available will be 9 instead of 10.

Maintenance and Error Handling

Any Phasor Data Concentrator (PDC) program which can communicate with the PMU is a good starting point for the trouble shooting. Use the TVA's (Tennessee Valley Authority) free PMU Connection Tester program (PDC) developed to support the Eastern Interconnect Phasor Project (EIPP) to check the basic communications with the PMU.

Download the TVA tester program and the installation procedure from the following web site:

<http://phasors.pnl.gov>

Downloads can be found under Resources/Tool's.

for details see 14 Maintenance Menu and Error Handling on page 1 describes a set of utilities that provide diagnostic, recovery and TCP/IP services.

Diagnosing the PMU Functionality

The following procedure helps in diagnosing the PMU functionality.

Select the device on your PC you communicate through. In HyperTerminal, this is done in the Connect Using field of its Properties control.

- For a direct serial link select an available serial port
- For a modem link select the appropriate modem
- For a network link select TCP/IP (Winsock) (available with HyperTerminal v1.2 or greater)

When you initiate the connection, the TESLA responds with a login prompt.

- In HyperTerminal use the Call button or menu command to initiate the connection.

At the login prompt, log in as **maintenance**

- Lower case
- No password is required. If you are asked for one, there is a mistake in the login name. Select *Enter* to get another login prompt and try again

When you get the display of maintenance menu choice, choose *15* for PMU diagnostics as shown below.

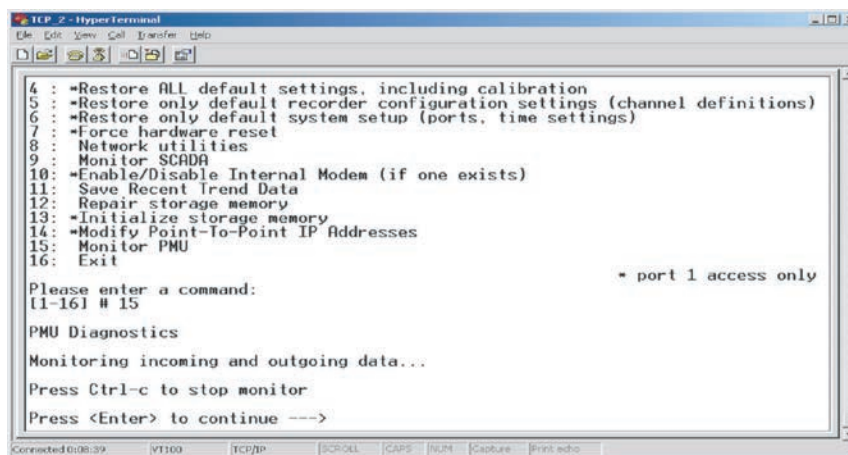


Figure 15.14: Terminal User Interface depicting options under Maintenance

When you select enter, data frame stream is displayed as shown below in hexadecimal format.

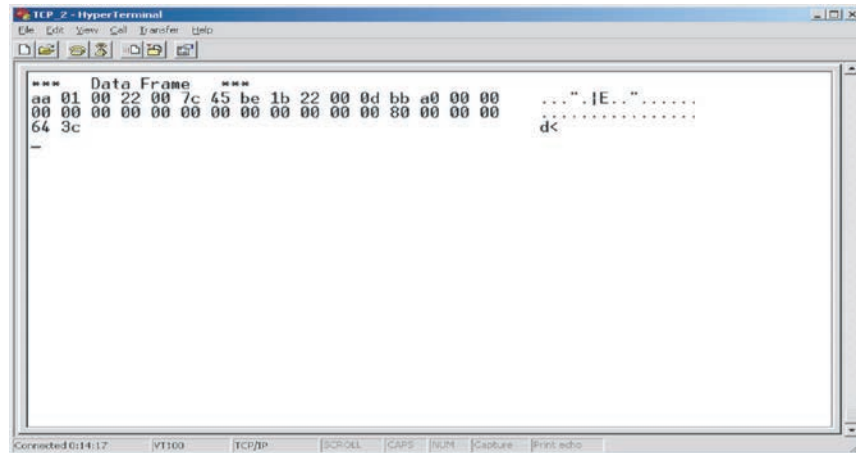


Figure 15.15: Display of PMU Data Stream in hexadecimal format

If the data transmission is disabled from a PDC program (example, TVA Connection Tester Program), following response is displayed.

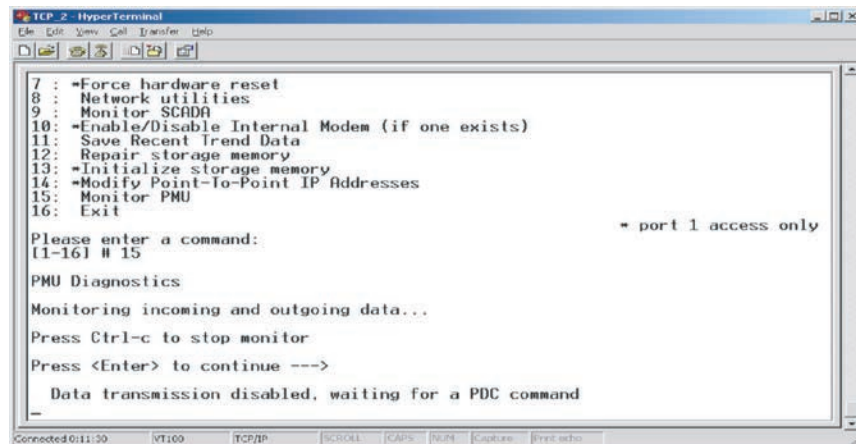


Figure 15.16: Response of terminal user interface when PDC requests to disable data transmission

With data transmission disabled, the PDC program can request for the configuration frame, which will be displayed as shown:

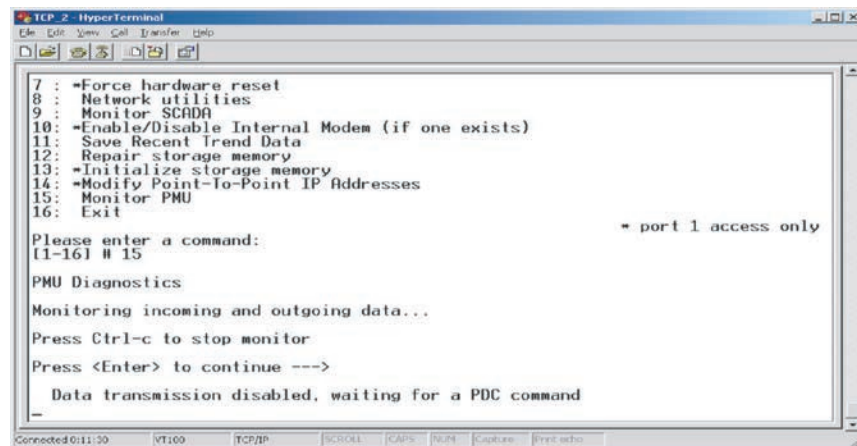


Figure 15.17: Diagnostic response to Configuration frame request from the PDC

The C37.118 standard protocol itself has number of diagnostics and/or health check messages, which can be read and analyzed. The description of these diagnostic fields is found in C37.118 standard

Appendix A Specifications

TESLA 3000 Disturbance Recorder			
Item	Quantity/Specs		Note
General:			
Weight	12.4 lbs		
Dimension	3U high (5.25"), 19" wide, 12" deep		Rack mount
Nominal Frequency	50 or 60 Hz		
Power Supply	40-300 Vdc, suitable for 48 Vdc, 125 Vdc, 250 Vdc nominal systems. Also accepts 30-200 Vac		Burden is less than 15W
Available Recording Channels	Available Analog and External input channels Sample Rate Analog External 32 / cycle 36 64 64 / cycle 36 64 96 / cycle 36 64 128 / cycle 36 64 256 / cycle 18 32 384 / cycle 9 32		18 channel model is limited to a maximum of 18 Analog and 32 External input channels.
Alarm Contacts	8 or 4, depending on model		
Sample Rate	Samples per cycle and per second (60 / 50 Hz) 32 samples / cycle (1,920 / 1,600 Hz) 64 samples / cycle (3,840 / 3,200 Hz) 96 samples / cycle (5,760 / 4,800 Hz) 128 samples / cycle (7,680 / 6,400 Hz) 256 samples / cycle (15,360 / 12,800 Hz) 384 samples / cycle (23,040 / 19,200 Hz)		
Measurement Accuracy	Amplitude Measurement Accuracy: ± 0.01% of full scale ± 0.5% of reading (above 1% of full scale) Phase Measurement Accuracy: ± 0.5 degrees at system frequency Frequency Measurement Accuracy: ± 0.001 Hz at system frequency		
Frequency Response	The following are the highest harmonics of the fundamental frequency (60 Hz / 50 Hz) that can be passed at the available sample rates: Sample Rate Harmonic 1,920 / 1,600 Hz 8th (480/400HZ) 3,840 / 3,200 Hz 16th (960/800HZ) 5,760 / 4,800 Hz 25th (1500/1250HZ) 7,680 / 6,400 Hz 33rd (1980/1650HZ) 15,360 / 12,800 Hz 66th (3960/3300HZ) 23,040 / 19,200 Hz 100th (6000/5000HZ)		
Noise	Signal to Noise ratio: 70 dB at full scale Common mode rejection: 70 dB at full scale Crosstalk: -07 dB		
Sample Skew	All channels sampled simultaneously		

TESLA 3000 Disturbance Recorder		
Item	Quantity/Specs	Note
Recording and Logging:		
Transient Fault	Maximum 15 second nominal, 30 second extended	At any selected system sample rate
Dynamic Swing	Maximum 15 minute nominal, 30 minute extended	
Event Logging	250 Events in the regular log, 1000 events in long term log	Long term event logging is part of the trending function
Record Storage	Up to 1000 records	1 Gigabyte FLASH drive standard. 2 Gigabyte FLASH drive available
Trending		
Available trend channels	Any of the recorder's existing configured analog channels (input or calculated) can be trended.	Evaluated phasor magnitude and angle quantities will be recorded as separate channels.
Accumulation mode	Minimum, maximum, average, damped or undamped.	
Sample Interval	User selectable sample interval from 10 seconds to 1 hour in 1 second increments.	All channels produce trend data simultaneously at the selected rate.
Maximum number of channels	Up to 60 channels can be trended simultaneously.	A channel with multiple accumulation modes is treated as multiple channels (e.g. the trending of minimum, maximum and average readings of a selected input would require 3 trend channels).
Trend storage	The recorder can store 90 days of data from each trend channel, regardless of the sample rate or the number of configured trend channels.	This is a non-configurable parameter.
Channels and Triggers:		
Analog Inputs	High and low threshold, positive and negative rate of change, harmonic level, THD level, sags, swells	All triggers have independent controls for delay, logging, transient or swing record initiation, alarm contact activation and cross triggering.
Summations	High/low threshold, +/- rate of change	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	
Impedance	Positive sequence circle	
External Inputs (digital)	Rising edge, falling edge or both	

TESLA 3000 Disturbance Recorder		
Item	Quantity/Specs	Note
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 analog input channel configured as a voltage.	
Interface & Communication:		
Front Panel Indicators	6 LEDs	Recorder Functional, IRIG-B Functional, Recorder Triggered, Records Stored, Test Mode, Alarm
Serial User Interface	Port 1 and 2 RS-232 ports to 58K baud	Port 2 can support an external modem
Internal Modem	33.6 Kbps, V.32 bis	Optional
Network	10/100BaseT Ethernet port	standard
SCADA Interface	DNP3 (RS-232 or Ethernet) or Modbus (RS-232)	Rear port
Configurable Alarms	6 contacts	Normally open
Cross-trigger	1 contacts (#4)	Normally open
Self Checking/Recorder Inoperative	1 contact (#1)	Normally closed
Time Sync	IRIG-B, BNC connector	Modulated or unmodulated
Ratings:		
Analog Input Channels	ac Voltage Module: Nominal Input: $V_n=69$ V RMS (120/ Root 3) Full Scale / Continuous: 138V RMS Burden: < 0.15 VA @ 69 V RMS ac Current Modules Nominal Input: $I_n = 5$ A or 1A RMS Continuous: 3x I_n Full Scale: 20x I_n for 1 second Thermal: 400A RMS for 1 second Burden: < 0.25 VA @ 5 A	
External Inputs (digital)	Will turn on: ≥ 38 Vdc Will not turn on: ≤ 25 Vdc Maximum input: <300 Vdc Burden: >10 kilo-ohm	Externally wetted
Alarm Contacts	Make: 8 A Vdc Carry: 8 A Vdc Break: 0.15 A at 125 Vdc 0.10 A at 250 Vdc	Cross trigger contact (#4) - Pick-up <10 ms, latch 100 ms User-definable contacts - Pick-up <1.0 s, latch 1.0 s
Environmental:		

TESLA 3000 Disturbance Recorder		
Item	Quantity/Specs	Note
Ambient Temperature Range	IEC 60068-2-1/IEC 60068-2-2	-10°C – 55°C
Humidity	IEC 60068-2-30	Up to 95% without condensation
Insulation Test (Hi-Pot)	IEC 60255-5	Power supply, analog inputs (through external isolation modules), external inputs, output contacts -1.5 kV, 50/60 Hz, 1 second.
Electrostatic Discharge	IEC 61000-4-2 Level 4, IEEE C37.90.3, IEC 60255-22-2 Level 4	
Voltage Dips, Interruptions, Variations	IEC 6100-4-11, IEC 60255-11	200ms Interrupt
Conducted RF Immunity	IEC 61000-4-6 Level 3, IEC 60255-22-6 Level 3	
Radiated RF Susceptibility	EC 61000-4-2 Level 3, IEC 60255-22-3 Level 3	
Electrical Fast Transient/Burst	IEC 61000-4-4 Level 3, IEC 60255-22-4 Class III	
Oscillatory Transient	ANSI/IEEE C37.90.1-1989, IEC 61000-4-12 Level 3, IEC 60255-22-1 Level 3	
Oscillatory Vibration	IEC 60068-2-6, IEC 60255-21-1 Class 1	
Seismic	IEC 60068-3-3, IEC 60255-21-3 Class 1	
Shock and Bump	IEC 60255-21-2 Class 1	

Appendix B TESLA Hardware Description

The TESLA is a modular high-quality power system recording system. It is available in 18 and 36 channel models.

Main Processor Board

The Main Processor Board consists of a DSP, a 586 processor, serial ports, an Ethernet port, 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 18 channel TESLA has 32 external inputs and 4 contact outputs, provided by External Input Board #1. Inputs are optically isolated and accepts up to 300 Vdc.

The 36 channel TESLA has a second bank of 32 external inputs and 4 contact outputs provided by External Input Board #2 for a total of 64 external inputs. 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.

Analog Input Board

The TESLA's analog input channels to the recorder are provided by the Analog Input Board. The 18 channel TESLA has only half of the board populated. Rear panel connection to the board is provided by removable screw terminal strips which are keyed, to ensure that the correct terminal strip is installed into the correct bank.

Comm Board

The Comm Board provides the TESLA with two RS-232 ports, IRIG-B time synchronization input, network or telephone connection. The RS-232 ports are female DB-9S connectors, IRIG-B is a male BNC, the telephone jack is an RJ-11 and the modem jack is an RJ-45.

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 40 to 300 Vdc or 120 Vac.

Storage Disk

Data storage for the TESLA recorder is a 1 GB solid state FLASH IDE drive. Other options are available.

Front Panel Board

The Front Panel Board provides visual indication of the status of the TESLA recorder and a front-panel RS-232 port.

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 C37.111-1991, 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.
Cooperative Recording Group	A set of TESLA 3000 recorders that work together to form a larger virtual recorder.
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.
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.
DUN	Dial-Up Networking, a facility in Windows providing dial-up access to Internet and other networks. DUN is provided with the Windows distribution.
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. 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.
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.

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).
Master Recorder	A member of a Cooperative Recording Group selected to be the primary interface between the recorder group and TESLA Control Panel or RecordBase Central Station.
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.
PTI	Power Technologies Incorporated
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 Modbus Functions

The TESLA recorder operates as a slave device on the Modbus network, with an address of 1 to 247 (decimal), 0x01 to 0xF7. The Point List can be printed through TESLA Control Panel to display the point names as they are configured. Please refer to “Printing a SCADA Address List” on page 8-45.

For further information on Modbus, please refer to your Modbus master device manual, or obtain Modicon’s *Modbus Protocol Reference Guide*, document PI-MBUS-300.

Read Coil Status (Function Code 01, 0X References)			
Channel	Address	Value	
Hold Readings	00001	0: Readings not held	1: Readings held
Reserved	00257	Reserved	
Contact 2	00513	0: Contact open (inactive)	1: Contact closed (active)
Contact 3	00514	0: Contact open (inactive)	1: Contact closed (active)
Contact 4	00515	0: Contact open (inactive)	1: Contact closed (active)
Contact 5	00516	0: Contact open (inactive)	1: Contact closed (active)
Contact 6	00517	0: Contact open (inactive)	1: Contact closed (active)
Contact 7	00518	0: Contact open (inactive)	1: Contact closed (active)
Contact 8	00519	0: Contact open (inactive)	1: Contact closed (active)
Logic Detector 1	00769	0: Off (inactive)	1: On (active)
Logic Detector 2	00770	0: Off (inactive)	1: On (active)
Logic Detector 3	00771	0: Off (inactive)	1: On (active)
Logic Detector 4	00772	0: Off (inactive)	1: On (active)
Logic Detector 5	00773	0: Off (inactive)	1: On (active)
Logic Detector 6	00774	0: Off (inactive)	1: On (active)
Logic Detector 7	00775	0: Off (inactive)	1: On (active)
Logic Detector 8	00776	0: Off (inactive)	1: On (active)
Logic Detector 9	00777	0: Off (inactive)	1: On (active)
Logic Detector 10	00778	0: Off (inactive)	1: On (active)
Logic Detector 11	00779	0: Off (inactive)	1: On (active)
Logic Detector 12	00780	0: Off (inactive)	1: On (active)
Logic Detector 13	00781	0: Off (inactive)	1: On (active)
Logic Detector 14	00782	0: Off (inactive)	1: On (active)
Logic Detector 15	00783	0: Off (inactive)	1: On (active)
Logic Detector 16	00784	0: Off (inactive)	1: On (active)
Logic Detector 17	00785	0: Off (inactive)	1: On (active)
Logic Detector 18	00786	0: Off (inactive)	1: On (active)
Logic Detector 19	00787	0: Off (inactive)	1: On (active)

Logic Detector 20	00788	0: Off (inactive)	1: On (active)
Logic Detector 21	00789	0: Off (inactive)	1: On (active)
Logic Detector 22	00790	0: Off (inactive)	1: On (active)
Logic Detector 23	00791	0: Off (inactive)	1: On (active)
Logic Detector 24	00792	0: Off (inactive)	1: On (active)
Logic Detector 25	00793	0: Off (inactive)	1: On (active)
Logic Detector 26	00794	0: Off (inactive)	1: On (active)
Logic Detector 27	00795	0: Off (inactive)	1: On (active)
Logic Detector 28	00796	0: Off (inactive)	1: On (active)
Logic Detector 29	00797	0: Off (inactive)	1: On (active)
Logic Detector 30	00798	0: Off (inactive)	1: On (active)
High/low speed recording active	01025	0: Off (inactive)	1: On (active)
High/low speed recording space nearly full alarm	01026	0: Off (inactive)	1: On (active)
Trend Recording Active	01281	0: Off (inactive)	1: On (active)
Trend Recording Accumulation Alarm	01282	0: Off (inactive)	1: On (active)

Read Input Status (Function Code 02, 1X References)			
Channel	Address	Value	
External I/P 1	10001	0: Off (inactive)	1: On (active)
External I/P 2	10002	0: Off (inactive)	1: On (active)
External I/P 3	10003	0: Off (inactive)	1: On (active)
External I/P 4	10004	0: Off (inactive)	1: On (active)
External I/P 5	10005	0: Off (inactive)	1: On (active)
External I/P 6	10006	0: Off (inactive)	1: On (active)
External I/P 7	10007	0: Off (inactive)	1: On (active)
External I/P 8	10008	0: Off (inactive)	1: On (active)
External I/P 9	10009	0: Off (inactive)	1: On (active)
External I/P 10	10010	0: Off (inactive)	1: On (active)
External I/P 11	10011	0: Off (inactive)	1: On (active)
External I/P 12	10012	0: Off (inactive)	1: On (active)
External I/P 13	10013	0: Off (inactive)	1: On (active)
External I/P 14	10014	0: Off (inactive)	1: On (active)
External I/P 15	10015	0: Off (inactive)	1: On (active)
External I/P 16	10016	0: Off (inactive)	1: On (active)
External I/P 17	10017	0: Off (inactive)	1: On (active)
External I/P 18	10018	0: Off (inactive)	1: On (active)
External I/P 19	10019	0: Off (inactive)	1: On (active)

External I/P 20	10020	0: Off (inactive)	1: On (active)
External I/P 21	10021	0: Off (inactive)	1: On (active)
External I/P 22	10022	0: Off (inactive)	1: On (active)
External I/P 23	10023	0: Off (inactive)	1: On (active)
External I/P 24	10024	0: Off (inactive)	1: On (active)
External I/P 25	10025	0: Off (inactive)	1: On (active)
External I/P 26	10026	0: Off (inactive)	1: On (active)
External I/P 27	10027	0: Off (inactive)	1: On (active)
External I/P 28	10028	0: Off (inactive)	1: On (active)
External I/P 29	10029	0: Off (inactive)	1: On (active)
External I/P 30	10030	0: Off (inactive)	1: On (active)
External I/P 31	10031	0: Off (inactive)	1: On (active)
External I/P 32	10032	0: Off (inactive)	1: On (active)
External I/P33	10033	0: Off (inactive)	1: On (active)
External I/P 34	10034	0: Off (inactive)	1: On (active)
External I/P 35	10035	0: Off (inactive)	1: On (active)
External I/P 36	10036	0: Off (inactive)	1: On (active)
External I/P 37	10037	0: Off (inactive)	1: On (active)
External I/P 38	10038	0: Off (inactive)	1: On (active)
External I/P 39	10039	0: Off (inactive)	1: On (active)
External I/P 40	10040	0: Off (inactive)	1: On (active)
External I/P 41	10041	0: Off (inactive)	1: On (active)
External I/P 42	10042	0: Off (inactive)	1: On (active)
External I/P 43	10043	0: Off (inactive)	1: On (active)
External I/P 44	10044	0: Off (inactive)	1: On (active)
External I/P 45	10045	0: Off (inactive)	1: On (active)
External I/P 46	10046	0: Off (inactive)	1: On (active)
External I/P 47	10047	0: Off (inactive)	1: On (active)
External I/P 48	10048	0: Off (inactive)	1: On (active)
External I/P 49	10049	0: Off (inactive)	1: On (active)
External I/P 50	10050	0: Off (inactive)	1: On (active)
External I/P 51	10051	0: Off (inactive)	1: On (active)
External I/P 52	10052	0: Off (inactive)	1: On (active)
External I/P 53	10053	0: Off (inactive)	1: On (active)
External I/P 54	10054	0: Off (inactive)	1: On (active)
External I/P 55	10055	0: Off (inactive)	1: On (active)
External I/P 56	10056	0: Off (inactive)	1: On (active)
External I/P 57	10057	0: Off (inactive)	1: On (active)
External I/P 58	10058	0: Off (inactive)	1: On (active)
External I/P 59	10059	0: Off (inactive)	1: On (active)

External I/P 60	10060	0: Off (inactive)	1: On (active)
External I/P 61	10061	0: Off (inactive)	1: On (active)
External I/P 62	10062	0: Off (inactive)	1: On (active)
External I/P 63	10063	0: Off (inactive)	1: On (active)
External I/P 64	10064	0: Off (inactive)	1: On (active)
External I/P1 Change latch	10257	0: Off (no change)	1: On (change)
External I/P 2 Change latch	10258	0: Off (no change)	1: On (change)
External I/P 3 Change latch	10259	0: Off (no change)	1: On (change)
External I/P 4 Change latch	10260	0: Off (no change)	1: On (change)
External I/P 5 Change latch	10261	0: Off (no change)	1: On (change)
External I/P 6 Change latch	10262	0: Off (no change)	1: On (change)
External I/P 7 Change latch	10263	0: Off (no change)	1: On (change)
External I/P 8 Change latch	10264	0: Off (no change)	1: On (change)
External I/P 9 Change latch	10265	0: Off (no change)	1: On (change)
External I/P 10 Change latch	10266	0: Off (no change)	1: On (change)
External I/P 11Change latch	10267	0: Off (no change)	1: On (change)
External I/P 12 Change latch	10268	0: Off (no change)	1: On (change)
External I/P 13 Change latch	10269	0: Off (no change)	1: On (change)
External I/P 14 Change latch	10270	0: Off (no change)	1: On (change)
External I/P 15 Change latch	10271	0: Off (no change)	1: On (change)
External I/P 16 Change latch	10272	0: Off (no change)	1: On (change)
External I/P 17 Change latch	10273	0: Off (no change)	1: On (change)
External I/P 18 Change latch	10274	0: Off (no change)	1: On (change)
External I/P 19 Change latch	10275	0: Off (no change)	1: On (change)
External I/P 20 Change latch	10276	0: Off (no change)	1: On (change)
External I/P 21 Change latch	10277	0: Off (no change)	1: On (change)
External I/P 22 Change latch	10278	0: Off (no change)	1: On (change)
External I/P 23 Change latch	10279	0: Off (no change)	1: On (change)
External I/P 24 Change latch	10280	0: Off (no change)	1: On (change)
External I/P 25 Change latch	10281	0: Off (no change)	1: On (change)
External I/P 26 Change latch	10282	0: Off (no change)	1: On (change)
External I/P 27 Change latch	10283	0: Off (no change)	1: On (change)
External I/P 28 Change latch	10284	0: Off (no change)	1: On (change)
External I/P 29 Change latch	10285	0: Off (no change)	1: On (change)
External I/P 30 Change latch	10286	0: Off (no change)	1: On (change)
External I/P 31 Change latch	10287	0: Off (no change)	1: On (change)
External I/P 32 Change latch	10288	0: Off (no change)	1: On (change)
External I/P 33 Change latch	10289	0: Off (no change)	1: On (change)
External I/P 34 Change latch	10290	0: Off (no change)	1: On (change)
External I/P 35 Change latch	10291	0: Off (no change)	1: On (change)

External I/P 36 Change latch	10292	0: Off (no change)	1: On (change)
External I/P 37 Change latch	10293	0: Off (no change)	1: On (change)
External I/P 38 Change latch	10294	0: Off (no change)	1: On (change)
External I/P 39 Change latch	10295	0: Off (no change)	1: On (change)
External I/P 40 Change latch	10296	0: Off (no change)	1: On (change)
External I/P 41 Change latch	10297	0: Off (no change)	1: On (change)
External I/P 42 Change latch	10298	0: Off (no change)	1: On (change)
External I/P 43 Change latch	10299	0: Off (no change)	1: On (change)
External I/P 44 Change latch	10300	0: Off (no change)	1: On (change)
External I/P 45 Change latch	10301	0: Off (no change)	1: On (change)
External I/P 46 Change latch	10302	0: Off (no change)	1: On (change)
External I/P 47 Change latch	10303	0: Off (no change)	1: On (change)
External I/P 48 Change latch	10304	0: Off (no change)	1: On (change)
External I/P 49 Change latch	10305	0: Off (no change)	1: On (change)
External I/P 50 Change latch	10306	0: Off (no change)	1: On (change)
External I/P 51 Change latch	10307	0: Off (no change)	1: On (change)
External I/P 52 Change latch	10308	0: Off (no change)	1: On (change)
External I/P 53 Change latch	10309	0: Off (no change)	1: On (change)
External I/P 54 Change latch	10310	0: Off (no change)	1: On (change)
External I/P 55 Change latch	10311	0: Off (no change)	1: On (change)
External I/P 56 Change latch	10312	0: Off (no change)	1: On (change)
External I/P 57 Change latch	10313	0: Off (no change)	1: On (change)
External I/P 58 Change latch	10314	0: Off (no change)	1: On (change)
External I/P 59 Change latch	10315	0: Off (no change)	1: On (change)
External I/P 60 Change latch	10316	0: Off (no change)	1: On (change)
External I/P 61 Change latch	10317	0: Off (no change)	1: On (change)
External I/P 62 Change latch	10318	0: Off (no change)	1: On (change)
External I/P 63 Change latch	10319	0: Off (no change)	1: On (change)
External I/P 64 Change latch	10320	0: Off (no change)	1: On (change)

Read Holding Register (Function Code 03, 4X References)			
Channel	Address	Value	Scaled up by
Tesla Clock Time (UTC). Read all in same query to ensure consistent time reading data			
Milliseconds Now	40001	0-999	1
Seconds Now	40002	0-59	1
Minutes Now	40003	0-59	1
Hours Now	40004	0-23	1
Day of Year Now	40005	1-365 (up to 366 if leap year)	1

Years since 1900	40006	90-137	1
Sync'd to IRIG-B	40007	0: No, 1: Yes	1
Time of Acquisition (UTC). Read all in same query to ensure consistent time reading data			
Milliseconds Acquisition	40008	0-999	1
Seconds Acquisition	40009	0-59	1
Minutes Acquisition	40010	0-59	1
Hours Acquisition	40011	0-23	1
Day of Year Acquisition	40012	1-365 (up to 366 if leap year)	1
Years since 1900	40013	90-137	1
Acquisition Time Sync'd to IRIG-B	40014	0: No 1: Yes	1
Offset of UTC to IED Local Time	40015	2's complement half hours, North America is negative	1

Analog Magnitude and Angle Metering Channels			
Channel	Address	Value	Scaled up by
AI1 Magnitude	40257	0 to 3276.7 units	10
AI1 Angle	40258	-180° to 180°	10
AI2 Magnitude	40259	0 to 3276.7 units	10
AI2 Angle	40260	-180° to 180°	10
AI3 Magnitude	40261	0 to 3276.7 units	10
AI3 Angle	40262	-180° to 180°	10
AI4 Magnitude	40263	0 to 3276.7 units	10
AI4 Angle	40264	-180° to 180°	10
AI5 Magnitude	40265	0 to 3276.7 units	10
AI5 Angle	40266	-180° to 180°	10
AI6 Magnitude	40267	0 to 3276.7 units	10
AI6 Angle	40268	-180° to 180°	10
AI7 Magnitude	40269	0 to 3276.7 units	10
AI7 Angle	40270	-180° to 180°	10
AI8 Magnitude	40271	0 to 3276.7 units	10
AI8 Angle	40272	-180° to 180°	10
AI9 Magnitude	40273	0 to 3276.7 units	10
AI9 Angle	40274	-180° to 180°	10
AI10 Magnitude	40275	0 to 3276.7 units	10
AI10 Angle	40276	-180° to 180°	10
AI11 Magnitude	40277	0 to 3276.7 units	10
AI11 Angle	40278	-180° to 180°	10
AI12 Magnitude	40279	0 to 3276.7 units	10

AI12 Angle	40280	-180° to 180°	10
AI13 Magnitude	40281	0 to 3276.7 units	10
AI13 Angle	40282	-180° to 180°	10
AI14 Magnitude	40283	0 to 3276.7 units	10
AI14 Angle	40284	-180° to 180°	10
AI15 Magnitude	40285	0 to 3276.7 units	10
AI15 Angle	40286	-180° to 180°	10
AI16 Magnitude	40287	0 to 3276.7 units	10
AI16 Angle	40288	-180° to 180°	10
AI17 Magnitude	40289	0 to 3276.7 units	10
AI17 Angle	40290	-180° to 180°	10
AI18 Magnitude	40291	0 to 3276.7 units	10
AI18 Angle	40292	-180° to 180°	10
AI19 Magnitude	40293	0 to 3276.7 units	10
AI19 Angle	40294	-180° to 180°	10
AI20 Magnitude	40295	0 to 3276.7 units	10
AI20 Angle	40296	-180° to 180°	10
AI21 Magnitude	40297	0 to 3276.7 units	10
AI21 Angle	40298	-180° to 180°	10
AI22 Magnitude	40299	0 to 3276.7 units	10
AI22 Angle	40300	-180° to 180°	10
AI23 Magnitude	40301	0 to 3276.7 units	10
AI23 Angle	40302	-180° to 180°	10
AI24 Magnitude	40303	0 to 3276.7 units	10
AI24 Angle	40304	-180° to 180°	10
AI25 Magnitude	40305	0 to 3276.7 units	10
AI25 Angle	40306	-180° to 180°	10
AI26 Magnitude	40307	0 to 3276.7 units	10
AI26 Angle	40308	-180° to 180°	10
AI27 Magnitude	40309	0 to 3276.7 units	10
AI27 Angle	40310	-180° to 180°	10
AI28 Magnitude	40311	0 to 3276.7 units	10
AI28 Angle	40312	-180° to 180°	10
AI29 Magnitude	40313	0 to 3276.7 units	10
AI29 Angle	40314	-180° to 180°	10
AI30 Magnitude	40315	0 to 3276.7 units	10
AI30 Angle	40316	-180° to 180°	10
AI31 Magnitude	40317	0 to 3276.7 units	10
AI31 Angle	40318	-180° to 180°	10
AI32 Magnitude	40319	0 to 3276.7 units	10

AI32 Angle	40320	-180° to 180°	10
AI33 Magnitude	40321	0 to 3276.7 units	10
AI33 Angle	40322	-180° to 180°	10
AI34 Magnitude	40323	0 to 3276.7 units	10
AI34 Angle	40324	-180° to 180°	10
AI35 Magnitude	40325	0 to 3276.7 units	10
AI35 Angle	40326	-180° to 180°	10
AI36 Magnitude	40327	0 to 3276.7 units	10
AI36 Angle	40328	-180° to 180°	10
Total Harmonic Distortion, Single Harmonic Level, DC Metering Channels			
* not supported yet			
AI1 THD	40513	0 to 327.67%	100
AI1 SHL	40514	0 to 327.67%	100
AI1 DC*	40515	-3276.8 to 3276.7 units	10
AI2 THD	40516	0 to 327.67%	100
AI2 SHL	40517	0 to 327.67%	100
AI2 DC*	40518	-3276.8 to 3276.7 units	10
AI3 THD	40519	0 to 327.67%	100
AI3 SHL	40520	0 to 327.67%	100
AI3 DC*	40521	-3276.8 to 3276.7 units	10
AI4 THD	40522	0 to 327.67%	100
AI4 SHL	40523	0 to 327.67%	100
AI4 DC*	40524	-3276.8 to 3276.7 units	10
AI5 THD	40525	0 to 327.67%	100
AI5 SHL	40526	0 to 327.67%	100
AI5 DC*	40527	-3276.8 to 3276.7 units	10
AI6 THD	40528	0 to 327.67%	100
AI6 SHL	40529	0 to 327.67%	100
AI6 DC*	40530	-3276.8 to 3276.7 units	10
AI7 THD	40531	0 to 327.67%	100
AI7 SHL	40532	0 to 327.67%	100
AI7 DC*	40533	-3276.8 to 3276.7 units	10
AI8 THD	40534	0 to 327.67%	100
AI8 SHL	40535	0 to 327.67%	100
AI8 DC*	40536	-3276.8 to 3276.7 units	10
AI9 THD	40537	0 to 327.67%	100
AI9 SHL	40538	0 to 327.67%	100
AI9 DC*	40539	-3276.8 to 3276.7 units	10
AI10 THD	40540	0 to 327.67%	100
AI10 SHL	40541	0 to 327.67%	100

AI10 DC*	40542	-3276.8 to 3276.7 units	10
AI11 THD	40543	0 to 327.67%	100
AI11 SHL	40544	0 to 327.67%	100
AI11 DC*	40545	-3276.8 to 3276.7 units	10
AI12 THD	40546	0 to 327.67%	100
AI12 SHL	40547	0 to 327.67%	100
AI12 DC*	40548	-3276.8 to 3276.7 units	10
AI13 THD	40549	0 to 327.67%	100
AI13 SHL	40550	0 to 327.67%	100
AI13 DC*	40551	-3276.8 to 3276.7 units	10
AI14 THD	40552	0 to 327.67%	100
AI14 SHL	40553	0 to 327.67%	100
AI14 DC*	40554	-3276.8 to 3276.7 units	10
AI15 THD	40555	0 to 327.67%	100
AI15 SHL	40556	0 to 327.67%	100
AI15 DC*	40557	-3276.8 to 3276.7 units	10
AI16 THD	40558	0 to 327.67%	100
AI16 SHL	40559	0 to 327.67%	100
AI16 DC*	40560	-3276.8 to 3276.7 units	10
AI17 THD	40561	0 to 327.67%	100
AI17 SHL	40562	0 to 327.67%	100
AI17 DC*	40563	-3276.8 to 3276.7 units	10
AI18 THD	40564	0 to 327.67%	100
AI18 SHL	40565	0 to 327.67%	100
AI18 DC*	40566	-3276.8 to 3276.7 units	10
AI19 THD	40567	0 to 327.67%	100
AI19 SHL	40568	0 to 327.67%	100
AI19 DC*	40569	-3276.8 to 3276.7 units	10
AI20 THD	40570	0 to 327.67%	100
AI20 SHL	40571	0 to 327.67%	100
AI20 DC*	40572	-3276.8 to 3276.7 units	10
AI21 THD	40573	0 to 327.67%	100
AI21 SHL	40574	0 to 327.67%	100
AI21 DC*	40575	-3276.8 to 3276.7 units	10
AI22 THD	40576	0 to 327.67%	100
AI22 SHL	40577	0 to 327.67%	100
AI22 DC*	40578	-3276.8 to 3276.7 units	10
AI23 THD	40579	0 to 327.67%	100
AI23 SHL	40580	0 to 327.67%	100
AI23 DC*	40581	-3276.8 to 3276.7 units	10

AI24 THD	40582	0 to 327.67%	100
AI24 SHL	40583	0 to 327.67%	100
AI24 DC*	40584	-3276.8 to 3276.7 units	10
AI25 THD	40585	0 to 327.67%	100
AI25 SHL	40586	0 to 327.67%	100
AI25 DC*	40587	-3276.8 to 3276.7 units	10
AI26 THD	40588	0 to 327.67%	100
AI26 SHL	40589	0 to 327.67%	100
AI26 DC*	40590	-3276.8 to 3276.7 units	10
AI27 THD	40591	0 to 327.67%	100
AI27 SHL	40592	0 to 327.67%	100
AI27 DC*	40593	-3276.8 to 3276.7 units	10
AI28 THD	40594	0 to 327.67%	100
AI28 SHL	40595	0 to 327.67%	100
AI28 DC*	40596	-3276.8 to 3276.7 units	10
AI29 THD	40597	0 to 327.67%	100
AI29 SHL	40598	0 to 327.67%	100
AI29 DC*	40599	-3276.8 to 3276.7 units	10
AI30 THD	40600	0 to 327.67%	100
AI30 SHL	40601	0 to 327.67%	100
AI30 DC*	40602	-3276.8 to 3276.7 units	10
AI31 THD	40603	0 to 327.67%	100
AI31 SHL	40604	0 to 327.67%	100
AI31 DC*	40605	-3276.8 to 3276.7 units	10
AI32 THD	40606	0 to 327.67%	100
AI32 SHL	40607	0 to 327.67%	100
AI32 DC*	40608	-3276.8 to 3276.7 units	10
AI33 THD	40609	0 to 327.67%	100
AI33 SHL	40610	0 to 327.67%	100
AI33 DC*	40611	-3276.8 to 3276.7 units	10
AI34 THD	40612	0 to 327.67%	100
AI34 SHL	40613	0 to 327.67%	100
AI34 DC*	40614	-3276.8 to 3276.7 units	10
AI35 THD	40615	0 to 327.67%	100
AI35 SHL	40616	0 to 327.67%	100
AI35 DC*	40617	-3276.8 to 3276.7 units	10
AI36 THD	40618	0 to 327.67%	100
AI36 SHL	40619	0 to 327.67%	100
AI36 DC*	40620	-3276.8 to 3276.7 units	10
Summation Metering Channels			

SUM1 Magnitude	40769	0 to 3276.7 units	10
SUM1 Angle	40770	-180° to 180°	10
SUM2 Magnitude	40771	0 to 3276.7 units	10
SUM2 Angle	40772	-180° to 180°	10
SUM3 Magnitude	40773	0 to 3276.7 units	10
SUM3 Angle	40774	-180° to 180°	10
SUM4 Magnitude	40775	0 to 3276.7 units	10
SUM4 Angle	40776	-180° to 180°	10
SUM5 Magnitude	40777	0 to 3276.7 units	10
SUM5 Angle	40778	-180° to 180°	10
SUM6 Magnitude	40779	0 to 3276.7 units	10
SUM6 Angle	40780	-180° to 180°	10
SUM7 Magnitude	40781	0 to 3276.7 units	10
SUM7 Angle	40782	-180° to 180°	10
SUM8 Magnitude	40783	0 to 3276.7 units	10
SUM8 Angle	40784	-180° to 180°	10
SUM9 Magnitude	40785	0 to 3276.7 units	10
SUM9 Angle	40786	-180° to 180°	10
SUM10 Magnitude	40787	0 to 3276.7 units	10
SUM10 Angle	40788	-180° to 180°	10
SUM11 Magnitude	40789	0 to 3276.7 units	10
SUM11 Angle	40790	-180° to 180°	10
SUM12 Magnitude	40791	0 to 3276.7 units	10
SUM12 Angle	40792	-180° to 180°	10
SUM13 Magnitude	40793	0 to 3276.7 units	10
SUM13 Angle	40794	-180° to 180°	10
SUM14 Magnitude	40795	0 to 3276.7 units	10
SUM14 Angle	40796	-180° to 180°	10
SUM15 Magnitude	40797	0 to 3276.7 units	10
SUM15 Angle	40798	-180° to 180°	10
SUM16 Magnitude	40799	0 to 3276.7 units	10
SUM16 Angle	40800	-180° to 180°	10
SUM17 Magnitude	40801	0 to 3276.7 units	10
SUM17 Angle	40802	-180° to 180°	10
SUM18 Magnitude	40803	0 to 3276.7 units	10
SUM18 Angle	40804	-180° to 180°	10
SUM19 Magnitude	40805	0 to 3276.7 units	10
SUM19 Angle	40806	-180° to 180°	10
SUM20 Magnitude	40807	0 to 3276.7 units	10
SUM20 Angle	40808	-180° to 180°	10

SUM21 Magnitude	40809	0 to 3276.7 units	10
SUM21 Angle	40810	-180° to 180°	10
SUM22 Magnitude	40811	0 to 3276.7 units	10
SUM22 Angle	40812	-180° to 180°	10
SUM23 Magnitude	40813	0 to 3276.7 units	10
SUM23 Angle	40814	-180° to 180°	10
SUM24 Magnitude	40815	0 to 3276.7 units	10
SUM24 Angle	40816	-180° to 180°	10
SUM25 Magnitude	40817	0 to 3276.7 units	10
SUM25 Angle	40818	-180° to 180°	10
SUM26 Magnitude	40819	0 to 3276.7 units	10
SUM26 Angle	40820	-180° to 180°	10
SUM27 Magnitude	40821	0 to 3276.7 units	10
SUM27 Angle	40822	-180° to 180°	10
SUM28 Magnitude	40823	0 to 3276.7 units	10
SUM28 Angle	40824	-180° to 180°	10
SUM29 Magnitude	40825	0 to 3276.7 units	10
SUM29 Angle	40826	-180° to 180°	10
SUM30 Magnitude	4827	0 to 3276.7 units	10
SUM30 Angle	40828	-180° to 180°	10
Sequence Metering Channels			
SEQ1 Positive	41025	0 to 3276.7 units	10
SEQ1 Negative	41026	0 to 3276.7 units	10
SEQ1 Zero	41027	0 to 3276.7 units	10
SEQ2 Positive	41028	0 to 3276.7 units	10
SEQ2 Negative	41029	0 to 3276.7 units	10
SEQ2 Zero	41030	0 to 3276.7 units	10
SEQ3 Positive	41031	0 to 3276.7 units	10
SEQ3 Negative	41032	0 to 3276.7 units	10
SEQ3 Zero	41033	0 to 3276.7 units	10
SEQ4 Positive	41034	0 to 3276.7 units	10
SEQ4 Negative	41035	0 to 3276.7 units	10
SEQ4 Zero	41036	0 to 3276.7 units	10
SEQ5 Positive	41037	0 to 3276.7 units	10
SEQ5 Negative	41038	0 to 3276.7 units	10
SEQ5 Zero	41039	0 to 3276.7 units	10
SEQ6 Positive	41040	0 to 3276.7 units	10
SEQ6 Negative	41041	0 to 3276.7 units	10
SEQ6 Zero	41042	0 to 3276.7 units	10
SEQ7 Positive	41043	0 to 3276.7 units	10

SEQ7 Negative	41044	0 to 3276.7 units	10
SEQ7 Zero	41045	0 to 3276.7 units	10
SEQ8 Positive	41046	0 to 3276.7 units	10
SEQ8 Negative	41047	0 to 3276.7 units	10
SEQ8 Zero	41048	0 to 3276.7 units	10
SEQ9 Positive	41049	0 to 3276.7 units	10
SEQ9 Negative	41050	0 to 3276.7 units	10
SEQ9 Zero	41051	0 to 3276.7 units	10
SEQ10 Positive	41052	0 to 3276.7 units	10
SEQ10 Negative	41053	0 to 3276.7 units	10
SEQ10 Zero	41054	0 to 3276.7 units	10
SEQ11 Positive	41055	0 to 3276.7 units	10
SEQ11 Negative	41056	0 to 3276.7 units	10
SEQ11 Zero	41057	0 to 3276.7 units	10
SEQ12 Positive	41058	0 to 3276.7 units	10
SEQ12 Negative	41059	0 to 3276.7 units	10
SEQ12 Zero	41060	0 to 3276.7 units	10
Watts/Vars Metering Channels			
WV1 P	41281	-3276.8 to 3276.7 W	10
WV1 Q	41282	-3276.8 to 3276.7 Var	10
WV1 S	41283	0 to 3276.7 VA	10
WV2 P	41284	-3276.8 to 3276.7 W	10
WV2 Q	41285	-3276.8 to 3276.7 Var	10
WV2 S	41286	0 to 3276.7 VA	10
WV3 P	41287	-3276.8 to 3276.7 W	10
WV3 Q	41288	-3276.8 to 3276.7 Var	10
WV3 S	41289	0 to 3276.7 VA	10
WV4 P	41290	-3276.8 to 3276.7 W	10
WV4 Q	41291	-3276.8 to 3276.7 Var	10
WV4 S	41292	0 to 3276.7 VA	10
WV5 P	41293	-3276.8 to 3276.7 W	10
WV5 Q	41294	-3276.8 to 3276.7 Var	10
WV5 S	41295	0 to 3276.7 VA	10
WV6 P	41296	-3276.8 to 3276.7 W	10
WV6 Q	41297	-3276.8 to 3276.7 Var	10
WV6 S	41298	0 to 3276.7 VA	10
WV7 P	41299	-3276.8 to 3276.7 W	10
WV7 Q	41300	-3276.8 to 3276.7 Var	10
WV7 S	41301	0 to 3276.7 VA	10
WV8 P	41302	-3276.8 to 3276.7 W	10

WV8 Q	41303	-3276.8 to 3276.7 Var	10
WV8 S	41304	0 to 3276.7 VA	10
WV9 P	41305	-3276.8 to 3276.7 W	10
WV9 Q	41306	-3276.8 to 3276.7 Var	10
WV9 S	41307	0 to 3276.7 VA	10
WV10 P	41308	-3276.8 to 3276.7 W	10
WV10 Q	41309	-3276.8 to 3276.7 Var	10
WV10S	41310	0 to 3276.7 VA	10
WV11 P	41311	-3276.8 to 3276.7 W	10
WV11 Q	41312	-3276.8 to 3276.7 Var	10
WV11S	41313	0 to 3276.7 VA	10
WV12 P	41314	-3276.8 to 3276.7 W	10
WV12 Q	41315	-3276.8 to 3276.7 Var	10
WV12S	41316	0 to 3276.7 VA	10
WV13 P	41317	-3276.8 to 3276.7 W	10
WV13 Q	41318	-3276.8 to 3276.7 Var	10
WV13S	41319	0 to 3276.7 VA	10
WV14 P	41320	-3276.8 to 3276.7 W	10
WV14 Q	41321	-3276.8 to 3276.7 Var	10
WV14S	41322	0 to 3276.7 VA	10
WV15 P	41323	-3276.8 to 3276.7 W	10
WV15 Q	41324	-3276.8 to 3276.7 Var	10
WV15S	41325	0 to 3276.7 VA	10
WV16 P	41326	-3276.8 to 3276.7 W	10
WV16 Q	41327	-3276.8 to 3276.7 Var	10
WV16S	41328	0 to 3276.7 VA	10
WV17 P	41329	-3276.8 to 3276.7 W	10
WV17 Q	41330	-3276.8 to 3276.7 Var	10
WV17S	41331	0 to 3276.7 VA	10
WV18 P	41332	-3276.8 to 3276.7 W	10
WV18 Q	41333	-3276.8 to 3276.7 Var	10
WV18S	41334	0 to 3276.7 VA	10
Frequency Metering Channels			
Channel Group 1 Frequency	41537	5/6 f _{nominal} to 7/6 nominal frequency	100
Channel Group 2 Frequency	41538	5/6 f _{nominal} to 7/6 nominal frequency	100
Impedance Metering Channels			
Impedance 1 Magnitude	41793	0 to 3276.7 ohm	10
Impedance 1 Angle	41794	-180° to 180°	10
Impedance2 Magnitude	41795	0 to 3276.7 ohm	10

Impedance 2 Angle	41796	-180° to 180°	10
Impedance 3 Magnitude	41797	0 to 3276.7 ohm	10
Impedance 3 Angle	41798	-180° to 180°	10
Impedance 4 Magnitude	41799	0 to 3276.7 ohm	10
Impedance 4 Angle	41800	-180° to 180°	10
Impedance 5 Magnitude	41801	0 to 3276.7 ohm	10
Impedance 5 Angle	41802	-180° to 180°	10
Impedance 6 Magnitude	41803	0 to 3276.7 ohm	10
Impedance 6 Angle	41804	-180° to 180°	10
Impedance 7 Magnitude	41805	0 to 3276.7 ohm	10
Impedance 7 Angle	41806	-180° to 180°	10
Impedance 8 Magnitude	41807	0 to 3276.7 ohm	10
Impedance 8 Angle	41808	-180° to 180°	10
Impedance 9 Magnitude	41809	0 to 3276.7 ohm	10
Impedance 9 Angle	41810	-180° to 180°	10
Impedance 10 Magnitude	41811	0 to 3276.7 ohm	10
Impedance 10 Angle	41812	-180° to 180°	10
Impedance 11 Magnitude	41813	0 to 3276.7 ohm	10
Impedance 11 Angle	41814	-180° to 180°	10
Impedance 12 Magnitude	41815	0 to 3276.7 ohm	10
Impedance 12 Angle	41816	-180° to 180°	10
Impedance 13 Magnitude	41817	0 to 3276.7 ohm	10
Impedance 13 Angle	41818	-180° to 180°	10
Impedance 14 Magnitude	41819	0 to 3276.7 ohm	10
Impedance 14 Angle	41820	-180° to 180°	10
Impedance 15 Magnitude	41821	0 to 3276.7 ohm	10
Impedance 15 Angle	41822	-180° to 180°	10
Impedance 16 Magnitude	41823	0 to 3276.7 ohm	10
Impedance 16 Angle	41824	-180° to 180°	10
Impedance 17 Magnitude	41825	0 to 3276.7 ohm	10
Impedance 17 Angle	41826	-180° to 180°	10
Impedance 18 Magnitude	41827	0 to 3276.7 ohm	10
Impedance 18 Angle	41828	-180° to 180°	10
Event Information (See Accessing TESLA Event Information below)	42052 – 42144		
Length (in 16 bit registers) of the cur- rent event message	42052		
Event Identification	42053		
Event Message	42054–42137		
Fault Locator ID	42138		
Fault Type	42139		

Fault Distance	42140		10
Fault Time	42141 – 42144		
Power Factor Function 1 Level	42305	0.0 to 1.0	100
Power Factor Function 2 Level	42306	0.0 to 1.0	100
Power Factor Function 3 Level	42307	0.0 to 1.0	100
Power Factor Function 4 Level	42308	0.0 to 1.0	100
Power Factor Function 5 Level	42309	0.0 to 1.0	100
Power Factor Function 6 Level	42310	0.0 to 1.0	100
Power Factor Function 7 Level	42311	0.0 to 1.0	100
Power Factor Function 8 Level	42312	0.0 to 1.0	100
Power Factor Function 9 Level	42313	0.0 to 1.0	100
Power Factor Function 10 Level	42314	0.0 to 1.0	100
Power Factor Function 11 Level	42315	0.0 to 1.0	100
Power Factor Function 12 Level	42316	0.0 to 1.0	100
Power Factor Function 13 Level	42317	0.0 to 1.0	100
Power Factor Function 14 Level	42318	0.0 to 1.0	100
Power Factor Function 15 Level	42319	0.0 to 1.0	100
Power Factor Function 16 Level	42320	0.0 to 1.0	100
Power Factor Function 17 Level	42321	0.0 to 1.0	100
Power Factor Function 18 Level	42322	0.0 to 1.0	100
High/low speed recording space used	42561	0.0 to 100.0	10
Trend Recording Days Accumulated	42817	0 to 90	1

Read Input Register (Function Code 04)

No input registers supported. Response from IED indicates "ILLEGAL FUNCTION."

Force Single Coil (Function Code 05)			
Only the "hold readings" coil can be forced. When active, this coil locks all coil, input and holding register readings simultaneously at their present values. When inactive, coil, input and holding register values will read their most recently available state.			
Channel	Type	Address	Value
Hold Readings	Read/Write	01	0000: Readings update normally (inactive) FF00: Hold readings (active)

Preset Single Register (Function Code 06)			
Channel	Address	Value	Scaled Up By
Event Information (See Accessing TESLA Event Information, below)	42099 – 42051		
Refresh event list	42049	No data required	N/A
Acknowledge the current event and get the next event	42050	No data required	N/A
Get the next event (without acknowledge)	42051	No data required	N/A

Diagnostic Subfunctions (Function Code 08)	
Return Query Data (Subfunction 00)	This provides an echo of the submitted message.
Restart Comm. Option (Subfunction 01)	This restarts the Modbus communications process.
Force Listen Only Mode (Subfunction 04)	No response is returned. IED enters "Listen Only" mode. This mode can only be exited by the "Restart Comm. Option" command.

Report Slave ID (Function Code 17/0x11)			
A fixed response is returned by the IED, including system model, version and issue numbers.			
Channel	Type	Bytes	Value
Model Number	Read Only	0 and 1	0x07D00 = 2000 decimal
Version Number	Read Only	2 and 3	Version number
Issue Number	Read Only	4 and 5	Issue number

- The TESLA IED model number is 3000.
- Version and issue will each be positive integers, say X and Y.
- The TESLA is defined as “Model 3000, Version X Issue Y”

Accessing TESLA Event Information	
All TESLA detector event messages displayed in the Event Log are available via Modbus. This includes fault location information. The following controls are available.	
Refresh Event List	(Function Code 6, address 42049): Fetches the latest events from the TESLA's event log and makes them available for Modbus access. The most recent event becomes the current event available for reading.
Acknowledge Current Event and Get Next Event	(Function Code 6, address 42050): Clears the current event from the read registers and places the next event into them. An acknowledged event is no longer available for reading.
Get Next Event	(Function Code 6, address 42051): Places the next event in the read registers without acknowledging the current event. The current event will reappear in the list when Refresh Event List is used.

Size of Current Event Message	(Function Code 3, address 42052): Indicates the number of 16 bit registers used to contain the current event. Event data is stored with two characters per register. A reading of zero indicates that there are no unacknowledged events available in the current set. (NB. The Refresh Event List function can be used to check for new events that have occurred since the last Refresh Event List.)
Fault Location Event Preset When Set to 0x464C	(Function Code 3, address 42053): Identifies fault location events. These events are identified by "FL" (0x464C) in this register. Non-fault location events contain " " in this location.
Read Event Message	(Function Code 3, addresses 42054 - 42137): Contains the current event message. Two ASCII characters are packed into each 16 bit register. All unused registers in the set are set to 0.
Fault Location – Fault Locator ID	(Function Code 3, address 42138): If the current event is a fault location event, this register contains the ID of the fault locator. The numbers from 1 to 5 are used for 18-channel recorders; the numbers from 1 to 10 are used for 36-channel recorders.
Fault Information – Type	(Function Code 3, address 42139): If the current event is a fault location event, this register contains the type of the fault. The following type bitmap: 0x0001 - Phase A 0x0002 - Phase B 0x0004 - Phase C 0x0008 - Ground Any number of the flags may be set for a given fault. If recorder could not determine the fault type, then the register will not have any flags set and will read 0x0000.
Fault Information – Fault Distance	(Function Code 3, address 42140): If the current event is a fault location event, this register contains the distance to the fault. It is scaled up by a factor of 10. The units are the same as the units set in the relay configuration.
Fault Information –Time of Fault	(Function Code 3, addresses 42141 and 42144): If the current event is a fault location event, these registers contain the time of the fault in seconds since 1970. Each of these 16-bit registers contains an 8-bit portion of a 32-bit time value. Register 42141 contains the upper 16 bits, register 42144 contains the lower 16 bits.

Register	Value	Meaning	
	High Byte	Low Byte	
42052	0x00	0x1B	Event text size = 27 (0x1B hex)
42053	0x46	0x4C	'F,L' - Fault locator event
42054	0x32	0x30	'2', '0'
42055	0x30	0x30	'0', '0'
42056	0x53	0x65	'S', 'e'
42057	0x70	0x32	'p', '2'
42058	0x31	0x20	'1', ''
42059	0x32	0x30	'2', '0'
42060	0x3A	0x31	':', '1'
42061	0x36	0x3A	'6', ':'
42062	0x31	0x36	'1', '6'
42063	0x2E	0x39	',' , '9'

Register	Value	Meaning	
42064	0x36	0x36	'6', '6'
42065	0x20	0x3A	' ', '.'
42066	0x20	0x4C	' ', 'L'
42067	0x69	0x6E	'i', 'n'
42068	0x65	0x20	'e', ' '
42069	0x31	0x36	'1', '6'
42070	0x3A	0x46	'.', 'F'
42071	0x4C	0x6F	'L', 'o'
42072	0x63	0x20	'c', ' '
42073	0x42	0x47	'B', 'G'
42074	0x20	0x33	' ', '3'
42075	0x39	0x2E	'9', '.'
42076	0x37	0x20	'7', ' '
42077	0x6D	0x69	'm', 'i'
42078	0x6C	0x65	'l', 'e'
42079	0x73	0x00	's'

Appendix E DNP3 Reference

The SCADA port supports DNP3. All metering values available through the terminal user interface are available by DNP3 protocol. Included are the device profile, implementation table and the point list for the DNP3 protocol.

Device Profile

Vendor Name: ERLPhase Power Technologies	Device Name: Recorder Model #
Highest DNP Level Supported: For Requests: 2 For Responses: 2	Device Function: _ Master x Slave
Maximum Data Link Frame Size (octets): Transmitted: 292 Received: 292	Maximum Application Frame Size (octets): Transmitted: 2048 Received: 2048
Maximum Data Link Re-tries: _ None x Fixed at 3 _ Configurable, range __ to __	Maximum Application Layer Re-tries: x None _ Configurable, range __ to __
Requires Data Link Layer Confirmation: _ Never _ Always _ Sometimes x Configurable, either always or never	Requires Application Layer Confirmation: _ Never _ Always (not recommended) x When reporting Event Data (Slave) x When sending multi-fragment responses (Slave) _ Sometimes _ Configurable
Timeouts (in seconds) while waiting for: Data Link Confirm __None x Fixed at 2 Complete Application Fragment x None __Fixed at 2 Application Confirm __None x Fixed at 5 Complete Application Response x None __Fixed at 2 Others _____ Select to execute delay __None x Fixed at 10	
Sends/Executes Control Operations: WRITE Binary Outputs x Never __Always SELECT/OPERATE __Never x Always DIRECT OPERATE __Never x Always DIRECT OPERATE No ACK __Never x Always Count > 1 x Never __Always Pulse On __Never x Always Pulse Off x Never __Always Latch On __Never x Always Latch Off __Never x Always Queue x Never __Always Clear Queue x Never __Always Maximum number of control objects per request: 16 Notes: Control Trip/Close - Code Combination supported: Latch On/NUL Latch Off/NUL Pulse On/NUL (Pulse duration fixed at 1 s)	
Report Binary Input Change Events when no specific variation requested: __Never __Only time-tagged x Only non-time-tagged _ Configurable to send both, one or the other	Reports time-tagged Binary Input Change Events when no specific variation requested __Never x Binary Input Change with Time _ Binary Input Change with Relative Time _ Configurable
Sends Unsolicited Response: x Never _ Configurable _Only certain objects _ Sometimes	Sends Static Data in Unsolicited Responses: x Never _ When Device Restarts _ When Status Flags Change No other options are permitted.

_ ENABLE/DISABLE UNSOLICITED Function codes supported	
Default Counter Object/Variation: x No Counter Reported _ Configurable _ Default Object _____ _ Default Variation _____ _ Point-by-point list attached	Counters Roll Over at: x No Counters Reported _ Configurable _ 16 Bits _ 32 Bits _ Other Value _____ _ Point-by-point list attached

Implementation Table

Object			Request		Response	
Grp	Var	Description	Function Codes	Qualifier Codes	Function Codes	Qualifier Codes
1	0	Binary Input -All Variations	1(read)	0x00, 0x01, 0x06, 0x07,0x08, 0x17,0x28		
1	1	Binary Input (default)	1(read)	0x00, 0x01, 0x06, 0x07,0x08, 0x17,0x28	129 (response)	0x00
1	2	Binary Input with status	1(read)	0x00, 0x01, 0x06, 0x07,0x08, 0x17,0x28	129 (response)	0x00
2	0	Binary Input Change - All Variations	1(read)	0x06, 0x07,0x08		
2	1	Binary Input Change without Time	1(read)	0x06, 0x07,0x08	129 (response)	0x17
2	2	Binary Input Change with Time (default)	1(read)	0x06, 0x07,0x08	129 (response)	0x17
2	3	Binary Input Change with Relative Time	1(read)	0x06, 0x07,0x08	129 (response)	0x17
10	0	Binary Output - All Variations	1(read)	0x00, 0x01, 0x06, 0x07,0x08, 0x17,0x28		
10	2	Binary Output Status (default)	1(read)	0x00, 0x01, 0x06, 0x07,0x08, 0x17,0x28	129 (response)	0x00
30	0	Analog Input - All Variations	1(read)	0x00, 0x01, 0x06, 0x07,0x08, 0x17,0x28	129 (response)	0x01
30	1	32-bit Analog Input	1(read)	0x00, 0x01, 0x06, 0x07,0x08, 0x17,0x28		
30	2	16-bit Analog Input	1(read)	0x00, 0x01, 0x06, 0x07,0x08, 0x17,0x28	129 (response)	0x01
30	3	32-bit Analog Input without flag	1(read)	0x00, 0x01, 0x06, 0x07,0x08, 0x17,0x28	129 (response)	0x01
30	4	16-bit Analog Input without flag (default)	1(read)	0x00, 0x01, 0x06, 0x07,0x08, 0x17,0x28	129 (response)	0x01
32	0	Analog Input Change Event - All Variations	1(read)	0x06, 0x07,0x08	129 (response)	0x28
32	1	Analog Input Change Event - 32-bit without Time	1(read)	0x06, 0x07,0x08	129 (response)	0x28
32	2	Analog Input Change Event - 16-bit without Time	1(read)	0x06, 0x07,0x08	129 (response)	0x28
32	3	Analog Input Change Event - 32-bit with Time	1(read)	0x06, 0x07,0x08	129 (response)	0x28
32	4	Analog Input Change Event - 16-bit with Time (default)	1(read)	0x06, 0x07,0x08	129 (response)	0x28
51	1	Time and data CTO			129 (response)	0x07, quantity=1
52	1	Time Delay Coarse			129 (response)	0x07, quantity=1
60	1	Class 0 Data	1(read)	0x06		
60	2	Class 1 Data	1(read)	0x06, 0x07,0x08		

Object			Request		Response	
Grp	Var	Description	Function Codes	Qualifier Codes	Function Codes	Qualifier Codes
60	3	Class 2 Data	1(read)	0x06, 0x07,0x08		
80	1	Internal Indications	2 (write)	0x00, index=7		
110	0	Octet String	1 (read)	0x06	129 (response)	0x07
111	0	Octet String Change Event	1 (read)	0x06	129 (response)	0x07
		No Object	14(warm start)			

Point List

The Point List can be printed through TESLA Control Panel to display the point names as they are configured. “Printing a SCADA Address List” on page 8-45.

Binary Inputs (Obj 1, 2)		
	Static Points	Change Event Points
Object group	1	2
Object variation	1 - Binary Input (default)	1 - Binary Input Change without Time
	2 - Binary Input with Status	2 - Binary Input Change with Time
		3 - Binary Input Change with Relative Time
Class	0	1
Change Event Buffer Size		200

Name	Point Index	Change Event Class
External Input 1	0	1
External Input 2	1	1
External Input 3	2	1
External Input 4	3	1
External Input 5	4	1
External Input 6	5	1
External Input 7	6	1
External Input 8	7	1
External Input 9	8	1
External Input 10	9	1
External Input 11	10	1
External Input 12	11	1
External Input 13	12	1

Name	Point Index	Change Event Class
External Input 14	13	1
External Input 15	14	1
External Input 16	15	1
External Input 17	16	1
External Input 18	17	1
External Input 19	18	1
External Input 20	19	1
External Input 21	20	1
External Input 22	21	1
External Input 23	22	1
External Input 24	23	1
External Input 25	24	1
External Input 26	25	1
External Input 27	26	1
External Input 28	27	1
External Input 29	28	1
External Input 30	29	1
External Input 31	30	1
External Input 32	31	1
External Input 33	32	1
External Input 34	33	1
External Input 35	34	1
External Input 36	35	1
External Input 37	36	1
External Input 38	37	1
External Input 39	38	1
External Input 40	39	1
External Input 41	40	1
External Input 42	41	1
External Input 43	42	1
External Input 44	43	1
External Input 45	44	1
External Input 46	45	1
External Input 47	46	1
External Input 48	47	1
External Input 49	48	1
External Input 50	49	1
External Input 51	50	1

Name	Point Index	Change Event Class
External Input 52	51	1
External Input 53	52	1
External Input 54	53	1
External Input 55	54	1
External Input 56	55	1
External Input 57	56	1
External Input 58	57	1
External Input 59	58	1
External Input 60	59	1
External Input 61	60	1
External Input 62	61	1
External Input 63	62	1
External Input 64	63	1
Fault Information Available for Fault Locator 1	64	1
Fault Information Available for Fault Locator 2	65	1
Fault Information Available for Fault Locator 3	66	1
Fault Information Available for Fault Locator 4	67	1
Fault Information Available for Fault Locator 5	68	1
Fault Information Available for Fault Locator 6	69	1
Fault Information Available for Fault Locator 7	70	1
Fault Information Available for Fault Locator 8	71	1
Fault Information Available for Fault Locator 9	72	1
Fault Information Available for Fault Locator 10	73	1

Binary Outputs (Obj 10)		
	Static Points	Change Event Points
Object Group	10	Not Applicable
Object Variation	2 – Binary Output Status (default)	Not Applicable
Class	0	Not Applicable
Note: Binary outputs are scanned with 500 ms resolution.		
No change event buffer.		

Name	Point Index	Change Event Class
Logic 1	0	N/A
Logic 2	1	N/A
Logic 3	2	N/A
Logic 4	3	N/A
Logic 5	4	N/A
Logic 6	5	N/A
Logic 7	6	N/A
Logic 8	7	N/A
Logic 9	8	N/A
Logic 10	9	N/A
Logic 11	10	N/A
Logic 12	11	N/A
Logic 13	12	N/A
Logic 14	13	N/A
Logic 15	14	N/A
Logic 16	15	N/A
Logic 17	16	N/A
Logic 18	17	N/A
Logic 19	18	N/A
Logic 20	19	N/A
Logic 21	20	N/A
Logic 22	21	N/A
Logic 23	22	N/A
Logic 24	23	N/A
Logic 25	24	N/A
Logic 26	25	N/A
Logic 27	26	N/A
Logic 28	27	N/A
Logic 29	28	N/A
Logic 30	29	N/A
Output Contact 2	30	N/A
Output Contact 3	31	N/A
Output Contact 4	32	N/A
Output Contact 5	33	N/A
Output Contact 6	34	N/A
Output Contact 7	35	N/A

Name	Point Index	Change Event Class
Output Contact 8	36	N/A
High/low speed recording active	37	N/A
High/low speed recording space nearly full alarm	38	N/A
Trend Recording Active	39	N/A
Trend Recording Accumulation Alarm	40	N/A
Retrieve Next Fault Information Event for Fault Locator 1	41	N/A
Retrieve Next Fault Information Event for Fault Locator 2	42	N/A
Retrieve Next Fault Information Event for Fault Locator 3	43	N/A
Retrieve Next Fault Information Event for Fault Locator 4	44	N/A
Retrieve Next Fault Information Event for Fault Locator 5	45	N/A
Retrieve Next Fault Information Event for Fault Locator 6	46	N/A
Retrieve Next Fault Information Event for Fault Locator 7	47	N/A
Retrieve Next Fault Information Event for Fault Locator 8	48	N/A
Retrieve Next Fault Information Event for Fault Locator 9	49	N/A
Retrieve Next Fault Information Event for Fault Locator 10	50	N/A

Analog Inputs (Obj 30, 32)		
	Static Points	Change Event Points
Object group	30	32
Object variation	1 - 32-bit Analog Input	1 - Analog Input Change - 32-bit without Time
	2 - 16-bit Analog Input	2 - Analog Input Change - 16-bit without Time (default)
	3 - 32-bit Analog Input without flag	3 - Analog Input Change - 32-bit with Time
	4 - 16-bit Analog Input without flag (default)	4 - Analog Input Change - 16-bit with Time
Class	0	2
Change Event Buffer Size		200

Name	Point Index	Units	Scale	Change Event Class
Analog Input 1 Magnitude	0		10	2
Analog Input 1 Angle	1	degrees	10	2
Analog Input 1 THD	2	%	100	2
Analog Input 1 SHL	3	%	100	2
Analog Input 1 DC	4		10	2

Name	Point Index	Units	Scale	Change Event Class
Analog Input 2 Magnitude	5		10	2
Analog Input 2 Angle	6	degrees	10	2
Analog Input 2 THD	7	%	100	2
Analog Input 2 SHL	8	%	100	2
Analog Input 2 DC	9		10	2
Analog Input 3 Magnitude	10		10	2
Analog Input 3 Angle	11	degrees	10	2
Analog Input 3 THD	12	%	100	2
Analog Input 3 SHL	13	%	100	2
Analog Input 3 DC	14		10	2
Analog Input 4 Magnitude	15		10	2
Analog Input 4 Angle	16	degrees	10	2
Analog Input 4 THD	17	%	100	2
Analog Input 4 SHL	18	%	100	2
Analog Input 4 DC	19		10	2
Analog Input 5 Magnitude	20		10	2
Analog Input 5 Angle	21	degrees	10	2
Analog Input 5 THD	22	%	100	2
Analog Input 5 SHL	23	%	100	2
Analog Input 5 DC	24		10	2
Analog Input 6 Magnitude	25		10	2
Analog Input 6 Angle	26	degrees	10	2
Analog Input 6 THD	27	%	100	2
Analog Input 6 SHL	28	%	100	2
Analog Input 6 DC	29		10	2
Analog Input 7 Magnitude	30		10	2
Analog Input 7 Angle	31	degrees	10	2
Analog Input 7 THD	32	%	100	2
Analog Input 7 SHL	33	%	100	2
Analog Input 7 DC	34		10	2
Analog Input 8 Magnitude	35		10	2
Analog Input 8 Angle	36	degrees	10	2
Analog Input 8 THD	37	%	100	2
Analog Input 8 SHL	38	%	100	2
Analog Input 8 DC	39		10	2
Analog Input 9 Magnitude	40		10	2
Analog Input 9 Angle	41	degrees	10	2

Name	Point Index	Units	Scale	Change Event Class
Analog Input 9 THD	42	%	100	2
Analog Input 9 SHL	43	%	100	2
Analog Input 9 DC	44		10	2
Analog Input 10 Magnitude	45		10	2
Analog Input 10 Angle	46	degrees	10	2
Analog Input 10 THD	47	%	100	2
Analog Input 10 SHL	48	%	100	2
Analog Input 10 DC	49		10	2
Analog Input 11 Magnitude	50		10	2
Analog Input 11 Angle	51	degrees	10	2
Analog Input 11 THD	52	%	100	2
Analog Input 11 SHL	53	%	100	2
Analog Input 11 DC	54		10	2
Analog Input 12 Magnitude	55		10	2
Analog Input 12 Angle	56	degrees	10	2
Analog Input 12 THD	57	%	100	2
Analog Input 12 SHL	58	%	100	2
Analog Input 12 DC	59		10	2
Analog Input 13 Magnitude	60		10	2
Analog Input 13 Angle	61	degrees	10	2
Analog Input 13 THD	62	%	100	2
Analog Input 13 SHL	63	%	100	2
Analog Input 13 DC	64		10	2
Analog Input 14 Magnitude	65		10	2
Analog Input 14 Angle	66	degrees	10	2
Analog Input 14 THD	67	%	100	2
Analog Input 14 SHL	68	%	100	2
Analog Input 14 DC	69		10	2
Analog Input 15 Magnitude	70		10	2
Analog Input 15 Angle	71	degrees	10	2
Analog Input 15 THD	72	%	100	2
Analog Input 15 SHL	73	%	100	2
Analog Input 15 DC	74		10	2
Analog Input 16 Magnitude	75		10	2
Analog Input 16 Angle	76	degrees	10	2
Analog Input 16 THD	77	%	100	2
Analog Input 16 SHL	78	%	100	2

Name	Point Index	Units	Scale	Change Event Class
Analog Input 16 DC	79		10	2
Analog Input 17 Magnitude	80		10	2
Analog Input 17 Angle	81	degrees	10	2
Analog Input 17 THD	82	%	100	2
Analog Input 17 SHL	83	%	100	2
Analog Input 17 DC	84		10	2
Analog Input 18 Magnitude	85		10	2
Analog Input 18 Angle	86	degrees	10	2
Analog Input 18 THD	87	%	100	2
Analog Input 18 SHL	88	%	100	2
Analog Input 18 DC	89		10	2
Analog Input 19 Magnitude	90		10	2
Analog Input 19 Angle	91	degrees	10	2
Analog Input 19 THD	92	%	100	2
Analog Input 19 SHL	93	%	100	2
Analog Input 19 DC	94		10	2
Analog Input 20 Magnitude	95		10	2
Analog Input 20 Angle	96	degrees	10	2
Analog Input 20 THD	97	%	100	2
Analog Input 20 SHL	98	%	100	2
Analog Input 20 DC	99		10	2
Analog Input 21 Magnitude	100		10	2
Analog Input 21 Angle	101	degrees	10	2
Analog Input 21 THD	102	%	100	2
Analog Input 21 SHL	103	%	100	2
Analog Input 21 DC	104		10	2
Analog Input 22 Magnitude	105		10	2
Analog Input 22 Angle	106	degrees	10	2
Analog Input 22 THD	107	%	100	2
Analog Input 22 SHL	108	%	100	2
Analog Input 22 DC	109		10	2
Analog Input 23 Magnitude	110		10	2
Analog Input 23 Angle	111	degrees	10	2
Analog Input 23 THD	112	%	100	2
Analog Input 23 SHL	113	%	100	2
Analog Input 23 DC	114		10	2
Analog Input 24 Magnitude	115		10	2

Name	Point Index	Units	Scale	Change Event Class
Analog Input 24 Angle	116	degrees	10	2
Analog Input 24 THD	117	%	100	2
Analog Input 24 SHL	118	%	100	2
Analog Input 24 DC	119		10	2
Analog Input 25 Magnitude	120		10	2
Analog Input 25 Angle	121	degrees	10	2
Analog Input 25 THD	122	%	100	2
Analog Input 25 SHL	123	%	100	2
Analog Input 25 DC	124		10	2
Analog Input 26 Magnitude	125		10	2
Analog Input 26 Angle	126	degrees	10	2
Analog Input 26 THD	127	%	100	2
Analog Input 26 SHL	128	%	100	2
Analog Input 26 DC	129		10	2
Analog Input 27 Magnitude	130		10	2
Analog Input 27 Angle	131	degrees	10	2
Analog Input 27 THD	132	%	100	2
Analog Input 27 SHL	133	%	100	2
Analog Input 27 DC	134		10	2
Analog Input 28 Magnitude	135		10	2
Analog Input 28 Angle	136	degrees	10	2
Analog Input 28 THD	137	%	100	2
Analog Input 28 SHL	138	%	100	2
Analog Input 28 DC	139		10	2
Analog Input 29 Magnitude	140		10	2
Analog Input 29 Angle	141	degrees	10	2
Analog Input 29 THD	142	%	100	2
Analog Input 29 SHL	143	%	100	2
Analog Input 29 DC	144		10	2
Analog Input 30 Magnitude	145		10	2
Analog Input 30 Angle	146	degrees	10	2
Analog Input 30 THD	147	%	100	2
Analog Input 30 SHL	148	%	100	2
Analog Input 30 DC	149		10	2
Analog Input 31 Magnitude	150		10	2
Analog Input 31 Angle	151	degrees	10	2
Analog Input 31 THD	152	%	100	2

Name	Point Index	Units	Scale	Change Event Class
Analog Input 31 SHL	153	%	100	2
Analog Input 31 DC	154		10	2
Analog Input 32 Magnitude	155		10	2
Analog Input 32 Angle	156	degrees	10	2
Analog Input 32 THD	157	%	100	2
Analog Input 32 SHL	158	%	100	2
Analog Input 32 DC	159		10	2
Analog Input 33 Magnitude	160		10	2
Analog Input 33 Angle	161	degrees	10	2
Analog Input 33 THD	162	%	100	2
Analog Input 33 SHL	163	%	100	2
Analog Input 33 DC	164		10	2
Analog Input 34 Magnitude	165		10	2
Analog Input 34 Angle	166	degrees	10	2
Analog Input 34 THD	167	%	100	2
Analog Input 34 SHL	168	%	100	2
Analog Input 34 DC	169		10	2
Analog Input 35 Magnitude	170		10	2
Analog Input 35 Angle	171	degrees	10	2
Analog Input 35 THD	172	%	100	2
Analog Input 35 SHL	173	%	100	2
Analog Input 35 DC	174		10	2
Analog Input 36 Magnitude	175		10	2
Analog Input 36 Angle	176	degrees	10	2
Analog Input 36 THD	177	%	100	2
Analog Input 36 SHL	178	%	100	2
Analog Input 36 DC	179		10	2
Summation 1 Magnitude	180		10	2
Summation 1 Angle	181	degrees	10	2
Summation 2 Magnitude	182		10	2
Summation 2 Angle	183	degrees	10	2
Summation 3 Magnitude	184		10	2
Summation 3 Angle	185	degrees	10	2
Summation 4 Magnitude	186		10	2
Summation 4 Angle	187	degrees	10	2
Summation 5 Magnitude	188		10	2
Summation 5 Angle	189	degrees	10	2

Name	Point Index	Units	Scale	Change Event Class
Summation 6 Magnitude	190		10	2
Summation 6 Angle	191	degrees	10	2
Summation 7 Magnitude	192		10	2
Summation 7 Angle	193	degrees	10	2
Summation 8 Magnitude	194		10	2
Summation 8 Angle	195	degrees	10	2
Summation 9 Magnitude	196		10	2
Summation 9 Angle	197	degrees	10	2
Summation 10 Magnitude	198		10	2
Summation 10 Angle	199	degrees	10	2
Summation 11 Magnitude	200		10	2
Summation 11 Angle	201	degrees	10	2
Summation 12 Magnitude	202		10	2
Summation 12 Angle	203	degrees	10	2
Summation 13 Magnitude	204		10	2
Summation 13 Angle	205	degrees	10	2
Summation 14 Magnitude	206		10	2
Summation 14 Angle	207	degrees	10	2
Summation 15 Magnitude	208		10	2
Summation 15 Angle	209	degrees	10	2
Summation 16 Magnitude	210		10	2
Summation 16 Angle	211	degrees	10	2
Summation 17 Magnitude	212		10	2
Summation 17 Angle	213	degrees	10	2
Summation 18 Magnitude	214		10	2
Summation 18 Angle	215	degrees	10	2
Summation 19 Magnitude	216		10	2
Summation 19 Angle	217	degrees	10	2
Summation 20 Magnitude	218		10	2
Summation 20 Angle	219	degrees	10	2
Summation 21 Magnitude	220		10	2
Summation 21 Angle	221	degrees	10	2
Summation 22 Magnitude	222		10	2
Summation 22 Angle	223	degrees	10	2
Summation 23 Magnitude	224		10	2
Summation 23 Angle	225	degrees	10	2
Summation 24 Magnitude	226		10	2

Name	Point Index	Units	Scale	Change Event Class
Summation 24 Angle	227	degrees	10	2
Summation 25 Magnitude	228		10	2
Summation 25 Angle	229	degrees	10	2
Summation 26 Magnitude	230		10	2
Summation 26 Angle	231	degrees	10	2
Summation 27 Magnitude	232		10	2
Summation 27 Angle	233	degrees	10	2
Summation 28 Magnitude	234		10	2
Summation 28 Angle	235	degrees	10	2
Summation 29 Magnitude	236		10	2
Summation 29 Angle	237	degrees	10	2
Summation 30 Magnitude	238		10	2
Summation 30 Angle	239	degrees	10	2
Sequence Function 1 Positive	240		10	2
Sequence Function 1 Negative	241		10	2
Sequence Function 1 Zero	242		10	2
Sequence Function 2 Positive	243		10	2
Sequence Function 2 Negative	244		10	2
Sequence Function 2 Zero	245		10	2
Sequence Function 3 Positive	246		10	2
Sequence Function 3 Negative	247		10	2
Sequence Function 3 Zero	248		10	2
Sequence Function 4 Positive	249		10	2
Sequence Function 4 Negative	250		10	2
Sequence Function 4 Zero	251		10	2
Sequence Function 5 Positive	252		10	2
Sequence Function 5 Negative	253		10	2
Sequence Function 5 Zero	254		10	2
Sequence Function 6 Positive	255		10	2
Sequence Function 6 Negative	256		10	2
Sequence Function 6 Zero	257		10	2
Sequence Function 7 Positive	258		10	2
Sequence Function 7 Negative	259		10	2
Sequence Function 7 Zero	260		10	2
Sequence Function 8 Positive	261		10	2
Sequence Function 8 Negative	262		10	2
Sequence Function 8 Zero	263		10	2

Name	Point Index	Units	Scale	Change Event Class
Sequence Function 9 Positive	264		10	2
Sequence Function 9 Negative	265		10	2
Sequence Function 9 Zero	266		10	2
Sequence Function 10 Positive	267		10	2
Sequence Function 10 Negative	268		10	2
Sequence Function 10 Zero	269		10	2
Sequence Function 11 Positive	270		10	2
Sequence Function 11 Negative	271		10	2
Sequence Function 11 Zero	272		10	2
Sequence Function 12 Positive	273		10	2
Sequence Function 12 Negative	274		10	2
Sequence Function 12 Zero	275		10	2
Watts/Vars Function 1 P	276	MW	10	2
Watts/Vars Function 1 Q	277	MVAR	10	2
Watts/Vars Function 1 S	278	MVA	10	2
Watts/Vars Function 2 P	279	MW	10	2
Watts/Vars Function 2 Q	280	MVAR	10	2
Watts/Vars Function 2 S	281	MVA	10	2
Watts/Vars Function 3 P	282	MW	10	2
Watts/Vars Function 3 Q	283	MVAR	10	2
Watts/Vars Function 3 S	284	MVA	10	2
Watts/Vars Function 4 P	285	MW	10	2
Watts/Vars Function 4 Q	286	MVAR	10	2
Watts/Vars Function 4 S	287	MVA	10	2
Watts/Vars Function 5 P	288	MW	10	2
Watts/Vars Function 5 Q	289	MVAR	10	2
Watts/Vars Function 5 S	290	MVA	10	2
Watts/Vars Function 6 P	291	MW	10	2
Watts/Vars Function 6 Q	292	MVAR	10	2
Watts/Vars Function 6 S	293	MVA	10	2
Watts/Vars Function 7 P	294	MW	10	2
Watts/Vars Function 7 Q	295	MVAR	10	2
Watts/Vars Function 7 S	296	MVA	10	2
Watts/Vars Function 8 P	297	MW	10	2
Watts/Vars Function 8 Q	298	MVAR	10	2
Watts/Vars Function 8 S	299	MVA	10	2
Watts/Vars Function 9 P	300	MW	10	2

Name	Point Index	Units	Scale	Change Event Class
Watts/Vars Function 9 Q	301	MVAR	10	2
Watts/Vars Function 9 S	302	MVA	10	2
Watts/Vars Function 10 P	303	MW	10	2
Watts/Vars Function 10 Q	304	MVAR	10	2
Watts/Vars Function 10 S	305	MVA	10	2
Watts/Vars Function 11 P	306	MW	10	2
Watts/Vars Function 11 Q	307	MVAR	10	2
Watts/Vars Function 11 S	308	MVA	10	2
Watts/Vars Function 12 P	309	MW	10	2
Watts/Vars Function 12 Q	310	MVAR	10	2
Watts/Vars Function 12 S	311	MVA	10	2
Watts/Vars Function 13 P	312	MW	10	2
Watts/Vars Function 13 Q	313	MVAR	10	2
Watts/Vars Function 13 S	314	MVA	10	2
Watts/Vars Function 14 P	315	MW	10	2
Watts/Vars Function 14 Q	316	MVAR	10	2
Watts/Vars Function 14 S	317	MVA	10	2
Watts/Vars Function 15 P	318	MW	10	2
Watts/Vars Function 15 Q	319	MVAR	10	2
Watts/Vars Function 15 S	320	MVA	10	2
Watts/Vars Function 16 P	321	MW	10	2
Watts/Vars Function 16 Q	322	MVAR	10	2
Watts/Vars Function 16 S	323	MVA	10	2
Watts/Vars Function 17 P	324	MW	10	2
Watts/Vars Function 17 Q	325	MVAR	10	2
Watts/Vars Function 17 S	326	MVA	10	2
Watts/Vars Function 18 P	327	MW	10	2
Watts/Vars Function 18 Q	328	MVAR	10	2
Watts/Vars Function 18 S	329	MVA	10	2
Group 1 Frequency	330	Hz	100	2
Group 2 Frequency	331	Hz	100	2
Impedance Function 1 Mag	332	ohms	10	2
Impedance Function 1 Angle	333	degrees	10	2
Impedance Function 2 Mag	334	ohms	10	2
Impedance Function 2 Angle	335	degrees	10	2
Impedance Function 3 Mag	336	ohms	10	2
Impedance Function 3 Angle	337	degrees	10	2

Name	Point Index	Units	Scale	Change Event Class
Impedance Function 4 Mag	338	ohms	10	2
Impedance Function 4 Angle	339	degrees	10	2
Impedance Function 5 Mag	340	ohms	10	2
Impedance Function 5 Angle	341	degrees	10	2
Impedance Function 6 Mag	342	ohms	10	2
Impedance Function 6 Angle	343	degrees	10	2
Impedance Function 7 Mag	344	ohms	10	2
Impedance Function 7 Angle	345	degrees	10	2
Impedance Function 8 Mag	346	ohms	10	2
Impedance Function 8 Angle	347	degrees	10	2
Impedance Function 9 Mag	348	ohms	10	2
Impedance Function 9 Angle	349	degrees	10	2
Impedance Function 10 Mag	350	ohms	10	2
Impedance Function 10 Angle	351	degrees	10	2
Impedance Function 11 Mag	352	ohms	10	2
Impedance Function 11 Angle	353	degrees	10	2
Impedance Function 12 Mag	354	ohms	10	2
Impedance Function 12 Angle	355	degrees	10	2
Impedance Function 13 Mag	356	ohms	10	2
Impedance Function 13 Angle	357	degrees	10	2
Impedance Function 14 Mag	358	ohms	10	2
Impedance Function 14 Angle	359	degrees	10	2
Impedance Function 15 Mag	360	ohms	10	2
Impedance Function 15 Angle	361	degrees	10	2
Impedance Function 16 Mag	362	ohms	10	2
Impedance Function 16 Angle	363	degrees	10	2
Impedance Function 17 Mag	364	ohms	10	2
Impedance Function 17 Angle	365	degrees	10	2
Impedance Function 18 Mag	366	ohms	10	2
Impedance Function 18 Angle	367	degrees	10	2
Power Factor Function 1 Level	368		100	2
Power Factor Function 2 Level	369		100	2
Power Factor Function 3 Level	370		100	2
Power Factor Function 4 Level	371		100	2
Power Factor Function 5 Level	372		100	2
Power Factor Function 6 Level	373		100	2
Power Factor Function 7 Level	374		100	2

Name	Point Index	Units	Scale	Change Event Class
Power Factor Function 8 Level	375		100	2
Power Factor Function 9 Level	376		100	2
Power Factor Function 10 Level	377		100	2
Power Factor Function 11 Level	378		100	2
Power Factor Function 12 Level	379		100	2
Power Factor Function 13 Level	380		100	2
Power Factor Function 14 Level	381		100	2
Power Factor Function 15 Level	382		100	2
Power Factor Function 16 Level	383		100	2
Power Factor Function 17 Level	384		100	2
Power Factor Function 18 Level	385		100	2
High/low speed recording space used	386	per	10	2
Trend Recording Days Accumulated	387	days	1	2
Fault Locator 1				
Fault Information - DNP Time - High 16 bits	388	N/A	1	2
Fault Information - DNP Time - Middle 16 bits	389	N/A	1	2
Fault Information - DNP Time - Low 16 bits	390	N/A	1	2
Fault Information - Fault Distance	391	User-specified	10	2
Fault Information - Type (see below for definition)	392	N/A	1	2
Fault Locator 2				
Fault Information - DNP Time - High 16 bits	393	N/A	1	2
Fault Information - DNP Time - Middle 16 bits	394	N/A	1	2
Fault Information - DNP Time - Low 16 bits	395	N/A	1	2
Fault Information - Fault Distance	396	User-specified	10	2
Fault Information - Type (see below for definition)	397	N/A	1	2
Fault Locator 3				
Fault Information - DNP Time - High 16 bits	398	N/A	1	2
Fault Information - DNP Time - Middle 16 bits	399	N/A	1	2
Fault Information - DNP Time - Low 16 bits	400	N/A	1	2
Fault Information - Fault Distance	401	User-specified	10	2
Fault Information - Type (see below for definition)	402	N/A	1	2
Fault Locator 4				
Fault Information - DNP Time - High 16 bits	403	N/A	1	2
Fault Information - DNP Time - Middle 16 bits	404	N/A	1	2
Fault Information - DNP Time - Low 16 bits	405	N/A	1	2
Fault Information - Fault Distance	406	User-specified	10	2

Name	Point Index	Units	Scale	Change Event Class
Fault Information - Type (see below for definition)	407	N/A	1	2
Fault Locator 5				
Fault Information - DNP Time - High 16 bits	408	N/A	1	2
Fault Information - DNP Time - Middle 16 bits	409	N/A	1	2
Fault Information - DNP Time - Low 16 bits	410	N/A	1	2
Fault Information - Fault Distance	411	User-specified	10	2
Fault Information - Type (see below for definition)	412	N/A	1	2
Fault Locator 6				
Fault Information - DNP Time - High 16 bits	413	N/A	1	2
Fault Information - DNP Time - Middle 16 bits	414	N/A	1	2
Fault Information - DNP Time - Low 16 bits	415	N/A	1	2
Fault Information - Fault Distance	416	User-specified	10	2
Fault Information - Type (see below for definition)	417	N/A	1	2
Fault Locator 7				
Fault Information - DNP Time - High 16 bits	418	N/A	1	2
Fault Information - DNP Time - Middle 16 bits	419	N/A	1	2
Fault Information - DNP Time - Low 16 bits	420	N/A	1	2
Fault Information - Fault Distance	421	User-specified	10	2
Fault Information - Type (see below for definition)	422	N/A	1	2
Fault Locator 8				
Fault Information - DNP Time - High 16 bits	423	N/A	1	2
Fault Information - DNP Time - Middle 16 bits	424	N/A	1	2
Fault Information - DNP Time - Low 16 bits	425	N/A	1	2
Fault Information - Fault Distance	426	User-specified	10	2
Fault Information - Type (see below for definition)	427	N/A	1	2
Fault Locator 9				
Fault Information - DNP Time - High 16 bits	428	N/A	1	2
Fault Information - DNP Time - Middle 16 bits	429	N/A	1	2
Fault Information - DNP Time - Low 16 bits	430	N/A	1	2
Fault Information - Fault Distance	431	User-specified	10	2
Fault Information - Type (see below for definition)	432	N/A	1	2
Fault Locator 10				
Fault Information - DNP Time - High 16 bits	433	N/A	1	2
Fault Information - DNP Time - Middle 16 bits	434	N/A	1	2
Fault Information - DNP Time - Low 16 bits	435	N/A	1	2

Name	Point Index	Units	Scale	Change Event Class
Fault Information - Fault Distance	436	User-specified	10	2
Fault Information - Type (see below for definition)	437	N/A	1	2

Object 110, 111 - Octet String for Event Log access

Object 110 and Object 111 are Octet String objects used to provide access to the Event Log text of the TESLA. These objects are described in Technical Bulletin 9701-004.zip_71 available from the DNP user group web page (www.dnp.org). Object 110 always contains the most recent event in the TESLA. Object 111 is the corresponding change event object. As stated in the DNP technical bulletin, the variation of the response object represents the length of the string. The string represents the ASCII values of the event text. The first 2 characters in the string can be used to quickly identify fault location events. Fault locator events begin with the characters “FL” (0x46, 0x44 hex). The following example shows a fault distance event returned through either of the octet string objects.

DNP Example: Event Message

“2000Sep21 20:16:16.966 : Line 16:FLoc BG 39.7 miles”

DNP Octet string object contents:					
0x46	0x4C	0x32	0x30	0x30	0x30
0x53	0x65	0x70	0x32	0x31	0x20
0x32	0x30	0x3A	0x31	0x36	0x3A
0x31	0x36	0x2E	0x39	0x36	0x36
0x20	0x3A	0x20	0x4C	0x69	0x6E
0x65	0x20	0x31	0x36	0x3A	0x46
0x4C	0x6F	0x63	0x20	0x42	0x47
0x20	0x33	0x39	0x2E	0x37	0x20
0x6D	0x69	0x6C	0x65	0x73	

Appendix F Input Modules

F.1 AC Voltage Input Module

The AC Voltage Input Module (Model 401006) provides 4 channels of isolation and scaling for standard secondary voltage. Inputs are ac coupled through transformers. The nominal signal level is 69 V RMS ($120/\sqrt{3}$) with a full-scale 2x over-range capability that can be sustaining continuously.

Output from the module is scaled to connect directly to the TESLA's analog input terminals. Due to impedance matching requirements, module channels cannot be connected to more than one TESLA input channel.

Modules can be located up to 1220 meters (4000 feet) from the recorder. The wire used for the connection between the modules and the recorder can range in size from 16 to 20 AWG. It is highly recommended that twisted-shielded wire be used for cables that are run outside of the panel in which the TESLA is located, noting that the shield should be grounded only at the recorder. Belden 9388, or its equivalent, is an example of an acceptable cable that can be used.

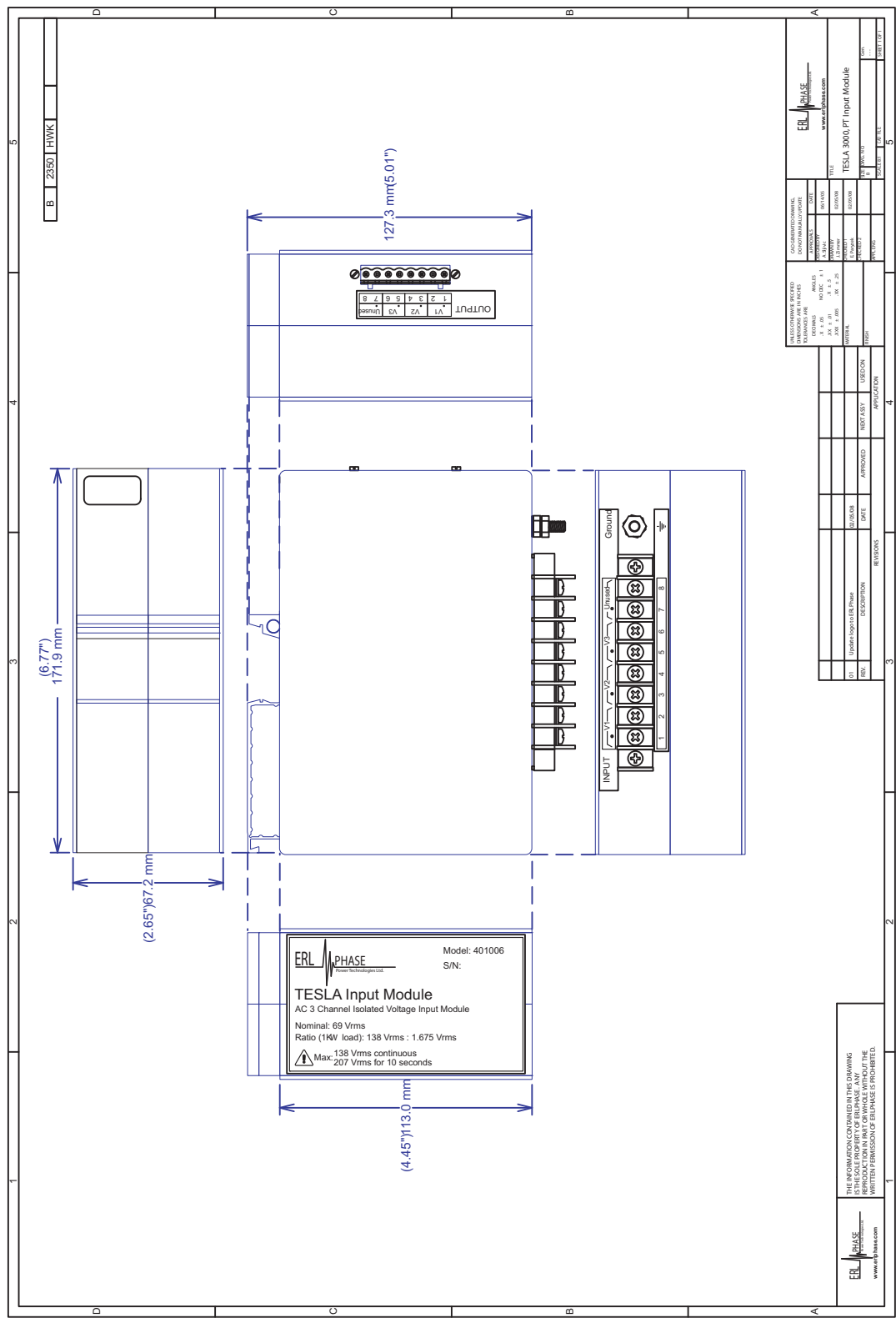


Figure F-1 AC Voltage Input Module

F.2 AC Current Input Module

The AC Current Input Module provides 4 channels of isolation and scaling for standard secondary current signals. Inputs are ac coupled through transformers. The module is available in 1A nominal (Model 401020) and 5A nominal (Model 401014) versions and has a dynamic range of 20x nominal. The module can withstand 20 A continuously and 100 A for 1 second.

Output from the module is scaled to connect directly to the TESLA's analog input terminals. Due to impedance matching requirements, module channels cannot be connected to more than one TESLA input channel.

Modules can be located up to 1220 meters/4000 feet from the recorder. Shielded wire (e.g. Belden 9728 or 9730) is recommended for connection to the recorder's inputs. The ground cable should be attached only at the recorder end.

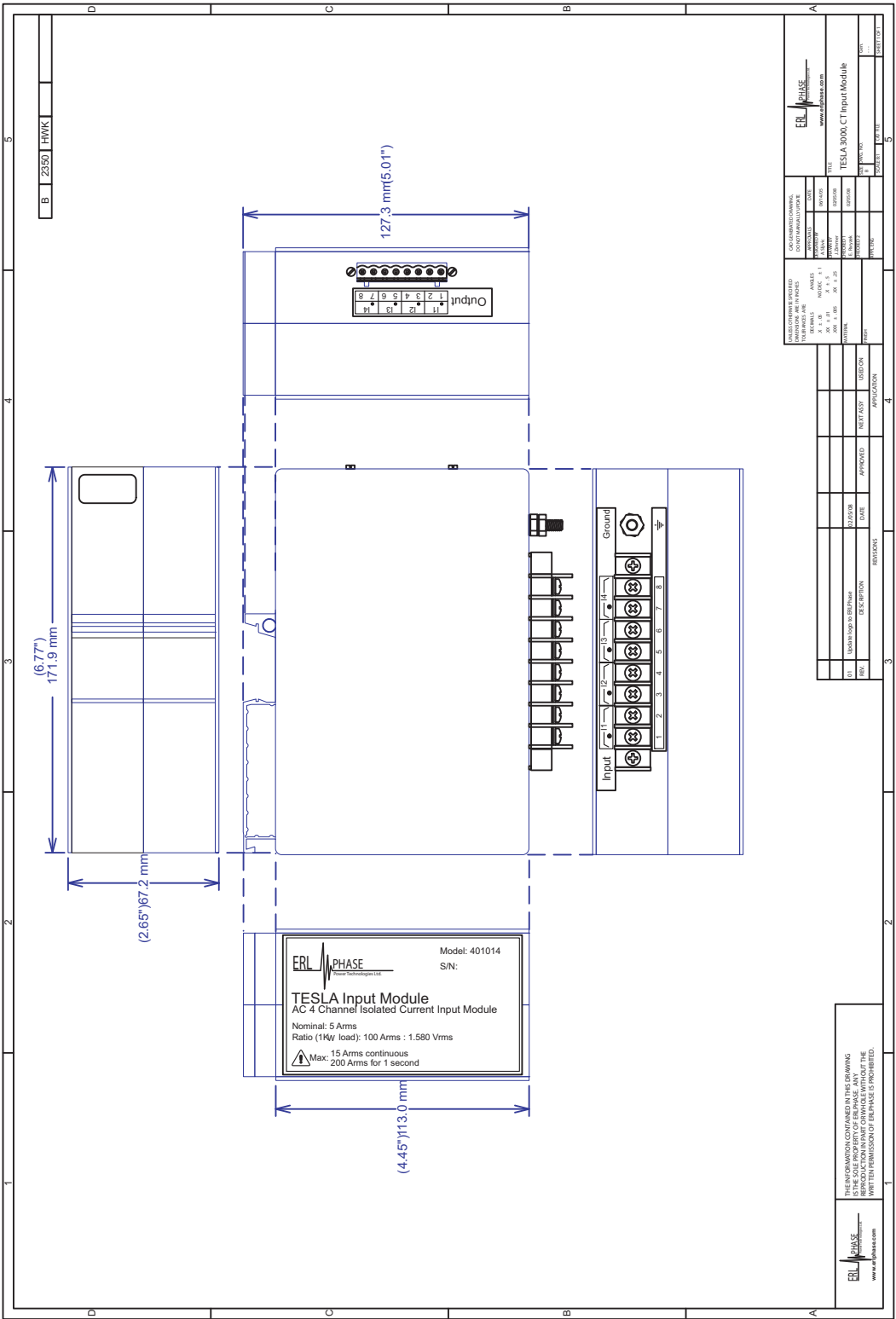


Figure F-2 AC Current Input Module

F.3 Split Core CT

The Split Core CT is designed to clamp around the secondary circuit wires from the primary current transformers. It is intended for situations where an outage is not possible to connect an in-line CT.

The Split Core CT has the same characteristics as the standard AC Current Input Module. It is available in 1A nominal (Model 401017) and 5A nominal (Model 401013) versions with a dynamic range that can pass 20x nominal currents continuously. The outputs from the CT are scaled and impedance matched to connect directly to the TESLA's analog input connectors. Due to impedance matching requirements, the CT cannot be connected to more than one TESLA input channel. The Split Core CT can be located up to 1220 meters/4000 feet from the TESLA.

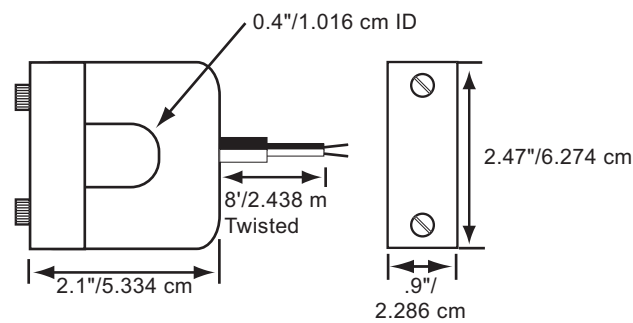


Figure F-3 Split Core CT

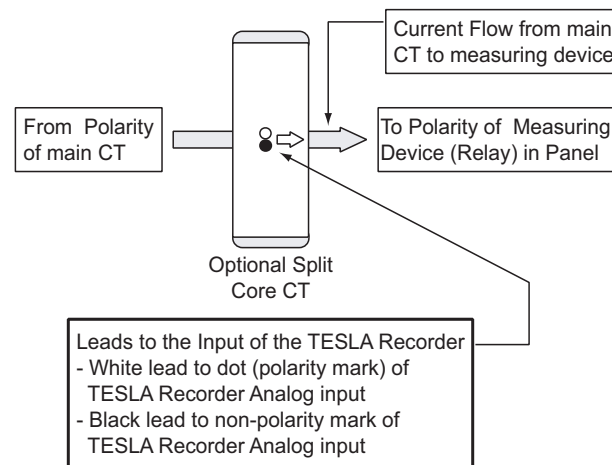


Figure F-4 Split Core CT Connection

F.4 Clamp-On CT

The Clamp-on CT (Model 401012) is a clothes-pin style device designed to clamp around the secondary circuit wires from the primary current transformers. It is intended for quick, temporary connection to existing circuits.

The Clamp-on CT has the same characteristics as the standard AC Current Input Module. It is scaled for a 5A nominal current with a dynamic range that can pass 20x nominal currents continuously. The outputs from the CT are scaled and impedance matched to connect directly to the TESLA's analog input connectors. Due to impedance matching requirements, the CT cannot be connected to more than one TESLA input channel.

Modules can be located up to 1220 meters/4000 feet from the recorder.

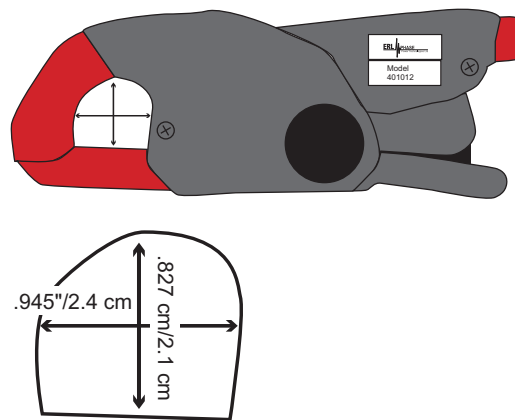


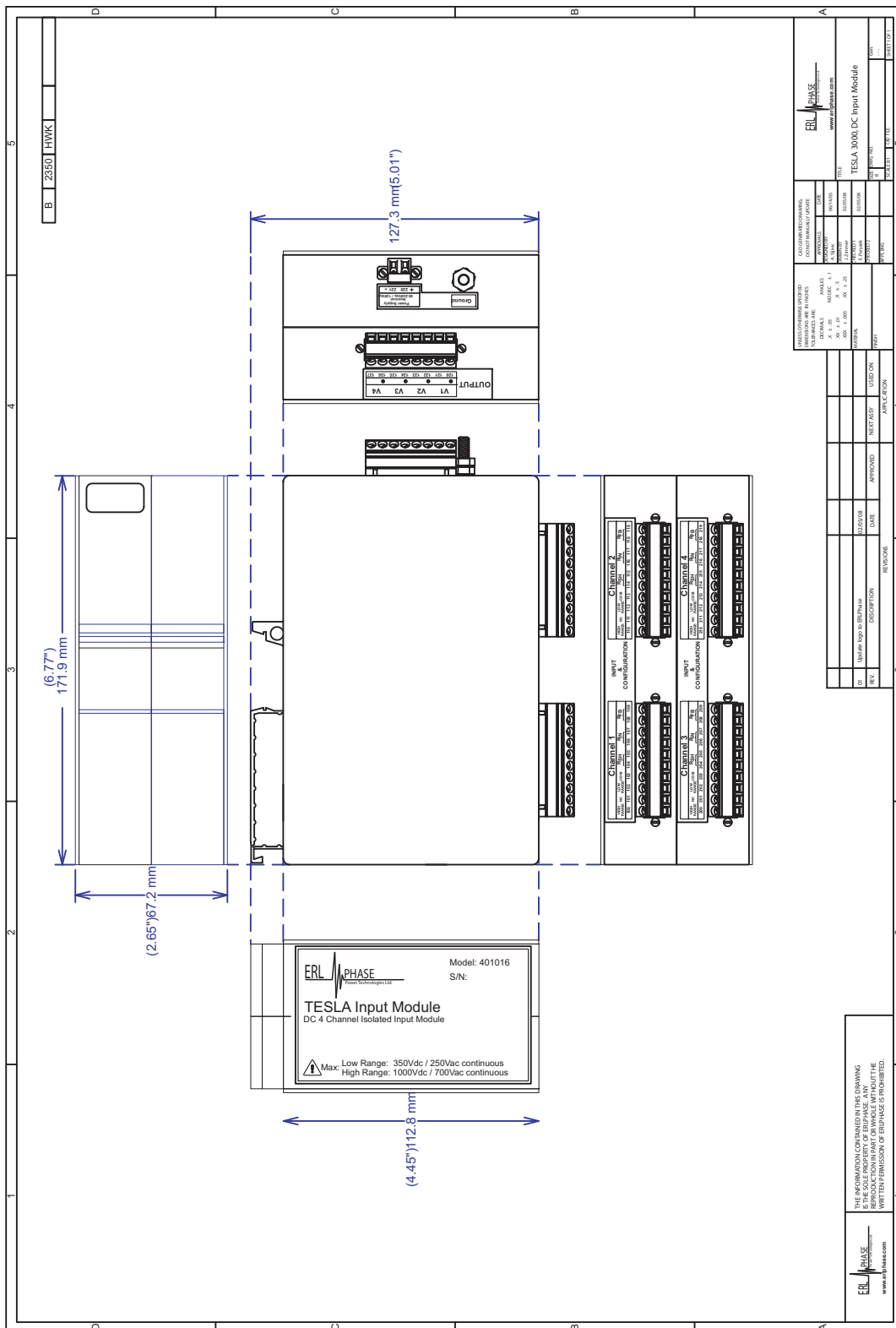
Figure F-5 Clamp-on CT

F.5 AC Low Voltage Input Module

The Low Voltage Input Module (Model 401022) provides 4 channels of isolation and scaling for low level ac voltages. Inputs are ac coupled through transformers. Scaling is set so that a 4 Vrms input represents a nominal signal level with a 2x over-voltage full scale range. The inputs can withstand 12 Vrms continuously and 15 Vrms for 10 seconds.

Output from the module is scaled to connect directly to the TESLA's analog input terminals. Due to impedance matching requirements, module channels cannot be connected to more than one TESLA input channel.

Modules can be located up to 1220 meters/4000 feet from the recorder. Shielded wire (e.g. Belden 9728 or 9730) is recommended for connection to the recorder's inputs. The ground cable should be attached only at the recorder end.



F.6 DC Input Module

The DC Input Module (Model 401016) provides DC-coupled isolation and scaling for four independent dc or ac voltage or current channels. Dc module channels have a dc to 2 kHz bandwidth, but the bandwidth may be limited by the recorder's input filters, depending on the sample rate. Externally mounted resistors set the input type and full scale range.

Output from the module is scaled to connect directly to the TESLA's analog input terminals. Due to impedance matching requirements, module channels cannot be connected to more than one TESLA input channel.

Modules can be located up to 1220 meters/4000 feet from the recorder. Shielded wire (e.g. Belden 9728 or 9730) is recommended for connection to the recorder's inputs. The ground cable should be attached only at the recorder end.

Input and Range Configuration

Resistors mounted on each channels input connector set the channel's input range. Up to three resistors are used, depending on the type and level of the signal to be applied.

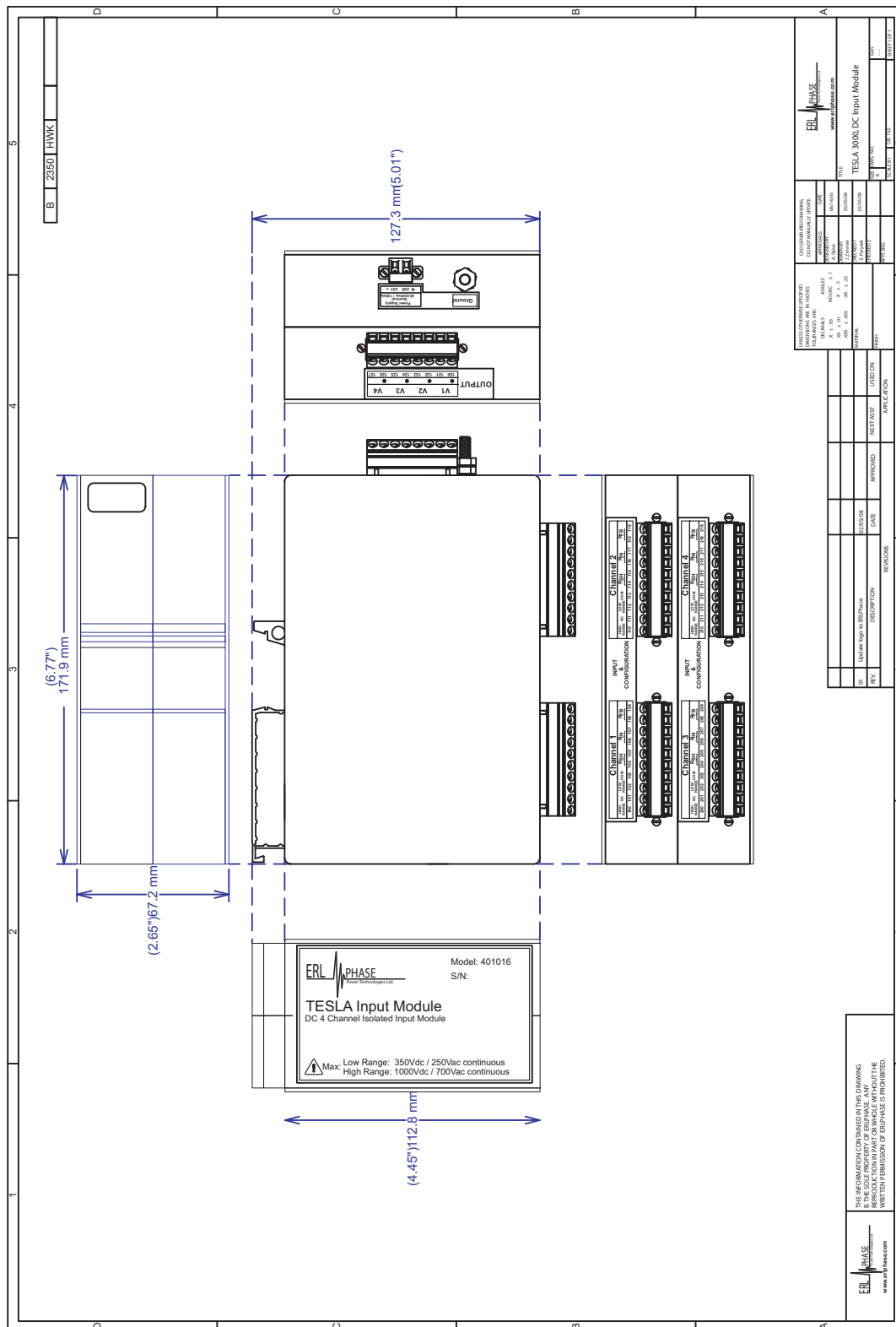
The input signal is applied to low or high range terminals, as appropriate for the selected input range.

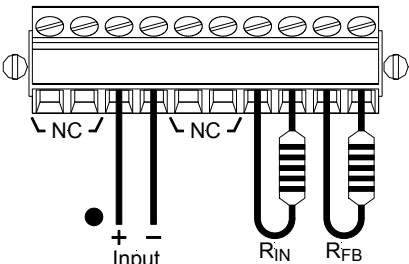
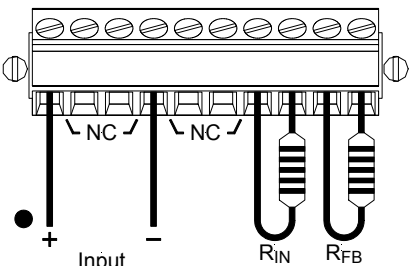
The following tables give resistor values and wiring examples for different applications. For applications that are not in these tables, contact ERLPhase.

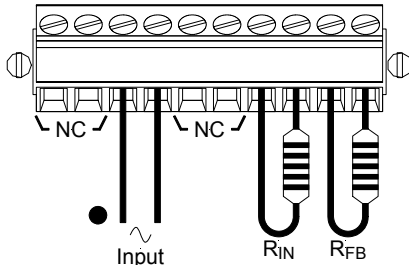
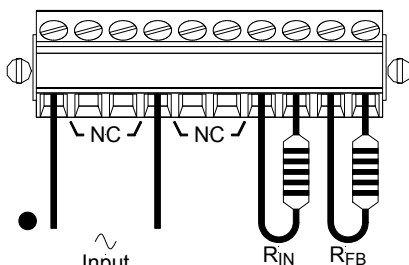
All resistors must be rated for ¼ watt or more, unless otherwise specified. Unless otherwise noted, the R_{IN} resistor must be rated to handle the full input voltage, which may require a physically larger resistor be used. This is generally true of any application that has an input in excess of 50 V peak.

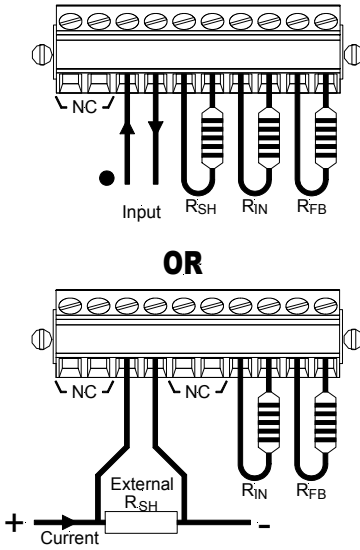
The resistor values specified are precision values as per the E48 standard series of resistance values in a decade. See the section L.3 Input and Range Configuration for the full table of standard values. It is possible to use other available values, although range and resolution may be compromised. Always select R_{IN} of equal or greater value to that shown, and select R_{FB} of equal or lesser value to that shown.

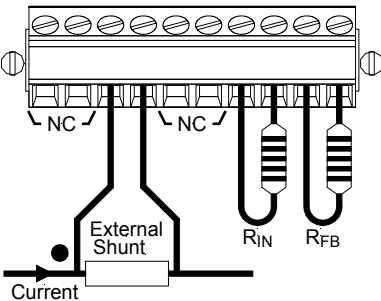
The Vishay CCF-2 series resistors in $\pm 1\%$ precision, or equivalent, are recommended for this application. These metal film flameproof resistors are rated for industrial power applications at up to 2 watts dissipation and up to 350 volt drop. Values of $4.99\ \Omega$ to $1\ M\Omega$ are available in this series - for higher values, use two resistors of appropriate value in series.



DC Voltage Input					
	Full Scale (V dc)	Shunt Resistance R_{SH} (Ω)	Input Resistance R_{IN} (Ω)	Feedback Resistance R_{FB} (Ω)	Input Impedance ($\Omega \pm 10\%$)
Low Range 0.1 V to 200 V dc FS 	± 0.1		332 Ω	open	10 k Ω
	± 0.2		0 Ω	422 k Ω	10 k Ω
	± 0.5		0 Ω	100 k Ω	10 k Ω
	± 1		0 Ω	40.2 k Ω	10 k Ω
	± 2		0 Ω	13.3 k Ω	10 k Ω
	± 5		1.40 k Ω	0 Ω	11 k Ω
	± 10		13.3 k Ω	0 Ω	22 k Ω
	± 20		38.3 k Ω	0 Ω	47 k Ω
	± 25		51.1 k Ω	0 Ω	60 k Ω
	± 50		121 k Ω	0 Ω	120 k Ω
	± 100		287 k Ω 1/2 W	0 Ω	240 k Ω
	± 150		511 k Ω 1 W	0 Ω	350 k Ω
	± 200		825 k Ω 1 W	0 Ω	450 k Ω
High Range 350 V to 880 V dc FS 	± 350		0 Ω	10.0 k Ω	1.5 M Ω
	± 500		0 Ω	3.48 k Ω	1.5 M Ω
	± 880		1 M Ω 2W	0 Ω	2 M Ω

AC Voltage Input						
		Full Scale (V rms)	Shunt Resistance R_{SH} (Ω)	Input Resistance R_{IN} (Ω)	Feedback Resistance R_{FB} (Ω)	Input Impedance ($\Omega \pm 10\%$)
Low Range 0.1 V to 150 V rms FS 	0.1			0 Ω	1.00 M Ω	10 k Ω
	0.2			0 Ω	237 k Ω	10 k Ω
	0.5			0 Ω	64.9 k Ω	10 k Ω
	1			0 Ω	23.7 k Ω	10 k Ω
	2			0 Ω	6.19 k Ω	10 k Ω
	5			6.19 k Ω	0 Ω	16 k Ω
	10			23.7 k Ω	0 Ω	33 k Ω
	20			59.0 k Ω	0 Ω	66 k Ω
	50			178 k Ω 1/2 W	0 Ω	160 k Ω
	100			464 k Ω 1 W	0 Ω	320 k Ω
	150 (for 69 V)			909 k Ω 2 W	0 Ω	490 k Ω
High Range 200 V to 600 V rms FS 	200			0 Ω	15.4 k Ω	1.5 M Ω
	250 (for 120 V)			0 Ω	9.53 k Ω	1.5 M Ω
	500 (for 240 V)			121 k Ω	0 Ω	1.6 M Ω
	600			750 k Ω 1 W	0 Ω	1.9 M Ω

DC Current Input (External Shunt Optional)						
		Full Scale (mA dc)	Shunt Resistance R_{SH} (Ω)	Input Resistance R_{IN} (Ω)	Feedback Resistance R_{FB} (Ω)	Full Scale Voltage Drop (V)
1 mA to 500 mA dc FS 	1	100 Ω	332 Ω	open	0.1	
	2	100 Ω	0 Ω	422 k Ω	0.2	
	5	100 Ω	0 Ω	100 k Ω	0.5	
	10	100 Ω	0 Ω	40.2 k Ω	1.0	
	20	100 Ω	0 Ω	13.3 k Ω	2.0	
	25 (for 4-20 mA)	100 Ω	0 Ω	8.25 k Ω	2.5	
	50	10 Ω	0 Ω	100 k Ω	0.5	
	100	1 Ω	332 Ω	Open	0.1	
	200	1 Ω	0 Ω	422 k Ω	0.2	
	500	1 Ω 1/2 W	0 Ω	100 k Ω	0.5	
		External shunt with value of R_{SH} may be used as shown instead of R_{SH} on the terminal block.				

AC Current Input (with External Shunt)						
		Full Scale (V rms) output of shunt	Shunt Resistance R_{SH} (Ω)	Input Resistance R_{IN} (Ω)	Feedback Resistance R_{FB} (Ω)	Input Impedance ($\Omega \pm 10\%$)
0.1 V to 1 V rms FS 	0.1		0 Ω	1.00 M Ω	10 k Ω	
	0.2		0 Ω	237 k Ω	10 k Ω	
	0.5		0 Ω	64.9 k Ω	10 k Ω	
	1.0		0 Ω	23.7 k Ω	10 k Ω	

Standard Series of Values in a Decade

The following tables show the standard values of resistance available in a decade. The lower numbered series are more common and easier to obtain, while the higher numbered series provide more resolution. In general, it is best to use the lowest numbered series which provides acceptable resolution, since this will be the easiest and least expensive to obtain.

Most often, distributors stock $\pm 2\%$ and $\pm 5\%$ resistors in the E24 series, 1% resistors in the E96 series, and $\pm 0.1\%$, $\pm 0.2\%$ and $\pm 0.5\%$ in the E192 series.

The values are not linear, but are instead approximately equal percentages apart from each other. Each value is related to the next by a ratio of approximately the Nth root of 10, where “N” is the series number (3 to 192).

E24, E12, E6 and E3 Series of Resistor Values (generally used for $\pm 2\%$ and $\pm 5\%$ resistors)			
E24	E12	E6	E3
10	10	10	10
11			
12	12		
13			
15	15	15	
16			
18	18		
20			
22	22	22	22
24			
27	27		
30			
33	33	33	
36			
39	39		
43			
47	47	47	47
51			
56	56		
62			
68	68	68	
75			
82	82		
91			

E192, E96 and E48 Series of Resistor Values (E96 generally used for $\pm 1\%$ resistors, E192 generally used for $\pm 0.1\%$, $\pm 0.2\%$ and $\pm 0.5\%$ resistors)											
E192	E96	E48	E192	E96	E48	E192	E96	E48	E192	E96	E48
100	100	100	178	178	178	316	316	316	562	562	562
101			180			320			569		
102	102		182	182		324	324		576	576	
104			184			328			583		
105	105	105	187	187	187	332	332	332	590	590	590
106			189			336			597		
107	107		191	191		340	340		604	604	
109			193			344			612		
110	110	110	196	196	196	348	348	348	619	619	619
111			198			352			626		
113	113		200	200		357	357		634	634	
114			203			361			642		
115	115	115	205	205	205	365	365	365	649	649	649
117			208			370			657		
118	118		210	210		374	374		665	665	
120			213			379			675		
121	121	121	215	215	215	383	383	383	681	681	681
123			218			388			690		
124	124		221	221		392	392		698	698	
126			223			397			706		
127	127	127	226	226	226	402	402	402	715	715	715
129			229			407			723		
130	130		232	232		412	412		732	732	
132			234			417			741		
133	133	133	237	237	237	422	422	422	750	750	750
135			240			427			759		
137	137		243	243		432	432		768	768	
138			246			437			777		
140	140	140	249	249	249	442	442	442	787	787	787
142			252			448			796		
143	143		255	255		453	453		806	806	
145			258			459			816		
147	147	147	261	261	261	464	464	464	825	825	825
149			264			470			835		
150	150		267	267		475	475		845	845	
152			271			481			856		
154	154	154	274	274	274	487	487	487	866	866	866
156			277			493			876		
158	158		280	280		499	499		887	887	
160			284			505			898		
162	162	162	287	287	287	511	511	511	909	909	909
164			291			517			920		
165	165		294	294		523	523		931	931	
167			298			530			942		
169	169	169	301	301	301	536	536	536	953	953	953
172			305			542			965		
174	174		309	309		549	549		976	976	
176			312			556			988		

Appendix G Recommended Spare Parts List

TESLA Model 3000 Recommended Spare Parts List

Part Number	Part Description	Quantity
106406	TESLA Model 3000 System Unit - 36 Analog Channels, 64 Digital Channels	*
107052	TESLA Model 3000 System Unit - 18 Analog Channels, 32 Digital Channels	*
101754	CT Isolation Module, four (4) current inputs rated 5 Amp each	*
101955	CT Isolation Modules, four (4) current inputs rated 1 Amp each	*
101756	PT Isolation Modules, three (3) voltage inputs rated 69 Volts RMS (120/Root3)	*
102079	LEA (Low Energy Analog) PT Module, three (3) voltage inputs rated 4 Volts RMS	*
106243	DC Module, four (4) isolated inputs	*
101783	Split-core current transducer rated 5 Amp	*
101784	Split-core current transducer rated 1 Amp	*
101850	Digital Input Shorting Bar, 8 inputs	*
106791	Users Manual in Binder	*
106724	One (1) GigaByte Flash Drive	*
107054	Two (2) GigaByte Flash Drive	*
107055	Sixty (60) GigaByte Hard Disk	*
106230	USB (Personal Computer) to DB9M Serial (TESLA) Cable	*
101787	DB9F Serial (Personal Computer) to DB9M (TESLA) Cable	*
101629	Modem adapter for use with 101787 Serial Cable	*
102404	RS232 to RS485 Converter, Optically Isolated, DIN Rail Mounting	*
102406	Power Supply for 102404, 120VAC to 12VDC, DIN Rail Mounting	*
107051	RS232 Serial to Parallel Port Converter	*

Note: * = One of each component used

Appendix H 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 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 I TESLA 3000 Drawings

This appendix contains mechanical and connection drawings for the TESLA 3000.

TESLA 3000 Mechanical Overview (2)

TESLA 3000 Rear Panel View

TESLA 3000 AC Input Module Connection

TESLA 3000 DC Input Module Connection

Electronic versions of the drawings in both PDF and DWG formats are available on the TESLA 3000 CD in the Manuals directory. The PDF documents are scaled for 11" x 17" printing for improved readability.

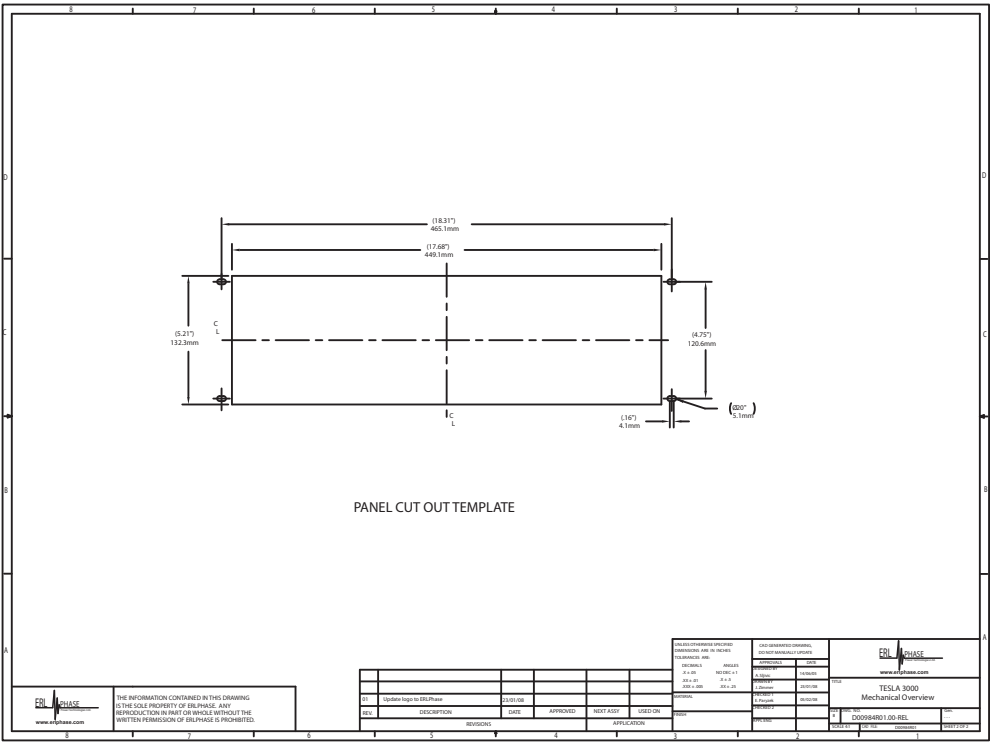
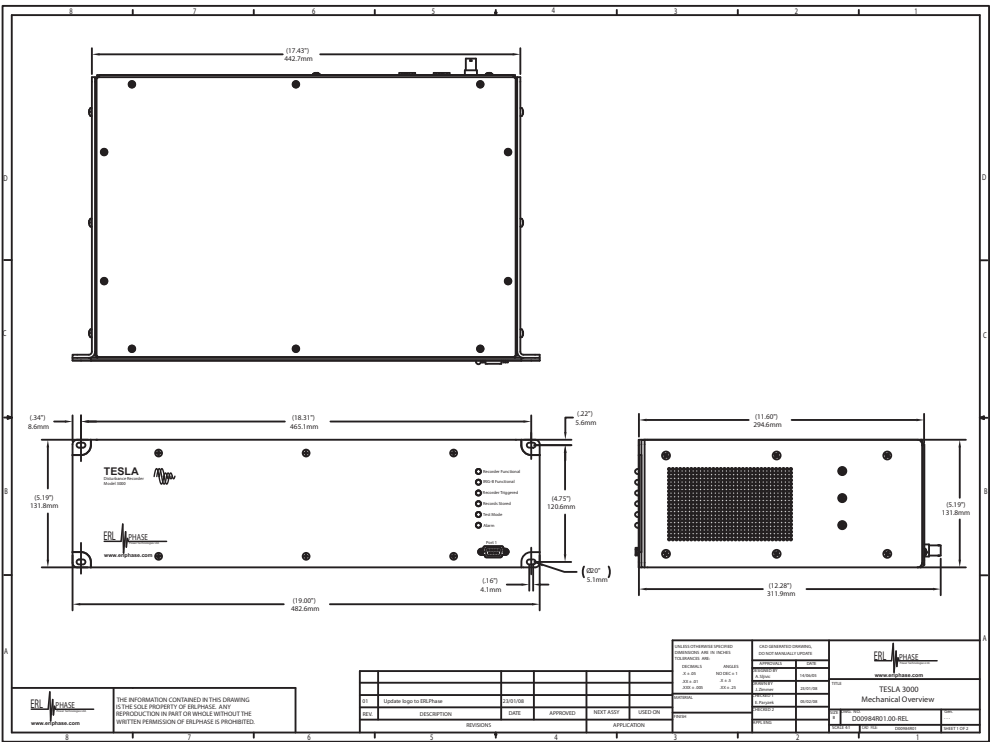


Figure I.1: TESLA 3000 Mechanical Overview - Dimensions

f

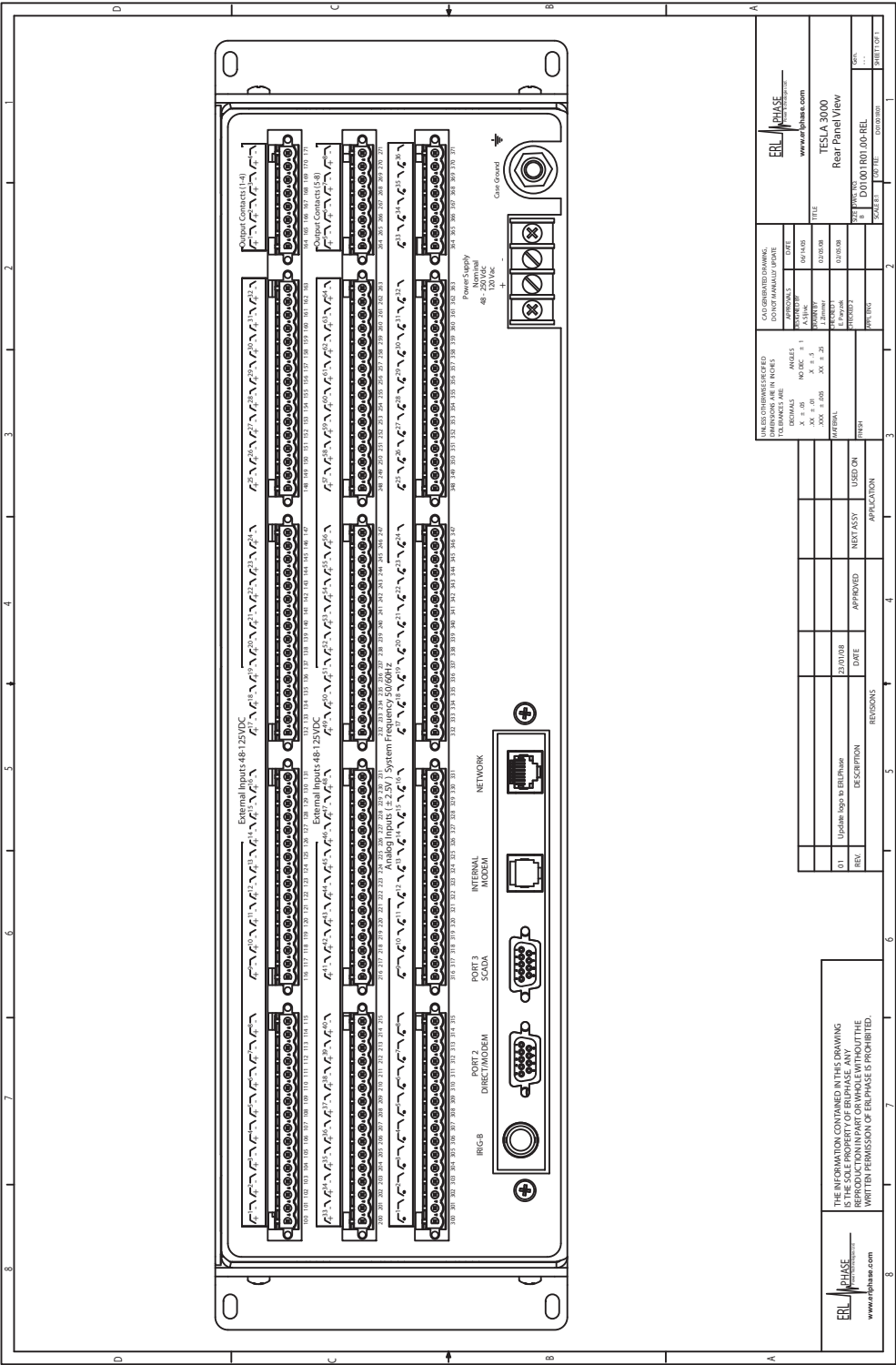


Figure I.2: TESLA 3000 Rear Panel

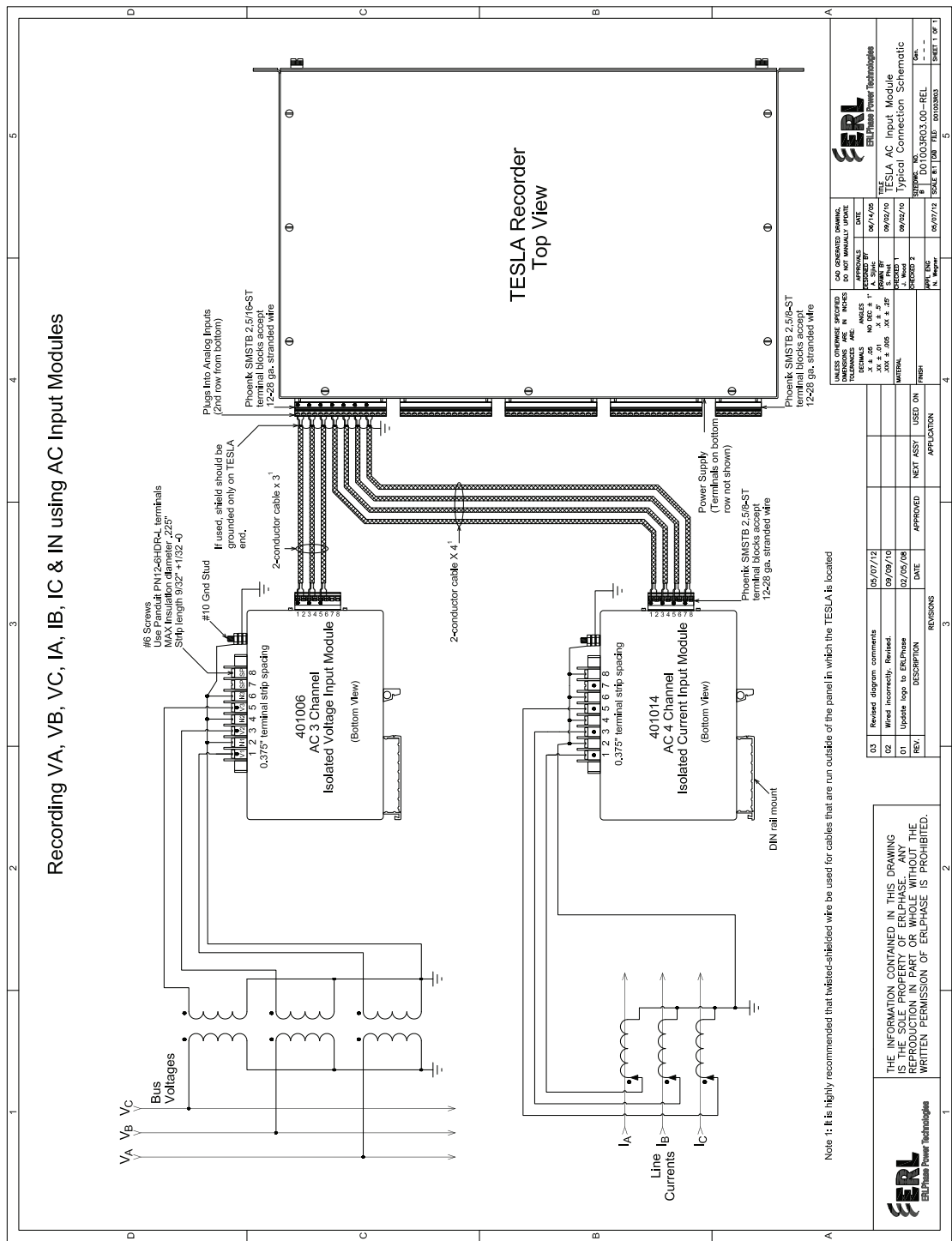


Figure I.3: TESLA 3000 AC Input Module Connection Diagram

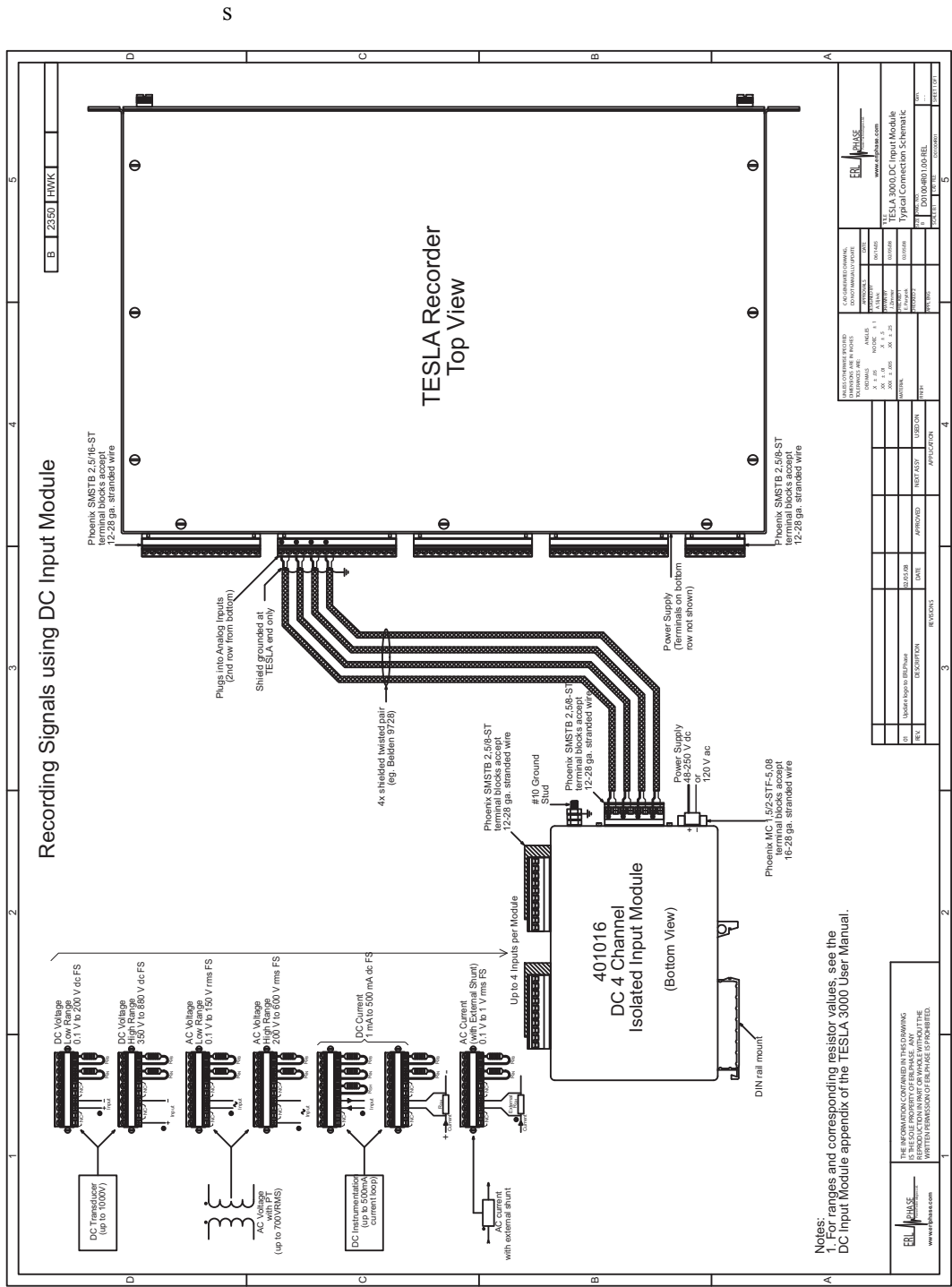


Figure I.4: TESLA 3000 DC Input Module Connection Diagram

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